RAWALPINDI DEVELOPMENT AUTHORITY (RDA)

CONSTRUCTION OF RAWALPINDI RING ROAD PROJECT

TECHNICAL SPECIFICATIONS

MARCH 2021

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED
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GENERAL

1. INTRODUCTION

1.1 SCOPE OF WORK

1.1.1 Objectives and Description of Project

Rawalpindi Ring Road project is a new cconstruction of approximately sixty five point three kilometers (65.3km) long road. This highway will begin from National Highway (N-5) near Rawat (Radio Pakistan) pass through M-2 motorway, Islamabad International Airport, China Pakistan Economic Corridor (CPEC), M-1 motorway and terminate at Sangjani National Highway Islamabad. To cater to the congested vehicular traffic to pass through Rawalpindi and Islamabad , the GoPb has decided to construct the Rawalpindi Ring Road in three segments: (i) starting from N-5 to DI Hakla six-lane dual carriageway (3 + 3 lanes both sides); (ii) starting from DI Hakla to M-1 two plus two (2+2) rigid pavements parallel to the already existing motorway; and (iii) starting from M-1 to Sangjani six-lane dual carriageway (3 + 3 lanes both sides) by engineering, procuring, constructing, financing, operating and maintaining, through Public Private Partnership on a design, build, finance, operate and transfer (the "DBFOT") basis, the Project Highway along with the Project Facilities in accordance with this Agreement and the subsequent Operation and Maintenance of the same in accordance with this Agreement.

A Constant ROW of 120 m has been adopted for package 1 (except at Interchanges), NHA ROW to be followed for package 2 and 60m (avg) ROW for Package 3.

The project is aimed at providing a high capacity and efficient road facility to cater inter suburban travel demand and through traffic to help relieve the city road network from congestion and pressure of extraneous traffic.

1.2 CONTROL OF WORK

These Project Specifications lay down requirements for Materials, Construction and Testing. Measurement & Payment clauses of these Specifications, if any, shall not be applicable.

The Project/Project Facilities shall conform to the minimum design requirements set out in Schedule of Design Requirements on basis of which the Detailed Project Report (DPR) has been prepared. Preliminary Design Report, Drawings and Setting Out & Profile Data are included in DPR to lay down minimum design requirements of the Project for the purpose of bid.

Functional parameters of the Project as given in the Geometric Design Criteria in Preliminary Design Report are the minimum requirements and must be met by the Concessionaire while preparing detailed design. However during Implementation Stage, without reducing these functional parameters, the Concessionaire may come up with an alternate design for any component of the Project e.g. interchanges, bridge structure, pavement structure, super pave, rigid pavement, solar panels etc. The Concessionaire shall submit its alternate design along with Specifications to the Independent Engineer/LRRA for checking and approval. Such alternate Specifications after approval by Independent Engineer and LRRA shall replace relevant part of these Specifications.

The terms Contractor, Engineer and Employer in these Specifications shall mean the Concessionaire, Independent Engineer and Lahore Ring Road Authority (LRRA) respectively.

1.2.1 Authority of the Engineer

The Engineer will decide all questions which may arise as to the quality and acceptability of materials furnished and Work performed and as to the rate of progress of the Work; specifications compliance; and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor. The Engineer will have the authority to suspend the Work wholly or

in part due to the failure of the Contractor to correct conditions unsafe for the workmen or the general public; for failure to carry out provisions of the Contract; for failure to carry out orders; for such periods as he may deem necessary due to unsuitable weather; for conditions considered unsuitable for the execution of the Work or for any other condition or reason deemed to be in the interest of the Employer.

In order to provide for the protection of the Work, for the protection of the public, for the most advantageous movement of public traffic, and to assure early completion of the Work when more than one Contractor is involved, the Engineer shall have the right to require the early completion or the delay of portions of the Work and to determine the order in which the Work shall be executed. His decision shall be final and he shall have executive authority to enforce and make effective such decisions and orders that the Contractor fails to carry out promptly.

Any Directives or written instructions to the Contractor which may be required may be served on said Contractor or his representative, either personally or by mailing to the address given in the Contract, or by leaving the same at said address.

1.2.2 Plans and Working Drawings

The approved plans will show details of all traffic control plans, lines, grades, typical cross sections of the roadway, location, and design of all structures. The Contractor shall keep one set of plans available at the Work Site at all times.

The plans will be supplemented by such working drawings as are necessary to adequately control the Work. Working drawings for structures shall be furnished by the Contractor and shall consist of such detailed plans as may be required to adequately control the Work. They shall include stress sheets, shop drawings, erection plans, false work plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data required of the Contractor. Working drawings for traffic control through work zones (Traffic Control Plans) shall be furnished by the Contractor. These working drawings shall include Geometrics and cross section detour layouts, signs and other traffic control device locations and traffic handling schemes. All working drawings must be approved in writing by the Engineer and such approval shall not operate to relieve the Contractor of any of his responsibility under the Contract for the successful completion of the Work. No related Work may proceed until approval is obtained from the Engineer. Deviations from the working drawings may likewise be approved in writing. Deviations without previous approval may be cause for rejection of the Work involved.

1.2.3 Conformity with the Plans and Specifications

All Work performed and all materials furnished shall be in conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in these Specifications.

In the event the Engineer finds the materials or the finished product in which the materials are used or the Work performed are not in conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, the Work, or materials shall be removed and replaced or otherwise corrected by the Contractor.

1.2.4 Coordination of Plans and these Specifications

These Specifications and the Plans and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all.

They are intended to be complementary and to describe and provide for a complete Work. The provisions of the Contract shall take precedence over the provisions or stipulations in Specifications. In the plans, calculated dimensions will govern scaled dimensions.

The Contractor shall take no advantage of any apparent error or omission in the Specifications. In the event the Contractor discovers such an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and

interpretations as may be deemed necessary for fulfilling the intent of the plans and Specifications.

1.2.5 Silence of Specifications

The apparent silence of the Specifications or plans as to any detail or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best generally accepted practice is to be used. All interpretations of the Specifications will be made by the Engineer on this basis.

1.2.6 Cooperation of Contractor

In order to coordinate the efforts of the Contractor or the several Contractors with those of the Engineer; to facilitate the movement of traffic; and to ensure the early completion of all phases of the Work; the Contractor shall, prior to beginning the Work, confer with the Engineer to arrange for a satisfactory Program of Work. Whenever work being done by other Contractors is contiguous or related to the Work included in this Contract, the sequence of handling the Work shall be such that the least delay possible will result to each Contractor and such sequence may be designated by the Engineer. The respective rights of the various interests involved shall be established by the Engineer, in order to secure the completion of the various portions of the Work in general harmony.

The Contractor shall have available on the Work one copy of the plans and Specifications at all times. He shall give the Work the constant attention necessary to facilitate the progress thereof and shall cooperate with the Engineer and other Contractors in every way possible. The Contractor shall at all times have a competent, English speaking, Site Engineer capable of reading and thoroughly understanding the plans and specifications, as his agent on the Work, who shall receive instructions from the Engineer or his authorized representatives. The Site Engineer shall have full authority to execute the orders or directions of the Engineer without delay and to supply promptly such materials, tools, plant equipment, and labor as may be required. The Site Engineer shall be furnished irrespective of the amount of Work sublet. Whenever the Contractor or his Site Engineer is not present on any part of the Work where the Engineer may desire to give orders or directions, they shall be received and obeyed by the Foreman or person in charge of the particular Work.

1.2.7 Construction Stakes, Lines and Grades

The Contractor shall set construction stakes establishing lines, slopes, and continuous profile grade in road work, and centerline and benchmarks for bridge work, culvert work, protective and accessory structures, and appurtenances as he may deem necessary and will furnish the Engineer with the original copy of the field notes together with all necessary information relating to lines, slopes and grades. These stakes and marks shall constitute the field control by and in accordance with which the Contractor shall establish other necessary controls and perform the Work.

The Contractor shall, prior to any stakeout Work, submit to the Engineer for his approval a planned method of operations for the staking-out of the project. The plan shall include minimum accuracy of stakes, the positions of the various types of stakes, the method of marking stakes, the methods to be used for protecting stakes, etc. No staking shall proceed prior to the Engineer's approval of the Contractor's staking plan.

At least twenty-four (24) hours before he intends to stakeout any portion of the Work, the Contractor shall submit written notice to the Engineer. Such notice shall include the time, location, and type of Work to be staked.

The Contractor will stakeout the Work and secure the Engineer's approval of his stakeout during the preparation period before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable, before or after stakeout, the Engineer will issue detailed instructions to the Contractor for such modifications and the Contractor will revise the stakeout for further approval.

The profiles and cross sections on the plans indicate the elevation of the top of road surface or as otherwise noted on the plans. Coordinates and elevations shown on the Drawings are in meters and are based upon an approved coordinate system.

The Contractor shall be held responsible for the preservation of all stakes and marks. If any of the construction stakes or marks have been destroyed or disturbed, the Contractor will replace them. Certain established Bench Marks are located in the vicinity of the Works and the Contractor shall ensure that they are not damaged or disturbed by his operations.

The Contractor shall be responsible for the accuracy of all lines, slopes, grades and other survey Work.

1.2.8 Duties of the Inspector

Inspectors, employed by the Engineer, will be authorized to inspect all Work done and materials furnished. Such inspection may extend to all or any part of the Work and to the preparation, fabrication, or manufacture of the materials to be used. The Inspector will not be authorized to alter or waive the provisions of the Specifications. The Inspector will not be authorized to issue instructions contrary to the plans and Specifications, or to act as foreman for the Contractor.

1.2.9 Inspection of Work

All materials and each part or detail of the Work shall be subject to inspection by the Engineer. The Engineer, or any person authorized by him, shall at all times have access to the Work and all workshops and places where Work is being prepared, or where materials, manufactured articles, or machinery are being obtained for the Work. The Contractor shall facilitate in obtaining the right to such access.

The Contractor shall submit a written request for inspection of any portion of the Work at least twenty-four (24) hours before such Work is to be performed. The request shall include the date, time, location and type of Work to be performed. When approved by the Engineer, a method of communication other than a written request may be used.

At any time before acceptance of the Work, the Contractor shall remove or uncover such portions of the finished and previously inspected Work as may be directed by the Engineer. After examination, the Contractor shall restore said portions of the Work to the standard required by the Specifications. Should the Work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, will be paid for by the Employer; but should the Work so exposed or examined prove unacceptable, the uncovering, or removing and the replacing of the covering or making good of the parts removed will be at the Contractor's expense.

Any Work done or materials used without inspection by the Engineer may be ordered to be removed and replaced at the Contractor's expense.

The inspection function shall in no way be replaced by the sampling and testing program used to determine the estimated percent defective and resultant value of work.

1.2.10 Templates and Straightedges

The Contractor shall provide a sufficient number of metal templates to be used by the Contractor and the Engineer to control and check the correct shaping of finished surfaces of the Work. The templates shall be as per dimensions shown on the plans or as directed by the Engineer.

In addition, the Contractor shall provide a sufficient number of metal straightedges, as required by the Specifications and the Engineer, for control of the longitudinal and transverse dimensions of the Work. Samples of the templates and straightedges shall be submitted to the Engineer for approval.

The templates and straightedges shall be maintained in good condition at all times. They will be checked from time to time by the Engineer and, if necessary, repaired, corrected or replaced by the Contractor as directed by the Engineer.

1.2.11 Removal of Unacceptable and Unauthorized Work

All work which, as determined by the Engineer, does not conform to the requirements of the Contract and results in an inferior or unsatisfactory product, will be considered unacceptable. Unacceptable Work, whether the result of poor workmanship, use of defective materials, damage through carelessness or any other cause, found to exist prior to the final acceptance of the Work, shall be removed or replaced at the Contractor's expense.

No work shall be done without lines and grades having been approved by the Engineer. Work done contrary to instructions of the Engineer, Work done beyond the lines shown on the plans or as given except as herein specified, or any extra work done without authority, will be considered as unauthorized. Such Work done may be ordered to remove or replace at the Contractor's expense.

Upon failure on the part of the Contractor to comply forthwith any order of the Engineer, made under the provisions of this article, the Engineer will have authority to cause unacceptable Work to be remedied or removed and replaced and unauthorized Work to be removed and to deduct the costs from any money due or to become due to the Contractor.

1.2.12 Load Restrictions

The Contractor shall comply with legal load restrictions in the hauling of materials on public roads beyond the limits of the project.

The Contractor shall use every reasonable means to prevent any of the highways or bridges intersecting with or on the routes to the Site from being damaged or injured by any traffic of the Contractor or any of his Subcontractors, and in particular shall select routes, choose and use vehicles, and restrict loads so that any such extraordinary traffic as will inevitably arise from the moving of plant and materials from and to the Site shall be limited as far as reasonably possible and so that no unnecessary damage or injury may be caused to such highways and bridges.

Should it be found necessary for the Contractor to move one or more loads of construction plant machinery or pre-constructed units, or parts of units of Work, over part of a highway or bridge, the moving of which is likely to damage any highway or bridge unless special protection or strengthening is carried out, then the Contractor shall, before moving the load onto such highway or bridge, give notice to the Engineer of the weight and other particulars of the load to be moved and his proposals for protecting or strengthening the said highway or bridge. Unless within fourteen (14) days of the receipt of such notice the Engineer shall by counter-notice direct that such protection or strengthening is unnecessary, then the Contractor will carry out at his own expense such proposals or any modification thereof that the Engineer shall require.

The Contractor shall bear all responsibility and liability for damages or injury resulting from his failure to abide by these provisions except when such transport or passage is done by special written permission of the Employer. The Contractor shall be responsible for all damage caused by his hauling within the limits of the Work.

Any type of equipment of such weight or so loaded as to cause damage to drainage structures of any kind, or to any other type of construction, either being constructed or previously constructed, will not be permitted to operate in any location where damage would be caused. No loads shall be permitted on a pavement or base before the expiration of the curing period.

The Contractor shall prepare proposals for routes to be taken by heavy construction traffic, particularly for hauling in fill material for use on the site. These routes should, where possible, avoid existing roads and built-up areas. The Contractor shall provide and maintain signs to

direct construction traffic onto haul routes. Details of haul routes and signage shall be submitted to the Engineer for approval within one (1) month of the commencement of the Contract and the signs shall be erected within a further one (1) month.

One-way traffic systems shall be operated on haul routes where required by the Engineer. The Engineer may, at any time, withdraw his approval to the use of any route until such strengthening or repair work as he considers necessary has been carried out on that route by the Contractor.

Where it is necessary for Contractor's plant or vehicles to cross public highways, and where required by the Engineer, all such crossings shall be equipped with manual-controlled traffic lights. During brief stoppages of crossings by Contractor's plant, the traffic signals shall be set to show "green" to the Public Highway. During extended period when the Contractor's plant is not using the crossing, the traffic signals shall be switched off, turned away from the carriageway and the advance warning signs obscured.

Stationary vehicles, equipment, huts, heaps of materials, etc. shall be kept clear of the crossing point so that all those using the highway and the haul road shall have a clear view.

1.2.13 Protection and Maintenance of the Works during Construction

The Contractor shall protect and maintain the Work throughout the Contract Period and until the Final Handover of the project. This protection and maintenance shall be done with adequate equipment and forces to the end that the roadway and structures are kept in satisfactory condition, as determined by the Engineer, at all times.

In the case of a requirement for the placing of a course upon a course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade during all construction operations.

1.2.14 Settlement of Differences

Any difference or dispute between the Employer and the Contractor shall be resolved as per provisions of the Contract.

1.2.15 Sign Boards

The Contractor shall, within sixty (60) days of signing of the Contract, provide and install two (2) metal project sign boards, written in Urdu and English. Each board shall conform to the construction, erection and message details shown on the Project Sign Standard Detail Drawing in the plans.

Each sign board is to be erected in a prominent and approved position, one at each end of the length of road included in the Contract. The sign boards shall be maintained in good order, for the duration of the Contract, by the Contractor. At the end of the maintenance period, the project sign boards and supports shall be dismantled and removed from the site by the Contractor.

1.2.16 Monuments

The Contractor shall be responsible for supplying a monument in a location selected by the Employer's Representative where the monument is to be placed, to the Specifications and Drawings prepared by an artist and approved by the Employer's Representative.

1.2.17 Water Wells

The Contractor shall make sure that Water Wells are drilled and maintained in accordance with the specifications approved by Tehsil Municipal Administration concerned. These water wells are to be handed over to Tehsil Municipal Administration concerned upon the completion of the project and the Contractor must attach the handing over certificate within

the final certificate.

1.3 CONTROL OF MATERIALS

1.3.1 Sources of Supply and Quality Requirements

All materials, manufactured articles, and machinery incorporated in the permanent Work shall meet all quality requirements of the Contract. They must, in all cases, be approved by the Engineer prior to their inclusion in the Work.

In order to expedite the Work, the Contractor shall, before placing any purchase order for materials, manufactured articles, and machinery to be a part of the permanent works, submit for the approval of the Engineer, a complete description of such items, the names of the firms from which he proposes to obtain such items, together with copies of all test records proving compliance with Contract provisions. No materials, manufactured articles, or machinery shall be ordered from any firm without the written approval of the Engineer. When directed by the Engineer or otherwise specified in the Contract, the Contractor shall submit samples for approval.

If it is found after trial that sources of supply for previously approved materials, manufactured articles, or machinery do not produce specified products, the Contractor shall replace the defective items and furnish the items from other sources approved by the Engineer and without additional compensation.

1.3.2 Local Material Sources

When sources of local materials are designated on the plans and/or described in these Specifications, the quality of materials in such deposits is considered to be acceptable in general, but the Contractor shall determine for himself the quality and the amount of equipment and work required to produce a material conforming to the specifications. The designation of a source of material in no way relieves the Contractor of his responsibility to produce materials conforming to the Specifications.

When sources of local materials are not described in these Specifications, the Contractor shall be totally responsible for locating and producing materials meeting the Specifications.

The exploring, testing of samples, and developing of such material sources are responsibility of the Contractor.

It shall be understood that it is not feasible to ascertain from samples the limits for an entire deposit and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject other portions of the deposits as unacceptable.

No material, regardless of its source, shall be incorporated in the Work until representative samples taken and tested in an approved laboratory by or in the presence of the Engineer, have been approved and written authority is issued by the Engineer for use thereof.

1.3.3 Sampling, Testing and Cited Specifications

All materials shall be presented to the Engineer for inspection, testing and acceptance before incorporation into the Work. All materials being used are subject to inspection, testing or rejection at any time prior to incorporation into the Work.

All sampling shall be in accordance with standard AASHTO/ASTM/BS procedures, unless otherwise stated in these Specifications. Random sampling shall be used for selecting location where to take a sample as per ASTM D-3665.

1.3.3.1 Quality or Source Approval Samples and Tests

All source approval samples shall be taken by the Contractor with notice given to the Engineer and opportunity afforded the Engineer to observe the sampling procedure. All source approval tests shall be performed under the supervision of the Engineer or, when specified, by an independent laboratory approved by the Employer's Representative.

Once a source of materials has been approved, the Contractor shall develop and produce from the source only to the extent that material is represented by the source approval samples. The expansion of the source or the changing of sources shall necessitate additional source approval samples and tests.

The Engineer shall periodically order new testing of previously approved sources to verify that they continue to comply with the Specifications. The Engineer may order the new testing to be performed at the same or at a different laboratory from the laboratory performing the original source approval tests. If new testing indicates that a previously approved source no longer complies with the specification requirements, the Contractor shall immediately cease production. He shall perform additional tests as ordered by the Engineer to ascertain the magnitude of the problem.

No source shall continue to be used which does not comply with the Specifications.

Stockpiles of materials not complying with Specifications shall not be incorporated into the Work.

1.3.3.2 Contractor Quality Control Samples and Tests

Contractor quality control tests (process control) are those tests performed by the Contractor during construction to ascertain specification compliance prior to submitting the material to the Engineer for acceptance. The Contractor is totally responsible for sampling and testing for process control. The Contractor shall inform the Engineer of the details of his quality control testing program and cooperate in any review of that program asked by the Engineer. While the Engineer will not normally specify the details of the Contractor's process control testing, he may declare the program unacceptable if there are chronic rejections of substandard Work as determined by the Project Acceptance Samples and Tests (see below). The Contractor may then be ordered to improve process control procedures, including increasing the frequency of tests and modifying construction procedures as necessary.

1.3.3.3 Project Acceptance Samples and Tests

All project acceptance samples shall be taken in a random manner and jointly by the Engineer and the Contractor after the Contractor has notified the Engineer that the material is ready for testing. These tests shall be performed in the Project Laboratory, or in-situ as appropriate, under the supervision of the Engineer. The Engineer may order the retesting of any material when there has been a significant delay in the construction operations or when he believes the material may have deteriorated since its original acceptance. Material which does not comply with the Specifications as determined by project control tests shall be rejected and removed from the Work and replaced, or corrected at the expense of the Contractor. The Engineer may order additional testing to ascertain the extent of non-specification material.

1.3.3.4 Split Samples and Tests

Split samples are a split part of a job-control or acceptance sample taken by project personnel and delivered to the Road Research and Material Testing Institute (RR&MTI) or an Employer's Representative approved independent Laboratory to verify the testing results of the field job control or acceptance tests.

1.3.3.5 Check Samples and Tests

The Engineer will perform or supervise the performance program of quality and acceptance check sampling and testing to verify the quality of materials being incorporated into the work and the sampling, testing and equipment. The Engineer may direct that the check tests be

performed by persons other than those normally responsible for project control testing, or he may direct the sample be transported to the RR&MTI or an Employer's Representative approved independent laboratory for testing. The Contractor shall be responsible for the costs of testing in an independent laboratory.

The cost of all materials taken as samples for testing shall be borne by the Contractor. The Contractor, at his own expense, shall supply the Engineer with all necessary test report forms and such expendable materials as may be removed to perform the required tests. Copies of all test results will be furnished to the Contractor or his representative.

Unless otherwise specified, all references to methods of test or specifications of AASHTO, ASTM, BSI and others shall be construed to mean those methods of test or specifications which have been most recently adopted and published prior to the date of the Contract.

1.3.3.6 Minimum Sampling and Testing Frequency

Minimum Sampling and testing frequency for each type of material shall be in accordance with the "Tables for Sampling and Testing Frequency" as specified in these Specifications. This sampling and testing shall be carried out under the supervision of the Engineer.

For all other materials, unless otherwise specified in these Specifications, AASHTO methods of sampling and testing shall govern. In the absence of such sampling and testing methods in the AASHTO Standard, the ASTM methods shall govern.

In the event that there are items of Work for which there are no testing frequencies listed in these Specifications, the Engineer will establish minimum frequencies based on the character of the materials and the specification requirements.

1.3.4 Quality Control Charts

The quality of materials and construction shall be controlled using control charts based on statistical techniques. The control charts shall be prepared and kept current daily by the Contractor. These charts shall be submitted to the Engineer every month for review and approval. The charts shall be drawn in the form of graphs with property characteristics on the vertical axis and test numbers on the horizontal axis.

Target line, upper and lower control and warning limits shall be drawn as directed by the Engineer. The Engineer will divide the work and the materials into lots. Each lot will be evaluated separately.

1.3.5 Plant Inspection

The Engineer may undertake the inspection of materials at the production plant.

In the event plant inspection is undertaken, the following conditions shall be met:

(1) the Engineer shall have the cooperation and assistance of the Contractor and/or the producer with whom he has contracted for materials; **(2)** the Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished; and **(3)** adequate safety measures are to be provided and maintained.

It is understood that the Engineer reserves the right to retest all materials which have been tested and accepted at the source of supply after delivery to the site and prior to incorporation into the Work and to reject all materials which are obviously defective or, when retested, do not meet the requirements of the Specifications.

1.3.6 Storage of Materials

Materials shall be so stored as to assure the preservation of their quality and fitness for the Work. Stored materials, even though approved before storage, may again be located so as to

facilitate their prompt inspection. Materials shall not be stored on the right-of-way except where and as permitted by the Engineer. Stockpiling of aggregate material within the right-of-way shall be confined to such authorized areas as may be approved by the Engineer. Where stockpiling is done outside the roadway on Government or private property, the site shall be abandoned immediately upon completion of the utilization of the stockpiled material and the natural surface shall then be restored as nearly as possible to the original condition by the Contractor at his own expense and to the satisfaction of the Engineer. Any costs for the use of privately-owned land for storage and/or for the placing of the Contractor's plant and equipment shall be borne by the Contractor. Private property shall not be used for storage purposes without written permission and release of the owner or lessee, and a copy of such written permission and release shall be furnished to the Engineer prior to any use of the land by the Contractor.

Explosives shall be stored in a secure manner marked clearly in Urdu and English "Danger Explosives." Storage shall be in compliance with Ministry of the Interior/Public Security regulations.

Storage shall be to the satisfaction of the Engineer. In no case shall the Contractor store explosives on the site without prior approval of the local authorities or the Engineer.

The Contractor shall keep a current inventory of all explosives and explosive devices and submit a monthly report to the Engineer, detailing the usage of all explosives by date and location.

1.3.7 Handling Materials

All materials shall be handled in such manner as to preserve their quality and fitness for the Work. Aggregates shall be transported from the storage site to the Work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order that there may be no inconsistencies in the quantities and qualities of materials intended for incorporation in the Work as loaded, and in the quantities and qualities as actually received at the place of operations.

1.3.8 Unacceptable Materials

All materials not conforming to the requirements of the Specifications at the time they are used shall be considered as unacceptable and all such materials will be rejected and shall be removed immediately from the site of the Work unless otherwise instructed by the Engineer. No rejected material, the defects of which have been corrected, shall be used until approval has been given.

1.3.9 Trade Names and Alternatives

For convenience in designation in the Specifications, certain articles or materials to be incorporated in the work may be designated under a trade name or the name of a manufacturer and the catalogue information. The use of an alternative article or material that is of equal quality and of the required characteristics for the purpose intended will be permitted, subject to the following requirements:

(a) The responsibility of proof as to quality and suitability of alternatives shall be upon the Contractor and he shall furnish all information necessary as required by the Engineer. The Engineer shall be the sole judge as to the quality and suitability of alternative articles or materials and his decision shall be final.

(b) Whenever the specifications permit the substitution of a similar or equivalent material or article, no tests or action relating to the approval of such substitute material will be made until the request for the substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made well in time to permit approval without delaying the work.

1.4 LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

1.4.1 Laws to be observed

The Contractor shall keep fully informed of all Government laws, all local ordinances, and regulations, and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the Work, or which in any way affect the conduct of the Work.
He shall at all times observe and comply with all such laws, bylaws, ordinances, regulations, orders, and decrees; and shall protect and indemnify the Government and/or Employer and its representatives against any claim or liability arising from or based on the violation of any such law, bylaws, ordinance, regulation, order, or decree, whether by himself, his employees, or his subcontractors.

1.4.2 Permits, Licenses and Taxes

The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful execution of the Work.

1.4.3 Patented Devices, Materials and Processes

If the Contractor employs any design, device, material, or process covered by letter of patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner. The Contractor and his Surety shall indemnify and save harmless the Government and/or the Employer, any affected third party, or political subdivision from any and all claim for infringement by reason of the use of any such patented design, device, material or process, or any trademark or copyright, and shall indemnify the Government and/or Employer for any costs, expenses, and damages which it may be obliged to pay by reason of any infringement, at any time during the execution or after the completion of the Work.

1.4.4 Royalties

The Contractor shall be responsible for all compensation and royalties due in respect to quarried materials. No special payment will be made for the compensation of royalties.

1.4.5 Relations between Contractor, his Employees and his Subcontractor's Employees

The Contractor shall provide adequate housing for his and his subcontractor employees, including sanitary facilities, in accordance with the Public Health Codes and Regulations, in especially as related to contagious diseases without creating undue pressure on local public utilities and facilities. Violation of this provision is punishable by fine in accordance with the law of public utilities protection. The Contractor, in his relations with his employees, shall comply with the regulations in force regarding compensation, medical treatment, securities, and transportation needed, as well as other benefits specified by the Labor Laws of Govt. of Pakistan as a minimum. The Contractor shall provide, at no profit to himself, a constant supply of food for his employees without creating a monopoly for himself or restricting their freedom to secure food from other sources.

The Employer will not be liable for any damages or compensation payable at Law in respect or in consequence of any accident or injury to any employee of the Contractor and the Contractor shall meet all claims, demands, proceedings, costs, charges, and expenses whatsoever in respect thereof or in relation thereto.

1.4.6 Insurance

The Contractor shall secure and maintain such insurance from an insurance company authorized to write casualty insurance in Pakistan as will protect himself, his Subcontractors, the Engineer and the Employer from claims for bodily injury, death, or property damage which may arise from operations under this Contract. Bodily injury and death insurance shall provide coverage for all persons of any age. The Contractor shall not commence the Work under this Contract until he has obtained all insurance required under this provision and shall have filed

the certificate of insurance or the certified copy of the insurance policy with both the Engineer and the Employer. Each insurance policy shall contain a clause providing that it shall not be cancelled by the insurance company without thirty (30) days written notice to both the Engineer and the Employer of the intention to cancel. The Contractor is directed to the relevant stipulation listed in the Conditions of Contract regarding insurance.

1.4.7 Safety and Accident Prevention Requirements

In performance of the Contract, the Contractor shall comply with all applicable laws and codes governing safety, health and sanitation. The Contractor shall provide all safeguards, safety devices, and protective equipment, and take any other needed actions, on his own responsibility or as the Employer may determine, reasonably necessary to protect the life and health of employees on the job and the safety of the public and to protect property in connection with the performance of the Work covered by the Contract.

1.4.8 Public Convenience and Safety

The Contractor shall at all time so conduct the Work as to ensure the least practicable obstruction to public traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property are of prime importance and shall be provided for by the Contractor in an adequate and satisfactory manner. When it is necessary for residents living along the project to use a portion of the road under construction, the Contractor shall maintain, within the limits of the specifications, that portion of the road in a suitable condition for vehicular traffic.

When it is indicated on the plans or provided in the Specifications that traffic shall be carried through construction, a suitable width shall be maintained level and smooth to provide satisfactory passage. The width shall be periodically watered or treated with dust control agents as directed to prevent dust nuisance. Traffic shall be maintained over or around structures and culverts.

The Contractor shall provide, and maintain in a safe condition, temporary approaches to and crossing of intersecting highways, railroads, private entrances, and approaches to partly constructed Work.

1.4.9 Handling Traffic through Work Zones

All features of the work zone traffic control shall be in accordance with in these Specifications and MUTCD.

The Contractor shall use every precaution to safeguard the persons and property of the traveling public who must move through or across the work zone. The failure of the Engineer to notify the Contractor to maintain barriers, lights, signals, or flagmen shall not operate to relieve the Contractor from his responsibility. When the plans specifically provide that traffic be carried through the construction, the Contractor shall not route traffic on a longer or more arduous route without the permission of the Engineer. If the plans do not detail a Traffic Control Plan (TCP) the Contractor shall be responsible for the development and submittal of a traffic control plan for handling of the traffic safely during the Period of Contract.

This traffic detour plan shall be approved in advance by Employer's Representative, Traffic Police Department and the local Municipality before implementation. The Engineer shall require additional barricades, lights, flagmen, or watchmen at any time or at any place that, in his opinion, it is necessary for proper protection of traffic, but approval by the Engineer of the Contractor's method of operation shall not relieve the Contractor of the responsibility of protecting the traffic.

When necessary to permit only one-way traffic, the Contractor shall station figures to direct traffic safety through or around the Work.

Where it is necessary for residents or businesses along the road to use the road, suitable means shall be provided for their entrance or exit.

The Contractor's responsibility for the maintenance of traffic control devices on any individual portion of the Work included in the Contract shall continue through the duration of the Contract.

1.4.10 Fossils, Antiquities etc

All fossils, coins, articles of value or antiquity and structures or other remains or things of geological or archaeological interest discovered on the site of the Work shall be considered the exclusive property of the Employer. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing or damaging such article or thing; and shall, upon discovery of such items or things, notify the Engineer thereof within not more than twenty-four (24) hours of such discovery, and shall carry out the Engineer's instructions concerning special requirements to salvage such items, at the expense of the Employer.

No interference shall occur with historical locations and buildings. The Contractor and his subcontractors shall abide by all Govt. of the Punjab Decrees regarding Historical Building regulations.

1.4.11 Alcoholic Drinks, Narcotics, Arms and Ammunition and Discipline

The Contractor shall not import, sell, give, barter, or otherwise handle any alcoholic drinks or narcotics, or permit such importation, sale, distribution as gifts, barter, or use by his employees or by the employees of his Subcontractors.

1.4.12 Use of Explosives

When the use of explosives is necessary for the execution of the Work, the Contractor shall exercise the utmost care not to endanger life or property, including new Work. The Contractor shall be responsible for any and all damage resulting from the use of explosives.

The Contractor shall comply with all the requirements of Section 1.3, "Control of Materials" and 100.3 "Explosives" in these Specifications.

1.4.13 Protection and Restoration of Property and Landscape

The Contractor shall be responsible for the preservation of all public and private property and shall protect carefully from disturbance or damage all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed.

The Contractor shall be responsible for all damage or injury to property of any character, during the execution of the Work, resulting from any act, omission, neglect, or misconduct in his manner or method of executing the Work, or at any time due to defective work or materials, and said responsibility will not be released until the project is completed and accepted.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the Work, or in consequence of the nonexecution thereof by the Contractor, he shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or he shall make good such damage or injury in an acceptable manner.

1.4.14 Furnishing Rights-of-Way

The Employer will be responsible for the securing of all necessary permanent rights-of-way for the Work in advance. However, the Contractor shall bear all expenses and charges for temporary access or ownership required by him in connection with access to the Work Site, material sources, materials, or equipment storage, or other construction operations outside of the permanent right-of-way. Any exception will be indicated in the Contract Documents.

1.4.15 Responsibility for Damage Claims

The Contractor shall assume all risk and liability for accidents and damages that may occur to persons or property during the execution of the Work, by reason of negligence or carelessness by himself, his agents or employees, and shall assume also all direct or indirect damage that may be suffered on account of any such construction or improvement, during the time thereof and until the Work is accepted.

Where the Work of the Contractor injures or damages the property of others, the Contractor shall negotiate with the party so damaged and pay for such damage, leaving the Employer free of liability. This shall, among other things, include damage to crops, trees, bushes, and disturbance of irrigation, water sources, etc. The Contractor shall maintain and repair damage due to his construction equipment traffic, at his own expense, on any public road used to, from, and through the project for construction and hauling. The acceptability of this maintenance will be as determined by the Engineer.

1.4.16 Opening of Sections to Traffic

Opening of sections of the Work to traffic prior to completion of the entire Contract may be desirable from a traffic service standpoint, or may be necessary due to conditions inherent in the Work, or by changes in the Contractor's work schedule, and may be necessary due to conditions or events unforeseen at the time of signing the Contract. Such openings as may be necessary due to any of the foregoing conditions shall be made when so ordered by the Engineer. When a section of the Work is ordered opened, the Contractor shall expedite the completion of all permanent traffic control devices and safety measures. Such devices and measures shall be completed by the time required to open the section to traffic.

Under no condition shall such openings constitute acceptance of the Work or a part thereof, or a waiver of any provisions of the Contract.

If the Contractor is dilatory in completing shoulders, drainage structures, or other features of the Work, the Engineer will so notify him in writing and establish therein a reasonable period of time in which the Work shall be completed. If the Contractor fails to make a reasonable effort toward completion in this period of time, the Engineer may then order all or a portion of the project opened to traffic. On such sections which are so ordered to be opened, the Contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic and shall not receive any added compensation due to the added cost of the Work by reason of opening such section to traffic.

1.4.17 Environmental Protection

The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the Works and all associated operations on-site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in this document or in EIA Study Report included in the Detailed Project Report.

1.5 STANDARDS

These Specifications describe the requirements and procedures for execution of work items to achieve required workmanship and quality. The materials to be used shall conform to specifications and testing procedures as per American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM) or British Standard (B.S.) as indicated in their latest editions. Samples of materials for laboratory tests and their subsequent approval shall be utilized according to these references.

1.6 MANPOWER

Contractor shall provide technical and skilled manpower in adequate number to the

satisfaction of the Engineer, who can perform execution with quality and workmanship control in accordance with the requirements of the work item.

1.7 EQUIPMENT

1.7.1 Specified Equipment

Number and kind of Equipment required for different items of work shall be planned by the Contractor keeping in view the workmanship required by a particular item and the quantity of finished item required to be carried out in eight hours shift. The Engineer shall approve such planning or any changes shall be proposed for guidance of the Contractor. However this procedure shall not relieve the Contractor of his contractual obligations pertaining to performance and maintenance of project.

1.7.2 Alternative Equipment

While few of these Specifications may provide that equipment of a particular size and type is to be used to perform portions of the work, it is to be understood that the deployment and use of new or improved equipment is to be encouraged.

The Contractor may request, in writing, permission from the Engineer to use equipment of a different size or type in place of the equipment specified or recommended in these chapters.

The Engineer, before considering or granting such request, may require the Contractor to furnish, at his expense, evidence to satisfy the Engineer that the equipment proposed for use by the Contractor is capable of producing work equal to or better in quality than, that which can be produced by the equipment specified.

If such permission is granted by the Engineer, it shall be understood that such permission is granted for the purpose of testing the quality of work actually produced by such equipment and is subject to continuous attainment of results which, in the opinion of the Engineer, are equal to, or better than, that which can be obtained with the equipment specified. The Engineer shall have the right to withdraw such permission at any time when he determines that the alternative equipment is not producing work of equal quality in all respects, to that which can be produced by the equipment specified. Upon withdrawal of such permission by the Engineer, the Contractor will be required to use the equipment originally specified and shall, in accordance with the directions of the Engineer, remove and dispose off or otherwise remedy, at his expense, any defective or unsatisfactory work produced with the alternative equipment.

Neither the Employer nor the Contractor shall have any claim against the other for either the withholding or the granting of permission to use alternative equipment, or for the withdrawal of such permission.

Nothing in this clause shall relieve the Contractor of his responsibility for furnishing materials or producing finished work of the quality specified in these Specifications.

1.8 TESTING

Whenever the Specifications provide an option between two or more tests, the Engineer will determine the test to be used.

Whenever a reference is made in the specifications to a specification manual, or a test designation either of the American Society for Testing and Materials, the American Association of State Highway and Transportation Officials, Federal Highway Specification, or any other recognized national organization, and the number or other identification representing the year of adoption or latest revision is omitted, it shall mean the specification, manual or test designation in effect on the day 30 days prior to the date for submission of bids. Whenever said specification manual or test designation provides for test reports (such

as certified mill test reports) from the manufacturer, copies of such reports, identified as to the lot of material, shall be furnished to the Engineer. When material that cannot be identified with specific test reports is proposed for use, the Engineer may, at his discretion, select random samples from the lot for testing. Test specimens from the random samples, including those required for retest shall be prepared in accordance with the referenced specification and furnished by the Contractor at his expense. The number of such samples and test specimens shall be entirely at the discretion of the Engineer. Unidentified metal products such as sheet plate, hardware, etc. shall be subject to the test requirements prescribed by the Engineer.

When desired by the Engineer, the Contractor shall furnish, without charge, samples of all materials entering into the work and no material shall be used prior to approval by the Engineer. Samples of material from local sources shall be taken by or in the presence of the Engineer, otherwise the samples will not be considered for testing.

1.8.1 Frequency of Tests & Test Designation

Frequency of tests for the items of construction has been given in subsequent chapters. Test designation and procedure will be used as given in the latest version of relative publication.

1.9 AS-BUILT DRAWINGS/SHOP DRAWINGS

During construction, the Contractor shall keep an accurate record of all deviations of work as actually installed from that shown or indicated on the Contract Drawings or revised during construction. Upon completion of the Works, the Contractor shall deliver all "As Built" drawings to the Engineer.

All shop drawings/ fabrication drawings shall be prepared by the Contractor and submitted to the Engineer before the start of the work. The Engineer shall check and approve or return the same to the Contractor for correction/ modification. All works are to be executed in accordance with shop drawings, approved before the commencement of the works. Shop drawings should truly reflect the provisions of typical drawings. Any deviation from the provision of contract drawings shall not be allowed unless written approval is issued by the Engineer.

1.10 UTILITY LINES

The Contractor shall conduct his operations, make necessary arrangements, take suitable precautions and perform all required works incidental to the protection of and avoidance of interference with power transmission, telegraph, telephone and natural gas lines, oil lines water and sewerage mains and other utilities within the areas of his operations in connection with his contract and the Contractor shall save harmless and indemnify the Employer in respect of all claims, demands, proceedings, costs, charges and expenses whatsoever arising out of or in relation to any such interference, damages and rectifications.

2. ABBREVIATIONS

Wherever in these Specifications the following abbreviations and terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

AASHTO	-	American Association of State Highway and Transportation Officials
ABC	-	Aggregate Base Course
ACBC		Asphalt Concrete Base Course
ACI	-	American Concrete Institute
ACPA	-	American Concrete Pavement Association
ACWC		Asphalt Concrete Wearing Course
ADM	-	Arrow Diagram Method

AI	-	Asphalt Institute
ASTM	-	American Society for Testing and Materials
AWG	-	American Wire Gauge
AWPA	-	American Wood Preservers Association
BS	-	British Standard Code of Practice
BSI	-	British Standards Institution
BTU	-	British Thermal Unit
^{o}C	-	Degree Centigrade
cm.	-	Centimeter
CM	-	Cubic Meter
CPM	-	Critical Path Method
CRSI	-	Concrete Reinforcing Steel Institute
EIAR		Environment Impact Assessment Report
EPA		Environmental Protection Agency
^{o}F	-	Degree Fahrenheit
FHWA	-	U.S. Federal Highway Administration
ft.	-	Foot
Gallon	-	U.S. Gallon
ha.	-	Hectare
in.	-	Inch
IEC	-	International Electrotechnical Commission
IEEE	-	Institute of Electrical and Electronic Engineers, Inc.
IES	-	Illuminating Engineering Society
JMF		Job Mix Formula
kg.	-	Kilogram
km.	-	Kilometer
lb.	-	Pound
LSL	-	Lower Specification Limit
ltr.	-	Litre
M	-	Meter
max.	-	Maximum
mm.	-	Millimeter
min.	-	Minimum
M&MP	-	Mitigation and Management Plan
MUTCD	-	Manual on Uniform Traffic Control Devices
PCA	-	Portland Cement Association
%	-	Percent
RR&MTI		Road Research and Material Testing Institute
SM	-	Square Meter

sq. cm.	-	Square Centimeter
Ton	-	Metric Ton (1000 Kg)
TCP		Traffic Control Plan
USL	-	Upper Specification Limit
WBM	-	Water Bound Macadam
wt.	-	Weight
yd.	-	Yard

SCHEDULE FOR SAMPLING AND TESTING OF EMBANKMENT AND SUBGRADE
(ITEM NO. 108 TO 113)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Soil	Classification	AASHTO M-145	1/2,000 CM.	3/Source

	Moisture Density by Proctor Method	AASHTO T-180	1/2,000 CM.	3/Source
	Relative Density	ASTM D-4254-83	1/1,000 CM.	3/Source
	CBR	AASHTO T-193	1/3,000 CM.	3/Source
	Swelling	AASHTO T-193	1/3,000 CM.	3/Source
	Field Density	AASHTO T-191	1/layer/carriageway/ 100 M Laid	-

SCHEDULE FOR SAMPLING AND TESTING OF GRANULAR SUBBASE
(ITEM NO. 201)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Aggregate	Gradation	AASHTO T-27	1/1000 CM	3/Source/Stock
	Plasticity Index	AASHTO T-89 and T-90	1/2000 CM	3/Source/Stock
	Moisture Density	AASHTO T-180	1/1000 CM	3/Source/Stock
	CBR	AASHTO T-193	1/2000 CM	3/Source/Stock
	Abrasion	AASHTO T-96	1/2000 CM	2/Source/Stock
	Field Density	AASHTO T-191	1/layer/Carriageway/ 100 M Laid. (Minimum 1/layer/Carriage-way for less than 100 M laid)	-

SCHEDULE FOR SAMPLING AND TESTING OF AGGREGATE BASE COURSE AND WATER BOUND (ITEM NO. 202 & 206)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Aggregate	Gradation	AASHTO T-27	1/1000 CM	3/Source/Stock
	Plasticity Index	AASHTO T-89 and T-90	As required based on visual observation.	3/Source/Stock
	Moisture Density	AASHTO T-180	1/1000 CM	3/Source/Stock
	CBR (only for 202)	AASHTO T-193	1/2000 CM	3/Source/Stock
	Abrasion	AASHTO T-96	1/3000 CM	2/Source/Stock
	Sodium Sulphate Soundness	AASHTO T-104	As required based on visual observation.	2/Source/Stock
	Fractured faces	Visual	As required based on visual observation.	3/Source/Stock
	Sand Equivalent	AASHTO T-176	1/1000 CM	3/Source/Stock
	Field Density	AASHTO T-191	1/layer/Carriageway/ 100 M laid (Minimum 1/layer/Carriageway for less than 100 M laid)	-

SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX (ITEM NO. 203)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	3/Source/Stock plus 1/5000 CM
	Abrasion	AASHTO T-96	1/5000 CM	3/Source/Stock plus 1/5000 CM
	Stripping	AASHTO T-182	2/5000 CM	3/Source
	Fractured faces	Visual	As required	3/Source
	Flat and Elongated Particle	Visual	As required	3/Source
	Specific Gravity and Absorption	AASHTO T-85	1/1000 CM	3/Source/Stock for each size in hot bins of asphalt plant
Fine Aggregate	Sand Equivalent	AASHTO T-176	2/1000 CM	3/Source/Stock
	Plasticity Index	AASHTO T-89 and T-90		
	Specific Gravity	AASHTO T-84	1/1000 CM	3/Source/Stock
	Friable Particles	AASHTO T-112	2/1000 CM	3/Source/Stock
Asphalt Cement	Specific Gravity	AASHTO T-228	2/Shipment	-
	Penetration	AASHTO T-49	3/Week of plant operation	Samples taken from heating tank
Asphalt Mixture	Extraction	AASHTO T-164	2/day's production	-
	Gradation	AASHTO T-30		
	Bulk Specific Gravity	AASHTO T-166 Method B		
	Maximum Specific Gravity	AASHTO T-209		
	Air Voids	AASHTO T-269	1/days Production	
	Marshal Stability, Flow and Loss of Stability	AASHTO T-245		
Mixture Compacted in place	Thickness	AASHTO T-230	1/layer/lane @ 100 M interval	-
	Compaction	AASHTO T-230 ASTM D2950		

Note: Test locations will be selected at random.

SCHEDULE FOR SAMPLING AND TESTING OF SOIL-CEMENT BASE COURSE (ITEM NO. 204)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Soil	Classification	AASHTO T-27, T-89 and T-90	1/1000 CM	3/Borrow/Source
	Moisture Density by Proctor method	AASHTO T-134	1/Soil Class	-
	Pulverization	Note (a)	1/300 M length /carriageway	-
	Field Density	AASHTO T-191	1/100 M length /carriageway	-
	Compressive Strength	ASTM D-1633	1/Soil Class	-
	Wetting & Drying	AASHTO T-135	1/Soil Class	For mix design.

Note: Screening of Soil through one inch and No. 4 sieves prior to mixing with cement.

SCHEDULE FOR SAMPLING AND TESTING OF CRACK-RELIEF LAYER (ITEM NO. 205)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Aggregate (Crushed)	Gradation	AASHTO T-27	Same as for item 202	Same as for item 202
Aggregate (Asphaltic open-graded plant mix)	Gradation	AASHTO T-27	Same as for coarse aggregate under item 203	Same as for coarse aggregate under item 203
Asphalt Cement Mixture	-	-	Same as for Item 203	Same as for Item 203
	Asphalt Coating	AASHTO T-195	1/day's production or as required	-

SCHEDULE FOR SAMPLING AND TESTING OF WEARING COURSE PLANT MIX (ITEM NO. 305)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	3/Source/Stock Plus 1/5000 CM
	Abrasion	AASHTO T-96	1/5000 CM	
	Stripping	AASHTO T-182	2/5000 CM	3/Source
	Fractured faces	Visual	As required	3/Source
	Flat and Elongated Particle	ASTM D-4791	As required	3/Source
	Specific Gravity and Absorption	AASHTO T-85	1/3000 CM	3/Source/stock for each size in Hot bins of Asphalt Plant
Fine Aggregate	Sand Equivalent	AASHTO T-176	2/1000 CM	3/Source/Stock
	Plasticity Index	AASHTO T-89 & T-90		
	Specific Gravity	AASHTO T-84	1/3000 CM	3/Source/Stock
	Friable Particles	AASHTO T-112	2/1000 CM	3/Source/Stock
Asphalt Cement	Specific Gravity	AASHTO T-228	2/shipment	-
	Penetration	AASHTO T-49	3/weeks of plant operation	Samples from heating tank
Asphalt Mixture	Extraction	AASHTO T-164	2/day's production	-
	Gradation	AASHTO T-30		
	Bulk Specific Gravity	AASHTO T-166 Method B		
	Maximum Specific Gravity	AASHTO T-209	1/days Production	
	Air voids	AASHTO T-269		
	Marshal Stability, Flow and Loss of Stability	AASHTO T-245		
Mixture compacted in place	Thickness	AASHTO T-230	1/layer/lane @ 100 M interval	-
	Compaction	AASHTO T-230 ASTM D-2950	1/layer/lane @ 100 M interval	-

Note: Test locations will be selected at random.

SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE
(ITEM NO. 401)

Material	Test	Designation	Sampling and Testing Frequency	
			Project Control	Source/ Stock
Coarse Aggregate	Gradation	AASHTO T-27	1/1000 CM	3/Source/Stock Plus 1/5000 CM
	Abrasion	AASHTO T-96	1/5000 CM	2/Source/Stock Plus 1/5000 CM
	Unit Weight	AASHTO T-19	1/1000 CM	3/Source
	Specific Gravity	AASHTO T-85	1/1000 CM	3/Source
	Soundness	AASHTO T-104	1/5000 CM	1/Source
	Deleterious Substance	AASHTO M-80	1/5000 CM	2/Source/Stock
	Petrographic Analysis	-	1/5000 CM	1/Source/Stock
Fine Aggregate	Sand Equivalent	AASHTO T-176	2/1000 CM	3/Source/Stock
	Specific Gravity	AASHTO T-84	1/1000 CM	3/Source/Stock
	Unit Weight	AASHTO T-19	1/1000 CM	3/Source/Stock
	Absorption	AASHTO T-84	1/1000 CM	3/Source/Stock
	Organic Impurities	AASHTO T-21	1/1000 CM	2/Source/Stock
	Soundness	AASHTO T-104	1/5000 CM	2/Source/Stock
	Fineness	AASHTO M-6	1/1000 CM	1/Source/Stock
	Deleterious Substance	AASHTO M-6	1/5000 CM	1/Source/Stock
	Petrographic Analysis	-	1/5000 CM	1/Source/Stock
Cement	Yield Test for Cement Content	AASHTO T-121	1/Lot or 1000 Bags	3/Source/Stock
	Setting Time	AASHTO T-131	1/Lot or 1000 Bags	3/Source/Stock
	Mortar Strength	AASHTO T-132	1/Lot or 1000 Bags	3/Source/Stock
Water	Chemical Tests	AASHTO T-26	-	2/Source/Stock
Concrete Mix	Compression (Cylinder)	AASHTO T-22	6/50 CM or Shift (Min)	-
	Slump	AASHTO T-119	3/50 CM or Shift (Min)	-

TABLE FOR ALLOWABLE TOLERANCES
(EARTHWORKS, PAVEMENT COURSES AND CONCRETE)

Description	Thickness (mm)	Level (mm)	5M Straight-edge (mm)	Cross-fall (%)	Longitudinal Grade in 30 M (%
Subgrade	± 20	+ 5 - 20	20	± 0.5	± 0.1
Subbase (Granular or Stabilized)	+ 10 - 20	+ 5 - 20	20	± 0.3	± 0.1
Base Course (Granular or Stabilized)	+ 5 - 10	+ 5 - 10	6	± 0.2	± 0.1
Asphaltic Base Course.	+ 5 - 10	+ 5 - 10	6	± 0.2	± 0.1
Asphaltic Wearing Course	± 3	± 3	5	± 0.2	± 0.1
Concrete for Pavements	± 5	± 5	5	± 0.2	± 0.1
Concrete for structures	± 5	± 10	5	-	-

Note: Accumulative tolerance shall not be more than that as specified against the final layer.

ALLOWABLE TOLERANCE FROM THEORETICAL WEIGHTS
(REINFORCEMENT)
AS PER AASHTO M-31

Diameter of Bars	Lot under	Individual Bar under
All	3.5 %	6%

) The term "Lot" means all bars of the same nominal weight per linear meter contained in an individual shipping release or shipping order.

Note: Reinforcing bars are evaluated on the basis of nominal weights. In no case shall the overweight of any bar or lot of bars be cause of rejection.

TABLE FOR ALLOWABLE TOLERANCE
(REINFORCED CONCRETE PIPES OF CLASS - II AND IV)
AS PER AASHTO M-170

Description	Internal diameter variation (%)	Wall Thickness	Permissible Variation in the Position of Reinforcement
Pipes of internal diameter of 300 mm to 610 mm	± 1.5	- 5 mm or - 5 percent Whichever is less	+ 10 percent of wall thickness or ± 12 mm. whichever is less
Pipes of internal diameter of 690 mm to 2750 mm	± 1.0	- 5 mm or - 5 percent Whichever is less	+10 percent of wall thickness or ± 12 mm. whichever is less

Notes: 1. Pipe having localized variations in wall thickness exceeding those specified above shall be accepted, if the three-edge bearing strength and minimum steel cover requirements are met.

2. Pipes having variations in the position of the reinforcement exceeding those specified above shall be accepted if the three-edge bearing strength requirements on a representative sample are met.

EARTHWORK AND ALLIED ACTIVITIES

ITEM 100 GENERAL

100.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of earth/soil, rock or other material from or to the roadway or adjacent thereto or from borrow areas, including the excavation of side and interception ditches, the removal of unsuitable subgrade material, the formation of lay-bys, the widening of cuts and the flattening of cut slopes whether to obtain material for embankments or backfill, or to increase the stability of the slopes, clearing and grubbing, the selective removal of trees, stripping and the removal of existing obstructions within the approved cross section for excavation, in accordance with these specifications and in conformity with the lines, grades, sections, and dimensions shown on the drawings or as directed by the Engineer.

100.2 SOIL INFORMATION

Any information concerning the properties of the soil or sub soil and other geotechnical information shown on the drawing or other documents forming part of the contract is for information only. The contractor is obliged to make his own assessment of site conditions prevailing. No claim for extra cost or time extension will be entertained based on the information provided.

The Contractor shall be deemed to have visited the site prior to making his bid and shall ascertain the nature of the earth/soil and rock, its quantity, locations and suitability to meet the specified requirements in particular the borrow pits, and he shall base his bid estimates solely on his own soil investigation. After the award of the contract no claim for a revision of bid prices depending on the sources of soil information will be entertained.

100.3 EXPLOSIVES

Where explosives are used the Contractor shall provide suitable buildings or warehouses in approved positions for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer or as per relative laws of government. Such storage places shall be accessible only to authorized personnel. They shall be properly marked; all doors or accesses thereto shall be constructed of materials as directed by the Engineer and provided with secure locks and all necessary means for preventing access by unauthorized persons. The Contractor shall be responsible for the prevention of any unauthorized issue or improper use of any explosives. The handling of explosives shall be entrusted only to experienced and responsible men, to the satisfaction of the Engineer, and in conformity with the statutory regulations.

All drilling and blasting shall be done in such a manner as to bring the excavation as close as possible to the required cross sections, and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, tunnels, or any other method shall be performed at the entire risk and responsibility of the Contractor who shall have no claim to payment for extra work occasioned by breakage outside the approved cross-sections or dimensions.

The greatest care shall be taken by the Contractor during all blasting operations to ensure that no injury be done to persons or damage to property or to the finished work. Shots shall be properly loaded and capped, and only a moderate charge shall- be used in each hole. A record of all explosives used, showing locations and amounts, shall be kept by the

Contractor for checking by the Engineer.

Where directed by the Engineer, the Contractor shall provide heavy mesh blasting mat for protection of persons, property and the work. If necessary, blasting shall be restricted to time prescribed by the Engineer.

The Engineer may prohibit blasting and order the rock to be excavated by other means, if, in his opinion, it would be dangerous to persons or adjacent structures, or is being carried out in a reckless manner. If traffic on the road has to be interrupted, the Contractor shall obtain approval of his schedule for such interruption from the proper authorities and shall satisfy the Engineer that he has obtained it. No extra payment shall be admissible for such arrangements as described here above.

100.4 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Items 101, 103, 105, 106, 107 and 108 shall include the cost of removal of all material regardless of its nature, encountered within the limits of the approved cross-section, including the removal and disposal, as required by the Engineer, of existing brick, stone, concrete or masonry, rock boulders or fragments, old pavements, culverts, bridges walls, buildings and roads or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item appears in the Bill of Quantities for such features.

100.5 REMOVAL OR DIVERSION OF WATER

Except where provided for, no separate payment will be made for control of or removal of water during or after earthwork operations. The cost of sheeting, shoring, cofferdams, pumping and draining shall be included in the bid prices for earthwork. The Contractor shall provide necessary facilities for dewatering and for draining or diverting watercourses when necessary for the protection of the contract work or where required by the Engineer.

The Contractor shall provide such drainage outlet ditches or canals as may be necessary to effect proper drainage before rain is expected. Such drainage ditches or canals for protection of work during construction and their maintenance and clearing to make them continuously effective during the work shall not be paid separately, but shall be deemed to be included in other items of work.

The Contractor shall also provide, fix, maintain and operate such engines, pumps, hoses, chutes and other appliances as are necessary to keep the accumulated water at a level required for the safety of the structures as directed by the Engineer.,

100.6 DITCHES

The Contractor shall construct side ditches, interception ditches, and inlet and outlet ditches as shown on the Drawings or where ordered by the Engineer, whether for temporary or permanent drainage. In order to keep water away from the embankment, subgrade, and/or pavement during construction, the Contractor shall at all times ensure adequate drainage by scheduling ditch and outlet so that the drainage is operative before work is stated on the embankment, subgrade or pavement. He shall clean and trim all such drainage ditches from time to time, so that there may be a free flow of water throughout the whole period of the Contract. Ditches shall first be trimmed according to approved cross-sections, and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of the other construction work and shall be a condition for final approval and acceptance.

Unless otherwise specified no separate payment will be made for the excavation of side ditches, interception ditches, inlet and outlet ditches but such payment will be made under item 105 or 106 whichever applicable.

Where indicated on the drawings or when required by the Engineer, the Contractor shall take cross-sections of existing stream channels, and in collaboration with the Engineer, mark them with details of the excavation required for the relocation of the stream channel. Work shall not proceed without written approval of the marked cross-sections by the Engineer.

100.6.1 Maintenance of Embankment Works during Construction

In addition to works defined in Item 100.6, the Contractor shall maintain the embankment structure during construction against the effects of rains resulting in rain cuts, washing away of side slopes or toe areas and shall effectively rectify, restore and maintain continuously till the embankment is complete to its true line and grades with slope protections, if any, as per plans and drawings.

No separate payment will be made for such works and the costs will be deemed to be included in Items 108.

100.7 EXCAVATION FOR CULVERTS

Except where otherwise specified excavation and backfill for culvert and drainage pipes, except granular backfill to under drains, will not be paid for separately, but shall be considered as a subsidiary obligation of the Contractor covered under the contract price for the various classes of pipe culvert as provided in Item 501. .

100.8 LANDSLIDES, BENCHES, FLATTENING OF SLOPES

The Engineer may order the removal of material resulting from landslides, the construction of benches in or above the cut slope or in the embankment slope or where .in his opinion the slope shows signs of instability, the flattening of the slope. Payment of all such work shall be at contract prices in Item 106 or 108 as the case may be.

100.9 SURVEY AND LEVELING PRIOR TO COMMENCEMENT OF EARTHWORK

The Contractor shall be responsible for the setting out of the work in accordance with Clause 17 of the General Conditions of Contract. Notwithstanding that project drawings have been issued to the Contractor, the Contractor shall also be responsible for taking joint cross-sections on the proposed alignment of the road, submitting three copies of the plotted cross-sections and longitudinal profile to the Engineer and obtaining the approval of the Engineer to such cross-section and longitudinal profile before any work in connection with Earthwork is commenced. These cross-sections and longitudinal profile shall be in the form and manner as instructed in writing by the Engineer.

100.10 SPECIAL FOUNDATION TREATMENT

Where the ground is determined to have large settlement potential, on the basis of close interval SPT measurement (SPT < 5) and thick cohesive soil deposit (> 5 m) to be further supplemented with consolidation testing, the Contractor shall submit method statement for the means he proposes to employ for speeding up of foundation settlement so that the work can be completed in time. No payment shall be made for any procedure the Contractor carries out in this respect."

100.11 QUALITY ASSURANCE PROCEDURES

The embankment/subgrade material shall be accepted by lot as specified in "Table for Sampling and Testing Frequency" in these Specifications. The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of

all samples and tests shall be recorded by roadway embankment height, centerline station (kilometer) and offset.

Embankment/subgrade Quality Assurance measuring or testing shall involve verification that the embankment/subgrade are constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the plans or staked by the Engineer

Laboratory and field testing for embankment/subgrade shall be done in accordance with ‘Tables for Sampling and Testing Frequency’ in these Specifications.

ITEM 101 CLEARING AND GRUBBING

101.1 DESCRIPTION

This work shall consist of removal to the specified depth, grubbing and disposal of all surface objects, as and where directed in writing by the Engineer, stumps, roots, bushes and trees with less than 150 mm girth, vegetation, logs, rubbish and other objectionable material except such objects as are designated to remain or are to be removed in accordance with other section of specification.

101.2 CONSTRUCTION REQUIREMENTS

101.2.1 Clearing/Grubbing

In roadway cut areas, all surface objects or any object to the depth of 30 Cm below subgrade level such as stumps, roots, vegetation, bushes, logs, rubbish shall be cleared and/or grubbed as directed by the Engineer. In roadway fill areas where clearing and grubbing is required, same shall be carried out to the depth of 30 Cm below natural surface level as described above.

After the clearing and grubbing operation, all the depression cavities etc shall be filled back with suitable material at the Contractor's cost to the average level of the undisturbed original ground.

Operation of clearing and grubbing shall in no way be deemed to effect any level or volume change of the area.

After clearing and grubbing, the compaction of the area will be restored to its original value without any extra payment. However Engineer may direct in writing to the Contractor for stripping (if so required) under item 103 or for compaction under item 104, Compaction of Natural Ground, if the original compaction is less than the required for respective zone. Payment of these items will be made separately under the relative items used for such purpose.

Before bottom layer of embankment is placed, Contractor will grub up and remove without extra payment, any vegetation that may, in the meantime have grown on surface previously cleared and grubbed.

All trees having girth less than 150 mm measured at (600) mm above ground and falling within the construction limits shall be felled & removed by the contractor. The excavation and removal of trees, roots and stumps including backfilling and compacting of holes and restoring the natural ground to the original condition shall be responsibility of the contractor for which no extra payment shall be made to him. The trees, stumps & roots remain property of the Employer, which shall be delivered at designated place as directed by the Engineer.

Rendering of the soil in the area, as unsuitable due to the Contractor's operation by way of littering and/or mixing of the cleared and grubbed material or any other reason, shall be to the Contractor's cost and shall be stripped and reinstated with acceptably suitable material without any payment.

Cleared and grubbed material shall not be left in or under embankments or other constructed facility. All removed materials shall be disposed of at locations outside the right-of-way and not visible from the roadway.

Disposal of removed materials at public and private sites away from the right of way shall be done at the Contractor's sole expense, in accordance with all laws and regulations, after an agreement with the property owner or public agency has been fully executed.

The Engineer shall be given fifteen (I5) days prior notice and a written release from the property owner or public agency on whose property the materials are to be placed.

Clearing and grubbing shall be waived off where the fill height is three (03) meters or more and at the discretion of the Engineer.

101.2.2 Protection and Restoration

The Contractor shall prevent damage to all pipes, conduits, wires, cables or structure above or below ground. No land monuments, property markers, or official datum points shall be damaged or removed until the Employer/Engineer has witnessed or otherwise referenced their locations and approved their removal. The Contractor shall so control his operations as to prevent damage to shrubs, which are to be preserved. Protection may include fences and boards latched to shrubs, to prevent damage from machine operations. Any damage as a result of contractor's operation shall immediately be rectified by him at his own expense.

ITEM 102 REMOVAL OF TREES

102.1 DESCRIPTION

This work shall consist of the removal of trees and stumps along with roots thereof to a depth, to ensure complete removal of roots and stumps and their disposal/stacking as provided in Particular Specifications and Special Provisions and Special Provisions or as directed in writing by the Engineer.

102.2 CONSTRUCTION REQUIREMENTS

Such individual trees as the Engineer may designate and mark in white paint shall be left standing uninjured. All other trees to be removed shall be counted and described in a detailed report called “Report on Existing Trees” showing tree #, girth of the tree, height of tree and shall be submitted to the Engineer prior to start of this activity. The Contractor shall be responsible for watch and ward of the staked/numbered logs of wood and the safe custody till final disposal thereof by the Engineer/Employer’s Representative.

When necessary to prevent injury to other trees or structures or to minimize danger to traffic, trees shall be cut in sections from top downwards.

Holes or loose earth resulting from the removal of trees shall be filled back with suitable material and re-compacted to a degree of compaction of adjoining area as per requirement of respective embankment zone. Any extra material required for such purpose shall not be measured for payment.

102.3 GENERAL REQUIREMENTS

The Contractor shall prevent damage to all under-ground utilities, such as pipes cables or conduits etc. For this purpose if so required, removal of trees shall be carried out manually. Any under and/or over ground property damaged by the Contractor shall be repaired immediately by the Contractor at his own expense.

ITEM 103 STRIPPING

103.1 DESCRIPTION

This work shall consist of removing unsuitable topsoil, transporting and depositing in stockpiles or spreading where indicated on the Drawings or as directed by the Engineer. Engineer shall give instruction in writing, stating area and depth to be stripped.

103.2 CONSTRUCTION REQUIREMENTS

The areas from which stripping of topsoil is required shall be as indicated on the Drawings or as directed by the Engineer. The Contractor shall remove topsoil from these areas to depth as directed by Engineer. Stripping of topsoil in any case shall be not less than 10 cm. in depth. The removed topsoil shall be transported, deposited in stockpiles at locations designated by the Engineer and/or spread where indicated on the drawings or as directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests (AASHTO M-145).

The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for topsoil removed from places other than that directed by the Engineer. Engineer shall, however identify the soil as unsuitable through laboratory tests (AASHTO M-145), before such a decision.

ITEM 104 COMPACTION OF NATURAL GROUND

104.1 DESCRIPTION

The natural ground or surface ready for construction purposes after clearing and grubbing or stripping (if required) will be considered as (natural) Ground for the purpose of this item. The compaction of natural ground shall be carried out through a written order by the Engineer.

104.2 CONSTRUCTION REQUIREMENTS

The natural ground/cleared and grubbed/stripped/excavated surfaces shall be broken up, ploughed, scarified; all sods and vegetable matters removed and compacted to a depth of 20 cm and to the specified density as given below:

For height of Embankment below subgrade level	**Percent of Maximum Dry Density as determined by AASHTO T-180***
0 to 30 cm	97
30 to 60 cm	95
60 to 105 cm	93
Over 105 cm	90
Below the foundation of structures	95

104.2.1 Compaction of Original Ground Surface in Areas of High Water Levels and Salinity

Refer to item 108.3.5 for materials and construction requirements under these conditions.

ITEM 105 UNCLASSIFIED ROADWAY & BORROW EXCAVATION FOR EMBANKMENT

105.1 DESCRIPTION

The work shall consist of excavating the roadway and borrow pits, removal and satisfactory disposal of all materials taken from within the limits of the work, also such excavation as is necessary for inlet and outlet ditches of structures and shall include all excavation, shaping and sloping for the construction, preparation of all embankment, subgrade, shoulders, intersections and approaches as directed and in conformity to the alignment, grade, level and cross-sections shown on the plans or established by the Engineer.

105.2 CLASSIFICATION OF EXCAVATION

105.2.1 Roadway Excavation

Roadway excavation shall include all materials excavated from within the staked construction limits of the project. Roadway excavation includes all types of materials encountered regardless of their properties. All roadway excavation shall be termed as "Common Excavation" in all types of material.

a) Common Excavation

Common Excavation shall consist of the removal and satisfactory disposal of all eolian, alluvial, residual materials, inplace unaltered and un-weathered strata irrespective of the firmness, rigidity including cementation, conglomerates, boulders, rocks (other than parent-rock / bed rock), in the excavation and any condition of moisture (dry, saturated, waterlogged, below and/or above water). Boulder / rock of any size shall also be classified as "Common Excavation". Eolian and alluvial materials consist of gravel, shale, volcanic ash, loess, dunes and, loams, sands and clays or any combination of these materials and in all its manifestations, are termed as Common Excavation.

Unclassified Borrow Excavation

Borrow Excavation shall comprise all excavation taken from borrow pits. Material from borrow pits shall normally be used for the construction of embankment or for the backfill when there is no material available from roadway excavation or structural excavation. Permission to use material from borrow pit shall first be obtained in writing from the Engineer. Nevertheless the total quantity of material from roadway excavation and structural excavation after deduction of the material declared unsuitable by the Engineer, shall be considered available for use in the work and any material used from borrow pits for formation of embankment shall not be measured for payment.

In making his bid, the Contractor shall inspect the site and prepare his estimate of the haulage cost on the basis of his own survey of the possible nature and locations of the borrow pits. Their distance from the work sites shall not be grounds for extra payment or revision of the contract price.

The consent of the landowner or tenant for excavating the borrow material and hauling along private access roads shall be secured by the Contractor who shall, if required, pay for such concession. Borrow pits shall be left in a condition acceptable to the landowner and/or tenant and the Engineer.

105.2.3 Structural Excavation

The description method of measurement and payment of this section shall conform to as specified in Item 107.

105.3 CONSTRUCTION REQUIREMENTS

All material removed from excavation shall be used in the formation of embankment, subgrade, shoulders, and at such other places as directed, unless it is declared unsuitable and ordered to waste by the Engineer. No excavated material shall be wasted without written permission from the Engineer, and when such material is to be wasted, it shall be so placed that it will present a neat appearance and not offer any danger to abutting property. The material shall be declared unsuitable if it does not meet the requirements specified in Item 108.

During construction of the roadway, the road bed shall be maintained in such a condition that it will be well drained at all times.

All slopes, except in solid rock or other material shall be trimmed precisely as per cross-sections, and care must be exercised that no material shall be loosened beyond the required slopes. In blasting rock slopes, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slope. All breakage and slides shall be removed by the contractor and disposed of as directed by the Engineer where appropriate drainage shall be reinstated.

Rock, shale and other unsuitable road bed material encountered in cuts shall be excavated to required width and depth indicated on the plans or as otherwise directed. Any over breakage below the depth shown on the plans will not be paid for. Backfill of the over cut shall be of approved earth material and shall have the same density requirements as specified on the plans and shall be at the expense of contractor.

Borrow pits shall be located so that the nearest edge of the pit is at least five hundred (500) meters from the roadway toe of slope unless otherwise directed by the Engineer.

Permission to use any borrow material, including its suitability, shall be obtained in writing from the Engineer before execution of work. It is responsibility of the Contractor to submit a request for test at least fifteen (15) working days prior to the day the Contractor intends to begin taking material from the borrow area.

Borrow material shall not be obtained within 2 kilometers downstream of any major hydraulic structure. However the borrow pit may be established at five hundred (500) meters upstream of the hydraulic structure. The side slopes of the pits or channels shall be constructed as shown on the plans or directed by the Engineer. In no case the side slopes of borrow pit be steeper than a slope; 1:5 (V:H).

Upon abandonment of borrow pit or quarry area, the contractor shall, at his own expense, clean and trim the borrow pit or quarry area, the right of way, and adjoining properties which were occupied during execution of work, all to the satisfaction of the Engineer.

All drilling and blasting shall be done in such a manner as will most nearly complete the excavation to the required grade line, and produce the least disturbance of the material to be left in place. Blasting by means of drill holes or any other methods shall be performed at the entire risk and responsibility of the contractor. Care shall be taken to ensure that no injury be done to persons or properties or to the finished work. Blasting shall be restricted to the hours prescribed by the local authorities or the Engineer.

The excavated material approved for fill under any item of the Bill of Quantities shall be used in the manner as described under the relevant item of work.

The unsuitable material shall be disposed of at the designated location in the manner as directed by the Engineer.

If the material is surplus to the fill requirements of the project, it shall be disposed of at the location in a manner approved by the Engineer.

ITEM 106 UNCLASSIFIED EXCAVATION OF UNSUITABLE OR SURPLUS MATERIAL

106.1 DESCRIPTION

The work shall consist of excavation of unsuitable or surplus material arising from Roadway and Structural Excavations which shall be declared in writing by the Engineer. Extent in plan and depth for removal of unsuitable material under the embankment and foundation of a structure shall be determined by the Engineer.

106.2 CONSTRUCTION REQUIREMENTS

All suitable material excavated within the limits and scope of the project shall, unless provision is expressly made to the contrary in the Specifications, be used in the most effective manner for the formation of the embankment, widening the roadway, backfill, widening or diversion of water courses, and/or other works included in the Contract.

Any surplus or unsuitable material, declared in writing by the Engineer shall be disposed of and leveled in thin layers by the Contractor in areas as designated by the Engineer.

When unsuitable material shall be removed and replaced as directed by the Engineer, the soil left in place shall be compacted to a depth of 20 cm to the density prescribed under Section 104.2. Payment for such compaction shall be made under pay Item 104.

When unsuitable material shall be removed and replaced with selected fill material under the structure footing, the excavated ground surface shall be compacted as per Subsection 107.3.1 (d) 'Preparation of Foundation of Footings' of the Particular Specification and Special Provision.

If the unsuitable material shall be removed below standing water level and the replaced material shall be gravel or a similar self-draining material of at least 30 cm in depth, the compaction shall be dispensed with if approved by the Engineer.

ITEM 107 UNCLASSIFIED STRUCTURAL EXCAVATIONS AND BACKFILL

107.1 DESCRIPTION

Structural excavation shall include the removal of all material of whatever nature, necessary for the construction of foundations of bridges, culverts, retaining walls, headwalls, wing walls, catch basins, manholes, inlets and other structures not otherwise provided for in these specifications and in accordance with the plans or as directed by the Engineer. It shall include the furnishing of all necessary equipment and construction of all cribs, cofferdams, caissons, dewatering, sheeting, shoring etc., which may be necessary for the execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposing of excavated material, which is not required for backfill, in a manner and in locations so as not to affect the carrying capacity of any channel and not to be unsightly. This includes excavation below original ground and backfilling with granular or selected fill. All common backfilling above level of the original ground shall be payable under Item 108.

107.2 MATERIAL REQUIREMENT FOR BACKFILL

107.2.1 Backfill around Structure

Backfill around structure shall be made with the following material.

a) Granular backfill of selected material as specified hereunder

b) Common backfill shall be carried out from excavated material or any other borrow material approved by the Engineer.

107.2.2 Granular backfill

a) Granular/Select fill material shall meet the following requirements:

1) Grading Requirement

mm	**inch**	% **passing**
25	1”	100
19	¾”	60-100
4.75	No. 4	50-80
2.0	No. 10	40-70
0.425	No. 40	25-45
0.075	No. 200	0-15

2) Material satisfying the requirements of coarse sand falling under soil classification A-3 (AASHTO). In case, coarse sand is utilized for granular fill it shall be ensured that the same is confined properly with approved material.

b) Common Backfill material shall have a Plasticity Index of not more than size (6) as determined by AASHTO T-89 and T-90.

107.2.3 Common backfill

Use of excavated material as backfill may be allowed under this item. Use of borrow material for common backfill shall be allowed subject to approval of borrow material by the Engineer as per the material requirements in Section 108.2.

107.2.4 Rock backfill

Rock material of small size shall be permitted in the backfilling of structures or walls subject to the approval of methodology by the Engineer.

107.2.5 Requirement of Select Fill Material Below Structures' Foundations

Requirement of Select Fill material below structures shall be as per clause 107.2.2 (a) and /or as directed in writing by the Engineer.

107.3 CONSTRUCTION REQUIREMENTS

107.3.1 Unclassified Structural excavation

a) General

All substructures, where practicable, shall be constructed in open excavation and, where necessary, the excavation shall be shored, braced, or protected by cofferdams in accordance with approved methods. When footings can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted with the approval of the Engineer, and the entire excavation filled with lean concrete to the required elevation of the top of the footing. The additional concrete shall be at the expense of the Contractor.

In case the contractor has excavated additional volumes than specified thereunder, the contractor shall at his own expense backfill the volume. If the depth of additional excavation is less than 500 mm, the concrete used for the backfilling shall be same class as the concrete specified for the footings. If the depth of the additional excavation exceeds 500 mm, the concrete used for the backfilling shall be no fines concrete.

The Contractor shall notify to the Engineer well in advance about the start of any structural excavation which constitute a pay item in the Bill of Quantities. The Engineer shall observe the cross-sectional elevations and measurements taken for the existing ground in the area of the structure. Any material removed or excavated before these measurements and approved by the Engineer will not be paid.

The Contractor shall minimize, to the extent possible, the length of time that excavated areas are open. He shall be solely responsible for damages due to weather, equipment, accidents, or other causes when excavation is left open.

In areas where the excavation is adjacent to public roads and walkways, the Contractor shall erect all barricades, barriers, enclosed walkways, and warning signs necessary to restrict the exposure of the public to the excavation. Special precautions shall be taken in play areas of children. The adequacy of all such safety measures shall be subject to the approval of the Engineer.

The Contractor shall take necessary precautions, including cofferdams and other shoring, to protect workmen. The Engineer will not enter excavated areas to approve the foundation. Further work shall not be started unless the area is considered safe.

b) Preservation of channel

Unless otherwise specified, no excavation shall be made outside of caissons, cribs, cofferdams, piling, or sheeting, and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs or cofferdams are in place, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with

material approved by the Engineer. Material deposited within the stream area from foundation or other excavation or from filling of cofferdams shall be removed and the stream bed freed from obstruction thereby.

c) Depth of Footings

The elevation of the bottoms of footings, as shown on the drawings, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevation of footings as may be necessary to secure a satisfactory foundation.

d) Preparation of Foundations of Footings

1) All rock or other hard foundation material shall be freed from all loose material, cleaned and cut to a firm surface, leveled, stepped, or roughened, as may be directed by the Engineer.

2) When masonry is to rest on an excavated surface other than rock special care shall be taken not to disturb the bottom of the excavation, and the final leveling of the grade shall not be made until just before the masonry is to be placed.

3) Foundation material on which structure is to be placed shall be compacted as per clause 107.3.3 unless otherwise directed by the Engineer. In case unsuitable material is encountered at foundation level (SPT<5), which is either unacceptable and / or cannot be compacted to required density shall be removed to the depth and extent as directed and replaced with suitable material of the type as determined by the Engineer.

4) (i) ***Placement of Select Fill***

All vegetation, topsoil and other unsuitable materials shall be removed. Prior to placement of the first layer of select fill, the ground surface shall be compacted as given in Section 104.2.

(ii) ***Compaction of Select Fill***

The select fill material shall be placed in layers of thickness appropriate to the type of compaction equipment and compacted to 100 % M.D.D as per AASHTO T 180 at OMC -2% to OMC+1%.

iii) Foundation material on which structure is to be placed shall be compacted to 95% M.D.D AASHTO T-180, unless otherwise directed by the Engineer. In case unsuitable material is encountered at foundation level (SPT<5), which is either unacceptable and / or cannot be compacted to required density shall be removed to the depth and extent as directed and replaced with suitable material of the type as determined by the Engineer.

e) Cofferdams and Cribs

1) For substructure work, the contractor shall submit, upon request, drawings showing his proposed method of cofferdams construction and other details left open to his choice or not fully shown on the Engineer's drawings. The Contractor shall not start work until the Engineer has approved such drawings.

2) Cofferdams and cribs for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed, and be made as water tight as is necessary for the proper performance of the work which must be done inside them. In general, the interior dimensions of cofferdams and cribs shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside the forms. Cofferdams

or cribs, which are tilted or moved laterally during the process of sinking, shall be righted, reset, or enlarged so as to provide the necessary clearance and this shall be solely at the expense of the Contractor.

3) When conditions are encountered which, in the opinion of the Engineer, render it impracticable to dewater the foundation before placing masonry, he may require the construction of a concrete foundation seal of such dimensions as may be necessary. The foundation water shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. During the placing of a foundation seal, the elevation of the water inside the cofferdam shall be controlled to prevent any flow through the seal, and if the cofferdam is to remain in place, it shall be vented or ported at low water level.

4) Cofferdams or cribs shall be constructed so as to protect green concrete against damage from a sudden rising of the stream or river and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry without written permission from the Engineer.

5) Unless otherwise provided, cofferdams of cribs with all sheeting and bracing shall be removed after the completion of the substructure, care being taken not to disturb or otherwise injure the finished masonry.

f) Pumping

Care shall be taken during excavation to prevent disturbance to the foundation. If ground water is encountered during excavation and a concrete seal course is not to be used, dewatering shall be commenced and shall proceed in advance of or concurrently with further excavation. The foundation shall be free of water at the time, footing concrete is placed and water control shall continue as necessary to prevent damage to the work.

All dewatering shall be performed at the Contractor's sole expense and shall be considered as included in the contract unit price(s) for the facility being constructed. The sides of excavations shall be sloped as required by soil conditions to stabilize the sides for safe working conditions. The quantities of excavations for said sloping will not be measured for payment. The backfilling shall be done with suitable materials as approved by the Engineer, at Contractor's expense.

1) Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping of water will be permitted during the placing of concrete or for a period of at least twenty four (24) hours thereafter, unless it is done from a suitable sump pit separated from the concrete work by a watertight wall or other effective means.

2) Pumping to unwater a sealed cofferdam shall not commence until the seal has set sufficiently to with stand the hydrostatic pressure.

g) Inspection

After each excavation is completed the Contractor shall notify the Engineer, and no concrete or masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

In case if an existing structure is to be replaced with a new structure the quantities for dismantling the structure shall be paid under item 510 (Dismantling of structures) and additional excavation required shall be carried out under this item.

h) Classification of Excavation

Classification of excavation shall be made as described under items 106.2 of these Specifications.

107.3.2 Excavation in Embankments

Unless otherwise specified, the Contractor may choose with the approval of the Engineer to excavate for structures, culverts, and pipe culverts after the embankment has been placed. Any space remaining after the placing of such structures or culverts shall be filled with material approved by the Engineer and compacted as follows:

Layers of not more than 20 cm in loose thickness shall be placed and compacted in succession, with mechanical tampers, plate compactors or hand guided rollers operated transversely to the roadway, to the densities specified in the item 108.3.1. Moisture content shall be adjusted as directed by the Engineer. Proper benching shall be made to ensure bonding of existing and new material without any extra payment.

The excavation in embankment and the placing of backfill for the purposes described above shall not constitute any claim for payment, also if sand or granular backfill is used by the contractor for his convenience, no extra payment will be made.

107.3.3 Backfill

a) Granular backfill where-ever directed shall be placed in the position and to the required depth, shown on the drawings or where and as required in writing by the Engineer and it shall be well compacted in layers not exceeding twenty (20) cm in thickness to 100 percent of Maximum Dry Density (MDD) as per AASHTO T-180 (D). In case of water logged areas the thickness of the layer shall not exceed fifty (50) centimeters or as directed by the Engineer. Volume of granular fill around structures shall be calculated within the vertical limits of approved "excavation for such a structure, where as the horizontal limits shall be those as specified on drawings.

b) Common backfill shall consist of earth free from large lumps, wood and other organic materials and of a quality acceptable to the Engineer, It shall be placed in the position and to the required depths shown on the Drawings and/or as required in writing by the Engineer and it shall be well compacted in layers not to exceed twenty (20) cms in depth to the density, 95 percent of maximum dry density, as per AASHTO T-180 (D). Backfill with sand (A-3) shall be compacted to 74 % Relative Density as per ASTM-D 4253 and 4254.

c) The rock backfill material whose individual sizes are not more than 30 cm shall be placed in the position to the required depth as specified and the voids shall be filled in layer of fine material approved by the Engineer. The compacting efforts shall be made so as to achieve the desired compaction approved visually by the Engineer. The depth of the layer in any case shall not exceed sixty (60) centimeters. However in water logged areas, the thickness may be increased as directed by the Engineer. Rock backfill will not be placed within two meters from concrete face of any structure.

d) All spaces excavated and not occupied by abutments, piers or other permanent work shall be refilled with earth or granular fill as approved by the Engineer up to the surface of the surrounding ground, with a sufficient allowance for settlement. All such backfill shall be thoroughly compacted and, in general, its top surface shall be neatly graded.

e) The fill behind abutments and wing walls of all bridge structures shall be deposited in well-compacted, horizontal layers not to exceed twenty (20) cm. in thickness. The common backfill in front of such units shall be placed first to prevent the possibility of forward movement.

Special precautions shall be taken to prevent any wedging action against the masonry, and the slope bounding the excavation for abutments and wingwalls shall be destroyed by stepping or roughening to prevent wedge action. Jetting of the fill behind abutments and wingwalls will not be permitted.

f) Fill placed around culverts and piers shall be deposited on both sides to approximately the same elevation at the same time. Where the Contractor does not have proper equipments to ensure compaction in restricted areas, Engineer may allow backfill with sand saturation method, at no extra cost to the Employer.

g) Adequate provision shall be made for the through drainage of all backfill. French drains shall be placed as weep holes.

h) No backfill shall be placed against concrete or masonry structure before fourteen (14) days of placement or until test cylinders show the strength to be 80 % of the 28 days' cylinder strength of concrete as per table 401-1 and backfilling shall be carried out on both sides of the structure simultaneously.

Any temporary backfill or platform constructed by the Contractor for piling purposes or any other work item(s), the removal of this work by the Contractor shall not be measured and included for payment purposes.

ITEM 108 FORMATION OF EMBANKMENT

108.1 DESCRIPTION

This work shall consist of formation of embankment, including preparation of area for placing and compaction of embankment material in layers and in holes, pits and other depressions within the roadway area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the plans or established by the Engineer. The work shall also include the compaction, trimming and shaping of the side slopes as shown on the plans and removal of any excess fill as directed by the Engineer.

108.2 MATERIAL REQUIREMENTS

Material for embankment shall consist of suitable material excavated under the foregoing Items 105 and 107 and approved by the Engineer. Borrow material however, shall only be used when there is no suitable material available from the roadway and/or structural excavation.

Wet excavated material which will be suitable when dry and if approved by the Engineer shall first be allowed to dry before being placed in the embankment.

The material under this Section shall conform to the following specification:

a) The Contractor shall use AASHTO Class A-1, A-2, A-3, A-4, A-5 soil as specified in AASHTO M-145 or other material approved by the Engineer. It shall meet the minimum requirements as given in Table - 108.1

Table - 108.1

Description of Zones	Material Type	Maximum Compacted Layer Thickness	Required Modified Compaction Percentage	Recommended Minimum CBR value
Top 30 cm	A-4 or better material	15 cm	95	8
30 cm - 75 cm	A-4 or better material	15 cm	93	8
Below 75 cm	A-4 or better material	20 cm	90	8

Plasticity Index (PI) of A-4 sub-grade material should not be more than six (6). Maximum Dry Density 'MDD' and soaked CBR value shall be determined according to AASHTO T-180 and T-193. The CBR value shall be determined at 95% of maximum dry density.

b) Swell value of the material for embankment formation shall not exceed five tenth (0.5) percent. However, while establishing the swell value, surcharge weights representing the overburden will be used.

c) In areas subject to flood and prolonged inundation of the embankment, such as at bridge sites, the material used in embankment, unless rock, shall be AASHTO Class A1 (a), A1 (b) and A-2-4 soils. Other soils may be used only with the written consent of Engineer and provision of suitable protection to the embankment slopes as directed by the Engineer.

d) In case non-cohesive material is used for embankment formation, it shall be properly confined at no extra cost, with a material having Liquid Limit not more than 25 and Plasticity Index not more than 6 or as approved by the Engineer.

e) For the purpose of embankment and subgrade construction the following shall be considered as unsuitable materials:

1) AASHTO soil classification group of A6 and A7;
2) Material from swamps, marshes and bogs;
3) Peat, logs, stumps and perishable materials;
4) Material susceptible to spontaneous combustion;
5) Organic Soils, as determined by ASTM D 2487-83 or USBR Earth Manual.

f) The moisture content of the soil at the time of compaction shall be optimum to achieve the compaction up to the specified density. The maximum dry density and optimum moisture content shall be determined from moisture density test (AASHTO T-180 Method D) performed on different type of soil to be used in the construction of the work. Optimum moisture content and the moisture range required for the soil to achieve the desired compaction shall be approved by the Engineer. The soil shall be compacted at optimum moisture content with +1 % to -2 % tolerances, commensurate with the soil type, unless otherwise directed by the Engineer.

When compaction is determined by "Relative Density Test" then tolerance for moisture content shall be finalized during the compaction trial and approved by the Engineer.

108.3 CONSTRUCTION REQUIREMENTS

108.3.1 Formation of Embankment with Borrow Common Material

If suitable material is not available in the Project area, the Contractor may opt, without any additional cost to the Employer, to blend pit sand with locally available A6/A7 soils to achieve a uniform blend that meets the material requirements stated above. Such widely divergent materials may be mixed, sampled and tested outside the embankment limits and the mixture may be used as a proposed source of borrow material as outlined in Section 108.2. However, the Contractor will submit his method statement to the Engineer and get it approved before proceeding with the work. Approval of this method statement by the Engineer shall not relieve the Contractor of his responsibility to use the suitable material in the Works. Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as required by the Engineer. The layers of loose material other than rock shall be not more than 20 cm. thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved for each material source and/or borrow area.

The material placed in layers and that scarified to the designated depth for formation of embankment shall be compacted to the density specified below:

For Depth below subgrade level	Percent of Maximum Dry Density as determined by AASHTO T-180*
0 to 30 cm	95
30 to 60 cm	93
Below 75 cm	90

Method 'B' or 'D' whichever is applicable or corresponding Relative Density in case of sand fill.

In-place density determinations of the compacted layers shall be made in accordance with AASHTO T-191 or other approved methods. For all soils, with the exception of rock fill materials, containing more than 10% oversize particles (retained on 3/4 inch/ 19 mm

sieve), the in-place density thus obtained shall be adjusted to account for such oversize particles or as directed by the Engineer. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted and accepted by the Engineer.

Material for embankment at locations inaccessible to normal compacting equipment shall be placed in horizontal layers of loose material not more than 15 centimeters thick and compacted to the densities specified above by the use of mechanical tempers, or other appropriate equipment.

The compaction of the embankment shall be carried out at the designated moisture content with the suitable compacting equipment. In forming the embankment, the Contractor shall take steps to ensure that the work can be drained free of rain water, and make due allowance in the height and width of the work for swelling and/or shrinkage.

Embankment material that does not contain sufficient moisture to obtain the required compaction shall be given additional moisture by means of approved sprinklers and mixing. Material containing more than the optimum moisture may not, without written approval of the Engineer, be incorporated in the embankment until it has been sufficiently dried out. The drying of wet material may be expedited by scarification, disking or other approved methods.

Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition. The slopes of the design road cross-section shall be trimmed and compacted to the densities as specified above for different zones". No surplus material shall be permitted to be left at the toe of embankment or at the top of cut section.

Relative Density Test

For cohesion-less free-draining soils for which impact compaction will not produce a well-defined moisture density relationship curve and the maximum density, the Test for the Relative density of Cohesion-less soils ASTM D-4253/4254 shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest state at which it can be placed by the laboratory procedures described in the ASTM D-4253/4254. The field Density and actual Moisture Content of the compacted embankment shall be determined by field tests according to AASHTO T 191, or by nuclear method AASHTO T-310/ASTM/D-1557.

a) Relative Density: The Relative Density as determined by the Relative density test shall be the standard to which the Field density is referred for comparison for each type of cohesion less soil used in the Work.

b) Field Density: The Field Density shall be the density of the compacted embankment determined by the field Density test.

c) Moisture Content: The Moisture Content shall be the actual moisture content of the soil in the compacted embankment.

108.3.2 Formation of Embankment with Rock Material

Embankment formed of material consisting predominantly of rock fragment of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding in thickness than the approximate average size of the rocks except that no layer shall exceed eighty (80) centimeters of loose measurement and compacted by a vibratory roller with the minimum mass as shown in the following table:

Mass per metre width of vibrating roll (Kg/M)	Depth of fill layer (mm)	Number of passes of the roller on each layer
2300 – 2900	400	5
2900 – 3600	500	5
3600 – 4300	600	5
4300 – 5000	700	5
> 5000	800	5

The material shall be carefully placed in layers, so that all larger stones will be well distributed and voids completely filled with smaller stones, clean small spals, shale, earth, sand, gravel, to form a solid mass. After placing final layer of rock material, surface shall be covered with a layer of fine material having thickness less than twenty (20) centimeters. Such fine material shall be reserved from roadway excavation by the Contractor. Should such material be available but not reserved, Contractor will supply and place borrow material for forming smooth grade without extra payment.

Each layer shall be bladed or leveled with motor grader, bulldozer or similar equipment capable of shifting and forming the layer into a neat and orderly condition. No rock larger than eight (8) centimeters in any dimension shall be placed in the top fifteen (15) centimeters of embankment unless otherwise allowed by the Engineer.

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less that one (1) percent of the layer thickness. In evaluation of settlement, survey points should be established and rolling continued until difference of levels as checked after two consecutive passes is less than one (1) percent of the total layer thickness. More over initial rolling of overlaid fine material shall be done without watering to ensure their intrusion in voids of rock layer beneath. Watering shall be done when voids are properly filled.

Embankments, which are formed of material that contain rock but also contain sufficient compactable material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner prescribed above and to the point when settlement is within above mentioned requirement. Each layer must be approved by the Engineer before the next layer is placed.

108.3.3 Formation of Embankment on Steep Slopes

Where an embankment is to be constructed against an existing slope of 1 vertical to 5 horizontal or steeper, hill sides, existing shoulders or where new fill is to be placed and compacted against existing pavement or where embankment is to be built along one half the width at a time, the existing slope shall be benched in slope of twenty (20) cm depth. The horizontal dimension of benches shall be greater than half the width of the compacting equipment in use except where this would result in a vertical dimension at the back of the bench of more than 60 cm in which case the horizontal dimension may be reduced.

The compaction of benches shall be as per Subsection 108.3.1 of these Specifications.

No additional payment will be made for this work and no measurement shall be made of the volume of material cut from the slope and reused else where for benching purpose. Filling against the slope will be calculated on the volume of fill placed against the original slope.

Existing slope in the context of this clause includes a partially constructed embankment but does not include the side of trench excavation.

Cut material shall be incorporated with the new embankment material and compacted in horizontal layers. No extra payment will be allowed for such an operation.

108.3.4 Formation of Embankment on Existing Roads

Before fill is placed and compacted on an existing roadway, the existing embankment and/or pavement may be leveled by cutting, rooting or scarifying by approved mechanical means to a level to be determined by the Engineer. The earth, old asphalt or other material arising as a result of this operation will be declared either suitable or unsuitable, for use in the embankment or other items, by the Engineer. The material declared suitable will be measured under relevant item and that declared unsuitable, will be measured under Item 106, unless a separate pay item appears in Bill of Quantities.

108.3.5 Formation of Embankment in Water Logged Areas

Where embankments are constructed across marshlands, tidal flats, or wet ground which is soft (such as SPT < 5) and compressible and will not support the weight and forces of hauling and compacting equipment, the lower part of the embankment may be constructed by dumping successive loads in a uniformly distributed layer (bridging lift) of a thickness not greater than necessary to support equipment hauling, and the placing and compacting of subsequent layers. Such supporting layers shall not be subjected to lift thickness and compaction requirements specified in Table 108.1. The remainder of the embankment shall be constructed in layers as specified.

The material for the working platform (bridging lift) shall consist of non-cohesive sandy material / processed granular fill material obtained from borrow excavation or quarry waste. This material shall conform to the following requirements of USSD Committee on Materials for Embankment Dams:

Size	% Passing
37.5 mm	100
25 mm	90~100
19 mm	55~85
# 4	35~55
# 30	8~30
# 200	0~5

It should also be checked that selected grading is such that intrusion into the working platform material of subgrade or natural ground surface material is not allowed.

For this condition to be met it will be required that the ratio as below shall be checked and followed:

$$\frac{\text{D15 - (Granular Fill Material)}}{\text{D85 - (Natural Ground Material)}} < 5$$

D15 and D85 mean the particle diameters corresponding to 15% and 85% respectively, passing (by weight) in a grain size analysis.

When the roadway profile is so low that the construction of the lower part of the embankment using a "bridging lift" will not permit the placement and compaction of sixty (60) centimeters of acceptable embankment material, Contractor shall prepare a proposal to raise profile of the embankment and submit it to the Engineer for his approval.

Boulders and rock fragments larger than twenty (20) centimeters in maximum dimension shall not be placed in the embankment any closer than sixty (60) centimeters from the

staked top of the embankment.

Rocks, broken concrete and other solid material having a diameter greater than ten (10) centimeters shall not be placed in embankment where piling is to be installed by driving or drilling.

Embankment settlement period for critical section, where height is greater than 5.0 meter, is approximately three (3) months. Embankment therefore, shall remain in place for the required settlement period before placing the 30 cm thick subgrade layer, excavating for abutments, wing walls or retaining wall foundations or installing foundation piles at each location.

On completion of the embankment, the Contractor shall carry out precise leveling of the crest of the embankment. This shall consist of leveling transverse sections (a minimum of five (5) points) at a maximum spacing of thirty (30) meters along the embankment. These shall be referenced to a stable approved datum. Leveling shall be carried out at suitable time intervals until the average rate of settlement over a period of one (1) month does not exceed 0.05 mm per day. No permanent pavement construction will be permitted until the specific criteria are achieved.

The embankment settlement test specified herein shall be in addition to the test section in subsection 108.3.9.

108.3.5.1 Formation of Embankment in Areas Subject to Prolonged Flooding

The locations identified on Drawings or as directed by the Engineer, Earthen Dowels shall be constructed to contain granular material platform as described in construction requirements.

Material Requirements for Earthen Dowels

The material for earthen dowels shall be Class A-1 or A-2 soils from roadway/borrow excavation or any other source as approved by the Engineer having a plasticity index in range of 6. It should be free of organic and other deleterious substances.

Construction Requirements for Earthen Dowels

The earthen dowels shall be constructed at toe of the embankment on outer sides of carriageways. The earthen dowels shall extend up to 1 meter from the toe of the embankment as shown on the drawings. No density requirements as per sub-section 108.2 are specified for the earthen dowels. However they shall be graded and compacted with two passes of vibratory roller.

Subgrade/Embankment

The subgrade/embankment above the granular material platform shall be compacted as specified in sub-section 108.2 for the applicable zones of compaction.

108.3.6 General Requirements

To avoid interference with the construction of bridge abutments and wing walls, the Contractor shall at points determined by the Engineer, suspend work on embankments and/or in cuts forming the approaches to any such structure until such time as the construction of the later is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works. The cost of such suspension of work shall be included in the contract unit prices for embankment. In carrying embankments up to or over bridges, culverts or pipe drainage, care shall be taken by the Contractor to have the embankments brought to equally on both sides and over the top of any such structure. Contractor shall make special arrangements to ensure proper compaction in restricted spaces and around structures. No compensation shall be made to the Contractor for working in narrow or otherwise restricted areas.

When as a result of settlement, an embankment requires the addition of material up to 30 cm in thickness to bring it up to the required grade level, the top of the embankment shall be thoroughly scarified before the additional material is being placed, without extra payment to Contractor for the scarification.

The Contractor shall be responsible for the stability of all embankments and shall replace any portions that in the opinion of the Engineer have been damaged or displaced due to carelessness or neglect on the part of the Contractor. Embankment material which may be lost or displaced as a result of natural causes such as storms, cloud-burst or as a result of unavoidable movement or settlement of the ground or foundation upon which the embankment is constructed shall be replaced by the Contractor with acceptable material from excavation or borrow. No additional compensation will be allowed for the replacement.

During construction, the roadway shall be kept in shape and drained out at all times. When unsuitable material has been placed in the embankment by the Contractor, he shall remove it without extra payment.

Embankment filling shall be brought up and compacted over the full width of the embankment of one carriageway in one operation in layers parallel with the subgrade level. At no time shall any part of the embankment width under one carriageway be left more than one layer lower than any other part of the embankment width.

Shoulder construction shall be brought up simultaneously with the pavement construction. In order to prevent water penetration into the pavement layers during construction, shoulder and median construction shall be brought up simultaneously with the pavement construction whenever the transverse slope of the subgrade slopes downwards towards the pavement or subgrade.

The backfill behind abutments and wing walls of all bridges, pipe culvert and box culverts shall be deposited in horizontal layers not exceeding twenty (20) cm in thickness and compacted to the density requirement as per clause 107.3.3.

Embankment side slopes shall be neatly trimmed to the dense lines and slopes shown on the drawings or as directed by the Engineer and the finished work shall be left in a neat and acceptable condition.

108.3.7 Formation of Embankment with A-3 Material

The construction of embankments with A-3 material shall be accomplished as shown on the plans, specified in Particular Specifications and Special Provisions and as directed by the Engineer. Construction of embankment with A-3 material shall be accomplished in a series of operations as follows:

Edge berms shall first be constructed along both sides of the staked embankment, except where the embankment is to be constructed against hillsides or existing embankment, using Class A-1 or A-2 soils from roadway excavation or borrow or any other source which resist erosion by wind and water and are approved by the Engineer. However, if Engineer so approved A-4 material having PI value 6-8 from borrow excavation can be used for confinement. Edge berms shall be constructed with an external side slope as shown on the plans or specified in the Particular Specifications and Special Provisions, but not steeper than one (1) vertical to three (3) horizontal. Edge berms shall be constructed not more than forty (40) centimeters in height and not less than 2.4 meters wide at the top. The materials shall be placed and spread in layers as specified in these Specifications and compacted as specified in Table 108.1.

A-3 material shall be excavated, hauled, deposited and spread within the edge berms to the full height of the edge berms using any means other than hydraulic sluicing.

108.3.8 Formation of Embankment on Existing Structures

When an embankment surface is to be constructed over an area previously occupied by a building basement, cellar, irrigation canal, well, any previous excavation, or other such construction that will not permit the use of normal compaction equipment, the embankment construction shall conform to the backfilling requirements specified in Structural Backfilling in these Specifications, until the normal compaction equipment can be used. The material shall be compacted to the density specified for the adjacent embankments.

108.3.9 Trial Section

Before starting the filling of the embankment, the Contractor shall construct trial sections of minimum 200 meters and maximum of 500 meters or as directed by the Engineer with each soil type/source proposed to use as fill material. The soils used in the trials shall be the same as those intended to be used for the formation of embankment and the compacting equipment shall be the same that the Contractor will use for the main work.

The construction of embankment with any type of soil/material source shall be subject to written approval of the Engineer after the trial section made for that particular type of soil/material source.

The objective of these trials shall be to determine the optimum moisture content and the relationship between the number of passes of compacting equipment and density obtained for the soil types under trial and for the verification of the soil type itself. No separate payment will be made for this work, which shall be required as a subsidiary obligation of the Contractor under Pay Item Nos. 108a, 108b or 108c, as the case may be. The Engineer may order additional compaction test sections when deems necessary.

108.3.10 Finishing Tolerances and Requirements

Embankment shall be completed & finished within the following tolerances and deadlines:

a) Embankment slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes within one (1) meter of top of embankment grade shall not vary by more than fifteen (15) centimeters from the staked slope measured at right angles to the slope. Slopes below one (1) meter shall not vary more than thirty (30) centimeters from the staked slope, measured at right angles to the slope.

b) Median and side slopes which are on a one (1) vertical to six (6) horizontal (6:1) or flatter slope in excavation as well as embankment shall be finished in accordance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope, measured at right angles to the slope. Flow-lines within medians shall be carefully graded to drain and shall not vary more than five (5) centimeters) from the grade line established by the Engineer.

c) The elevation of the finished top of embankment shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five (25) meters with additional sections as directed by the Engineer. The allowable tolerance of the finished embankment above the staked elevation shall be two (2) centimeters.

d) The allowable tolerances in design elevation of the finished embankment are stated in ‘Table for Allowable Tolerances’ in these Specifications.

ITEM 109 SUBGRADE PREPARATION

109.1 DESCRIPTION

The subgrade preparation shall be that part of the work on which, the subbase is placed or, in the absence of subbase, act as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders and laybyes as indicated on the Drawings or as specified herein.

109.2 CONSTRUCTION REQUIREMENT

109.2.1 Prior Work

Before commencing the work all culverts, drains, ditches including fully compacted backfill over them outlets for drainage, head walls/wing walls of culverts and any other minor structure below thirty (30) centimeters of existing subgrade level or all structures which will be below thirty (30) centimeters of newly placed subgrade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to subgrade by surface water. No work of subgrade preparation will be started before the prior works described herein have been approved by the Engineer.

109.2.2 Compaction Requirement

All materials down to a depth of 30 cm below the subgrade level in earth cut or embankment shall be compacted to at least 97 percent of the maximum dry density as determined according to AASHTO T-180 Method 'B' or 'D' whichever is applicable.

109.2.3 Subgrade Preparation in Earth Cut

In case bottom of subgrade level is within thirty (30) cm of the natural ground, the top $\leq$ fifteen (15) cm material shall be removed and stockpiled at a nearby location, the exposed surface shall then be scarified, broken up, adjusted to moisture content and compacted to minimum density of ninety seven (97) percent of the maximum dry density as determined by AASHTO T-180 Method D. Second layer of subgrade shall then be prepared by using the above mentioned stockpiled material to ensure that the depth of subgrade layer is thirty (30) cm.

In case, the bottom of subgrade is below the natural ground by more than thirty (30) cm, the material above the top of subgrade shall be removed and subsequent layer of thirty (30) cm shall be prepared in two layers as per the method describe above.

In case, unsuitable material is encountered at the subgrade level within a depth of thirty (30) cm, the same shall be removed in total and replaced by the approved material. The Contractor shall be paid for removal of unsuitable material as per pay Item 106a and for replacement of approved material, the payment will be made under pay Item 108c.

Subgrade of thirty (30) cm shall in any case be prepared and compacted in two layers of fifteen (15) cm each.

109.2.4 Subgrade Preparation in Rock Cut

Excavation in rock shall extend to the subgrade level as shown on drawings. Rock shall be undercut to required elevation and sections shown on the plans or as directed by the Engineer. Transverse and longitudinal profiles checked by template shall be accurate to the requirement. Cuts below subgrade level shall be backfilled with selected subbase material and compacted to minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO T-180, method 'D'. No compensation shall be made to the Contractor for over-cut or remedial measures as described above.

No rock shall be higher than two (2) centimeters above the under cut section elevation. The under cut material shall be placed in embankment or disposed of at the direction of Engineer.

109.2.5 Subgrade in Embankment

When the subgrade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimeters below subgrade level shall meet compaction requirement of 109.2.2. Soil having a minimum value of CBR of eight (08) percent and a free swell value of not more than 0.5 percent shall be used. Unsuitable material if encountered within the existing formation layer as per laboratory specified test, shall be removed, disposed of and replaced by suitable one as per direction of the Engineer of which the payment will be made under relevant items of work.

Rollers and other equipments of approved size and type, accepted by the Engineer, shall be used for compaction. Water shall be added to obtain optimum moisture content; if necessary. Contractor shall ensure proper compaction in restricted areas by use of special equipments and rollers. No compensation shall be made for extra work due to restricted space.

Performance of this item of work shall not be paid for under this section but shall be deemed to be covered by the contract price for pay item 108a through 108e, Formation of Embankment.

109.2.6 Subgrade Level in Existing Road

Where indicated on the Drawings or directed by the Engineer that the existing road surface is to be used as the subgrade, the correct elevation on which the base or subbase is to be laid shall be obtained, where necessary, either by means of leveling course or by excavation. The leveling course shall be constructed to the requirements of the Engineer and paid for under the appropriate Pay Item involved. Excavation shall include disposal of any surplus material in the adjacent embankment or elsewhere as directed by the Engineer.

In case, the design level of subgrade is within 30 cm of the existing ground/road then the item shall be measured and paid accordingly.

109.2.7 Subgrade Reinforcement

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the subbase or base to be placed upon it, the Engineer may order to strengthen and support the subbase or base on one or both sides of the existing pavement. This work shall consist of the removal and disposal of any unsuitable material and its replacements with suitable material to such width and depth as required by the Engineer.

The excavated material shall, if declared suitable for use elsewhere in the embankment by the Engineer be so used, and payment for its removal shall be covered under the contract price of Pay Item No. 108a; if declared unsuitable it shall be disposed of and paid as provided in Item 106a. The finished compacted surface of the subgrade shall be as specified in Item 109.2.3.

109.2.8 Protection of Completed Work

Any part of the subgrade that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being allowed to ply on the the subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for

such repair. He shall limit the area of subgrade preparation to an area easily maintained with the equipment available. Subgrade preparation and subbase or base placing shall be arranged to follow each other closely. The subgrade, when prepared too soon in relation to the placing of the subbase, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the subgrade as may be necessary to restore it to the state specified herein. It will be at discretion of the Engineer to check some or all such reaches for compaction and moisture content before placing the next layer.

109.2.9 Templates and Straightedges

The Contractor shall provide for the use of the Engineer, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the subgrade levels have been checked and approved by the Engineer.

109.2.10 Finishing Tolerances and Requirements

Quality Assurance measuring or testing shall involve verification that the subgrade is constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the Plans or staked by the Engineer within the following tolerances and deadlines:

a) Subgrade slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope measured at right angles to the slope.

b) The elevation of the top of subgrade surface shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five (25) meters with additional sections as directed by the Engineer.

c) During compaction operation formation of thin layers shall not be allowed.

The allowable tolerances in design elevation of the finished subgrade are stated in ‘Table for Allowable Tolerances’ in these Specifications.

ITEM 110 IMPROVED SUBGRADE

110.1 DESCRIPTION

This work shall consist of preparation of subgrade, with an approved blend of materials, uniformly mixed, compacted, shaped and finished to the lines, grades and typical cross-section shown on the Drawings, or in thickness as directed by the Engineer.

Improved subgrade as herein referred to may be defined as material suitable for embankment to which better quality of material is blended in proper proportion to improve its strength properties or performance.

110.2 MATERIAL REQUIREMENTS

The major component of improved subgrade shall consist of material conforming to Item 108.2 - "Material requirements for embankment."

The blending material shall be any soil that classifies as A-1 (a), A-1 (b), or A-3 according to AASHTO M-145 with PI of not more than 6.

The blended mixture shall exhibit a laboratory soaked CBR (96 hours) of not less than 20, or as specified in the drawings at 95% of the Maximum Dry Density determined as per AASHTO T 180.

110.3 CONSTRUCTION REQUIREMENTS

110.3.1 Preparation

The surface of the roadbed on which the improved subgrade is to be constructed shall be compacted to the density specified under Item 108.3.1.

110.3.2 Proportioning of Materials

Prior to start of construction, the proportion of each material to be incorporated for improved subgrade shall be established as approved by the Engineer. The Engineer shall specify a single percentage of each material to be blended and shall establish the gradation of the resulting mixtures alongwith the ranges of permissible gradation tolerances to obtain the required CBR for the improved subgrade.

The blend proportions thus established shall apply only when each material to be used is obtained from same source. Should a change in source of material be made, a new proportion shall be established. When unsatisfactory results or other conditions make it necessary, the Engineer may require additional laboratory tests.

110.3.3 Mixing and Spreading

Improved subgrade may be constructed with any combination of machines or equipment that will yield results meeting these specifications.

a) Stationary Plant Method

The soil ingredients and water shall be mixed in an approved mixing plant (Pug Mill). The plant shall be equipped with feeding and metering devices that will add the materials to be blended in the specified quantities. Water shall be added during the mixing operation in the quantity required for proper compaction, which is approximately optimum moisture content plus or minus two (2) percent. The mixing time shall be that which is required to secure a uniform mixture. After mixing, the blended material shall be transported to the job site while it contains the sufficient

moisture and shall be placed on the roadbed by means of an approved mechanical spreader. The mixture shall be spread at rate that will produce a uniform compacted thickness conforming to the required grade and cross-section. Compaction shall start as soon as possible after spreading and shall continue until the specified relative compaction is achieved.

b) Traveling Plant Method

The traveling plant shall be either a flat transverse shaft type or a windrow type pugmill. After the materials have been placed by a mechanical spreader or windrow sizing device the materials shall be uniformly mixed by the traveling mixing plant. During the mixing operation, water shall be added as necessary to bring the moisture content of the mixture to the percentage suitable for proper compaction.

110.3.4 Compaction

Unless otherwise permitted by the Engineer based on the performance of the compacting equipment used as determined from the trial section, each layer of improved subgrade shall be placed in horizontal layers of uniform loose thickness not exceeding twenty (20) centimeters. Each layer shall be compacted to the density conforming to the requirements specified in Item 109.2.2.

During compaction operations formation of paper/thin layers shall not be allowed.

In-place density determinations of the compacted layers shall be made in accordance with AASHTO T-191, T-238 or other approved methods.

110.3.5 Trial Sections

Prior to the formation of the improved subgrade, the Contractor shall construct three trial sections of 200 meter length one (1) for each blend of improved material proposed to be incorporated for improved subgrade, or as directed by the Engineer. The compacting equipment to be used in the trial sections shall be the same equipment that the Contractor intends to use for main work, accepted by the Engineer.

The object of these trials is to determine the proper moisture content, the relationship between the number of passes of compacting equipment, density obtained for the blended material, and to establish the optimum lift thickness that can be effectively compacted with the equipment used. No separate payment will be made for this work, which will be regarded as a subsidiary obligation of the Contractor under pay Item No. 110.

110.3.6 Protection of Completed Work

Any part of the completed improved subgrade shall be protected and well drained and any damage shall be repaired as directed by-the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being allowed to ply on the the improved subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the improved subgrade preparation to an area easily maintained with the equipment available. Subgrade preparation and placement of succeeding layer to follow each other closely. The improved subgrade, when prepared too soon in relation to the placing of the layer above it, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the improved subgrade as may be necessary to restore it to the state specified herein. It will be at discretion of the Engineer to check some or all such reaches for compaction and moisture content.

110.3.7 Templates and Straightedges

The Contractor shall provide for the use of the Engineer, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the improved subgrade level have been checked and approved by the Engineer.

110.3.8 Tolerance

The allowable tolerances for the finished improved subgrade surface prior to placing the overlying subbase, base or asphaltic concrete course are given in the relevant, "Table for Allowable Tolerances" in these specifications.

ITEM 111 SOIL CEMENT STABILIZED SUBGRADE

111.1 DESCRIPTION

The work shall consist of performing all operations in connection with the formation of soil cement stabilized subgrade and all incidentals in accordance with the Specifications and in conformity with the lines and level, grade and typical cross-sections shown on the plans or directed by the Engineer.

111.2 MATERIAL REQUIREMENTS

111.2.1 General

The mix in place method of construction shall only be applied to sites with naturally occurring sand, gravel or sand and gravel mixture. For the stationary plant method of construction the materials shall comply with the Specifications or materials from any other source selected by the Contractor shall be subject to the Engineer's approval.

111.2.2 Soil

Soil used for cement stabilization shall be either "Silty or Clayey Soils" or sandy and gravely soils with the following characteristics

a) Silty and Clayey Soils

When this type of soil is used for cement stabilization it shall fulfill the following requirements:

1)	Liquid Limit (Max).	45%
2)	Plastic Limit (Max).	20%
3)	P.H. Value	Not less than 12
4)	Soluble Sulphate Content max:	4%
5)	Soluble Chloride Content max:	8%

If the soil at site does not have P.H. value specified above, it shall be improved by adding calcium chloride upto two (2) percent by weight of the dry soil.

Soils, which don't meet above requirement, shall be subject to the approval of Engineer.

b) Sandy and Gravely Soils

Sandy and gravely soils used for cement stabilization shall fulfill the following requirements:

1)	Passing maximum size fifty (50) mm sieve	100%
2)	Passing five (5) mm (No. 4) sieve	above 50%
3)	Passing 0.4 mm (No. 36) sieve,	above 15%
4)	Passing 0.075 mm (No. 200) sieve	below 5%
5)	Finer than 0.002 mm (Clay)	below 3%

Soil which does not meet above requirements shall be subject to the approval of Engineer after reviewing the laboratory testing results.

111.23 Cement

The Cement to be used for stabilization shall be Portland cement or Sulphate resistant cement as directed by the Engineer according to the results of laboratory tests. Portland and Sulphate resistant cements shall conform to requirement of AASHTO M-85.

Immediately upon arrival to site, the Cement bags shall be stored in weather proof building to protect from dampness on raised platform. At the time of use, all cement shall be free flowing and free of lumps. Under normal circumstances cement shall not be stored for a period longer than four months. Any cement that has remained in store for a period in excess of four months, or of which there is any doubt as to its quality, shall be retested for Specification requirements. No such cement shall be used in the works without the approval of Engineer.

111.2.4 Water

Water to be used shall be free from injurious quantities of oil, alkali, vegetable matter and salts. It shall not contain more than 1000 parts per millions of Sulphates. In no case, water shall contain impurities to the extent that will cause change in setting time of cement by more than twenty five percent nor reduction in compressive strength of mortar after fourteen (14) days by more than five (5) percent when compared to results obtained with distilled water.

111.2.5 Mix Design Requirement in Laboratory

Before starting the work of stabilization, the proposed mix design showing exact percentage of cement and water to be used so as to obtain a mixture, shall be submitted by the Contractor for the approval of Engineer. The mix proportions shall be such so as to satisfy the following requirements:

a) Mixture sample, stored in box, with maximum humidity of ninety five (95) % for twenty four (24) hours and submerged in water for two hours before crushing, shall have a minimum compressive strength of 17 kilogram per square centimeter.

b) The maximum permissive swelling of volume shall be two (2) % and maximum loss in weight eight (8) % when tested in accordance with AASHTO T-135.

c) Maximum permissible tolerance of cement and water content during construction shall be as under:

Cement Content: $\pm$ 1.0 percent of that given in the mix design
Water Content: 0 to (+) 2 percent of that given in the mix design

111.2.6 Composition of Mixture at Site

Soil shall be mixed with sufficient cement to obtain required crushing strength. The cement content shall be determined at the laboratory so that minimum compressive strength of mixture is thirty (30) Kg/square centimeter at seven (7) days. The moisture content of the mix cement stabilized material shall not be less than the optimum as determined by AASHTO T-134 Method and not more than two (2) percent above the optimum as determined by this test or such higher value as may be agreed by the Engineer on basis of preliminary trial.

111.3 CONSTRUCTION REQUIREMENTS

111.3.1 Mix in Place Method

The field equipments used for pulverizing and mixing the stabilized material shall be approved by the engineer on the basis of preliminary trials to ensure that the plant is capable of producing the required degree of mixing and uniformity of stabilized material to the full thickness of layer being processed. The mixers shall be equipped with a device for controlling the depth of processing and the mixing blades shall be maintained so that correct depth of mixing is obtained at all times. The cement shall be spread ahead of mixer by means of a cement spreader, fitted with a device to ensure a uniform and controllable rate of spread of cement both transversely and longitudinally.

Water shall be added to adjust moisture content of material to optimum for compaction using water sprayer in uniform and controllable manner both transversely and longitudinally.

The mixing machine shall be set so that, it slightly cuts edge of adjoining lane processed previously to ensure proper processing of all material throughout the depth of layer. The output of the mixing plant shall not be less than twenty five linear meters per hour measured longitudinally of completed stabilized layer in order to achieve satisfactory compaction.

111.3.2 Stationary Plant Method

The stationary plant shall be of the power driven paddle or pan type and may be of the batch or continuous type. In case the batch mixes are used, the appropriate measured quantity of material and cement shall first be placed in the mixer and then water be added as necessary to bring the moisture content of the resulting mixture with in the range specified above.

Care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers, the cement is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized. Mixing shall be continued until the mixture has the uniformity and mixing time will not be less than one (1) minute.

111.3.3 Compaction

Any modification to meet the Specifications shall be completed together with compaction, within one and a half ($1^1/_2$) hours after mixing, or making good to deficient areas at Contractor's expense. Thickness shall be as shown on the drawings or as directed by the Engineer and shall comply the following requirements.

Immediately after spreading and shaping operation, the mixture shall be thoroughly and uniformly compacted with approved rollers. Rolling shall continue until entire depth and width of subgrade is uniformly compacted to maximum density of Ninety seven (97) % as tested in accordance with AASHTO T-134. Compaction shall be completed as soon as possible after mixing, normally within three hours, depending mainly on setting time of cement and weather conditions.

Compaction shall not be carried out after cement hydration and any soils material, which has been mixed or deposited after cement hydration, shall be removed and replaced with fresh mixed material.

After compaction, stabilized subgrade shall be protected against drying out by keeping it continuously damp or wet for a period of at least three (3) days or by coating with approved curing material. Surface shall be maintained in an acceptable condition at all times prior to the construction of sub-base.

No vehicular traffic shall run on the stabilized subgrade within a minimum curing period of seven days.

111.3.4 Tolerance

Tolerance in the thickness of compacted layers shall conform to as specified in the relevant, "Table for Allowable Tolerances" in these Specifications.

ITEM 112 LIME STABILIZED SUBGRADE

112.1 DESCRIPTION

The work shall consist of performing all operations in connection with construction of lime stabilized subgrade and all incidentals in accordance with these specifications and in conformity with lines and level, grade and typical cross-sections shown on the plans or as directed by the Engineer.

112.2 MATERIAL REQUIREMENTS

112.2.1 Soil

Naturally occurring heavy clay soils, clayey gravels or soils containing a sufficient proportion of clay or silty clay to enable satisfactory stabilization with lime shall be required for the Mix in Place method of construction and shall conform to properties as specified in Item 111.2, "Material Requirements" under soils cement stabilized sub grade. Materials from any other sources selected by the Contractor shall comply with the specification all as approved by the Engineer in case of stationary plant construction method.

Lime stabilization has been used successfully in clayey soils having plasticity index more than ten (10). This type of stabilization is applicable to that soil which contain a high percentage of clay or silty clay.

112.2.1 Lime

Lime to be used for stabilization shall be calcium hydroxide (slaked or hydrated lime) or Calcium oxide (quick lime) to the requirements for building lime as in table given below or lower quality lime produced from temporary burning pits or Kilns when approved by the Engineer.

Table 112.2

SPECIFICATION REQUIREMENT FOR LIME

Property	LIME	
	Quick Lime (Ca O)	Hydrated Lime $Ca(OH)_2$
Calcium or Magnesium Oxides	Not less than 92%	Not less than 95%
Carbon Dioxide-at Kiln Carbon	Not more than 3%	Not more than 5%
Dioxide-elsewhere	Not more than 3%	Not more than 7%

112.2.3 Water

Water used for lime stabilization shall be clean and free from injurious substances. Potable water is preferred and organic water is not permitted. It shall neither contain more than 1,000 parts per million of chlorides nor more than 1,300 parts per million of sulphates (S04). Water from doubtful sources shall not be used until tested as specified in AASHTO- T-26 and approved by the Engineer.

112.2.4 Mix Design in Laboratory

The mix design shall be worked out in the laboratory and it shall state the following field requirements:

a) The percentage of lime and water (optimum content and tolerances)
b) The field density of lime stabilized mixture to minimum ninety five (95) percent of

laboratory density established with modified AASHTO T-134 test

c) The required results of the compressive strength in laboratory at 7 days shall not be less than ten (10) Kg/sq. cm

112.2.5 Composition of Mixture at Site

Soil containing clay shall be mixed with sufficient lime; normally three (3) percent to eight (8) percent lime content, so that minimum compressive strength is seven (7) Kilogram force per square centimeters at seven (7) days. Moisture content of the lime stabilized material shall be not less than the optimum nor more than two (2) percent above the optimum as determined by Vibrating Hammer Method Test of BS 1924.

As guide trials, lime content should be established starting with 1% of lime by weight of dry soil for each ten (10) percent of clay in soil.

112.3 CONSTRUCTION REQUIREMENTS

112.3.1 Stationary Plant Method

The construction requirements of this clause shall conform to as specified in sub item 111.3.2.

112.3.2 Mix in Place Method

The requirements of construction under this clause shall be in accordance with sub item 111.3.1.

112.3.3 Precautionary Measures

Keeping in view the caustic nature of calcium oxide (quick lime), special measures shall be taken in handling, since it will attack equipment corrosively and precautions shall also be taken against the risk of severe skin burns to personnel. Suitable handling methods shall be used such as fully mechanized or bottom dump handling equipment, and protective clothing worn by the operators. Working operations should take into account the wind direction to minimize the dust problem and consequent eye or skin irritation to any personnel involved in the vicinity. Even when calcium hydroxide (slaked or hydrated lime) is used, care must be taken against the effects of prolonged exposure to skin.

112.3.4 Compaction Requirement

Immediately upon completion of spreading and shaping operation, the mixture shall be thoroughly compacted with approved roller. Compaction shall be continued until the entire depth of subgrade is uniformly compacted to the maximum density of 97% as determined by AASHTO T-134.

If quick lime is used, it shall not be permitted to compact the layers immediately after spreading the lime, because the hydration of the lime will cause damage to the compacted layers. The time within which compaction shall be completed will be estimated in the laboratory. Dry density of compacted layers shall not be less than Ninety seven (97) % of the maximum dry density determined in laboratory.

Compaction shall not take place after hydration of lime and any lime stabilized material that has been mixed and deposited after hydration of lime, shall be removed and replaced with fresh material, mixed and treated in accordance with the requirements of this clause.

Surface of subgrade shall be acceptable in all respects to specification, together with compaction with One and half (I.1/?) hours after mixing. Contractor will be responsible for any removal of or making good to deficient area without any extra payment. No vehicle or equipment shall be allowed to move over stabilized subgrade before initial setting of 7 days.

112.3.5 Tolerance

Tolerance for lime stabilized subgrade shall be as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

112.3.6 Weather Limitation

The laying of lime courses shall be avoided as far as practicable during cold and wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid on any surface, which is frozen or covered with ice or snow, and laying shall cease when the atmospheric temperature reaches five (5) degree C. on a falling thermometer or as directed by the Engineer. If wet weather threatens to be prolonged, the manufacture and laying of stabilized mix shall be suspended.

ITEM 113 BITUMEN STABILIZED SUBGRADE

113.1 DESCRIPTION

The work shall consist of performing all operations in connection with construction of bitumen stabilized subgrade and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

113.2 MATERIAL REQUIREMENTS

113.2.1 Soil

This method will only apply to sites with naturally occurring non plastic material such as sand. If the material is brought at site, it shall be non-plastic having uniform gradation.

113.2.2 Bitumen

Bituminous material used for subgrade stabilization shall comply with the requirement as per relevant tables specified in item 301, "Asphaltic Materials" for hot mix asphaltic concrete or can be viscous cut back that requires heating in areas where moisture content of sand is high, necessitating heating and drying of sand.

In dry areas, where natural moisture content of sand is low, the bituminous binder shall be fluid cut back conforming the requirements as given in tables 301-3 and 301-4 respectively of item 301 "Asphaltic Materials".

Bitumen emulsion or foamed penetration grade bitumen can also be used subject to the approval of Engineer after trial test.

Bitumen-sand mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshall Test to determine the quantity of bitumen required using either heated or unheated sand. The quantity of bitumen required will generally lie between three (3) to six (6) percent by weight of dry sand, the higher proportions being required with fine-grained materials.

113.3 CONSTRUCTION REQUIREMENTS

Equipment, tools, and machines used for bitumen stabilized subgrade shall be subject to the approval of Engineer and shall be maintained in satisfactory working conditions all the times.

Mix in place method of bitumen stabilization will be subject to the approval of Engineer to ensure full control of bitumen content, uniform and thorough mixing and satisfactory processing of the material to the full depth of the layer. For scarification of in situ material and spreading of bituminous material, grader with blade and bitumen distributor shall be used

The stabilized soil shall be left uncompacted after pulverization and mixing to allow for evaporation of volatile materials thus increasing stability and decreasing water absorption particularly in fine grained sand when temperature is low.

113.3.1 Compaction

Immediately after completion of spreading, aeration and shaping operation, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until entire width and depth of subgrade is uniformly compacted to give soaked (96 hours) unconfined compressive strength according to design requirement to meet

traffic loading. Steel wheeled tandem roller shall be used to carry out final rolling of compacted surface to eliminate the tyre marks.

To determine the efficiency of mixing, spreading, degree of compaction of equipment and suitability of construction method, trial sections as directed by the Engineer, shall be prepared by the contractor before main work of stabilization is started.

If thickness of compacted layer is less than 20 centimeters, it shall be laid as single operation where as if thickness of compacted stabilized layer is more than twenty centimeter, material shall be placed in two or more layers, each within the range of eight (8) to twenty (20) centimeters in compacted thickness.

The results of CBR test for measuring the strength of bitumen stabilized materials or cone stability test for designing bitumen-sand mixture shall not supersede those of Marshall Test unless agreed by the Engineer. In-situ density of compacted layer shall be determined using method as described by AASHTO T-191 or AASHTO T-238 and shall be minimum ninety seven (97) % maximum dry density obtained in laboratory according to the above mentioned methods.

Frequency of testing in field and in laboratory will be according to relevant schedule for sampling and testing of these specifications.

113.3.2 Tolerance

Compacted layer shall comply with the tolerance requirements as specified in relevant, 'Table for Allowable Tolerances" in these specification.

113.3.3 Weather Limitation

The laying of bituminous courses shall be avoided as for as practicable during wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid on any surface, which is frozen or covered with ice or snow and laying shall cease when the air temperature reaches five (5) degree C on a falling thermometer. Laying shall not commence until the air temperature is at least five (5) degree C on a rising thermometer unless otherwise directed by the Engineer and also if wet weather threatens to be prolonged the manufacture and laying of stabilized mix shall be suspended.

ITEM 114 DRESSING AND COMPACTION OF BERMS

114.1 DESCRIPTION

This work shall consist of scarification of berms, which are undulated, or out of level. The existing material shall be scarified, watered, mixed and properly leveled and compacted according to specification described here under or as directed by the Engineer.

114.2 MATERIAL REQUIREMENTS

In this item no fresh material is required, however, if fresh material is used it shall be measured and paid under other relative items of works.

114.3 CONSTRUCTION REQUIREMENTS

114.3.1 Dressing of Berm without the Use of Extra Material

The berms shall be scarified to a depth of 15 cm and material will be watered, mixed and compact with appropriate equipment approved by the Engineer in case the berms show undulation of more than 5 cms in level from the reconstructed pavement structure.

114.3.2 Dressing of Berm with the Use of Extra Material

In case the difference of elevation of existing berm with respect to reconstructed road structure is less than 15 cm than additional material (to be measured under other items of work) shall be added to bring the level of berms in conformity with the lines and grades of the existing road. Existing and fresh material shall be properly mixed, watered and compacted as directed by the Engineer.

114.3.3 Compaction Requirement

Compaction requirement of the fresh and existing material shall be in accordance with the type of material used in berms, as under:

Depth in cm	Compaction Requirement as per AASHTO T-180 (D)
0 - 15 (Top layer)	95% for Common Earth Material
0 - 15 (Top layer)	100% for Subbase Material

114.3.4 Compaction of slopes

While reinstating/dressing of berms, it shall be ensured that compaction requirements are observed on slopes of the berms. The degree of compaction shall be as per direction of the Engineer.

ITEM 115 REINSTATEMENT OF SHOULDERS FROM BRICK KILN MATERIAL

115.1 DESCRIPTION

This work shall consist of furnishing and placing in single layer of Brick Kiln material on shoulders and to mechanically interlock by watering and rolling, in conformity with lines, grades and cross-sections shown on drawing.

115.2 MATERIAL REQUIREMENTS

The material shall conform to the following requirements:

115.2.1 Texture

The Kiln material shall be fully burnt having reddish brown/black colour. No unburnt or semi burnt material shall be allowed. The material shall behave like improved sub grade with following properties.

115.2.2 Gradation

The grading shall conform to the following limits.

Sieve Designation	Mass Percent Passing
1" (25 mm)	100
3/8" (9.5 mm)	80 - 100
No. 10	50 - 85
No. 200	15 - 35

Note: Material coarser than 1" (25 mm) may be allowed upto five (5) percent by the Engineer.

115.2.3 Physical Requirements

The additional physical requirements of the kiln material will satisfy the following limits:

a)	P.I. value	6.00% max.
b)	Swell value	0.20% max.
c)	Soaked C.B.R. (96 hours)	20.00% min.

115.3 CONSTRUCTION REQUIREMENTS

115.3.1 General

Material for shoulders, obtained and approved as provided above shall be placed and thoroughly mixed with water in horizontal layer of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings. The layer of loose material shall not be more than twenty (20) centimeters in thickness unless otherwise approved by the Engineer.

The compaction of the shoulders shall be carried out at the designated moisture content, consistent with the approved compacting equipment. Shoulder material that does not contain sufficient moisture to obtain the required compaction shall be given additional

moisture by means of approved sprinklers and mixing operation. Material containing moisture more than necessary to obtain the required compaction may not, without written approval of the Engineer be incorporated in the shoulders until it has been sufficiently dried out. The drying of wet material may be expedited by discing or other approved methods.

Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be kept in a neat and acceptable condition.

115.3.2 Compaction

All material shall be compacted to a minimum ninety five (95) percent of the maximum dry density as determined according to AASHTO T-180 method 'B' or 'D' whichever is applicable. In place density determination of the compacted layer shall be made in accordance with AASHTO T-191 or other approved method.

ITEM 116 REMOVAL OF BRICKS FROM EXISTING SHOULDERS

116.1 DESCRIPTION

This work shall consist of removal of bricks from existing shoulders in certain reaches of the road, their handling, stacking and disposal to the designated places as decided by the Employer. These bricks shall become property of the Employer. The work shall be completed in all respects as per lines and dimensions shown on the Drawings and as per directions of the Engineer.

ITEM 117 FILLING OF EARTH FOR LANDSCAPING

117.1 DESCRIPTION

The work shall consist of providing & filling earth for landscaping at the locations shown on the drawings and/or directed by the Engineer.

117.2 MATERIAL REQUIREMENTS

The filling for landscaping shall predominantly comprise two layers of soil suitable for healthy growth of grasses, shrubs, trees or other vegetation. The top layer of river silt (*BHALL*) shall be 0.3 meter (1.0 foot) thick while the underlying layer of loamy soil (*KASSOO*) shall be 1.2 meters (4.0 feet) or 2.7 meters (9.0 feet) thick. Loamy soil should contain minimum 20% clay and maximum 55% sand.

Thickness of kassoo should be at least 1.2 meters (4.0 feet) for areas where shrubs/grass plantation is expected/planned and at least 2.7 meters (9.0 feet) for areas where tree plantation is expected/planned. Thickness of kassoo for each landscaping area shall be decided by the Engineer in accordance with Plantation plans.

This material (kassoo and bhall) should not have any salinity, gravels, plastic objects/bags or roots.

Any additional filling required to be done below the above-cited minimum requirements of suitable soil shall be made using “unsuitable or surplus material from roadway or structural excavation” as directed by the Engineer. The material for this additional fill may have gravels but should not have any salinity, plastic objects/bags or roots.

The Engineer shall also look into the possibility of using “unsuitable or surplus material from roadway or structural excavation” available on any other package of the same Project and instruct its use, if feasible.

117.3 CONSTRUCTION REQUIREMENTS

The Contactor shall notify the area to the Engineer at least 7 days prior to his intentions of working in that area and submit his methodology for placement of suitable soil as well as “unsuitable or surplus material from roadway or structural excavation” to achieve finished ground profiles given in Landscaping plans. The operation shall start only after approval of this methodology by the Engineer.

Placement of “unsuitable or surplus material from roadway or structural excavation”, wherever required and approved by the Engineer, under the suitable soil shall be done in such a way that it does not form hard or impervious strata.

Spreading shall not be done when the ground topsoil is excessively wet or otherwise in a condition detrimental to the work. The material shall be evenly spread in layers not exceeding 0.45 meter (1.5 feet). Each layer shall be watered after large clods, stones, roots, stumps and other such unwanted material, if any, has been raked and removed.

Contours as per Landscaping plans shall be achieved before placement of suitable material is started.

Top layer of suitable material (bhall) shall be finished to required profiles and adequately compacted to avert erosion.

The area being landscaped shall be kept well-drained and the roadway surfaces shall be kept clean during hauling and spreading operations.

ITEM 118 ROAD WORKS IN AREAS OF OVERLAY AND WIDENING

During execution of the Works it may be required to adjust level of the existing roads or to widen the existing roads in small or variable widths.

All such areas where these treatments are to be carried out are subject to the submission of Contractor's detailed survey and the proposed cross-section prior to commencement of work for confirmation and approval by the Engineer. Despite the piece-meal nature of the above work it shall be measured under the standard pay items provided in Bills No. 1, 2 & 3.

ITEM 119 EXISTING STRUCTURES TO BE REMOVED

Where structures are within the limits of the cross-section, their removal, where required, shall be measured and paid under Pay Item No. 106 “Excavate Unsuitable or Surplus Common Material”, except where specific items are included in the Bill of Quantities.

SUBBASE AND BASE

ITEM 200 GENERAL

200.1 DESCRIPTION

The work shall consist of furnishing, spreading, and compacting graded crushed aggregate subbase course, crushed aggregate base course, crushed water bound macadam base course, open graded granular subbase shoulders/lay-bys material, crushed limestone base course, cement stabilized subbase and base course, lime stabilized subbase and bitumen stabilized subbase and base, crack relief layers, constructed on a prepared bed and all incidentals in accordance with Particular Specification in conformity with the lines, grade thickness and typical cross-section shown on the Drawings and/or as directed by the Engineer.

200.2 MATERIAL

The material shall consist of sand, gravel or a sand gravel mixture obtained from the source approved by the Engineer. Material requirements for this work are specified under various items of the section.

200.2.1 Sampling and Testing

Adequate representative samples shall be submitted to Engineer for testing and preliminary approval not less than twenty days, before the intended material is to be used in the work. The material, when deemed necessary by the Engineer, shall be sampled and tested in his presence by the contractor for particular subbase, base course as called for in the specification of particular application and /or the bill of quantities, and/or as shown on the drawing, to assure conformance with the requirements of specification. Any material found not to conform to the requirements will be subject to rejection. All rejected material shall be removed and replaced with the material meeting the Specifications, at no additional cost to the Employer.

Preliminary approval of source shall not mean that all the material in the source is approved.

Sampling and testing, unless otherwise stated, shall be according to the standard methods prescribed in the latest edition of the American Association of State Highway and Transportation Officials (AASHTO) or standard specification and methods of sampling and testing, provided in latest version of American Society of Testing and Materials (ASTM) or, for particular materials or procedures, the British Standards. Any deviation from the methods and procedure prescribed therein may be made only as directed in writing by the Engineer as per relevant "Table for Sampling and Testing Frequency".

200.2.2 Selection of Place for Sampling

The selection of representative samples for testing shall be by "Random Sampling Method ASTM D-3665" by which every part of a lot or stockpile has equal chance to be selected. When it is necessary to sample stockpiles, every effort should be made to enlist the service of power equipment that is capable of exposing the material at various levels and locations. In sampling sand from stockpiles, the outer layer which may have become dry, causing segregation shall be removed and representative samples of the damp sand selected.

200.2.3 Number and Size of Samples

The number and size of sample required depends on the intended use of the material, the

quantity of material involved and the variation both in quality and size of aggregate. A sufficient number of samples shall be obtained to cover all variations in the material. The quantities must be sufficient to provide for proper execution of the required tests.

200.2.4 Schedule for Sampling and Testing

The sampling frequency, acceptance limits, and other information for proper control of each work shall be as given in "Tables for Sampling and Testing Frequency" which will provide the minimum testing frequency under normal conditions. Where sampling frequencies are not given in the table they shall be as directed by the Engineer. Where frequencies are given as per layer or per strip this will mean the width of strip or layer being laid at any time. If the materials or operations are variable and good control is difficult to maintain, greater sampling frequency may be taken as directed by the Engineer.

200.2.5 Maintenance and Protection

Following construction of the different layers, the compacted layer shall be maintained by the Contractor at his expense. The Contractor shall blade, broom, and otherwise maintain the layer, keeping it free from raveling and other defects that result in loss in density until such time as the next element of the pavement structure is placed. Water shall be applied at such times and in such quantities as directed by the Engineer and the Engineer shall have full authority to require the suspension of all other work on the project to ensure proper maintenance of previously compacted material.

The Engineer shall determine when the surface of the subbase is in the proper condition to permit the placement of base course. The Contractor must continue to maintain the surface of the base course, including the application of necessary water, at his expense until such time as the bituminous prime or the subsequent layer is applied. Any additional expense incurred by the Contractor because of delay in placing subsequent layers or applying the bituminous prime coat when so permitted by the Engineer will not be considered as the basis for a claim for additional cost.

200.2.6 Tolerances

The allowable tolerances for the subgrade prior to placing the overlying layers, together with the allowable tolerances for the subbase and base are as specified in "Table for Allowable Tolerances", in these specifications.

200.3 PLANT & EQUIPMENT

All equipment, tools and machines used in the performance of work shall be maintained in satisfactory conditions at all times and be subject to the approval of the Engineer. List of recommended type of equipment is only for guidance of Contractor. However Contractor will be responsible to give required quality and workmanship through any type of equipment irrespective of any approval given by the Engineer.

The Contractor shall furnish all necessary equipment for production, (not necessarily crusher plants, if aggregates are commercially according to the specifications) stockpiling and hauling aggregate, preparing the subgrade and placing, compacting, finishing and maintaining the aggregate subbase according to the minimum type and number outlined in the contractor’s detailed Program of Work as approved by the Engineer.

Blending and mixing aggregates and adjusting the moisture content as required for compaction shall be performed in a central mixing plant or by other approved means that ensure uniformity. The Contractor will not be allowed to water and mix over the prepared and accepted subgrade and subsequent layers.

200.4 TRIAL STRIPS

Contractor shall prepare trial strip for any item as appearing in this chapter, to establish the following:

a) Maximum thickness of loose layer, which can be laid, and compacted to required density, subject to the maximum specified in relevant subsection pertaining to that item.
b) Type of equipment to be used
c) Watering and mixing procedures
d) Number of passes required to satisfactorily compact the layer to required degree/density
e) Any other requirement ordered by the Engineer

Engineer shall then inspect and test the Trial Strip and approve the procedure in writing, to carry out the work. However this approval shall not relieve the contractor from his contractual obligation.

200.5 QUALITY ASSURANCE PROCEDURES

The crushed aggregate subbase/base/WBM, open graded granular subbase shoulder/lay-bys and asphalt concrete base course shall be accepted by lot as specified in “Table for Sampling and Testing Frequency” in these Specifications. The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer).

All crushed aggregate subbase/base/WBM, open graded granular subbase shoulder/lay-bys material and asphalt concrete base course shall be placed, trimmed and finished in a neat and workmanlike manner in accordance with the lines, grades and typical cross sections shown on the plans or staked by the Engineer.

Crushed aggregate subbase/base/WBM, open graded granular subbase shoulder/lay-bys and asphalt concrete base course shall be sampled and tested in accordance with “Table for Sampling and Testing Frequency” in these Specifications.

The completed asphalt concrete base/leveling course shall be compacted as specified, smooth, free from ruts, humps or depressions, or irregularities. Any ridges, indentations, roller checking, or other objectionable marks left in the surface, as determined by the Engineer, shall be eliminated by whatever means are necessary and approved by the Engineer. The use of any equipment that leaves ridges, indentations or other objectionable marks shall be discontinued.

ITEM 201 CRUSHED AGGREGATE SUBBASE

201.1 DESCRIPTION

This item shall consist of furnishing, spreading in one or more layers and compacting crushed aggregate subbase according to the Specifications and drawings and/or as directed by the Engineer. It shall also consist of reuse of Broken Pavement Material from existing road as Subbase in service roads.

201.2 MATERIAL REQUIREMENTS

Crushed aggregate subbase material shall consist of crushed rock/stone and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm and stable subbase.

The material shall comply with the following grading and quality requirements:

a) The Subbase material shall conform to gradation requirement as specified in ASTM D-2940 and given below:

Grading Requirements for Crushed Aggregate Subbase Material		
Sieve Designation		**Mass Percent Passing**
mm	**Inch**	
50.0	2	100
37.5	$1^1/_2$	90-100
25.0	1	78-92
9.5	3/8	50-73
4.75	No. 4	30-60
2.00	No. 10	24-50
0.425	No. 40	13-32
0.075	No. 200	0-12

The final gradation decided within the limit designated in the table shall be all graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves or vice versa.

This material shall be obtained by mechanically crushing the material retained on 3″ size sieve.

Gradation requirements shall not apply on Broken Pavement Material from existing road being reused as Subbase on service roads.

b) The Material shall have a CBR value of at least 50%, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.

c) The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

d) In order to avoid intrusion of silty and clayey material from the subgrade in the subbase, the ratio D15 (Subbase)/D85 (Subgrade) should be less than 5.

   Where D85 and D15 are the particle diameters corresponding to eighty five (85) % and fifteen (15) %, respectively, passing (by weight) in a grain size analysis, curve.

e) The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two third of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 4 or less.

f) Sand Equivalent shall be 30 minimum as per AASHTO T 176.

g) Crushed Aggregate (material retained on sieve No. 8) shall consist of material of which ninety five (95) percent by weight shall be crushed particles having a minimum one fractured face and at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

h) Friable particles tested according to AASHTO T-112 shall not exceed 0.25 %.

i) Flat and elongated aggregate particles shall not exceed 15 % of total volume of Crushed Aggregate Subbase.

201.3 CONSTRUCTION REQUIREMENTS

201.3.1 Material Processing/Spreading

Blending and mixing of aggregates and adjusting the moisture content as required for compaction shall be performed in a central plant that ensure uniformity. Crushed aggregate subbase shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

Crushed aggregate subbase shall be deposited on the roadbed or shoulders in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the subbase material. In case any material is to be added to compensate for levels, the same shall be done after scarifying the existing material, to ensure proper bonding of additional material.

When the required thickness is fifteen (15) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than seven and one half (7.5) centimeters thick. Where the required thickness is more than 15 cm, the aggregates shall be spread and compacted in 2 or more layers of approximately equal thickness, but in any case the maximum compacted thickness of one layer shall not exceed 15 cm. All subsequent layers shall be spread and compacted in a similar manner.

Crushed aggregate subbase shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in "Table for Allowable Tolerances" in these Specifications. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of subgrade or contamination of subbase material.

The material shall be handled so as to avoid segregation. If the approved spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment to the spreading operation, the use of such approved spreader shall be discontinued, and it shall be replaced. All segregated material shall be removed and replaced with well-graded material. No "skin" patching shall be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances shall be permitted during the

compaction process.

Before placing the mixture, the subgrade or previous layer shall be wetted to ensure bond between the layers. The mixture shall be placed and shaped by power equipment to the lines, elevations, cross sections, thickness and density specified in the specifications.

201.3.2 Compaction Trials

Prior to commencement of crushed aggregate subbase operation, Contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the approved subbase material as will be used during construction to determine the adequacy of the Contractor's equipment, loose depth measurement necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.

201.3.3 Compaction

The subbase material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on superelevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. .While the rolling progresses, the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density.

Any area inaccessible to rolling equipment shall be compacted by means of hand guided rollers, plate compactors or mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of subbase material or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and re-compact the material before succeeding layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of base course the subbase layer (both under the traveled way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layers of the material, the top surface of each layer shall be made sufficiently moist to ensure bond between the layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the plans.

No material for construction of the base shall be placed until the subbase has been approved by the Engineer.

201.3.4 Compaction requirements

The relative compaction of each layer of the compacted subbase shall not be less than Ninety-eight percent (98 %) of the maximum dry density determined according to AASHTO T-180 Method-D after adjustment of coarse particles obtained during field density test (retained on 19 mm sieve or 4.75 mm sieve whichever is applicable) as per AASHTO Method T-224. The field density shall be determined according to AASHTO T-191 or other approved method.

201.3.5 Moisture Content Determination

Same size of sample should be placed in oven for moisture determination in case of laboratory density (Proctor) and field density to ensure proper compaction results.

201.3.6 Surface Tolerance

The surface layer of the aggregate subbase shall be evaluated for compliance with the following surface tolerances:

a) The cross section of the finished crushed aggregate subbase surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer.

b) The allowable tolerances in design elevation of the finished crushed aggregate subbase are stated in “Table for Allowable Tolerances” in these Specifications.

201.3.7 Protection of Completed Work

Any part of the subbase that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being allowed to ply on the subbase. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the area of subbase preparation to an area easily maintained with the equipment available. Subbase preparation and placing of aggregate base course shall be arranged to follow each other closely. The subbase, when prepared too soon in relation to the placing of the aggregate base course, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the subbase as may be necessary to restore it to the state specified herein. It will be at discretion of the Engineer to check some or all such reaches for compaction and moisture content before placing the next layer.

ITEM 202 AGGREGATE BASE COURSE

202.1 DESCRIPTION

This item shall consist of furnishing, spreading and compacting one (1) or more layers of aggregate base on a prepared subgrade, subbase, or existing road surface, in accordance with the Specifications and the drawings and/or as directed by the Engineer.

2.2.2 MATERIAL REQUIREMENTS

Material for aggregate base course shall consist of crushed hard durable gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm and stable base for both flexible and rigid pavements.

The aggregate base shall comply with the following grading and quality requirements:

a) The gradation curve of the material shall be smooth, well graded and within the specified allowable tolerances and the envelope.

The grading table as per ASTM D 2940 given below:

Grading Requirements for Crushed Aggregate Base Material		
Sieve Designation		**Mass Percent Passing Grading**
mm	**Inch**	
50.0	(2)	100
37.5	(1.5)	95-100
19.0	(3/4)	70-92
9.5	(3/8)	50-70
4.75	No. 4	35-55
0.600	No. 30	12-25
0.075	No. 200	0-8

The final gradation decided within the limit designated in the table shall be all graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves or vice versa.

This material shall be obtained by mechanically crushing the material retained on 3″ size sieve.

The material shall be well graded so that the coefficient of Uniformity D60/D10 shall be greater than four (4).

b) The material passing the 19 mm sieve shall have a CBR value of minimum ninety (90) percent, tested according to the AASHTO T-193 / ASTM D-1883. The CBR value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

The Coarse aggregate shall have a percentage of wear by the Loss Angeles Abrasion test (AASHTO T-96) of not more than forty percent (40%).

c) The fraction passing the No. 200 sieve shall not be greater than two third of the fraction passing the 0.425 mm (No 40) sieve.

d) The portion of filler, including any blended material, passing No. 40 mesh sieve shall have a liquid limit not more than 25 and a plasticity index not more than 4 as per AASHTO T 89 & T 90

e) The sand equivalent determined according to AASHTO T-176 shall not be less than 45.

f) Crushed Aggregate (material retained on sieve No. 8) shall consist of material of which hundred (100) percent by weight shall be crushed particles having a minimum one fractured face and at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

g) The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T-104.

h) Flat, elongated, soft and disintegrated pieces shall not exceed 12 % of total volume of Crushed Aggregate Base Course.

i) Friable particles tested according to AASHTO T-112 shall not exceed 0.25 %.

202.2.1 Filler for Blending

If filler, in addition to that naturally present in the crushed aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the crushing plant or in a pugmill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer. The material shall be free from organic matter, dirt, shale, clay and clay lump or other deleterious matter and shall conform to following requirement:

AASHTO Sieve	**Percent Passing**
3/8 Inch	100
4	85 – 100
100	10 – 30
Plasticity Index (AASHTO T-90)	4 maximum
Sand Equivalent (AASHTO T-176)	45 minimum

However the combined aggregates prepared by mixing the coarse material and filler shall satisfy the requirements as mentioned in clause 202.2 above.

202.3 CONSTRUCTION REQUIREMENTS

202.3.1 Mixing of Aggregate Material

Mixing of different sizes of aggregate and stone dust shall be mixed in the central mixing plant/pugmill at proper moisture content. Mixing at site/prepared subbase shall not be allowed in any case.

It shall be mandatory for the Contractor to lay aggregate base course in specified thickness, line and grade on approved surface using mechanical paver. Dumping the aggregate base material on prepared subbase and spreading with motor grader will not be allowed. The paver shall be power propelled unit, provided with automatically controlled screeds and feed controls capable of spreading the aggregates and

maintaining specified thickness and grade. The paver shall be equipped with receiving hoppers having sufficient capacity for a uniform paving operation. The paver shall be operated at a speed to give best results. The mechanical paver has to be approved by the Engineer's Representative prior to start of paving activity.

202.3.2 Preparation of Surface for Crushed Aggregate Base Course

In case crushed aggregate base is to be laid over prepared subbase course, the subbase course shall not have loose material or moisture in excess to optimum moisture content.

202.3.3 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in Item 201 (201.3.3).

202.3.4 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than 100 percent of the maximum dry density determined according to AASHTO T-180, Method D after adjustment of coarse particles obtained during field density test (retained on 19 mm sieve or 4.75 mm sieve whichever is applicable) as per AASHTO Method T-224.The field density shall be determined according to AASHTO T-191 or other approved method.

Completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When base course is to carry traffic for an indefinite length of time before receiving surfacing, the Contractor shall maintain the surface until final acceptance and shall prevent reveling by wetting, blading, rolling and addition of fines as may be required to keep the base tightly bound and leave a slight excess of material over the entire surface which must be removed and the surface finish restored before application of prime coat.

202.3.5 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under clause 201.3.5 for subbase.

202.3.6 Trial Sections

Prior to commencement of crushed aggregate base course operations, a trial section of two hundred (200) meters minimum, but not to exceed five hundred (500) meters shall be prepared by the Contractor using same material and equipment as will be used at site to determine the adequacy of equipment, loose depth measurement necessary to result in the specified compacted layer depths, field moisture content, and relationship between the number of compaction passes and the resulting density of material.

202.3.7 Surface Tolerance

Grade control shall be accomplished by means of grade stakes, steel pins or forms, placed in lanes parallel to the centerline of the road and at intervals sufficiently close to permit placing of string lines or straightedges for checking purposes.

The surface layer of the crushed aggregate base course shall be evaluated for compliance with the following surface tolerances:

a) The cross section of the finished aggregate base surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer.

b) The allowable tolerances in design elevation of the finished base are stated in "Table for Allowable Tolerances" in these Specifications.

Isolated deviations below the design elevation shall be compensated by additional thickness of the subsequent pavement layer. Additional cost and materials resulting from deviations from the design elevation shall be borne by the Contractor.

202.3.8 Acceptance, Sampling and Testing

Acceptance of sampling and testing with respect to materials and construction requirements shall be governed by the relevant, "Table for Sampling and Testing Frequency" or as approved by the Engineer.

202.3.9 Protection of Completed Work

Any part of the aggregate base course that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being allowed to ply on the aggregate base course. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the area of aggregate base course preparation to an area easily maintained with the equipment available. Aggregate base course preparation and placing of asphalt base course shall be arranged to follow each other closely. The aggregate base course, when prepared too soon in relation to the placing of the asphalt base course, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the aggregate base course as may be necessary to restore it to the state specified herein. It will be at discretion of the Engineer to check some or all such reaches for compaction and moisture content before placing the next layer.

ITEM 203 ASPHALT BASE COURSE (HOT PLANT MIX)

203.1 DESCRIPTION

This work shall consist of furnishing plant, labour, equipment, materials, mixing aggregates and asphalt binder and additive material (where required) at a central batch asphalt mixing plant, to a specified temperature, hauling, including loading unloading, laying and compacting the mixture on an approved primed subgrade, subbase or base course in accordance with these Specifications and in conformity with the lines grades and typical cross-sections shown in the Drawings or as directed by the Engineer.

203.2 MATERIAL REQUIREMENTS

203.2.1 Mineral Aggregate

Mineral aggregate for bituminous base course shall consist of coarse aggregate, fine aggregate and filler material, if required, all conforming to the following requirements:

Coarse aggregate which is the material retained on AASHTO No. 4 sieve shall consist of crushed rock, crushed gravel or crushed boulder. It shall be clean, hard, tough, sound, durable, and free from decomposed stones, organic matter, shale, clay lump or other deleterious substances. Rock or boulders, from which coarse aggregate is obtained, shall be of uniform quality throughout the quarry.

The crushing shall be so regulated that (material retained on sieve # 4) shall have all faces crushed without any uncrushed surface. The type of source shall be uniform throughout the quarry location from where such a material is obtained. Rock to be crushed for use as bituminous concrete aggregate, shall be screened in such a manner that all material to be crushed is retained on a 75 mm (3″) screen.

Fine aggregate which is material passing No. 4 sieve, shall consist of 100% crushed limestone material from rock or boulder and shall be stored respectively. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, including dust from plant collection system, hydrated lime, hydrated cement or other suitable mineral matters free of deleterious material conforming to the requirements of AASHTO M-17. However, in case the coarse aggregates are of quartizitic nature, then hydrated lime or a better material shall be allowed. At the time of use, it shall be sufficiently dry to flow freely. Filler material shall conform to following gradation:

US Standard Sieve	Percent Passing by Weight
No. 30	100
No. 50	95 – 100
No. 200	70 – 100

The ratio of filler to binder should range from 1.0-1.5.

The coarse and fine aggregates shall meet the following requirements:

a) The coarse aggregate shall have a percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) not more than forty (40).

b) The coarse and fine aggregates shall have a Specific Gravity Value of not less than 2.60 and value for absorption of water not more than 2% as determined by AASHTO T 84 and T 85.

c) The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to (AASHTO T-104).

d) The Sand Equivalent (AASHTO T 176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45).

e) The fine fraction of the material shall have a liquid limit not more than twenty five (25) and a Plasticity Index (as determined by AASHTO T-89 and T-90) not more than four (4). The plasticity index of mineral filler should not be more than four (4).

f) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than ten (10) percent by weight of flat and/or elongated particles as determined in accordance with ASTM D 4791, standard test method for flat and/or elongated pieces.

g) The coarse aggregate when tested by the Coating and Stripping Test (AASHTO T-182) shall have a coated area above ninety five (95) percent.

h) Petrographic examination of the coarse aggregate is mandatory for the approval of source. The coarse aggregates shall be checked for cationic and anionic behavior so that their affinity with the bitumen to be used is verified.

203.2.2 Asphaltic Material

Asphalt binder for asphalt base course shall be asphalt cement 60-70 penetration grade, conforming to the requirement in Table 301-2 of Item Asphaltic Materials in these Specifications.

When asphalt cement 60-70 penetration grade is used, the optimum ratio between bituminous material and filler shall be so determined that the bituminous filler mixture will reach its softening point, not less than eighty five (85) degree centigrade when tested in accordance with AASHTO T 53

203.2.3 Asphalt Base/Leveling Course Mixture

The composition of the asphalt base/leveling course mixtures for base course shall conform to classes shown in the following table:

Table 203-1

Combined Aggregate Grading Requirements

Mix Designation	**Class-A**	**Class-B**
Use	Leveling/Base	Leveling/Base
Compacted Thickness	75-100 mm	60-80 mm
U.S. Standard Sieve Size	***Percent passing by weight***	
1½" (38 mm)	100	100
1" (25 mm)	75-90	90-100
3/4" (19 mm)	65-80	-
1/2" (12.5 mm)	55-70	56-80
3/8" (9.5 mm)	45-60	-
No. 4 (4.75 mm)	30-45	29-59
No. 8 (2.38 mm)	15-35	19-45
No. 50 (0.300 mm)	5-15	5-17
No. 200 (0.075 mm)	2-7	1-7
Asphalt Content by weight of mix (%)	3 (Minimum)	

The grading limits specified are based on materials of uniform specific gravity and shall be adjusted by the Engineer to compensate any variation in specific gravity of individual sizes. The grading may be varied by the Engineer on the basis of Marshall Tests to obtain optimum stability and life of completed asphalt pavement. Limits determined by Fuller Equation (MS – 2) should be avoided.

The asphalt leveling/base course mixture shall meet the following Marshall Test Criteria:

Compaction, number of blows to each end of specimen	75
Stability (30 minutes/60 °C)	1,000 kg (Min.)
Flow, 0.25 mm (0.01 in.)	8-14 (2 – 3.5)
Percent air voids in mix	4-6
Percent voids in mineral aggregates	According to table 5.3 MS-2, Asphalt Institute sixth edition or the latest edition
Percent voids filled with asphalt	50-65
Loss of Marshall Stability	25 percent (max.)

203.2.4 Job-Mix Formula

At least eight (8) weeks prior to commencement of asphalt, the Contractor shall start the tests for the design of JMF for the asphalt base course production for the Project. At least one week prior to production, a JMF for the asphalt mix to be used shall be established jointly by the Contractor and the Engineer meeting Project Specification requirements.

The JMF shall be established by Modified Marshall Method of Mix Design for Large Aggregate according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), Sixth Edition, taking into account following recommendations.

The JMF, with the allowable tolerances shall be within the range specified in Item 203.2.3 and herein. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

Marshall mixing temperature shall be one hundred and sixty plus/minus five (160 ± 5) degree centigrade at which heated asphalt produces a kinematic viscosity one hundred and seventy ± twenty (170 ± 20) centistokes.

Marshall compacting temperature shall be one hundred and forty five plus/minus five (145 ± 5) degree centigrade at which heated asphalt produces a kinematic viscosity of two hundred and eighty plus/minus thirty (280 ± 30) centistokes.

The combined gradation should produce a smooth curve approximately parallel grading band limits for designated mix. The job-mix formula with allowable tolerances for a single test then becomes the job control grading band. If application of job-mix tolerances results in a job control grading band is outside the master grading band, the full tolerances shall still apply. The asphalt content thus determined shall be used to check for compliance for stability, flow and voids filled, etc. as per the specifications. Minimum coating of bitumen film on aggregate should be 8 micron.

Prior to final approval, the proposed job mix, with a Asphalt content at the permissible upper percentage limit determined in JMF, shall be compacted to refusal density (blows not exceeding 900 taking care against excessive breakage of aggregates) such that the resulting air voids in the mix shall not be less than 3%.

Once JMF is established, all mixtures furnished for the project represented by samples

taken from the asphalt plant during operation, shall conform thereto Moreover upon receiving the job-mix, approved by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that when compared to job mix formula shall be within the following limits.

Maximum Variation of Percentage of Materials

Retained No. 4 and larger	± 7.0 %
Passing No. 4 to No. 100 sieve	± 4.0 %
Passing No. 200	± 1.0 %
Asphalt Content (weight % of total mixture)	-0.2% to +0.2 %

In addition to meeting the requirements specified in the preceding items, the mixture as established by the JMF shall also satisfy the following physical properties:

a) Loss of Marshall Stability by immersion of specimen in water at sixty (60) degree centigrade for 24 hours as compared with stability measured after immersion in water at sixty (60) degrees centigrade for twenty (20) minutes shall not exceeds twenty five (25) percent. If the mixture fails to meet this criterion, the JMF shall be modified.

b) In case mix fails to meet the stripping test requirement then anti-stripping agent shall be used for which no separate payment shall be made.

c) Should a change of source of materials be made, a new JMF shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new Job Mix Formula will be required

d) The assistance of the Engineer in the preparation of the job standard mix in no way relieves the Contractor of the responsibility of producing an Asphalt mix meeting the requirements of the Specifications.

e) The density of the compacted mixes shall be related to the daily Marshall Density which shall be determined by making three standard Marshall Specimens from samples of the mix taken from behind the paver. The density of each sample shall be determined and compared with the mean value. Any individual result which varies from the mean by more than 0.015 gm/cc shall be rejected. Marshall Test shall be repeated on a daily basis to establish the daily Marshall Density for that particular day's work or one sample of 500T production. The daily Marshall Density shall not vary from the Job Mix Design Density by more than ± 1.0%. Loss of stability shall be tested on other three Marshall Specimens from samples of the mix taken from behind the paver.

f) The compliance criteria contained in the Job Mix Tolerances provide an indication of the maximum acceptable value of the standard deviation for each parameter. If asphalt mix shows variation in excess of these limits, the source of variation shall be determined by the contractor and rectified by him to the satisfaction of Project Specifications and Engineer. If the excessive variations continue, the Engineer shall order stoppage of production and laying for the Works, until the Contractor has demonstrated his ability to re-establish acceptable control.

203.2.5 Asphalt Additives

Hydrated lime or any other additive may be used as an anti-stripping agent as and when required. When used, hydrated lime shall be added at a rate between 1% and 2% by weight of the total mix with the aim of eliminating stripping tendencies. Hydrated lime shall be fed by a separated feeding system into pug mill for each batch. Percentage of additive and relative specifications for any other type of additives shall be based on manufacturer's specifications for the product, subject to approval of the Engineer.

No additional cost shall be paid for use of hydrated lime or any other anti-stripping additive, and payment shall be deemed to be included in the respective pay items of

asphaltic base course.

203.3 CONSTRUCTION REQUIREMENTS

203.3.1 Asphalt Mixing Plant

Mixing plants used for the preparation of Asphalt Mixtures shall be batch plants conforming to AASHTO M-156, and of adequate capacity, coordinated and operated to produce a mixture within the limits of specifications. Plant shall have minimum three cold bins and at least 3.5 decks of hot sieves to effectively control the gradation of hot bins. It should be provided with facilities necessary for protection of environment such as dust control facility. Special emphasis shall be given on the following:

- A large bucket to handle a batch in a single weighing.
- The mixer box shall be equipped with a dust hood to prevent loss of dust by dispersion.
- A mechanical batch counter shall be installed as part of the timing device and shall be designated to register only completely mixed batches.
- The plant shall be fully computerized batch-plant.
- The automatic proportioning system shall be capable of consistently delivering materials within the full range of batch sizes within the following tolerances:

Description	Total Batch Weight of Paving Mix %
Batch aggregate component	±1.5
Mineral filler	±0.5
Bituminous material	±0.1
Zero return (aggregate)	±0.5
Zero return (bituminous material)	±0.1

An automatic graphic or digital record shall be produced for each batch of bituminous concrete indicating the proportions of each aggregate component, mineral filler, and bituminous material. Such records of the batches shall be further identified through a print of day and date. Bituminous material proportions shall be recorded either as weight or volume.

The digital tape or ticket recorder shall record the proportions as indicated on the batching scale or meter within accuracy of 0.5 % of maximum batch size.

203.3.2 Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphalt base courses shall be separated into three or more sizes and stored separately in cold bins. One bin shall contain aggregate of such size that eighty (80) percent will pass sieve No. 4, and the other two bins shall contain aggregate of such sizes that eighty (80) percent will be retained on sieve No. 4. Should fine material, be incorporated in the mix, a separate bin shall be provided in addition to the three bins mentioned above. If filler is used as a separate component it will also be stored and measured separately and accurately before being fed into the mixer through filler screw mechanism.

Each aggregate ingredient shall be heated and dried at a temperature not to exceed one

hundred and seventy (170) degree centigrade. If aggregates contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of one hundred and seventy (170) degree centigrade they shall be removed from the bins and returned to their respective stock piles. Immediately after heating, the aggregates shall be screened to required sizes and stored in separate bins for batching and mixing with Asphalt material

In placing the materials in bins or in moving those from bins to the mixer, any method which causes segregation or uncontrolled combination of material of different grading shall be discontinued.

Asphalt cement shall be heated within a temperature range of hundred and thirty five to hundred and sixty three (135-163) degree centigrade at the time of mixing. Asphalt cement heated above maximum shown shall be considered overheated and shall be rejected and removed from job site.

Dried aggregate weighed and drawn to pugmill shall be combined with proportionate quantity of asphalt cement according to the job mix formula. Temperature of asphalt, except for temporary fluctuations, shall not be lower than fifteen (15) degree centigrade below the temperature of the aggregate, at the time; the two materials enter into the pugmill. In no case shall the temperature of an asphalt mix exceed one hundred and sixty five (165) degree centigrade when discharged from the pugmill.

203.3.3 Hauling Equipment

Dump truck used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with an approved material to prevent adhering of material to the beds Each truck shall have a cover of canvas or of other suitable material of sufficient size as to protect the mixture from the weather. The mixture will be delivered on the road at a temperature not less than hundred and forty five plus/minus five (145 ± 5) degree C. Drivers of dump trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

203.3.4 Bituminous Pavers

Bituminous pavers shall be self-contained, power-propelled units, provided with an automatically controlled activated screed or strike-off assembly, heated if necessary, capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing course of bituminous plant mix material in widths shown on the plans.

The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

The screed or strike-off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

When laying the mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The paver shall be operated at speeds which will give the best result for the type of power being used.

The mixed material shall be delivered to paver in time to permit completion of spreading, finishing and compaction of mixture during day light hours.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope. The sensor shall be so constructed that it will operate from a reference line or a ski-like arrangement.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.

Manual operation will only be permitted in the construction of irregularly shaped and minor areas.

Whenever a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the contractor to use the asphalt already produced at the plant or in transit, provided this method of operation will produce results otherwise meeting the specifications.

Reference lines will be required for both outer edges of the traveled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference lines or by means of a ski and a slope control device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to the established tolerance and, when in the opinion of the Engineer, further improvement to the line, grade, cross sections and smoothness can best be achieved without the use of the reference line; a ski-like arrangement may be substituted subject to the approval of the Engineer. The use of the reference lines shall be reinstated immediately whenever the Contractor fails to maintain a superior pavement. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory operation of the automatic control equipment.

203.3.5 Rollers

Rollers shall be steel wheel, pneumatic tyre and vibratory, or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Vibratory rollers shall be acceptable for bituminous mixture compaction. The use of equipment, which results in excessive crushing of the aggregate, will not be permitted.

203.3.6 Preparation of Base or Existing Pavement Surface

Before spreading materials, the surface of base or existing pavement on which the mix is to be placed shall be conditioned by application of a prime or tack coat as specified.

After a prime coat is applied, it shall be left undisturbed not less than twenty four (24) hours. The Contractor shall maintain the primed surface until the mix material has been placed. This maintenance shall include the spreading of sand or other approved material, if necessary to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, and patching any breaks in the primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the mix is placed, to the satisfaction of Engineer. It shall be ensured that primed surface is not in tacky condition, when premix is laid.

After a tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the mix. The tack coat shall be applied only as far in advance of the placing of mix, as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired.

When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by leveling course as directed. The leveling course mixture shall conform to the requirements of Item 203.2.

A thin coating of bituminous material shall be sprayed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous mixture being placed against them.

203.3.7 Spreading and Finishing

The mixture shall be laid upon an approved surface, spread and struck off to the section and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

Longitudinal joints for each course shall be offset thirty (30) centimeters from the joint in the immediate underlying course. Transverse joints shall be offset a minimum of sixty (60) centimeters from the joint of the immediate underlying course.

Longitudinal joints shall be located within fifteen (15) centimeters of the centerline of the roadway or within fifteen (15) centimeters of the centerline of a lane. Longitudinal joints shall be held to the minimum practical number. Longitudinal joints shall be formed by lapping the screed over the first layer placed, crowding a ridge of Asphalt material at the joint and crimping the ridge of material into the joint by a compaction roller while the material is hot.

Transverse joints shall be formed by cutting back the first layer placed to the full depth of the layer, removing and wasting the material, spreading new Asphalt material in sufficient quantity to create a compacted thickness equal to the thickness of the first layer. The joint shall be cross rolled with one coverage and the joint checked with a straight edge not less than four (4) meters in length. High points shall be removed and sags filled with additional Asphalt material and the joint rolled a second time. The joint shall again be checked with a straight edge, humps and sags adjusted as necessary, and rolled until the joint is complete and compacted as specified.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand-tools. For such areas the mixture shall be dumped, spread and screeded to give the required compacted thickness, ensuring even distribution of coarse and fine material.

When production of the mixture can be maintained and wherever practical, pavers shall be used in echelon to place the wearing course in adjacent lanes and compacted to form a surface without lateral joint.

All mixtures shall be spread at a temperature of not less than hundred and forty five plus/minus five (145 ± 5) degree C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degree C and 190 degree C. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

Asphalt concrete pavement asphalt base course shall not be placed on any wet or frozen surface, during rain, dust or sand storms, when wind or other weather conditions prevent the proper handling of the Asphalt mixtures or when atmospheric temperature is five (5) degree centigrade or less. Care should be taken during spreading operation under windy condition in winter, even if temperature is above five (5) degree centigrade.

The spreading operations should be immediately terminated if it begins to rain during the operation.

Hand laying of any Asphalt material will be permitted only in the following circumstances:

a) For laying regulating courses of irregular shape and varying thickness;

b) In confined spaces where it is impracticable for a paver to operate;

c) For footways;

d) At the approaches to expansion joints at bridges or viaducts;

203.3.8 Compaction

After spreading and strike off and as soon as the mix condition permits the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling shall not be prolonged when cracks appear on the surface.

Initial or breakdown rolling shall be done by means of either a tandem steel roller or three wheeled steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement.

The number and weight of rollers shall be sufficient to obtain the required compaction while the mixture is still in workable condition. The sequence of rolling and the selection of roller types shall provide the specified pavement density. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible.

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centerline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centerline. Intermediate rolling with a pneumatic tyred roller shall be done behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree C. for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety seven (97) percent of a laboratory compacted specimen made from asphalt material obtained for daily Marshall Density is achieved.

Relevant test methods for density of bituminous concrete in place by Nuclear Methods such as ASTM D 2950 (latest version) and or other method as directed by the Engineer shall be used to establish the proper rolling effort and pattern to achieve the required density and to ensure achieving the specified percent compaction during the placement of the bituminous concrete as quality control testing. A calibration factor for the Nuclear Method must be established as per the equipment's manufacture's requirements, and at any time a change is made in the paving mixture, in construction process or after every fifteen days of asphalt production whichever is earlier. Compare the results obtained to samples compacted to Marshall Density to determine percentage of compaction.

Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, wheels of rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, tempers be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with fresh hot mixture, which shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced.

Three steps of rolling are as follows:

a) Breakdown Rolling

Breakdown Rolling may be accomplished with static or vibratory steel-wheeled rollers. Compaction shall be carried out using rollers of approved dead weight smooth wheeled rollers or by multi-wheeled pneumatic tyred rollers of equivalent mass, or by vibratory rollers or a combination of these. Asphalt base/leveling course material shall always be surface finished with a smooth wheeled roller which may be a dead weight roller or alternatively a vibratory roller in non-vibrating mode. Vibratory rollers shall not be used in vibrating mode on bridge decks.

Vibratory rollers may only be used if they are capable of achieving at least the standard of compaction of 9-tonne dead weight roller to meet the specified percent compaction of Marshall Max. Density, and shall be equipped or provided with devices indicating the frequency at which the mechanism is operating and the speed of travel which can be read from the ground.

It is important to start the rolling operation on the low side of the mat (usually the outside of the lane being paved) and progress towards the high side. When adjoining lanes are placed, the same rolling procedure should be followed but only after compaction of the longitudinal joint.

b) Intermediate Rolling

Intermediate rolling with pneumatic tyre rollers and should follow breakdown rolling as closely as possible, while the asphalt mix is still well above the minimum temperature at which densification can be achieved.

Intermediate rolling should be continuous until all of the mix placed has been thoroughly compacted. Regardless of the type of rollers used, the rolling pattern should be developed in the same manner as for breakdown rolling.

c) Finish Rolling

Finish rolling is done solely for the improvement of the surface. It should be accomplished with steel-tired, static-weight tandems or vibratory tandems without vibration while the material is still warm enough for removal of roller marks.

The material shall be rolled in a longitudinal direction with the driven rolls nearest the paver. The roller should first compact the material adjacent to any joints and then work from the lower to the upper side of the layer overlapping on successive passes by at least half the width of the rear roll or in the case of a pneumatic tyre roller, at least the nominal width of one tyre.

Rollers shall not stand on freshly laid material while there is a risk that it will be deformed thereby.

203.3.9 Frequency of Testing for Cores

One core shall be taken for each 100 linear meter of each lane of Asphalt Base, or fraction thereof, in special cases. If the core so taken is failed against the specified 97% density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either side with respect to the failing core and shall be tested against field density. If all the three cores give an average of 97% compaction, and the individual compaction of the core is not less than ninety five (95) percent, then the compaction is acceptable. If average of the cores further fails against compaction, then retake the cores at a distance of fifteen (15) meters on either side and compaction shall be checked for all the five cores in the same fashion. If average of five cores is 97%, the area will be accepted. In case average is ninety six 96% or more, then Engineer may withhold the payment in full or partly and observe behaviour during

maintenance period, for the release of payment or otherwise. In case of failure of the average of these five cores giving average compaction of less than 96%, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner at the expense of contractor.

203.3.10 Surface Tolerances

Surface smoothness of asphalt base/leveling course shall be measured with four (4) M straightedge by Engineer at selected locations. The variation of surface from testing edge of straightedge between any two (2) contacts shall be determined by placing it parallel and perpendicular to center line of roadway and value thus determined should not vary more than limits prescribed by “Table for Allowable Tolerances” in these Specifications.

Any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new asphalt base course without additional cost to the Employer.

203.3.11 Base Thickness Tolerances

For determination of thickness, one (1) core for each hundred (100) linear meter of each lane shall be taken. Unless otherwise permitted, cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements.

When layer thickness of asphaltic base course is deficient by more than five (5) mm from that specified in the Drawings, the deficiency shall be removed with satisfactory base course material and/or made up by additional asphalt concrete wearing course thickness without extra cost to the Employer. If such remedial action is authorized, revised thickness determinations shall be made by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor, but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

203.3.12 Acceptance Sampling and Testing

Acceptance of samples and testing of materials and construction requirements, shall be governed by the relevant, "Table for Sampling and Testing Frequency" or as approved by the Engineer.

203.3.13 Trial Section

At least 3 days before material from each source of the asphalt concrete is first laid in the Works, the Contractor shall lay a trial area to demonstrate the compaction plant and rolling procedure selected by him for achieving the specified density.

a) The trial area shall be not less than 200 m in length and of a width to be approved by the Engineer. If the trial area complies with the Specifications, it may form part of the permanent Works;

b) For the trial the Contractor shall use the materials, mixing and laying plant proposed for the main works;

c) Where the required level of compaction is not achieved the trial area shall be removed and the trial repeated.

The Engineer shall approve test results and general performance of test area before actual commencement of the work.

ITEM 204 SOIL CEMENT STABILIZED SUBBASE AND BASE

204.1 DESCRIPTION

The work shall consist of performing all operations in connection with the construction of cement stabilized subbase or base and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

204.2 MATERIAL REQUIREMENTS

204.2.1 Mineral Aggregate

Aggregate shall be clean, tough, hard durable particles free of decomposed stone, organic matter" and other deleterious substances and shall consist of material of which at least 50% by weight of the total aggregates shall have at least two (2) mechanically fractured faces for cement stabilized subbase whereas for cement stabilized base course, material shall have at least Ninety (90) percent by weight of total aggregate having two (2) mechanically fractured faces.

Coarse aggregate retained on sieve No. 4 shall have a percentage of wear by Los Angeles Abrasion as determined by AASHTO T 96 not more than . Forty five (45) for base course and fifty (50) for subbase material.

Fraction passing 0.075 mm (No. 200) shall not be greater than two-third of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 25% and plasticity index not greater than 6.

Sandy and gravely soils used for cement stabilization shall fulfill the following grading requirements.

Passing maximum size 50 mm sieve	100%
Passing AASHTO No. 4 sieve	above 50%
Passing AASHTO No. 40 sieve	above 15%
Passing AASHTO No. 200 sieve	below 5%
Clay fraction, finer than 0.002 mm	below 3%

204.2.2 Cement

Cement shall conform in all respect to requirement specified under sub-item 111.2.2 and item 401 "Concrete".

204.2.3 Water

Water used for cement stabilized base course or subbase shall conform in all respect to requirements specified under sub-item 112.2.3.

204.2.4 Mix Design Requirements in Laboratory

Prior to commencement the work of stabilization, proposed mix design indicating the exact percentage of cement and water to be used so as to obtain a uniform mixture, shall be submitted by the Contractor for Engineer's approval, and shall fulfill the following requirements:

a) The mixture sample submerged in water for two hours before crushing, after storage in a box having minimum humidity of ninety five (95) percent for Twenty four (24) hours shall have a minimum compressive strength of twenty three (23) kg/sq.cm for sub base and thirty (30) kg/sq. cm for base respectively.

b) The maximum permissive swelling of volume shall be two (2) percent and maximum loss in weight eight (8) percent when tested in accordance with AASHTO T-135.

c) Maximum variation during constructions shall be as given below:

1) Cement Content: -1 to + 1% of that given in the mix design.

2) Water contents: 0 to + 2% of that given in the mix design.

d) Bituminous material for curing seal shall be any one of the following:

Type	**Applicable Specifications**
RC - 250	AASHTO M - 81
MC - 250	AASHTO M - 82
SS - 1	AASHTO M - 140
RT - 5	AASHTO M - 52

Optimum moisture content shall be determined in accordance with AASHTO T-134 by placing moist sample under shade for seven days and crushing after two hours of immersion in water.

204.2.5 Composition of Mixture at Site

The granular material shall thoroughly be mixed at site with sufficient cement to obtain required crushing strength. The cement content shall be determined at the laboratory so that minimum compressive strength of mixture is fifty (50) kg/sq. cm for sub base and eighty (80) kg/sq. cm for base respectively at seven (7) days. The moisture content of the mix cement stabilized material shall not be less than the optimum as determined by AASHTO T-134 Method and nor more than two (2) percent above the optimum as determined by this test or such higher value as may be agreed by the Engineer on basis of preliminary trial.

204.3 CONSTRUCTION REQUIREMENTS

204.3.1 Stationary Plant Method

Equipment, tools, machines used in the performance of cement stabilized subbase, base shall be subject to the approval of Engineer and shall be maintained in satisfactory working condition at all times.

If stationary plant is used, it shall be of the power driven paddle or pan type and may be of batch or continuous type.

If batch mixer is used, measured amount of material and cement shall first be placed in mixer, water being added to bring moisture content of mixture within the optimum range. Mixing shall be continued until mixture is uniformly mixed but in no case less than one minute mixing time.

The mixing plant shall be of approved type, coordinated and operated as to produce mixture within mix design requirements and shall be of sufficient capacity.

The aggregate, cement and water shall be mixed at an approved central mixing plant by either continuous-flow or batch type mixer revolving blades or rotary drum mixer.

The plant shall be equipped with feeding and metering devices that add the materials; cement and water into the mixer in specified quantities; mixed thoroughly and sufficiently to obtain intimate and uniform mixture with out cement lumps.

The mixture shall be transported to paving area in trucks or other approved equipments having clean bed within a maximum hauling time of forty five (45) minutes.

The mixture shall be placed on moist subgrade/or subbase without segregation at a rate that will produce a uniformly compacted layer conforming to the required grade and cross-section. The mixture shall be spread by spreader within thirty minutes after placement of mixture.

Compaction shall start as soon as possible after spreading and elapsed time between the addition of water to mixture and start of compaction shall not exceed ninety (90) minutes.

204.3.2 Mix in Place Method

Cement stabilized subbase/base course can also be constructed by MIX-IN-PLACE method. The plant used for pulverizing and mixing the stabilized material shall be approved by the Engineer on the basis of trial conducted to establish that the plant is capable of producing the degree of mixing and uniformity of material according to specification requirement. The material shall be processed throughout the depth of layer with blades of approved mixing equipment. The cement shall be spread ahead of mixer by means of cement spreader, fitted with a device to ensure uniform and required rate of spread of cement both transversely and longitudinally.

Moisture content of the material shall be adjusted to optimum using water sprayer of such design that water is discharged in uniform and controllable manner both transversely and longitudinally.

204.3.3 Construction Joints

In the end of each day construction, a straight transverse construction joint shall be formed by cutting into completed work to form a true vertical face.

For large area, a series of parallel lanes of convenient length and width meeting approval of Engineer shall be built with true vertical face free of loose or shattered material.

Guide stakes shall be set for cement spreading and mixing.

Grade and alignment stakes shall be furnished, set and maintained by contractor, in order that the work shall conform to the lines, grade and cross-sections shown on the drawing.

All material shall be placed and spread evenly by mechanical spreader capable of leveling off the material to an even depth. The mixture shall be mixed uniformly with proper moisture content. Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirements, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly mixed into previously placed material, adding water as required to obtain the specified density.

204.3.4 Compaction

The thickness of layer shall be as shown on the Drawings but in no case shall be less than eight (8) centimeters. If thickness of each layer does not exceed twenty centimeters, it shall be constructed as one layer. If thickness of layer exceeds twenty (20) centimeters, it shall be constructed in two or more layers each within the range of eight (8) to twenty (20) centimeters in compacted thickness.

The mixture shall be spread and finished true to crown and grade by machine or hand method where machine methods are impracticable as determined by the Engineer and shall be thoroughly compacted with approved rollers until entire depth and width of subbase/base is uniformly compacted to 98% of the maximum dry density determined according to AASHTO T-134.

The compaction shall be complete as soon as possible after mixing, normally within three (3) hours after adding water depending on setting time of cement and the weather conditions.

Compaction shall not take place after cement hydration and any material that has been mixed or deposited after cement has hydrated shall be removed and replaced with fresh mix material.

204.3.5 Preliminary Trial

At least one (1) week before main work of stabilization is started contractor shall construct a trial section of two hundred (200) meters in length at location approved by the Engineer with same material, equipment, mix proportion and construction procedure that he proposes to use for the main work.

Purpose of this trial section is to determine efficiency of mixing, spreading, compaction, suitability of construction procedures, and depth of layer being compacted with available compactive effort.

In place density determination will be made using AASHTO T-191 & T-238 Method.

204.3.6 Curing/ Maintenance

After compaction the stabilized subbase/base layer shall be protected against drying out by keeping it continuously damp for a period of at least three (3) days or by coating with approved curing material at the rate approved by the Engineer.

The completed cement stabilized subbase/base shall be maintained in an acceptable condition at all the times, prior to construction of subsequent asphaltic layer.

No vehicular traffic shall be allowed to pass on the compacted layer until curing period has elapsed with a minimum no-traffic period of seven (7) days.

Cement stabilized subbase/base shall be constructed only when the atmospheric temperature is above 4 degrees centigrade and when the weather is not rainy.

204.3.7 Tolerance

The surface of each subbase/base course shall be properly shaped to a smooth uniform surface parallel to the finished surface of the carriageway and shall not vary more than the limits as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

The completed Subbase/Base course shall be tested for required thickness and surface before acceptance. Any area having compacted thickness less than the thickness shown in the bill of quantities and/or on the drawings shall be rectified by scarifying the top seventy five (75) mm, reshaping with added material and recompacting all to specification. Skin patching of an area without scarifying the surface to permit proper bonding of added material will not be permitted.

ITEM 205 CRACK - RELIEF LAYER

205.1 DESCRIPTION

The work shall consist of constructing a layer of graded crushed aggregate or asphaltic open-graded plant mix on a prepared soil-cement base course in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings.

205.2 MATERIAL REQUIREMENTS

205.2.1 Aggregates

Material for graded crushed aggregates shall in all respects conform to the requirements specified under Item 202, with the following exceptions and supplementary requirements:

a) The portion of the aggregate retained on the 9.5 mm. (3/8 inch) sieve shall not contain more than 10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 2.5:1).

b) Crushed aggregates shall consist of particles with not less than Ninety (90) percent of the portion retained on the 4.75 mm. (No. 4) sieve having at least two fractured faces.

Aggregates for the asphaltic open-graded plant mix shall conform to the requirements of Item 203.2.1 with the following exceptions:

c) Fine aggregates and mineral filler will be required.

d) Sand equivalent and plasticity requirements are not applicable.

205.2.2 Asphaltic Material

Asphaltic binder shall be asphalt cement, 60-70 penetration grade, meeting the requirements of AASHTO M-20.

205.2.3 Asphaltic Open-Graded Mixture

The composition of the asphaltic open-graded crack-relief layer shall meet the following criteria:

Aggregate Grading Requirements		
Sieve Designation		Percent Passing by Weight
mm	Inch	
50	2	100
37.5	1½	75 – 90
19	¾	50 – 70
4.75	No. 4	8 – 20
0.15	No. 100	0 – 5
Asphalt Cement Content of Total Mix		2 – 3% by weight
Mixing Time		30 Seconds (Maximum)
Mix Design		Within Master Range Gradation

The exact percentage of asphalt cement content shall be such that at least Ninety five (95) percent coating of aggregates will be achieved when tested in accordance with AASHTO T-195.

205.3 CONSTRUCTION REQUIREMENTS

Prior to construction of the crack-relief layer (CRL) the completed soil-cement base course shall be duly accepted by the Engineer.

205.3.1 Graded Crushed Aggregate

Construction of this layer shall conform in all respects to the requirements specified under Item 202.3.

205.3.2 Asphaltic Open-Graded CRL

Construction of this layer shall conform in all respects to the requirements specified under Item 203.3, except as provided below:

a) Compaction shall be accomplished by ten (10) Ton steel wheeled tandem rollers. A maximum of three complete coverages, or as otherwise directed by the Engineer, shall be sufficient. No density test will be required, however the compaction shall be achieved in the same manner as displayed in the total test and to satisfaction of the Engineer.

b) The consistency and temperature of the mix shall be such controlled that it does not squeeze out or move under the pressure of compacting roller. For this purpose, trial reaches shall be prepared by the contractor to fix the above parameters.

   In order to ensure the stability of CRL before the placement of any subsequent layer or opening of a layer to traffic, a priming time of 4 days in hot weather will be allowed. This tine may be reduced to two days where the lower temperature allows.

c) All traffic shall be kept off this layer until a subsequent layer has been placed on it. Any damage caused by traffic moving directly on the crack-relief layer shall be the responsibility of the Contractor and all necessary repair work thereto shall be at the Contractor's expense.

ITEM 206 WATER BOUND MACADAM BASE COURSE

206.1 DESCRIPTION

This work shall consist of furnishing and placing one (1) or more courses of clean crushed stone base mechanically interlocked by rolling, and voids thereof filled with screening and binding material with the assistance of water, laid on a prepared subgrade, subbase, or existing pavement in conformity with the lines, grades and cross-sections shown, on the drawings.

206.2 MATERIAL REQUIREMENTS

206.2.1 Coarse Aggregate

Strong and durable crushed coarse aggregate shall conform to the quality requirements as specified hereunder.

The gradation curve of the coarse aggregate shall be within the envelop limits given below:

Sieve Designation		Percent Passing by Weight	
mm	**Inch**	**Grading I**	**Grading II**
75	**3”**	100	-
63	**2½”**	90-100	100
50	**2”**	35-70	90-100
37.5	**1½”**	10-30	38-72
25	**1”**	5-15	10-26
19	**¾”**	2-12	0-15
12.5	**½”**	-	0-5

The additional physical requirements are:

a) The Coarse aggregate shall have a percentage of wear by the Loss Angeles Abrasion test (AASHTO T-96) of not more than forty (40).

b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T-104) shall be less than twelve (12).

c) Crushed Aggregate (material retained on sieve 19mm/12.5mm) shall consist of material of which hundred (100) percent by weight shall be crushed particles having a minimum one fractured face and at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

d) Flakiness Index, maximum 12 %

206.2.2 Binding Material

Binding material to prevent raveling of WBM shall consist of crushed stone screening material approved by the Engineer. It shall be free from clay lumps, dirt and other objectionable material. It shall meet the following gradation and quality requirements:

Sieve Designation		Percent passing by weight
mm	in/No.	
9.5	3/8”	100
4.75	No. 4	80-92
0.425	No. 40	33-51
0.15	No. 100	10-30

The material passing No. 40 sieve shall have a Liquid Limit of not more than twenty five (25) and a Plasticity Index of not more than four (4).

Sand Equivalent shall be 45 minimum as per AASHTO T 176.

206.3 CONSTRUCTION REQUIREMENTS

206.3.1 Equipment

Any combination of machines or equipment that will produce the results meeting these specifications may be used with the approval of the Engineer. These include mechanical spreaders, water sprinklers and rollers/compactors.

206.3.2 Surface Preparation

The subbase to receive WBM course shall be prepared to the required grade and camber and shall not have loose material or moisture in excess to optimum moisture content.

Before starting with WBM Construction, necessary arrangements shall be made for the lateral confinement of aggregates. One method is to construct shoulders with Aggregate Base Course in advance to a thickness corresponding to the compacted layer of the WBM course. After shoulders are ready, their inside edges may be trimmed vertical and the included area cleaned of all spilled material thereby setting the stage for spreading of coarse aggregates Lateral support to the WBM base is also provided by lines of parallel kerbs or bricks. The practice of constructing WBM in a trench section excavated on the embankment/formation must be avoided.

Sufficient setting out pegs, strings, camber boards, straight edges etc shall be established or made available to ensure that the water bound macadam layer will comply with the required specifications for thickness, width and camber.

All drainage works necessary to keep the underlying layer and subsequent construction free of standing water should be completed.

206.3.3 Spreading and Compaction

Coarse aggregate shall be uniformly spread on the prepared surface to the proper thickness by means of mechanical spreader so that the compacted thickness of each layer will not be less than two (2) times the maximum aggregate size (layer may not exceed 6”). It therefore may be necessary to construct the water bound macadam pavement layer with more than one sub-layer. Ideally all sub-layers should be of similar thickness.

Coarse aggregate should be spread approximately 30% thicker than the required thickness when compacted, although this figure should be checked during construction trials and changed as appropriate.

Each layer shall be inspected thoroughly before rolling to detect high or low spots. High or low spots (if any) shall be remedied by removing or adding aggregates by means of draishee (manual) to provide a true surface.

Each layer of coarse aggregate shall be compacted with a vibratory roller until it locks and individual stones can no longer be moved. Normally it is necessary for a 10 to 12 Ton roller to pass over the surface to interlock the stones for required number of passes as determined during the construction of trial section.

Compaction should begin at the edges of the road and progress to the centre parallel to the center line of road and overlapping uniformly each preceding rear wheel track by one half width until the entire area of the course has been rolled by rear wheel. On the super elevated portions of road, the rolling shall commence from the lower edge and progress gradually towards the upper edge of road.

After initial rolling, dry screening shall be applied uniformly over the surface in successive thin layers. Spreading of dry screening shall be followed by rolling with a smooth wheel vibratory roller weighing at least 10 to 12 Ton until it fills the voids to the bottom of the coarse aggregate matrix. Rolling should progress as described above. Dry rolling shall be continued while screenings is being applied until the matrix is full. The surface shall be swept with mechanical or hand brooms to aid spreading of the screenings.

The screenings shall not be dumped in piles on coarse aggregate. In no case shall the screenings be applied as fast and thick to form cakes or ridges on the surface making the filling of voids difficult or preventing the direct bearing of the roller on the coarse aggregates. Damp and wet screening shall not be used under any circumstances.

When the interstices in the coarse aggregate are filled with screenings, the surface shall be sprinkled with water until it is saturated. Surface is compacted using vibration in order to further compact the fines into the matrix. Spreading, watering and compaction continues until the no more fines move into voids and the layer is strongly locked. Hand brooms shall be used to sweep the wet screenings into voids and distribute them evenly. Care shall be taken to see that the sub-base does not get damaged due to the addition of the excessive quantity of water during construction.

After the layer has completely dried, any loose material remaining on the surface is brushed off. All defective areas shall be removed, cut back and repaired with new material.

When more than one layer is required to complete the Macadam base course to the thickness shown on the drawings, each layer shall be constructed as before prescribed.

The relative compaction of each layer of the compacted WBM Base Course shall not be less than 100 percent to the maximum dry density determined according to AASHTO T-180, Method D after adjustment of coarse particles obtained during field density test.

The completed layer shall not be more than 15 mm thicker or more than 5 mm thinner than the required thickness.

206.3.4 Construction Control Testing

The following procedures shall be adopted to assure the quality of WBM base course:

1. Field Density Test by Sand Replacement Method as per AASHTO T-191 with at least 8 inch dia cone and plate.

2. The aggregates retained on 25.4 mm (2 inch) sieve during FDT should not be returned back to hole. The weight of aggregate retained on 25.4 mm (2 inch) sieve shall be included in determination of field wet density of the compacted WBM layer.

3. Maximum Dry Density Test in laboratory by Using Method AASHTO T 180 “D” by taking passing 19 mm (3/4 inch) or passing 4.75 mm (# 4) sieve from the reach. (crushing of coarse aggregate to produce passing 19 mm (3/4 inch) material should not be allowed). The density thus obtained shall be adjusted as per AASHTO T 224 “Correction of Coarse Particles in Soil Compaction Test” for coarse particles and moisture content in the field for obtaining compaction of WBM.

4. Taking a sample from the compacted layer and determining percentage fines.

5. No voids whatsoever are to be visible in the compacted layer.

6. Levels shall be taken by placing a flat steel plate 4″ x 4″ x 1/8″ thick on the layer compacted by the approved number of passes of the designated Roller to check for zero settlement under another pass of the roller.

7. Proof Rolling with 24 T Pneumatic Tyre Roller to ascertain 100 percent compaction as above.

206.3.5 Sampling and Testing

Sampling and testing with respect to materials and construction requirements shall be governed by the "Table for Sampling and Testing Frequency" or as approved by the Engineer. The frequencies are the minimum and the Engineer has the authority to have these tests carried out at more frequent intervals where quality is in doubt. The exact location for sampling and testing shall be based on random sampling in accordance with Standard Practice for Random Sampling of Construction Materials (ASTM D-3665).

206.3.6 Tolerances

The completed water bound macadam base course shall be tested for required thickness and smoothness before acceptance. The allowable tolerances shall be according to the “Table for Allowable Tolerances” in these Specifications.

206.3.7 Maintenance

The completed base course shall be maintained in an acceptable condition until the necessary subsequent treatment is applied.

Grade control shall be accomplished by means of grade stakes, steel pins, placed in lanes parallel to the centerline of the road and at intervals sufficiently close to permit placing of string lines or straightedges for checking purpose.

206.3.8 Trial Section

Prior to commencement of WBM base course operations, a trial section of two hundred (200) meters minimum, but not to exceed five hundred (500) meters shall be prepared by the contractor using same material and equipment as will be used at site to determine the adequacy of equipment, loose depth measurement necessary to result in the specified compacted layer depths, field moisture content, and relationship between the number of compaction passes and the resulting density of material. In-place CBR may also be determined as directed by the Engineer.

206.3.9 Protection of Completed Work

Any part of the water bound macadam (WBM) that has been completed shall be protected and kept well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being allowed to ply on the water bound macadam (WBM). He shall repair any ruts or ridges occasioned

by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the area of water bound macadam (WBM) preparation to an area easily maintained with the equipment available. Water bound macadam (WBM) preparation and placing of asphalt base course shall be arranged to follow each other closely. The water bound macadam (WBM), when prepared too soon in relation to the placing of the asphalt base course, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the water bound macadam (WBM) as may be necessary to restore it to the state specified herein. It will be at discretion of the Engineer to check some or all such reaches for compaction and moisture content before placing the next layer.

ITEM 207 DEEP PATCHING

207.1 DESCRIPTION

This work shall be carried out in patches of roads where the existing road base material has moved and is lying in loose condition. Requirement under this item is to remove the existing road base and to strengthen it to take new layer of aggregate or water bound macadam base.

207.2 MATERIAL REQUIREMENTS

Fresh aggregate base or water bound macadam base may be required to be added to existing road base. Specification for such material shall conform to material requirements of item 202.2 or 206.2.

207.3 CONSTRUCTION REQUIREMENTS

Patches of roads in which surface courses have broken and road base has moved the material which has lost its compaction shall be removed. Next layer shall be watered and compacted, thereby the removed material shall be placed back duly screened to remove plastic contamination, by hand picking and passing though sieve No. 4. after properly watering and mixing. Material will be recompacted in layers not exceeding fifteen (15) cms thick with approved equipments. Additional material will be added, if needed particularly non-plastic fines passing sieve No. 4.

ITEM 208 REINSTATEMENT OF ROAD SURFACE

208.1 DESCRIPTION

This work shall consist of reinstatement of worn out road surface with a material approved by the Engineer. Pot holes, ditches and depressions shall be filled with the approved materials in layers in conformity with lines, grades, sections and dimensions, as directed by the Engineer.

208.2 MATERIAL REQUIREMENTS

The material used under this item shall conform to the material requirement of different B.O.Q. items selected for use by the Engineer.

208.3 CONSTRUCTION REQUIREMENTS

The contractor shall remove loose material from the pot holes or from road depressions and shall also reshape the holes and depression by removing firm material as directed by the Engineer and dispose all material according to the instruction of the Engineer. The surface thus exposed shall be compacted in accordance with applicable requirement, for reinstatement of surface the Engineer shall select item of work as mentioned here under:

a) Granular subbase.
b) Aggregate base course.
c) Water bound macadam.
d) Asphalt base course.
e) Surface treatment.

The Engineer may select one, or more than one of the items mentioned above to reinstate the pot hole or depressions in the road surface according to size and depth of the hole or depression.

ITEM 209 SCARIFICATION OF EXISTING ROAD / BREAKING OF ROAD PAVEMENT STRUCTURE

209.1 DESCRIPTION

This item shall consist of scarification of existing road surface or breaking of existing road pavement structure to ensure bondage of new layer with the existing road pavement and to ensure drainage of water below the surface of freshly laid granular layers. The surface on which the fresh granular layer is to be constructed shall be approved and accepted by the Engineer prior to placing this new layer.

209.2 CONSTRUCTION REQUIREMENTS

The method of scarification of road surface or breaking of pavement structure shall be proposed by the Contractor and approved by the Engineer, in accordance with the requirements under site conditions.

After the existing pavement structure has been broken off, the unusable material i.e asphalt concrete and bitumen-coated WBM aggregate shall be removed and disposed of outside the right of way, according to satisfaction of the Engineer. Average thickness of this unusable material for the purpose of quantification shall be decided by the Engineer as per site conditions.

The remaining reusable material shall be removed and stockpiled to be reused as subbase material in service roads etc as directed by the Engineer.

Payment for re-working & re-cambering of surface obtained after breaking and removal of the existing pavement to achieve lines and grades of new design and its compaction to the density required for the specific zone of new design in which that layer falls shall also be included in the contract price for Pay Item No. 209a.

ITEM 210 PAVEMENT WIDENING

210.1 DESCRIPTION

This work shall consist of the widening of the existing pavement and finishing of the completed work in accordance with the specifications and in conformity with the lines, grades, thickness of each pavement component and typical cross-sections shown on the plans or as directed by the Engineer.

210.2 MATERIALS

Materials for the construction of "Pavement Widening" shall conform to the requirements specified in relevant items of Subbase and Base course in these specifications.

210.3 TRENCHING

The contractor shall excavate along the edge of the existing pavement for the full depth and width as indicated on the Drawings or as directed by the Engineer. The bottom of the trench shall be compacted with rollers and/or tampers approved by the Engineer to minimum ninety five (95) % of the maximum dry density as per AASHTO T-180 method. If the plans do not call for a specific type of compaction, the subgrade, subbase or base shall be compacted by rolling with an approved type trench roller until the entire surface is smooth, firm and at the designated elevation. Adequate provisions shall be made for drainage of the trench to prevent damage to the subgrade. Prior to placing any widening material, the trench shall be cleaned of all loose material. The edge of the existing pavement shall be thoroughly cleaned. The trench must be approved by the Engineer, before placing any widening material. All subsequent layers shall be compacted to the degree as shown under relevant item of these specifications

210.4 SPECIAL PROVISIONS FOR HANDLING TRAFFIC

Widening operations shall be permitted on only one (1) side of the pavement at a time and excavation of trenches shall be permitted only sufficiently in advance of other operations to ensure a continuity of the operations of excavating, placing widening material, and rolling.

Reflectorized barricades shall be placed along open trenches day and night. Lighting shall be placed at each barricade at night. Barricades and lights shall be approved by the Engineer. The barricades shall be placed at intervals not to exceed one hundred (100) meters or as directed by the Engineer.

The Contractor shall make adequate provision to enable traffic to cross open trenches at intersecting roads, streets and private entrances.

Partial shouldering shall be performed immediately after completion of widening of portions of the Work in order to eliminate the hazard.

No separate payment will be made for handling traffic which will be considered subsidiary to the item of "Pavement Widening."

ITEM 211 LIME STABILIZED AGGREGATE BASE COURSE

211.1 DESCRIPTION

This work shall consist of performing all operations in connection with construction of "Lime Stabilized Aggregate Base Course" on the prepared Subbase or Subgrade surface and all incidentals in accordance with the specifications in conformity with the lines and level grade, and typical cross-sections shown on the plans.

211.2 MATERIAL REQUIREMENTS

211.2.1 Coarse Aggregate

Coarse Aggregates for crushed Lime stabilized Base Course shall be composed of hard, tough, sound durable crushed limestone, particles free from thin and elongated, soft and disintegrated material or other objectionable matters, complying with the following requirements.

Table 211.2

CRUSHED STONE GRADING

Sieve Designation		Percent Passing by Weight
mm	Inch	
37.5	1½	100
25.0	1	80 - 100
12.5	1/2	50 - 80
4.75	No. 4	30 - 60
0.425	No. 40	10 - 30
0.075	No. 200	5 - 15

The fraction of material passing 0.075 mm (No. 200 Sieve) shall not be more than 60% the fraction passing 0.425 mm (No. 40 Sieve).

Crushing of boulder or rock shall be regulated in such a way that fraction of aggregates retained on sieve No. 4 (4.75 mm) shall contain at least Ninety (90) percent by weight of crushed particles having more than one mechanical fractured faces.

The Abrasion loss of Crushed Lime Stone as determined by AASHTO T 96 shall not exceed forty five (45) percent.

211.2.2 Fine Aggregate

The fraction of crushed aggregates passing No. 4 sieve shall consist of stone screenings free of loam, organic or other matter.

The material passing 0.425 mm (No. 40) sieve when prepared in accordance with AASHTO T 89 & T 90 and tested by appropriate methods shall conform with the following requirement.

Liquid Limit 25% Maximum
Plasticity Index 6% Maximum

The calcium sulphate content of the fraction retained on sieve No. 4 shall not exceed ten (10) percent by weight.

211.3 CONSTRUCTION REQUIREMENTS

211.3.1 Equipment

All equipment, tools and machines used in the performance of the work shall be in good working condition and maintained all the times.

Blade graders, if used for spreading, the material shall have adjustable blades for slopes.

All sprinkling equipment shall be suitable for applying water uniformly and at controlled quantities to variable width of surface.

Transport vehicles carrying plant mix material shall have a capacity suited to the output of mixing plant and the site condition.

Mixing plant shall be of approved type, coordinated and operated so as to produce a mixture within required specification limit and shall have sufficient capacity.

211.3.2 Construction

Grade and alignment control stakes shall be furnished, set and maintained by the contractor in order that work shall conform to the lines, grade and cross-section shown on the drawings.

Material shall be placed and spread evenly using mechanical spreader. The spreader shall be adjustable so that width and thickness of the spreader can be set to any dimension required by the drawings and for uniform and complete coverage.

Aggregate shall be spread to loose thickness necessary to obtain the required compacted thickness of the layer.

Immediately after spreading and shaping operation, the mixture shall be thoroughly compacted with approved rollers. Water shall be applied to the materials during the rolling operation in such amount as may be required to obtain the specified density. In all the places not accessible to the rolling equipment, the material shall be compacted thoroughly with approved mechanical or hand tampers to density comparable to that obtained by rolling. The surface of the final layer shall be finished by blading and the addition of water, until the surface is smooth and free from waves and irregularities and is true to grade and cross-section. Where the thickness exceeds twelve and half (12.5) centimeters, it shall be compacted in two layers of equal thickness except that if vibratory roller is used for compaction, the layer thickness may be increased to maximum of twenty five (25) centimeters provided that satisfactory compaction is achieved.

Each layer shall be compacted until the entire depth of course is at least 100 % of density at optimum moisture content as determined by AASHTO T 180. Compaction shall be completed as soon as possible after the material has been spread.

211.3.3 Thickness and Finish

Completed base course shall be tested" for the required thickness and smoothness before acceptance. Any areas of the completed base course having compacted thickness less than the thickness shown on the drawing, or waves and irregularities as specified in the relevant, "Table for Allowable Tolerances", in these Specifications shall be corrected by scarifying the surface, adding approved material, reshaping, recompacting and finishing as specified and as approved by the Engineer. Skin patching of an area without scarifying the surface to permit proper bonding of added material will not be permitted.

211.3.4 Maintenance

The completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When the base course is to carry traffic for an indefinite length of time before receiving the surfacing or pavement, the contractor shall maintain the surface until final acceptance and shall prevent raveling by wetting, blading, rolling and the addition of fines as may be required to keep the base tightly bound and leave a slight excess of material over the entire surface, which must be removed and the finish restored before the application of prime coat.

ITEM 212 BITUMEN STABILIZED SUBBASE OR BASE

212.1 DESCRIPTION

This work shall consist of performing all operation in connection with construction of bitumen stabilized subbase or base and all incidentals in conformity with the lines and level, grade, thickness and typical cross-section shown on the drawings or as directed by the Engineer.

212.2 MATERIAL REQUIREMENTS

If stationary plant is used for blending, all ingredients shall comply with any of the grading curve given in Table 1 whereas for mix in place method, in situ sand and gravel shall meet the gradation requirement as per Table 2 for bitumen stabilized Subbase or Base Course.

Coarse aggregate retained on 4.75 mm (No. 4) sieve shall consist of tough, hard and durable particles free from decomposed stone, organic matter and other deleterious substances.

Crushing of material shall be regulated such that material retained on 4.75 mm (No. 4) sieve shall have 50% by weight of total aggregates with at least two (2) mechanically fractured faces in case of bitumen stabilized subbase where as for bitumen stabilized base, material retained on No. 4 sieve shall have at least Ninety (90) percent by weight of total aggregate with two (2) mechanically fractured faces.

Aggregate retained on sieve No. 4 shall have a percentage of wear by Los Angles Abrasion Test as determined by AASHTO T-96 not more than forty five (45) percent in case of base course material and fifty (50) percent in case of sub-base material.

Fraction passing 0.075 mm (No. 200) sieve shall not be greater than 2/3 rd of the fraction passing the 0.425 mm (No. 40) sieve. The fraction passing 0.425 mm (No. 40) shall have a liquid limit not greater than 25% and plasticity Index not greater that 6.

If mineral aggregates contain moisture thus necessitating drying, bitumen material shall be of such nature that it will not foam when heated to hundred and eighty (180) degree centigrade and shall conform to requirements as shown in Table 301.2.

In dry areas, where natural moisture content of mineral aggregate is low bitumen binder shall be cut back conforming to the following requirements. Cut back shall meet the requirement of AASHTO M 81 and M 82 for rapid and medium curing type respectively. It shall comply with the requirements of AASHTO T 49, T 50 and T 78 for the selected grade to suit the cutback as approved by the Engineer. Alternatively the bituminous binder shall be asphaltic cement of 80/100 penetration in summer and 120/150 in winter; bitumen emulsion of 80/100 penetration in summer and 150/180 penetration in winter. The bituminous emulsion shall comply with the requirements of AASHTO M 100 and be tested in accordance with AASHTO T 59.

Bitumen-Aggregate mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshal Method to determine the amount by weight of dry material, and using either heated or unheated aggregates as appropriate.

TENTATIVE CRITERIA FOR BITUMEN-AGGREGATE SUBBASE / BASE MATERIAL

Characteristic	Subbase	Base
Marshal Stability (Min)	250 Kg	400 Kg
Flow (Min)	2 mm	2 mm

TABLE – 1

SELECTED SUBBASE / BASE MATERIAL GRADING

Sieve Designation		Percent Passing by weight		
mm	Inch	Type - A	Type - B	Type - C
75	3	100	—	—
50	2	90 – 100	100	—
25	1	55 – 90	70 – 100	100
9.5	1/8	35 – 65	50 – 80	65 – 95
4.75	No. 4	25 – 55	40 – 65	50 – 80
2.0	No. 10	20 – 40	30 – 50	40 – 65
0.425	No. 40	10 – 25	15 – 25	20 – 35
0.075	No. 200	3 – 10	3 – 10	3 – 10

TABLE – 2

SAND - GRAVEL SUBBASE MATERIAL – GRADING

Sieve Designation		Percent Passing by Weight
mm	Inch	
37.5	1½	100
25.0	1	80 – 100
12.5	1/2	50 – 80
4.75	No. 4	30 – 60
0.425	No. 40	10 – 30
0.075	No. 200	5 – 15

Fine aggregate passing 4.75 mm (No. 4 Sieve) shall consist of sharp natural sand, free from organic or other objectionable substances.

212.3 CONSTRUCTION REQUIREMENTS

All equipment, tools, machines used in the performance of work shall be in good working condition and be subject to the approval of the Engineer, and shall be maintained in satisfactory working condition at all times.

Blade grader if used shall have an adjustable blade for slopes and shall be self propelled.

212.3.1 Mix in Place Method of Construction

Mix in place method of construction may be adopted where the use of low viscosity binder i.e. Cutback or Bitumen emulsion are found suitable.

Grade and alignment control stakes shall be furnished, set and maintained by the contractor in order that work shall conform to the line, grade and cross-section shown on the drawings. The stakes shall be set in rows on and parallel to the center line of pavement and spaced so that string line may be stretched between them.

All material shall be placed evenly using mechanical spreader or spreader box operated with a mechanism which levels off the surface to an even depth.

Mixing shall be accomplished on one or more passes of the mixer through the material and shall be continued until the resulting mixture is entirely uniform and of proper moisture content. Moisture content, if less than required, shall be adjusted by sprinkling equipment, which shall be suitable for applying water uniformly and at controlled amount to variable depth of layer.

Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirement of specified, additional approved material shall be spread in such amounts as are found to be necessary and the added material shall be uniformly spread adding water if required to obtain the specified density.

212.3.2 Stationary Mixing Plant Method

Stationary plant method of construction will be used where stabilization with asphalt cement binder of penetration grade 80/100 is necessary.

The mixing plant shall be designed, coordinated and operated so as to produce mixture within required Job-Mix-Formula and shall have sufficient capacity. The plant shall be weigh batch type.

Transport vehicles carrying plant mix material shall have a capacity suited to the output of mixing plant and the site condition and be capable of discharging cleanly. Segregation of material shall be avoided.

212.3.3 Compaction

Immediately after spreading, shaping to required level, crown and grade, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until the entire depth and width of Subbase/Base is uniformly compacted. Rolling shall begin at the low side and progress towards the higher side overlapping each preceding trip until entire surface has been rolled. Alternate trip of roller shall be of slightly different length. Roller shall be in good working condition, capable of reversing without back lash and shall be operated by skilled operator.

Compaction shall be checked on stabilized layer in accordance with ASTM-D 915. The bulk density of the mixture shall not be less than ninety eight (98) % of the laboratory bulk density. Deficient pavement shall be removed and replaced with satisfactory material.

212.3.4 Tolerance

Tolerance in the compacted layer shall be as specified in the relevant, "Table for Allowable Tolerances" in these specifications.

212.3.5 Curing and Maintenance

After compaction, the stabilized Subbase/Base shall be protected against damage and

maintained in an acceptable condition at all times prior to the construction of subsequent courses.

No vehicular traffic shall be allowed to pass on the stabilized surface for a minimum period of two (2) days.

212.3.6 Weather Limitations

Laying of bitumen stabilized base/subbase shall be avoided when air temp is four degrees centigrade or below or when whether is rainy or foggy. Placing of mixture shall also be avoided when surface is wet or on any surface which is frozen or covered with ice or snow.

ITEM 213 COLD RECYCLING OF ROAD PAVEMENT STRUCTURE / SOIL STABILIZATION

213.1 DESCRIPTION

This item shall consist of breaking, removal, mixing, relaying and compaction of layers of surface, base and subbase course in a single operation. In this operation, addition of water or binder will also be required to add strength to the mix.

213.2 MATERIAL REQUIREMENTS

No fresh material is to be used as far as quarry materials are concerned. However in order to achieve proper strength of the relayed material; water, cement or bitumen binder may be required to be added. Specification requirements of these ingredients shall be same as described under relative items of work. Cement and bitumen binder of following nomenclature shall be used:

a) Ordinary Portland cement (Type-1)
b) Emulsified asphalt (RS-1, RS-2, SS-1, SS-1h)

213.3 CONSTRUCTION REQUIREMENTS

213.3.1 Equipment

Equipment utilized for this item of work shall ensure following activities in a single operation:

a) Breaking of layers in full depth in single operation.
b) Pulverizing and mixing of different types of materials to give homogeneous mix.
c) Mixing of water or bitumen binder in the total mass.
d) Laying of treated material in smooth layer, keeping the grade and line as per design.

213.3.2 Cold Recycling of Asphalt

a) Milling Process

This work shall be carried out by specialized equipment designed to break and pulverize the asphaltic layer in a manner that maximum size of broken material reduces to basic size of aggregates. Asphaltic material lumps shall be reduced to a maximum size of fifteen (15) mm.

b) Additives

Bitumen binder (Emulsified Asphalt) shall be added to the mix through a computerized, electronically controlled unit for selecting and measuring the required amount. Bitumen binder and additives shall be added with pump and spray/ injection system. Quantity of bitumen binder shall be controlled by programmable micro processors with respect to forward speed, milling depth, milling width and density of material.

c) Mixing and Laving

Milled materials and additives shall be mixed in a forced mixer to make the mass completely homogeneous. Material thus prepared shall be relayed through paving block having tamping and vibrating paving screeds. Paving screeds should be designed to provide initial compaction and shaping the surface to give the required grade and profile.

d) Compaction

Initial compaction shall be provided with paving screeds; however final compaction shall be carried out with conventional rolling equipment approved by the Engineer considering the type of material and thickness of recycled layer. However final compaction shall be checked after completion of rolling as determined by AASHTO T-230 method and shall not be less than ninety seven (97) percent of the Marshall density.

e) General

Total width of road asphalt shall be recycled in a number of strips, depending on width of recycling equipment and width of road. However all longitudinal and lateral joints shall be properly worked up to ensure smooth riding quality.

213.4 SOIL STABILIZATION

a) Milling Process

This work shall be carried out by specialized equipment designed to break and pulverize asphaltic layers and base and subbase courses to a depth of maximum three hundred (300) mm in a single operation. Breaking and pulverizing shall ensure reduction of binding material to reduce to a size of 50 mm (maximum) or to a smaller size depending on the thickness of relayed layer.

In case cement is to be used for improving the strength of relayed mix, the same shall be calculated and spread over the pavement structure before milling starts.

b) Additives

Water shall be added to the mix through a computerized, electronically controlled unit for selecting and measuring the required amount, water shall be added with pump and spray/injection system. Quantity of water shall be controlled by programmable micro processor with respect to forward speed, milling depth, milling width and density of materials.

c) Mixing and Laving

Milled materials and additives shall be mixed in a forced mixer to make the mass completely homogeneous. Material thus prepared shall be relayed through paving block having tamping and vibrating paving screed. Paving screeds should be designed to provide initial compaction and shaping the surface to give the required grade and profile.

d) Compaction

Initial compaction shall be provided with paving screeds; however final compaction shall be carried out with conventional rolling equipment approved by the Engineer considering the type of material and thickness of recycled layer. However final compaction shall be checked after completion of rolling as determined by AASHTO T-230 method and shall not be less than Ninety Five (95) percent of the modified proctor density.

e) General

Total width of road asphalt shall be recycled in a number of strips, depending on width of recycling equipment and width of road. However all longitudinal and lateral joints shall be properly worked up to ensure smooth riding quality.

ITEM 214 ASPHALT BINDER COURSE

214.1 DESCRIPTION

This work shall consist of furnishing and mixing aggregates and asphalt binder at a central mixing plant, transporting, spreading and compacting the mixture on a prepared base in accordance with these specifications and to the lines, grades and typical pavement sections shown on the Drawings or as directed by the Engineer.

214.2 MATERIAL REQUIREMENTS

214.2.1 Aggregates

Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, vegetable matter and other deleterious substances, and be of uniform quality, geology and petrology. Water borne material such as river bed gravel, if used, shall also conform to the above criteria.

Coarse aggregate, which is material retained on the No. 4 sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. The aggregate shall contain not more than 8% by weight of flats/or elongated particles (ratio maximum to minimum 5:1) and shall contain 100% angular material, such that all faces of each piece are fractured faces in cuboids shape.

Fine aggregate, which is material passing the No. 4 sieve shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock crust, hydrated lime, hydraulic cement or other suitable mineral matter and shall conform to the following gradation:

US Standard Sieve	Percent Passing by Weight
NO. 30	100
NO. 50	95 – 100
NO. 200	70 - 100

The Coarse and fine aggregates shall meet the following requirements:

a) The percentage of wear by the Los Angles Abrasion test (AASHTO T 96) shall not be more than 40%.
b) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T 104) shall be less than 12%.
c) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement should not be less than 45.
d) All aggregates shall have a liquid limit of not more than 25% and a Plasticity Index of not more than 4 as determined by AASHTO T-89 and T-90.
e) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 3:1).

214.2.2 Asphalt Material

Asphalt binder to be mixed with the aggregate to produce asphalt base shall be as asphalt cement penetration grade 40-50, or 60-70 or 80-100, as specified by the Engineer. Generally it will meet the requirement of AASHTO M-20.

214.2.3 Asphalt Concrete Binder Course Mixture

The composition of the asphalt concrete paving mixture for binder course shall conform to class shown in the following table:

Table No. 1

Combined Aggregate Grading Requirements

Sieve Designation		**Percent Passing by Weight**
mm	**Inch**	
25	1	100
19	3/4	90 – 100
9.5	3/8	56 – 80
4.75	No. 4	35 – 65
2.38	No. 8	23 – 49
0.30	No. 50	5 – 19
0.075	No. 200	2 – 8

Asphalt Content Weight Percent of total mix	**3.5 (minimum)**
The asphalt concrete binder course mixture shall meet the following Marshal Test Criteria:	
Compaction, number of blows each end of Specimen	75
Stability (Minimum)	1000 Kg.
Flow, 0.25 mm (0.01")	8 – 14
Percent air voids in mix.	4 – 6
Percent voids in mineral aggregate	According to article 5.3, MS-2, (Asphalt Institute USA) edition 1993.
Loss of stability	25% (Max.)
Filler/Bitumen ratio	1-1.5

214.2.4 Combined Aggregates Gradation

Retained No. 4 ± 7.0%
Passing No. 4 to No. 100 sieves ± 4.0%
Passing No. 200 ± 1.0%

Asphalt Content

Weight percent of total mix - 0.2% to + 0.1%

Should a change of sources of materials be made a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other conditions made it necessary, a new Job Mix Formula will be required.

214.2.5 Job-Mix Formula

At least one week prior to production, a Job-Mix Formula (JMF) for the asphalt concrete

course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshal Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2) Sixth Edition 1993.

The JMF, with the allowable tolerances, shall be within the master range specified in Table No. 1. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregates.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto to the tolerances as per clause 214.2.4 of these specifications.

214.3 CONSTRUCTION REQUIREMENTS

Construction requirements for this item shall conform to the same construction requirements specified for Asphalt Base Course Plant Mix under Item 203.3, except as modified in the following sub-items.

214.3.1 Preparation of Base Course Surface

Before spreading materials the surface of the previously constructed and accepted base course on which the mix is to be placed shall be conditioned by application of a tack/or prime coat, as directed by the Engineer.

214.3.2 Pavement Thickness and Tolerances.

The asphalt concrete binder course shall be compacted to the desired level and cross slope as shown on the drawings or as directed by the Engineer.

The tolerances in compacted thickness of the binder course shall be + 10 percent from the desired thickness shown on the drawings. For determination of the thickness, one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than + 10 percent, the Engineer shall decide whether to accept the deficit thickness or to direct reconstruction.

The surface of the binder course shall be tested by the Engineer using at 3-meter straight edge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point + 5.0 millimeters. The cross fall (camber) shall be within + 0.2 percent of that specified, and the level at any point shall be within drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective works and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

ITEM 215 GEOTEXTILES

215.1 DESCRIPTION

The work covered by this section shall consist in furnishing all material, labour, equipment and placing of Geotextiles on prepared surfaces complete in accordance with the specifications for the work items involved, in thicknesses and to the dimensions shown on the typical cross-sections of applicable drawings or as directed by the Engineer.

215.2 MATERIAL REQUIREMENTS

215.2.1 Geotextile Functions

Where indicated on the drawings or directed by the Engineer, Geotextile will be placed to perform one or more of the following functions:

- One road foundation for the purpose of separation between road fill material and soft underlying soils in order to eliminate the need for removal of poor subsoil material and quick and effective drainage of soil-fill interface.
- For subgrade stabilization and increasing soil shear strength by providing bonding mechanism of the Geotextile - soil system.
- As a filter for all drainage systems where a danger of clogging by fine particles of adjacent soil is possible. The geotextile will retain the particles from passing whilst allowing the seepage water to pass through.
- As a filter element for all bodies of water where the soil can be eroded by current, wave action or changing water levels.
- For permanent protection of synthetic sealing systems (Geomembranes) against mechanical damage during installation and after completion of construction.

215.2.2 Composition and Environmental Behaviour

The raw material of geotextile shall be Ultra Violet stabilized polypropylene. The fibers shall consist of continuous filaments of approximately 40 micron diameter and mechanically bonded by needling. The geotextile material shall be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime, cement and concrete, resistant to all naturally occurring bacteria and fungi. A prolonged outside exposure of several months shall have no effect on the properties of Geotextile.

215.2.3 Mechanical and Hydraulic Properties

- To ensure free drainage, the geotextile shall have high water permeability.
- Geotextile shall offer high retention capability for almost all types of soils.
- The geotextile shall have optimum stress-strain behaviour even with low unit weight for high resistance against installation damage.

215.2.4 Geotextile Testing

Geotextiles testing shall be in accordance with following standard test methods:

Weight	ASTM D-3776
Thickness	ISO 9863
CBR Puncture Resistance Test	BS 6906/4
Strip Tensile Test	ASTM D-4595
Grab Tensile Test	ASTM D-1682
Tear Strength Test	ASTM D-1117
Penetration Resistance Test (Drop Test)	NT Build 243
Vertical Permeability	BS 6906/3
Pore Size	E DIN 60500/6

Based on the required functions and the type of stresses, the Contractor shall propose the type of Geotextile. The Contractor shall furnish technical literature and Manufacturer's Certificate of Guarantee for the type of geotextile material for approval of Engineer prior to delivering the material to the site. The certificate shall note compliance to the specifications and shall state the results of the tests performed on the material, as required by the specifications. The Contractor shall, when directed by the Engineer, have the Geotextile material tested for conformance to the applicable specifications at an approved testing laboratory. All costs connected with certificate of Guarantee and any subsequent quality testing shall be at the contractor's expense.

215.3 CONSTRUCTION REQUIREMENTS

215.3.1 Preparation

The surface shall be fairly leveled before placement of Geotextile. It is to be ensured that there are no protruding stones which may damage the geotextile fabric.

215.3.2 Geotextile Placement

The Geotextile shall be rolled out directly on top of the prepared surface in a manner as recommended by the manufacturer. It shall be over lapped at the edges as shown on the drawings or as recommended by the manufacturer.

215.3.3 Placement of Fill

The first layer of fill material shall be applied by overhead placement. Traffic on the geotextile itself shall be avoided. Necessary precautions shall be observed to ensure that geotextile shall not be damaged during placement.

215.3.4 Spreading

Spreading of fill material shall be done with suitable equipment and procedure ensuring that geotextile must not be damaged by high axle load stresses of spreading equipment traveling on sharp fill over the geotextile.

215.3.5 Compaction

The compacting method (Static/Dynamic) shall be suited to subgrade/fill material.

215.3.6 Jointing of Geotextile Panels

A tension joint shall be achieved by overlapping, welding or sewing as shown on drawings or approved by the Engineer.

a) Overlapping

Overlapping width shall not be less 30 cm on even surface and 50 cm on uneven surface. In order to avoid displacing the geotextile during backfill over end panel joints, the connecting panel must be placed underneath the end of the previously rolled out geotextile.

b) Welding

Welding width shall not be less than 10 cm. A wide pattern gas torch shall be used at a low temperature and about 20 cm from the geotextile. The welded geotextile section shall be continuously pressed down by walking on it during placement.

c) Sewing

The stitching method shall be single thread, double thread or butterfly type suitable to

geotextile thread type and strength. The thread shall be sufficiently tightened and stitch density shall be three to six stitches per inch.

215.3.7 Geotextile Function for Repaving

This section deals Geotextile placed between old pavement and new asphalt overlay, along with suitable tack coat of bitumen. Where indicated on drawings or directed by the Engineer, geotextile will be placed to perform one or more of the following functions:

- To ensure proper adhesion between old pavement and new asphalt overlay & thus reducing the over all flexural tensile stresses and increasing life of road surface.
- As a cut off layer for the prevention of propagation of cracks in the pavement.
- As water barrier, even under high pressure to stop reflective cracking in the pavements.

215.3.7.1 Construction Requirements

- Removal of dirt, dust and vegetation from wearing surface and cracks.
- Filling potholes and larger cracks (> 5 mm) with hot mix or an adequate filler.
- Removal of sharp or craggy edges on surface.
- On badly damaged roads, a level course of approx. 1.5 cm shall be laid to avoid the labour intensive and time consuming operation of crack filling.

215.3.7.2 Applying the tack coat

Depending on the condition of the old surface, a calculated amount of tack coat (Qef) of approx. 1.1 kg/m2 active binder is to be sprayed evenly on the prepared surface before laying geotextile, making sure that:

- The bitumen is applied beyond the width of the geotextile by about 5 cm on either side.
- The spraying temperature for pure bitumen is kept between 150° C and 170° C to achieve a coating as even as possible.
- When using bitumen emulsion, the coating amount is adjusted to contain the required average amount of bitumen.
- The coating is only applied to areas where the paving felt is to be laid.
- No additional pre-spray agent is applied on top of the paving felt.
- Where only sections for the road are covered with the paving felts, their surfaces must be gritted.

215.3.8 Laying Geotextile

Geotextile shall be laid by hand or machine taking into account that:

- When using pure bitumen as tack coat, Geotextile may be laid immediately after coating.
- When using bitumen emulsions, Geotextile shall not be laid until the emulsion has cured.
- Wrinkles shall be avoided.
- Edges lengthways and across overlap by 5-10 cm, an additional pure bitumen binder of 0.9 kg/m^2 shall be applied on the overlapping seams.
- Transverse overlapping is to be carried out with reference to the direction in which the asphalt finisher will proceed i.e. under the previous one so that the felt does not shift out of place when the asphalt concrete is applied.
- When one half of the road is made (leaving the other open to traffic), at least 25 cm of the lengthways felt edge shall remain uncovered to allow overlapping when laying the other half of the road.
- During short time stoppages of construction work, the road under construction shall be opened only to slow traffic without detriment to Geotextile.
- Rain water on the Geotextile surface shall be allowed to evaporate before applying a

top layer.

215.3.9 Applying the asphalt concrete surface

The asphalt concrete surfacing shall be applied immediately after laying Geotextile preferably by crawler type finisher, taking the following points into consideration:

- The material mix shall have a temperature between 145° C and 165° C.
- To avoid types of the finisher or truck sticking to the felt (which can happen in hot climates or where too much tack coat has been applied), some of the mix can be spread manually in the pathway of the vehicles.

ITEM 216 SOLING STONE

216.1 DESCRIPTION

This item shall consist of laying of soling stone, handpacked on a surface (subgrade) prepared earlier and all interstices filled with sand or similar approved materials to provide proper bonding of all the stones with each other.

216.2 MATERIAL REQUIREMENTS

The material for soling shall be round and durable rock, properly shaped or boulders of maximum size 15-20 cm. The filler material to fill the interstices shall be coarse sand or rock dust or any other material approved by the Engineer. Material shall be cohesionless and clean to allow its free flow down to the bottom of soling area.

216.3 CONSTRUCTION REQUIREMENT

216.3.1 The subgrade to receive the soiling stone shall be prepared under relative item of the work.

216.3.2 Placing of Soling Stone

The soling stone shall be placed from outer edges of the road and finishing at the crown of the road in such a way that all stones are properly handpacked and keyed with the surrounding stones. It shall be ensured that the maximum dimension is kept in vertical position ensuring the variation of the size of the stone does not exceed + 1" of specified thickness of soling stone.

The filler material shall be dry and in free flow condition when placed over the soling stone. The filler material shall be kept adding while the soling stones are rolled under a 6 tons roller. The addition of filler material shall continue till the area does not absorb more filler material and it is ensured that all interstices are fully filled. The area will then be watered and kept under rolling to achieve a smooth surface.

ITEM 217 INTERLOCKING CONCRETE PAVING BLOCKS

217.1 DESCRIPTION

The work shall consist of precast concrete paving blocks intended for the construction of low speed roads, parking areas, lay byes, industrial and other paved surfaces subjected to all categories of static and vehicular loading and pedestrian traffic. Paving blocks covered by these Specifications are designed to form a structural element and the surfacing of pavements, having the block to block joints filled, so as to develop frictional interlock and placed in conformity with the lines, grades, thicknesses and typical cross-section shown on the drawings or as directed by the Engineer.

217.2 MATERIAL REQUIREMENTS

For execution of this item provisions made in BS 6717 shall be applicable. Detailed requirement of materials and construction shall be as under:

217.2.1 Binders and Binder Constituents

Paving blocks shall be made using one or more of the following binders or binder constituents complying with the requirements of the relevant standards:

Ordinary Portland Cement	BS 12
Portland Blast furnace Cement	BS 146: Part 2
Portland Pulverized Fuel ash Cement	BS 6588
Pulverized fuel ash	BS 3892: Part 1
Ground granulated Blast furnace slag	BS 6699

Where pulverized fuel ash is used, the proportions and properties of the combination with Portland Cement shall comply with BS 6588.

Where ground granulated blast furnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146: Part 2.

217.2.2 Aggregates

Paving blocks shall be made using one or more of the following aggregates complying with the relevant standards:

Natural Aggregates (Crushed or Uncrushed)	BS 882 (except grading requirements in clause 5)
Air Cooled blast furnace slag	BS 1047 (except grading requirements in 4.8)
Pulverized fuel ash	BS 3892 : Part-1 or Part-2
Ground granulated blast furnace slag	BS 6699

217.2.2.1 Acid Soluble Material (Fine Aggregate)

When tested as described in BS 812 : Part 119, the fine aggregate (material passing a 5 mm sieve complying with BS 410) shall contain not more than 25% by mass of acid soluble material either in the fraction retained on, or in the fraction passing, a 600 [i m sieve.

217.2.3 Water

The water shall be of drinking quality or in accordance with the recommendations of appendix A of BS 3148.

217.2.4 Admixtures and Pigments

Proprietary accelerating, retarding and water reducing agents shall comply with BS 5075: Part 1.

Pigments shall comply with BS 1014.

Calcium chloride shall comply with BS 3587.

217.2.5 Finishes

The finish should be agreed between the manufacturer and the Engineer.

Concrete described as "natural colour" shall contain no pigment.

In composite paving blocks the surface layer shall be formed as an integral part of the block and shall be not less than 5 mm thick.

217.2.6 Binder Content

The cement content of the compacted concrete shall be not less than 380 kg/m^3. For equivalent durability, paving blocks made with binder constituents other than ordinary Portland cement shall have a higher binder content than paving blocks made in a similar way using only Portland Cement. The Engineer will decide the additional binder content. The compressive strength test will be the only guide to the amount of additional binder needed.

217.2.7 Sizes and Tolerances

217.2.7.1 Sizes

Paving blocks shall have a work size thickness of not less than 60 mm. Type-R blocks shall be rectangular with a work size length of 200 mm and a work size width of 100 mm. Type-S blocks shall be of any shape fitting within a 295 mm square coordinating space and shall have a work size width not less than 80 mm.

The preferred work size thicknesses are 60 mm, 65 mm, 80 mm & 100 mm.

A chamfer around the wearing surface with a work size not exceeding 7 mm in width or depth shall be permitted.

All arises shall be of uniform shape.

217.2.7.2 Tolerances

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as follows:

Length	± 2 mm
Width	± 2 mm
Thickness	± 3 mm

Where a paving block includes profiled sides, the profile shall not deviate from the manufacturer’s specification by more than 2 mm.

217.2.8 Compressive Strength

The compressive strength of paving blocks shall be not less than 49 N/mm2 and the crushing strength of any individual block shall be not less than 40 N/mm2.

217.2.9 Sampling

The following sampling procedure shall be used for the compressive strength test:

a) Before laying paving blocks, divide each designated section, comprising not more than 5000 blocks, in a consignment into eight approximately equal groups, Clearly mark all samples at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample are clearly defined. Take two (2) blocks from each group.

b) Dispatch the sample to the test laboratory, taking precautions to avoid damage to the paving blocks in transit. Each sample shall be accompanied by a certificate from the person responsible for taking the sample, stating that sampling was carried out in accordance with this Part of BS 6717.

c) Protect the paving blocks from damage and contamination until they have been tested. Carry out any tests as soon as possible after the sample has been taken.

217.2.10 Marking

The following particulars relating to paving blocks made in accordance with this standard shall be indicated clearly on the delivery note invoice, manufacturer's or supplier's certificate or brochure supplied with the consignment of blocks:

a) The name, trade mark or other means of identification of the manufacturer.

b) The number and date of this British Standard, i.e. BS 6717 : Part 1 : latest revision.

217.3 CONSTRUCTION REQUIREMENTS

217.3.1 Laying the Concrete Blocks

The total area to be covered with paving block shall be prepared by:

a) Compaction of subgrade
b) Laying of subbase in a thickness specified
c) Laying of crushed aggregate base or lean concrete in thickness as per typical section

217.3.2 Tolerance

Tolerance of these layers shall be as per applicable requirement of each item of these Specifications.

Payment for each of the above item shall be made under the relative item of work.

The total area will thereby be divided with nylon strings into sectors of not more than 1.5 square meters. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

ITEM 218 OPEN GRADED GRANULAR SUBBASE SHOULDER/LAY-BYS

218.1 DESCRIPTION

This work shall consist of constructing open graded granular subbase shoulder/lay-bys furnishing, spreading, compacting granular subbase material in layers according to the specifications and drawings and / or as directed by the Engineer.

218.1.1 Definitions

Shoulder That portion of the completed road construction which lies above the elevation of the subgrade or base and which extends from the edge of the through travel lanes to the point of intersection with the embankment slopes on either side of the road centerline.

Lay-bys Where shown on the plans, or where directed by the Engineer, areas adjacent to the roadway shall be constructed of the specified materials and to the dimensions shown on the plans, and in the manner herein specified. These areas will be for the parking of motor vehicles off the roadway other than the space defined as shoulders. Such areas will be called "Lay-bys."

218.2 MATERIAL REQUIREMENTS

Open graded granular subbase shoulder/lay-bys material shall consist of pit run gravel, rock/stone and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily to form a firm, stable subbase.

a) The open graded shoulder material shall have a graded granular/crushed aggregate with sand/crushed stone dust conforming to the following requirements:

Grading Requirements for Open graded granular subbase shoulder/lay-bys Material		
Sieve Designation		**Mass Percent Passing Grading**
mm	**Inch**	
50.0	2	100
37.5	$1^1/_2$	90-100
25	1	60-80
9.5	3/8	40-60
4.75	No. 4	30-45
0.075	No. 200	5-8

The final gradation decided within the limit designated in the table shall be all graded from course to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves or vice versa.

b) The Material shall have a CBR value of at least 50%, determined according to AASHTO T-193 ASTM D-1883. The CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.

c) The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

d) In order to avoid intrusion of silty and clayey material from the subgrade in the open graded granular subbase shoulder/lay-bys, the ratio D15 (Open graded granular Subbase Shoulder/Lay-bys)/D85 (Subgrade) should be less than 5.

Where D85 and D15 are the particle diameters corresponding to eighty five (85) % and fifteen (15) %, respectively, passing (by weight) in a grain size analysis, curve.

e) The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 4 to 6.

f) The sand equivalent determined according to AASHTO T-176 shall not be less than 25.

g) Friable particles tested according to AASHTO T-112 shall not exceed 0.25 %.

218.3 CONSTRUCTION REQUIREMENTS

218.3.1 Material Processing/Spreading

Blending and mixing aggregates and adjusting the moisture content as required for compaction shall be performed in a central plant to ensure uniformity.

Open graded granular subbase shoulder/lay-bys material shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

Open graded granular subbase shoulder/lay-bys material shall be deposited on the shoulders in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the open graded granular subbase shoulder/lay-bys material. In case any material is to be added to compensate for levels, the same shall be done after scarifying the existing material, to ensure proper bonding of additional material.

When the required thickness is twenty (20) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than ten (10) centimeters thick. Where the required thickness is more than 20 cm, the aggregates shall be spread and compacted in 2 or more layers of approximately equal thickness, but in any case the maximum compacted thickness of one layer shall not exceed 20 cm. All subsequent layers shall be spread and compacted in a similar manner.

Open graded granular subbase shoulder/lay-bys material shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in “Table for Allowable Tolerances" in these specifications for crushed aggregate subbase. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of subgrade or contamination of sub base material.

The material shall be handled so as to avoid segregation. If the approved spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment to the spreading operation, the use of such approved spreader shall be discontinued, and it shall be replaced. All segregated material shall be removed and replaced with well-graded material. No "skin" patching shall be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances shall be permitted during the compaction process.

No hauling or placement of material will be permitted when, in the judgment of the

Engineer, the weather or road conditions are such that hauling operations will cause rutting of the road surface or cause contamination of the open graded granular subbase shoulder/lay-bys material. Before placing the mixture, the subgrade or previous layer shall be wetted to ensure bond between the layers. The mixture shall be placed and shaped by power equipment to the lines, elevations, cross sections, thickness and density specified in these Specifications.

218.3.2 Construction Trials

Prior to commencement of open graded granular subbase shoulder/lay-bys construction operation, contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the approved open graded granular subbase shoulder/lay-bys material as will be used during construction to determine the adequacy of the contractor's equipment, loose thickness measurement necessary to result in the specified compacted layer thickness, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.

218.3.3 Compaction

The open graded granular subbase shoulder/lay-bys material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyre rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on super elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain a smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformly compacted to the specified density.

Any area inaccessible to rolling equipment shall be compacted by means of hand guided rollers, plate compactors or mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of subbase material or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and recompact the material before subsequent layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of open graded granular subbase shoulder/lay-bys the subgrade layer (both under the traveled way and the shoulders) shall conform to the required level and shape. Prior to placing the subsequent layers of the material, the top surface of each layer shall be made sufficiently moist to ensure bond between the layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the plans.

No material for construction of the base shall be placed until the subbase has been approved by the Engineer.

218.3.4 Compaction requirements

The relative compaction of each layer of the compacted open graded granular subbase shoulders/lay-bys shall not be less than Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D. The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used.

218.3.5 Moisture Content Determination

Same size of sample should be placed in oven for moisture determination in case of laboratory density (Proctor) and field density.

218.3.6 Surface Tolerances

The surface layer of the open graded granular subbase shoulder/lay-bys shall be evaluated for compliance with the following surface tolerances:

a) The cross section of the finished open graded granular subbase shoulder/lay-bys surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer.

b) The allowable tolerances in design elevation of the finished open graded granular subbase shoulder/lay-bys are stated in “Table for Allowable Tolerances” in these Specifications.

ITEM 219 RAMPS FOR JOINING/INTERSECTING ROADS

219.1 DESCRIPTION

This work shall consist of constructing ramps for joining/intersecting metalled roads in accordance with these specifications and in conformity with the lines, grades and dimensions shown on drawings or as directed by the Engineer.

219.2 MATERIAL REQUIREMENTS

The materials required for the work shall conform to the specifications mentioned under each respective item of work involved as shown on drawings or as directed by the Engineer.

219.3 CONSTRUCTION REQUIREMENTS

The construction requirements shall be the same as mentioned under the respective item involved to complete the work as per the drawings or directions of the Engineer. Scarification and breaking of existing pavement and/or deep patching may also be required as directed by the Engineer. Contractor shall be responsible for proper maintenance of traffic to and from these joining roads in a satisfactory manner as prescribed in section 705 and as approved by the Engineer.

SURFACE COURSES AND PAVEMENT

ITEM 300 GENERAL

This section describes the requirements and procedures for execution of surface courses and pavements. The materials to be used shall conform to specifications and testing procedures as per American Association of State Highway and Transportation Official (AASHTO) or the American Society for Testing and Material (ASTM) or, for particular materials, or procedures the British Standards Institution, as indicated in their latest editions. Samples of materials for laboratory tests and their subsequent approvals shall be utilized according to these references unless otherwise directed by the Engineer.

Materials which do not conform to the requirements of these specifications will be rejected whether in place" or not. They shall be removed immediately from the site of the work at the expense of contractor. While subgrade/subbase and paving operations are in progress, a detour shall be provided for vehicular flow in order to avoid any public inconvenience and thoroughly be maintained till completion of that particular section of the project or as a whole. In order to expedite the passage of public traffic through or around the work, the contractor shall install road signs, warning lights, flares, barricades and other facilities for the safety, convenience and direction of public traffic. Also where directed by the Engineer, the contractor shall furnish competent flagmen whose sole duties shall consist of directing the movement of public traffic through or around the work. The cost of furnishing and installation of such road-signs, lights, flares barricades and other facilities, shall be included in the respective work item. Should the Engineer point out the inadequacy of warning and protective measures, and require additional measures, such action on the part of the Engineer shall not relieve the contractor from responsibility for public safety or abrogate his obligation to furnish and pay for these services.

300.1 QUALITY ASSURANCE PROCEDURES

Asphalt concrete wearing course shall be accepted by lot as specified in “Table for Sampling and Testing Frequency” in these Specifications. The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer).

Asphalt concrete wearing course shall be placed, trimmed and finished in a neat and workmanlike manner in accordance with the lines, grades and typical cross sections shown on the plans or staked by the Engineer.

Asphalt concrete wearing course shall be sampled and tested in accordance with “Table for Sampling and Testing Frequency” in these Specifications.

The completed asphalt concrete wearing course shall be compacted as specified, smooth, free from ruts, humps or depressions, or irregularities. Any ridges, indentations, roller checking, or other objectionable marks left in the surface, as determined by the Engineer, shall be eliminated by whatever means are necessary and approved by the Engineer. The use of any equipment that leaves ridges, indentations or other objectionable marks shall be discontinued.

ITEM 301 ASPHALTIC MATERIALS

301.1 ASPHALT CEMENT

Asphalt Cement shall be an oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin and shall be homogeneous and free from water. No emulsification shall occur when a thirty (30) gram sample is boiled for two (2) hours with two hundred and fifty (250) cubic centimeters of distilled water in a five hundred (500) cubic centimeters Erienmeyer flask equipped with a reflux condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to the requirements set forth in Table 301-2. The grade of asphalt to be used shall be in accordance with these specifications or the Special Provisions or as directed by the Engineer.

301.2 ENVIRONMENTAL FACTORS

In areas where highly frost susceptible soils and severe low temperature conditions are encountered, it may be necessary to remove and replace soils susceptible to frost heave or take other precautions prior to pavement construction. In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table below gives recommended asphalt grades for various temperature conditions.

SELECTING ASPHALT GRADE

Temperature Condition	Asphalt Grade +
Cold, mean annual air temperature $\leq 7^0$ C (45^0 F).	AC - 10 AR - 4000 80 / 100 pen
Warm, mean annual air temperature between 7^0 C (45^0 F) and 24^0 C (75^0 F).	AC – 20 AR - 8000 60 / 70 pen
Hot, mean annual air temperature $\geq 24^0$ C (75^0 F).	AC – 40 AR - 8000 40 / 50 pen

* Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types:

Cationic (ASTM D 2397 or AASHTO M 208) or anionic (ASTM D977 or AASHTO M 140). Selecting one of the two shall depend on the type of aggregate used for better affinity.

The grade of emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D 244, AASHTO T 59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used, and the curing rate.

301.3 CUT-BACK ASPHALT

Liquid asphalts (cut back) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Table 301-3 and 301-4.

Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent.

Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of grade 80-100, fluxed or blended with a naphtha solvent.

301.4 EMULSIFIED ASPHALT

Asphaltic emulsions shall be composed of a bituminous base uniformly, emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting or Slow Setting, and shall conform to the requirements specified in Table 301-5.

The bituminous base used in manufacturing RS-1 type emulsion shall be asphalt cement, Grade 120-150 or Grade 200-300, as designated by the Engineer.

The bituminous base used in manufacturing SS1 type emulsion shall be paving asphalt, Grade 60-70 or Grade 120-150, as designated by the Engineer.

APPLICATION TEMPERATURES

TABLE 301-1
Application Temperature Range, °C

Asphalt Type/ Grade	Mixing Temp	Spraying Temperature Road Mixes
a) Asphalt Cement (All grades)	As required to achieve viscosity of 75-150 **sec**. Saybolt-Furol or as required to achieve a Kinematic Viscosity of 150-300 centistokes.	160 (Max)
b) Emulsified Asphalts		
RS – 1	—	—
RS - 2	—	—
MS - 1	10 – 70	20 – 70
MS - 2	10 – 70	20 – 70
MS - 2h	10 – 70	20 – 70
HFMS - 1	10 – 70	20 – 70
HFMS - 2	10 – 70	20 – 70
HFMS - 24	10 – 70	20 – 70
SS - 1	10 – 70	20 – 70
SS - 1h	10 – 70	20 – 70
CRS - 1	10 – 70	20 – 70
CRS - 2	—	—
CMS - 2	—	—
CMS - 2h	10 – 70	10 – 70
CSS - 1	10 – 70	10 – 70
CSS - 1h	10 – 70	10 – 70
c) Cutback Asphalts (RC, MC, SC)		
30 (MC only)	—	—
70	—	20 min.
250	55 – 80	40 min.
800	75 – 100	55 min.
3000	80 – 115	—

TABLE 301 - 2

REQUIREMENTS FOR ASPHALT CEMENT (AASHTO M - 20)

	40 – 50		60 – 70		80 – 100		120 – 150	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Penetration at 77° F (25° C) 100 gms./ 5 Sec.	40	50	60	70	80	100	120	150
Flash point, Cleveland Open Cup, ° F (° C)	450 (232)	- -	450 (232)	- -	450 (232)	- -	425 (218)	- -
Ductility at 77° F (25° C) 5 cm per min., cm.	100	-	100	-	100	-	100	-
Solubility in trichloroethylene percent.	99	-	99	-	99	-	99	-
Thin-film oven test, 1/8 in. (3.2 mm), 325° F (163° C) 5 hr Loss on heating, percent.	-	0.80	-	0.80	-	1.0	-	1.3
Penetration, of residue, percent of original.	58	-	54	-	50	-	46	-
Ductility of residue at 77° F (25° C) 5 cm. per min., cm.	-	-	50	-	75	75	100	-

TABLE 301 - 3

REQUIREMENTS FOR MEDIUM-CURING TYPE ASPHALTS (AASHTO M - 82)

	MC – 70		MC – 250		MC – 800	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Water, percent	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup), Degree C.....	38	-	66	-	66	-
Kinematic Viscosity at 60°C (140°F) (See Note 1) Centistokes ….....	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate at 360° C (680° F)						
at 225° C (437° F)	0	20	0	10	-	-
at 260° C (500° F)	20	60	15	55	0	35
at 315° C (600° F)	65	90	60	87	45	80
Residue from distillation at 360° C (680° F) Volume percentage of sample by difference.....	55	-	67	-	75	-
Tests on residue from distillation:						
Penetration, 100g., 5 sec., at 25°C (77°F).....	120	250	120	250	120	250
Ductility, 5 cm/ min, cm (see note 2).....	100	-	100	-	100	-
Solubility in Trichloroethylene, percent.....	99.0	-	99.0	-	99.0	-

Notes:

1. As an alternative, Saybolt-Furol viscosities may be specified as below:

Grade MC-70 Furol Viscosity at 50° C (122° F) - 60 to 120 Sec.
Grade MC-250 Furol Viscosity at 60° C (140° F) - 125 to 250 Sec.
Grade MC-800 Furol Viscosity at 82.2° C (180° F) - 100 to 200 Sec.

2. If penetration of residue is more than 200 and its ductility at 25° C (77° F) is less than 100 cm., the material will be acceptable if its ductility at 15.5° C (60° F) is more than 100 cm.

TABLE 301-4

REQUIREMENTS FOR RAPID-CURING TYPE ASPHALTS (AASHTO M-81)

	RC – 70		RC – 250		RC – 800	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
Water, percent.....	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup), Degree C	-	-	27	-	27	-
Kinematic Viscosity at 60° C (140° F) (See Note) Centistokes.....	70	140	250	500	800	1600
Distillation test Distillate, percentage by volume of total distillate at 360° C (680° F):						
at 190° C (374° F).....	10	-	-	-	-	-
at 225° C (437° F).....	50	-	35	-	15	-
at 260° C (500° F).....	70	-	60	-	45	-
at 315° C (600° F).....	85	-	80	-	75	-
Residue from distillation at 360° C (680° F) Volume percentage of sample by difference.....	55	-	65	-	75	-
Tests on residue from distillation:						
Penetration, 100g: 5 Sec., at 25° C (77° F).....	80	120	80	120	80	120
Ductility, 5 cm/min, of 25° C (77° F) cm	100	-	100	-	100	-
Solubility in Trichloroethylene, percent.....	99.0	-	99.0	-	99.0	-

Note: As an alternative, Saybolt-Furol viscosities may be specified as below:

Grade RC-70	Furol Viscosity at 50° C (122° F)	-	60 to 120 Sec.
Grade RC-250	Furol Viscosity at 60° C (140° F)	-	125 to 250 Sec.
Grade RC-800	Furol Viscosity at 82.2° C (180° F)	-	100 to 200 Sec.

TABLE 301 – 5

REQUIREMENTS FOR EMULSIFIED ASPHALTS (AASHTO M - 140)

Type	Rapid – Setting				Slow – Setting			
Grade	RS – 1		RS – 2		SS – 1		SS - Hi	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Tests on Emulsions:								
Viscosity, Saybolt-Furol at 77° F (25° C). Sec ……....	20	100	-	-	20	100	20	100
Viscosity, Saybolt-Furol at 122° F (50° C) Sec	-	-	75	400	-	-	-	-
Settlement 5 days, percent (a) ……	-	5	-	5	-	5	-	5
Storage stability test 1 day (b) ……	-	1	-	1	-	1	-	1
Demulsibility, 35 m1. 0.02 $NCaCl_2$ percent	60	-	60	-	-	-	-	-
Cement mixing test, percent ……	-	-	-	-	-	2.0	-	2.6
Sieve test, percent ……	-	0.10	-	0.10	-	0.10	-	0.10
Residue by distillation, percent ……..	55	-	63	-	57	-	57	-
Test on Residue from Distillation Test Penetration, 77° F(25^0 C) 100 g. /5 Sec.....	100	200	100	200	100	200	40	90
Ductility, 77°F (25 °C). 5 cm/mln. cm.....	40	-	40	-	40	-	40	-
Solubility in trichloroethylene, percent ……....	97.5	-	97.5	-	97.5	-	97.5	-
Suggested Uses	Surface treatment, penetration macadam and tack coat		Surface treatment & penetration macadam		Plant or road mixture with graded and fine aggregates, a substantial quantity of which passes a No. 8 (2.3 mm) sieve and a portion of which may pass a No. 200 (0.075 mm) sieve; slurry seal treatments			

a) The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the Engineer may require that the settlement test be run from the time the sample is received until it Is used, if the elapsed time is less than 5 days.

b) The 24-hr. (1 day) storage stability test may be used instead of the 5 days settlement test.

c) The demulsibility test shall be made within 30 days from date of shipment.

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ITEM 302 BITUMINOUS PRIME COAT

302.1 DESCRIPTION

This work shall consist of furnishing all plants, labours, equipment, materials and performing all operations in applying cut back bituminous material onto previously prepared untreated subgrade, Crushed Aggregate Base Course (ABC), Water Bound Macadam (WBM) base course, concrete surfaces or roadway shoulders within the lines shown on the plans, specified or established by the Engineer strictly in accordance with these Specifications.

302.2 MATERIALS

302.2.1 Asphaltic Material

Asphaltic material shall conform to the requirements of item 301 “Asphaltic Materials” either cutback or emulsified whichever is specified in Bill of Quantities.

302.2.2 Blotting Sand

Natural sand, manufactured sand, or combinations thereof that are free from organic matters or clay, having a grading consisting of one hundred percent (100%) passing the 4.75 mm (No. 4) sieve and not more than five percent (5%) passing the 0.150 mm (No. 100) sieve.

302.3 CONSTRUCTION REQUIREMENT

Prior to application of the prime coat, the surface shall conform to the specified compaction and elevation tolerance and be free of organic and other deleterious materials. The application is prohibited when the weather is foggy or rainy, or when the atmospheric temperature is below fifteen (15) degree centigrade unless otherwise directed by the Engineer.

Areas to be primed will be classified as under:

a) The top of earth surface or crushed aggregate base course from a point two hundred (200) mm outside the edge of the pavement line shown on the Drawings to the corresponding line on the opposite side of the carriageway or as directed by the Engineer.

b) The top surface of base course on the shoulders from a line two hundred (200) mm outside the edge to the edge of the pavement line or as directed by the Engineer.

c) The bridge wearing surface from kerb to kerb and end to end of the bridge wearing surface.

d) Other surfaces as shown on the Drawings or ordered by the Engineer.

302.3.1 Equipment

The liquid asphaltic material shall be sprayed by means of truck mounted pressure distributor of approved make, of not less than 4000 litre capacity, capable of uniformly spraying bituminous material in full lane width. Load produced on the road surface will not exceed 1 KN per cm width of tyre.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid up to one hundred and eighty (180).degree centigrade The heating device shall be such that over heating will not occur. Consequently, the flames must not touch directly on the walls

of the tank containing the asphaltic liquid or gases therefrom. The Contractor will be responsible for any fire or accident resulting from heating of bituminous materials. The liquid shall be circulated or stirred during the heating. The tank shall be insulated in such a way that when the tank is filled with asphaltic liquid at one hundred and eighty (180) degree centigrade and not heated, the drop in temperature will be less than two (2) degree centigrade per hour. A thermometer shall be fixed to the tank in order to be able to measure continuously the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a device that indicates the volume of contents. The pipes for filling the tank shall be furnished with an easily replaceable filter.

The distributor shall be able to vary the spray width of the asphaltic liquid in maximum steps of 0.1 m to a total width of four (4) m. The spraying bar shall have nozzles from which the liquid is sprayed fan shaped on the road surface equally distributed over the total spraying width.

For adding the liquid asphalt material, either driven by a separate motor or with a device to synchronize its speed with the speed of the distributor, the pump shall be furnished with an indicator showing the rate of flow in litres per minute. At the suction side the pump shall have an easily changeable filter. A thermometer shall be fixed, which indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with a tachometer indicating its speed in metres per minute. The tachometer shall be visible from the driver's seat. The function of the distributor shall be so precise that the deviation from the prescribed quantity to be spread on any square metre does not exceed 10%. The distributor shall be equipped with a device for hand spraying of bituminous liquid.

302.3.2 Preparation

Prior to the application of the prime coat, all loose materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and hand brooms, until it is as free from dust as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. All expansion joints shall be cleaned and filled as directed by the Engineer. Surface cleaned shall be given a light application of water and allowed to dry to a surface-dry condition before bituminous material is applied. Asphaltic materials shall be applied at temperatures stated herein by approved pressure distributors operated by skilled workmen. The spray nozzles and spray bars shall be adjusted and frequently checked so as to ensure uniform distribution. Spraying shall cease immediately upon any clogging or interference of any nozzle and remedial measures taken before spraying is resumed. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Application rate and temperature shall be determined from test section(s) constructed under the direction of Engineer within the range given below:

Type of Surface	Litres per Square Meter		Spray Temperature (^{O}C)
	Minimum	Maximum	
Earth surfaces, Aggregate and Base Course	0.65	1.75	75-100
Bridge, Wearing Surfaces, Concrete Pavement	0.10	0.15	75-100

302.3.3 Test Section and Selection of application Rates

The Contractor shall provide a set of troughs 50 mm wide and shall carry out in the

presence of the Engineer the Deposit Tray Test as described in Section 14.52 to 14.56 of "Bituminous Materials in Road Construction " published by HMSO, London, to demonstrate that lateral distribution of the material is in accordance with BS 1707. This test shall be carried out before the spraying work commences on site and subsequently as required by the Engineer from time to time. Spraying shall not be commenced until the results of the test are satisfactory.

On the basis of tests the Engineer shall determine the rate of spread of prime coat material.

302.3.4 Weather Limitations

Bituminous material for prime coat shall not be applied to any surface until the air and surface temperatures are at least fifteen degrees Celsius (15 oC) and rising or during rain, dust or sand storms.

302.3.5 Control

The prime coat shall be left undisturbed for a period of at least 48 hours. The Contractor shall provide proper traffic control so that vehicles do not damage the primed area. Work shall not be started on the portion previously covered until it has dried and is ready to take traffic. The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts; any excess shall be blotted with blotting sand. Any such blinding material which is loose shall be broomed off before commencement of construction of the next layer.

ITEM 303 BITUMINOUS TACK COAT

303.1 DESCRIPTION

This work shall consist of furnishing all plant, labour, equipment, material and performing all operations in applying cut back bituminous material on a previously prepared, Bituminous Base/Leveling Course(s) within the lines shown on the plans, specified or established by the Engineer, strictly in accordance with these Specifications.

303.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of item 301 “Asphaltic Materials” either cutback or emulsified whichever is specified in Bill of Quantities.

303.3 CONSTRUCTION REQUIREMENTS

Prior to application of the tack coat, the surface shall conform to the specified compaction and elevation tolerance and be free of organic and other deleterious material. The tack coat shall be applied only when the surface is dry. Its application shall be avoided in case of foggy or rainy weather. Prior to the application, an inspection of the prepared surface will be made by the Engineer to determine its fitness to receive the asphalt base/leveling courses & wearing courses, Tack coat will not be applied until the surface is approved by the Engineer.

303.3.1 Equipment

Equipment shall conform in all respects to the provision under subsection 302.3.1 in these Specifications, and shall be subject to the approval of the Engineer in addition to the maintenance of the same in a satisfactory working condition at all times.

303.3.2 Preparation

Before applying the tack coat, all loose material, dirt or other objectionable material, shall be removed from the surface to be treated by power brooms and/or blowers, supplemented with hand brooms, as directed by the Engineer.

Asphaltic materials shall be applied at temperatures stated herein by approved pressure distributors operated by skilled workmen. The spray nozzles and spray bars shall be adjusted and frequently checked so as to ensure uniform distribution. Spraying shall cease immediately upon any clogging or interference of any nozzle and remedial measures taken before spraying is resumed.

All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Application rate and temperature shall be determined from test section(s) constructed under the direction of Engineer within the range given below:

Type of Surface	Litres per Square Meter		Spray Temperature (^{O}C)
	Minimum	Maximum	
Asphalt Base/Leveling Course	0.2	0.4	50-80

303.3.3 Test Section and Selection of Application Rates

The Contractor shall provide a set of troughs 50 mm wide and shall carry out in the presence of the Engineer the Deposit Tray Test as described in Section 14.52 to 14.56 of "Bituminous Materials in Road Construction " published by HMSO, London, to demonstrate that lateral distribution of the material is in accordance with BS 1707. This test shall be carried out before the spraying work commences on site and subsequently as required by the Engineer from time to time. Spraying shall not be commenced until the results of the test are satisfactory.

On the basis of tests the Engineer shall determine the application rate of spread of tack coat material.

303.3.4 Weather Limitations

Bituminous material for tack coat shall not be applied to any wet surface until the air and surface temperatures are at least fifteen degrees Celsius (15 oC) and rising or during rain, dust or sand storms.

303.3.5 Control

Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance of the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been placed. Any area that has become fouled, by traffic, dust or otherwise, shall be cleaned by the Contractor at his own cost before the next course is applied.

ITEM 304 BITUMINOUS SURFACE TREATMENT AND SEAL COAT/ PAD COAT

304.1 DESCRIPTION

This work shall consist of one or more applications of asphaltic material and one or more covers of aggregates or an application of asphaltic material without aggregates applied in accordance with these specifications and in conformity with the lines and width shown on the typical cross-sections or as established by the Engineer.

304.2 MATERIAL REQUIREMENTS

304.2.1 Aggregate

Aggregate shall consist of clean, dry, hard, durable, tough, angular, sound crushed stone or crushed gravel of uniform quality, and free from dirt, clay and other objectionable matter. Aggregates from only the approved sources with desirable adhesion properties should be used. The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty (40). Aggregate crushing value (ACV) when tested as per BS-812, Part 110 shall not exceed 25%. When subjected to five (5) cycles of sodium-sulfate soundness testing as determined by AASHTO T-104, it shall have a weight loss of not greater than ten (10) percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed three (3) percent by weight plus one-half (1/2) the water absorption of the aggregate at the time of delivery to the Project. In no case shall free moisture be drawing from the truck bed.

The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than fifteen (15) percent of particles by weight of flat or elongated, or both, that the ratio between the maximum and the minimum dimensions exceeds 2.5:1. Flakiness Index, tested under BS-812 Part 105, shall be 25 (max) for nominal size 18 mm and 12 mm and 30 (max) for nominal size 9 mm.

The nominal sizes of aggregates used for surface treatment; shown against table 304-1 shall be as under:

Size No. 1	-	Nominal size	18 mm
Size No. 2	-	Nominal size	12 mm
Size No. 3	-	Nominal size	9 mm
Size No. 4	-	Nominal size	6 mm

The nominal size are defined in the table below:

Nominal Size (mm)	Specified Size *			
	Passing		Retained	
	Sieve (mm)	%age	Sieve (mm)	%age
18	19	100	12.5	85
12	12.5	100	9.5	85
9	9.5	100	6.3	85
6	6.3	100	4.75	85

* By convention, this item defines a fraction of material within the respective sieves.

For Material passing 3/8" Sieve, following Table shall be used:

Sieve Designation		Percent Passing by Weight			
mm	**Inch**	**Size No. 1**	**Size No. 2**	**Size No. 3**	**Size No. 4**
9.5	3/8	0 – 15	0 – 10	-	-
4.75	No. 4	0 – 5	0 – 5	0 – 10	-
2.38	No. 8	-	-	0 – 5	0 – 5
1.18	No. 16	-	-	-	0 – 3
0.075	No. 200	0 – 2	0 – 2	0 – 1	0 – 1

304.2.2 Asphaltic Material

The asphaltic material shall conform to the requirements of Item 301 'Asphaltic Materials'. The type shall be one of the following, as shown in the Bill of Quantities or ordered by the Engineer. Spraying temperature shall be as shown against each type.

Table: Spraying Temperatures (°C) for Surface Treatments

Asphalt Type / Grade	Spraying Temperature (°C)
a. Asphalt Cements	
AC - 2.5	130 min.
AC - 5	140 min.
AC - 10	140 min.
AC - 20	145 min.
AC - 40	150 min.
AR - 1000	155 min.
AR - 2000	140 min.
AR - 4000	145 min.
AR - 8000	145 min.
AR - 16000	-
200 - 300 pen.	130 min.
120 - 150 pen.	130 min.
85 - 100 pen.	140 min.
60 - 70 pen,	145 min.
40 - 50 pen.	150 min.
b. Emulsified Asphalts	
RS - 1	20 - 60
RS - 2	50 - 85
MS - 1	20 - 70
MS - 2	-
MS - 2h	-
HFMS - 1	20 - 70
HFMS - 2	-
HFMS - 2h	-
HFMS - 2S	-
SS - 1	-
SS - 1h	-
CRS - 1	50 - 85
CRS - 2	50 - 85
CMS - 2	-
CMS - 2h	-
CSS - 1	-
CSS - 1h	-

Asphalt Type / Grade	Spraying Temperature (°C)
c. Cut-back Asphalts (RC, MC, SC)	
30 (MC only)	30 min.
70	50 min.
250	75 min.
800	95 min.
3000	110 min.

304.3 CONSTRUCTION REQUIREMENTS

At the time of the application, the weather shall be warm and dry, and the road surface shall be clean and dry. Spraying shall not be done unless the road temperature is above twenty (20) degree C for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than twenty (20) degree C during the spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the surface and surface shall be primed as per item 302. If so directed by the Engineer, the surface shall be cleaned by power brooming or wire brush until all loose and foreign materials are removed.

304.3.1 Equipment

Equipment shall conform in all respects to the provisions under Item 302.3.1. The equipment shall be operated by the manpower specially trained for this work. Necessary safety arrangement for the workers, equipment and traffic shall be ensured during the operations.

304.3.2 Preparation of Surface

Irregularities and surface damage e.g. pot-holes, depressions, raveling, shall be corrected prior to surface dressing. The Engineer shall also satisfy himself that fundamental pavement defects e.g. base failure, drainage problems etc. have been remedied before surface dressing is attempted. Areas, which are excessively rich in bitumen e.g. 'bleeding', shall be cut out and patched. All patches, however, occasioned shall be thoroughly compacted, sealed and blinded with crusher dust before opening to traffic for several days before surface dressing commences.

Immediately prior to the application of binder all dirt, dust are foreign material shall be removed by thorough brooming and / or the use of compressed air. Adhering mud or other soiling may be removed using water and brushes, the general use of water to wash the road shall not be permitted.

304.3.3 Application of Asphaltic Materials

Asphalt cement, liquid asphalt and emulsified asphalt shall be applied by means of pressure distributor manual or automatic at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the ranges given in Table 304-1.

The spread of bituminous materials shall be at least ten (10) cm more than the width to be covered by the aggregate from the spreading device. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface. The length of spread of bituminous material shall not exceed than that which trucks loaded with cover coat material can immediately cover. Under no circumstances shall operations proceed in such manner that bituminous material will be allowed to chill, set up, dry, or otherwise impair retention of the cover coat.

The distributor when not spreading shall be so designed that the spray bar or mechanism will not drip bituminous material on the surface of the traveled way. Distribution of the bituminous material shall be so regulated and sufficient bituminous material left in the distributor at the end of each application, so that there will be a uniform distribution of bituminous material. In no case shall the distributor be allowed to expel air with the bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is ensured. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

304.3.4 Spreading of Aggregate

Immediately after applying the asphaltic material, dry aggregate shall be uniformly and evenly distributed over the treated surface from an approved mechanical aggregate spreader or any other means approved by the Engineer. The truck carrying the aggregate shall move backward as it spreads same, so as to prevent the tyres of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt. No portion of the binder shall remain uncovered for a period in excess of twenty (20) minutes after spraying.

Immediately after spreading of the aggregate, the treated surface shall be rolled with a self-propelled pneumatic-tyre roller having a minimum contact pressure of 2.8 Kg/square centimeter. A steel-wheeled roller weighing between six (6) to eight (8) tons may be used as a second roller. Rolling shall continue only until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping, or turning of any piece of equipment which results in displacement of the cover material or damage to the seal courses be prohibited.

Any place where binder shows on the surface shall be covered with additional aggregate and further rolled and broom dragged until an even surface result, and does not adhere to wheels of vehicles. Overlapping the applications of cover material shall be avoided and all spillage shall be removed from the surface.

The quantity of aggregates to be applied shall be within the ranges specified in Table 304.1.

304.3.5 Maintenance of Traffic

Detouring of highway traffic for this work on running road will not be provided for or permitted, except when authorized by the Engineer. All construction operations shall be coordinated to result in the least practicable delay of traffic. One way traffic shall be maintained and traffic speeds restricted to fifteen (15) Km per hour. The contractor shall provide flagmen, warning signs, barricades, and a sufficient number of pilot cars to control traffic through the bituminous sealing operations when so directed by the Engineer. Pilot cars shall be used to lead the traffic through the areas of all distribution and sealing operations. Pilot cars shall be light "Pick up" trucks or other approved vehicles and shall be equipped with signs reading "PILOT CAR - DO NOT PASS" in both English and Urdu languages. Two (2) signs shall be mounted on the vehicles so as to be clearly visible from both directions. One (1) flagman shall be stationed immediately ahead of the application of the bituminous material and one (1) flagman immediately behind the section being rolled. Suitable speed limit signs shall be displayed, and the signs shall move forward with the flagman as the work progresses.

No separate payment shall be made for conformance to this paragraph. All these items being considered subsidiary to the item (s) given in the Bill of Quantities.

304.3.6 Working Period

All work shall be so conducted that the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favorable weather conditions as determined by the Engineer.

304.3.7 Maintenance of completed work

When directed by the Engineer, the Contractor will be required to add bituminous material or aggregate or both to the portion of road identified for such purpose on the project. Furnishing additional bituminous material and furnishing, spreading, dragging and rolling of additional aggregate will not be paid for separately but will be considered as subsidiary work pertaining to the relevant item of "Bituminous Surface Treatment".

304.3.8 Opening to Traffic and after-care

There shall be no delay in opening a completed surface dressing to traffic at a controlled speed. Prior to opening to traffic any spillage of aggregates shall be removed and any binder drips or wind blown contamination shall be dusted with crusher waste. After 2-3 days under traffic, excess stone will be removed by brushing.

304.3.9 Pad Coat

To ensure chipping retention when surface dressing a very hard surface, a pad coat consisting of application of an initial binder spray followed by 6 mm. chipping will be applied. After stabilizing of pad coat under traffic, the appropriate surface dressing will be applied.

304.4 MEASUREMENT AND PAYMENT

DELETED

TABLE 304-1

Quantities of Materials for Bituminous Surface Treatments

Surface Treatment		Aggregate		Bituminous Material	
Type	**Application**	**Size No.**	**Quantity (Kg./ Sq.M.)**	**Quantity (Litres / Sq.M.)**	**Type**
Single	Single	2	12.5	1.19	(a)
				1.63	(b)
Double	First	1	24.0	1.90	(a)
				2.14	(b)
	Second	3	12.5	1.19	(a)
				1.63	(b)
Triple	First	1	24.0	1.90	(a)
				2.14	(b)
	Second	2	12.5	1.19	(a)
				1.63	(b)
	Third	3	6.5	0.68	(c)
Seal Coat / Pad Coat with Aggregate		4	4	0.5	(c)

Notes:

i) Bituminous material types are (a) asphalt cement, (b) cut-back or emulsified and (c) asphalt cement, cut-back and emulsified.

ii) Quantities of bituminous material may be varied by the Engineer by ± 15% depending on site conditions.

iii) Prime coat shall be applied prior to the surface treatment for the newly constructed pavement at the rate as specified in the item 302.3.2.

ITEM 305 ASPHALT WEARING COURSES – HOT PLANT MIX

305.1 DESCRIPTION

This work shall consist of furnishing and mixing aggregates, asphalt binder and additive material (where required) at a central asphalt mixing plant, to a specified temperature, hauling, including loading unloading, laying and compacting the mixture on an approved primed or tacked base, bridge deck or concrete pavement in accordance with these Specifications and in conformity with the lines grades and typical cross-sections shown in the Drawings or as directed by the Engineer.

305.2 MATERIAL REQUIREMENTS

305.2.1 Asphalt Material

Asphalt Binder for Wearing Course shall be 60/70 penetration grade conforming to requirement in Table 301-2 section Asphaltic Materials in these Specifications.

When penetration grade asphalt 60/70 is used, the optimum ratio between bituminous material and filler shall be so determined that the bituminous filler mixture will reach its softening point, not less than eighty five (85) degree centigrade when tested in accordance with AASHTO T 53.

305.2.2 Mineral Aggregates

Mineral aggregates shall consist of coarse aggregate, fine aggregate and crushed rock filler material.

The coarse and fine aggregates shall be clean, hard, durable and sound particles of uniform quality, free from decomposed material, organic material, clay lumps or other deleterious substances.

The coarse aggregate which is the material retained on sieve No. 4 (4.75mm) shall consist of crushed rock 100 % particles having all faces fractured mechanically. The working face of the quarries from which mineral aggregates are being extracted shall be acceptably uniform and be free from layers, veins or intrusions of weathered rock, soil or other unsuitable minerals.

Rock to be crushed for use as bituminous concrete aggregate, shall be screened in such a manner that all material to be crushed is retained on a 75 mm (3″) screen.

Fine aggregate which is material passing an AASHTO No. 4 sieve (Khaka / Stone dust), shall consist of 100% crushed limestone from rock having all faces fractured. Fine aggregate shall be stored separately. Natural sand shall not be used in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing the AASHTO No. 200 sieve, supplemental fine aggregate shall be mineral filler consist of finely divided rock dust including dust from the plant dust collection system or cement free of deleterious material conforming to the following grading:

Standard Sieve Size AASHTO	Percentage Passing by Weight
No. 30	100
No. 50	95-100
No. 200	70-100

Mineral filler, at the time of use, shall be dry, free flowing, without lumps or agglomerations and conform to the requirements of AASHTO M-17.

The ratio of filler to binder should range from 1.0-1.5

The coarse and fine aggregates shall meet the following requirements:

a) The coarse aggregate shall have a percentage loss by the Los Angeles Abrasion test (AASHTO T-96) of not more than thirty (30) percent.

b) The coarse aggregates and fine aggregate shall have a Specific Gravity Value of not less than 2.65 & 2.60 respectively and value for absorption of water not more than 2% as determined by AASHTO T 84 and T 85.

c) The material shall have a loss of less than ten (10) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T-104.

d) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45)

e) The fine fraction of the material shall have a liquid limit not more than twenty five (25) and a plasticity index (as determined by AASHTO T-89 and T-90) not greater than three (3). The plasticity index of mineral filler should not be more than four (4).

f) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than twelve percent (12 %) flat and/or elongated particles (ratio of maximum to minimum dimensions = 3:1) or as determined in accordance with ASTM D 4791, standard test method for flat and/or elongated pieces.

g) The coarse aggregate when tested by the Coating and Stripping Test (AASHTO T-182) shall have a coated area above 95 percent. In addition to this test, a test for coating and stripping shall be run after submerging the coated material in water at 60^{o} C for 96 hours. The aggregate in this test shall have a coated area of above 80 percent.

h) Petrographic examination of the coarse aggregate is mandatory for the approval of source. The coarse aggregates shall be checked for cationic and anionic behavior so that their affinity with the bitumen is verified.

305.2.3 Asphalt Concrete Wearing Course Mixture

The grading of combined aggregates prior to addition of bituminous material shall conform to gradation requirements within the following range:

Combined Aggregate Grading Requirements as per ASTM D 3515

Standard AASHTO Sieve Sizes	Percentage Passing by Weight	
	Class A	Class B
1″ (25.0 mm)	100	-
3/4″ (19.0 mm)	90 – 100	100
½" (12.5 mm)	-	90 - 100
3/8″ (9.5 mm)	56 – 80	-
No. 4 (4.75 mm)	35 – 65	44 - 74
No. 8 (2.36 mm)	23 – 49	28 - 56
No. 50 (0.3 mm)	5 – 19	5 - 21
No. 200 (0.075 mm)	2 – 8	2 - 10

The minimum binder content shall be 3.5 percent by mass of total weight of mix. “The

grading limits specified are based on materials of uniform specific gravity and shall be adjusted by the Engineer to compensate any variation in specific gravity of individual sizes. The grading may be varied by the Engineer on the basis of Marshall Tests to obtained optimum stability and life of completed Asphalt Concrete Pavement. Limits determined by Fuller Equation (MS – 2) should be avoided".

The asphalt concrete wearing course mixture shall meet the following Marshall Test Criteria:

Compaction (number of blows each end of specimen)	75
Stability (minimum) 30 minutes/60^{0}C	1200 kg
Flow, 0.25 mm (0.01 inch)	8 – 14 (2 – 3.5)
Percent of air voids in mix	3 – 5
Minimum voids in mineral aggregate	According to Table 5.3 MS-2, Asphalt Institute, sixth edition 1993
Percent Voids filled with Asphalt	60 – 75
Loss of stability (maximum)	20

305.2.4 Asphalt Concrete Job-Mix Formula (JMF)

At least eight (8) weeks prior to commencement of asphalt production, the Contractor shall start the tests for the design of a proposed JMF as described in Subsection 305.2.3 above. At least one (1) week prior to production, a JMF for the asphalt mix to be used shall be established jointly by the Contractor and the Engineer.

The JMF shall be established by Marshall Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), Oct; 1993 Edition or the latest edition with the following recommendations taken into account:

The JMF, with the allowable tolerances shall be within the range specified in Item 305.2.3 and herein. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

- Marshall mixing temperature shall be one hundred and sixty plus/minus five (160 ± 5) degree centigrade at which heated asphalt produces a kinematic viscosity one hundred and seventy plus/minus twenty (170 ± 20) centi stoke.

- Marshall compacting temperature shall be one hundred and forty five plus/minus five (145 ± 5) ^{o} C at which heated asphalt produces a kinematic viscosity of two hundred and eighty plus/minus thirty (280 ± 30) centi stoke.

- The combined aggregate gradation should produce a smooth curve parallel to the specified envelope and be adjusted within the allowable limits to achieve maximum stability whilst not going below the minimum requirement for void content.

- The minimum bitumen binder content according to the results of the Marshall Method of Mix Design should be used provided that it will still satisfy the durability, the stability and the void content requirements.

- The optimum asphalt content shall be based on the percent asphalt content having at least 4.0% air voids for wearing course. The asphalt content thus determined shall be used to check for compliance for stability, flow and voids filled, etc. as per the specifications. Minimum coating of bitumen film on aggregate should be 8 micron.

- Prior to final approval, the proposed job mix, with a bituminous content at the permissible upper percentage limit, shall be compacted to refusal, (400 to 600 blows) and the resulting voids in the mix shall not be less than 2%.

Once JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto Moreover upon receiving the job-mix, approved by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that when compared to job mix formula shall be within the following limits.

Tolerances for Job-Mix Formula:

Sieve Size	**Tolerance %**
19 mm (3/4") and larger	± 5
9.5 mm (3/8") and 4.75 mm (No. 4)	± 5
2.36 mm (No. 8)	± 4
300 µm (No. 50)	± 3
75 µm (No. 200)	± 1
Asphalt Content (weight % of total mixture)	-0.2 % to +0.2 %

In addition to meeting the requirements specified in the preceding items, the mixture as established by the JMF shall also satisfy the following physical property.

Loss of Marshall Stability by immersion of specimens in water at sixty (60)^{o}C for twenty four (24) hours as compared with the stability measured after immersion in water at sixty (60)^{o}C for twenty (20) minutes shall not exceed twenty (20) percent. If the mixture fails to meet this criterion, the JMF shall be modified or an approved anti-stripping agent shall be used. No payment shall be made for anti stripping agent.

Test results along with samples shall be presented to the Engineer for verification and final approval of JMF.

Should a change of source of materials be made, a new JMF shall be established before the new material is used. Also, if results or other conditions make it necessary a new JMF will be required.

The density of the compacted mixes shall be related to the daily Marshall Density which shall be determined by making six standard Marshall Specimens from samples of the mix taken from behind the paver. The density of each sample shall be determined and compared with the mean value. Any individual result which varies from the mean by more than 0.015 gm/cc shall be rejected. Marshall Test shall be repeated on daily basis to establish daily Marshall Density for that particular day's work or one sample for 500 T production. The daily Marshall Density shall not vary from the Job Mix Design Density by more than ± 1.0%. Loss of stability shall be tested on other three Marshall Specimens from samples of the mix taken from behind the paver.

The assistance of the Engineer in the preparation of the job standard mix in no way relieves the Contractor of the responsibility of producing a bituminous mix meeting the requirements of the Specifications.

The compliance criteria contained in the Job Mix Tolerances provide an indication of the maximum acceptable value of the standard deviation for each parameter. If asphalt mix shows variation in excess of these limits, the source of variation shall be determined by the contractor and rectified by him to the satisfaction of the Specifications and the Engineer. If the excessive variations continue, the Engineer shall order stoppage of production and laying for the Works, until the Contractor has demonstrated his ability to re-establish acceptable control.

305.3 CONSTRUCTION REQUIREMENTS

305.3.1 Asphalt Mixing Plant

As per Subsection 203.3.1 of these Specifications.

305.3.2 Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphalt concrete shall be separated into two or more sizes and stored separately in cold bins. One bin shall contain aggregate of such size that eighty (80) percent will pass a 2.36 mm sieve and the other bin shall contain aggregate of such size that eighty (80) percent will be retained on the 2.36 mm sieve. Should fine material be incorporated in the mix, a separate bin shall be provided in addition to the two bins mentioned above. If filler is used as a separate component it shall also be stored and measured separately and accurately before being fed into the mixer.

Asphalt cement shall be heated within a temperature range of one hundred and thirty five to one hundred and sixty three (135-163) ^{o}C at the time of mixing. All material heated above the maximum shall be considered overheated and shall be rejected and removed from job site.

Dried aggregate weighed and drawn to pugmill shall be combined with proper amount of asphalt cement according to the job mix formula. The temperature of asphalt, except for temporary fluctuations, shall not be lower than fifteen (15) ^{o}C below the temperature of the aggregate, at the time the two (2) materials enter into the pugmill.

In placing the materials in bins or in moving those from bins to the mixer, any method which causes segregation or uncontrolled combination of material of different grading, shall be discontinued.

Each aggregate ingredient shall be heated and dried at a temperature not to exceed one hundred and seventy (170) degree centigrade. If aggregates contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of one hundred and seventy (170) degree centigrade, they shall be removed from the bins and returned to their respective stock piles. In no case shall the temperature of an asphalt mix exceed one hundred and sixty five (165) degree centigrade when discharged from the pugmill.

Immediately after heating, the aggregates shall be screened to required sizes and stored in separate hot bins for batching and mixing with bituminous material.

305.3.3 Hauling Equipment

As per subsection 203.3.3 of these Specifications.

305.3.4 Laying (Spreading)

Unless otherwise directed by the Engineer, where successive layers are to be placed, the surface of existing layer shall be swept, cleaned with a power broom, or by other means as approved by the Engineer, and a tack coat is applied. Tack coat shall not be required between two lifts of Asphalt courses when previous lift is less than one day old.

Asphalt mixture shall be laid using self-contained, power-propelled units. The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed. It will be provided with an automatically controlled activated screed or strike-off assembly, fitted with heaters, capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and uniform thickness, required evenness and texture without tearing, shoving or gouging the mixture shown on the plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing course

of Asphalt plant mix material in widths shown on the plans. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated continuously without stoppage to ensure an even and uniform flow of material across full carriageway width, free from dragging or tearing and without segregation of the material.

When laying the mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture. The paver shall be operated at speeds which will give the best result for the type of power being used.

The mixed material shall be delivered to paver in time to permit completion of paving, finishing and compaction of mixture during day light hours.

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope. The sensor shall be so constructed that it will operate from a reference line or a ski-like arrangement. When the finish of the grade prepared for paving is superior to the established tolerance and, when in the opinion of the Engineer, further improvement to the line, grade, cross sections and smoothness can best be achieved without the use of the reference line; a ski-like arrangement may be substituted subject to the approval of the Engineer. The use of the reference lines shall be reinstated immediately whenever the Contractor fails to maintain a superior paving. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory operation of the automatic control equipment.

The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.

Manual operation will only be permitted in the construction of irregularly shaped and or minor areas.

Whenever a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the contractor to use the asphalt already produced at the plant or in transit, provided this method of operation will produce results otherwise meeting the Specifications.

Asphalt material which is hotter than one hundred and forty (140) degree centigrade shall not be laid or deposited on bridge deck waterproofing systems unless precautions against heat damage have been agreed by the Engineer.

Asphalt concrete pavement wearing course shall not be placed on any wet or frozen surface, during rain, dust or sand storms, when wind or other weather conditions prevent the proper handling of the Asphalt mixtures or when atmospheric temperature is five (5) degree centigrade or less. Care should be taken during spreading operation under windy condition in winter, even if temperature is above five (5) degree centigrade.

The spreading operations should be immediately terminated if it begins to rain during the operation.

Hand laying of any Asphalt material will be permitted only in the following circumstances:

a) For laying regulating courses of irregular shape and varying thickness;

b) In confined spaces where it is impracticable for a paver to operate;

c) For footways;

d) At the approaches to expansion joints at bridges or viaducts;

305.3.5 Joints

Longitudinal joints for each course shall be offset thirty (30) centimeters from the joint in the immediate underlying course. Transverse joints shall be offset a minimum of sixty (60) centimeters from the joint of the immediate underlying course.

The Contractor will use either full width paver or two pavers in unison to avoid any longitudinal joints within the pavement width. However, where it becomes unavoidable due to break down of paver, the Contractor will ensure the leading half of half-roadway paving shall not get ahead of the trailing half of the pavement by more than half a kilometer ahead of the trailing half.

Longitudinal joints in wearing course shall, after cutting back, be of good alignment and preferably coincident with the position of carriageway markings. Except where laying in echelon, joints in wearing course shall be cut back to a vertical face and tack coated. Kerb faces, ironwork and the like in contact with wearing course shall be tack coated prior to laying of wearing course.

Longitudinal joints shall be located within fifteen (15) centimeters of the centerline of the roadway or within fifteen (15) centimeters of the centerline of a lane. Longitudinal joints shall be held to the minimum practical number. Longitudinal joints shall be formed by lapping the screed over the first layer placed, crowding a ridge of Asphalt material at the joint and crimping the ridge of material into the joint by a compaction roller while the material is hot.

Transverse joints shall be formed by cutting back the first layer placed to the full depth of the layer, removing and wasting the material, spreading new Asphalt material in sufficient quantity to create a compacted thickness equal to the thickness of the first layer. The joint shall be cross rolled with one coverage and the joint checked with a straight edge not less than four (4) meters in length. High points shall be removed and sags filled with additional Asphalt material and the joint rolled a second time. The joint shall again be checked with a straight edge, humps and sags adjusted as necessary, and rolled until the joint is complete and compacted as specified.

The outer edges of wearing course shall be cut back to a good alignment, parallel with the road alignment. This will require a small additional width of wearing course to be laid and cut back.

No payment shall be paid for this additional width and for all cutting back of wearing course. Tack coating of vertical faces will not be measured for payment.

305.3.6 Preparation of Base or Existing Pavement Surface

Before spreading materials, the surface of base or existing pavement on which the mix is to be placed shall be conditioned by application of a tack coat as specified.

After a tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the mix. The tack coat shall be applied only as far in advance of the placing of mix, as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired.

A thin coating of asphalt material shall be sprayed on contact surface of curbing, gutters, manholes, and other structures, prior to the asphalt mixture being placed against them.

305.3.7 Rollers

Rollers shall be steel wheel, pneumatic tyred and vibratory, or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the asphalt mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. Vibratory rollers shall be acceptable for

asphalt mixture compaction. The use of equipment, which results in excessive crushing of aggregate, will not be permitted.

305.3.8 Compaction

Asphalt material shall be laid and compacted in layer thicknesses which enable surface level and regularity requirements to be met and adequate compaction to be achieved. The maximum thickness of wearing course material laid in one pass of the paver shall be 5 cm.

When production of the mixture can be maintained and wherever practical, pavers shall be used in echelon to place the wearing course in adjacent lanes and compacted to form a surface without lateral joint.

All mixtures shall be spread at a temperature of not less than one hundred and forty five plus/minus five (145 + 5) degree centigrade.

Material shall be uniformly compacted as soon as rolling can be effected without causing undue displacement of the mixed material and shall be substantially completed while the temperature of the mixed material is greater than hundred twenty (120) degree centigrade. Rolling shall continue until all roller marks have been eliminated from the surface.

The density achieved shall be not less than 97 percent of the Marshall Density of each day's production.

Relevant test methods for density of bituminous concrete in place by Nuclear Methods such as ASTM D 2950 (latest version) and or other method as directed by the Engineer shall be used to establish the proper rolling effort and pattern to achieve the required density and to ensure achieving the specified percent compaction during the placement of the bituminous concrete as quality control testing. A calibration factor for the Nuclear Method must be established as per the equipment's manufacture's requirements, and at any time a change is made in the paving mixture, in construction process or after every fifteen days of asphalt production which ever is earlier. Compare the results obtained to samples compacted to Marshall Density to determine percentage of compaction.

Compaction shall be carried out using 8-10 tonne dead weight smooth wheeled rollers or by multi-wheeled pneumatic tyred rollers of equivalent mass, or by vibratory rollers or a combination of these. Wearing and base courses material shall always be surface finished with a smooth wheeled roller which may be a dead weight roller or alternatively a vibratory roller in non-vibrating mode. Vibratory rollers shall not be used in vibrating mode on bridge decks.

Vibratory rollers may only be used if they are capable of achieving at least the standard of compaction of 9-tonne dead weight roller to meet the specified percent compaction of Marshall Max. Density, and shall be equipped or provided with devices indicating the frequency at which the mechanism is operating and the speed of travel which can be read from the ground.

Three steps of rolling are as follows:

i) Breakdown Rolling

Breakdown Rolling may be accomplished with static or vibratory steel-wheeled rollers.

It is important to start the rolling operation on the low side of the mat (usually the outside of the lane being paved) and progress toward the high side. The reason is that hot mixtures tend to migrate toward the low side of the mat during compaction. If rolling is started on the high side, migration is much more pronounced than if rolling starts from the low side. When adjoining lanes are placed, the same rolling procedure

should be followed but only after compaction of the longitudinal joint.

ii) Intermediate Rolling

Intermediate rolling should follow breakdown rolling as closely as possible, while the asphalt mix is still well above the minimum temperature at which densification can be achieved.

Intermediate rolling should be continuous until all of the mix placed has been thoroughly compacted. Regardless of the type of rollers used, the rolling pattern should be developed in the same manner as for breakdown rolling.

iii) Finish Rolling

Finish rolling is done solely for the improvement of the surface. It should be accomplished with steel-tired, static-weight tandems or vibratory tandems without vibration while the material is still warm enough for removal of roller marks.

The material shall be rolled in a longitudinal direction with the driven rolls nearest the paver. The roller should first compact the material adjacent to any joints and then work from the lower to the upper side of the layer overlapping on successive passes by at least half the width of the rear roll or in the case of a pneumatic tired roller, at least the nominal width of one tyre.

The smoothness of the surface and its good acceptable ridability as specified shall be adhered. Following points need special attention:

a) Variation in the surface on which the asphalt course is laid shall be free from variations and be well within the allowable tolerances.

b) The asphalt laid through the pavers will be checked immediately after initial rolling and defects will be rectified as required.

c) Frequent stopping/starting of paver is not allowed. Paver speed should be adjusted to average rate of delivery of material, even if some trucks are delayed in dumping loads. If stop cannot be avoided, the section of pavement at the location of stop should be checked by straightedge before and after compaction.

d) Joint should be checked with a straightedge immediately after construction and corrections made while the material is still hot. All corrections should be made with a lute. Rakes should be used only for loosening material. Poor joints must be corrected immediately, later grinding of high spots is a poor substitute for proper construction.

e) The paver should be adjusted so that back casting of fill in low spots is not required.

f) Irregular rolling or letting the roller stand on hot pavement is not allowed.

g) Non-uniform asphalt mixture shall not be allowed.

h) Pulling of mat by screed of the paver is not allowed. This results in regularly spaced, very small, cracks in mat. The compacted mat is thinner in the vicinity of cracks due to lack of material, resulting in a corrugated surface.

i) If the truck brakes are set too hard or the paver is bumped by a truck, irregularities occur. Truck should stop before hitting the pavers.

j) Non-uniform temperature of material is not allowed. Cold loads do not compact to the same thickness as hot loads. The temperature of each load should be checked for uniformity as per specifications before dumping.

k) Frequent adjustment of screed controls is undesirable. Sometimes paver crews

constantly change the screed controls manually in order to maintain a uniform thickness. The result is poor riding quality.

l) Ridability of the paved surface shall be checked regularly as per 305.3.10.2.

305.3.9 Trial Areas

At least 3 days before material from each source of the asphalt concrete is first laid in the Works, the Contractor shall lay a trial area to demonstrate the compaction plant and rolling procedure selected by him for achieving the specified density.

a) The trial shall be not less than 200 m in length and of a width to be approved by the Engineer. If the trial area complies with these Specifications it may form part of the permanent Works;

b) For the trial the Contractor shall use the materials, mixing and laying plant proposed for the main works.

Where the required level of compaction is not achieved the trial area shall be removed and the trial repeated.

The Engineer shall approve test results and general performance of test area before actual commencement of the work.

305.3.10 Surface Tolerances

305.3.10.1 Surface Test by Straightedge

After completion of final rolling, the finished surface shall be tested for smoothness with five (5) meters straightedge by the Engineer at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts shall be determined by placing it parallel and perpendicular to centerline of roadway and value thus determined should not vary more than limits prescribed by “Table for Allowable Tolerances” in the Specifications.

305.3.10.2 Surface Test by Profilograph

The smoothness of pavement will meet the following criteria as determined by a profilograph, over each designated lane, by ASTM Designation E-1274 (Reapproved 1993).

The Contractor shall furnish paving equipment and employ methods that produce a riding surface having a profile index of 175 mm per 1600 m or less. The profile will terminate 5 m from each bridge approach pavement or existing pavement that is joined by the new pavement. Excluded from testing will be acceleration and deceleration lanes, storage lanes for turns, crossovers shoulders, side streets or side road connections under 150 m in length, and sections less than 15 m.

Pavement profiles will be taken 1 m from and parallel to each edge of pavement for pavement placed at a 4 m width or less. When pavement is placed at a greater width than 4 m, the profile will be taken 1 m from and parallel to each edge and from the approximate location of each planned lane marking. Added profiles may be taken only to define the limits of an out-of-tolerance surface variation.

During the initial paving operations, either when starting up or after a long shutdown period, the pavement surface will be tested with the profilograph as soon as the final rolling has been completed. Initial testing will be used by the Contractor and the Engineer to evaluate the paving methods and equipment.

After the initial pavement smoothness, paving methods, and paving equipment are acceptable to the Engineer, the Contractor may proceed with the paving operation. After

initial testing, profiles of each day's paving will be run prior to continuing paving operations and prior to opening the pavement to public traffic.

A daily average profile index will be determined for each day's paving. A day's paving is a minimum of 160 m of full-width pavement placed per day. If less than 160 m is paved, the day's production will be grouped with the next day's production. If an average profile index of 300 mm per 1600 m is exceeded in any daily paving operation, the paving operation will be suspended and will not be allowed to resume until the Contractor takes corrective action. If paving operations are suspended because of the average profile index exceeding 300 mm per 1600 m, subsequent operations will be tested according to the initial paving testing procedures.

For determining pavement section where corrective work or pay adjustments will be necessary, the pavement will be evaluated in 160 m sections using the profilogram. Within each 160 m section, all areas represented by high points having deviations in excess of 10 mm in 8 m or less shall be corrected by the Contractor. After correcting individual deviations in excess of 10 mm in 8 m, corrective action shall be made to reduce the profile index to 250 mm per 1600 m or less. In addition, any 160 m section including bumps having an initial profile index in excess of 300 mm per 1600 m shall be corrected to reduce the profile index to 250 mm per 1600 m or less.

Overlaying for the corrective work

Asphalt concrete pavement overlays shall consist of asphalt concrete pavement materials meeting the Contract requirements. The overlay lift shall extend the full width of the underlying pavement surface and have a finished compacted thickness sufficient to correct the roughness and produce a final surface meeting specified surface tolerance. If the overlay does not meet the longitudinal smoothness requirement, the same shall be re-laid by the Contractor as directed by the Engineer. All the corrective action including the resultant overlays shall be to the Contractor's cost.

Removing and Replacing

Corrections made by removal shall be replaced by asphalt concrete pavement materials meeting the contract requirements.

305.3.11 Wearing Course Thickness Tolerance

The asphalt concrete wearing course shall be compacted to the desired level and cross slope as shown on the drawing or as directed by the Engineer.

The tolerances in compacted thickness of the wearing course shall be $\pm$ 3 mm from the desired thickness shown on the drawings. For determination of thickness one (1) core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in Table-1, clause 305.4.2.(2) of these Specifications.

The surface of the wearing course shall be tested by the Engineer using a 5 meters straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point exceed five (5) millimeters. The cross fall (camber) shall be with $\pm$ 0.2 percent of that specified, and the level at any point shall be within $\pm$ three (3) mm of the level shown on the Drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer.

305.3.12 Acceptance of Sampling and Testing

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer).

Acceptance of sampling and testing for this item with respect to materials and construction requirements, not specified herein, shall be in accordance with the relevant "Tables for Sampling and Testing Frequency" in these Specifications.

305.3.13 Surface Smoothness

The completed asphalt wearing course shall be compacted as specified, smooth, free from ruts, humps or depressions, or irregularities. Any ridges, indentations, roller checking, or other objectionable marks left in the surface, as determined by the Engineer, shall be eliminated by whatever means are necessary and approved by the Engineer. The use of any equipment that leaves ridges, indentations or other objectionable marks shall be discontinued.

Allowable tolerances for riding quality/smoothness of finished asphalt concrete wearing course are stated in “Table for Allowable Tolerances” and Subsection 305.3.10.2 in these Specifications.

305.3.14 Frequency of Testing of Cores for Compaction

One core shall be taken for each 100 linear meter of each lane of Asphalt Base, or fraction thereof, in special cases. If the core so taken fail against the density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) metres on either side with respect to the failing core and shall be tested against field density. If these cores pass, then the individual compaction of the core shall not be less than ninety six (96) percent and the average of these three cores, in no case shall be less than ninety seven (97) percent. If the average of the cores further fails against compaction, then further cores shall be taken at a distance of fifteen (15) metres on either side and shall be checked in the same fashion. In case of failure of the average of these five cores, the failed area shall be removed and subsequently be replaced by the specified mix in an approved manner at the expense of the Contractor.

ITEM 306 SHOULDER TREATMENTS

306.1 DESCRIPTION

This work shall consist of constructing shoulders of the types specified hereinafter in accordance with the specifications and- in conformity to the lines, grades thickness and typical cross-sections shown on the plans or established by the Engineer.

306.1.1 Definition of Shoulders

That portion of the completed road construction which lies above the elevation of the subgrade or sub-base and which extends from the edge of the wearing course to the point of inter-section with the embankment slopes on either side of the road centerline.

306.2 MATERIAL REQUIREMENTS

306.2.1 Earth Shoulders

The material used for "Earth Shoulders" shall consist of suitable materials from roadway or structural excavation supplemented by additional suitable material from borrows excavation or as designated on the plans and shall be obtained from sources approved by the Engineer.

306.2.2 Aggregate Shoulders

Material used for "Aggregate Shoulders" shall be of class designated on the plans and shall conform to all the requirements of item 201, "Granular Subbase", item 202, "Aggregate Base Course" or item 206, "Water Bound Macadam Base".

306.2.3 Soil Cement Stabilized Shoulders

Material for soil cement shoulders shall conform to all the requirements of item 204, "Soil Cement Stabilized Subbase or Base".

306.2.4 Asphaltic Materials

Materials for surface treatment of shoulders shall be liquid asphalts, emulsified asphalts or asphalt cement as specified or shown on the drawings and in the Bill of Quantities. Asphaltic materials shall conform to all the requirements of item 301 for the type specified.

306.3 CONSTRUCTION REQUIREMENTS

306.3.1 General

All shoulders shall be formed and compacted as soon as practicable after the asphalt paving on the traffic lanes is completed, however in the case of cement concrete surfacing, shouldering operation shall not be initiated prior to Engineer's approval.

306.3.2 Shouldering and delineation

On projects that carry traffic through construction, the contractor shall begin shouldering on the second day of the laying of the final roadway surfacing layer, unless weather conditions prevent this operation, in which case the shouldering shall begin as soon as the weather does permit. If the contractor fails to begin the shouldering within a reasonable time after the last layer has been laid, whether the project has a flow of traffic through construction or not, the Engineer may order the contractor to cease paving until

the shoulder work has begun. The shouldering shall be a continuous operation from that time on until completion, with the weather being the only delaying factor. The Contractor shall, on roads under traffic or as directed by the Engineer, delineate the edge of pavement as soon as the surfacing is begun and maintain the delineation until the shoulders are completed. The delineators shall be approved prior to use and shall be placed at the edge of the surfacing at approximately one hundred (100) meter intervals. The cost of this delineation will be considered subsidiary to other items in the Bill of Quantities and will not be paid for directly.

306.3.3 Earth Shoulders

Earth shoulders shall be constructed in accordance with the applicable paragraphs under Item 108.

306.3.4 Aggregate Shoulders

Aggregate shoulders shall be constructed in accordance with the requirements of Item 201, 202 or 206 whichever is shown on the drawings.

306.3.5 Soil Cement Stabilized Shoulders

Soil cement stabilized shoulders shall be constructed in accordance with the requirements of item 204.

306.3.6 Asphaltic Treatment of Shoulders

The asphaltic treatment of the prepared shoulders shall be either a bituminous surface treatment or seal coat or a layer of asphaltic concrete as shown on the plans or in the Bill of Quantities. Detailed construction procedures for the particular treatment specified are outlined under item 203, 304, or 305.

ITEM 307 BIT - MAC

307.1 DESCRIPTION

This item shall consist of furnishing and mixing aggregates with asphalt binder at site in mobile mixing plant, spreading, compacting on an approved primed subgrade, subbase or base course, for potholes repair, leveling course and wearing course in accordance with the specification and in conformity with the lines, grade, thickness and typical cross-section shown on the Drawings or as directed by the Engineer including sealing of cold bituminous surface cracks with sand-bitumen slurry.

307.2 MATERIAL REQUIREMENTS

307.2.1 Mineral Aggregate

Mineral aggregates for BIT-MAC Construction shall consist of coarse aggregates, fine aggregate and filler material, all conforming to the following specification requirements:

a) Coarse aggregate which is the material retained on No. 4 Sieve and Passing 25.4 mm sieve, shall consist •")f crushed rock crushed boulder, or crushed gravel. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shales, clay lumps or other deleterious substances. Rock or boulders, from which coarse aggregates shall be obtained, must be of uniform quality throughout the quarry location.

b) Fine aggregates which is the material passing No. 4 sieve shall consist of crushed sand.

c) When combined gradation of coarse and fine aggregates is deficient in material passing No. 200 sieve, mineral tiller shall be added. The filler material shall consist of finely divided rock dust from sound rock, hydrated lime or hydraulic cement. At the time of use it shall be sufficiently dry to flow freely, free from lumps.

Aggregate should be stored on hard clean surface so as to facilitate prompt inspection and control. Private property shall not be used for storage purposes without written consent of the owner or lessee and payment to him by contractor, if necessary. Material shall be stored in such a way as to prevent segregation and coning to ensure proper control of gradation. The equipment and methods used for stockpiling and removing aggregates shall be such that no degradation of aggregate will result and no appreciable amount of foreign material will be incorporated into the aggregate. When aggregates containing a wide range of sizes are to be incorporated, they must be stockpiled separately to prevent intermingling. Mineral Filler must be protected from moisture to eliminate caking and hardening.

307.2.2 Bituminous Binder

Asphaltic binder used shall conform to standard specification of petroleum asphalt having grades 60-70 or 80-100 penetration. Generally it will meet the requirement of AASHTO M-20, Table 301-2. .

307.2.3 Design Characteristics

Optimum Grading Curves for different types of hot mix asphaltic design related to quantum of repair work and maximum size of aggregates, given in Table 307.2-A, must be carefully selected considering average thickness of patches.

Design sheet under table No. 307.2.A showing Dense Graded Mix used for leveling courses and potholes should use little asphalt content of such quantity to prevent

bleeding through subsequent wearing course or surface treatment. Design sheet under table No. 307.2.B. is suitable for open graded wearing course having rough surface texture with good skid resistance thus having minimum bleeding tendency.

307.3 CONSTRUCTION REQUIREMENTS

307.3.1 Mixing Requirement

Asphalt cement shall be heated to a max. temperature of 163 degrees centigrade at the time of mixing. Asphalt cement heated above 163 degrees centigrade shall be rejected. Temperature of asphalt shall be checked frequently. Each aggregate ingredient shall be heated to temperature ISO-160 degrees centigrade for at least six'(6) minutes before mixing of asphalt cement to ensure complete drying of aggregates. The range of heating of aggregates shall be strictly followed, to ensure proper coating of aggregates. Fine aggregates shall be introduced into the dryer (mixer) first followed by the coarse aggregates to assure proper mixing. Quantity of aggregates fed to dryer (mixer) must be accurately controlled by suitable measuring device (Iron box) having predetermined volume of one (1) cubic foot or as instructed by Engineer.

Both bitumen and aggregates must be heated before they are combined in the mixer drum. Mixing temperature should be kept within the range of 140-170 degrees centigrade.

To achieve uniform mixing and proper coating, aggregates and asphalt cement must be thoroughly mixed for a minimum duration of ninety (90) seconds. Mixing time shall be prolonged to hundred (100) seconds if coating of aggregates is not proper. After one hundred and twenty (120) seconds if it is still not possible to get good coating, the aggregate drying time must be increased.

307.3.2 Deep Patches/Pot holes

The surfaces of base course thus prepared as mentioned under Item 207, shall be primed to receive Bit Mac in a thickness as per drawings or as directed by the Engineer, Bit Mac shall be spread carefully to avoid segregation. Compaction shall be done with equipment suited to the size of job. A vibratory plate compactor is recommended for small patches. Whereas roller may be more practical for larger areas. Straight edge or stringline shall be used to check riding quality and the alignment of the patch.

307.3.3 Leveling Course

All local depressions corrugated surface, ripples across the pavement should be rectified before leveling course is placed. Clean the area free of dust or other loose material with mechanical broom or compressed air. Apply light tack coat, 0.2 to 0.7 litres per square meter of A.C 80/100 penetration grade. After drying dense graded hot Bit-Mac shall be spread in layer not more than seven (7) centimeters in thickness. Spread shall be done carefully to prevent segregation and compact with steel wheeled and pneumatic tyred roller. For small pot holes hand tempers shall be allowed. Use stringline to check the riding quality of the leveling course.

TABLE 307.2-A

DESIGN SHEETS FOR DENSE GRADED HOT MIX FOR LEVELING AND POTHOLES

RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE

AGGREGATE IN MIX	FILLER	FINE AGGREGATE	COARSE AGGREGATES					BITUMEN USED (by Weight of Mix)	REMARKS
Sieve Size (Inch) (mm)	200 (0.075)	No. 8 (2.36)	No. 4 (4.75)	3/8" (9.5)	1/2" (12.5)	3/4" (19)	1" (25)		
Specification Range	4-12	43-56	55-75	90-100	-	-	-	4%	Min. Layer Thickness: 20 mm Aggregate Max. Size: 9 mm Rate of Aggr. Appl.: 50 Kg/SM
Allowed % Passing	9	48	65	100	-	-	-		
% by Weight	57%		43%		-	-	-		
Quantity by Proportion	4		3		-	-	-		
Specification Range	3-11	30-45	46-60	72-87	87-100	-	-	4%	Min. Layer Thickness: 30 mm Aggregate Size: 12 mm Rate of Aggr. Appl.: 70 Kg/SM
Allowed % Passing	8	36	54	80	100	-	-		
% by Weight	46%		54%			-	-		
Quantity by Proportion	3		4			-	-		
Specification Range	4-11	32-46	46-60	65-80	75-88	90-100	-	3.5%	Min. Layer Thickness: 50 mm Aggregate Size 20 mm Down Rate of Aggr. Appl.: 115 Kg/SM
Allowed % Passing	8	38	53	73	82	100	-		
% by Weight	46%		54%				-		
Quantity by Proportion	3		4				-		
Specification Range	4-12	24-37	34-47	49-61	57-70	70-87	88-100	3.5%	Min. Layer Thickness: 60 mm Aggregate Size: 25 mm Down Rate of Aggr. Appl.: 150 Kg/SM
Allowed % Passing	8	30	40	54	62	76	100		
% by Weight	46%		54%				-		
Quantity by Proportion	3		4				-		

TABLE 307.2 - B

DESIGN SHEETS FOR OPEN GRADED HOT MIX FOR WEARING COURSE

RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 8O-100 PENETRATION GRADE

AGGREGATE IN MIX	FILLER	FINE AGGREGATE	COARSE AGGREGATES					BITUMEN USED (by Weight of Mix)	REMARKS
Sieve Size (Inch) (mm)	200 (0.075)	No. 8 (2.36)	No. 4 (4.75)	3/8" (9.5)	1/2" (12.5)	3/4" (19)	1" (25)		
Specification Range	2-10	24-37	40-50	88-100	-	-	-	4%	Min. Layer Thickness: 20 mm Aggregate Max. Size: 9 mm Rate of Aggr. Appl.: 50 Kg/SM
Allowed % Passing	6	30	43	100	-	-	-		
% by Weight	36%		64%		-	-	-		
Quantity by Proportion	1		2		-	-	-		
Specification Range	1-9	14-28	32-45	57-70	75-100	-	-	3.5%	Min. Layer Thickness: 30 mm Aggregate Size: 12 mm Rate of Aggr. Appl.: 70 Kg/SM
Allowed % Passing	6	25	37	63	100	-	-		
% by Weight	31%		69%			-	-		
Quantity by Proportion	1		2			-	-		
Specification Range	1-10	14-28	25-40	45-57	58-70	87-100	-	3.5%	Min. Layer Thickness: 50 mm Aggregate Size 20 mm Down Rate of Aggr. Appl.: 110 Kg/SM
Allowed % Passing	6	20	32	50	65	100	-		
% by Weight	26%		74%				-		
Quantity by Proportion	1		3				-		
Specification Range	2-10	12-25	20-35	36-51	45-60	65-81	82-100	3.5%	Min. Layer Thickness: 60 mm Aggregate Size: 25 mm Down Rate of Aggr. Appl.: 135 Kg/SM
Allowed % Passing	6	17	26	41	52	72	100		
% by Weight	23%		77%				-		
Quantity by Proportion	1		3				-		

307.3.4 Wearing Surface

307.3.4.1 Mini Mixing Plant

Local made bitumen aggregate mixer equipment used for preparation of Bit-Mac shall be in good working condition, of sufficient capacity, capable of being operated to produce a uniform blend with the given ingredients.

307.3.4.2 Preparation of aggregates

Aggregates shall be stored and handled as discussed under item 307.2, Material Requirement.

307.3.4.3 Hauling Equipment

Bit-Mac mixed material shall be delivered in tight, clean and smooth metal bed hand trolleys, or any method as convenient to the Contractor and approved by the Engineer.

307.3.4.4 Preparation of Base or Existing Pavement Surface

Surface of base or existing pavement upon which Bit-Mac mix is to be placed shall be cleaned by means of compressed air to remove dust or as approved by the Engineer.

Priming shall be done in a manner as described in item 302. The rate of application of prime coat shall be 0.8-1.5 litres per square meter. Tack coat shall be done in a manner as described in item 303. The rate of application of tack coat shall be 0.2-0.4 litres per square meter. When surface of existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by leveling course as described above.

Sand bitumen slurry to seal the cracks in clod bituminous surface shall be injected by pressure pumps with nozzles filled at the end instead of spray pipe in conventional harris trolley.

307.3.4.5 Spreading and Finishing

Bit-Mac mixture shall be placed on approved surface, struck off to required section manually with rakes or hand tools by experienced foreman, distributed over the entire width or partial width as required. All mixtures shall be spread at temperatures not less than one hundred and forty (140) degrees centigrade. Mixture shall not be placed on any wet surface or when the atmospheric temperature is below five (5) degree centigrade or when the •weather is foggy or rainy.

307.3.4.6 Compaction

Roller shall be steel wheel or pneumatic tyred. The roller (s) shall be in good working condition, capable of reversing without backlash, capable to be operated at speeds slow enough to avoid displacement of Bit-Mac. The number and weight of rollers shall be sufficient to compact the mixture while it is still in workable condition to obtain compaction to Engineer's satisfaction. The use of equipment which results in excessive crushing of aggregates shall not be permitted.

After spreading and strike off as soon as the mix condition permit the rolling to be performed without excessive shoving or tearing, the Bit-Mac mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged to avoid appearance of cracks. Rolling will be done longitudinally, beginning at the lower side of the spread and proceeding towards the higher side, overlapping successive trips by at least one half (1/2) the width of rear wheels of roller.

Roller shall be operated at speed slow enough to avoid displacement of mixture. To prevent adhesion of mixture to rollers, the wheels of rollers shall be kept properly moist with water, but avoiding excess water. Rolling shall be continued until all roller marks have been eliminated.

Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or mechanical tampers.

Any mixture that has become cold enough, mixed with dirt or is defective in any way shall be replaced with fresh hot mixture and compacted to conform the requirement.

ITEM 308 HOT RECYCLING OF ASPHALT CONCRETE

308.1 DESCRIPTION

This item shall consist of heating and removal of the existing asphalt concrete layer to a designated depth, adding a calculated quantity of asphalt binder, adding of freshly prepared asphalt concrete of specified quality, mixing, laying and compaction of properly mixed asphalt concrete in thickness and width as per drawings or as directed by the Engineer.

308.2 MATERIAL REQUIREMENTS

Material specifications for coarse and fine aggregates and asphalt binder shall correspond to the specification requirements elaborated under items 203, 300 and 305 respectively.

308.3 CONSTRUCTION REQUIREMENTS

308.3.1 Heating the Existing Pavement

Asphalt pavement shall be heated and softened by preheaters or in built infrared gas fired heaters, to temperatures between 140-170 degrees C.

308.3.2 Scarifying Asphalt Course

Rotating shaft scarifiers fitted with carbide bits shall remove asphaltic course to a depth as specified in drawings or as directed by the Engineer. Scarifiers shall be controlled by electronic devices to ensure removal of materials to a specified depth and grade.

308.3.3 Mixing of Reclaimed Material

Formula for the admixture will be based on material analysis of existing pavement by bitumen extraction and sieve analysis. Material to be added may be asphalt binder or aggregate, which will be calculated to ensure preparation of proper final mix.

308.3.4 Addition of Fresh Asphalt Concrete

Fresh asphalt concrete of specified design prepared as per Item 203 or 305 shall be added in proportion to be established as per requirement of line and grades or as directed by the Engineer. This shall be done in conventional way through dumper-hopper arrangement. Fresh material shall be carried by drag-slat conveyor into a second mixer. Exact mixing ratio will be achieved by calibrating the speed of the electronically adjustable drag-slat conveyor to the forward advance speed of the remixer. A second mixer shall ensure homogeneity of reclaimed and fresh asphalt. Engineer shall establish the ratio of fresh and existing asphalt premix to be relayed, before starting this operation. This ratio shall depend upon the quality of existing asphaltic concrete.

308.3.5 Laving and Compaction

Laying and preliminary compaction of mixed asphalt shall be effected by tamping and vibrating screeds of the recycling equipment. Screeds shall be able to lay the mix true to the levels and grades required by the drawings or as directed by the Engineer. Compaction shall be carried out by conventional equipment to achieve ninety seven (97) percent compaction with respect to the laboratory compaction achieved by the mixed asphalt as per Marshall method.

308.4 GENERAL REQUIREMENTS

Any other physical property essential for workmanship or quality control shall be fixed by the Engineer and contractor jointly. Physical properties of the fresh material shall correspond to the applicable requirements of such ingredients in this specifications.

ITEM 309 COLD MILLING

309.1 DESCRIPTION

This work shall consist of milling (cutting) of concrete or asphaltic layer to a designated level and width by means of Specialized Equipment, removal of cut material and disposal as per these Specifications or as directed by the Engineer.

309.2 CONSTRUCTION REQUIREMENTS

Specialized equipment to be used for this item of work shall be capable of following operations:

i) Milling drum shall be capable of level and grade adjustments and it shall have variable speed provision to ensure production of smooth or rough milled surface.

ii) Level and grade control shall be ensured through electronic sensors, capable of giving an accuracy of “plus two” (+2) mm.

iii) Scraper bars and belt conveyor system shall ensure picking and loading of milled material in a truck.

309.2.1 Construction Procedure

Area shall be earmarked with respect to depth of milling, which shall be split in strips looking to the width of milling drum and width of area to be milled.

Milling machine shall be adjusted to cut to required depth. Milling drum shall be correlated to sky or stringline arrangement to ensure milling according to required grade and profile.

Milling shall proceed from one edge of the road, strip by strip in a manner that may ensure resulting surface even and level.

Milled material shall be removed and disposed as per these Specifications or as directed by the Engineer.

Milled surface shall be cleaned by wire brushes or compressed air for subsequent operation.

ITEM 310 CONCRETE PAVEMENTS

310.1 DESCRIPTION

This work shall consist of a pavement composed of Portland cement concrete with or without reinforcement as specified constructed on a prepared subgrade or base course in accordance with these specifications and in conformity with the lines, grades, thickness and typical cross-sections shown on the plans. Both plain and reinforced concrete shall include deformed bars for contraction joints and dowel bars for expansion joints or as shown on the Drawings.

310.2 MATERIAL REQUIREMENTS

310.2.1 Concrete

Concrete materials shall conform to the requirements indicated in item 401 and as specified hereinafter. In addition to it the contractor shall advise the Engineer immediately after the award of the contract of the source of all materials to be used in proportioning concrete for the work. If the contractor later proposes to obtain materials from a different source, he shall notify the Engineer at least thirty (30) days before such materials are to be used.

310.2.2 Reinforcing Steel

Concrete reinforcement shall conform to item 404 or as indicated on the Drawings. If required, steel fabric for reinforcement of concrete shall conform to AASHTO M 55-73. It must be supplied in sheets.

310.2.3 Joint Filler

Joint filler shall consist of cane or other suitable long fibres of a cellular nature uniformly impregnated with asphalt. The asphalt content of the joint material shall be between thirty and fifty per cent. The joint material will not deteriorate under any weather conditions and is to be of such a character as not to be permanently deformed or broken by moderate twisting, bending or other ordinary handling. Strips of the joint filler which do not conform to the specified dimensions within the tolerance + two (2) mm for thickness and + twelve (12) mm for depth are to be rejected. All damaged strips are to be rejected too.

310.2.4 Joint Sealing Compound

Joint sealing compound is to be as BS 2499 type A1 or A2, or as approved by the Engineer.

The compound is to be impermeable, is to withstand all weather conditions and is to be capable of adhering to the concrete without cracking, spalling or disintegrating and will not require an impracticable condition of dryness or cleanliness of the concrete slabs.

Where recommended by the manufacturer of the sealing compound, a primer supplied by him is to be used to improve adhesion.

310.2.5 Dowel Bars

Dowel bars shall be cut from mild steel bars and will be approved by the Engineer. The Contractor's attention is directed to the requirement that one end of each dowel bar in all joints, except bonded construction joints, shall be sawn and not sheared so that no irregularities likely to interfere with its sliding action in the concrete shall occur. The minimum length of the dowel bars spaced at one meter centre to centre or as shown on the drawings, shall -be thirty five (35) times the diameter of the bar used unless otherwise specified or as directed by the Engineer.

310.2.6 Expansion Caps

Expansion caps for dowel bars in expansion joints shall consist of pressed metal sleeves plugged at one end by punching the specified joint filler board of a wad of cotton waste of similar compressibility and sealed at the end against entry of mortar. The tube shall have an internal diameter permitting sliding on the dowel bar but close enough to prevent entry of mortar.

310.2.7 Darkening Agent

Darkening agent for the top course of concrete pavements if ordered and specified shall be a carbon black; either as an aqueous dispersion containing at least 25% of solids, to be added to the mixing water, or as a self-dispersing powder to be-added to aggregate and cement.-It shall be approved by the Engineer as non-deleterious and as giving a grey colour and shall be added at the rate of 0.1 % by weight of the mixed concrete if it is aqueous dispersion. The minimum quantity of self-dispersing powder shall be 0.025% by weight of the concrete aggregate.

The darkening agent shall be free from sulphur trioxide and from any other matter deleterious to concrete.

310.2.8 Crack Inducing Battens

Crack inducing battens shall be of wood or of any other suitable material proposed by the Contractor at the time of tendering and approved of at the award of the Contract or approved by the Engineer at his discretion after the award of the Contract. Battens of highly absorbent wood or other- material shall be of cross-sectional dimensions shown on the Drawings, and treated to prevent adhesion between them and the concrete.

310.2.9 Sampling and Testing

All materials shall be approved by the Engineer prior to use in the work. Additional samples will be taken and tested by the Employer during the progress of the work to check on the quality of the materials being supplied and/or placed by the Contractor. The results of these tests will be available for the Contractor’s use, however they are not intended for construction control purpose. The contractor should set up his own test facilities or arrange the same from a private laboratory, to assure that his materials and workmanship comply with the specification.

310.3 CONSTRUCTION REQUIREMENTS

310.3.1 Pavement Base

The base upon which the concrete pavement is laid shall be leveled compacted and true to the grades and cross-sections shown on the plans and shall, be so maintained, as provided under such other items throughout the period of placing concrete pavement.

To ensure the proper depth and section, a scratch template true to depth and section and resting on accurately set side forms shall be moved over the surface immediately before placing concrete and any irregularities shall be immediately corrected. High spots shall be planed down and the Contractor shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered compacted and struck off to the required grade or of placing additional concrete. No measurement or payment will be made for such additional concrete.

Until" the subgrade has been checked and approved, no material shall be deposited thereon. Storing or stock piling of materials on the subgrade and placing of surfacing material or laying of pavement on muddy or frozen subgrade will not be permitted.

310.3.2 Forms

Side forms shall be made of metal of an approved section and construction provided with adequate devices for secure setting so that when in place, they shall withstand the impact and vibration of the compacting and finishing equipment with settlement not exceeding 1.5 mm in three (3) meters form a true plane surface on the top of the form and inside face shall not vary more than six (6) millimeters from a plane surface. The width of the bases of steel forms shall be not less than their height except that the forms having a base not less that two-third (2/3) of their height and meeting all other requirements herein may be used for manual laying of non rectangular bays.

The depth shall be equal to the thickness of the pavement at the edge or as shown on the plans. The forms sections shall be tightly joined by each joint free from play in any direction. These forms shall be stacked with steel stakes and shall be of a length approved by the Engineer. Each section of forms shall have stake pocket at each end and at intervals of not more than one and one-half (1:5) meters between ends.

Each section of forms shall be straight and free form bends and warps at all times.

Side forms for machine placing shall have rolted section steel rails which shall be of adequate stiffness to carry the laying, compaction and finishing machines.

These machines shall not run on folded sheet metal form tops. The top faces of the forms are to be carefully cleaned and maintained. The forms shall be without horizontal joints and with flange braces extending outward on the base not less than two-thirds the height of the forms. Each stack pocket shall be equipped with a positive non-detachable wedge. These forms shall be placed by using at least three steel pins of the size and length approved by the Engineer or as shown in the plans. They shall be equipped with positive locking devices which will permit neat tight joints and do not deform under impact vibration by thrust. Pins for stacking forms in place shall be made of steel at least two (2) centimeters in diameter as directed by the Engineer in case of impractical use.

Wooden forms may be used for curves having a radius of less than fifty (50) meters. They shall be made of two and half (2.5) centimeters well seasoned surfaced planks fastened together and shall be attached securely to a wooden base in width. All wooden forms shall be braced at least every sixty(60) centimeters with steel pins of the size and length here in specified. Straight forms shall be set out as chords to convex edges and as tangents to concave edges, but payment will not be made for concrete outside the curved edges shown on the Drawings.

Before placing forms the underlying material shall be excavated to the required grade, and shall be firm and compact. The forms shall have full bearings upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement.

Forms shall be set to the required lines and grades well in advance of placing concrete, preferably not less than two hundred (200) meters. Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement which in the opinion of the Engineer is damaged due to the careless removal of forms shall be repaved by the Contractor as directed by the Engineer at the Contractor's own expense.

Forms shall be thoroughly cleaned and oiled each time they are used.

Special forms or other supporting devices meeting the approval of the Engineer shall be used to support the joint filler at transverse control joints when concrete is to be placed on only one side of the filler. When pavement is placed adjoining existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true uniform surface of sufficient width to accommodate the wheels of the finishing equipment if necessary to obtain proper smoothness of the pavement.

310.3.3 Composition and Compressive Strength of Concrete

a) Composition

1) All concrete shall be proportioned by weighing and shall conform to the following strength and mix requirements:

i)	Compressive Strength, 28 days minimum	280 kg/sq. cm.
ii)	Cement content, sacks (50 Kg)	7.5 (min.)
iii)	Water cement ratio, maximum	0.45
iv)	Slump	25 - 50 mm
v)	Entrained air percent	3±0.6
vi)	Nominal size of aggregate	1½" Max.

2) At least 35 days prior to the start of paving operations and after approval of all materials to be used in the concrete, the contractor shall submit for approval, the mix design he intends to use based on proportioned weights of cement, air entrainment agent, saturated surface dry aggregates and water. This mix design will be tested by the Engineer and approval will not be granted unless the average twenty eight (28) days compressive strength exceeds the minimum strength requirement by at least 15 percent. However the Engineer may allow paving operation on the basis of seven (7) days strength if he is satisfied with the results of seven (7) days strength.

3) The cement content given in the foregoing table is minimum. If it is not sufficient to produce concrete of the compressive strength specified it shall be increased as necessary with out additional compensation under the contract.

4) The compressive strength of the concrete will be determined by testing standard cylinders made from concrete taken from the mixer. The making, curing and testing of the specimens will be in accordance with AASHTO T 23.

5) During the course of construction, when the source of any material for the concrete is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strengths.

b) Consistency

The required consistency of the concrete mixture shall be such that the mixture will be cohesive, uniform and plastic, permitting proper handling and finish. When deposited it shall not flow, but shall remain in a conical pile. There shall be minimum of segregation and surplus water during the process of handling and finishing. The slump shall be determined by AASHTO T 119 except that during the course of construction control of concrete may be accomplished by the ball penetration as outlined in AASHTO T 183. Two and a half (2.5) centimeter ball penetration **is** considered equivalent to a slump of five (5) centimeters.

The cement content shall be determined by means of a yield test in accordance with AASHTO T 121.

310.3.4 Batching and Mixing

Concrete shall either be batched and mixed at a central batching and mixing plant or batched at a central batching plant for either mixing in field mixers adjacent to the forms for slabs, or mixed in a truck mixer. When cement is supplied in bags, each batch of concrete shall contain a whole number of bags of cement.

a) Batching Equipment

All aggregates and bulk cement for use in pavement shall be batched by weight by

means of automatic devices of approved type conforming to the requirements specified herein below.

The batching shall consist of dividing the aggregates into three sizes, each stored in a separate bin, of placing the cement in another bin, and of recombining these ingredients as herein provided.

Material discharged from the several bins shall be controlled by gates or by mechanical conveyors. The means of withdrawal from the several bins and of discharge from the weigh box shall be so- interlocked that not more than one bin can discharge at a time; that the order of discharge cap be changed as desired by the Engineer.; and that the weigh box cannot be tripped until the required quantity from each of the several bins has been deposited therein. Should a separate weigh box be used for each size of aggregate, all bins may be operated and discharged simultaneously. The discharge shall be so regulated that the amount of material discharged into the weigh hopper from any bin, with weighing devices at rest. will be within two (2) kg of the weight called for by the scale setting for the bin.

When the discharge from the several bins is controlled by gates, each gate shall automatically lock in an open or partially open position until the required weight is discharged into the weigh box, after which the gate shall automatically close and lock.

Scales utilized in the batching device may be of the springless dial type .or of the multiple beam type.

If they are the dial type, the dial shall be of such size and so arranged that it may be easily read from the ground. The automatic weighing device of the dial scale shall be so marked that the number of proportions required may be set on the dial at the same time and that proportions may be changed without delay.

If they are the multiple beam type, the separate beams shall be automatically connected to the hopper or weigh box in sequence. Multiple beam scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will be operated during the addition of the last .seventy kilograms of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.

The beams or dial of automatic scales shall be so arranged that the weighing units will be in a compartment that may be locked at the requirement of the Engineer.

It is the intention of this Specification that the device shall be automatic to the extent that the only manual operation required for combining the ingredients for one batch shall be a single operation of a switch or a starter.

All receptacles used for weighing materials, together with the scales of any kind used in batching materials, shall be so insulated against the vibration or movement of the rest of the plant due to any operating equipment, that the error in weighing with the entire plant running will not exceed two per cent of any setting nor exceed one and a half per cent of any batch.

Should separate supplies of aggregate materials of the same size group, but of different moisture content, be available at the batching plant, withdrawals shall be made from one supply exclusively and the material therein completely exhausted before starting on another.

The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the batching plant to the point of mixing. Aggregates containing excess moisture shall be stockpiled prior to use until sufficiently dry to meet the above requirement.

Except where small quantities of concrete only are to be used, when the Engineer may permit otherwise, the equipment for batching of concrete materials shall conform to the following requirements:

1) The batching equipment shall be substantially constructed on a firm foundation, high enough above trucks being loaded to function properly. It shall have three (3) bins and a weighing hopper. The bins shall have a total capacity of not less than 100 tons, and the partitions between them shall extend not less than one (1) meter above the bins. The bins shall be equipped with baffle boards so as to assist drainage of the aggregates and prevent the drained out water from passing through the outlet gate. Al platform shall extend around the weighing hopper for easy means of inspection, adjustment and weighing.

2) The weighing hopper shall have a single compartment with arrangements for ready removal of excess material, and with a discharge gate opening parallel to the portion of receiving trucks. The amount of opening of the discharge gate shall be readily controlled. There shall be sufficient clearance at all points for the weighing hopper to function properly. The ' weighing scale shall be of the beam or springless dial type of standard design and make, and shall be able to record the true weight within two (2) kg at maximum load. The beam type shall have separate beams for each size of aggregate, and each beam shall have an easily operated locking device. A dial which will show the weight when the load is within forty five (45) kg of that required and an approved signal device shall be provided.

3) The weighing scales shall be arranged for ready standardization, and with each scale shall be furnished a set of standard weights including seven 25 kg, two 10 kg, two 5 kg and two (2) kg weights. For batchers of capacity of half (1/2) cubic meter or less, the standard weight to be furnished shall be as approved by the Engineer. The tolerance to these scales shall be within those listed in table 3 of the US national bureau of standard NBS handbook 44. The standard weights shall be protected against the defacement and injury, and shall be easily to handle and attached. All parts of the weighing devices and appurtenance of the batching equipment shall be substantially made and shall be maintained in proper operating condition. If in the opinion of the Engineer, any part or all of the weighing devices or other appurtenances are not satisfactory, they shall be replaced in satisfactory at the Contractor's expense.

4) In lieu of the automatic devices for controlling the weighing of the aggregates and bulk cement as described in the forgoing specification for batching equipment, the Contractor may be permitted to substitute manually controlled devices, provided approval for such devices is granted by the Engineer.

b) Unloading and Hauling Equipment

Aggregate shall be transported from the batching plant to field paver mixers in batch boxes, vehicle bodies or other containers of adequate capacity and construction to carry the volume required, properly.

Partitions separating batches shall be adequate and effected to prevent spilling from one compartment to another while transit or being dumped. Where cement is stored in bulk, the contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to mixer, with chute, boot or other approved device, to prevent loss of cement and arranged to provide positive assurance of the actual presence .in each batch of the entire cement specified.

Loose cement shall be transported to the mixer in waterproof compartments carrying the full amount of the cement required for the batch or it may be carried in compartments covered by the aggregate. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within one and a half hours of such contact. Cement in originally shipping packages may be transported on top of

the aggregates, each containing the number of bags required by the Job mix.

Batches shall be delivered to mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss of cement, and when more than one batch is carried on the truck without spilling of material from one batch compartment into another.

c) Batching to Central Mixing Plant

At a central mixing plant, batches shall be discharged from the weighing, hopper into the mixer either directly by gravity or by elevating container, large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from the weighing hopper to mixer drum.

d) Field Mixing Equipment

The concrete mixer shall be a batch mixer so designed as to ensure positive, uniform distribution of materials throughout the mass. The size and type of mixer used on various classes of work shall be as specified below and shall be approved by the Engineer. For all work, where the volume of concrete to be placed justifies it, the mixer shall have a capacity of not less than one cubic meter, shall be of approved make and acceptable to the Engineer, and shall comply with the following requirements:

1) Mixers shall have a locking device preventing the mixture from being discharged before the expiration of the specified mixing time; an automatic locking device preventing materials being placed in the mixer before discharge gate is closed; a regulator that will maintain the rate of speed for which the mixer has been designed; a signal device that will function when water is added; a vertical water tank with an automatic device that will measure and discharge the required volume of water; valves to prevent overflow into the mixing chamber or on to the ground when the discharge valve is closed and into the tank when open; and valves and piping in proper order to prevent any leakage. The automatic device for measuring and discharging the required volume of water shall be arranged to discharge a predetermined volume, to be easily adjusted to discharge a larger or smaller volume, and to register the volume discharged accurately on a gauge or dial which shall be calibrated before the mixer is used and shall be kept properly calibrated. A by-pass valve shall permit the discharge of all the water into a measuring can for the purpose of calibration. The measuring of the volume of water required shall be done by means of adjustable discharge device only.

2) The loading skip of the mixer shall be substantially made and shaped so that wet sand and other materials will not remain in it when it is being discharged. The mixer shall not be used when any of the devices above stated are not functioning properly, or when the blades of the mixer have worn down to ninety (90) per cent of their original width. The Contractor shall furnish a certified statement from the manufacturer as to their original width. The mixer shall be kept clean and free from hardened mortar.

e) Truck Mixers

Truck mixers shall be used only when permitted by the Engineer in writing. Each transit mixer shall have a watertight drum, suitable mounted and fitted with adequate blades capable of properly combing the mixture. A batch meter and locking device to prevent discharge prior to completion of mixing shall be provided on each unit. Measuring tanks, equipped with outside taps and valves to facilitate checking their calibration, shall be provided for the mixing water. All water added to the mixer shall be passed through an approved water meter, located between the water tank and mixer drum, equipped with indicating dials and totaliser, and capable of measuring and discharging a specified amount of water within an accuracy of one per cent. The device shall provide means of readily verifying the amount of water added to mixing

shall be provided on each mixer. An inspection opening shall be provided on each mixer, to permit ready determination of the consistency of the concrete being placed in the forms. When pick-up and throw over blades are worn down two (2) centimeter or more in depth, they shall be replaced with new blades. The Contractor shall furnish a certified statement from the manufacturer as to the original depth of the blades.

310.3.5 Placing Concrete

a) General

The mixer shall be operated outside of the forms at all times except at locations where the Engineer deems it not feasible to do so.

When ordered by the Engineer, the subgrade shall be moistened as directed, prior to the placement of the subgrade paper such as polythene sheeting.

Concrete mixed in central plant shall be transported without delay from the mixing plant to the position for laying and any concrete which in the opinion of Engineer has been mixed too long before reaching, the work will be rejected and shall be removed from the site. The concrete shall be deposited on the subgrade in successive batches for the full width between forms and in a manner which will require as little rehandling as possible. Spreading shall be done by an approved mechanical paver in a manner that will prevent segregation and separation of the materials. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances, the amount of material deposited shall be sufficiently in excess of that required to form the pavement to the required cross-section after consolidation in order to provide a roll of concrete ahead of the front screed of the finishing machine for the full length of the screed.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all expansion joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade or a side form. In no case shall the vibrator be operated longer than fifteen (15) seconds. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper on to a joint assembly. The hopper is well centered on the joint assembly. Damage to joint assemblies caused by dumped concrete shall be repaired immediately as directed by the Engineer at Contractor's expense. Trucks delivering concrete shall not run on polythene sheeting nor shall they run on completed slabs until at least fourteen (14) days after placing the concrete.

Should any concrete materials fall on or be worked into the surface of completed slab, they shall be removed immediately by methods approved by the Engineer.

Placement of concrete ahead of the initial spreader strike off shall not be more than fifteen (15) minutes ahead of final spreader strike-off. If concrete is placed in one (1) layer only, the placement of concrete shall not be more than twenty (20) minutes ahead of the spreader strike off.

In order to secure adequate compaction, the concrete is to be spread with a surcharge above the finished level of the layer. Spreading, compacting and finishing operations are to be completed without delay.

The total time taken from the addition of the water to the mix until the completion of the surface finishing operations shall not exceed thirty (30) minutes when the shade or mix temperature exceeds twenty seven (27) degree C or forty (40) minutes when less than twenty seven (27) degree C. The mixing and placing of the concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The additives shall be added to the concrete mix so as to ensure more setting time. The top of the forms shall be kept free from accumulation of concrete or foreign material. The Contractor shall not permit the accumulation of laitance along the edge of a slab poured adjacent to one previously placed. Any accumulation of laitance shall be removed and replaced with fresh concrete. As soon as the side forms are removed, the edges of the slab shall first be inspected by the Engineer and any minor honey combed areas shall then be filled in with mortar composed of one part of cement to two parts of fine aggregate under the supervision of the Engineer.

b) Weather Conditions

For concreting during hot/cold weather, requirements 401.3.6 (I) of these specifications will be followed.

310.3.6 Placing Reinforcement

All pavement reinforcement shall be placed as shown on the plans. All marginal bars, dowel bars, and tie bars required by the plans shall be held in proper position by sufficient number of metal bar supports or pins as approved by the Engineer. If the center joint is to be sawed in lieu of placing the metal center strip, the tie bars may be installed mechanically by means of equipment and methods approved by the Engineer. The satisfactory placement of the tie bars shall depend upon the ability of the mechanical device to place the tie bars in their true position- The Engineer may require, when satisfactory placement is not obtained by mechanical means, that the tie bars be installed ahead of placing the concrete and that they be securely staked and tied if necessary to hold them in their exact position. The use of removable devices, supporting the bars from the forms, will not be permitted.

Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans. When reinforced concrete pavement is placed in two (2) layers, the entire width of the bottom layer shall be struck-off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete after which the top layer of the concrete shall be placed, struck off and screeded. Any position of the bottom layer of the concrete which has been placed more than thirty (30) minutes with out being covered with the top layer shall be removed and replaced with freshly mixed concrete at the contractor's expense. Plain concrete and bar reinforced bridge approach pavement may be placed in one (1) layer.

The bottom layer shall be supported in the required position with bar chairs where two (2) layers of wire mesh reinforcement are required as at bridge approaches. Separators shall be used for the top layer if the strike off cannot be properly used for the operation. Laps in adjustment sheets or mats of reinforcement shall be as shown on the plans. Laps parallel to the centerline of the pavement will not be permitted except for unusual widths of pavement lanes or for irregular areas. If the plans do not show dimensions for laps, the minimum lap either perpendicular or parallel of the centerline of the pavement shall be fifteen (15) centimeters. The adjacent sheets shall be fastened or tied together to hold all parts of the sheets in the same plane.

Reinforcing steel shall be free from detrimental amounts of dirt, oil, paint, grease, loose mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

310.3.7 Joints

Joints shall be constructed exactly in accordance with the details shown on the plans and specifications and with the best of workmanship. Failure to construct the joints as called for and in the best possible manner, as determined by the Engineer, will be cause for suspension of work until .the cause of the defective work is remedied.

If removal of existing pavement of any type is required to connect with the new pavement, and the termination of the removal is not at an existing Joint, the new joint shall be made by sawing the existing pavement not less than five (5) centimeters deep before removal.

a) Expansion joints

The subgrade at Expansion joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement.

A string line shall be stretched between the pavement forms along the centerline of the joint. One half of the length of each dowel bar shall be painted in accordance with the directions shown on the plans and then thoroughly coated with hard grease, or lubricant as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.

The entire joint assembly shall be of a type designated on the plans and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the centerline of the pavement slab and the dowels lie parallel to the centerline of the slab. Finished joints shall not deviate more than six (6) millimeters in the horizontal alignment from a straight line. No plugs of concrete shall be permitted any where within the expansion space.

A slip sleeve of the dimensions shown on the plans shall be placed on the greased end of each dowel. The greased ends shall be free to slide in the dowel holder and shall extend in the direction as indicated on the plans. Any excess grease on the dowel holder shall be removed.

The joint shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure the joint and the dowel bars will remain in their proper position after the concreting and finishing operations are completed.

Joints for pavement designed for two (2) or less lanes of traffic shall be assembled and installed in one (1) continuous piece or the connections between sections shall be made rigid and tight to prevent offsets in sections of the joints. The length of individual pieces of the expansion joint filler shall be not less than the width of one (1) traffic lane of the pavement.

The finishing machine shall be operated in a manner that will prevent displacement of the joint. If for any reason it is necessary to straighten a joint, any depression caused by this operation shall immediately be filled with fresh concrete, respaded and brought to the original crown in advance of the longitudinal finishers. Any fluid laitance or mortar caused by this operation shall be removed and replaced with fresh concrete.

As the finishing machine approaches the joint on the first trip, the excess concrete shall be shoveled ahead and the tamper and each screed, in turn, shall be lifted over the joint. On the second trip of the finishing machine, the screed may be operated over the joint.

b) Contraction Joints

Contraction joints shall be of the type and dimensions and at the spacing shown on the plans. Sawed contraction joints shall be cut by means of an approved concrete saw. The joints shall not be sawed until the concrete has hardened to the extent that tearing and reveling is precluded. All joints shall be sawed during the initial curing period and the sawing shall begin before the pavement starts shrinking and before uncontrolled cracking takes place. Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints. In no case shall the

pavement be left overnight without having the joints sawed. The joints shall be sawed at the depth, spacing , and lines shown on the plans. Guidelines or devices approved by the Engineer shall be provided to ensure cutting the joint in a straight line and perpendicular to the centerline of the pavement. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut, and before filling with joint compound. When the plans specify that dowels be installed through contraction joints, "the subgrade at the contraction joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the center line of the joint. Each dowel shall be painted and thoroughly coated with hard grease or lubricant, in accordance with the direction shown on the plans or as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel. The entire joint assembly shall be of the type designated on the plans and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the center line of the slab and the dowels lie parallel to the slab surface and parallel to the centerline of the slab. The greased ends of the dowels shall be placed in the direction as indicated on the plans and shall be free to slide in the dowel holder. Any excess hard grease on the dowel holder shall be removed.

c) Longitudinal Joints

Longitudinal joints shall be constructed in conformance with the details shown on the plans. When the fabricated steel strip is specified, it shall be held rigidly in place with an adequate number of pins driven into the subgrade to ensure that it will remain true to line and grade during concreting and finishing operations. On multiple lane pavements where longitudinal joints are constructed at the form line, an approved recessed form and tie bars will be required. The full depth fabricated steel strip designated for other longitudinal joints will not be permitted. When sawed joints are specified or used, suitable guidelines or devices shall be furnished to ensure cutting the longitudinal joint on the true lines as shown on the plans. The sawing of longitudinal joints shall be performed at a time that will preclude erratic or uncontrolled cracking. Sawed joints shall be filled with the type of joint compound indicated on the plans. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of air jet or a combination of air and water applied under pressure immediately after the joint has been cut and before filling with joint compound.

d) Construction Joints

A butt construction joint shall be made perpendicular to the centerline of the pavement at the close of each days work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete will have taken its initial set. This joint shall be formed by using a clean plank header having a nominal thickness of five (5) centimeters, a width of not less than the thickness of the pavement and a length of not less than the width of the pavement. The header shall be cut true to the crown of the finished pavement and shall be accurately set and held in place in a plane at right angles to centerline and perpendicular to the surface of the pavement.

The top surface of the header shall be protected with steel as approved by the Engineer. On the face along with the center of the header there shall be fastened a trapezoidal piece of metal or wood the full length of the header, five (5) centimeters wide and at least twenty five (25) millimeters in depth to form a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars hereinafter specified. Upon resumption of Work any surplus concrete remaining upon the subgrade shall be removed. The header shall then be carefully removed and fresh concrete deposited against the old in such a manner as to avoid injury to the edge of the old concrete. The fresh concrete shall be vibrated into the groove in a manner to ensure an interlocking joint.

Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the plans. If no such details are shown on the plans, tie bars as provided for the longitudinal joint, and spaced at forty-five (45) centimeter centers, shall be placed across the joint in a plane parallel to the surface of the pavement approximately midway between the top and bottom surfaces of the pavement. The edges of the joint shall be grooved, edged, and sealed with the material used for sealing expansion and contraction joints.

No construction joint shall be placed within three (3) meters of an expansion, contraction, or other construction joint.

e) Sealing Joints

1) **Materials**: Joints shall be sealed with material of the type designated on the plans.

2) **Hot Poured Joints**: The joints shall be sawed as provided in sub item 310.3.7(b) and covered as provided in sub item 310.3.7(c). After the fourteen (14) or seventeen (17) day curing period for the pavement has elapsed, the jute or;.; other protective covering shall be removed from the joint and the joint thoroughly cleaned of all loose scale, saw dust, dirt, laitance or other matter. Cleaning may be accomplished with a compressed air jet, air and water under pressure, wire brushes or in extreme cases the joint shall, when directed by the Engineer, be resaved to ensure a completely clean joint. The joint surfaces and adjacent areas of the slab shall be thoroughly clean.

   The hot poured joint material shall be heated in a heating unit approved by the Engineer to the temperature within the range required as shown by tests. The joint shall be filled from the bottom of the saw cut to the surface of the pavement. Any joint with a depth greater than twenty five (25) millimeters shall be filled with a minimum of two (2) layers, each layer being approximately equal in depth.

3) **Cold Poured Joints**: The joints shall be sawed as provided in sub-item 310.3.7(b) & 310.3.7(c) and cleaned of all loose saw dust, laitance, dirt, other foreign matter and free water.

   The joints shall be filled immediately after cleaning. The nozzle used must be so designed that the joint is filled completely from bottom to top. The joint shall be

filled so it is rounded on top about six (6) millimeters above the pavement surface. Immediately after the joints have been filled, they shall be covered with strip of non-absorptive paper at least four (4) centimeters wide. Eleven (11) kilogram glass-line or heavy craft is suitable. The paper shall remain on the joint until it weathers or wears off.

f) Permanent Header Board

Immediately after the forms are removed from the ends of concrete pavement that will be exposed to other than permanent type surfacing and temporary and permanent traffic, a header board having dimensions of not less than eight (8) centimeters (nominal) by twenty (20) centimeters shall be bolted securely to the end of the pavement in a manner to protect the edge of the pavement from damage. The header board shall extend the full roadway width, but may be in two (2) sections. At the time of placing the concrete , six (6) (three for each lane), thirteen (13) millimeters by twenty (20) centimeters bolts shall be embedded in the end of the pavement in a manner that will hold the header board securely. The header board shall be shaped to conform to the crown of the pavement and shall be installed flush with the concrete pavement surface. The finishing and installing of the header board shall be considered subsidiary Work pertaining to the other items in the Bill of Quantities and will not be paid for directly.

The header will not be required on concrete base course Work.

310.3.8 Consolidating and Finishing

After being spread and struck-off as provided in sub-item 310.3.5 "Placing Concrete," the concrete shall be further struck-off and consolidated with an approved finishing machine to such an elevation that when finishing operations are completed, the surface will conform to the required grade and crown. The finishing machine shall operate over the entire surface at least twice, the first time with the finishing machine tamper and both screeds in operation. A uniform roll of concrete approximately fifteen (15) centimeters above the pavement grade shall be maintained ahead of the front screed for its entire length during the first trip over with the finishing machine. Excessive tamping or finishing resulting in bringing an excess of mortar to the surface will not be permitted.

After the last pass of the finishing machine, a mechanical longitudinal finisher shall be operated over the concrete surface. toward motion of the longitudinal finisher shall be so adjusted that the screed will pass over each portion of the surface at least twice. The longitudinal finisher shall be operated in a manner that will prevent excessive slumping of the concrete at the form lines or the metal center strip or the loss of the crown of the pavement. If necessary or when ordered by the Engineer, the finisher shall be operated in one direction only or shall be operated from only the form to the centerline in order to ensure that the proper cross section of the pavement is obtained. The leading edge of the screed shall clear the forms upon completion of each transverse pass in order to clear the pavement surface of any laitance or thin mortar.

In general, the addition of superficial water to the surface of the/concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted by the Engineer, it shall be applied as a fog spray by means of approved spray equipment.

As an alternative to the longitudinal finisher, the contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by four (4) or more visible wheels riding on, and constantly in contact with, the side forms.

When directed by the Engineer, following one of the preceding methods of longitudinal finishing, long-handled floats having blades not less than one and one half (1.5) meters in length and fifteen (15) centimeters in width shall be used to smooth and fill in open-textured areas in the pavement, Long-handled floats shall not be used to float the entire

surface of the pavement in lieu of, or supplementing, one of the preceding methods of longitudinal finishing.

When the longitudinal finishing has been completed, the entire surface shall be tested with straightedges not less than three (3) meters in length. The straightedges shall be operated parallel to the pavement centerline starting at the center and progressing toward the forms. Advance along the pavement shall be in successive stages of not more than one half (1/2) the length of the straightedges. All laitance, surplus water, and inert material shall be removed from the surface. All high places shall be worked down and all low places filled by combined operations of floats and straight edges until no irregularities exist. The proper crown of the pavement shall be maintained throughout the operations.

After floating and straightening has been completed, the concrete shall be finished by using a belt made of canvas, rubber, or other approved belting not less than fifteen (15) centimeters in width, nor less than sixty (60) centimeters longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion. Care shall be exercised in the use of the belt to ensure that the edges of the belt do not dig into the surface of the concrete or work the crown out of the pavement. Either machine belting or hand belting will be permitted.

As soon as all excess moisture has disappeared, and while the concrete is still plastic enough to make a granular surface possible, a drag shall be used which shall consist of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform surface of gritty texture after dragging it longitudinally along the full width of pavement. For pavement (5) meters or more in width, the drag shall be such that a strip or burlap or fabric at least one and one half (1.5) meters wide is in contact with the full width of pavement surface while the drag is used. The drag shall be maintained in such condition that the resulting surface is of uniform appearance and reasonably free from grooves over two (2) millimeters in depth, as determined by the Engineer. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

After dragging the surface with burlap, the concrete over the expansion joint filler shall be completely removed and the joint finished. The edges of the concrete at expansion joints, shall be finished with an edger to the radius shown on the plans. The exposed edge of the pavement shall be finished with an edger to a radius of six (6) millimeters. Any tool marks appearing on the slab adjacent to the joints or edge of slab shall be eliminated by dragging the surface. In doing this, the rounding of the comer of the slab shall not be disturbed.

310.3.8.1 Hand Finishing

Unless otherwise specified, hand finishing methods will not be permitted except under the following conditions:

a) In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs, and no additional concrete shall be placed until such equipment is repaired to the satisfaction of the Engineer.
b) Narrow widths or areas of irregular dimensions where operation of mechanical equipment is impractical as determined by the Engineer, may be finished by approved hand methods.
c) Short lengths of pavement, such as bridge approach pavement, where the operation of mechanical equipment is impractical may be-finished by approved hand methods.

Concrete, as soon as placed, shall be struck-off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used.

The screed for the surface shall be at least one (1) meter longer than the maximum width of the slab to be struck-off. It shall be of approved design, sufficiently rigid to retain its

shape, and be constructed either of metal or other suitable material shod with metal.

Consolidation shall be attained by the use of a suitable vibrator or other approved equipment.

In operation the screed shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

After the concrete has been struck-off, it shall be further smoothed, trued, and consolidated by means of a longitudinal float. The hand operated longitudinal float shall be not less than three and one-half (3.5) meters in length and fifteen (15) centimeters in width, properly stiffened to prevent flexing and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete, shall be worked with a sawing motion, while held in a floating position parallel to the road centerline, and passing gradually from one side of the pavement to the other, Movement ahead along the centerline of the pavement shall be in successive advances of not more than one half (1/2) the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass.

At the option of the Engineer, the long-handled floats having blades not less than one and one half (1.5) meters in length and fifteen (15) centimeters in width may be substituted for the hand operated longitudinal float.

All other operations after this substitution for the mechanical equipment shall be performed in the manner previously described.

Concreting operation shall be performed only in daylight, under no circumstances shall concrete pavement placed or finished at night.

310.3.9 Removing Forms

Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as specified for the surface. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the Contractor's expense, as directed by the Engineer. Any area or section so removed shall not be less than three (3) meters in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) meters in length, shall also be removed and replaced.

310.3.10 Protecting and Curing of Concrete Pavement

a) Initial Curing

As the surface of the newly-laid pavement is progressively finished, the initial curing and protection operations shall be started.

Upon completion the finishing operation and while the surface of concrete is still moist, but no free water remains, a liquid curing membrane approved by the Engineer shall be applied to the exposed surface of the pavement at the rate not less than one (1) litre per three and two-thirds (3-2/3) square meters of surface area when mechanical pressure distributors are used. The curing membrane, except on irregular areas, shall be applied by means of approved self-propelled mechanical pressure distributors or approved hand sprays. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during its use. The mechanical spraying equipment may be either a full width spray bar equipped with

multiple nozzles or a traversing spray which travels from one edge of the pavement to the other. In either case the path of adjacent nozzles or passes of the traversing spray shall overlap a minimum of one-half (1/2) the width of the spray pattern so that all portions of the surface shall receive double applications from adjacent nozzles or passes. The pumping, pressure and distribution arrangement shall be correlated with the forward speed to provide adequate and uniform coverage of the pavement at not less than the minimum rate required. Irregular areas to which the mechanical distributor cannot be adapted may be covered with hand sprays.

When hand sprays are used, the curing membrane shall be applied in two (2) applications, each at a rate of not less than one (1) litre per five (5) square meters of surface area so as to provide a total rate of application of one (1) litre per two and one half (2-1/2) square meters of surface area. The path of the spray on the second application shall be at right angles to the path of the spray on the first application. When hand operated sprays are permitted, the equipment supplying the pressure to the. spray nozzle shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane compound at the rate required. If from any cause, such as rain-fall soon after its application, the curing membrane is damaged, the Contractor shall immediately apply another application of curing membrane to the surface of the pavement. The rate of application for the replacement membrane shall be the same as for the original membrane.

Unless otherwise directed by the Engineer, immediately following the application of the curing membrane, an approved shade-canvas shall be placed approximately thirty (30) centimeters above the pavement surface. The shade-canvas shall be constructed of materials and in a manner approved by the Engineer. In no case shall any portion of the shade-canvas come in contact with the pavement. The initial curing shall be continued for a period of twenty four (24) hours from the time the curing membrane is applied.

When forms are removed, whether during the initial or the final curing period, the edges of the pavement shall receive curing membrane at the rate of coverage specified for the pavement surface.

The curing membrane may be applied to the vertical edges of the pavement by means of hand sprays or by nozzles attached to the mechanical distributor, but the edges of the pavement shall be covered with curing membrane at the rate specified within thirty (30) minutes after removal of the forms.

When cold-poured joint compound is used, all joints shall be sawed during the initial curing period. The shade-canvas may be moved at joint locations for short periods of time to permit the sawing. Before being sealed, the joints shall be thoroughly cleaned of all loose saw dust, laitance, dirt, other foreign matter, and free of water. As the method of final curing is different from that of the initial curing, the cleaning and sealing of joints shall be performed immediately following the removal of the shade-canvas at the end of the initial curing period and prior to the application of the polyethylene sheeting.

When hot poured joint compound is used, the joints shall be sawed, cleaned, and filled with jute or other acceptable protective material in the same time sequence as for cold-poured joints.

In no case shall any portion of the concrete pavement be exposed to the direct rays of the sun for more than one (1) hour.

Following jointing operations, curing membrane shall be applied to the joint area at the rate specified for the pavement surface.

b) Final Curing

Upon completion of the initial curing period and after the shade-canvas has been

removed and jointing operation has been completed, the pavement shall be completely covered with White Opaque Polyethylene Film as specified in AASHTO M 171. Adjoining sheets shall be lapped a minimum of forty five (45) centimeters. The sheeting shall be held in place in a manner approved by the Engineer.

Final curing shall be continued until the concrete reaches an age of fourteen (14) days. During this period, the curing membrane and polyethylene film shall be protected from damage from any cause. Any damage from one cause shall be immediately repaired by the Contractor at his expense. No traffic, including workmen and pedestrians, shall be allowed on the surface of the pavement until the expiration of the fourteen (14) day curing period.

When concrete is being placed during the time that the air temperature may be expected to drop below fifteen (15) degrees C. a sufficient supply of burlap, straw, hay, or other suitable blanketing material shall be provided along the work to protect the concrete and maintain a minimum temperature of fifteen (15) degrees C in the concrete as measured on the surface of the pavement. An approved moisture barrier such as wet burlap or plastic sheeting shall be placed on the concrete prior to placing the blanketing material. This type of cure shall be maintained for a period of seventy two (72) hours as the initial cure. After the initial cure as specified above, a final cure as specified above may be used. The final cure shall be maintained for a period of fourteen (14) days, thus making a seventeen (17) day curing period for cold weather concreting.

310.3.11 Surface Tolerance

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a three (3) meter straightedge or other specified devices. Areas showing high spots of more than three (3) millimeters, but not exceeding twelve (12) millimeters in three (3) meters between any two contact points, shall be marked and immediately ground down with an approved grinding tool to a tolerance of less than three-(3) mm as described above. Where the departure from correct cross section exceeds twelve (12) millimeters, the pavement shall be removed and replaced by and at the expense of the Contractor.

Any area or section so removed shall be neither less than three (3) meters in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) meters in length, shall also be removed and replaced at the Contractor's expense.

310.3.12 Tests for Thickness of Pavement and Degree of Compaction

a) Thickness of Pavement

The Employer will not be liable for payment of any excess in thickness of depth of pavement. During the progress of the work, the thickness or depth of pavement will be determined by the Engineer from cores cut from the concrete pavement by the Contractor. The cost of cutting and recovering all the cores described in this clause and the following paragraph shall be deemed to be included in the rates and prices for Portland Cement Concrete Pavement entered by the Contractor in the Bill of Quantities.

Unsatisfactory work shall be repaired, replaced, or will be paid for at an adjusted price, as follows:

1) One 15 cm diameter core will be removed by the Contractor from each lane, at such locations as the Engineer may direct, and shall represent not more than 1000 SM of pavement area. A lane shall be considered the pavement surface between longitudinal joints, or a longitudinal joint and pavement edge.

2) If any core measurement is deficient more than 6.5 mm from the required

thickness a core measurement shall be taken at each 30m interval in both directions longitudinal from the first deficient core in the same lane, as defined herein, until the thickness of the pavement is found to be not more than 6.5 mm deficient from the required thickness. Each deficient core shall be considered as representing the condition in the same lane or longitudinal section, as above defined, for a distance of 15m, in each direction longitudinally from the core.

3) Sections of pavement which are deficient in thickness, as determined by cores, by an amount more than 1.3 cm shall be removed and replaced with pavement of the specified thickness at the expense of the Contractor. The removal and replacement shall start at the determined point of deficiency and proceed longitudinally as hereinafter specified, until the pavement is to be not more than 6.5 mm deficient from the required thickness. The old reinforcing steel shall be left extended a sufficient distance so as to allow the new reinforcement steel to be lapped with the old, the required distance to be welded to the satisfaction of the Engineer.

4) The removal and replacements of pavements shall extend transversely the full width each lane in which such deficiency is found.

5) All pavements within two (2) meters of the deficiency spot shall be removed, except that when any joint is more than two (2) meters, all pavements shall then be removed to the next joint.

6) Sections of pavement which are deficient in thickness, as determined by measurement of cores in accordance with AASHTO T148-49, by an amount more than 6.5 mm, but not more than 1.3 cm, will be paid for at an adjusted price as specified in Table Below:

DEFICIENCY IN THICKNESS AS DETERMINED FROM CORES

Thickness	Proportional Part of Contract of Contract Price to be allowed
3.00 mm to 6.5 mm	95%
6.5 mm to 13 mm	75%

b) Degree of Compaction

The cores that have been cut from the concrete pavement according to the requirements of (i) above shall be examined by the Engineer's Representative to check the degree of compaction achieved through the slab and to check the effectiveness of the bond between the top and bottom course concrete.

Should any core reveal that any part of the slab has not been adequately compacted by revealing honeycombed or segregated concrete and should the bond between the top and bottom layers of concrete be such that a plane of weakness is present, then additional cores shall be taken to check the areas of defective concrete pavement according to the procedure laid down in (i) above for determining the areas of concrete pavement deficient in compaction.

Any areas of defective pavement concrete so found shall be replaced with new concrete in accordance with this section at contractor's own expense.

The Engineer reserves the right to carry out crushing tests on any or all of the concrete cores taken in accordance with this clause, and should these tests show that any area of pavement concrete has failed to meet the strength requirements of the specification, then such areas of concrete shall be removed and replaced with new concrete, mixed, laid, compacted and finished to the requirements of this section

at contractor's own expense.

c) Refilling of Holes

Holes in the pavement created by the cutting of cores shall be thoroughly coated on the inside with a neat cement grout and shall then be filled with concrete of the same mix as shown in the pavement. The filling shall be in two equal layers and each shall be rodded 25 times to its full depth. The surface shall be finished flush and broomed. The surface shall be kept thoroughly wet for 72 hours thereafter.

310.3.13 Replacement of Defective Concrete

Any concrete not complying with the specification shall be cut out and replaced in accordance with the specification over the full width of the slab between longitudinal construction joints and over a length extending between two transverse joints each of a type other than a warping feint.

310.3.14 Concrete Lug Anchors

"Concrete Lug Anchors" shall be constructed in accordance with the dimensions and notes and at the locations shown on the plans. Unless otherwise indicated on the plans, the class, composition, consistency, proportioning, batching, mixing and curing of the concrete used in concrete lug anchors shall conform to the same requirements as the concrete pavement. Reinforcing steel, concrete and excavation for lug anchors shall be subsidiary to the Bill of Quantities item "Concrete Lug Anchors."

ITEM 311 ASPHALT CONCRETE WEARING COURSE (PLANT MIX) WITH CELLULOSE FIBER

311.1 DESCRIPTION

The work shall consist of furnishing aggregates, asphalt binder and cellulose fiber at a control asphalt batching plant, mixed at a specified temperature, spreading and compacting the mixture in an approved manner on primed or tacked surface of base, subbase. bridge deck or concrete pavement, in accordance with these specifications and in conformity with lines, grades, typical cross-sections, shown on the drawings or as directed by the Engineer.

311.2 MATERIALS REQUIREMENTS

311.2.1 Mineral Aggregates

a) Coarse Aggregates

Coarse Aggregates shall be crushed, non-absorptive stones and unless otherwise stipulated, shall conform to the following quality requirements:

1.	Los Angeles abrasion, AASHTO T 96	30% max.
2.	Flat and Elongated Particles, ASTM D 4791, Comparing length to thickness (measured on material retained above the No. 4 sieve), 3:1	12% max.
3.	Sodium sulfate soundness loss (5 cycles), AASHTO T 104	12% max.
4.	Particles retained on the No. 4 sieve shall have all fractured faces	100%
5.	Absorption, AASHTO T 85	2% max.
6.	Coarse and fine durability index. AASHTO T 210	40% mix.

Mixes with relatively pure carbonate aggregates or any aggregates known to polish shall not be used.

b) Fine Aggregates

Fine aggregate shall consist of a blend of 100 % crushed, manufactured sand (stone dust). The sodium sulphate soundness loss in 5 cycles shall not exceed 12 percent. In addition, the liquid limit shall not exceed 25 as determined by AASHTO T 89.

c) Combined Aggregates

The several aggregate fractions of course and fine for the mixture shall be sized, graded, and combined in such proportions that the resulting composite blend conforms to Table-A below.

Table A

(Percentage by Weight Passing Sieves, AASHTO T 27 & T 11)

Sieve Designation	Percentage Passing
3/4 in.	100%
½	85 - 95
3/8	60 - 75
No. 4	20 - 23
No. 8	16 - 24
No. 30	12 - 16
No. 50	12 - 15
No. 200	8 - 10
0.020 mm	less than 3*

* To be controlled from a combination of aggregate and mineral filler taken from representative stockpile samples.

311.2.2 Asphalt Cement

a) Asphalt Cement shall be AC-20 or similar grade and conform to AASHTO M 226.

b) Asphalt Cement shall be mixed at a temperature as required to achieve a kinematic viscosity of 150 to 300 centistokes. Typical plant mixing temperature is 310° - 325° F and at no time shall the mixing temperature exceed 325° F.

311.2.3 Mineral Filler

a) Mineral filler should consist of finely divided mineral mater such as rock or limestone dust or other suitable material. At the time of use it should be sufficiently dry to flow freely and essentially free from agglomerations. Filler should be free from organic impurities and have a plasticity index not greater than 4. Filler material for the mix shall meet the requirements of AASHTO M17.

b) Commercial mineral filler added to the mixture, shall be limited to less than 20% of its weight smaller in size than 0.02 mm.

311.2.4 Cellulose Fiber

Fiber stabilizer, cellulose fiber is to be utilized. Dosage rate for cellulose is 0.3% by weight of the total mix. Allowable tolerances of fiber dosage shall be + 10% of the required fiber weight. The selected fiber shall meet the properties described in Table-B utilizing the listed test procedures.

TABLE - B

CELLULOSE FIBER PROPERTIES

1) Sieve Analysis:

   a) Method A - Alpine Sieve Analysis:

Fiber Length:	0.25" (maximum)
Passing No. 100 sieve	70% (± 10%)

   b) Method B - Mesh Screen Analysis:

Fiber Length:	0.25" (maximum)
Passing No. 20 sieve	85% (± 10%)
No. 40 sieve	65% (± 10%)

	No. 140 sieve	30% (± 10%)
2)	Ash-Content:	18% (± non-volatiles)
3)	pH:	7.5 (± -.0)
4)	Oil Absorption:	5.0 (± 1.0) (times fiber weight)
5)	Moisture Content:	< 5%

1) Sieve Analysis

a) *Method A - Alpine Sieve Analysis*

This test shall be performed using as Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fiber shall be sieved for 14 minutes at a controlled vacuum of 22 inches (± 3) of water. The portion remaining of the screen shall be weighted.

b) *Method B - Mesh Screen Analysis*

This test shall be performed using standard No. 20, 40, 60, 80, 100 and 140 sieves, nylon brushes and a shaker. A representative 10 gram sample of fiber shall be sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve shall be weighed and the percentage passing calculated. Repeatability of this method is suspect and needs to be verified.

2) Ash Content

A representative 2-3 gram sample of fiber shall be placed in a tarred crucible and heated between 1100° F for not less than two hours. The crucible and ash shall be cooled in a desiccator and reweighed.

3) pH Test

Five grams of fiber shall be added to 100 ml of distilled water, stirred and let set for 30 minutes. The pH shall be determined with a probe calibrated with pH 7.0 buffer.

4) Oil Absorption Test

Five grams of fiber shall be accurately weighed and suspended in an excess of mineral spirits for not less than five minutes to ensure total saturation. It will then be placed in a screen mesh strainer (approximately 0.5 square millimeter hole size) and shaken on a wrist action shaker for ten minutes (approximately 1 - 1/4 inch motion at 240 shakes/minute). The shaken mass shall be then transferred without touching, to a tarred container and weighed. Results shall be reported as the amount (number of times its own weight) the fibres are able to absorb.

5) Moisture Content

Ten grams of fiber shall be weighed and placed in a 250° forced air oven for two hours. The sample will then be reweighed immediately upon removal from the oven.

311.2.5 Design Mix Requirements

Design parameter shall be in accordance with Hot Mix Asphalt Design by Marshal Method utilizing AASHTO T - 245.

S. No.	Test	Parameter	Designation
i.	VTM (%)	3 - 5	T-166,T-209,T-269
ii.	Asphalt Content (% of total mix)	6.0 min.	
iii.	Stability (Kg)	1000 min.	Marshall Method
iv.	VMA (%)	17 min.	MS-2
v.	Flow 0.01 inch	8 - 14	Marshall Method
vi.	Compaction (No. of blows on each side of specimen)	50	Marshall Method
vii.	Drain Down Test (%)	0.3 max.	

The mix design test property values and cures used to develop the job mix in accordance with the Asphalt Institutes Manual Series No. 2 (MS-2). Acceptable deviations from various values of JMF shall be as under:

a) Aggregates

Passing No. 4 and larger sieves	+ 5%
Passing No. 8 to No. 100 sieves	+ 3%
Passing No. 200 sieve	+ 1%

b) Asphalt Cement

Percent by wt. in total mix	+ 0.3%

c) Cellulose Fiber

Percent by weight in total mix	+ 0.03%

311.3 CONSTRUCTION REQUIREMENTS

311.3.1 Mixing Plant

Plants used for the preparation of the mixture shall conform to AASHTO M 156 and the following.

a) Handling Filler

Adequate dry storage shall be provided for the mineral filler, and provisions shall be made for proportioning the filler into the mixture uniformly and in the desired quantities. Mineral filler in a batch plant will be added directly into the weigh hopper. In a drum plant mineral filler will be added directly into the drum mixer. Special attention is directed to providing appropriate equipment for accurately proportioning the relative large amounts of mineral filler required for mixture.

b) Fiber Addition

Adequate dry storage shall be provided for the fiber additive, and provisions shall be made for proportioning fiber into the mixture uniformly and in the desired quantities.

c) Batch Plant

Loose fiber or palletized fiber shall be added through a separate inlet directly into the pug mill before adding bitumen in the mix. The addition of fiber should be timed to occur during the hot aggregate charging. Adequate dry mixing time is required to ensure proper blending of the aggregate and fiber stabilizer. Dry mixing time shall be

increased 5 to 15 seconds. Wet mixing time shall be increased at least 5 seconds for cellulose fibres to ensure proper blending with the asphalt cement.

d) Hot - Mixture Storage

When the hot mixture is not to be hauled immediately to the project and placed, suitable bins shall be provided. Such bins shall be either surge bins to balance production capacity with hauling and placing capacity or storage bins which are heated and insulated and which have a controlled atmosphere around the mixture. The holding time shall be within limitations imposed by the Engineer, based on laboratory tests of the stored mixture. In no case will mixture be kept in storage overnight.

311.3.2 Hauling Equipment

Hauling equipment and paver shall be of a type normally used for the transport and placement of dense grade asphalt hot mix. Truck beds shall be covered and insulated if necessary, so that the mixture may be delivered on the road at a temperature of not less than 130° C.

311.3.3 Pavers

Pavers shall be a type normally used for the placement of dense graded asphalt hot mix. They shall be self-contained, power-propelled units provided with an adjustable activated screed, heated and capable of spreading and finishing coursed of asphalt plant mix material in lane widths applicable to the specified typical section and thickness shown on the plants.

The paver shall be capable of being operated at forward speeds consistent with satisfactory placement and compaction of the mixture. The paver shall be capable of striking a smooth finish of uniform texture.

311.3.4 Conditioning of Existing Surface

a) Immediately before placing the mixture, the existing surface shall be cleaned of loose or deleterious material by brooming or other approved means.

b) A thin tack coat of asphalt emulsion (SS-1, SS-1 h, CSS-1, CSS-1 h or similar material) conforming to AASHTO M 140 or M 208 shall be applied to ensure uniform and complete adherence of the overlay. The asphalt emulsion used for this purpose will be diluted with an equal part of water and be applied at the rate of approximately 1 gal/square yard.

c) Where the existing surface is distorted, a leveling course of hot asphalt mix shall be required to restore proper cross-section prior to construction of the overlay.

311.3.5 Facing and Finishing

The mixture shall be placed at a temperature not less than 290° F. The mixture temperature shall be measured in the truck just prior to dumping into the spreader.

The mixture shall be spread and struck off to the established grade and elevation with asphalt pavers.

Facing speed will be adjusted so that sufficient time is allowed for compaction operations and to provide continuity.

311.3.6 Compaction

Immediately after the mixture has been spread and struck off, it shall be thoroughly and uniformly compacted by rolling.

a) Due to the nature of mixture, the surface shall be rolled immediately. Rolling shall be accomplished with steel wheel rollers of a minimum weight of 10 tons. Rolling procedures shall be adjusted to provide the specified pavement density. Rollers shall move at a uniform speed not to exceed 3 mph with the drive roll nearest the paver. Rolling shall be continued until and roller marks are eliminated and the minimum density has been obtained. The Contractor shall monitor density during the compaction process by use of nuclear density gauges to assure that the minimum required compaction is being obtained.

b) To prevent adhesion of the mixture to the rollers, it shall be necessary to keep the wheels properly moistured with water mixed with very small quantities of detergent or other approved material.

c) The pavement shall be compacted to at least 94% of maximum theoretical density and at no more than 6% air voids.

d) Once sufficient in-place density has been' achieved, rolling operating should cease, as over-rolling may cause migration of asphalt cement and filler to the compacted pavement surface.

311.4 CONTROL OF ASPHALT MIXTURE

The mixture furnished by the Contractor shall conform to the job-mix formula, within the allowable deviations from the target values. The allowable deviations from the target values for the JMF of the aggregate shall be +/- 4% for the 3/4", 1/2" and 3/8" sieve, +/- 3% for the No. 4, No. 8, No. 30 and No. 50 sieve, and +/- 2% for-the No. 200 sieve. The allowable deviation from the target value for the asphalt content shall be +/- 0.3 percent.

311.5 TRIAL/ EXPERIMENTAL SECTIONS

Test section (s), a minimum of 200 meter each, shall be constructed to examine the mixing plant process control, placement procedures, mix surface appearance, compaction patterns and to calibrate the nuclear density device.

311.6 WEATHER LIMITATIONS

The mixture shall be placed only when the air temperature is four (4) degrees centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

ITEM 312 PROOF ROLLING

312.1 DESCRIPTION

The work shall consist of conducting proof rolling by a specified type of roller to confirm the adequacy of compaction for the underlying layers of an existing road, natural surface or prepared grade. Proof rolling shall be performed to locate isolated soft areas that are not detected in grade inspection process and will involve driving a heavy pneumatic-tired roller/vehicle over the existing road, natural surface or prepared grade. The proof rolling shall be carried out in accordance with these Specifications and in conformation with the lines shown on the drawings or as directed by the Engineer.

312.2 CONSTRUCTION REQUIREMENTS

a) The proof rolling is to be carried out on any type of granular material, subgrade material or asphaltic layers as the case may be. However, in case, the proof rolling is to be carried out on granular material / subgrade, all the undulations shall be removed by the Contractor as a pre-requisite of this item without any extra cost to the Employer.

b) A fully loaded tandem axle truck or pneumatic tired roller shall be used as proof-roller. Steel rollers are not recommended because they may potentially distribute the load across soft areas without any observed movement.

c) Proof rolling is also recommended if an un-stabilized base is to be used between the concrete pavement and subgrade.

STRUCTURES

ITEM 400 GENERAL

400.1 DESCRIPTION

This item contains a general description of the specific items of work, the materials, construction requirements, and methods of measurement and payment for all concrete structures including bridges, culverts, piles, composite structures of concrete such as barriers and steel, prestressed and post tensioned girder and all brick and stone masonry structures built as indicated on the drawings and in conformity with the lines, grade, dimension in conjunction with any instructions issued by the Engineer. Materials, equipment, workmanship and construction methods applied in the work shall conform to the requirements laid down herein and shall also follow the best modern construction practices with the approval of Engineer. This item shall also include construction of certain structural features and incidental items which are either common to all types of structures or which may apply to any of them.

In the absence of Specification of any materials, the same shall conform to relevant ASTM or AASHTO Standards/Specifications as approved by the Engineer.

Tender drawings should not be used for construction. All work shall be carried out in accordance with the Construction Drawings and the Contract Documents.

400.2 CLEARING OF SITE

The Contractor shall clear the sites for proposed structures of trees, bushes, stumps and debris, in the manner outlined in section 101 "Clearing and Grubbing" cost of which shall be deemed to be included in the price bid for the various items. Special clearing of site such as removal of existing bridges, buildings, concrete pavement etc., will be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with the special clearing shall be deemed to be included in the price tendered for various items of the structures in the Bill of Quantities.

Removal or relocation of public or private utilities such as telephone, telegraph lines, power lines, sewer and water pipe lines, railway tracks and their appurtenances etc. shall be arranged by the Employer's Representative with the concerned Government Agency/Agencies, Autonomous Bodies, Utility companies involved. The Employer shall bear the costs of relocating such utilities.

400.3 ALIGNMENT AND GRADE

All structural members such as prefabricated girders, cast in situ deck slab, cast in situ superstructures, bridge rails including kerbs, wheel guards, safety fencing shall be so constructed and placed that finished vertical alignment and grade shall be as shown on the drawings.

Rails, sidewalks and kerbs on the curved portion of structure shall be constructed, as far as possible after the completion of the entire superstructure slab. In such cases, the height of rail, sidewalk and/ or kerb may vary with respect to the grade line of the slab in order to produce the desired appearance.

400.4 FOUNDATION DATA

Refer to clause 400(A).3 (b)

400.5 FINAL CLEARING

Upon completion of structure, the Contractor shall clean up the site; remove all temporary buildings, false work, lumber, equipment and all other debris. The Contractor shall level off all excavated material not used for back fill around piers, bents, abutment, culvert, and headwalls and on embankment slopes. Bridge decks and sidewalks shall be left in clean and workmanlike condition.

400.6 OPENING TO TRAFFIC

Bridges or slab or box culverts having decks constructed with Specified Cement concrete shall remain closed to all traffic and Contractor's equipment subject to the results of tests made of the concrete but not less than twenty eight (28) days after the placing of concrete.

The above time of opening to traffic is applicable when temperatures are above ten (10) degree C. When temperatures are below ten (10) degree C, the time of opening to traffic shall be increased at the discretion of the Engineer. In any event bridges or culverts with concrete decks shall not be opened to traffic without the approval of the Engineer.

MEASUREMENT AND PAYMENT

DELETED

ITEM 400 (A) BRIDGES AND CULVERTS

400.A.1 DESCRIPTION

All steel and concrete bridges, underpasses and concrete culverts shall be constructed as indicated on the plans, in conformity with the lines, grades, dimensions and design shown on the plans and in accordance with the provision of item 107 "Structural Excavation and Backfill", item 401 "Concrete", item 402 "False Work and Centering for Bridges", item 403 "Form Work", item 404 "Steel Reinforcement", and item 405 "Pre Cast Concrete Structures", and all other pay items which are to constitute the complete construction of the structure, as directed by the Engineer.

400.A.2 MATERIALS

The materials used shall be those prescribed for several contract items which are to constitute the complete structure.

400.A.3 CONSTRUCTION REQUIREMENTS

a) Clearing the Site

The Contractor shall clear the site of the proposed structure of trees, bushes, stumps, and debris in accordance with section 101 "Clearing and Grubbing". Special clearing of site such as removal of existing buildings, concrete pavement shall be paid for at the prices tendered for these items, but where no such prices are provided for, all costs in connection with this special clearing shall be deemed to be included in the price tendered for the various items of structures in the tendered Bill of Quantities.

Removal or relocation of public or private utilities such as telephone or telegraphs lines, power lines, underground cable lines, sewer and water supply lines, railway tracks and their appurtenances etc. shall be arranged by the employer representative with the specific government agency, utility companies and person involved. The Employer shall bear the cost of relocating such utilities.

b) Foundation Data

Foundation data including the location of all boreholes together with the records of ground conditions encountered have been obtained from soil investigation by test boring, test pits or other sources. It is the Engineer's responsibility to ensure by additional investigations through the Contractor at the very beginning of construction work that the foundation levels given in the Drawings coincide with the local requirements.

c) Alignment and Grades

All structural members such as prefabricated girders, cast in situ deck slab, cast in situ superstructures, bridge rails including kerbs, wheel guards, safety fencing shall be so constructed and placed that finished vertical alignment and grade shall be as shown on the Drawings.

Rails, Sidewalks and Kerbs on the curved portion of structure shall be constructed, as far as possible after the completion of the entire superstructure slab. In such cases, the height of rail, sidewalk and/or kerb may vary with respect to the grade line of the slab in order to produce the desired appearance.

d) Erection Method

Before moving any construction equipment to the site, the Contractor shall submit for approval an outline of the method he proposes to follow in the erection of structure.

e) Cross Communication

1) *Navigable Streams*

The channel of navigable streams shall be kept clear for safe passage of water. The Contractor shall provide and maintain all necessary light and signals in accordance with the navigation authority's requirements. The Contractor shall pay due regard to the hazard of the river flow during period of intense rainfall. All material deposited in the channel shall be removed to the required depth and clearance lines at the Contractor's expense.

2) Roads

In case of existing roads crossing the alignment of Project Road, the Contractor shall construct detours, install road/warning signs, lit the area and shall deploy enough labor and equipment for safe operation of detours. In case of bridges over railway tracks, earth work will be carried out without permanent stoppage of railway traffic. Short stoppages, however shall be requested to Railway Authorities through Client and agreed schedule in this regard will be followed.

f) Concreting

The concrete of Bridges or culverts shall be poured and surface finished and cured as per requirements conforming to item 401.3

g) Final Clearing

Upon completion of structures, the Contractor shall clean up the site conforming to requirements in item 400.5

h) Public Bodies/Service Authorities

The Contractor's methodology shall meet all statutory requirements of the railway, irrigation or Service Authorities and his rates shall include for all costs of meeting these requirements.

ITEM 401 CONCRETE

401.1 DESCRIPTION

This work consists of furnishing placing, curing, finishing including transport of cement concrete made from approved type of Cement, water, fine and coarse aggregates and chemical admixtures as may be required all in accordance with the requirements in these specifications and conforming to the lines, grades, and typical sections shown on the Drawings or called for in these Specifications and to the approval of the Engineer.

401.1.1 Classes of Concrete

The classes of concrete recognized in these specifications shall be designated: A_1, A_2, A_3, B, C, D_1, D_2, D_3, Y and Lean Concrete. The Class of concrete to be used shall be as called for on the Drawings or as directed by the Engineer or specified in these Specifications. The following requirements shall govern unless otherwise shown on the Drawings.

Class A_1 Concrete shall be used everywhere, for non-reinforced and reinforced concrete structures, except as noted below or directed by the Engineer. Concrete placed under water shall be Class A_2 with a minimum cement content of three hundred fifty (350) kg per cubic meter of concrete with a slump between ten (10) and fifteen (15) cm. Concrete placed for piles shall be class A_3 with a minimum cement content of four hundred (400) Kg per cubic meter.

Class B Concrete shall be used only where specified.

Class C Concrete shall be used for cribbing, or as otherwise directed by the Engineer or specified in these Specifications or on the Drawings.

Class D_1, D_2 or D_3, concrete shall be used for pre-stressed and post-tensioned elements, as indicated on drawings.

Class Y concrete shall be used as filler in steel grid bridge floors, in thin reinforced sections, or as otherwise specified in the these Specifications.

Lean Concrete shall be used in thin layers underneath footings and when called for on the Drawings or directed by the Engineer.

The concrete of the various classes shall satisfy the requirements shown in Table 401-1.

TABLE 401-1
Portland Cement Concrete Requirements

Class of Concrete	Minimum Cement (Kg/Cubic Meter)	Maximum Size of Coarse Aggregate (mm)	28 days' Min Cylindrical Compressive Strength (Kg/Sq.cm)	Consistency (Range in Slump) Vibrated (mm)	Maximum Permissible Water - Cement Ratio
A_1	325	20	210	25-75	0.50
A_2	400	20	280	50-100	0.50
A_3	400	38	280	100-150	0.58
B	250	38	170	25-75	0.65
C	275	38	210	25-75	0.58

D_1	450	20	350	50-100	0.40
D_2	500	20	425	50-100	0.40
D_3	550	20	500	50-100	0.40
Y	400	13	210	25-75	0.50
Lean Concrete	200	38	150	-	-

Maximum slump is two hundred (200) mm if the approved mix design contains high range water reducer.

401.1.2 Types of Concrete Works

a) Sub-Structure Concrete

It includes concreting of open foundations at or below N.S.L, counterfort walls, wing walls, abutment seat, transom, concrete pads, approach slab and all structural members concreted below laminated elastomeric bearing pad.

b) Super-Structure Concrete

It includes concreting of deck slab, diaphragm, precast R.C Beams, curtain wall and all structural members concreted above laminated elastomeric bearing pads.

c) Box Culvert Concrete (including those used as Underpasses)

It includes concreting of box culverts for water courses, drainage culverts, pedestrian underpasses and vehicular underpasses.

401.2 MATERIAL REQUIREMENTS

401.2.1 Portland Cement

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in local storage by Contractor for more than three (3) months after shipment from the factory may be retested before use and shall be rejected if it fails to meet any of the specification requirements.

Portland cement shall conform to the requirements of the Standard Specifications for Portland cement, AASHTO Designation M85 (ASTM Designation C150).

Sampling of cement shall be in accordance with AASHTO Designation T-127.

Mill certificates shall accompany delivery of the material to the work.

Cement shall be delivered in sufficient quantities to ensure that there is no suspension of concrete work at any time. Different brand or different types of cement from the same mill, or the same brand or type from different mills shall not be mixed or used alternately in the same member of a structure unless authorized by the Engineer, after preparing new mix design.

401.2.2 Fine Aggregate

The fine aggregate shall consist of sand, having clean, hard, strong, sound, durable, uncoated grains free from injurious amount of dust, lumps, soft or flaky particles, shale alkali, organic matter, material reactive with alkalis in the cement loam or other deleterious substances, and shall not contain more than three (3) percent of material passing the No. 200 sieve by washing nor more than one percent of clay lumps or one (1) percent of shale.

For exposed work, the fine aggregate shall be free from any substance that will discolour the concrete surface.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO Designation T-11 and T-27 shall meet the following grading requirements:

GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight.
3/8 inch	100
No. 4	95 - 100
No. 16	45 - 85
No. 50	10 - 30
No. 100	2 - 10
No. 200	0 - 3

Fine concrete aggregate shall meet the following requirements.

Fineness Modulus, AASHTO M6	2.3 to 3.1
Sodium Sulphate Soundness, AASHTO T-104, 5 cycles, percent loss (max)	10
Clay Lumps and Friable Particles AASHTO T-112, Percent (max)	1
Test for Organic Impurities, AASHTO T-21	Lighter than standard
Sand Equivalent AASHTO T-176 (min)	75
Potential Cement – Aggregate Reactivity ASTM C 289, as supplemented by ASTM C 227	Innocuous

Petrographic analysis shall be done to check alkali-silica reactivity.

For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus of greater than 0.20 either way from the fineness modulus of mix design samples submitted by the Contractor may be rejected till new trial mixes are prepared and tested by the Contractor.

Testing of the aggregate is specified under Item 401.3.9 of these specifications.

401.2.3 Coarse Aggregate

The coarse aggregate shall consist of crushed aggregate having clean, hard, strong, sound, durable uncoated particles, free from injurious amount of soft, friable, thin elongated or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of these Specifications. Percentage of Clay Lumps and Friable Particles (AASHTO T-12) shall be 1% Maximum.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 401-2 and when tested in accordance with AASHTO Designation T-11 & T-27 shall meet the following grading requirements:

TABLE 401.2
GRADING OF COARSE AGGREGATES

Designated Sizes	Percentage by Weight Passing Laboratory Sieves having Square Openings, in Inches							
	2½	2	1½	1	3/4	1/2	3/8	No. 4
1/2" to No. 4	-	-	-	-	100	90-100	40-70	0-15*
3/4" to No. 4	-	-	-	100	90-100	-	20-55	0-10*
1" to No. 4	-	-	100	95-100	-	25-60	-	0-10*
1½" to No. 4	-	100	95-100	-	35-70	-	10-30	0-5
2" to No. 4	100	95-100	-	35-70	-	10-30	-	0-5
1½" to 3/4"	-	100	90-100	20-55	0-15	-	0-5	-
2" to 1"	100	90-100	35-70	0-15	-	0-5	-	-

* Not more than five 5 percent shall pass No. 8 sieve.

Coarse aggregate shall contain not more than one (1) percent by weight of material passing the No. 200 sieve by washing and not more than five (5) percent of soft fragments.

It shall have an abrasion loss of not more than forty (40) percent at five hundred (500) revolutions, when tested in accordance with AASHTO T-96.

When tested in accordance with AASHTO T-104, for five cycles, the loss with the sodium sulphate soundness test shall be not more than 12 percent.

Testing of coarse aggregate is specified under Item 401.3.9 of these Specifications.

The aggregate shall be non-alkali/silica reactive where the concrete is to be poured under water or exposed to humid conditions.

Coarse aggregate shall not contain materials such iron pyrites, coal, mica, laminated materials or other materials which may adversely affect the strength and durability of the concrete.

Coarse aggregates shall meet the following requirements:

Flakiness Index BS 812: Part 105:	15%
Potential Cement – Aggregate Reactivity ASTM C 289, as supplemented by ASTM C 227	Innocuous

Sodium Sulphate Soundness, AASHTO T-104, 5 cycles, percent loss (max)	12
Clay Lumps and Friable Particles AASHTO T-112, Percent (max)	1
Soft Fragments and Shale, AASHTO M-80, Percent (max)	5
Potential Cement – Aggregate Reactivity ASTM C 289, as supplemented by ASTM C 227	Innocuous

Petrographic examination and description, including approximate composition against alkali-silica reactivity shall be done as per ASTM C 295. Under no circumstances shall the Contractor use Dacite Andesite Hyolite, Opal Cherts or Tuffs.

401.2.4 Combined Aggregate

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

Changes from one gradation to another shall not be made during the progress of the work unless approved by the Engineer, and shall meet the following requirements for the combined aggregate:

Material passing the 200 sieve by weight	3% Maximum
Water soluble Chlorides	0.04% Maximum

Water soluble Sulphates:

Pre-stressed concrete	0.05% Maximum
Reinforced concrete	1.0% Maximum
Non-reinforced concrete	2.0%

The water soluble chlorides and Sulphates limits specified for the fine and coarse aggregate individually, are subject to the following overriding requirement:

The total water-soluble chloride content (AASHTO T 260) in any mix from all sources, including any chloride present in other materials and the mixing water, shall not exceed the following limits as a percentage of the weight of cement in the mix:

Reinforced concrete in humid environment and exposed to chloride	0.1%
Reinforced concrete in humid environment but not exposed to chloride	0.15%
Pre-stressed concrete	0.06%

In case of any likeliness of alkali reactivity the following further tests shall be conducted, as soon as practicable after the Contract is awarded to the Contractor:

1) Potential Reactivity Tests

- Gel Pat Test
- ASTM Test C 289 (Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates - Chemical Method)
- ASTM Test C 227 (Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates - Mortar Bar Method)

2) Shrinkage

The properties of the aggregates shall be such that Drying Shrinkage of concrete prepared and tested in accordance with the United Kingdom Building Research Station Digest No 35 (second series) shall not exceed forty five thousandths percent (0.045%).

The initial Drying Shrinkage of all the proposed concrete mixes prepared and tested in accordance with BS 1881 shall not exceed six hundredths percent (0.06%).

3) Reactivity

Aggregates for use in concrete or mortar that will be subject to wetting, extended to humid atmosphere, or contact with moist ground, shall not contain any materials that are deleteriously reactive with the alkalis in the cement, or any which may be additionally present in the aggregates and mixing water or water in contact with the concrete or mortar, in amounts sufficient to cause excessive localized or general expansion of concrete or mortar.

401.2.5 Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of tough, sound, and durable rock. The stone shall be free from coatings, seams, or flaws of any character. In general, the percentage of wear shall not exceed fifty (50) when tested in accordance with the Standard Method of Testing for Abrasion of Coarse Aggregate by the use of the "Los Angeles Machine", ASTM C535.

401.2.6 Storage of Cement and Aggregates

a) All cement shall be stored, immediately upon arrival on the site of the work, in weather-proof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity of a sufficient quantity of cement for at least thirty (30) days use. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. However, if approved, sacked cement on small jobs may be stored in the open, upon a raised platform provided that ample waterproof covering is ensured. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use all cement shall be free flowing and free of lumps. Cement bags shall be weighed at random to check for variation.

   Copies of cement records shall be furnished to the Engineer showing such detail as, the quantity used during the day run or at each part of the work. Cement held in storage for a period of over sixty (60) days, or cement which, for any reason the Engineer may suspect of being damaged, shall be subject to a retest before being used in the work.

b) The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

   In order to secure greater uniformity of the concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stock piles to prevent the material at the edges of the piles from becoming intermixed.

   If aggregates are stored on the ground the bottom layer of aggregate shall not be disturbed or used without recleaning and as approved by the Engineer.

401.2.7 Water

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than twenty five (25) percent or a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) percent when compared to the result obtained with distilled water.

The water shall be free from oil, alkali, vegetable matter, salt and other impurities. If the specific conductance is less than fifteen hundred (1500) microhms per centimeter, the total solids content requirement may be waived. Water for washing aggregates, mixing, and curing shall contain no chlorides as Cl, nor sulfates as exceeding the values for the type of the work as follows:

Type of Work	Chlorides (Parts per million)	Sulphates (Parts per million)
Conventionally Reinforced	500	1,000
Prestressed Concrete	500	1,000

In non-reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than two thousands (2,000) parts per million of chlorides nor more than one thousand five hundreds (1,500) parts per million of sulfates as SO_4.

In addition to the above requirements, water for curing concrete shall not contain any impurities in a sufficient amount to cause discolouration of the concrete or produce etching of the surface.

When required by the Engineer, the quality of the mixing water shall be determined by the Standard Method of Test for Quality of Water to be used in concrete, AASHTO Methods of Sampling and Testing, Designation: T 26.

401.2.8 Admixtures

Admixtures shall only be allowed to be used with written permission from the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer, and shall conform to the requirements for each of the agents specified by the manufacturer.

Chemical and air entraining admixtures containing chlorides as determined by ASTM Designation C 1152 shall not be used in reinforced or prestressed concrete.

Calcium chloride shall not be used in concrete containing any embedded metals, including reinforcing steel, unless otherwise specified.

If more than one admixture is to be used, such admixtures shall be compatible in combination as used in the concrete.

Admixtures shall conform to the following test requirements:

Chemical Admixtures	AASHTO M194
Air Entraining Admixtures	AASHTO M154
Calcium Chloride	AASHTO M144
Mineral Admixtures	ASTM Designation C618-89

Loss on ignition shall not exceed four percent (4%).

All Admixtures to be used in the work shall be accompanied by a Certificate of Compliance signed by a responsible representative of the manufacturer.

When concrete is designated by compressive strength no reduction in the minimum required cement will be allowed.

The cost of admixture shall not be paid separately and shall be included in the unit cost of concrete.

401.2.9 Mix Design

The mix design shall be based on “Standard Practice for Selecting Proportions for Normal Heavy Weight and Mass Concrete ACI 211.1” Standards. The Contractor shall perform all necessary mix design testing and furnish the results in a written report not less than thirty

five (35) days prior to beginning concrete production using the same batching plant from which the concreting of the structural members is to be carried out. The report furnished by the Contractor shall contain all test results for materials proposed for use and trial mixes and specific recommendations for the following:

a) The weight ratio of coarse and fine aggregates per cubic meter.
b) The cement content in kilograms per cubic meter of concrete.
c) The maximum allowable water content in liters per kilogram of cement, or equivalent units including surface moisture, but excluding water absorbed by the aggregates.
d) Slump or slumps designated at the point of delivery.
e) Description of all changes from the mix proportions previously approved.
f) Initial and final setting time for concrete as per AASHTO T-197.
g) Drying shrinkage for the recommended concrete mix according to ASTM C 596.
h) The dosage of the proposed admixture in either liter or kilogram per cubic meter.

401.3 CONSTRUCTION REQUIREMENTS

The manufacturing, transport, handling and placing of concrete shall conform to the requirements given hereinafter.

Cement as specified in sub-heading 401.2.1 shall be used in all structures unless specified or directed otherwise by the Engineer.

401.3.1 Proportioning of Concrete

All concrete shall be proportioned by weighing, except as specified herein. The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and consistency shall be approved by the Engineer. Such approval may be withdrawn at any time, and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various materials to be used in the batch size adopted. The required consistency shall also be shown. Such lists are subject to approval by the Engineer, and shall be posted at the mixer. The amount of water in the mix is the total amount of free water, including the free water held by the aggregates.

No concrete shall be placed in the works until the results of the twenty eight (28) days test indicate that the design proportions are satisfactory as per requirements under Item 401.3.10 "Testing of Compressive Strength". Adjustment of the proportions shall be subject to the following provisions:

a) Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportions originally approved, the Engineer shall make such changes as are necessary.

b) Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes.

The Contractor’s attention is drawn to the time required to prepare and test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is not delayed.

The Contractor shall provide the Engineer with access at all times to laboratory facilities and personnel during the preparation of trial mixes. The trial mixes prepared by the Contractor shall produce dense concrete mixtures containing the minimum cement content and having the specified consistency and minimum compressive strength for

each Class of concrete listed in the Bill of Quantities. The compressive strength reported shall be the average cylinder strength of either three (3) or two (2) individual cylinder test results.

The maximum aggregate size in all classes of concrete included in the Specifications, except blinding concrete, shall be not larger than one-fifth of the narrowest dimension between sides of forms, one-third of the depth of slabs nor two-thirds of the minimum clear spacing between individual reinforcing bars or bundles of bars.

After the Contractor completes the necessary mix design testing and obtains approval of the job-mix proportions for each class of concrete by the Engineer, he shall sample all materials used in the design of the concrete mixtures along with a copy of the approved job-mix reports and submit them. All material samples shall be certified by the Engineer as being representative of those used in the testing procedure and shall be in sufficient quantities for the conduct of all specified physical and chemical tests as well as for preparation of the required test specimens for strength evaluation purposes.

When the materials proposed for use by the Contractor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the proportions shall be adjusted to produce concrete with the required consistency and workability without exceeding such allowable water content. No increase in payment shall be allowed when such changes cause an increase in cement content.

Six (6) test cylinders shall be prepared for each trial mix and each class of concrete to be furnished. The Contractor shall provide facilities for the proper curing of the test cylinders. The Contractor, after giving notice to the Engineer and providing an opportunity for the Engineer to be present, shall break three (3) cylinders after seven (7) days curing and the remaining three (3) cylinders after twenty-eight (28) days curing.

After receipt of the Contractor's mix design report, the Engineer shall review the information. When the trial mix information, for any class of concrete, fails to meet the Specifications, the Engineer will direct the Contractor to prepare additional trial mixes. When the Engineer has determined that the Contractor's recommended concrete materials and mix proportions conform to the Specifications he shall allow production of concrete to begin. No class of concrete shall be produced or placed until the Engineer has reviewed trial mix information and allowed production to begin.

The approval of mix proportions by the Engineer, to the Contractor in establishing those proportions, shall not relieve the Contractor from responsibility for producing concrete which conforms to the Specifications.

All costs connected with furnishing laboratory facilities and personnel, testing all materials, preparing every required trial mix, reporting the information to the Engineer and all other tasks associated with preparing design mixes for all specified classes of concrete shall be borne by the Contractor.

401.3.2 Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be determined to be as dry as it is practicable to satisfy the requirements for transportation and placing of the concrete as described hereinafter.

Consistency of concrete shall be determined as specified in AASHTO T-119. The Consistency of concrete at the time of delivery shall be as shown in Table 401.1 or as designated by the Engineer.

401.3.3 Mixing Concrete

a) General

The concrete shall be mixed only in the quantity required for immediate use. Concrete that has developed an initial set shall be rejected.

Concrete shall be thoroughly mixed in a mixer of an approved size and type that will ensure a uniform distribution of the materials throughout the mass.

All concrete shall be mixed in mechanically operated mixers. Mixing plant and equipment for transporting and placing concrete should be arranged with an ample auxiliary installation to provide a minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete should be disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to a construction joint.

Equipment having components made of aluminum or magnesium alloys, which would have contacted with plastic concrete during mixing, transporting or pumping of Portland cement concrete, shall not be used.

Concrete mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the quantity of water used.

Materials shall be measured by weighing, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall ensure accurate measurement of each ingredient.

The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one (1) percent of the desired value. Cement in standard packages (bags) approved by the Engineer need not be weighed. The water measuring device shall be accurate to plus or minus half percent $\pm$ 0.50%. All measuring devices shall be subject to the approval of the Engineer; Scales and measuring devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.

Weighing equipment shall be isolated so that vibration or movement of other operating equipment does not affect the accuracy of reading. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer more than one (1) percent for cement, one and half ($1^1/_2$) percent for any size of aggregate, or one (1) percent for the total aggregates in any batch.

The moisture content of the fine aggregate shall be uniform throughout the stock pile and not exceed eight percent (8%) at the time of mixing. The Contractor shall remix aggregate stockpiles when ordered by the Engineer. During batching in windy conditions, it is to the discretion of the Engineer to discontinue the batching process or instruct the Contractor to add additional cement at no cost.

No mixing or pouring of concrete will be allowed at ambient temperature higher than 32 ° Celsius, without an agreement of the Engineer on the Contractor's proposals for cooling measures. The temperature of mixed concrete immediately before placing will not be more than 30 ° Celsius. The Contractor will take all specific precautions according to AASHTO-Standard Specifications-Division II 8.6.3 (2002) so as to achieve the above mentioned temperature for which no extra payment shall be made.

b) Mixing at Site

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixer shall be restored or

replaced when any part or sections is worn two and half ($2^1/_2$) cms or below than the original height of the manufacturer's design. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used.

When bulk cement is used and volume of the batch is one cubic meter or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall also be interlocked against opening when the amount of cement in the hopper, is underweight by more than one percent or overweight by more than three (3) percent of the amount specified.

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The temperature of mixed concrete, immediately before placing, shall be not more than thirty (30) degree C. Aggregates and water shall be cooled as necessary to produce concrete within this temperatures limit. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and- charged into the mixer by means that will not result in loss due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than one and half ($1^1/_2$) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not repaired within twenty four (24) hours, further use of the mixer will be prohibited until repairs are made.

The first batch of concrete material placed in the mixer shall contain cement, sand, and water in excess to the requirement of mix, to ensure that the drum does not extract mortar from the mix changing its design characteristics. When mixing is to stop for a period of one hour or more, the mixer shall be thoroughly cleaned.

c) Plant Mixing

At central mixing plant, batches shall be 'discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.

The plasticizer, accelerator or retarder or water reducing admixture, if required, shall

be fed separately at the rate recommended by the manufacture, or as established by laboratory trials.

d) Transit Mixing

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. The truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in case the concrete batch is poured within twenty five (25) minutes of adding water.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer, and stamped in metal on the mixer. Truck mixing shall be continued for not less than fifty (50) revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than six (6) rpm, nor more than ten (10) rpm.

Mixing shall begin within thirty (30) minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above thirty two (32) degree C, this limit shall be reduced to fifteen (15) minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

e) Partial Mixing at the Central Plant

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at the stationary plant mixer may be reduced to thirty (30) seconds and the mixing completed in a truck mixer/agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

f) Stiff Concrete Mix

For mixing concrete of zero slump to be laid by slipform pavers, gravity mixer shall not be used. Only force mixer of moving blades shall be allowed to ensure homogenous mix.

g) Hand Mixing

Hand mixing of materials shall not be allowed in any case.

401.3.4 <u>Hauling and Delivery of Mixed Concrete</u>

a) Hauling

Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer's rated capacity and shall conform to all the requirements specified for ready mixed concrete in AASHTO M157. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

Bodies of non-agitating hauling equipment shall be so constructed that leakage of the concrete mix, or any part thereof, will not occur at any time, and they shall be self-cleaning during discharge.

For zero slump concrete to be laid be paver, concrete will be allowed to be hauled in open trucks. However concrete hauled in open-top vehicles shall be protected during hauling against rain or exposure to the sun for more than twenty (20) minutes when the ambient temperature exceeds twenty five (25) degree C.

No additional water shall be incorporated into the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixer agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before two hundred fifty (250) revolutions of the drum or blades, whichever comes first, after the introduction of cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, a time less than one hour will be required except when retarder is used in which case it shall be one (1) hour.

When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is thirty (30) degree C or above, the time between the introduction of cement to the aggregates and discharge shall not exceed forty five (45) minutes.

b) Delivery

The organization supplying concrete shall have sufficient plant capacity and transportation vehicles to ensure continuous delivery at the rate required. The rate of the delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed twenty (20) minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum rehandling and without damage to the structure of the concrete.

c) Retempering

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete that has developed initial set shall not be used. Concrete that has partially hardened shall not be retempered or remixed.

401.3.5 Handling and Placing Concrete

a) General

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork, and struts, stays and braces serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under Item 401.3.4 "Hauling and Delivery of Mixed Concrete".

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes, and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. In any case the Engineer will reject the use of equipment for concrete transportation that will allow segregation, loss of fines, or in any other way will have a deteriorating effect on the concrete quality.

Open troughs and chutes shall be of metal or metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run; water used for flushing shall be discharged clear off the structure.

When placing operations would involve dropping the concrete more than one and half ($1^1/_2$) meters, it shall be conveyed through sheet metal or other approved pipes. As far as practicable, the pipe shall be kept buried in the newly placed concrete. After initial set of the concrete the forms shall not be jarred and no loading of any kind shall be placed on the ends of projecting reinforcement bars.

The concrete shall be placed as nearly as possible to its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

Precast concrete units shall be delivered to the site in such quantities and at such times as will ensure the continuity of the installation. Units shall be stored so as to ensure safety against cracking, distortion, staining, or other physical damage. Units shall be lifted and supported at the designated lift points only. Precast concrete units shall be lifted and supported at the designated lift points only.

Before concreting in any section, reinforcement will have to be completely clean and free from all contaminations, including hardened concrete (if any) which may have been deposited on it from previous operations. Concreting will take place only once the Engineer has inspected the placing of the reinforcement and given his approval.

The Contractor will allow the Engineer at least eight (8) working hours after all the reinforcement is in place before pouring of concrete to conduct the inspection.

The Engineer should check the records of concrete placing as stated below:

1) Records, in a form agreed by the Engineer, shall be prepared by the Contractor of the details of every pour of concrete placed. These records shall include Class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture content of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cylinder sample points and details of any cores taken. Originals shall be provided to the Engineer and a copy shall be retained by the Contractor.

2) The Contractor shall supply to the Engineer two copies of summary of these records each week covering work carried out during the preceding week. In addition, he shall supply to the Engineer monthly histograms of all 28 days cylinder strengths together with accumulative and monthly standard deviations and any other information, which the Engineer may require concerning the concrete placed in the Works.

b) Pneumatic Placing

Pneumatic placing of concrete will be permitted only if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine.
At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

c) Pumping

The placing of concrete by pumping will be permitted only if specified in these Specifications or if authorized by the Engineer. The equipment shall be so arranged that no vibration will occur that might damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is obtained. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

d) Placing Concrete under Water

Concrete shall not be placed under water except where inevitable in which case approval must be sought from the Engineer and the work carried out under his immediate supervision. In this case the method of placing shall be as hereinafter specified.

Concrete deposited under water shall be class A_3 concrete with a minimum cement content of four hundred (400) Kg per cubic meter of concrete.

The slump of concrete shall be maintained between ten (10) and fifteen (15) cm. To prevent segregation, it shall be carefully placed in a compact mass, in its final position, by means of a tremie, a bottom-dump bucket, or other approved means, and it shall not be disturbed after being placed. Water must not be allowed to flow past the fresh concrete surface.

A tremie shall consist of a tube having a diameter of not less than 25 cm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the concrete work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping or other means, which will not injure the surface of the concrete.

e) Compaction

Concrete, during and immediately after placing shall be thoroughly compacted, except lean concrete under footings and concrete deposited under water. Concrete in walls, beams, columns, etc. shall be placed in horizontal layers not more than thirty (30) centimeters thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer, which has not taken an initial set.

The compaction shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given by the Engineer or is provided herein. Vibrators shall be of a type, design, and frequency approved by the Engineer. The intensity of vibration shall be such as visibly to affect a mass of concrete with a 3 cm slump over a radius of at least half a meter. The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freshly placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued at any-one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall not be applied directly to the reinforcement or to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be ' used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to transport concrete neither in the forms nor in troughs or chutes.

Vibration shall be supplemented by such external vibrator as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the normal vibrators.

401.3.6 <u>Casting Sections, Construction and Contraction Joints</u>

a) General

The concrete in each integral part of a structure shall be placed continuously, and the Contractor will not be allowed to commence work on any such part unless sufficiently inspected and approved material for the concrete is at hand, and manpower and equipment are sufficient to complete the part without interruption in the placing of the concrete.

Construction joints shall be allowed only where specified on the plans or otherwise approved. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or bond the two sections together. When shear keys or inclined reinforcement are not provided, the concrete shall be roughened as directed. Joints in the concrete due to discontinuity of work shall be avoided as far as possible. Such joints, when necessary, shall be constructed to meet the approval of the Engineer.

When the placing of concrete is temporarily discontinued, the concrete after becoming firm enough to retain its shape shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. Where a "feathered edge" might be produced at a construction joint, as in the sloped top surface of a wing v/all, an inset formwork shall be used to produce an edge thickness

of not less than 15 centimeters in the succeeding layer. Work shall not be discontinued within fifty (50) centimeters of the top of any face, unless provision has been made for a coping less than 50 centimeters thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of coping.

Immediately following the discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. Care shall be exercised, during the cleaning of the reinforcing steel, not to injure or break the concrete steel bond near the surface of the concrete.

b) Slab Culverts

In general, the lean concrete below the foundation shall be placed and allowed to set before the reinforced concrete is started.

After the construction of masonry abutment walls, as specified in these Specifications, the concrete bed plate and curtain walls shall be constructed monolithically. Construction joints in wing walls where unavoidable shall be horizontal and so located that no joint will be visible in the exposed face of the wing wall above the ground line.

c) Box Culverts

Vertical construction joints shall be at right angles to the axis of the culvert.

In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. In this case, suitable provision shall be made for bonding the sidewalls to the culvert base, preferably by means of raised longitudinal keys so constructed as to prevent, as far as possible, the percolation of water through the construction joint.

In the construction of box culverts one and quarter (1.1/4) meters or less in height, the sidewalls and top slab may be constructed as a monolithic unit. When this method of construction is used, necessary construction joints shall be vertical and at right angles to the axis of the culvert.

In the construction of box culverts more than one and quarter (1.1/4) meters in height the concrete in the walls shall be placed and allowed to set before the top slab is placed. In this case, appropriate keys shall be left in the sidewalls for anchoring the cover slab.

If possible, each wing wall shall be constructed as a monolithic unit. Construction joints, where unavoidable, shall be horizontal and so located that no joint will be visible in the exposed face of the wing wall above the ground line.

d) Girders, Slabs, Voided Slab and Columns

For simple spans, concrete shall preferably be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers. For continuous spans, where required by design considerations, the concrete placing sequence shall be shown on the plans or in these Specifications.

Concrete in girder haunches less than one (1) meter in height shall be placed at the same time as that in the girder stem, and the column or abutment tops shall be cut back to form seats for the haunches. Whenever any haunch or fillet has a vertical height of one (1) meter or more, the abutment or columns, the haunch, and the girder shall be placed in three successive stages; first, to lower side of haunch; second, to the lower side of the girder; and third to completion.

For haunched continuous girders, the girder stem (including haunch) shall be placed to the top of stem. Where the size of the pour is such that it cannot be made in one continuous operation, vertical construction joints shall preferably be located within the area of contraflexure.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided. The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case a special shear anchorage shall be provided to ensure monolithic action between girder and floor.

In voided slab construction, the voids of required shape can be formed from polystyrene blocks, with a minimum cover of 150 mm of concrete over top and bottom of the voids. As the polystyrene void forms are lighter than water, these should, therefore, be properly secured in place by ties through the formwork below or alternatively, some heavy loads can be placed on the void forms and removed after initial setting of concrete under and around the voids. Drainage pipes shall be provided at the lowest point in each void to prevent any build-up water pressure during or after curing of concrete.

Concrete in T-beam or deck girder spans may be placed on one continuous operation or may be placed in two separate operations; each of which shall be continuous; first, to the top of the girder stems and second, to completion. In the latter case, the bond between stem and slab shall be provided by suitable shear keys or by artificially roughening the surface of the top of the girder stem. In general, suitable keys may be formed by the use of timber blocks approximately five (5) by ten (10) cm in cross-section and having a length of ten (10) cms less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than thirty (30) cms center to center. The blocks shall be removed as soon as the concrete has set sufficient to retain its shape.

Concrete in box girders may be placed in two or three separate operations. In either case the bottom slab shall be placed first. Bond between the bottom slab and stem shall be positive and mechanical. If the webs are placed separately from the top slab, bond between the top slab and webs shall be secured in the same manner as for T-beams. Requirements for shear keys for T-beams shall also apply to box girders, except that keys need not be deeper than the depth to the top of bottom slab reinforcement.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 24 hours before the caps are placed.

When friction collars are used to support cap forms, the concrete of columns shall have been poured at least seven (7) days earlier.

Unless otherwise permitted, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until the test cylinders representing the bents have obtained the minimum compressive strength but in no case in less than seven (7) days.

e) Construction Joints

Construction joints shall be made only where shown on the Drawings or called for in the pouring schedule, unless otherwise approved by the Engineer, If not detailed on the Drawings, construction joints, also in cases of emergency shall be placed to meet the approval of the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete, which has hardened, the forms shall be re-tightened. The surface of the hardened concrete shall be roughened

as required by the Engineer, in a manner that will not leave loose particles of aggregate or damage concrete at the surface.' It shall be thoroughly cleaned of foreign matter and laitance. When directed by the Engineer, the surface of the hardened concrete which will be in contact with new concrete shall be washed with water to ensure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and watered surfaces, including vertical and inclined surface, shall first be thoroughly covered with a coating of mortar of the same proportion of sand and cement as the class of concrete used against which the new concrete shall be placed before the grout or mortar has attained its final set.

The placing of concrete shall be carried out continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation.

The Contractor may require a different location of construction joints which are not shown on the Drawings. If so, this requirement shall be subjected to the Engineer's approval. If necessary the Contractor may be asked to check stress distribution with his proposed location of joints. In case quantities of steel and formwork are increased, no extra payments will be made. Elsewhere, on visible faces, aesthetical treatment of construction joint will be provided without extra payment.

Contraction Joint

The contraction joints shall be constructed where shown on the drawings or as directed by the Engineer. The surface of set concrete in the joint shall be painted with two coats of bitumen, conforming to AASHTO M-115, and new concrete shall be placed against it only when dry.

f) Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of Class B concrete containing large embedded stones. The stone for this class of work shall be placed carefully so as to avoid damage to the forms or to the partially set adjacent concrete. Stratified stone shall be placed upon its natural bed. Stone shall be washed and saturated with water before placing.

The total volume of the stone shall not be greater than one third of the total volume of the portion of the work in which it is placed. For walls of piers greater than sixty (60) cms in thickness, stone of such size that one man can handle it, shall be used. Each stone shall be surrounded by at least fifteen (15) cms of concrete and no stone shall be closer than thirty (30) cms to any top surface or any closer than fifteen (15) cms to any coping. For walls or piers greater than one (1) meter in thickness, larger stone (50 Kg or more) may be used. Each stone shall be surrounded by at least thirty (30) cms of concrete, and no stone shall be closer than sixty (60) cms to any top surface or closer than twenty (20) cms to any coping.

g) Concrete Exposed to Sea Water

Unless otherwise specifically provided, concrete for structures exposed to sea water shall be Class A. The clear distance from the face of the concrete to the nearest face of reinforcement steel shall be not less than 10 cms. The concrete shall be mixed for a period of not less than 2 minutes and the water content of the mixture shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly compacted and air pockets shall be avoided. No construction joints shall be formed between levels of extreme low water and extreme high water as determined by the Engineer. Between these levels sea water shall not come in contact with the concrete for a period of not less than thirty (30) days. The original surface, as the concrete comes from the forms, shall be left undisturbed.

h) Concrete Exposed to Alkali Soils or Alkali Water

Where Concrete may be exposed to the action of alkaline water or soils, special care shall be taken to place it in accordance with specifications herein. Wherever possible, placing shall be continuous until completion of the section or until the concrete is at least fifty (50) cms, above ground or water level. Alkaline water or soils shall not be in contact with the concrete during placement and for a period of at least seventy two (72) hours thereafter.

i) Protection of Concrete from Environmental Conditions

1) *General*

Precautions shall be taken as needed to protect concrete from damage due to weather or other environmental conditions during placing and curing operations.

Any concrete placed during hot weather or during cold weather shall be at the Contractor's risk and any damaged concrete shall be removed and replaced at the Contractor's expense.

2) *Rain Protection*

Under conditions of rain, the placing of concrete shall not commerce or shall be stopped unless adequate protection is provided to prevent damage to the surface mortar or damaging flow or wash of the concrete surface.

3) *Work in Hot Weather*

The temperature of concrete shall not exceed thirty two (32) degree C at the time of laying, unless the Contractor incorporates in the mix a retarding chemical admixture meeting requirements of AASHTO M 194 (ASTM C 494), of a make and in proportion which he has shown by laboratory tests and full scale trial to be satisfactory, to eliminate detrimental effects of high temperature without introducing any other detrimental effect on quality.

The following may be used to keep the temperature of concrete below the above limitations:

i) Chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water shall be free from ice at the time of entry into the mixer.
ii) Cooling of coarse aggregate by watering provided that the water content of the aggregate so cooled shall be uniform.
iii) Reclaiming of aggregate from stock piles by the tunnel method to avoid using the surface layer of the stockpile with shade and wind protection of conveyor elevating to batching plant.
iv) Night work provided that (i), (ii) and (iii) are proved inadequate or unsatisfactory in their results and providing also that the Engineer has no other reason for refusing permission for night work.

The Engineer shall have power to order the suspension of concrete production in case of not taking precautionary measures by the Contractor as mentioned above. Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this clause.

4) *Work in Cold Weather*

Except by written approval of the Engineer, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below five (5) degree C, nor resumed until an ascending air temperature in the shade and away from artificial heat reaches two (2) degree C. In such cases, the mixing water and/or aggregates shall be heated to not less than twenty one (21)

degree C nor more than sixty six (66) degree C, prior to being placed in the mixer by an approved type of heating device so that the temperature of the concrete shall not be less than ten (10) degree C, nor more than twenty seven (27) degree C, at the time of placing. No materials containing frost shall be used. Cement or fine aggregates containing lumps or crusts of hardened materials shall not be used.

401.3.7 Concrete Surface Finishing/Rendering

a) General

Concrete surface finishes shall be classified as follows:

Bridge Deck Surface Finish
Sidewalk Surface Finish
Ordinary Surface Form Finish
Class 1 Surface Form Finish
Side walls and wing walls of vehicular underpass finish

The bridge deck surface finish shall be given to the surface of the bottom slabs of all box type underpass structures.

The requirements for sidewalk surface finish apply to the surface of the bottom slabs in box culverts, except that the acceptable variation from a three-meter straightedge shall be 10 mm, and brooming shall be omitted.

The ordinary surface form finish shall be the final finish applied to all surfaces after removal of forms, unless otherwise specified or called for on the drawings.

The Class 1 surface form finish shall be applied only where specified, or as required by the Engineer when the ordinary surface finish did not produce the required smooth, even surface of uniform texture and appearances.

b) Bridge Deck Surface Finish

A smooth riding surface of uniform texture, true to the required grade and cross-section, shall be obtained on all bridge roadway decks. The Contractor may use hand tools, or finishing machines or a combination of both, conforming to the requirements specified herein for finishing bridge roadway deck concrete.

Finishing of concrete placed in bridge decks shall consist essentially of compacting and striking off the surface of the concrete as placed and floating with longitudinal floats the surface so struck off.

The placing of concrete in bridge roadway decks will not be permitted until the Engineer is satisfied that the rate of producing concrete will be sufficient to complete the proposed placing and finishing operations within the schedule time, that experienced finishing machine operators and concrete finishers are employed to finish the deck, that fogging equipment and all necessary finishing tools and equipment are on hand at the site of the work and in satisfactory condition for use. Finishing machines shall be set up sufficiently in advance of use to permit inspection by the Engineer during the daylight hours before each pour.

The adjustment and operation of deck finishing machines shall be verified by moving the machine over the full length of the deck section to be placed and traversing the float completely across all end bulkheads before placement of concrete is begun.

Unless adequate lighting facilities are provided by the Contractor, the placing of concrete in bridge decks shall cease at such time that finishing operations can be completed during daylight hours.

Rails for the support and operation of finishing machines and headers for hand-

operated strick-off devices shall be completely in place and firmly secured for the scheduled length for concrete placement before placing of concrete. Rails for finishing machines shall extend beyond both ends of the scheduled length for concrete placement to a sufficient distance that will permit the float of the finishing machine to fully clear the concrete to be placed. Rails or headers shall be adjustable for elevation and shall be set to elevations, with allowance for anticipated settlement, camber, and deflection of false work as required to obtain a bridge roadway deck true to the required grade and cross-section. Rails or headers shall be of a type and shall be so installed that no springing or deflection will occur under the weight of the finishing equipment and shall be so located that finishing equipment may operate without interruption over the entire bridge roadway deck to be finished.

Rails or headers shall be adjusted as necessary to correct for unanticipated settlement or deflection, which may occur during finishing operations.

Should settlement or other unanticipated events occur, which in the opinion of the Engineer would prevent pouring of bridge deck conforming to the requirements of these specifications, placing of deck concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial set of the concrete in the effected area, the placing of concrete shall be discontinued and a bulkhead installed at a location determined by the Engineer. All concrete in place beyond the bulkhead shall be removed.

Unless otherwise permitted by the Engineer, bridge deck concrete shall be placed in a uniform heading approximately parallel to the bridge pier or bent caps. The rate of placing concrete shall be limited to that which can be finished before the beginning of initial set except that concrete for the deck surface shall not be placed more than three (3) meters ahead of strick off.

After the concrete has been placed, compacted, and consolidated, the surface of the concrete shall be carefully struck off by means of a hand-operated strick board operating on headers, or by a finishing machine operating on rails. A uniform deck surface true to the required grade and cross-section shall be obtained.

Following strike off, the surface of the concrete shall be floated longitudinally. In the event strike-off is performed by means of a hand-operated strike board, two (2) separate hand-operated float boards for longitudinal floating shall be provided. The first float shall be placed in operation as soon as the condition of the concrete will permit and the second float shall be operated as far back of the first float as the workability of the concrete will permit.

In the event the strike off is performed with a finishing machine, longitudinal floating of the concrete shall be performed by means of a hand-operated float board or a finishing machine equipped with a longitudinal wooden float. The longitudinal wooden float on the finishing machine shall have a length of not less than two and half ($2^1/_2$) meters nor more than three and half ($3^1/_2$) meters. When both strike off and longitudinal floating are to be performed by finishing machines, one machine, with operator, shall be used for strike off and a second machine, with a second operator, shall be used for longitudinal floating. Longitudinal floating may be performed with the same finishing machine that is used for strike off provided that the length of deck unit being placed is not more than 10 meters and the strike off operation is completed for said deck unit before the condition of the concrete requires that longitudinal floating be started.

Finishing machines used for strike off having a wheel base 1.8 meters or less shall be followed by 2 separate hand-operated float boards for longitudinal floating. All the provisions in this Item pertaining to hand-operated float boards shall apply to the 2 separate float boards for longitudinal floating.

Longitudinal floats, either hand-operated or machine-operated, shall be used with the

long axis of the float parallel to the center line of the bridge roadway. The float shall be operated with a combined longitudinal and transverse motion planing off the high areas and floating the material removed into the low areas. Each pass of the float shall lap the previous pass by one-half the length of the float. Floating shall be continued until a smooth riding surface is obtained.

In advance of curing operations, the surface of the concrete shall be textured by brooming with a stiff bristled broom or by other suitable devices, which will result in uniform scouring. The operation shall be performed at a time and in a manner to produce a hardened surface having a uniform texture.

Hand-operated float boards shall be from three and half ($3^1/_2$) to five (5) meters long, ribbed and trussed as necessary to provide a rigid float and shall be equipped with an adjustable handle at each end. The float shall be wood, not less than two and half ($2^1/_2$) cms thick and from ten (10) cm to twenty (20) cm wide. Adjusting screws spaced as not to exceed 60 cms on centers shall be provided between the float and the rib. The float board shall be maintained free of twist and true at all times.

Hand-operated float boards shall be operated from transverse finishing bridges. The finishing bridges shall span completely the roadway area being floated & a sufficient number of finishing bridges shall be provided to permit operation of the floats without undue delay. Not less than two (2) transverse finishing bridges shall be provided when hand-operated float boards are used. When a finishing machine is used for longitudinal floating, one finishing bridge equivalent to the transverse finishing bridge specified herein shall be furnished for use by the Engineer.

All finishing bridges shall be of rigid construction and shall be free of excessive wobble and springing when used by the operators of longitudinal floats and shall be easily moved.

Immediate following completion of the deck finishing operations, the concrete in the deck shall be cured as specified in Item 401.3,8 "Curing Concrete" hereinafter.

The finished surface of the concrete shall be tested by means of a straightedge three (3.0) meters long. The surface shall not vary more than three (3) mm from the lower edge of the straightedge. All high areas in the hardened surface in excess of three (3) mm as indicated by testing shall be removed by abrasive means. After grinding by abrasive mean has been performed, the surface of the concrete shall not be smooth or polished. Ground areas shall not be of uniform texture and shall present neat and approximately rectangular patterns.

Where the concrete of the bridge deck is to be covered by bituminous surfacing, earth, or other cover, two and half ($2^1/_2$) cms or more in thickness, the surface of the concrete shall not vary more than nine (9) mm from the lower edge of the three (3) meter straightedge.

Bridge deck surfaces under the curbs, railings and sidewalk shall be struck off to the same plane as the roadway and left undisturbed when future widening is shown on the plans.

c) Sidewalk Surface Finish

After the concrete has been placed it shall be compacted and the concrete shall be struck off by means of a strike board, floated with a wooden or cork floating and finished with a broom. An approved edging tool shall be used on all edges and at all expansion joints. Brooming shall be transverse to the line of traffic and if water is necessary, it shall be applied to the surface immediately in advance of brooming. The surface shall not vary more than six (6) mm under a three-meter straightedge, and the finished surface shall be free of blemishes.

d) Ordinary Surface Form Finish

Ordinary surface form finish will follow AASHTO-Standard Specifications-Division II 8.12.2. Non – shrink mortar will be used.

Ordinary surface form finish shall be applied to all concrete surfaces, except those of Class 1 form finish which are defined hereafter.

e) Class 1 Surface Form Finish

Class 1 surface form finish will follow the AASHTO-Standard Specifications-Division II 8.12.3.

Fiber or plywood forms in good condition will be used exclusively.

Class 1 surface finish is systematically required to be applied as the final finish for the following surfaces, unless otherwise directed by the Engineer:

i) All form finish surfaces of bridge super-structures, including the under surfaces between girders and the inside vertical surfaces of T girders.
ii) All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three tenth (0.3) meter below finished ground.
iii) All surfaces of open spandrel arch rings, spandrel columns and abutment walls.
iv) All surfaces of pedestrian undercrossings, except floors and surfaces to be covered with earth.
v) Surface above finished ground of culvert headwalls, end walls and retaining walls.
vi) All surfaces of pedestrian underpasses, side walls and wing walls of vehicular underpasses except floors and surfaces to be covered with earth.
vii) All surfaces of railings and New Jersey Barriers.
viii) All surfaces of voided slab.

f) Surface Rendering

All faces of concrete which are to come in contact with back fill or pavement materials shall be applied two coats of hot bitumen of approved quality, before placing any material around concrete.

401.3.8 <u>Curing Concrete</u>

a) General

All newly placed concrete shall be cured in accordance with these specifications, unless otherwise directed by the Engineer.

All newly-placed concrete shall be cured for at least seven (7) days. When there is a forecast of air temperatures below two degrees Celsius (2°C), during the curing period, the Contractor shall submit for approval by the Engineer, a cold weather curing plan detailing the methods and equipment which will be used to assure that concrete temperature does not fall below ten degrees Celsius (10°C.) during the entire curing period which will be seven (7), eight (8), nine (9), or ten (10) days after placement.

The cold weather curing plan shall detail the Contractor's proposed method of maintaining or providing heat and moisture to the concrete during the placement and curing period. No part of the structure surface shall be heated in excess of thirty-three degrees Celsius (33°C) or charge by more than ten degrees Celsius (10°C.) in eight (8) hours while heating or insulating equipment is in use or immediately thereafter.

The Contractor shall provide continuous recording thermometers at the approximate frequency of one thermometer for each thirty (30) cubic meters curing during the

initial seven (7) day period.

b) Method of Curing

The curing method shall be one or more of the following as described hereinafter.

Water Method
Curing compound Method
Reinforced Waterproof Paper Method if required by the Engineer.
Forms-in-Place Method
Steam Method
Polyethylene Sheeting Method

Water Method

The concrete shall be kept continuously wet by the application of water for a minimum period of seven (7) days after the concrete has been placed.

Cotton mats, burlaps, rugs, carpets, or earth or sand blankets, may be used as a curing medium to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. The moisture from the nozzle shall not be applied under pressure directly upon the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period the concrete surface shall be cleared of all curing mediums.

When concrete bridge decks and flat slabs are to be cured without the use of a moisture retaining medium, the entire surface of the bridge deck or slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than seven (7) days.

Curing Compound Method

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer.

The membrane-forming compound used shall consist of a practically colourless liquid. The use of any membrane forming compound that will alter the natural colour of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film, and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. Type-2 liquid membrane curing compound as specified in AASHTO M 148 may be used as the initial and final curing agent on structural concrete. In the event of any delay in the application of curing compound which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under "Water Method", shall be started immediately and shall be continued until application of the compound which shall not be applied over any free standing water surface. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compounds shall not hard settle in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within one hundred twenty (120) days after the date of manufacture, the Engineer may require additional testing before use to determine compliance to requirements.

An anti-settling agent of combination of anti-settling agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located at the job-site. On-site storage tanks shall have a permanent system designed to completely re-disperse any settled material without introducing air or any other foreign substance. Containers shall be well sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labeled with the manufacturer's name, specification number, batch number, number of gallons, and date of manufacture, and shall have a label warning concerning flammability. The label shall also warn that the curing compound shall be well stirred before use. When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.

Curing compound may be sampled by the Engineer at the source of supply and at the job-site.

Reinforced Waterproof Paper Method

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the waterproof paper shall be placed. The paper shall remain in place for a period of not less than 72 hours.

Reinforced waterproof paper shall comply with ASTM C 171 specifications. It shall be composed of two sheets of Kraft paper cemented together with a bituminous adhesive and reinforced with fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface.

All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.

The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within seventy two (72) hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of sheets, which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete, shall not be used,

Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the forms-in-place The forms shall remain in place for a minimum period of seven (7) days after the concrete has been placed, except that for members over five (5) cms in least dimension, the forms shall be in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

Steam Method

After placing and vibrating, the concrete shall be allowed to attain its initial set before

steam is applied. During the placing of concrete and application of steam, provision shall be made to prevent surface drying by means of a coating of approved material. The optimum curing temperature shall not exceed sixty five (65) degree C.

Polyethylene Sheeting Method

The wet surface of fresh concrete shall be covered with white polyethylene sheeting as soon as possible without marring the surface and should cover all exposed surfaces of the concrete. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer to provide an air-tight cover. Adjoining sheets shall overlap not less than thirty (30) cms and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer to provide an air-tight cover.

c) Curing Structures

All newly placed concrete for cast-in-place structures, other than highway bridge decks, shall be cured by the water method, the forms-in-place method, or, as permitted herein, by the curing compound method, all in accordance with the requirements in Item 401.3.8 (b), "Methods of Curing".

The curing compound method may be used on concrete surfaces which are to be buried underground, and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform colour is not required and which will not be visible from any public traveled way.

The top surface of highway bridge decks shall be cured by both the curing compound method, and by the water method. The curing compound shall be applied progressively during the deck finishing operation immediately after finishing operations are completed on each individual portion of the deck. The water cure shall be applied not later than four (4) hours after completion of the deck finishing or, for portions of the decks on which finishing is completed after normal working hours, the water cure be applied not later than 8.00 a.m. the following morning.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surfaces being cured by the curing compound method or by the forms-in-place method, until the Engineer determines that a cooling effect is no longer required.

d) Curing Precast Concrete Members

Precast concrete members shall be cured for not less than seven (7) days by the water method or by steam curing for a period in which 80% of strength achieved, at the option of the Contractor. Steam curing for precast members shall conform to the following provisions:

After placement of the concrete, members shall be held for a minimum four (4) hours precasting period.

To prevent moisture loss on exposed surfaces during the presteaming period, members shall be covered immediately after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of the tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

Steam at jets shall be low pressure and in a saturated condition. Steam at jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the

steam, the temperature rise within the enclosure shall not exceed twenty (20) degree C per hour. The curing temperature throughout the enclosure shall not exceed sixty five (65) degree C and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per sixty (60) meters of continuous bed length will be required for checking temperature.

Curing of precast concrete will be considered completed after a termination of the steam curing cycle.

e) Curing Precast Concrete Piles

All newly placed concrete precast piles, both conventionally reinforced and prestressed shall be cured by the "Water Method" as described in Item 401.3.8(b) except that the concrete shall be kept under moisture for at least fourteen (14) days. At the option of the Contractor steam curing may be used in which case the steam curing provisions in Item 401.3.8(b) "Curing Precast Concrete Members" shall apply except that the concrete shall be kept wet for at least seven (7) days including the holding and steaming period.

401.3.9 Testing of Aggregates

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source or sources of aggregate and to obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to begin.

Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods:

1.	Sampling aggregates	T - 2
2.	Sieve analysis	T - 27
3.	Amount of material passing the No. 200 sieve	T - 11
4.	Organic impurities	T - 21
5.	Mortar Strength	T - 71
6.	Sodium sulphate soundness	T - 104
7.	Friable particles	T - 112
8.	Abrasion loss	T - 96
9.	Specific Gravity	T - 84
10.	Absorption	T - 85
11.	Production of Plastic Fines	T - 210
12.	Fineness Modulus	T - 27
13.	Sand Equivalent	T - 176
14.	Potential Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method)	ASTM C 586
15.	Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).	ASTM C 227
16.	Potential Reactivity of Aggregates (Chemical Methods)	ASTM C 289

No aggregate for testing during the production of concrete shall be sampled at the discharge gates of the bins feeding the weight hopper. The Contractor, at his expense, shall provide safe and suitable facilities for obtaining the samples. No concreting work on the project will be permitted until the Engineer signifies in writing his approval, following the performance of the necessary tests, on all the materials involved in making concrete.

401.3.10 Testing of Compressive Strength

Concrete compressive strength requirements consist of a minimum strength at the age of twenty eight (28) days and the minimum strength which must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 401-1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with AASHTO T 23 and AASHTO T 22.

A set of six (6) cylinders shall be taken from each fifty (50) cubic meters of each class of concrete or fraction thereof placed each day, three (3) of the six (6) cylinders to be tested after seven (7) days and three (3) after twenty eight (28) days.

a) The minimum average 28 days test result of all samples tested at any time shall be the specified twenty eight (28) days strength.
b) No individual samples tested after 28 days shall show a test result lower than eighty five (85) percent of the required twenty eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor, at his expense, provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with AASHTO T-24.

Test results of the cores shall meet the following requirements:

a) Average test result of the cores shall not be less than the minimum required twenty eight (28) days' strength.
b) No individual core shall show strength less than Ninety five (95) percent of the required twenty eight (28) days' strength.

Should the above test results fail to comply with the requirements, concrete of that particular pour shall be rejected and removed as directed by the Engineer. Furthermore the Contractor shall redesign the concrete mix for approval of the Engineer.

In case, seven (7) days strength shows less than seventy (70) percent of the twenty eight (28) days' strength, Engineer may stop further work on that particular portion of concrete, unless twenty eight (28) days strength gives satisfactory results.

Trial Batches for Mix Productions

The placing of concrete shall not begin until trial batches of the mix design to be used have been produced by the Contractor and tested and approved by the Engineer. The trial mix proportions shall be such that the average strength of five (5) consecutive test cylinders shall be 20% higher than the specified twenty eight (28) days strength and no individual test cylinder shall be below the specified strength.

When concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member, test cylinders will be cured under conditions similar to those at the casting site. The compressive strength of concrete determined for such purposes will be evaluated on the basis of individual tests.

ITEM 402 FALSEWORK AND CENTERING FOR BRIDGES

402.1 DESCRIPTION

This work shall consist of the design, supply and construction of falsework which will provide the necessary rigidity to support the loads imposed, and produce a structure, finished to the lines and grades indicated on the plans or as required by the Engineer.

402.2 MATERIAL REQUIREMENTS

Timber and lumber to be used for falsework shall be of sound lumber and comply with the requirement in AASHTO M 168.

Structural steel to be used for falsework shall comply with the requirements of Standard Specifications for Structural Steel ASTM A-36. Reinforcing steel if it is to be used for falsework shall comply with the requirements of AASHTO M 31. Concrete when used shall conform to Item 401 of these specifications.

402.3 CONSTRUCTION REQUIREMENTS

402.3.1 False work Design and Drawings

Detailed working drawings and backup calculations of the falsework shall be furnished by the Contractor to the Engineer. No falsework construction shall start until the Engineer has reviewed and approved the drawings. The Contractor shall provide sufficient time for the Engineer to complete this review. Such time shall be proportionate to the complexity of the falsework design and in no case shall be less than one (1) week.

The Contractor may revise the falsework drawings at any time provided sufficient time is allowed for the Engineer's review before construction is started on the revised portions.

Assumptions used in design of the falsework shall include but not be limited to the following:

a) For designing falsework and centering, a weight of 2,600 Kg per cubic meter shall be assumed dead loads including weight of concrete, reinforcing steel, forms and falsework. All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Engineer may require the Contractor to employ screw jacks or approved wedges to take up any settlement in the formwork either before or during the placing of concrete.

b) The entire superstructure cross-section, except railing, shall be considered to be placed at one time, except when in the opinion of the Engineer a portion of the load is carried by girders previously cast and having attained certain strength.

c) When falsework is supported on piles, the piles shall be driven to a bearing value equal to 125% of the calculated pile loading shown on the falsework drawings.

d) Soil bearing values and soil conditions (wet and dry) shall be designated by the Contractor on the falsework drawings. Falsework footings shall be designed to carry the loads imposed upon them without exceeding estimated soil bearing values or allowable settlements.

e) Falsework shall be set to give the finished structure, the camber specified or indicated on the Drawings.

f) Arch centering shall be constructed according to the approved centering plans. Provisions shall be made by means of suitable wedges, sand boxes, or other devices

for the gradual lowering of centers to render the arch self-supporting. When directed, centering shall be placed on approved jacks in order to take up and correct any slight settlement, which may occur after the placing has begun.

g) The maximum loading and deflections used on jacks, brackets, columns, and other manufactured devices shall not exceed the manufacturer's recommendations. If requested by the Engineer, the Contractor shall furnish catalogues or other data verifying these recommendations.

h) If the concrete is to be prestressed, the falsework shall be designed to support any increased or readjusted loads caused by the prestressing forces.

i) Joints supporting slabs and overhangs shall be considered as falsework and designed as such.

j) Falsework and centering shall be designed and constructed to support the total anticipated dead and live loads, including wind loads, during all stages of construction, with a deflection not to exceed two thousandths (0.002) of the falsework span.

k) Wedges or screw jacks shall be used in all falsework construction and shall be so placed that they can be adjusted to give proper form alignment. The Contractor shall provide means for adjusting forms at any time prior to concrete placement. If screw jacks are used, they shall be adequately braced and secured in such a manner that will prevent tipping of the jacks in any direction.

l) Horizontal pressure shall be based on an assumed unit weight between fourteen hundred (1400) and twenty six hundred (2600) Kilograms per cubic meter depending on the rate of placement and the effect of retarding admixture as approved by the Engineer.

m) Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than two hundred forty five (245) kilograms per square meter applied over the area supported plus eleven hundred (1100) Newton per meter at the outside edge of deck falsework overhangs.

n) The total vertical design load for falsework is the sum of the vertical dead and live loads. A total vertical design load of not less than forty eight hundred (4800) shall be used.

o) The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind however, the assumed horizontal load to be resisted in any direction shall not be less than two percent (2%) of the total load for falsework up to ten (10) meters high. The falsework shall be designed so that it will have sufficient rigidity to resist the horizontal load prior to the placement of concrete.

p) The falsework design drawings shall include the following minimum information:

1) Type and grade of structural materials.
2) Allowable material stresses in bending, compression and shear.
3) Modulus of Elasticity, "E".
4) Stress factors if used for short term duration loading (timber only).
5) Summary of critical tower leg loads and location on falsework drawings.
6) Weight of deck finishing machine and wheel or support spacing.
7) References for load data used for standardized falsework components.
8) Specification references for design criteria.
9) The bearing value of the soil as determined by the Contractor when footing type foundations are used.

q) If the concrete is to be post-tensioned in the field, falsework shall be designed to support any increased or readjusted loads caused by the prestressing forces as shown on the drawings.

r) Falsework footings shall be designed to carry load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements.

For the construction of falsework over and adjacent to road ways where falsework openings are required for maintaining traffic, the Contractor shall provide any additional features for the work needed to ensure that the falsework will be stable if subjected to impact by vehicles.

The falsework design at the locations where said openings are required shall include but not be limited to the following minimum provisions:

i) Each exterior stringer in a span shall be securely anchored to the falsework cap or framing.

ii) Adequate bracing shall be used during all stages of falsework construction and removal over or adjacent to public traffic.

iii) Falsework members shall be at least thirty (30) cms clear of temporary protective railing members.

The falsework drawings shall include a superstructure placing diagram showing proposed concrete placing sequence and construction joint location, except that where a schedule for placing concrete is shown on the contract plans, no deviation will be permitted therefrom unless approved in writing by the Engineer.

The falsework drawings shall show any pedestrian openings, which are required through the falsework.

Anticipated total settlements of falsework and forms shall be indicated by the Contractor on the falsework drawings. These should include falsework footing settlement and joint take-up. Anticipated settlements over two (2) cms will not be allowed unless otherwise permitted by the Engineer. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

Detailed calculations by the Contractor showing the stresses, deflections, and camber necessary to compensate for said deflections in all load supporting members shall be included in the working drawings.

After approving the Contractor's falsework deflection camber, the Engineer will furnish to the Contractor the amounts of camber necessary to compensate for vertical alignment or anticipated structure deflection, if this is not shown on the drawings. The total camber used in constructing falsework shall be the sum of the afore-mentioned cambers.

402.3.2 False work Construction and Drawings

The falsework shall be constructed to conform to the falsework drawings. The materials used in the falsework construction shall be of the quantity and quality necessary to withstand the stresses imposed. The workmanship used in falsework construction shall be of such quality that the falsework will support the loads imposed on it without excessive settlement or take-up beyond that shown on the falsework drawings.

Falsework shall be founded on footings, capable of supporting the loads imposed on it.

When falsework is supported on piles, the piles shall be driven to a bearing value, equal to 125% of the calculated pile loading as shown on the falsework drawings.

Suitable jacks or wedges shall be used in connection with falsework to set the forms to their required grade and to take up any excessive settlement in the falsework either

before or during the placing of concrete.

The Contractor shall provide tell-tales attached to the soffit forms easily readable and in enough systematically-placed location to determine the total settlement of the entire portion of the structure where concrete is being placed.

Should events occur, including settlements that deviate more than ± 2 cm from those indicated on the drawings, which in the opinion of the Engineer would prevent the structure conforming to the requirements of the Contract documents, the placing of concrete shall be discontinued until corrective measures have been carried out to the satisfaction of the Engineer.

402.3.3 Removal of Falsework and Formwork

Falsework shall not be removed before the concrete has attained sufficient strength to support its own mass and any loads that may be imposed on it. This condition shall be assumed to require falsework to remain in place, after placing of the concrete, for the appropriate minimum period of time given in the Table 402-1, unless the Contractor can prove to the satisfaction of the Engineer that shorter periods are sufficient to fulfill this condition.

Falsework shall be removed carefully without shock, disturbance and damage to the cast concrete or structure.

Weather may be regarded as “normal” when atmospheric temperatures adjacent to the concrete, as measured by a maximum and minimum thermometer, do not fall below fifteen (15) degrees Centigrade and as “cold” when the temperatures measured as aforesaid fall below five (5) degrees Centigrade. When minimum temperatures are between these values, stripping times shall be between the periods specified for normal and cold weather. Any period during which the temperature remains below two (2) degrees Centigrade shall be disregarded in calculating the minimum time which elapses before forms are removed.

On continuous reinforced concrete structures the falsework and supporting formwork shall not be removed before the concrete of the last pour has reached the appropriate minimum age given in Table 402-1 or the appropriate minimum strength. Where the structure is constructed in stages the falsework and supporting formwork shall be removed as specified on the drawings or directed by the Engineer.

In lieu of the times specified in Table 402-1, the falsework and formwork to soffit of slabs and beams may be removed once the concrete has attained 80% of its specified cylinder crushing strength. The compressive strength of the concrete shall be determined from a representative and adequate number of cylinders that have been stored under conditions that simulate the field conditions. Similarly side forms may be removed when the concrete has attained cylinder strength of 60 kg/cm^2.

Removal of Falsework and Formwork
Minimum Time in Days
Table 402-1

Sr. No.	Component	Normal Weather	Cold Weather
1	Sides of beam, footing, Columns/ pier and walls	1.75	2.5
2	Soffits of slabs and beams	16	27
3	Deck Slab with span over 6 m	28	35

All falsework materials shall be completely removed. Falsework piling shall be removed atleast sixty (60) cms below one surface of the original ground or stream bed. When falsework piling is driven within the limits of ditch or channel excavation areas, the

falsework piling within such areas shall be removed to atleast sixty (60) cms, below the bottom and side slopes of said excavated areas.

All debris and refuse resulting from work shall be removed and the premises left in a neat and presentable condition.

ITEM 403 FORMWORK

403.1 DESCRIPTION

The work shall consist of providing, erecting and removing concrete forms of sufficient strength with all necessary bracings, fasteners, etc. and in conformity with the requirements hereinafter specified.

The Contractor may propose for formwork of “in-situ” concreted slabs, the use of an alternative solution (not shown on drawings) for “lost formwork” such as pre-cast reinforced concrete slabs or fiber-cement planks. In that case, he will have to submit the proposal with materials and method of placing to Engineer for approval. This proposal will be accompanied by back-up calculations. Any extra steel material, equipment, labor, effort or extra-foundation to be added due to this proposal shall be borne by the Contractor.

403.2 MATERIAL REQUIREMENTS

Forms shall be of wood, metal or other approved materials and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations.

403.3 CONSTRUCTION REQUIREMENTS

403.3.1 Formwork Design and Drawings

The Contractor shall prepare working drawings, backup calculations and material data for the formwork and falsework to be submitted to the Engineer for approval unless otherwise directed.

The requirements for design of formwork are the same as described under Item 402.3.1 - Falsework Design and Drawings.

403.3.2 Formwork Construction

Concrete forms shall be constructed and maintained so as to prevent warping and the opening of joints due to the shrinkage of the lumber and shall be true to the dimensions, lines and grades of the structure and with the sufficient strength, rigidity, shape and surface smoothness as to leave the finished works true to the dimensions shown on drawings or required by the Engineer and with the surface finish as specified.

All work shall comply with the tolerances given in Table 403-1.

Dimensional Tolerances
Table 403-1

Dimensions	Permissible Deviation (mm)
Position on plan of any point measured form the nearest grid line Verticality	+ 10
Plumbness in height 1 to 400 maximum permitted Cross section and linear dimensions	+ 25
Dimensions of beams, slabs, columns and walls Up to and including 600 mm	+ 10
Over 600 mm up to and including 3 m	+ 15

Over 3 m up to and including 15 m	+ 20
Bow and camber other than designed camber of any point of the surface from a straight line joining the extremities of that surface up to and including 3 m apart.	+ 5
Level from designed level with reference to the nearest datum of the upper or lower surface as may be specified of any slab or other element or component.	+ 20

Forms shall be mortar tight and sufficiently rigid to prevent distortion from pressure of the concrete and other loads incidental to the construction operations including vibration. Forms shall be constructed and maintained to prevent opening of joints due to shrinkage of lumber. They shall be designed to permit easy removal without injury to the concrete. The Contractor shall submit samples, specifications, and other pertinent information to the Engineer and secure his written approval prior to use of the form lining. Fibre or plywood forms in good condition will be used exclusively.

Forms shall be maintained after erection to eliminate warping and shrinkage. They shall be checked for dimensions and conditions immediately prior to the placement of concrete. The Engineer may at any time require the revision or reconstruction of forms and may refuse permission to place concrete within the forms until they are satisfactorily constructed. If at any period of the Work during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shall be removed to the extent directed by the Engineer, the forms brought to the proper position, and new concrete placed. No allowance will be made to the Contractor for such extra work.

Unless otherwise directed, the exterior side of all forms exposed to the sun shall be painted with an approved good quality, high gloss white oil based enamel prior to placing of concrete. When complete coverage is not obtained with one coat, the Engineer will order additional coats as he deems necessary to obtain complete coverage. Forms shall be repainted when ordered by the Engineer.

Form joints shall be closed by moistening the forms with water prior to concrete placement. Forms that are to be reused shall be thoroughly cleaned and roiled and, if necessary, shall be reconditioned by revision or reconstruction. Unsatisfactory lumber will be condemned by the Engineer, and shall be removed from site.

Placement of reinforcing steel shall not begin on any part of a structure until the location, alignment, and construction of forms and falsework are approved by the Engineer for that part of the structure.

The Contractor shall conduct all surveyed and dimensional checks required by the Engineer to verify the adequacy of the forms and falsework. The forms shall be clean and free of all debris before concrete is placed.

Forms shall be filled at all sharp corners (Minimum two (2) cms triangular fillets) and shall be given a level or draft in the case of all projections, such as girders and copings, to ensure easy removal.

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement. Bolt and tie positions shall be arranged to conform to the symmetry of formwork panels. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted. Metal ties or anchorage within the forms shall be so constructed as to permit their removal to a depth of at least five (5) cms from the face without injury to the concrete or to the minimum depth of cover for the class of concrete and exposure condition.

Fitting for metal ties shall be of such design that, upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in colour. Anchor devices may be

cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorages for fastening forms or form supports to concrete will not be permitted.

Void former shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on pre-cast concrete blocks on rigid welded steel cradles to the approval of the Engineer. The ties securing the void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or be supported on the reinforcement.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms, which will later be removed, shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolour the concrete. Care shall be taken to ensure that the lubricant does not come into contact with the reinforcement. All exposed surfaces of similar portions of a concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, colour and appearance.

Concrete shall not be deposited in the forms until all work in connection with constructing the forms has been completed, all materials required to be embedded in the concrete have been placed for the unit to be poured, and the Engineer has inspected and approved said forms and materials.

The rate of depositing concrete in forms shall be such as to prevent deflections of the forms or form panels in excess of the deflections permitted by these specifications. Maximum deflection allowed due to prop settlement is 5 mm and due to bending of shutters is 3 mm, when measured with 3 meter straight edge.

Forms for all concrete surfaces, which will not be completely enclosed or hidden below the permanent ground surface, shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be considered to be completely enclosed surfaces.

Formwork for concrete placed under water shall be watertight. When lumber is used, this shall be planed and tongued and grooved.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding either two (2) mm or 1/270 of the center to center distance between studs, joists, form stiffeners, form fasteners, or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications have been made to satisfaction of the Engineer. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

Forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods, which shall be determined, as herein specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged lumber must be resized before being reused. Forms that are unsatisfactory in any respect shall not be reused.

For narrow walls and columns, where the bottom of the form is inaccessible, the lower form boards shall be adjustable so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

403.3.3 Removal of Formwork

In the determination of the time for the removal of falsework and forms, consideration shall be given to the location and character of the structure, the weather, and other conditions influencing the setting of the concrete, and the materials used in the mix.

The minimum period for the removal of formwork shall be similar to that for the removal of falsework as specified in clause 402.3.3 of these Specifications.

Side forms for cast-in-place beams, girders, columns, or other members where the forms do not resist dead load, bending shall remain in place for at least forty (40) hours after placing concrete for the members. Side forms for precast members may be removed the next day after placing concrete therein.

If high early strength cement is used or by the use of additional cement, these periods may be reduced as directed.

When field operations are controlled by cylinder tests, the removal of forms, supports and housing, and the discontinuance of heating and curing (where applicable) may begin when the concrete is found to have the required compressive strength, provided in no case shall supports be removed in less than seven (7) days after placing the concrete.

All forms shall be removed, except when no permanent access is available to the cells, the forms supporting the deck of box girders and the forms in hollow abutments or piers may remain in place. Prior to completion of forming for the deck forms, the inside of box girders shall be cleared of all loose material and swept clean.

Methods of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In general, arch centering or falsework shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers, as may be necessary to avoid jamming of the expansion joints.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centers shall be approved by the Engineer.

If the required finish has not been attained in the work, as determined by the Engineer, the Contractor shall promptly carry out at his own expense all remedies required by the Engineer to obtain the specified finish. These may include grit blasting followed by the application of polyester or epoxy paint. Where such remedial action is ordered by the Engineer, the entire exposed surface shall be so treated, irrespective of whether the defective areas are localized or extensive.

ITEM 404 STEEL REINFORCEMENT

404.1 DESCRIPTION

This work shall consist of furnishing, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with these Specifications and in conformity with the requirements shown on the Drawings and Special Provisions or as directed by the Engineer.

404.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given. Test reports from approved sources shall be submitted to the Engineer for all steel reinforcement used. These reports shall show the results of chemical and physical tests made.

a) Deformed Billet Steel Bars (Grades 40 and 60) for Concrete Reinforcement-AASHTO M 31 (ASTM A 615)

b) Deformed Steel Wire for Concrete Reinforcement-AASHTO M 225 (ASTM A 496)

c) Welded Steel Wire Fabric for Concrete Reinforcement-AASHTO M 55 (ASTM A 185)

d) Steel Bar Mats for Concrete Reinforcement-AASHTO M 54 (ASTM A 184)

e) Cold-Drawn Steel Wire for Concrete Reinforcement-AASHTO M 32 (ASTM A 82)

f) Welded Deformed Steel Wire Fabric for Concrete Reinforcement-AASHTO M 221 (ASTM A 497)

g) Structural Shapes for Concrete Reinforcement ASTM A 36

404.3 CONSTRUCTION REQUIREMENTS

404.3.1 Fabrication of Bent Bars

a) Order Lists

Bent bar reinforcement shall be cold bent (05^{o}C to 100^{o}C) to shapes and dimensions shown on the drawings with equipment approved by the Engineer. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expenses incident to the revisions of material furnished in accordance with such lists and diagrams to make it comply with the Drawings shall be borne by the Contractor.

Project shop drawings for bar lists and bending diagrams (bar bending schedule) shall be based on standard drawings and submitted by the Contractor to the Engineer for approval, according to AASHTO-Standard Specifications-Division II 9.3. These documents shall be given to the Engineer for his approval at least one month before placing the order for steel. All bar bending schedule shall conform to ACI 315 & ACI 318 and shall be subject to approval of the Engineer.

b) Storing and Surface Condition of Reinforcement

Steel reinforcement shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose seals, paint, grease, oil, or other foreign materials. Reinforcement shall be free from

injurious defects such as cracks and laminations. Surface seams, surface irregularities or mill scale will not be cause for rejection, provided the minimum dimensions, cross-section area and tensile properties of a hand-wire brushed specimen meet the physical requirements for the size and grade of steel specified.

c) Fabrication

Bent bar reinforcement shall be cold bent (05^{o}C to 100 ^{o}C) to the shapes and dimensions shown on the drawings with equipment approved by the Engineer. Bars shall be bent around a pin having the following diameters (D) in relation to the diameter of the bar (d):

- Stirrups & ties D = 6 d
- Other bars having:

  d = # 3 to # 8 D = 5d

  d = # 9 to # 11 D = 8d

For Grade 60 deformed bars, bending shall be made only by mechanically operated equipment.

d) Shipping

All Grade 60 reinforcement shall be shipped to the site in straight bars.

404.3.2 <u>Placing and Fastening</u>

a) Protection of Material

Steel reinforcement shall be protected at all times from injury. When steel, placed in position as shown on the Drawings, has easily removable and detrimental rust, loose scale, or dust, it shall be cleaned by a satisfactory method, approved by the Engineer.

b) Placing and Fastening

Reinforcing steel shall be accurately placed in the position shown on the Drawings and firmly held during the depositing and finishing of the concrete. Cover, the distance between the external face of the bar and the face of the finished concrete, shall be as indicated on the Drawings. Reinforcing steel bars embedded in concrete shall not be bent after they are in place. Bars shall be tied at all intersections with 16 gauge black annealed wire except that where spacing is less than 1 ft (0.3 m) in each direction, alternate intersections need to be tied. All intersections shall be tied in the top mat of reinforcement placed on bridge decks and the top slabs of box culverts. Abrupt bends shall be avoided except where one steel bar is bent around the other.

Stirrups and ties shall always pass around the outside of main bars and be securely attached thereto. All reinforcing steel shall be securely held at the proper distance from steel forms, which remain in place by means of galvanized steel bars or chairs placed on the forms. All reinforcing steel, except as mentioned above, shall be securely held at the proper distance from the forms by means of templates, concrete blocks or galvanized steel chairs. Metal chairs shall not be used against formed surfaces, which will be exposed in the finished structure after the forms are stripped. Blocks for holding reinforcement away from contact with the forms shall be precast concrete blocks of approved shape and dimensions and shall have sixteen (16) gauge black annealed tie wires embedded in them. The precast concrete block shall have a compressive strength equal to that specified for the class of concrete to be placed in the work. Layers of bars shall be separated by approved metal chairs or bolsters.

Any broken or damaged concrete spacer blocks shall be removed before concrete is placed. The use of pebbles, pieces of broken stone or brick, metal pipe or wooden blocks as spacers will not be permitted. Reinforcing steel when placed in the work shall be free from flake rust, dirt and foreign material and before any concrete is placed, any mortar that may be adhering to the reinforcing steel shall be removed. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcing steel and given permission to place the concrete. The Contractor shall allow the Engineer one (01) day's time after the reinforcement and forms are in place to conduct the inspection. Any bar of incorrect size, length or shape shall be removed and replaced with correct bars. Any bar located or spaced incorrectly shall be relocated or spaced correctly before permission is given to place concrete and such replacements and corrections shall be at the Contractor's expense. All concrete placed in violation of these provisions shall be rejected and removed.

The supports for reinforcing steel shall not be spaced more than one and two-tenths (1.2) meters apart transversally or longitudinally. No reinforcement shall be placed before the Engineer has inspected the formwork and given his approval.

c) Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Splicing of bars will not be permitted without written approval of the Engineer except where shown on the Drawings. Splices shall be staggered as far as possible and with a minimum separation of not less than forty (40) times bar diameters. Not more than one third (1/3) of the bars may be spliced in the same cross-section, except where shown on the Drawings.

Unless otherwise shown on the Drawings, bars shall be lapped with a minimum overlap of fifty (50) times the bar diameter. In lapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide a minimum clear distance of one bar diameter or one and one third ($1^1/_3$) the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and one half ($1^1/_2$) turns or by butt welding unless otherwise shown on the Drawings.

d) Lapping of Bar-Mat

Sheet of mesh or bar-mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one mesh in width.

e) Covering

The minimum covering, Measured from the surface of the concrete to the face of any reinforcement bar shall, unless otherwise shown on the Drawings or directed by the Engineer, be not less than five (5) cm except as follows:

Top of slab	4.0 cm
Bottom of slab	3.0 cm
Stirrups and ties in T-beams	3.5 cm

In the footings of abutments and retaining walls the minimum covering shall be seven and a half ($7^1/_2$) cm. In work exposed to the action of sea water the minimum covering shall be ten (10) cm.

ITEM 405 PRESTRESSED CONCRETE STRUCTURES

405.1 DESCRIPTION

This work shall consist of furnishing and placing precast, pretensioned, specified cement members or post-tensioning cast-in-place concrete structures in accordance with details shown on the plans and as specified in these Specifications.

This work shall include the furnishing and installation of all items necessary for the particular prestressing system to be used, including but not limited to prestressing and reinforcing steel, ducts, anchorage assemblies and grout used for pressure grouting ducts. The Work also includes curing, storing, transportation and erection of precast pretensioned members complete and in-place.

405.2 MATERIAL REQUIREMENTS

405.2.1 Prestressing Reinforcement Steel

Prestressing steel shall be high-tensile wire conforming to ASTM Specification A-421 or AASHTO Designation M-204; seven wire – strand or rope conforming to ASTM Specification A-416 or AASHTO Designation M-203 or high tensile alloy bars as follows:

High-tensile-strength alloy bars shall be stress relieved and cold stretched to a minimum of 9,100 Kg/sq.cm. After cold stretching the physical properties shall, be as follows:

a)	Minimum Ultimate tensile strength	16,570 Kg/ Sq. cm.
b)	Minimum yield strength, measured by the 0.7 percent extension under load method shall be not less than	9,100 Kg/ Sq. cm.
c)	Minimum modulus of elasticity	1.75 x 10 Kg/ Sq. cm.
d)	Minimum elongation in 20 bar diameter	4 percent
e)	Diameters after rupture	- 0.75 mm
f)	Diameters tolerance	- 0.25 mm

The steel shall be free from injurious defects and shall have a smooth surface. Material, which shows injuries defects during or prior to its installation in the work, shall be rejected.

Wire and strand shall be supplied in coils of sufficient diameter to ensure that they lie out straight.

The Engineer may call for a relaxation test on prestressing steel in case, he is not satisfied with the source of manufacture. Relaxation for prestressing steel shall be measured over a period of thousand (1000) hours stressed at seventy (70) percent of its ultimate tensile strength giving less than six (6) percent elongation.

Testing

All wires, strands, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be shipped shall be likewise identified.

All samples submitted shall be representative of the lot to be furnished.

All of the materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

The contractor shall furnish for testing the following samples selected from each lot as

ordered by the Engineer. The selection of samples shall be made at the manufacturer's plant by the Engineer or his representative.

Pretensioning: Samples at least 2.10 M long shall be furnished of each wire, or strand size. A sample shall be taken from each and every coil.

Post-Tensioning: Samples of the following lengths shall be furnished:

Wires: sufficient length to make up one parallel-lay cable one and half (1.5) M long consisting of the same number of wires as the cable to be furnished

Strands: one and half (1.5) M length

Bars: bars to be with threaded ends and nuts, one and half (1.5) M between threads at ends

Anchorage Assemblies: Two anchorage assemblies of each size of anchorage to be used shall be furnished, complete with distribution plates.

All anchorages and couplers for post-tensioning shall be capable of holding the prestressing steel at a load producing a stress of not less than ninety five (95) percent of the specified ultimate tensile strength of the prestressing steel. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself.

Couplers and coupler components shall be enclosed in housing long enough to permit necessary movements. Couplers shall not be used at points of sharp tendon curvature.

Anchorage devices shall have a minimum clear concrete or grout coverage of 50 mm in every direction.

Allowance for draw-in of the tendon during anchoring shall be in accordance with the Engineer's/Designer's instructions and the actual slip occurring shall be recorded for each individual anchorage.

405.2.2 Concrete

The materials for concrete shall conform to the requirements of item 401. The concrete shall be Class D as shown in table 401-1 unless otherwise shown on the plans.

405.2.3 Reinforcement Steel

Reinforcement steel shall conform to the requirements of item 404.

405.3 CONSTRUCTION REQUIREMENTS

Unless otherwise ordered by the Engineer, the Contractor shall be let out the work to approved specialized firm approved by the Engineer for pre-stressing / post-tensioning accompanied by experience certificates for Expressway and Motorway Projects including list of qualified technicians for completion of pre-stressing operations, equipment for jacking, calibration certificates for equipment to be used and methodology to be adopted for early completion of work.

The tensioning process shall be conducted so that the tension being supplied and the elongation may be measured at all times.

During the prestressing operations, standing behind or under jack will not be allowed in order to ensure that no one is injured by the flying spindle, tendon or the jack in the event of a break occurring.

405.3.1 Prestressing System

In case Contractor wants to use alternate systems provided in the drawings, he shall provide details of the system he proposes to use to the Engineer for his approval.

The method of prestressing to be used shall be optional with the Contractor, provided he introduces no change in the position of centroid of the total prestressing force over the length of the member and in the magnitude of the final effective prestressing force as prescribed in the Drawings. The prestressing system chosen by the Contractor shall have been indicated in the tender. This option shall be subject to all requirements hereinafter specified.

Independently from the prestressing system to be applied, the following points have to be ensured.

a) The safety of the anchorage of the prestressing tendons and their suitability for the transmission of forces to the concrete under all loads whatsoever.

b) That the actual losses due to friction coincide with the calculated ones for the prestressing.

c) The suitability of the proposed steel for the chosen prestressing system.

d) The length of transmission of the force to the concrete and the minimum strength of the latter necessary for prestressing in systems, where the prestressing elements are fully or partially anchored to the concrete through bond and friction.

e) The suitability of measures taken to protect prestressing tendons from corrosion until the final tensioning is carried out.

The Contractor shall submit well in advance to the Engineer for approval complete details of the methods, materials, and equipment he proposes to use in the prestressing operations. Such detail shall outline the method and sequence of stressing, complete specifications and details of the prestressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing units in the members.

An agreement certificate for the prestressing system shall be submitted and approved by the Engineer before any structural member to be prestressed may be tensioned; this agreement certificate must be issued by an authorized testing laboratory otherwise the Engineer may order such an agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this agreement certificate here in after are subject to the approval of the Engineer.

The Contractor shall submit to the Engineer for review and approval working drawings of the prestressing system proposed for use. For initial review, six (6) sets of such drawings shall be submitted. The Engineer shall return one (1) approved set or one (1) set with corrections and modifications. After modifications, six (6) sets showing any required corrections shall be resubmitted for final approval. Such time shall be proportional to the complexity of the work but, in no case, shall such time be less than two months.

The design shall be prepared and signed by a qualified Contractor's structural Engineer who has been approved in advance by the Engineer.

No additional payment will be made to the Contractor for any changes required as a result of reviews and approval.

In his submittal, the Contractor will also describe techniques he intends to use for:

- placing ducts and strands
- making ducts completely tight against accidental entrance of laitance during concreting.

- prestressing operations and measurement of elongation.
- Injection
- Cutting of tendons surplus, and filling anchorage recesses.

He will also ensure that all precautions will be taken for the protection of prestressing steel, ducts, anchorages, jacking and grouting equipments and all miscellaneous items. Protection will be on storage areas, and also at every stage of construction until injection by grouting and concreting of anchorages recesses.

All type of protections will be described in details (methodology and materials) by the Contractor in his submittal. As for the "storage of materials on site" he will follow AASHTO-Standard Specifications-Division II 10.6.

It is ensured that all these precautions will be sufficient to ensure that the friction coefficient of strands/ducts will be included between 0.20 and 0.24 and no oxidation on steel (ducts and strands) will occur.

405.3.2 Prestressing Equipment

Hydraulic jacks shall be equipped with accurate pressure gauges. The contractor may elect to substitute screw jacks or other types for hydraulic jacks. In that case, proving rings or other approved devices shall be used in connection with the jacks. At least three (3) functional jacks will be provided on the job in good condition. All devices, whether hydraulic jack gauges or other wise, shall be calibrated so as to permit the stress in the prestressing steel to be computed at all times. A certified calibration curve shall accompany each device. Safety measures shall be taken by the contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process. All equipments shall be thoroughly washed with clean water at least once every three (3) hours during the grouting operations and at the end of use for each day.

Grouting equipment shall be capable at a pressure of at least seven (7) Kg/sq cm. Grouting equipment shall be furnished with a pressure gauge having a full scale reading of not more than 20 Kg/sq cm. Reciprocating pumps or equipment that produces a pulsating flow shall not be used. Grouting equipment shall be thoroughly washed with clean water at least once every three (3) hours during grouting operations and at the end of use each day. Grout injection pipes shall be fitted with positive mechanical shut off valves. Vents and ejection pipes shall be fitted with valves capable of withstanding the pumping pressure.

405.3.3 Enclosures

Enclosures for prestressing steel shall be accurately placed at locations shown on the plans or approved by the Engineer.

All enclosures shall be of strong ferrous metallic material and shall be completely mortar-tight. Enclosures shall be strong enough to maintain their shape under such forces as will be imposed upon them. They shall be six (6) mm. larger in internal diameter than the bar, cable, strand or group of strands, which they enclose. Where pressure grouting in specified, cores or ducts shall be provided with the pipes or other suitable connection for the injection of grout after the prestressing operations have been completed.

When approved by the Engineer, ducts shall be of the flexible, corrugated type, delivered to the site on large diameter wooden drums.

Ducts shall be protected from rusting, damage, oil or any other deleterious matter. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete and shall be bent without crimping or flattering. Joints in adjacent ducts shall be staggered by at least 300 mm. Waterproof tape shall be used at the connections.

405.3.4 Placing Steel

All steel units shall be accurately placed in the position shown on the Drawings or

required by the Engineer and firmly held during the placing and setting of the concrete.

Distance from the forms shall be maintained by stays, blocks, ties, or hangers approved by the Engineer. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be left in the concrete.

Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in place in true position in the enclosure.

Density of supports, their stiffness and accuracy of position are parameters that affect the loss of tension in cables due to wobbling. The Contractor will take all suitable provisions to reduce this “wobbling effect".

In particular, the space between two supports will be less than 1m.

405.3.5 Placing Concrete

Concrete shall be controlled, mixed, and handled as specified in other articles of this section unless otherwise specified herein.

Concrete shall not be poured in the forms until the Engineer has inspected the placing of the reinforcement, conduits, anchorages, and prestressing steel and has given his approval thereof.

The concrete shall be vibrated internally or externally, or both, as ordered by the Engineer. The vibrating shall be done with care in such a manner as to avoid displacement of reinforcement, conduits, or wires.

405.3.6 Pretensioning

The pretensioning elements shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongation produced thereby. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units, if necessary; to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor end anchorages released, until the concrete has attained a compressive strength, as shown by cylinder tests, of at least two hundreds and eighty (280) kg/sq.cm and as approved by the Engineer. The elements shall be cut or released in such an order that lateral eccentricity of prestress will be a minimum.

405.3.7 Post-Tensioning

Tensioning shall be carried out only in the presence of the Engineer or his representative unless permission has been obtained to contrary. Immediately before tensioning, the contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the applications of prestress.

Tensioning of prestressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions, indicate that the concrete of the. particular member to be prestressed has attained a compressive strength of at least 280 Kg/sq.cm.

After the concrete has attained the required strength, the prestressing reinforcement shall be stressed by means of jacks to the required tension and stress transferred to the end anchorage(s). Stressing shall be from both ends unless otherwise required in the Contract or agreed by the Engineer. The tensioning process shall be so conducted that the tension being applied and the elongation of the prestressing elements may be measured at all times. The friction loss in the elements, i.e., the difference between the tension at the jack and the minimum tension in the prestressing steel shall be determined by the formula:

$$F_t = 2\left(F1 - \frac{a\ c\ E}{d}\right)$$

Where

F_T = total friction loss

F_1 = Observed tension at the jack

a = cross-sectional area of the prestressing element

c = observed elongation of the element when the force at the jack is F_1

E = secant modules of elasticity of the element for the stress F_1 as determined from the stress-strain diagram of the element

d = distance from the jack to the point of lowest tension in the element. Where jacking is done from both ends of the members, the point of minimum tension is the center of the member. Where jacking is done from one end only, d is the distance to the other end of the member

Any surplus length of tendon shall be cut off by an approved method which will not affect the strength of the stressed tendon, with particular care if uses of spark erosion or oxyacetylene burning methods of cutting are approved by the Engineer.

A record shall be kept of gauge pressures and elongation at all times and submitted to the Engineer for his approval with in twenty four (24) hours of each tensioning operation. The tendons shall be maintained in such a condition that they can be re-stressed until the Engineer has given final approval after inspecting the tensioning log.

After cutting surplus length of cables, recess will be filled by concrete Class D.

405.3.8 Grouting of Bonded Steel

All ducts used for post-tensioning will be filled by injection of grout.

a) Grout

It shall be a mixture of Portland cement, water and approved admixtures. Composition of the mix shall be submitted to the Engineer for approval, along with following information:

- The nature, quality and origin of the constituents
- Measure by weight of each constituent,
- Sequence of mixing

The cement will be Portland cement conforming to ASTM C150 that does not exhibit phenomenon of "false setting" (Test of TUSSCHENBROOK), without any sulphur ions S^{--}, with a chloride ions Cl^- less than 0.05%, and without any element susceptible to induce corrosion of steel.

The water will not contain chloride ions Cl^- more than 500 mg/l, sulphate ions SO_4^{--} more than 400 mg/l, and no detergent.

Admixtures, if used, should impact the properties of low water content, good flow ability, minimum bleed and expansion if desired. Its formulation should contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Admixtures containing chlorides (as C1 in excess of 0.5% by weight of admixture), fluorides, sulfites and nitrate shall not be used.

All admixtures should be used in accordance with the instructions of the manufactures.

The submittal will include the chemical composition of the grout and results of laboratory tests for the following features:

- Sweating
- Fluidity
- Mechanical Strength

Sweating:

The quantity of water due to sweating at the surface of the grout maintained at rest during three (3) hours must be less than 2% of the volume of the grout; this water must be totally re-absorbed twenty-four (24) hours after the mixing.

Fluidity:

The flow-out time through the MARSH cone with a 10 mm diameter hole, will be included between 13 and 25 seconds during the time foreseen for the grouting, and at least for 1 hour, at a temperature of 32°C.

Mechanical Strength:

- Three days 230Kg/sq cm
- Seven days 300Kg/sq cm
- Twenty eight days 350Kg/sq cm

(b) Grouting Operation

AASHTO-Standard Specifications-Division II -10.6 & 10.9 will be followed.

Note that mixing water will have to be cooled in summer when temperature of concrete will be above 32°C.

(c) Quality Control

1) Laboratory tests

They will be made to verify the suitability of the grout composition to the intended basic features here above specified.

2) Checking tests on site

Checking for sweating and fluidity will be made 24 hours before beginning of the injections at the conditions that will really prevail at the injection time; same materials and equipments will be used for that purpose.

Results of tests will be transmitted to the Engineer for approval.

3) Tests during grouting operations

For each operation, three series of fluidity tests will be made. Each series consists of one test on the grout at the entry vent and one test on the grout at the exit vent. Results of tests will be transmitted to the Engineer as well as quantities of grout actually consumed for each duct.

405.3.9 Handling

Precast prestressed concrete members shall be transported in an upright position and the points of support with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. In the event that the Contractor deems it expedient to transport or store precast girders in other than this position it should be done at his own risk.

Care shall be taken during storage, hoisting, and handling of the precasting units to prevent cracking or damage. Units shall be lifted and supported at the designated lift points

only. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

Prestressed structural members shall be constructed in conformity with the drawings governing the particular type of structure to be built or as required by the Engineer.

Working Shop Drawings of handling and all operations to the final positioning of girders will be submitted to the Engineer.

If permanent displacements of the piers/abutments or of the neoprene bearings are induced as a result of Contractor's methodology, these displacements will be calculated by the Contractor and provisions, like jacking, will be provided by him at his own cost to relieve the structure of these displacements.

Calculation notes showing that stability of beams, inclusive lateral buckling, are ensured at every stage until concreting & achieving desired compressive strength of diaphragms and deck slab. This submittal does not relieve the Contractor of his full responsibility during handling, transport, placing, and attached operations like jacking or slimming.

In case of voided slab construction which is to be cast in situ, the Contractor shall submit proposal to the Engineer for approval on various aspects listed hereunder:

a) Preparation of bed capable to take loads of wet concrete cast in situ, scaffolding and construction loads etc.
b) Type of scaffolding and shuttering to be used to have Class 1 surface finish.
c) Prestressing Operations
d) Methodology of placing & holding of ducts during concreting operation.
e) Removal of formwork.

405.3.10 Off- Site Manufacture of Prestressed Members

a) The details of the method of manufacture shall be approved by the Engineer before work is started. When the method has been approved, no changes shall be made without the consent of the Engineer.

b) The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and the dates when tensioning of tendons, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

c) The Contractor shall send to the Engineer not more than seven (7) days after the transfer of stress, a certificate showing the force and strain in the tendons immediately after they were anchored, the strength and age of the test cubes cast in accordance with specified procedure and the minimum age in hours of the concrete at the time the stress was applied to the member. A copy of all twenty eight (28) days cube test results relating to the work shall be sent to the Engineer as these become available. Records shall be kept so that the identity of those who stress the tendons, cast the concrete and transfer the stress on any member or line of members can be traced.

d) Where the Engineer's Representative requires tests to be carried out, no beams to which the tests relate shall be dispatched to site until the tests have been satisfactorily completed.

405.3.11 Composite Slab Bridges

a) The manufacturing tolerances for the precast members shall nowhere exceed those given for the length, cross-section and straightness in BS Code of Practice CP116 (1969). The structural use of precast concrete. In addition, where beams are laid side by side in a deck:

    1) The difference in soffit level between adjacent units before the in situ concrete is

placed shall no-where exceed five (5) mm for units up to five (5) meters nor ten (10) mm for longer units.

2) The width of the deck soffit shall be within plus twenty five (+25) mm of that described in the Contract.
3) In adjacent spans, the continuity of line of the outside beams shall be maintained.
4) The width of the gap between individual beams shall not exceed twice the nominal gap described in the contract.
5) The alignment of transverse holes shall permit the reinforcement or prestressing tendons to be placed without distortion.

b) The in-situ concrete shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports.

c) Beams shall be prevented from moving laterally during the placing of the in-situ concrete.

405.3.12 Sampling and Testing

a) Testing of Pretensioned Beams

1) Any beam required by the Engineer to be subjected to a load test will be selected after transfer and wherever possible before the beam has been removed from the casting yard to the storage area. The Contractor shall not proceed with a load test until he has obtained the approval of the Engineer to the detailed arrangements. Except where otherwise agreed by the Engineer, the load test shall be carried out not less than twenty eight (28) days after casting. The cost of the load test shall be born by the Contractor.

2) The beam shall be supported at its design points of bearing. The specified test loads shall be applied equally at the third points of the span in not less than ten (10) approximately equal stages. The maximum load shall be sustained for five (5) minutes and then removed in not less than five (5) approximately equal stages. The mid-span deflection relative to a straight reference line joining the points of support shall be measured for each value of the load and five (5) minutes after removal of the load.

3) Loads shall be measured with an accuracy of $\pm$ two (2) percent or 50 kg and deflections with an accuracy of + decimal five (0.5) millimeter.

4) The load-deflection graph shall be plotted from these values and shall show no appreciable variation from a straight line. If after five (5) minutes of removal of the load the beam does not show a recovery of at least ninety (90) per cent of the maximum deflection recorded during the test, the test loading shall be repeated. The beam shall be considered to have failed the test if the recovery five (5) minutes after removal of the test load for the second time is not at least ninety (90) per cent of the maximum deflection recorded during the second test.

5) The result of the test shall be deemed to apply to the other beams cast in the same production line but in the event of failure any additional beam may be separately tested at the contractor's option.

6) The contractor shall supply to the Engineer record sheets of the test showing the age of the beam at the time of the test, loads, deflections, load-deflection curves and calculated value of Young's Modules of Elasticity (E).

7) In addition, the record sheets supplied by the contractor to the Engineer shall show the temperatures of the top and bottom surfaces of the beam measured at the time of the test.

b) Testing of Prestressing Anchorages

Anchorages for post-tensioning shall be tested in accordance with the procedure described in BS4447 or as approved by the Engineer. For each anchorage system used in the Works, the characteristic value for anchorage efficiency shall be not less than ninety (90) percent.

405.3.13 Curing Concrete

a) General

For all prestressed concrete operations the curing procedures shall be well established and properly controlled. Curing shall be commenced immediately following initial set or completion of surface finishing. Members shall be kept wet during the entire period of curing.

b) Method of Curing

The curing methods shall conform to those detailed under item 401.3.8.

ITEM 406 JOINTS AND BEARING DEVICES FOR CONCRETE STRUCTURES

406.1 DESCRIPTION

The work covered in this item shall consist of furnishing all plant, equipment, materials and labour in performing all operations in connection with furnishing and placing (in concrete structures) all expansion joints and seals, metal bearing pads and elastomeric bearing pads complete and in accordance with the specifications, the Drawings, and or as required by the Engineer.

The work in this Item shall also cover the horizontal and vertical joints of all types mentioned in the drawings relating to concrete retaining walls, rigid concrete pavements and at any other place as shown on the drawings or as required by the Engineer. For bridge decks refer to Item 416 (Manufactured Trade Mark Expansion Joints).

406.2 MATERIAL REQUIREMENTS

406.2.1 Concrete Joint Filler with Bitumastic Seal

a) Preformed Expansion Joint Filler

Unless otherwise directed by the Engineer preformed joints filler shall conform to the requirements of AASHTO M-213. The joint filler shall be covered with bitumastic seal as shown on the drawings.

b) Neoprene Rubber Sheet with Bitumastic Seal

Unless otherwise directed by the Engineer, neoprene rubber sheets six (6)mm in thickness, meeting the requirements as given hereunder, shall be used as a joint filler covered with a bitumastic seal as shown in the Drawings.

Neoprene shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall have the following physical characteristics in accordance with ASTM Method D15, Part B:

Hardness, Durometer A, ASTM D 2240	45 $\pm$ 5 points
Tensile Strength, ASTM D 412	127 kg/sq. cm. min.
Elongation at Break	400 percent min.
Compression Set, 22 Hours at 70 **º**C. ASTM D 395, Method B.	20 percent max.
Low Temperature, ASTM D 746	Not brittle at 40 **º**C
Ozone Resistance, Exposure to 100 PPHM Ozone for 70 hours at 38 **º**C. Sample under 20 percent. ASTM D 1149.	No cracks
Oil Deterioration - Volume increase after soaking in ASTM oil No. 3 for 70 hours at 100 **º**C. ASTM D 470	120 % max.

406.2.2 Steel for Deck Expansion Joint Seals

Plates, angles or other structural shapes including anchor bolts required for the expansion joint seals shall conform, unless otherwise directed by the Engineer, to the requirements of AASHTO M-160 and shall be hot zinc sprayed (galvanized) with the exception of the nuts and washers which shall be in stainless steel.

406.2.3 Elastomer for Deck Expansion Joint Seals

Elastomer shall be of the component as neoprene or of polyvinyl chloride (PVC), at the

option of the Contractor. Neoprene shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall have the required physical characteristics as given in 406.2.1(b) above.

406.2.4 End Support for Girders, Precast Reinforced Beams and Slabs

End supports for girders shall be structural steel supports with anchors and other details as shown on the drawings. The work shall include fabrication of structural steel, welding as per relevant AWS Standard, galvanization and installation of the supports as shown on the drawings and as directed and approved by the Engineer.

406.2.5 Elastomeric Bearing Pads

General

Elastomeric bearings as herein specified shall include plain bearings (consisting of elastomer only) and laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded laminates.

The reinforcing steel plate's laminations for bearing pads shall conform to the requirements of ASTM A36/ A36-01.

Elastomeric bearing pads shall conform to the requirements in these specifications and the Special Provisions.

Pads twelve (12) mm and less in thickness may be either laminated or all elastomer.

Pads over twelve (12) mm in thickness shall be laminated.

Laminated pads shall consist of alternate laminations of elastomer and metal or elastomer and fabric bonded together.

The thickness called for an elastomeric bearing pad is deemed to be the total effective thickness of the elastomeric laminations.

The outside laminations shall be metal or fabric. The outside edges of metal laminations shall be coated over with elastomer not more than three (3) mm in thickness.

The edges of the steel reinforcing plates of the bearing pads shall be carefully treated to prevent notch effects.

Steel plates shall be fully enclosed in elastomer so that there is no danger of corrosion.

Laminations of elastomer shall be 6 $\pm$ 1 mm thickness. Variation in thickness of an individual elastomer lamination shall not exceed one (1) mm within the width or length of a pad and the variation in thickness of all elastomer laminations within a pad shall be such that each metal or fabric lamination will not vary by more than one (1) mm from a plane parallel to the top or bottom surface of the pad.

The total overall thickness of a pad shall not be less than the thickness shown on the plan nor more than six (6) mm greater than that thickness. Variation of total thickness within an individual pad shall not exceed one (1) mm.

The length and width of a pad shall not vary more than one (1) mm from the dimensions shown on the Drawings.

Where elastomeric bearing pads over twelve (12) mm, in thickness are shown on the Drawings or required by the Engineers, such pads may be manufactured as a molded laminated pad, or at the option of the Contractor, may be made up by stacking individual laminated pads.

When laminated pads are stacked, their contact surfaces shall be cleaned prior to

stacking and an approved method shall be used to hold the individual pads in the stack in proper alignment. Pads of all elastomer or with fabric laminations may be cut from large sheets. Cutting shall be performed in such a manner as to avoid heating of the material and to produce a smooth edge with no tears or other jagged areas and to cause as little damage to the material as possible.

Corners and edges of molded pads may be rounded at the option of the Contractor. Radius at corners shall not exceed ten (10) mm and radius of edges shall not exceed three (3) mm.

The bond between elastomer and metal or fabric shall be such that, when a sample is tested for separation, failure shall occur within the elastomer and not between the elastomer and metal or fabric.

Metal laminations shall be rolled mild steel sheets not less than twenty (20) gauge in thickness.

Fabric laminations shall be either, (1) a long chain synthetic polymer containing at least eighty five (85) percent of polyester from ethylene glycol and teraphthalic acid or (2) a long chain synthetic polymeric amid from hexamethylene diamine and adipic acid. Each ply of fabric shall have a breaking strength of not less than 125 Kg. per cm. of width in both directions. Fabric laminations shall be single ply at top and bottom surfaces of the pad and either double ply or double strength within the pad.

The sole polymer in the elastomeric compound shall be neoprene and shall be not less than sixty (60) percent by volume of the total compound.

The elastomer, as determined from test specimens, shall conform to the following:

Test	**ASTM Designation**	**Requirements**
Tensile strength, kg/sq. cm.	D 412	160 min.
Elongation at break, percent	D 412	350 min.
Compression set, 22 hours at 67 ^{o}C, (percent) Method B	D 395	25 max.
Tear Strength, kg/sq. cm.	D 624 (Die C)	13 min.
Hardness (Shore A)	D 2240	60 $\pm$ 5 Points
Ozone resistance 20% strain, 100 hours at 38 ^{o}C $\pm$ 100 $\pm$ 20 parts 1 ^{o}C.	D 1149	(except No Cracks per 100,000,000)
Low temperature stiffness, Young's Modulus at 35 ^{o}C, kg/sq. cm.	D 797	350 max.
Low temperature brittleness, 5 hours at - 40 ^{o}C	D 376	Passed

After accelerated aging in accordance with ASTM Designation D 573 for 70 hours at 100 degree C, the elastomer shall not show deterioration changes in excess of the following:

Tensile strength, percent	$\pm$ 15
Elongation at Break, percent	- 50 (but not less than 300% total elongation of the material)
Hardness, points	+ 10
Shear Test (without vertical load)	+ 10

Sampling shall be performed in accordance with AASHTO M 251 as appropriate for the

tests required during or immediately after manufacture.

The Contractor shall furnish to the Engineer a certification by the manufacturer that the elastomer, and fabric (if used), in the elastomeric bearing pads to be furnished conforms to all of the above requirements. The certification shall be supported by a certified copy of the results of tests performed by the manufacturer upon samples of the elastomer and fabric to be used in the pads.

The Engineer will take a sample of not less than 15 x 30 cm in size for testing from each lot of pads or batch of elastomer to be furnished, whichever results in the greater number of samples. The samples will be selected at random at the point of manufacture or, at the option of the Contractor at the job site. Samples taken at the job site shall consist of complete pads as detailed on the plans, and the Contractor shall furnish additional complete pads to replace those taken for testing. Pads shall be available -for sampling three (3) weeks in advance of intended use. All sample pads for testing shall be furnished by the Contractor at his expense.

406.3 CONSTRUCTION REQUIREMENTS

406.3.1 Open Joints

Open joints shall be constructed at the locations shown on the Drawings or required by the Engineer using a suitable material, which is subsequently removed. When removing the material, care shall be exercised to avoid chipping or breaking of concrete. Reinforcement shall not extend across an open joint, unless shown on the Drawings.

406.3.2 Filled Joints

When joints of preformed type are required on the Drawings or by the Engineer, the filler shall be placed in correct position before concrete is being placed against the filler. Preformed Filler with holes and cracks shall not be permitted and shall be rejected.

406.3.3 Steel Joints

Plates, angles or other structural shapes shall be accurately shaped at the shop, to conform to the section of the concrete floor as per drawings. The fabrication shall conform to the requirements in Special Provisions. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Methods approved by the Engineer shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that to avoid impairment of the clearance in any manner.

406.3.4 Waterstops (Joint Seals)

Waterstops shall be furnished and installed in accordance with the details shown on the Drawings or where required by the Engineer and in accordance with the provisions in these specifications.

Waterstops shall be furnished in full length for each straight portion of the joint, without field splices. Manufacturer’s shop splices shall be fully vulcanized.

Reinforcing bars provided to support the waterstops shown on the Drawings or as required by the Engineer shall be securely held in position by the use of spacers, supporting wires, or other approved devices. Such reinforcing bars shall be considered, for payment purposes, as a part of the waterstop. If, after placing concrete, waterstops are materially out of position or shape, the surrounding concrete shall be removed, the waterstop reset, and the concrete replaced, all at the Contractor’s expense.

Field splices for neoprene waterstops shall be either vulcanized, or mechanical, using stainless steel parts, or made with a splicing union of the same stock as the waterstop, at

the option of the Contractor. All finished splices shall have a full size tensile strength of eighteen (18) kg per cm of width.

Field splices for polyvinyl chloride waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not char the plastic.

Waterstops when being installed shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

Waterstops shall be of the type, size, and shape shown on the plans. They shall be dense, homogenous, and without holes or other defects.

Waterstops will be in polyvinyl chloride (PVC), according to AASHTO-Standard Specifications-Division II 8.9.2.6.2, tested according to AASHTO-Standard Specifications-Division II 8.9.2.6.4 and installed according to Specifications-Division II 8.9.3.4. The frequency of sampling for PVC waterstop will be per lot supplied.

The Contractor will submit the samples of the waterstops at least 1m long, and certificates of the approved patent international manufacturer showing that specified specifications are complied with. He will indicate the methodology of placing and concreting around in vertical and horizontal positions. Waterstop will be carefully stored on site, away from humidity and sunlight. The manufacturer shall also submit the list of international projects where this product has been used.

The 225 mm wide & 10 mm thick PVC waterstop shall be provided in specified construction joints, contraction joints and expansion joints of walls, culverts / subways, retaining walls etc., at locations shown on the drawings or as directed by the Engineer.

406.3.5 End Support for Girders, Precast Reinforced Beams and Slabs

The work shall include fabrication of structural steel (as per ASTM A36 Standards), welding as per relevant AWS Standard, galvanization and installation of supports as shown on the drawings and as directed and approved by the Engineer. They shall be cast in situ with precast reinforced beams, post – tensioned girders and solid slabs.

406.3.6 Elastomeric Bearing Pads

When elastomeric bearing pads are shown on the Drawings, the concrete surfaces on which pads or packing are to be placed shall be wood float finished to a level plane which shall not vary more than one and a half (1.5) mm from a straightedge placed in any direction across the area. The finished plane shall not vary more than three (3) mm from the elevation shown on the Drawings or that required by the Engineer.

The Contractor will submit manufacturer's recommendations regarding complete method for installation of elastomeric bearing pads for approval of Engineer.

ITEM 407 PILING

407.1 DESCRIPTION

This work shall consist of performing all operations in connection with cast-in-place concrete piles. It will also include exploratory drilling at major structure locations, if required by the Engineer. Scope and details of exploratory drilling have been defined in Item 419.

When test piles and load tests are required in conformance with subsection 407.3.6 and 407.3.7 respectively, the data obtained from such test loads will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer will not prepare the Itemized list of piles for any portion of the foundation area until all loading tests representative of that portion have been completed.

The Contractor shall provide an outline of his proposed method of constructing the piles when submitting his tender; the proposed method of boring being stated and taking due considerations for running water conditions .

Not less than two weeks before the Contractor proposes to commence piling, detailed proposal for the piling shall be delivered to the Engineer. These proposals shall include full details of material, equipment and method to be used in the construction of piles.

If it is proposed to use bentonite slurry, this shall also be described giving full details.

Work on piling shall not commence until the Contractor's proposals have been approved by the Engineer and communicated to him.

The requirements herein are minimum. Strict compliance with these requirements will not relieve the Contractor of the responsibility for adopting whatever additional provisions may be necessary to ensure the successful completion of the work.

The kind and type of piles shall be as shown on the Drawings and/or as specified. No alternate types or kinds of piling shall be used, except with the written approval of the Engineer each time.

Where running water is encountered, the Contractor shall submit method statement of boring and casting piles in-situ to the Engineer for approval. It should include type of barge/boat used for making temporary platform to carry out boring, lowering of steel reinforcement cage and piling activity including concreting.

407.2 MATERIAL REQUIREMENTS

407.2.1 Reinforced Concrete Cylindrical Piles

Diameter of reinforced concrete piles shall be as shown on the Drawings and may or may not have permanent lining,

Reinforcing Steel shall conform to the requirements under Item 404 - Steel Reinforcement.

Concrete for piles shall meet all the requirements of Class A3 as provided under Item 401.

407.2.2 Steel Liner

When permanent steel casing is shown on the Drawings, the steel shall conform to the ASTM A 36 or equivalent (BS-15).

The minimum thickness of permanent steel liner shall be 10 mm. If the permanent liner is used in the boring operation or if the handling and transport require a stiffness to avoid deformation or buckling, the stiffness shall be provided by the Contractor at his own

expense.

The steel casing shall be furnished in appropriate lengths and joints shall be approved by the Engineer.

The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work it shall be free from dirt, oil grease, paint, mill scale and loose or thick rust.

The outside surface of the permanent casing of piles, for the depth indicated on the Drawings shall receive two coats of anticorrosion, tar type paint. The paint shall be approved by the Engineer and its application shall follow the manufacturer's instructions at no extra cost.

407.3 CONSTRUCTION REQUIREMENTS

407.3.1 Cast-in-Place Piles

Piles, cast-in-place, shall consist of one of the following two types either shown on the drawing and /or as specified:

a) Pile Cast in Drilled-Bore hole-Steel lined

The pile shall be cast as stated in 407.3.1(b) and shall be steel lined if required. The Contractor shall provide a permanent lining suitably formed of ten (10) mm minimum thickness steel plate. The plates shall be cut and rolled to the inner diameter not less than the nominal diameter of the pile or such larger diameter as to allow the requisite pile diameter hole in the unlined length of pile. The rolled plates shall be connected by full penetration butt welds generally complying with B.S.5133.No more than three (3) longitudinal seam welds shall be employed in any one cross-section and such welds shall be staggered in position in the cross-section between one length and the next. The dimensional accuracy of the lining shall be as stated on the drawings.

b) Piles Cast in Drilled-Borehole

1) *Boring Procedure*

The method of boring shall be one which maintains stability, vertically or batter (as shown on the Drawing) of the wall and base of borehole by the use of temporary casing and/or bentonite slurry. The variation from alignment shall not exceed plus or minus one half (0.5) degrees.

All holes shall be drilled to the tip elevation shown on the Drawings, unless otherwise specified or approved by the Engineer. Rejected bore holes shall be filled with sand by Contractor at his expense and allowed to be consolidated for at least 5 days under saturated conditions before allowing bore for adjacent or alternate pile.

The method/ procedure used in execution of bore hole and other operations shall not be such as to cause vibrations resulting in damage to completed or partially completed piles or to adjacent structures, services or other property. The procedure shall not be such as to cause harmful loosening or softening of soil outside the pile that has to be filled with concrete The equipment used for execution of borehole shall be adequate to ensure that each pile penetrates to the required founding level. Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is poured. Casing, if used in drilling operations (as approved by the Engineer) shall be removed from the hole as concrete is poured unless otherwise specified. The bottom of the casing shall be maintained not less than fifty (50) cm below the top of the concrete during withdrawal and pouring operations unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided.

Reinforcement, if called for, shall conform to the requirements under Item 404.

2) *Temporary Casing*

The temporary casing of appropriate diameter for locating the pile and piloting the borehole shall be pitched at the exact locations as given on the drawings to ensure that the casing when sunk is within the specified tolerances. The casing shall be sunk to sufficient depth by approved methods. The depth shall be at least sufficient to prevent the ingress of alluvium or other loose materials into the bore when executed below the bottom level of the casing. In addition, the depth shall be such as the Contractor considers necessary for the stability of the casing and/or temporary works system during construction in general and for the following conditions and operations:

i) Open temporary casing to ensure against blow -in of soil.
ii) Concreting of the pile, until temporary casing is extracted.

The Contractor shall take all such measures and provide such strengthening and bracing as is necessary and to the approval of the Engineer to ensure that the temporary casing is not disturbed, overturned, over-stressed or under-eroded in any condition of temporary casing and shall be such that it will not disturb the freshly cast concrete and/or permanent lining and /or reinforcement.

Where the use of temporary casing is approved for the purpose of maintaining the stability and over-rapid withdrawal of the boring tools which could lead to excessive removal of soil and water and disturbance of the surrounding ground and when boring through any permeable stratum (including silt), the water level in the boring shall be maintained between one (1) meter and two (2) meters above the external water level, unless the Engineer directs other-wise.

The temporary casing shall be free from distortion and of uniform cross-sections throughout each continuous length. During concreting these shall be free from encrusted concrete or any internal projections which might prevent the proper formation of the pile.

3) <u>Bentonite Slurry</u>

Where the use of bentonite slurry is approved for the purpose of maintaining the stability of the walls and base of bore the Contractor's proposals in accordance with 407.1 shall include details of the slurry. These shall include inter-alia:

i) The source of the bentonite
ii) The constitution of the slurry.
iii) Specific gravity, viscosity, shear strength and pH value of slurry.
iv) The methods of mixing, storing, placing, removing and recirculating the slurry, and
v) The provision of stand-by equipment.

Tests shall be carried out to ensure that the proposed constitution of the slurry is compatible with the ground water. Proposals for the constitution and physical properties of the slurry shall include average, minimum and maximum values. The specific gravity of the slurry shall not be less than one and three hundredth (1.03) in any case at any time The Contractor shall use additives where necessary to ensure the satisfactory functioning of the slurry.

A manufacturer's certificate showing the properties of the bentonite powder shall be delivered to the Engineer for each consignment delivered to site. Independent tests shall be carried out at laboratory approved by the Engineer on samples of bentonite frequently.

The Contractor shall carry out tests at site during the course of the piling to check

the physical properties of the bentonite slurry in the works. These tests shall include, inter-alia, density, viscosity, shear strength and pH tests. The test apparatus and test methods shall be those given in “Recommended practice” Standard by American Petroleum Institute, New York City, 1957, reference API RP 29,Section -I, II and VI.

The frequency of tests shall be that which the Contractor considers necessary to ensure that the bentonite slurry is in accordance with his proposals and as such other times as the Engineer may direct.

Should the physical properties of any bentonite slurry deviate outside the agreed limits, such slurry shall be replaced, irrespective of the number of times it has been used by new bentonite slurry of correct physical properties.

Adequate time shall be allowed for proper hydration to take place, consistent with the method of mixing, before using slurry in the works.

The Contractor shall control the bentonite slurry so that it does not cause a nuisance either on the site or adjacent waterway or other areas. After use it shall be disposed in manner to the approval of the Engineer.

The level of the slurry in the bentonite shall be maintained so that internal fluid pressure always exceeds the external water pressure.

If chiseling is used when boring through hard strata or to overcome obstructions, the stability of the excavation shall be maintained by methods acceptable to the Engineer.

4) Excavation from Boreholes

The soil and debris from inside the pile boreholes shall be removed by bucket, auger or circulating bentonite slurry provided that no jetting at the foot of the borehole shall be permitted. Methods of excavation which in the opinion of the Engineer may damage the permanent lining of the pile shall not be employed.

Should the excavation reveal any soil stratum below the bottom of a pile which is, in the opinion of the Engineer, unsuitable for supporting the loads that will be imposed on it, the Contractor shall remove all such soil stratum to the satisfaction of the Engineer and shall lengthen the pile to sound acceptable foundation as directed, and cost of any such lengthening shall be paid as per this contract at the given BOQ item rate.

Excavation shall be carried out as rapidly as possible in order to reduce to a minimum the time in which any strata are exposed to the atmosphere, bentonite slurry or water. The time gap between end of boring and start of concreting shall not exceed six (6) hours, in any case. Besides, the concreting of a pile shall be completed within a maximum period of twelve (12) hours following completion of the corresponding borehole.

The materials from pile excavation shall be disposed so that the same does not interfere with any part of the permanent works of this project, in neat and workmanlike manner.

5) Samples and Tests

The Contractor shall take soil samples as given below as directed by the Engineer and shall carry out in-situ Standard Penetration Tests (if required by the Engineer) within, and ahead of borehole at least 3 meter depth below the tip elevation, as and when directed by the Engineer on the line of vertical axis of the pile at these locations at one and half (1.5) meter interval. Undisturbed and disturbed samples, its type, frequency and testing shall be as directed by the Engineer. The costs of tests and collection of samples shall be deemed to be included in the unit rates

quoted by the Contractor. Each disturbed sample shall, as far as possible, be truly representative of the grading of in situ soil at the point from which it is taken, shall be without contamination by other material. It shall be approximately five (5) Kg. in weight and shall be placed in a strong air tight container immediately after its removal from the sampler. The container shall be sealed as soon as the sample has been placed in and shall be taken to the site laboratory/laboratories approved by the Engineer. The samples to be tested and the tests to be carried out for each sample shall be as specified by the Engineer. The types of tests are:

The apparatus and procedure for the Standard Penetration Test shall be in accordance with the provisions of ASTM D 1586 Penetration Test and Split-barrel sampling of soils and/or ASTM D 1587 thin-walled sampling of soils, (except insofar as any such provisions may conflict with other requirements of the contract). No separate payments for the sampling/testing shall be made.

6) Limitations of Boring Sequence

Piles shall be constructed in such a manner and sequence as to ensure that no damage is sustained by piles already constructed in adjacent positions. The Contractor shall submit to the Engineer for his approval a programme showing sequence of construction of various piles.

7) Tolerances

The heads of piles at the designated cut off level shall be within seventy five (75) mm of their position in plan as shown on the drawings and no pile shall deviate from the vertical alignment by more than one half (0.5) degree. Forcible methods of correction of any casing or piles shall not be used.

8) <u>Inspection</u>

After the borehole has reached its final stipulated position, after the samples have been taken out, as required by the Engineer and the borehole has been completely cleaned of all loose matter and otherwise made ready to receive the reinforcement and thereafter the concrete, the Contractor shall so inform the Engineer.

The Engineer shall inspect the soil samples and test results thereon, check the elevation of the bottom of the borehole and the amount and direction, if any, by which the top of the casing is out of position, or out-of-plumb having satisfied himself on these and on any other points which he may consider relevant, shall sign permission authorizing the Contractor to proceed with the placing of reinforcement. The Contractor shall under no circumstances proceed with the placing of reinforcement or with the subsequent concreting without having first obtained the authority signed separately for each and every borehole by the Engineer.

9) <u>Pile Reinforcement</u>

The reinforcement for each pile shall be assembled and securely tied by means of binding wire and by welded reinforcement rings of twenty five (25) mm diameter bar as shown on the drawings, in such a manner as to form a rigid cage.

The required concrete cover to the reinforcement shall be maintained by suitable spacers securely attached to the reinforcement and of sufficient strength to resist damage during handling of the reinforcement cage into the pile. The distance between the spacers shall be such that the required cover is maintained throughout and that there is no displacement of the reinforcement cage in the course of the concreting operation.

Should the Contractor prefer to lower the reinforcement cage assembly into the borehole in sections, he may do so provided the same lapping requirements as for assembly on the ground are followed, namely, the longitudinal reinforcement shall be lapped as shown on the drawings and the spiral reinforcement shall be doubled

over the lap zones. Spacers maintaining concrete cover shall be located immediately below and above the laps at four points spaced around the cage.

407.3.2 Concreting of Piles

In general, Item 401 of the Standard Specifications shall be followed, however, the following particular requirements shall be observed.

1) Materials

Concrete in piles shall be Class A3 concrete as prescribed in Item 401, except as otherwise indicated.

Suitable retarder, plasticizer may be added as approved by the Engineer.

The Contractor shall submit the detailed proposed additive for approval which shall be approved after laboratory trial mix results. The dosing of retarders shall ensure initial setting time of not less than five (5) hours corresponding to the ambient temperature at which the concreting is proposed to be carried out.

Maximum slump range for pile concrete is 200 mm if approved mix design contains high range water reducer.

2) Commencement of Concreting

Prior to placing any concrete:

a) Any heavy contaminated bentonite slurry which could impair the free flow of concrete from the tremie pile shall be removed. A sample of bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.20, the placing of concrete shall not proceed and the bentonite shall be modified or replaced subject to approval by the Engineer.

b) Any loose or soft material/water soil shall be removed from the bottom of the bore by methods acceptable to the Engineer.

The Contractor shall not proceed with the concreting of the pile until the Engineer gives specific permit to do so after satisfying himself of the:

- Adequacy of the Contractor's equipment, materials (including reinforcement cages) and arrangement.
- Proficiency of his personnel.
- Cleanliness of the borehole.
- Contractor shall have a suitable lighting arrangements at all times for inspecting the entire length of the shells, pipe or hole before placing the reinforcing steel or concrete.

Prior to the concreting a pile, sample of slurry shall be taken from the base of the borehole using an approved sampling device and its specific gravity shall be determined.

3) Placing of Concrete

The tremie shall be of not less than two hundred and fifty (250) mm diameter made of water-tight construction. The means of supporting the tremie shall be such as to permit the free movement of the discharge end in the concrete in the pile. The tremie pipe shall be fitted with travelling plug, which shall be placed at the top of the pipe before charging the tremie pipe with concrete as barrier between the concrete and water or bentonite

slurry, so as to prevent water or bentonite slurry entering the tube and mixing with the concrete. The tremie shall be carefully lowered into the borehole so that the end of the tube shall rest at about one hundred and fifty (150) mm above the bottom of the borehole, with reinforcement in the borehole, and the hopper end of the tremie tube shall be filled with concrete as aforesaid. It shall be slightly raised so that when the concrete reaches the bottom it flows out of the lower end of the tube, and fills the bottom of the borehole. Thereafter, the rate of withdrawal of the tremie shall be gradual so as to ensure the end of the tremie pipe is always one and half (1.5) meters below the top of the concrete in the borehole. An allowance shall be made for the top one thousand (1000) mm of concrete in borehole during concreting being unsatisfactory. When the next batch is placed in the hopper the tremie shall be slightly raised but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. This operation shall be controlled by calculating the volume of concrete required to fill one linear meter of pile and then by measuring the rate of withdrawal of the tube corresponding to the volume of the batch in the hopper. The flow shall then be retarded by lowering the tube. The depth of the concrete in borehole shall be measured at intervals to keep a constant check that the tremie pipe bottom is immersed in concrete.

Concreting in each pile shall be carried out in a continuous operation without stoppages until the pile has been completed.

If the bottom of the tremie pipe ceases to be immersed in the body of the concrete in the pile and the seal is broken, concreting shall cease immediately and such remedial measures as the Engineer may accept or direct shall be carried out. The Contractor shall take precautions to ensure that the concrete is free of voids and shall prevent the entry of water and/or collapse of soil into concrete. If any soil or other deleterious or extraneous materials fall into any pile excavation prior to or during concreting, it shall be removed immediately.

Concreting shall continue until the concrete has reached an elevation one thousand (1000) mm higher than the designated pile cut off level shown on the drawings, or as otherwise directed by the Engineer.

The concrete shall be placed in one continuous operation from tip of cut-off elevation and shall be carried out in such a manner as to avoid segregation. The method of placing the concrete and consistency (slump) shall conform to the requirements of Item 401 or to the satisfaction of the Engineer.

407.3.3 Withdrawal of Temporary Casing

If the method of construction involves partial withdrawal of temporary casing as concreting proceeds, a sufficient head concrete shall be maintained above the bottom of the temporary casing to ensure that no voids are formed within the pile and to prevent the entry of ground water and to prevent the collapse of soil into the concrete.

If such entry or collapse should occur, the temporary casing shall be re-driven before the concrete has set and all defective concrete shall be removed or the construction of the pile shall be abandoned, in which case the provision of the clause herein which refers to “Defective Piles” shall apply.

The withdrawal of the temporary casing shall be carried out before the adjacent concrete has taken its initial set. The method and timing of withdrawal must be such as to ensure that the space between the pile and the surrounding ground shall be filled with concrete.

407.3.4 Cutting of Piles

Tops of piles shall be embedded in the concrete footing as shown on the drawings. Concrete piles shall, when approved by the Engineer, be cut off at such a level that at least seventy five (75) mm of undamaged pile can be embedded in the structure above. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer. The longitudinal reinforcement of the piles shall be embedded in the structure above to a length as shown on the Drawings. The distance from the side of any

pile to the nearest edge of the footing shall not be less than twenty (20) cm. When the cut-off elevation for a cast-in-place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete construction according to Item 401, if approved by the Engineer.

407.3.5 Defective Piles

Any pile delivered with defects such as damaged during casting, placed out of its proper location, incapable or partially capable of permanently carrying the load which it is intended to carry, driven below the elevation fixed by the Drawing or by the Engineer, due to the immature setting of the concrete in the pile or due to caving/collapse of the borehole fully or partially, or due to any cause of which Engineer shall be sole judge to determine shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer:

a) The pile shall be withdrawn and replaced by a new and when necessary, by longer pile.

b) A second pile shall be cast adjacent to the defective pile.

c) The pile shall be built up as otherwise provided herein or the underside of the footing lowered to properly imbed the pile.

d) The Contractor shall undertake such additional tests/works as the Engineer may specify to provide additional foundations to supplement the defective piles and so modify the structure to be supported as to ensure that load will be transferred safely to the additional foundations of existing pile. The Contractor shall be responsible for the cost of such additional tests and/or of the extra work carried out in such modification to the structure.

   A concrete pile shall be considered defective if it has a visible crack or cracks, extending around the four sides of the pile, or any defect which, in the opinion of the Engineer affects the strength or life of the pile.

   When a new pile is cast to replace a rejected one, the Contractor, at his expense, shall enlarge the footing as deemed necessary by the Engineer.

407.3.6 Test Piles

Test piles which are shown on the Drawings or ordered by the Engineer shall conform to the requirements for piling as specified.

Test piles to be load tested in accordance with Item 407.3.7 shall be cast-in-situ at location determined by the Engineer. The test pile subject to 2.5 times of the design load shall not be utilized in the structure. The proof load tests shall however be performed on the selected working piles to a maximum load of 1.5 times the design load.

Any pile, which after serving its purpose as a test pile is found unsatisfactory for utilization in the structure, shall be removed if so ordered by the Engineer, or if approved by the Engineer it shall be cut-off below the ground line and footings, but such approval does not in any way relieve the Contractor of his responsibilities.

407.3.7 Pile Load Tests

An ultimate load test shall consist of the application of a load equal to a minimum of two and half (2.5) times the design load or as otherwise provided for herein or as directed by the Engineer. A proof load test (to be performed on two working piles) shall however, be taken to a maximum load of 1.5 times the design load of pile. Load tests shall be made where specified and/or where called for by the Engineer. Unless otherwise permitted by the Engineer, the load tests shall be completed before any working pile.

Load tests shall generally be made in line with the latest ASTM D1143 procedures or by the methods approved by the Engineer. The Contractor shall submit to the Engineer detailed plans of the loading system and apparatus he intends to use at least three weeks in advance. The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. The pressure gauge/ jack assembly and the micrometers to be used shall calibrate afresh from a laboratory approved by the Engineer. The load test shall not be started until the concrete has attained a minimum compressive strength equal to twice the anticipated compressive stress induced by the maximum load during the test. If he so elects, the Contractor may use, “subject to the approval of the Engineer” high early strength cement in the concrete of the load test pile. The test shall not be started earlier than 14 days age, to allow for development of sufficient skin frictional resistance.

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of at least three times the design load for the pile being tested. Reference points for measurement of pile settlement shall be sufficiently away from the test pile to preclude all possibility of disturbance.

All pile load settlements shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer’s level. Increments of settlement shall be read just after each load increment is applied and at close intervals thereafter. The safe load from the test shall be determined by the Engineer

The first load to be applied to the test pile shall be 25%, of the pile design load or as approved by the Engineer and the first increment shall be up to the pile design load by applying additional loads in three equal increments. A minimum period of 2 hours shall intervene between the applications of each increment; except that no increment shall be added until a settlement of less than one tenth (0.1) mm is observed for a 15-minute interval under the previously applied increment. If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by fifty (50) percent, at the direction of the Engineer, in order that a more closely controlled failure curve may be plotted. The full test load shall remain on the test pile not less than forty eight (48) hours. The full test load shall then be removed and the permanent settlement read up to 24 hours period or as approved by the Engineer.

When directed by the Engineer ultimate load tests shall be continued beyond the double design load in 10-ton increments to failure or a maximum of three times the design load.

407.3.8 Backfilling Empty Boring

When each pile has been cast, the empty bores remaining shall not be backfilled unless required by the construction procedures and activities following the completion of piling work.

407.3.9 Pile Records

The Contractor shall keep records of the piles installed. A copy of the record shall be given to the Engineer within two (2) days after each pile is cast. The record form to be used during pile construction is enclosed. The following minimum information shall form an essential part of this record.

Cast-in-Place Piles
Pile type and nominal dimensions.
Date of boring commenced, level reached each day and date of casting.
Soil samples taken from pile boring operation and soil test results.
Strata and groundwater encountered with levels, description shall be in accordance with B.S.C.P. 2001.

Length of finished pile and tip elevation.
Dia. of borehole.
Elevation of the bottom of borehole.
Date of placing concrete; theoretical and actual quantities of concrete used in pile.
Lengths and dia. of temporary casing and permanent lining and the elevation of the tip of temporary casing and of permanent lining.
Details of Reinforcement.
Details of penetration during boring operation.
Quality, consistency and other test results of concrete.
Time interval between boring and concreting. Any other relevant information.

A Performa recommended for keeping the pile construction record is attached at the end.

On completion of the piling for each structure, the Contractor shall deliver to the Engineer a drawing recording the exact location and the final depth (tip elevation) of all piles.

PILE CONSTRUCTION REPORT

GENERAL INFORMATION

PROJECT _____ JOB NO. _____ CONTRACTOR _____
LOCATION _____ PILE NO. _____ PILE DIA _____ mm
METHOD OF BORING _____

ACTIVITY	BORING	CAGE LOWERING	CONCRETING
DATE STARTED			
TIME STARTED			
DATE COMPLETED			
TIME COMPLETED			

SURVEY & LEVELS

BENCH MARK (B.M) = _____ M
BACK SIGHT (B.S) = _____ M
H.I * = (B.M + B.S.) = _____ M
FORE SIGHT (F>S) = _____ M
G.L. ** = (H.I-F.S) = _____ M
CT/RTT *** = (H.I-F.S) = _____M
PILE TIP ELEVATION (P.T.E) _____M

SOUNDING AFTER BORING _____M
SOUNDING BEFORE CAGE LOWERING _____M
SOUNDING BEFORE CONCRETING _____ M
LENGTH OF CASING _____ _M
LENGTH OF UNCASED HOLE _____M
PILE BATTER _____DEG
BORE LENGTH (G.L-P.T.E)_____M

BOREHOLE LOG

DEPTH (M) FROM	TO	DESCRIPTION OF MATERIALS
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____
4. _____	_____	_____

REINFORCEMENT DETAILS

		DIAMETER (mm)	LENGTH (M)	OVERLAP (M)	PITCH (mm)
MAIN BARS	1				
	2				
	3				
SPIRAL	1				
	2				
	3				

* HEIGHT OF INSTRUMENT
** GROUND LEVEL
*** CASING TOP/ROTARY TABLE TOP

TREMIE AND CASING INSTALLATION AND REMOVAL

TOTAL LENGTH OF BORE _____ M

SR. NO.	* LENGTH OF TREMIE PIPE (M)	REQUIRED SOUNDING OF TREMIE PIPE (M)	ACTUAL SOUNDING OF TREMIE PIPE (M)	REQUIRED SOUNDING OF CASING PIPE (M)	ACTUAL SOUNDING OF CASING PIPE (M)
10					
09					
08					
07					
06					
05					
04					
03					
02					
01					

CONCRETING

TYPE OF CEMENT _____
CONCRETE MIX RATIO_____W/C RATIO _____

NUMBER OF CYLINDERS / CUBES _____

	1	2	3	4	5	6
BATCH NO.						
SLUMP (mm)						
CYLINDER BATCH NO.						

CEMENT BAGS AVAILABLE _____
CEMENT BAGS WASTED _____
CEMENT BAGS CONSUMED _____
TYPE OF ADMIXTURE _____
DOSAGE OF ADMIXTURE _____

TOP OF CONCRETE _____M
ACTUAL PILE LENGTH _____M
NOMINAL CONCRETE VOLUME _____CM
ACTUAL CONCRETE VOLUME _____CM
OVER CONSUMPTION CONCRETE_____ %

* TO BE INSTALLED IN REVERSE ORDER

CATEGORY OF PILE (TO BE CATAGORISED BY PILING INCHARGE)	EXCELLENT	GOOD	FAIR	POOR

REMARKS (ATTACH ADDITIONAL SHEET IF REQUIRED)

SHIFT DUTIES

SR. NO.	INSPECTOR	DATE	SHIFT FROM	SHIFT TO	SIGNATURE
1.					
2.					
3.					

SIGNATURE PILING INCHARGE

ITEM 408 SHEET PILING

408.1 DESCRIPTION

This item shall consist of furnishing, driving, cutting off and removal, if required, of sheet piles in accordance with the Drawings, or as designated by the Engineer. Sheet piles for cofferdams in connection with foundations for structures shall be included in the unit price for Item 107-Structural Excavation. Sheet piling shall be a separate pay item only when stated in the Bill of Quantities.

408.2 MATERIAL REQUIREMENTS

408.2.1 Timber Sheet Piles

The timber, unless otherwise definitely noted on the Drawings or in the Special Provisions, may consist of any species, which will satisfactorily stand driving. It shall be sawn or hewn with square corners or with tongue-and-groove joint as directed by the Engineer and shall be free from holes, loose knots, wing shakes, decay or unsound portions, or other defects which might impair its strength or tightness.

408.2.2 Concrete Sheet Piles

Concrete, reinforcement, and manufacture of Concrete Sheet Piles shall conform to the Specifications governing Precast Concrete Piles under Item 407 - Piling. Joint details shall be as indicated on the Drawings.

408.2.3 Steel Sheet Piles

Steel Sheet piles shall be of the type and weight indicated on the Drawings. The steel shall conform to AASHTO M 223 or ASTM A 572. Permanent steel sheet piles shall be coated with red lead paint conforming to AASHTO M 72 as instructed by the Engineer.

408.2.4 Bracing

Bracings or anchors for sheet piles shall be made of wood or steel according to the Drawings or as designated by the Engineer.

For temporary sheet piling like cofferdams for excavations, the Contractor shall be solely responsible for the design and construction of the bracing. The Drawings shall have the approval of the Engineer, but such approval does not in any way relieve the Contractor of his responsibility.

408.3 CONSTRUCTION REQUIREMENTS

408.3.1 Installation

Timber and concrete sheet piles shall be sharpened at their lowest ends.

All sheet piles shall be driven to the elevation shown on the Drawings or as directed by the Engineer. Where it is impossible to drive to the elevation shown on the Drawings due to sub-surface conditions, the piles may be stopped at a higher elevation with the written permission of the Engineer. However, before granting such permission the Engineer shall investigate to ascertain that the Contractor has adequate equipment for the required driving and that the piles can not be driven to the elevation shown with the proper use of this equipment.

The tops of a permanent sheet piling shall be driven or cut-off to a straight line at the

elevation indicated on the Drawings.

The requirements governing the installation of sheet piling shall conform to those governing piles as set forth under Item 407.3.3 and 407.3.11.

408.3.2 Removal

Temporary sheet piling shall be removed or cut off at the stream bed or the original ground when directed by the Engineer.

In case when the Engineer orders sheet piling to be left in place for erosion protection, the Contractor and the Engineer shall agree on an equitable price.

ITEM 409 WELL FOUNDATIONS

409.1 DESCRIPTION

This item shall consist of performing all operations in connection with the construction of a well to be used as a foundation for a pier or abutment. The work shall be comprised of five separate main operations: **1)** the casting of well kerb in proper position. **2)** the erection of well steening by stages **3)** the sinking of the erected kerb and well steening to the required elevation. **4)** the proper plugging of the well, and **5)** the construction of the transom slab all in accordance with specifications, and the Drawings or as directed by the Engineer.

409.2 MATERIAL REQUIREMENTS

409.2.1 Structural Steel

Structural steel shall conform to the requirements of AASHTO M 183 (ASTM DESIGNATION: A 36 unless otherwise specified).

409.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirements under item 404 Steel Reinforcement.

409.2.3 Structural Concrete

Structural concrete shall conform to Class A concrete requirements as specified under Item 401-Concrete.

409.2.4 Brickwork

Brickwork shall conform to the requirements as specified under Item 410-Brick Masonry of these specifications.

409.2.5 Fill Sand

Fill sand shall consist of natural sand free from deleterious materials subject to the approval of the Engineer and as specified and shown on the Drawings.

409.3 CONSTRUCTION REQUIREMENTS

409.3.1 Construction Equipment

All equipment to be used in construction shall be on the Site in first class working condition and shall have been approved by the Engineer before construction is started.

The number of units, the sizes, etc., of all equipment shall be adequate to ensure completion of the work within the time specified in the Contract.

No equipment shall be removed from the Site without the written approval of the Engineer.

All equipment, tools and machinery used shall be maintained in a satisfactory working condition throughout the required period of their use.

409.3.2 Structural Steel Work

a) Notice of Rolling and Fabrication: The contractor shall give ample advance notice

to the Engineer of the beginning of the work at the mill and shop, so that inspection may be provided. No material shall be rolled or fabricated before the Engineer has been notified where the orders have been placed.

b) Facilities for Inspection: The Contractor shall furnish all facilities for the Inspection of materials and workmanship in the mill and shop, and inspector shall be allowed free access to the necessary parts of the premises.

c) Inspection of Fabricated Work at Site: The Engineer may waive shop inspection and make complete inspection of all fabricated work upon its delivery at the Site of structure. All structural steel works shall conform to the applicable ASTM requirements as shown under item 413. In case these requirements are not met, the material thus fabricated shall be rejected.

d) Handling Members: The field assembling of the component parts of the structure shall be done by the use of twisting, bending or otherwise deforming the metal. No members slightly bent or twisted shall be put in place until their defects are corrected and any members seriously damaged in handling will be rejected.

e) Finish of Structural Steel Work: The workmanship and finish shall be first class and equal to the best practice in modern bridge shops. Shearing and clipping shall be done neatly and accurately and all portion of the work exposed to view shall be neatly finished.

409.3.3 Special Construction Operations

a) Casting Well Kerbs: The cutting edge of the well kerb will be structural steel pre-fabricated and supplied in segments convenient for Site assembly by bolting together as per lines and dimensions shown on the Drawings. The segments of the cutting edge shall be interchangeable. The fitting together shall be checked at the site of fabrication work by the assembly of at least two complete cutting edges, formed of segments chosen at random before these are accepted for dispatch to the site of work. None of the steel work is to be painted and no surface preparation is called for other than the removal of the rust and loose adhering mill scale.
Reinforcing steel work in the cutting edge will be properly bolted to the steel work and placed and assembled as shown on the Drawings.
Structural concrete for the cutting edge will be of the required strength and shall be finished to the form and dimensions shown on the Drawings-

b) Well Steening: Well steening shall be made either of brick work in (1:3) cement mortar or Portland cement concrete of the required strength and of the form and dimensions as shown on the Drawings.
Reinforcing steel work will continue from the cutting edge into the well steening with spacers made of structural steel work consisting of mild steel plates of the size and dimension as shown on the Drawings. '

c) Well Sinking: Well sinking includes all operations required to sink the well in position and to the required elevation.

1) ***Positioning:*** Each well kerb shall be correctly positioned in place and approved by the Engineer before commencement of further work.

2) ***Support:*** Well kerb shall be adequately supported to prevent shift or tilt during the initial operation and on excavation and sinking whether the well has been started on made up ground or in water in excavation.

3) ***Excavation of Sinking:*** The soil from inside the well shall be removed by mechanical grabbing or by other devices as approved by the Engineer. The accuracy of the sinking will be the responsibility of the Contractor.

4) ***Dewatering:*** The Contractor will be required to pump out the water from inside

the wells in such a way as shall be approved by the Engineer; but notwithstanding any dewatering aid that the Contractor may use to assist in the operation of sinking the wells, the safety of plant and labour will remain the responsibility of the Contractor.

5) ***Limits of Tilt and Shift:*** The limit of departure from true vertical position of any well shall not exceed one unit measured horizontally in a vertical distance of sixty units.

The maximum horizontal displacement of any well away from its correct position shall not exceed twenty (20) cm.

6) ***Correcting Tilt etc:*** It will be entirely the responsibility of the Contractor to keep the tilt and shift within the specified tolerances. If the above limits are exceeded, the Contractor will be required to adopt measures to overcome the adverse affects of such shifts and tilts. In any case maximum pressure at the base of foundations after accounting for all shifts and tilts shall remain within the specified limits. The measures taken shall be allowed only after its approval has been received from the Engineer.

7) ***Kentledge:*** The use of rails and other heavy weights is permissible in well sinking and in correcting error of tilt and horizontal displacement. But the Contractor must take care not to damage the well in the process; and in any case he must obtain the approval of the Engineer for his proposed method.

8) ***Limits of Well Sinking:*** Each and every well shall be sunk to the level indicated on the Drawings. But in no case shall the Contractor stop well sinking unless he has first obtained the approval of the Engineer. ,

d) Plugging of Well: When the well has reached the final elevation to which it is to sink and has been approved by the Engineer, the bottom of the well will be plugged by the depositing concrete of the required strength.

1) ***Concrete under Water:*** The concrete deposited under water shall have ten (10) percent excess cement. To prevent segregation it shall be carefully placed in the final position by means of a dump bucket or other approved method and shall not be disturbed after being deposited. The concrete shall be placed under the supervision of the Engineer.

2) ***Continuous Placing:*** The concrete shall be placed in one continuous operation.

e) Sand Filling: When the well bottom has been plugged, the well hole will be filled with sand as specified and shown on Drawings. The sand shall be free from deleterious materials.

f) Transom Slab: When the well bottom has been plugged, the well top will be provided with a transom slab made of structural concrete of required strength, and reinforcing steel work, all according to the lines, dimensions and form shown on the Drawings.

409.4 SAMPLING AND TESTING

The Contractor will have adequate arrangements to the satisfaction of the Engineer to collect disturbed samples of soil at every one and half (1.5) meter elevation and at every change of soil strata and to deliver it in proper bags to the representative of the Engineer.

The Contractor will also be required to obtain three samples of the natural soil at the elevation at which the well kerb has been stopped and another sample three (3) meters below that elevation before he is allowed to plug the well.

ITEM 410 BRICK MASONRY

410.1 DESCRIPTION

This work shall consist of furnishing all materials, equipment and labour required for constructing brickwork as shown on the drawings and in accordance with these specifications.

410.2 MATERIAL REQUIREMENTS

410.2.1 Portland Cement

Portland cement shall conform to the requirements set forth under item 401.2.1.

410.2.2 Sand

Sand for mortar used in brickwork shall be according to AASHTO M 45.

410.2.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities. No water shall be used without the approval in writing of the Engineer.

410.2.4 Mortar

The mortar for all brickwork shall consist of one (1) part of Portland cement to three (3) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use.

410.2.5 Bricks

The size of the bricks shall be standard size (9"x4 1/2"x3") 22.86 cm x 11.43 cm x 7.62 cm. They shall be well-burnt without being vitrified. They shall be of uniform colour, regular in shape and size with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall conform to requirements of ASTM C-62.

410.3 CONSTRUCTION REQUIREMENTS

410.3.1 Mixing of Mortar

Methods and equipment used for mixing mortar shall be such that each ingredient entering into the mortar shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use. All mortar not used within thirty (30) minutes after addition of the water to the' mix shall be wasted. Retempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

410.3.2 Brick Laying

Brickwork shall not be placed during heavy or prolonged rain to wash the mortar from the bricks. Mortar already spread, diluted by rain shall be removed and replaced before

restoring the work.

All bricks to be used in brickwork with mortar joints shall be immersed in water from three (3) to four (4) hours before use.

All bricks shall be skillfully laid with level courses, uniform joints, square comers, plumb verticals and true surface, except where otherwise shown on the Drawings.

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets can be obtained and shall be spaced not more than two (2) meters center to center.

All surfaces exposed to weather, shall be struck pointed to give a good workmanlike appearance and to seal the cavities in mortar joints.

410.3.3 Curing

All brickwork shall be cured for at least seven (7) days after laying. The curing method shall be to the satisfaction of the Engineer.

ITEM 411 RANDOM AND DRESSED UNCOURSED STONE MASONRY

411.1 DESCRIPTION

The item shall consist of Random and Dressed uncoursed Stone Masonry with or without mortar. Dimensions of such masonry may vary as per drawings or as directed by the Engineer.

411.2 MATERIAL REQUIREMENTS

411.2.1 Stone

Random or dressed stone shall be of approved quality, sound and durable, free from segregation's, seams, cracks and other structural defects or imperfection tending to reduce its resistance to weather. It shall be free from rounded or weathered surfaces.

411.2.2 Mortar

Mortar for laying stone and pointing shall be composed of one part of Portland cement and four parts of sand unless otherwise shown on the drawings. Portland cement shall meet the requirements of AASHTO M-85 and sand shall meet the requirements of AASHTO M-45. Water used in preparation of mortar shall conform to the requirement set forth under item 401.2.7.

411.3 CONSTRUCTION REQUIREMENTS

411.3.1 Stone Size and Shape

Individual stones shall have a thickness of not less than twenty (20) cms and a width of at least one and a half ($1^1/_2$) times the thickness and length of atleast one and a half ($1^1/_2$) times their width.

Shape of stones may be irregular in random masonry; however for dressed uncoursed masonry, stones shall be cut in such a way that a well locked masonry can be laid. The size and shape of ring stones for arches shall be as shown on the drawings.

411.3.2 Dressing of Stones

For "A-Class" Masonry, Stones shall be dressed to exact sizes and shapes • and cut to lay on beds with top and bottom truly parallel. Hallow beds shall not be permitted. Beds of face stone shall be fine finished for a depth of not less than thirty (30) centimeters. Vertical joints of face stone shall be fine finished and full to the square for a depth of not less than twenty five (25) centimeters.

Exposed surfaces of face stone shall be according to the plans, with edges pitched to true lines and exact batter, chisel drafts-four (4) centimeters wide shall be cut at all exterior corners.

Stones for B-Class Stone Masonry shall be roughly squared on joints, beds and faces. Selected stones, roughly squared pitch to line shall be used at all angles and ends of wall.

411.3.3 Stretchers

Stretcher shall have a width of bed not less than one and a half ($1^1/_2$) times their thickness, and length of bed not less than twice nor more than three and a half ($3^1/_2$) times their thickness but in no case less than ninety centimeters. Stone masonry in

cement mortar shall be cured for at least seven (7) days.

411.3.4 Headers

Header, placed in each course, shall have width not less than one and a half ($1^1/_2$) times their thickness. In walls having thickness of 1.2 meters or less, the headers shall extend entirely through the wall. In walls of greater thickness, the length of headers shall be not less than two and a half ($2^1/_2$) times their thickness when the course is forty five (45) centimeters or less in height, and not less than 1.2 meters in courses of greater height. Header shall bond with the core or backing not less than thirty (30) centimeters. Header shall hold in the heart of the wall spaced not further a part than 2.5 meters center to center. There shall be atleast one header to every two stretchers.

411.3.5 Cures and Backing

Core and backing shall consist either of roughly bedded and jointed headers and stretchers, as specified above or concrete as may be specified. When stone is used for cores of backing, at least one-half (1/2) of the stone shall be of the same size and character as the face stone and with parallel ends. No course shall be less than twenty (20) centimeters thick. Concrete used for cores and backing shall conform to the requirements specified in Item 401. The headers and stretchers in walls, having a thickness of one meter or less shall have a width or length equal to the full thickness of the wall. No backing will be allowed.

411.3.6 Living Stone

It shall conform to the requirement as specified in Item 412.2.9.

411.3.7 Arches

Refer to Item No. 412.2.14.

ITEM 412 DRESSED COURSED STONE MASONRY

412.1 DESCRIPTION

This item shall consist of dressed coursed stone masonry with mortar. Dimensions of such masonry may vary as per drawings or as directed by the Engineer.

412.2 MATERIAL REQUIREMENTS

412.2.1 Stone Size

The individual stones shall be large and well proportioned. They shall not be less than twenty (20) nor more than fifty (50) cms in thickness. The thickness of courses, if varied, shall diminish regularly from bottom to top of wall. The size of ring stones in arches shall be as shown on the plans.

412.2.2 Mortar

Mortar shall conform to the requirement set forth under Item 411.2.2.

412.3 CONSTRUCTION REQUIREMENT

412.3.1 Surface Finishes of Stone

For the purpose of this specification the surface finishes of stone are defined as follows:

Smooth-finished: Having a surface in which the variations from the pitch line do not 1 exceed 0.15 cm.

Rough-finished: Having a surface in which the variations from the pitch line do not exceed 1.25 cm.

Scrabbled: Having a surface in which the variations from the pitch line do not exceed two (2) cm.

Rock-faced: Having an irregular projecting face without indication of tool marks. The projections beyond the pitch line shall not exceed seven and half (7.5) cm and no part of the face shall recede back of the pitch line.

412.3.2 Dressing Stone

Stones shall be dressed to exact sizes and shapes before being laid and shall be cut to lie on their natural beds with top and bottom truly parallel. Hollow beds will not be permitted. The bottom bed shall be the full size of the stone and no stone shall have an overhanging top. In rock-face construction the face side of any stone shall not present an undercut contour adjacent to its bottom axis giving a top-heavy, unstable appearance when laid.

Beds of face stone shall be fine-finished for a depth of not less than thirty (30) cm.

Vertical joints of face stone shall be fine-finished and full to the square for a depth of not less than fifteen (15) cm.

Exposed surfaces of the face stone shall be given the surface finish indicated on the plans, with edges pitched to true lines and exact batter, Chisel drafts four (4) cm wide shall be cut at all exterior corners. Face stone forming the starling or nosing of piers shall be rough-finished unless otherwise specified.

Holes for stone hooks shall not be permitted to show in exposed surfaces.

412.3.3 Stretchers

Stretchers shall have a width of bed of not less than one and a half ($1^1/_2$) times their thickness. They shall have a length of bed not less than twice nor more than three and half ($3^1/_2$) times their thickness, and not less than ninety (90) cm.

412.3.4 Headers

Headers shall be placed in each course and shall have a width of not less than one and half ($1^1/_2$) times their thickness. In walls having a thickness of 1.2 meters or less, the headers shall extend entirely through the wall. In walls of greater thickness, the length of headers shall be not less than two and half ($2^1/_2$) times their thickness when the course is forty five (45) cm. or less in height, and not less than 1.2 meters in courses of greater height. Headers shall bond with the core or backing not less than thirty (30) cm. Headers shall hold in the heart of the wall the same size shown in the face and shall be spaced not further apart than 2.5 meters center to center. There shall be at least one header to every two stretchers.

412.3.5 Cores and Backing

Cores and backing shall consist either of roughly bedded and jointed headers and stretchers, as specified above, or concrete, as may be specified.

When stone is used for cores of backing, at least one-half (1/2) of the stone shall be of the same size and character as the face stone, and with parallel ends. No course shall be less than twenty (20) cm. thick.

Concrete used for cores and backing shall conform to the requirements specified in Item 401.

The headers and stretchers in walls having a thickness of one meter or less shall have a width or length equal to the full thickness of the wall. No backing will be allowed.

412.3.6 Mixing Mortar

The mortar shall be hand or machine mixed, as may be required by the Engineer. In the preparation of hand-mixed mortar, the sand and cement shall be thoroughly mixed together in a clean, tight mortar box until the mixture is of uniform colour, after which clean water shall be added in such quantity as to form a stiff plastic mass. Machine-mixed mortar shall be prepared in an approved mixer and shall be mixed not less than one and half ($1^1/_2$) minutes. Mortar shall be used within forty five (45) minutes after mixing. Retempering of mortar will not be permitted.

412.3.7 Laying Stone

a) General

Stone masonry shall not be constructed in freezing weather or when the stone contains frost, except by written permission of the Engineer and subject to such conditions as he may require. Stone Masonry in Cement mortar shall be cured for a minimum period of seven (7) days.

b) Face Stone

Stone shall not be dropped upon, or slid over the wall, nor will hammering, rolling, or turning of stones on the wall be allowed. They shall be carefully set without jarring the stone already laid and they shall be handled with a Lewis or other appliance that will not cause disfigurement.

Each stone shall be cleaned and thoroughly saturated with water before being set and the bed, which is to receive it, shall be cleaned and well moistened. All stones shall be well bedded in freshly made mortar and settled in place with a suitable wooden maul before the setting of the mortar. Whenever possible, the face joints which can not be so pointed shall be prepared for pointing by raking them out to a depth of five (5) cm. before the mortar has set. The face surfaces of stones shall not be smeared with the mortar forced out of the joints or that used in pointing. No pinning up of stones with spawls will be permitted in beds.

Joints and beds shall be neither less than one (1) cm. nor more than one and quarter ($1^1/_4$) cm. in thickness and the thickness of the joint or bed shall be uniform throughout.

The stone in any one course shall be placed so as to form bonds of not less than thirty (30) cm. with the stones of adjoining courses. Headers shall be placed over stretchers and, in general, the headers of each course shall equally divide the spaces between the headers of adjoining courses, but no headers shall be placed over a joint and no joint shall be made over a header.

c) Stone Backing and Cores

Stone backing shall be laid in the same manner as specified above for face stone, with headers interlocking with face headers when the thickness of the wall will permit. Backing shall be laid to break joints with the face stone. Stone cores shall be laid in full mortar beds so as to bond not less than thirty (30) cm. with face and backing stone and with each other. Bed joints in cores and backing shall not exceed 4.5 cm. and vertical joints shall not exceed ten (10) cm. in thickness.

d) Concrete Cores and Backing

The operations involved in the handling and placing of concrete used in cores and backing shall conform to the requirements specified in Item 401. However, the puddling and compacting of concrete adjacent to the ashlars masonry facing shall be done in a manner that will ensure the filling of all spaces around the stones and secure full contact and efficient bond with all stone surfaces.

412.3.8 Leveling Courses

Stone cores and backing shall be carried up to the approximate level of the face course before the succeeding course is started.

The construction joints produced in concrete cores or backing by the intermittent placing of concrete shall be located, in general, not less than fifteen (15) centimeters below the top bed of any course of masonry.

412.3.9 Resetting

In case any stone is moved or the joint broken, the stone shall be taken up, the mortar thoroughly cleaned from bed and joints, and the stone reset in fresh mortar.

412.3.10 Dowels and Cramps

Where required, coping stone, stone in the wings of abutments, and stone in piers shall be secured with wrought-iron cramps or dowels as indicated on the plans.

Dowel holes shall be drilled through each stone before the stone is placed and, after it is in place, such dowel holes shall be extended by drilling into the underlying course not less than fifteen (15) cm.

Cramps shall- be of the shapes and dimensions shown on the plans or approved by the Engineer. They shall be inset in the stone so as to be flush with the surfaces.

Cramps and dowels shall be set in lead, care being taken to completely fill the surrounding spaces with the molten metal.

412.3.11 Copings

Stones for copings of wall, pier, and abutment bridge seats shall be carefully selected and fully dimensioned stones. On piers, not more than two stones shall be used to make up the entire width of coping. The copings of abutment bridge seats shall be of sufficient width to extend at least ten (10) cm. under the back-wall. Each step forming the coping of wingwall shall be formed by a single stone, which shall overlap the stone forming the step immediately below it at least thirty (30) cm.

Tops of copings shall be given a bevel cut at least five (5) cm. wide, and beds, bevel cuts, and tops shall be fine-finished. The vertical joints shall be smooth-finished and the coping shall be laid with joints not more than 0.6 cm in thickness. The undersides of projecting copings, preferably, shall have a drip bead.

Joints in copings shall be located so as to provide not less than a thirty (30) cm. bond with the stones of the under course and so that no joint will come directly under the superstructure masonry plates.

412.3.12 Arches

The number of courses and the depth of voussoirs shall be as shown on the plans. Voussoirs shall be placed in the order indicated, shall be full size throughout, dressed true to template, and shall have bond not less than the thickness of the stone. Beds and joints shall be fine-finished and mortar joints shall not exceed two (2) cm. in thickness. Exposed surfaces of the intrados and arch ring shall be given the surface finish indicated on the plans.

Backing may consist of concrete as specified or of large stones shaped to fit the arch, bonded to the spandrels, and laid in full beds of mortar. The extrados and interior faces of the spandrel walls shall be given a finishing coat of one ratio three (1:3) cement sand mortar which shall be trawled smooth to receive the waterproofing.

Arch centering, waterproofing, drainage, and filling shall be as specified for concrete arches.

412.3.13 Pointing

Pointing shall neither be done in freezing weather nor when the stone contains frost.

Joints not pointed at the time the stone is laid shall be thoroughly wet with clean water and filled with mortar after proper raking. The mortar shall be well driven into the joints and finished with an approved pointing tool. The wall shall be kept wet while pointing is being done and in hot or dry weather the pointed masonry shall be protected from the sun and kept wet for a period of at least 3 days after completion.

After the pointing is completed and the mortar set, the wall shall be thoroughly cleaned and left in a neat and workmanlike condition.

ITEM 413 STEEL STRUCTURES

413.1 DESCRIPTION

413.1.1 General

This work shall consist of steel structures and the steel structure portions of composite structures, constructed in conformity with the lines, grades and dimensions shown on the drawings or as established by the Engineer.

The work will include all labour, materials and equipment required to furnish, fabricate, erect and paint structural metals called for in these Specifications or as shown on the plans. Structural metals will include rivet, welding, special and alloy steels, metallic electrodes, steel forging, and castings, and iron castings. This work will also include any incidental metal construction not otherwise provided for, all in accordance with these specifications, Drawings or as directed by the Engineer.

413.1.2 Drawings

The Contractor shall submit to the Engineer working Drawings for steel structures for approval prior to use in construction. Such working Drawings shall be submitted sufficiently in advance of the start of the related work to allow time for review by the Engineer and correction by the Contractor of the Drawings without delaying the work. Such time shall be proportional to the complexity of the work, but in no case shall such time be less than six (6) weeks.

The working Drawings shall show details of any permitted options proposed in the work, details for connections not dimensioned on the plans, the direction of rolling the plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout Drawing of the entire structure, the location of any temporary supports that are to be used and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations shall be submitted with the working Drawings.

413.1.3 Inspection

Structural steel will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least ten (10) days notice before commencing the fabrication of any structural steel.

The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports and a Certificate of Compliance for all structural steel to be used in the work other than steel which is to be used under the provisions in Item 413.2.6, "Unidentified Stock Material". Certified mill test reports for steels with specific impact values shall include, in addition to other, test results, the results of Charpy V-notch impact tests. When fine grain steel is specified, the test report shall include the grain size. Copies of mill orders shall be furnished at the time, orders are placed with the manufacturer. Certified mill test reports and Certificates of Compliance shall be furnished prior to start of fabrication of material covered by these reports. The Certificates of Compliance shall be signed by the manufacturer and shall certify to the Engineer the specifications to which the material has been manufactured and tested, and that the material is in conformance with said specifications and test requirements.

Material to be used shall be made available to the Engineer so that the each piece can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where said material is stored or where work on said material is being performed.

413.1.4 Shipping. Handling and Storing Materials

Members weighing more than two and one half (2.5) metric tons shall have the weight marked thereon.

In handling and shipping of the steel work, every care shall be taken to avoid bending, scraping, or overstressing the pieces. All pieces bent or otherwise injured will be rejected.

The loading, transporting, and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above the ground upon platforms, skids, or other supports, and shall be kept free from dirt, grease, and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

413.1.5 Falsework

Falsework used for the erection of structural steel shall conform to the provisions in Item 402, "Falsework and Centering for Bridges", except that dead loads shall consist of the weight of the structural steel and any other portions of the structures which are supported by the falsework.

Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within fifteen (15) cms. of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girders.

Loads imposed on existing, new or partially completed structures by the Contractor's construction methods and equipment shall not exceed the load carrying capacity of the structure, or portions thereof, as determined by the Pakistan Code of Practice for Highway Bridges, 1967 or as specified by the Engineer.

413.1.6 Continuous Members

Unless otherwise noted on the plans, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may at his option erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this Item.

If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be pre-assembled in a no-load condition in a horizontal or an upright positions.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with calculations, in sufficient detail to substantiate that girder capacity and geometry will be correct.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall, after erection, have a load carrying capacity at least equal to the designed structure shown on the plans. The Contractor may increase the cross-sectional area or change the steel grades to provide the specified load carrying capacity subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be made for the convenience of the Contractor and no additional payment will be made therefore.

413.2 MATERIAL REQUIREMENTS

413.2.1 Description

The various materials shall conform to the specifications of ASTM as listed in the following tabulation with certain modifications and additions as specified.

Material	ASTM Designation
Structural Steel.....	A 36
High strength low alloy structural manganese vanadium steel..... ...	A 441
High strength low alloy columbium vanadium steel.....	A 572, Grade 50
High-yield strength quenched and tempered alloy steel plate suitable for welding.....	A 514
High strength steel bolts, studs, and threaded rods for general applications.....	A 449
High strength structural steel bolts, nuts and washers.....	A 325
High strength low alloy structural steel.....	A 588
Bolts and nuts.....	A 307
Carbon steel for forging, pins and rollers.....	A 668, Class G
Alloy steel for forging.....	A 668, Class G
Pin nuts.....	A 36
Carbon-steel castings.....	A 27, Grade 65-35
Gray iron castings.....	A48, Class 30B
Malleable iron castings.....	A 47, Grade 32510
Carbon steel structural tubing.....	A 500, Grade B or A
	501
Steel pile (Hydrostatic testing will not apply).....	A 53, Type E or S
Grade B; A 106	
Grade B; or A 139,	
Grade B	
Stud Connectors.....	A 108, grades 1010
Through 1020 either semi- or fully skilled.	

Structural steel designed on the plans as high strength low alloy structural steel shall conform to the following:

Thickness	Materials - ASTM Designation
0 to 2 cms	A 441; A 572, Grade 50; A 588
2 to 5 cms	A 572, Grade 50; A 588
5 to 10 cms	A 588

All structural steel conforming to ASTM Designations: A 36, A 441 and A 572 shall be other than rimmed or capped steel.

Coiled steel plate shall not be used for the fabrication of flanges, eyebars and hanger plates nor for flanges and eyebars.

All structural steel precut prior to arrival at the fabrication site shall be cut so that the plate orientation complies with the requirements of Item 413.3.3, "Orientation of Plates".

All structural steel plate used for the fabrication of tension flanges, eyebars and hanger plates and for splice plates of tension flanges and eyebars shall meet the longitudinal Charpy V-

notch impact value requirements specified herein. Sampling procedures shall conform to the provisions in ASTM Designation; A 673. The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM Designations: A 36, A 441, A 572 and A 588. The P (Piece) frequency of testing shall be used for structural steel conforming to ASTM Designation: A 514. Charpy V-notch impact values shall be determined in accordance with ASTM Designation: E 23.

Charpy V-notch (CVN) impact values shall conform to the following minimum values: (Note: all metric values in this test are rounded to closest decimal).

Material	**Impact Value Ft. Lbs. at Temp. (Kg-m at Temp.)**
A36.....	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 441.....	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 572*	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 588* 2" and under in thickness ..... (50.8 mm & under in thickness).....	15 at 40 deg. F. (2.07 at 4.45 deg. C)
A 588* Over 2" to 4" in thickness ..... (Over 50,8 mm to 101.6 mm in thickness) …….	20 at 40 deg. F. (2.77 at 4.45 deg. C)
A514 • 2.1/2 & under in thickness ……..... (63.5 mm & under in thickness) …….…....	25 at 0 deg. F. (3.46 at-17.8 deg. C)
A514 Over 2.1/2" to 4" in thickness ..... (Over 63.5 mm to 101.6 mm in thickness) …….	35 at 0 deg. F. (4.84 at-17.8 deg. C)

*If the yield point of the material exceeds 65.000 psi (4569.5 Kg/Sq.cm), the temperature for the CVN impact value for acceptability shall be reduced to 15 deg. F. (-9.45 deg. C) for each increment of 10,000 psi (703 Kg/Sq.cm) above 65,000 psi (4569.5 Kg/Sq.cm).

Stud connector's shall be produced by cold heading, cold rolling or cold machining. Finished stud connectors shall be of uniform quality and free of injurious laps, fins, seams, crocks, twists, bends or other defects. Studs shall not have cracks or bursts deeper than one half (1/2) the thickness from the periphery of the head to the shaft. Tensile strength of stud connectors shall be determined by test of bar stock after drawing or of full diameter finished studs at the option of the Contractor, Strength requirements shall conform to the following:

Tensile Strength	**Elongation**	**Reduction of Area (Min.)**
(Min.) 60,000 psi (4218 Kg/Sq.cm)	(Min.) 20% in 2 inches (50.8 mm)	50%

Stud connectors shall be furnished with arc shields (ferrules) of heat-resistant ceramic or other suitable material for welding.

413.2.2 Structural Steel

Unless otherwise specified or shown on the plans, all structural steel plates, shapes and bars shall conform to ASTM Designation: A 36.

At the option of the Contractor, girder flange plates shown on the plans may be increased in thickness, and may be increased in length provided that the change does not involve a decrease in detailed thickness of any portion of said plates. For continuous girders, increases in length of girder flange plates, which involve changes in locations of butt welds between different thicknesses of flange plates, shall be approved in writing by the Engineer prior to fabrication.

When stud type shear connectors longer than twenty (20) cms. are to be used, they may consist of two (2) or more shorter studs of the type shown on the plans connected together with full penetration welds.

Rolled shapes may be substituted for the welded sections, and welded sections may be substituted for the rolled shapes shown on the plans, provided that the shapes and sections to be substituted comply with the following provisions:

a) The depth, width and average thickness shall be at least equal to those for the shape or section shown on the plans.
b) For welded sections, the flanges shall be welded to the web with continuous fillet welds on each side of the web. All welding shall conform to the provisions in Item 413.2.7, "Welding".
c) The strength classification of the material shall not be reduced.

413.2.3 Castings

Steel, gray iron, and malleable iron castings shall be provided with adequate continuous fillets cast in place in all re-entrant angles. The radius of curvature of the exposed surface of a fillet shall define the size of the fillet. The size of fillets shall not be less than one-half (1/2) of the thickness of the thinnest adjoined member nor less than one and one quarter (1.25) cms.

The dimensions of the finished casting shall not be less than the specified. Castings shall not be more than seven and half (7.5) percent overweight. Large castings shall be suspended and hammered over their entire area. No cracks, flaws or other defects shall appear after such hammering.

413.2.4 Bearing Pads

a) Metal Bearing Devices

Unless otherwise directed by the Engineer, the materials for metal bearing shall conform to the following requirements:

AASHTO M 107 for bronze bearings.
AASHTO M 108 for rolled copper alloy bearings.
ASTM B 438 for sintered metal power bearings.
AASHTO M 160 for galvanized steel bearings.

b) Preformed Fabric Pads

The preformed fabric pads shall be composed of multiple layers of two hundred and seventy (270) gms/SM (8-ounce) cotton duck impregnated and bound with high-quality natural rubber, or of equivalent suitable materials compressed into resilient pads of uniform thickness. The number of ply shall be such as to produce the specified thickness, after compression and vulcanizing. The finished pads shall with-stand compression loads perpendicular to the plane of the laminations of not less than seven hundred (700) Kg/sq.cm without detrimental reduction in thickness or extrusion.

c) Electrometric Bearing Pads

Elastomeric bearing pads shall conform to the requirements in Item 406.2.5, "Elastomeric Bearing Pads".

413.2.5 Asbestos Sheet Packing (Concrete Joints)

Asbestos sheet packing shall be approximately fifteen (15) mm thick unless otherwise shown on the plans, and shall be composed essentially of compressed white chrysotile asbestos fibres bound together with a synthetic rubber binder and fillers.

The deformation of the sheet packing under a load of three hundred and fifty (350) Kg/sq.cm shall be not more than fifteen (15) percent. When tested between planed steel plates under a load of fifty five (55) Kg/sq.cm, the sheet packing shall show a static coefficient of friction less than 0.4 after 1.00-1.25 cm. movements.

Where asbestos sheet packing is shown on the plans to be placed in joints in the concrete, the bottom layer of the packing shall be firmly attached to the concrete using water-proof cement.

413.2.6 Unidentified Stock Material

Unidentified stock material, consisting of material which cannot be identified with certified mill test reports, may be used subject to the requirements in this item.

When unidentified stock material is proposed for use the Engineer may, at his discretion, select random test specimens from each piece. The number of such test specimens shall be entirely at the discretion of the Engineer. Test specimens shall be cut and machined in accordance with ASTM requirements. Test specimens from unidentified stock material, including those required for retest, shall be furnished, machined and got tested by the Contractor from approved laboratory at his expense.

Fabrication shall not be commenced until the materials involved have been approved by the Engineer.

Not more than fourteen (14) metric tons of unidentified stock material may be used on one contract.

Unidentified stock material shall be segregated from all other materials to be used in the work.

413.2.7 Welding

Welding materials, welding, welder qualification, and inspection of welding shall conform to the requirements of the American Welding Society Structural Welding Code or other accepted codes as shown on the plans or as approved by the Engineer. Correction of weld faults shall be carried out in the presence of the Engineer.

413.2.8 Galvanizing

When galvanizing is shown on the Drawings, such galvanizing of products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips three (3) mm thick or thicker, shall conform to the specifications of AASHTO M 111 (ASTM A 123), except that complete seal welding of tightly contacting surfaces of such products prior to galvanizing is required only where seal welding is shown on the plans. Except for pre-galvanized standard pipe, galvanizing of material three (3) mm thick or thicker shall be performed after fabrication into the largest practical sections.

Galvanizing will not be required for stainless steel, mono metal and similar corrosion resistant parts.

All welded areas shall be thoroughly cleaned prior to galvanizing to remove all slag and other material that would interfere with the adherence of the zinc. When it is necessary to

straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating.

Components of bolted assemblies shall be galvanized separately before assembly. Galvanizing of tapped holes will not be required. Galvanized surfaces, which are specified to be painted, shall not be chemically treated after galvanizing and prior to cleaning and painting.

413.2.9 Cleaning

All steel works shall be blast cleaned after fabrication in accordance with the Drawings and to the satisfaction of the Engineer. Steel work which is to be in contact with concrete shall be, after fabrication, wire brushed and cleaned to remove all loose rust, dirt and grease.

413.2.10 Painting

a) Shop Coat (Prime Coat)

The shop or prime paint coat for metal structures including edges, nuts, bolts, etc. shall be a factory mixed red lead Ready-Mixed Paint, AASHTO M-72.

Red lead pigment in the dry form or as a paste in oil shall conform to ASTM D 83. The ninety seven (97) % grade shall be specified for dry pigment.

b) First Field Coat (2nd prime Coat)

The first field coat shall be red lead paint as specified for the shop coat, tinted light brown as required with lamp black in an amount not to exceed 30 gms. per litre of linseed oil.

c) Second Field Coat (Finish Coat)

The paint to be used for the second field coat shall be field mixed and conform, unless specified otherwise on the Drawings, to one of the following AASHTO Specifications:

Foliage Green Bridges Paint	M 67
Black Bridge Paint	M 68
Aluminum Paint (Paste-Mixing Vehicle)	M 69
White and Tinted Ready-Mixed Paint (Lead and Zinc Base)	M 70
Red Lead (Dry and Paste-in Oil)	M 71
Red Lead Ready-mixed Paint (Tinted with Lamp black as directed by the Engineer)	M 72

d) Number of Coats and Colour

Steel shall be painted with one shop or prime coat and with not less than two field coats. The colour shall be as specified or determined by the Engineer. Coats shall be different in colour to permit detection of incomplete application.

e) Weather Conditions

Paint shall not be applied when the steel is damp, the air is misty, or when in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

f) Application

Painting shall be done in a neat manner and may be applied with hand brushes or by spraying (without the addition of a thinner). Aluminum paint shall preferably be applied by spraying. By either method the coating applied shall be smoothly and uniformly spread so that no excess paint will collect at any point.

g) Inaccessible Surfaces

All surfaces which will" be inaccessible after fabrication or erection, with the exception of contact surfaces shall prior to assembly receive the full protective treatment specified for the component of the structure including any additional priming coat and finishing coats, which for accessible surfaces would be applied subsequent to erection.

h) Inspection of Cleaning and Painting

The cleaning and painting of all structural steel parts shall be subject to detailed inspection and approval of the Engineer. Contractor shall be responsible for all defects or faults and the correction thereof at his own expense during fabrication, erection or subsequently discovered before or during the Period of Maintenance.

413.3 CONSTRUCTION AND FABRICATION REQUIREMENTS

413.3.1 General

The Contractor shall submit as soon as possible to the Engineer for his prior approval, full details of their proposed fabrication and erection procedures together with details and calculations of any temporary works which the Contractor proposes to install for the purposes of erection of the structural steel work. Workmanship and finish shall be equal to the best general practice in modern bridge shops.

413.3.2 Straightening Material

Rolled material before being laid out or worked shall be straight. Subassemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer. Details for methods proposed for straightening shall be submitted in writing to the Engineer prior to their use. After straightening, evidence of fracture or other damage will be cause for rejection of the material.

413.3.3 Orientation of Plates

Steel plates for flanges, eyebars, hangar plates, and splice plates for flanges and eyebars shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile or compressive stress in the member.

413.3.4 Cutting with Torch

Torch cutting shall conform to the requirements for preparation of material to the American Welding Society's Structural Welding Code or equivalent.

413.3.5 Facing and Bearing Surfaces

Surface of bearing and base plates and other metal bearing surfaces that are to come into contact with each other or with ground concrete surfaces or with asbestos sheet packing shall be flat to within three tenths (0.3) cm. and to within one and six tenths (1.6) mm tolerance overall. Surface of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric bearing pads or Portland cement mortar shall be flat to within three (3) mm tolerance in thirty (30) cm and to within five (5) mm tolerance overall.

Steel slabs where not in contact with other metal bearing surfaces may be hot-straightened in lieu of machining at the option of the Contractor, provided the above tolerances are met.

413.3.6 Fit of Stiffeners

Girder stiffeners designated on the Drawings as bearing stiffeners shall be welded in accordance with details shown on the Drawings. Where the end of a stiffener is shown as Tight-fit" on the plans, the end of the plate shall be so fitted that it bears on the girder flange

with at least point bearing. Local clearances between the end of the stiffener and the girder flange shall not exceed one and six tenths (1.6) mm. Except where stiffeners are cut back, local clearances between the end of the stiffener and the girder flange which are too great to be sealed by the paint, film shall be caulked prior to painting.

413.3.7 Bent Plates

Cold-bent load-carrying rolled steel plates shall conform to the following:

a) They shall be so taken from the stock plates that the direction of bending will be at right angles to the direction of rolling.

b) The radius of bend, measured from the concave face of the metal shall be as specified in the Manual of Steel Construction published by the AISC or equivalent.

c) Before bending, the corners of the plate shall be rounded to radius one and five tenths (1.5) mm throughout that portion of the plate at which the bending is to occur. If a shorter radius is essential, the plates shall be bent hot.

413.3.8 End Connection Angles

Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detailed Drawings.

413.3.9 Finished Members

Finished members shall be true to line and free from twists, bends and open joints.

413.3.10 Screw Threads

Screw threads shall make close fits in the nuts and shall be American Standard Form, except that for pin ends of diameters greater than 3.81 cm (1.1/2 inches) they shall be made with six (6) threads to 2.54 cms (1 inch).

413.3.11 Match - Marking

Connecting parts pre-assembled for the purpose of setting up for welding or for drilling or reaming holes for field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

413.3.12 Finish

Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately. All sharp corners and edges, and edges that are marred, cut or roughened in handling or erection shall be slightly rounded by grinding or other suitable means.

413.3.13 Bolted Connections

Bolted connections unless otherwise shown on the Drawings shall be made with high-strength steel bolts conforming to ASTM Designation A 325. All bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

Bolts may be tightened to the required tension by use of a calibrated manual torque wrench, the turn-of-nut method, or by tightening and using direct tension indicators. The torque value or the direct tension indicator gap needed to develop the bolt tension will be determined by the Engineer. Checking of bolt tension shall be done by the Contractor in the presence of the Engineer and in such a manner that the Engineer can read the torque wrench gauge or direct tension indicator during checking.

Nuts shall be located, wherever practicable, on the side of the member, which will not be visible from the traveled way. Nuts or bolts that will be partially embedded in concrete shall

be located on the side of the member that will be encased in concrete.

413.3.14 Bolt Holes

Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed.

Attention is diverted to the provisions in Item 413.3.17, "Assembly", and details shown on the Drawings for connections where drilling or reaming is required after the joint is assembled.

The finished holes shall be cylindrical, perpendicular to the plane of the connection and shall not be more than one and half (1.5) mm larger than the nominal diameter of the bolt. Holes shall be clean cut, without torn or ragged edges. All burns, fins, sharp edges and hole irregularities which would prevent solid seating of the parts shall be removed.

All holes punched full size, sub-punched, or sub-drilled shall be located with sufficient accuracy so that after assembling (before any reaming is done) a cylindrical pin three (3.0) mm smaller in diameter than the nominal size of the punched, sub-punched, or sub-drilled hole may be passed through the hole without drifting in at least seventy five (75) percent of the holes for each connection. All holes shall pass a pin four and a half (4.5) mm smaller in diameter than the nominal size of the hole.

Mis-punched or mis-drilled holes shall not be corrected by welding unless approved by the Engineer.

Punching, drilling and reaming shall conform to the following:

a) Punching

Punching or sub-punching of structural steel conforming to ASTM Designation A 26 where the material is thicker than two and a quarter (2.25) cm. will not be permitted. Punching or sub punching of high-strength structural steel where the material is thicker than two (2.0) cm. will not be permitted.

Holes sub-punched for reaming shall be sub-punched decimal six five (0.65) cm less in diameter than that of the finished hole.

b) Drilling

Drilling full size shall be done with the parts assembled on to a steel template with hardened bushings or may be performed with gang drill equipment if approved by the Engineer. The Engineer may require a proof assembly to check the fit of major field connections.

Where bolt holes are sub-drilled for reaming, they shall be sub-drilled decimal six five (0.65) cm less in diameter than that of the finished hole.

Drilling through templates shall be performed only after the templates have been accurately placed and firmly clamped or bolted.

If members are drilled while assembled, the parts shall be held securely together while drilling is being done.

Stock drilling of plate parts with precision gang drills will be permitted if all parts are firmly clamed during drilling and if the drill bits remain perpendicular to the work during drilling operations.

c) Reaming

Reaming shall be done after the pieces forming a built-up member are assembled and are firmly bolted together so that the surfaces are in close contact or after templates are securely located over the member. The pieces shall be taken apart before bolting, if necessary, and shavings removed. If it is necessary to take the members apart for

shipping or handling, the pieces reamed together shall be so marked in order that they may be reassembled in the same position. Reamed parts shall not be interchanged.

Reaming templates shall have hardened steel bushings and holes accurately dimensioned. Templates shall have reference lines, which will permit accurate location of the template on the member or members to be reamed. Templates used for reaming shall be properly located on the material and shall be firmly clamped or bolted in position. Templates used for the reaming of matching members, or the opposite faces of one member, shall be exact duplicates.

Holes through assembled material that are to be reamed shall not consist of both sub-punched or sub-drilled holes and holes punched or drilled full size.

413.3.15 Pin Connections

Pins shall be accurately turned to the dimensions shown on the plans and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finished cut.

Pins and rollers shall be forged and heat-treated in accordance with the designation shown on the plans.

If pins are larger than twenty three (23) cms. in diameter, a hole not less than four decimal seven, five (4.75) cms. in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

Holes for pins shall be bored true to the specified diameter, smooth and straight, at right angels to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

Machined surfaces for pins and holes shall be coated with a rust inhibitor that can be easily removed.

The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that shown on the plans by more than decimal eight (0.8) mm.

The diameter of the holes for pins shall not exceed that of the pins by more than half (0.5) mm for pins thirteen (13) cm. or less in diameter, or decimal eight (0.8) mm. for larger pins.

Holes for pins in built-up members shall be bored after assembly of the member, or may be bored prior to assembly, provided procedures approved in advance by the Engineer are followed which result in such holes being positioned to the same degree of accuracy as would be obtained if the holes were bored after assembly.

Pin-connected hangar plates shall be bored in pairs or in stacks firmly bolted or clamped together so that each pair of hangar plates is matched. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin nuts on pin connections shall be tightened and the threads burred at the face of the nuts with a pointed tool. .

413.3.16 Anchor Bolts

No anchor bolts shall be cast in the concrete.

Anchor bolts shall be set in round holes drilled or cast in the masonry. The size and length of bolts shall be as indicated on the Plans.

Bolts shall be accurately positioned by means of templates set to correct location and alignment so as to ensure proper span lengths, and tops of bolts shall be carefully set to proper elevation. Unless otherwise noted, bolts shall be installed plumb or normal to the finished bearing surface of the masonry.

When anchor bolt holes are drilled, a template shall be used to locate the bolts accurately and permit reinforcing steel bars to be shifted clear of holes before pouring concrete to prevent cutting these bars during drilling. The drilling shall be done prior to the erection of structural steel.

Bolts set in holes drilled or cast in the masonry shall have the portion below the bridge seat swedged, and the drilled or cast holes shall have a diameter at least one 1 inch (25 mm) in excess of the diameter of the bolt.

Anchor bolts for steel stringers for all bridges (weathering steel and/or painted steel) shall be A-36 galvanized steel and shall not be painted. The nuts and washers used on anchor bolts shall also be galvanized and shall not be painted.

Holes cast in the masonry for swedged bolts shall be formed with removable round sleeves sealed at their lower ends, and they shall be completely removed after the hole is cast. During cold weather, effective methods shall be used to prevent the freezing of water in anchor bolt holes.

After anchor bolts are finally and correctly positioned, the holes around them shall be completely filled. No grouting of anchor bolts will be permitted until all structural steel is set in its final position. After the masonry plates or shoes are set, the space between the bolts and the round holes through fixed plates or shoes shall also be filled with the same material. Slotted holes in expansion devices shall remain unfilled to allow free movement.

Mortar used for grouting anchor bolts shall be composed in accordance with one of the following:

a) One part Portland Cement and one part mortar sand by dry loose volume.

b) Non-shrink grout shall be used when specified. The grout shall have a minimum compressive strength of 350 Kg/Sq.cm (5000 psi) in seven days when tested in accordance with AASHTO T 106 except that the cube moulds shall remain intact with a top firmly attached throughout the curing period. The non-shrink grout shall have a minimum expansion of 0.0 percent after seven days when tested in accordance with AASHTO T 160.

When air temperature is below four (4) degree C, the Contractor shall provide adequate cold weather protection to maintain a minimum air temperature of four (4) degree C around surface of mortar for a period of three days.

If anchor bolts are mortared in place during cold weather, the bolts and surrounding masonry shall be kept at a minimum temperature of four (4) degree C for a period of three days.

When mortar filling is used for bolts inserted in holes drilled or cast in the masonry, the holes shall first be checked for depth by inserting and withdrawing the bolts. They shall then be partially filled with mortar into which the bolts shall be forced by uniform pressure or light blows from a hammer (flogging and running will not be permitted) so that excess mortar is pushed out at the top of the hole. The excess mortar shall be removed and finished off flush with the top surfaces of the masonry, masonry plate or shoe as the case may be.

Bolts shall be set to project approximately half (0.5) inch (13 mm) above the nut and shall be threaded to approximately half (0.5) inch (13 mm) below the nut in its final position.

Nuts shall be drawn up tight except over the slotted holes of expansion devices in which case they shall be positioned half (0.5) inch (13 mm) clear of the moveable parts. All anchor bolt threads shall be burred with a sharp pointed tool at the top of the nut. When nuts are set half (0.5) inch (13 mm) clear of moveable parts, the bolt thread shall also be burred immediately under the nut to prevent it becoming tight against the moveable parts.

Rockers or expansion plates with slotted holes shall be set with the proper tilt or offset as determined by the temperature prevailing at the time and so that they will be in their midway position at twenty (20) degree C or as indicated on the Drawings.

413.3.17 Assembly and Erection Procedures

a) General

The Contractor shall submit as soon as possible to the Engineer for his prior approval full details of their proposed erection procedure together with details and calculations of any temporary works which the Contractor proposes to install for the purposes of the erection of the structural steel work.

b) Storage at Site and Handling

The structural steelwork after arrival on Site shall be laid out in the area allocated by the Contractor. It shall be unloaded by crane, or other appliance, and carefully stacked on timbers and subsequently handled for erection in such a manner that no distortion or damage is done to the various members. No steelwork shall be stored directly on the ground.

c) Erection Generally

The works on site shall comply with the requirements stated in these specifications and the Contractor shall be responsible for providing all materials, skilled and unskilled labour, plant, equipment, supervision and all other things necessary for the erection of the steelwork on the Site as specified in the Contract Documents and shown on the Drawings.

The Contractor shall ensure that suitable plant and equipment of adequate capacity is used on the Site.

d) Supervision

The erection of the steelwork shall be under the direct charge of a competent Supervisor who has had sound experience in the erection of structural steelwork and who shall work full time on the Site from start to completion of the work.

e) Security During Erection

During erection the work shall be securely bolted or otherwise fastened and where necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions, including those due to the erection equipment and its operation.

Each part of the structure shall be aligned as soon as possible after it is erected. Members shall not be permanently connected until the structure has been sufficiently aligned, leveled, plumbed and temporarily connected to ensure that they will not be displaced during the erection or alignment of the remainder of the structure. All temporary bracing shall be left in position until such time as erection is sufficiently far advanced for it to be no longer required.

f) Temporary Connections

Connections for temporary bracing and additional holes, members or cleats used to facilitate handling or erection shall be provided in a manner, which -does not weaken the permanent structure or impair its serviceability.

g) Erection Packs, Etc

The Contractor shall provide and shall be deemed to have included in his rates and prices for providing a suitable range of steel erection packs, shims and wedges to be used as necessary to ensure the accurate adjustment of line and level of the steelwork erected on Site and for the temporary works referred to in the previous sub-item.

h) Setting Out

The Contractor shall be responsible for the final positioning, leveling, plumbing and

alignment of all steelwork and the accurate placing of every part of the steelwork in accordance with the Drawings and his own fabrication drawings.

No steelwork shall be finally concreted until the positioning, levels, plumbing and alignment of the steelwork (or part of the steelwork if agreed by the Engineer) has been finally checked by the Contractor.

i) Work on Site

The steelwork after erection and fixing complete shall comply with the following maximum permissible dimensional tolerances:

Departure from overall plan dimensions at any level	ten (10) mm
Departure from theoretical centres of adjacent beams or girders in any floor or roof	five (5) mm
Departure from the true alignment of any plate girder relative to the associated setting out geometry shown on the Drawing	five (5) mm
Departure from the true vertical centre line or any girder throughout its length of height	five (5) mm
Departure from the specified level of the top of any beam	five (5) mm

j) Site Connections

The Contractor shall make all site connections in accordance with the details shown on the Contractor's detailed fabrication drawings, which shall comply with the requirements of these Specifications.

Drifting shall not be used to correct a bad alignment.

Any additional holes required in the steelwork (which must first be approved by the Engineer) shall be drilled on the Site. Burning holes in the steelwork will not be permitted.

k) Contact Surfaces

All steel to steel contact surfaces shall be thoroughly cleaned and painted with two coats of primer as described in clause No 413.2.10 in this Specification. The surfaces shall be brought together while the second coating is still tacky.

l) Site Welding

Site welding will only be permitted where shown on the Drawings and with prior consent of the Engineer.

m) Inspection of Site Works

All parts of the steel-work will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for inspection during the progress of the works.

The Contractor shall whenever possible, give the Engineer at least twenty four hours notice of when materials or parts of the steelwork will be ready for inspection.

Materials or workmanship or parts rejected shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the contract.

Inspection as aforesaid by the Engineer shall not absolve the Contractor from being responsible for any error or fault that may be discovered subsequently and for the final accuracy of the Works.

n) Painting after Erection

1) All paints shall be applied in accordance with the manufacturer's instructions and as specified under clause 413.2.10.

2) Damaged areas of paint-work shall be thoroughly scraped, wire-brushed and cleaned to remove all rust, dirt, grease and loose primer, back to sound paint.

All surfaces shall be thoroughly cleaned prior to further painting.

Damaged areas shall then be treated as described in the cleaning and painting section.

The second priming coat shall be allowed to dry for at least twenty-four hours before application of the finishing coat.

o) Inspection

1) The structural steelwork shall be subject to inspection by the Engineer. That inspection will as far as possible be carried out at the Contractor's workshops, but the Engineer may at his discretion defer inspection of any parts of the structural steelwork until after those parts have been delivered to the Site. The Contractor and his suppliers shall afford the requisite facilities at all reasonable times and at all places for inspection and testing to be carried out by the Engineer.

2) All parts of the Works done on the Site will be subject to inspection by the Engineer. The Contractor shall afford all facilities and assistance for inspection as aforesaid during the progress of the Site Works and until the completion of the contract.

3) Materials or workmanship or parts rejected on inspection as aforesaid shall be remedied or replaced by the Contractor without extra charge and without affecting the time for completion of the whole or any part of the Works.

ITEM 414 REINFORCED EARTH RETAINING WALLS & ABUTMENTS

414.1 GENERAL

This work shall consist of constructing retaining walls and abutments using a proprietary Mechanically Stabilized Earth (MSE) system in accordance with the Employer approved Manufacturer's construction drawings prepared in conformity to the Tender design drawings as duly approved and or directed by the Engineer. The MSE wall system must be designed according to the approved engineering data provided by the Engineer and supplied by a specialty firm duly recommended by the Engineer and approved by the Employer hereinafter referred to as the Principal System Proprietor who will be responsible for design, technical assistance for proper execution and performance of the final product, having a minimum of twenty years of documented successful experience in the design and construction of such wall systems. In addition, the soil reinforcement for the MSE system recommended by the Principal System Proprietor should be an approved system by British Board of Agreement (BBA) or equivalent.

All works under this Specification shall be carried out on recommendations of the Principal System Proprietor and after approval from the Engineer.

The proprietary materials supplied by the Principal System Proprietor shall be tested for quality as per the system certificates of the Principal System Proprietor and applicable design codes and also verified by experienced independent testing agency/authority. All other material shall be tested as specified elsewhere in the contract; and subject to approval by the Engineer.

414.2 DESIGN & INSURANCE

The construction of the wall shall be done on a Design and Construct basis. The Design of the Reinforced Earth walls/abutments shall be carried out by the Principal System Proprietor who shall also be responsible for the supply of the specialist materials as per Pay Items 414b(i) and 414b(ii) of these specifications. The Principal System Proprietor shall be responsible for the Design provided by him in accordance with the internationally accepted codes mentioned hereafter and shall provide an insurance cover for the same as stipulated herein. The Principal System Proprietor shall also be responsible for Technical Assistance to the Execution Contractor for proper execution of the works as per the design and method statements provided by the Principal System Proprietor.

414.2.1 Design

The design shall address the climatic and soil conditions existing at site and provide a design life equal to the requirement of design life of the other structures being designed for the project up to a maximum of 120-years.

The design shall be made in accordance with the Engineering Data provided by the design consultant as approved by the client and shall cater for any expected submerged conditions for the Reinforced Earth structures. However, the responsibility for the adequacy of the internal design of the Reinforced Earth walls & Abutments shall remain with the Principal System Proprietor.

The design shall be in accordance to the British Standard 8006 and the British Board of Agreements (BBA) Certificates No. 99/R110 & 99/R106. The latest applicable British Standards shall be used.

The design of wall coping and the counterbalance slab shall be provided by the Reinforced Earth Principal System Proprietor and approved by the Engineer.

When the bridge superstructure loads are to be carried by the Reinforced Earth in lieu of substructures such as piles etc, the design of the same shall be carried out accordingly.

414.2.2 Insurance & Guarantee

The Contractor shall obtain necessary insurance/guarantee from the system provider..

414.3 STANDARDS

The following standards and codes shall be applied to works covered by this specification where applicable together with the system specifications and the propriety system license of the Principal System Proprietor. In case of a conflict, the recommendations of the Principal System Proprietor's system license from the British Board of Agreement (BBA) or equivalent shall override the standards mentioned hereunder:

ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A123	Standard Specification for Zinc Coating (Hot-Dip Galvanizing) for Steel and Iron Products
ASTM A153	Standard Specification for Zinc Coating (Hot-Dip Galvanizing) for Steel & Iron Hardware
ASTM A325	Standard Specification for Structural Bolts, Steel, Heat Treated
ASTM A1011	Standard Specification for Steel, Sheet and Strip, Carbon Hot-rolled
ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM D1752	Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
AASHTO T90	Standard Method of Test for determining the Plastic Limit and Plasticity Index of Soil
ASTM D2000	Standard classification system for Rubber products in Automotive applications
BS 8006	Code of Practice for strengthened/reinforced soils and other fills
BS 5400	Steel, Concrete and Composite Bridges
BS 4449	Specification for carbon/hot-rolled steel bars for the reinforcement of concrete
BS 4483	Steel fabric for the reinforcement of concrete
BS EN 10025 S355JR	New standard for structural steel
NF P 94-210/220(0&1) (1994/98)	French standard for battered retaining walls, soil reinforcement/backfilled structures with inextensible or inflexible and flexible strips or sheets

All design and execution carried out under this item shall, as a minimum meet the AASHTO specifications for MSE walls.

414.4 MATERIALS

414.4.1 General

The Contractor shall make his own arrangements with the Principal System Proprietor to provide all necessary materials to complete the works under these specifications.

In order to safeguard the Reinforced Earth structures against any corrosion, only synthetic components shall be used for reinforcing strips and Dunois coated metallic connections in abutments (bridge load bearing). In reinforced earth walls the connections may be either synthetic or Dunois coated metallic.

414.4.2 Concrete Facing Panels

The structural design of the concrete facing panels shall be provided by the Principal System Proprietor. The panels shall use approximately between 7 & 11 Kg per square meter of facing of AASHTO M31 Grade 60 steel and approximately 0.17 CM per square meter of facing (plus any concrete in the pattern) of Class D (350 kg/sq. cm. minimum compressive cylinder strength at 28 days). The Contractor shall provide routine concrete tests under the supervision of the Engineer in order to verify this for every day of production. Sulphate resisting cement shall be used in concrete mix design, where sulphates contents in backfill or soil in contact with concrete exceed the allowable limits, as per Standards adopted in 414.3 at no extra cost.

Moulds with inbuilt liners shall be used to cast a pattern on the concrete facing panels to give an aesthetically appealing finish. One concrete panel surface pattern shall be selected by the Employer from amongst the two patterns (sketches attached) or amongst those offered by the Principal System Proprietor. The facing patterns may also be formed by using metallic dyes (either built-in or attached to the moulds).

Water-based release agent as suggested and approved by the Principal System Proprietor shall be sprayed in the moulds (in quantity suggested by the manufacturer and approved by the Principal System Proprietor) to ensure safe use of moulds and liners and smooth de-moulding / striking after concrete in moulds has cured to the strength suggested by the Principal System Proprietor. Strict compliance to the Method Statements issued by the Principal System Proprietor shall be ensured and damaged moulds due to non-compliance to the Method Statements shall be replaced by the Contractor at his own cost.

The rear face of the panels shall be coated with bitumen. The bitumen coating shall consist of 2 coats of hot bitumen grade 10/20 @ 1.0 Kg/sq. m. per coat.

The rear face of the panel shall be roughly screeded to eliminate open pockets of aggregates and surface distortions in excess of 6.5mm.

Maximum Tolerance for dimensions of the panels shall be 5mm in each direction. Maximum angular distortion with regards to the height of the panels shall be 0.2 Degrees or 7-mm in 2-meters.

All Panels shall be handled and stored in accordance with the Principal System Proprietor's recommendations and in such a manner as to eliminate the danger of chipping, cracking and fracturing. Panels in storage shall be supported on firm blocking located immediately adjacent to tie-strips to avoid damage to these tie-strips.
Joint spacing and details for expansion, contractions, and construction and control joints shall be as recommended by the Principal System Proprietor.

The date of manufacture, type of cement used and the type of panel shall be clearly scribed on the rear of each panel.

The forms shall remain in place until test cylinders cured with the facing give compressive strength of 100 Kg/cm2.

Transportation of panels shall only be allowed at a minimum compressive strength of 350 kg./sq. cm.

Facing panels shall be subject to rejection by the Engineer or the Principal System Proprietor Assistance staff if not in conformance with these specifications or if any of the following defects are evident by visual inspection:

a) Defects that indicate imperfect corners
b) Defects indicating honeycombed or open texture concrete
c) Defects and cracks due to improper curing
d) Panels damaged during transportation

Repairs shall neither be allowed nor shall repaired panel be used. No extra payment shall be made to the Contractor on account of rejected panels.

414.4.3 Wall Coping & Counterbalance Slab

Concrete for wall coping & counterbalance slab shall be Class A1 (210 kg/sq. cm. compressive cylinder strength). The wall coping and the counterbalance slab system (including any stitch beam) shall use approximately 1.15 cubic meters of Concrete and approximately 100 Kg of Grade 60 steel as per AASHTO M31 per running meter length of the wall. However, the design of the coping and the counterbalance slab as provided by the Principal System Proprietor and approved by the Engineer shall be followed.

414.4.4 Reinforcing Steel

All reinforcing steel in the facing panel, wall coping, and counterbalance slab shall be Grade 60 (ø10, ø12, ø16& ø20 bars) as per AASHTO M31 and as specified on the project drawings.

The minimum concrete cover over steel reinforcement shall be 75mm on the rear face of the panels in contact with soil, 60 mm for the front side or as specified by the drawings issued by the Principal System Proprietor.

414.4.5 Concrete Leveling Pad

The concrete (un-reinforced) for the leveling pad shall be of Class A1 (minimum compressive cylinder strength 210 kg/sq. cm. at 28 days). The leveling pad shall use approximately 0.10 CM of concrete per running meter of Pad. The Principal System Proprietor shall provide the final design of the leveling pad. The concrete shall be cured for a minimum of 72 hours or 147 kg/sq. cm. strength is achieved prior to placing of the panels on it.

414.4.6 Soil Reinforcement

The soil reinforcement shall be in accordance to the Principal System Proprietor's certified MSE system. Only use of soil reinforcement approved by the British Board of Agreement (BBA) or equivalent and having a minimum track record of 15-years under similar works and project area considerations shall be allowed.

414.4.6.1 Synthetic Soil Reinforcement

The synthetic soil reinforcement shall be manufactured in accordance with BBA 99/R110 and shall conform to the following:

a) The synthetic soil reinforcement shall comprise of polyester tendons encased in a polyethylene sheath (continuous across its width) and shall be manufactured in four grades as given below:

Grade (Minimum) Ultimate Strength), kN	Coil Length (m)	Min Weight +/-0.2 (kg)	Nominal Width (mm)	Nominal Thickness (mm)
30	100	14.7	85	2.2
50	100	22.7	90	3.5
75	100	29.7	90	4.7
100	100	36.5	90	6.0

b) The synthetic soil reinforcement shall be made from high-tenacity polyester fiber concentrated into separate bundles and encased in polyethylene using a vacuum die-coating process.

c) Factory production control shall be undertaken by the manufacturer throughout all stages of manufacturing with checks on:

1) Incoming Material
2) Yarn Feeds
3) Manufacturing Temperatures
4) Sheath Widths
5) Length & Weights of Coils
6) Mechanical Properties

414.4.7 Fixings (Panel to Soil Reinforcement Connectors)

The Soil Reinforcements shall be connected to the Pre-cast Concrete facing panels by Fixings as follows. However, as the Fixings for the Reinforced Earth technology are evolving globally, the Principal System Proprietor may provide an alternate system of fixings under Guarantee as in SP 414.2.2 after approval from the Engineer.

414.4.7.1 Fixings for Synthetic Soil Reinforcement

Synthetic soil reinforcements may be connected to the panels using either of the following as provided in the design and drawings issued by the Principal System Proprietor.

a) Loops made out of the material used to manufacture Synthetic Soil Reinforcement as provided in 414.4.6.1 above and Toggles manufactured using Fiber Glass or Steel encased in a protective coating.

b) Loops made out of the material used to manufacture Synthetic Soil Reinforcement as provided in 414.4.6.1 above and Toggles manufactured using Grade 355JR Steel encased in Dunois coating of Zn/Al spray mix of 85:15 and a coating thickness of 70 microns.

c) BS EN 10025 Grade 250 (Loops) and Grade 355 JR (Toggles) encased in Dunois coating of Zn / Al spray mix of 85:15 and a coating thickness of 70 microns.

d) The Panel Lugs cast into the Panels shall be as per BS EN10025 Grade 355JR with minimum tensile, bearing and shear strength of 510 N/mm^2 having a silicon content of not less than 0.25% and not more than 0.35%. After fabrication, the Panel Lugs shall be Dunois-coated with Zn/Al spray mix of 85:15 and a coating thickness of 70 microns. Other properties of the Lugs shall be as per section 414.4.7.2 below.

e) U-shaped plastic pipe joints casted into panels allowing the weaving of the soil reinforcement strip through the U-shaped plastic pipe joints. Whenever this type of joint is used, the concrete facing panel may need to be thickened (locally or universally) unto a maximum thickness of 225mm. The details of the panel thickening shall be provided by the Principal System Proprietor.

414.4.8 Joint Fillers (Geotextile, Sealing Foam) & EPDM Pads

Filler for vertical and horizontal joints between panels shall be:

Filler for vertical joints between units shall be flexible, open cell Polyurethane foam.

Thermally bonded, non-woven polypropylene Geotextile grade T6 or Flexible open/ closed cell polyethylene foam strips (25mm +/- 2mm) unless otherwise noted on the approved construction drawings.

At the base of each facing panel (except for the bottom panel resting on the concrete leveling pad), toothed bearing pads shall be placed having a minimum cross-section of 22mm by 70mm. The bearing pads shall conform to TA2000 standard A405 & meet the following requirements:

Composition: 30 to 40% EPDM grade 989T
15 to 20% Plastifying agent
45 to 50% Carbon filler

Main characteristics: Minimum Density 1.15
Hardness 80 $\pm$ 5 Shore A
Minimum Strength at failure 12 MPa
Minimum Strength upon shear failure 0.35 MPa

The EPDM bearing pads shall be conform to the following requirements when compression load tests are carried out sandwiching the EPDM bearing pads in two concrete Class D (350 kg/sq. cm.) blocks of 100mmX100mmX300mm:

Applied Load (KN)	Minimum Deformation (mm)	Maximum Deformation (mm)
0	0	0
10	1.5	4.5
20	3.0	7.0
40	5.0	9.5
60	6.0	10.5
80	7.0	11.0
100	8.0	12.0
120	8.5	12.5
140	9.0	13.5

414.4.9 Selected Reinforced Earth Fill

The Reinforced Earth Fill shall be compacted to 95% MDD AASHTO T-180 from prepared bottom ground level to the top of wall. However, in case these Specifications require a higher compaction level in any zone of embedment/subgrade, the same shall be achieved.

The Contractor shall exercise quality control over the fill material used (as per 414.4.9.1) in the MSE structures under direct supervision of the Engineer. Any material which is unsuitable and does not comply with the specified requirements shall not be used.

The Reinforced Earth backfill shall comply with the following requirements:

414.4.9.1 Fill with Synthetic Soil Reinforcement and or Dunois Coated Metallic Connectors (Fixings)

a) Non-Plastic
b) Free from organic or otherwise deleterious materials
c) Maximum size of particles 75 mm
d) Maximum 15% passing No 200 sieve
e) Coefficient of uniformity Cu (=D60/D/10) ≥ 5
f) Minimum Angle of Shearing Resistance Φ>= 36 degrees, tested with Shear Box under slow drained conditions translating into Coefficient of friction between fill and soil reinforcement μ>=0.65.

414.5 CONSTRUCTION REQUIREMENTS

414.5.1 Foundation preparation

The foundation for the structures shall be graded level for a width equal or exceeding the length of reinforcing strips or otherwise shown on the approved shop drawings. Prior to wall construction, except where constructed on rocks, the bearing capacity of the soil under the structures shall be studied and tested by the contractor executing boreholes/test-pits or as recommended by the Principal System Proprietor. Results of the investigation shall be forwarded to the Principal System Proprietor of the proprietary MSE system who will advise on the type of foundation treatment to be carried out in case of weak soils. In any case the foundation shall be compacted with vibratory roller, to an average density of not less than 95% of MDD AASHTO T-180. It should be noted that the Reinforced Earth structures require approximately a minimum 22 kN/m2 at serviceability limit state of allowable bearing capacity per meter height of the wall. Anticipated live loads should be added as per selected design code. The actual bearing capacity to be proven by testing shall be a minimum of the calculated imposed bearing pressure times the appropriate Factor of Safety required by the selected design standard.

414.5.2 Erection of Concrete Facing Panels

Precast facing panels shall be aligned vertically as per the Principal System Proprietor's recommendations. Panels shall be placed in successive horizontal lifts in the sequence shown on the approved plans as backfill placement proceeds. As fill material is placed behind the panels, the panels shall be maintained in vertical position by means of clamps placed at the junction of adjacent panels and temporary wooden wedges placed in the horizontal of vertical joint at the junction of the two adjacent panels on the external side of the wall. External bracing may also be required for the initial lifts. Vertical tolerances (plumb) and horizontal alignment tolerances shall not exceed 25mm when measured along with a three meters straight edge. The maximum allowable offset in any panel joint shall be 20mm. The overall vertical tolerance of the wall (plumb from top to bottom) shall not exceed 25mm per three meters of wall height and 50mm overall. Steel reinforcement bar which anchors synthetic strip at far end of the panel should be bitumen coated.

414.5.3 Backfill placement

Backfill placement shall closely follow the erection of each lift of panels. At each reinforcement level, backfill should be roughly leveled with a percentage shown on the shop drawings before placing and attaching reinforcements. Backfill shall be placed as per the specifications, except that the maximum lift thickness shall not exceed 20 cm loose and shall closely follow panel erection. The Contractor shall decrease this lift thickness if necessary to obtain the specified density. At the end of each day's operations, the Contractor shall shape the last level of backfill so as to permit run-off of rain water away from the wall face. Backfill compaction shall be accomplished without disturbance or distortion of reinforcement and panels. Compaction in a strip one meter wide adjacent to the rear side of the wall shall be achieved with light compactor and after the compaction of the remaining area has been carried out. Under no conditions, any plant or equipment weighing more than 1-ton shall be brought within 2-meter of the facing panels during the course of works. The contractor will provide the required compaction as specified in 414.4.9. The Contractor shall provide compaction tests for every layer of backfill in place as specified.

When drainage material is required, a geotextile membrane shall be used between the drainage material and the selected backfill.

Any wall protection measures recommended by the Principal System Proprietor such as earth fill outside the wall at the base or Rip Rap etc shall be executed either prior to the wall construction or simultaneously with it. In no case shall these protective works be left for construction after the wall is erected.

ITEM 415 WATERPROOFING

415.1 DESCRIPTION

This work shall consist of furnishing and installing materials to waterproof or dampproof concrete surfaces. The surfaces to be waterproofed or dampproofed and the type of system to be installed shall be as shown on the plans or otherwise specified and as directed and approved by the Engineer.

415.1.1 Waterproofing

Waterproofing shall consist of either a constructed in place asphalt/bitumen system or a preformed membrane system, both of which include appropriate priming materials.

415.1.2 Dampproofing

Damp proofing shall consist of a coating of primer and two coats of waterproofing asphalt.

415.2 MATERIAL REQUIREMENTS

415.2.1 Asphalt Membrane Waterproofing System

415.2.1.1 Asphalt

Waterproofing asphalt shall conform to the Specification for Asphalt for Dampproofing and Waterproofing, ASTM D 312-00, Type I shall be used below ground and Type II used above ground.

415.2.1.2 Primer

Primer for use with waterproofing asphalt shall conform to the Specification for Primer for Use With Asphalt in Dampproofing and Waterproofing, ASTM D 41-05.

415.2.1.3 Fabric

The fabric shall conform to either the Specification for Bitumen-saturated Cotton Fabrics used in roofing and Waterproofing, ASTM D173-03 or the Specification for Hot – mixed, Hot - laid bituminous paving mixtures, ASTM Designation: D 3515-01.

The fabric shall be stored in a dry, protected place. The rolls shall not be stored on end.

415.2.1.4 Polythene Sheet

Polythene shall conform to ASTM D 4397 Standards or equivalent as approved by the Engineer.

415.2.2 Preformed Membrane Waterproofing Systems

415.2.2.1 Primer

Primer for use with the rubberized asphalt membrane shall be a neoprene based material, and the primer for use with the modified bitumen membrane shall be a resin or solvent based material. Primers shall be of a type recommended by the manufacturer and duly approved by the Engineer.
Primed surfaces shall not be covered until all solvent constituent has evaporated. When spirit-based primer is used, a minimum of twenty (20) hours at temperatures between ten and sixteen degrees Celsius (10 to16 °C) shall elapse before waterproofing is laid.

415.2.2.2 Preformed Membrane Sheet

Preformed membrane sheet shall be of either the rubberized asphalt type or the modified bitumen type. The rubberized asphalt type shall consist of a rubberized asphalt sheet reinforced with a polyethylene film or mesh and, as directed and approved by the Engineer. The modified bitumen sheet type shall consist of a polymer modified bitumen sheet reinforced with at stitch-bonded polyester fabric or a fiberglass mesh. The membrane sheet shall conform to the following requirements:

Property	Test	Value	
		Rubberized Asphalt Type	Modified Bitumen Type
Tensile Strength	ASTM D 882	20 lbs/in.	20 lbs/in.
% Elongation at Break	ASTM D 882	150%	25%
Pliability	ASTM D 146	No cracks	No cracks
Thickness (Min.)		60 mils	60 mils
Softening Point (Min.)	AASHTO T53	165 ^{o}F	210 ^{o}F

415.2.2.3 Mastic

The mastic for use with preformed rubberized sheets shall be rubberized asphalt cold applied joint sealant. The mastic for use with modified bitumen sheet shall be a blend of bituminous and synthetic resins.

415.2.2.4 Bitumen Painting

Two (2) coats of cut-back bitumen complying with BS 3690 of viscosity grade within the range of twenty five (25) to fifty (50) seconds (standard tar viscometer) at forty degrees Celsius (40 $^{\circ}$C) with a coverage of one and eight –tenths (1.8) square meters per liters or any material approved by the Engineer.

The manufacturer's limitations on heating shall be compiled with. High temperatures shall not be maintained for periods larger than needed for installation and in no case for more than three (3) hours. Bitumen shall not be heated to a temperature higher than fourteen degrees Celsius (14°C) below flash point.

415.2.3 Damp proofing

The primer and asphalt used for dampproofing shall conform to as specified.

415.2.4 Inspection and Delivery

All waterproofing and dampproofing materials shall be tested before shipment. Unless otherwise ordered by the Engineer, they shall be tested at the place of manufacture, and, when so tested, a copy of the test results shall be sent to the Engineer by the chemist or inspection bureau which has been designated to make the tests, and each package shall have affixed to it a label, seal, or other make of identification, showing that it has been tested and found acceptable, and identifying the package with the laboratory tests.

Factory inspection is preferred, but, in lieu thereof, the Engineer may order that representative samples, properly identified, be sent to him or her for test prior to shipment of the materials. After delivery of the materials, representative check samples shall be taken which shall determine the acceptability of the materials.

All materials shall be delivered to the work in original containers, plainly marked with the manufacturer's brand or label.

415.3 CONSTRUCTION REQUIREMENTS

415.3.1 Surface Preparation

All concrete surfaces which are to be waterproofed or dampproofed shall be free of foreign material that would prevent bond and from projections or holes which might cause puncture of the membrane or dampproofing. The surface shall be dry and, immediately before the application of the primer, the surface shall be thoroughly cleaned of dust and loose materials.

No waterproofing or dampproofing shall be done in wet weather, or when the surface temperature is below 4° C, or that recommended by the manufacturer, without special authorization from the Engineer. Should the surface of the concrete become temporarily damp, it shall be covered with a 50 mm layer of hot sand, which shall be allowed to remain in place from 1 to 2 hours, or long enough to produce a warm and surface-dried condition, after which the sand shall be swept back, uncovering sufficient surface for beginning work, and the operation repeated as the work progresses.

415.3.2 Application

Waterproofing shall not be applied to any surface until the Contractor is prepared to follow its application with the placing of the protective covering and backfill within a sufficiently short time that the membrane will not be damaged by men or equipment, exposure to weathering, or from any other cause. Damaged membrane or protective covering shall be repaired or replaced by the Contractor at his or her expense.

Care shall be taken to confine all materials to the areas to be waterproofed or dampproofed and to prevent disfigurement of any other parts of the structure by dripping or spreading of the primer or asphalt.

415.3.3 Asphalt Waterproofing

415.3.3.1 General

Asphalt membrane waterproofing shall consist of one coat of primer applied to the prepared surface and two coats of waterproofing asphalt/ bitumen (Type III Waterproofing) conforming to the specification, @ 1.00 kg/ sq. m. per coat, and as approved by the Engineer.

415.3.4 Preformed Membrane Waterproofing Systems

415.3.4.1 General

Performed membrane water proofing system shall consist of primer applied to the prepared surface, a single layer (Type II Waterproofing) or two layers (Type I Waterproofing) or two layers (Type IV Waterproofing covered with polythene sheet) of adhering performed membrane sheet.

415.3.4.2 Installation

Installation of preformed membranes on concrete surfaces other than bridge decks shall conform to the applicable requirements as per AASHTO –Standard Specifications- Division II- Construction 21.4.2.2 and the following.

Preformed membrane material shall be placed vertically with each successive sheet lapped to the preceding by a minimum of 75 mm. Horizontal splices shall be lapped by a minimum of 150 mm.

Exposed edges of membrane sheets shall have a troweled bead of manufacturer's recommended mastic or sealing tape applied after the membrane is placed.

All projecting pipe, conduits, sleeves or other facilities passing through the preformed membrane waterproofing shall be flashed with prefabricated or field-fabricated boots, fitted coverings, or other devices as necessary to provide watertight construction.

Joints in polythene sheet are to have an overlap as directed by the Engineer. Overlaps and ends shall be secure with adhesive tape to tape to hold polythene cover in-place until backfilling operations are completed.

ITEM 416 MANUFACTURED TRADEMARK EXPANSION JOINTS

416.1 GENERAL

Expansion joints will follow Specifications of AASHTO-SS-Division II-section 19 “Bridge deck joints seals”

This work shall consist of furnishing and installation of materials for expansion joints and nosing in reinforced concrete deck slab and the furnishing and installation of fabricated bridge deck joints.

The Contractor shall submit to the Engineer, complete documentation about the Expansion joints he intends to use for the movements shown on the drawings, including references of the last 10 years, material specification for metal, rubber and bonding between them, fixations, and test certificates from authorized laboratories showing that the proposed joints meet the specifications.

Elsewhere the submittal will be accompanied by samples of at least 0.50 m, with its fixations.

The expansion joints shall satisfy the following functional requirements:

a) It shall withstand traffic loads of the highway, and accommodate movements between the deck and abutment or the adjacent deck.
b) It shall have good rigidity quality and shall not cause any inconvenience to road user.
c) It will not cause skidding hazard.
d) It will not generate excessive noise or vibration during the passage of vehicles.
e) Parts liable to wear out shall be easily replaceable.
f) It will be watertight and will have provision for carrying away water and silt.
g) It will be easy to inspect and maintain.
h) It will be resistant in hot and very sunny climate.

When directed all materials shall be tested prior to commencement of the bridge work as deemed necessary by the Engineer. Tests samples shall be supplied by the Contractor at his own expense. Testing shall be conducted by a qualified laboratory approved by the Engineer which will issue a certificate indicating the test results. All costs in connection with manufacturer’s certificates of guarantee, laboratory analysis and certificate, and all subsequent testing shall be borne by the Contractor. The testing shall be conducted in the presence of the Consultant, the Engineer and the Contractor at source.

The testing of elastomer is specified as hereunder:

▪ Hardness	ASTM D2240
▪ Tensile strength at breaking	ASTM D412
▪ Deformation Under constant compression	ASTM D395
▪ Resistance to aging	ASTM D573
▪ Resistance to oils (variation in volume)	ASTM D471
▪ Resistance to ozone	ASTM D1149
▪ Brittleness at low temperature	ASTM D746
▪ Bond to metal	ASTM D429

416.2 SUBMITTALS

The Contractor shall submit to the Engineer for approval copies of manufacturer’s specifications, certifications and laboratory test reports and instructions for maintenance for all manufactured materials. Installation procedure of finished expansion joints and items of equipment recommended to be used by the manufacturer shall be also included.

416.3 STORAGE AND HANDLING

Manufactured joints shall be delivered in weatherproof and protective packaging and shall be so handled and stored so that they remain free from physical damage.

416.4 CONSTRUCTION REQUIREMENTS

The methodology of placing the expansion joints will be clearly described by the Contractor with a complete set of drawings on the basis of approved manufacturer's recommendations and submit to the Engineer for approval.

Connection or overlapping between roadway and walkway expansion joints will be clearly shown.

Connection with waterproofing of the deck will be detailed.

All necessary provisions in deck reinforcement will be indicated.

Initial gap at the time of placing will be clearly indicated and justified.

The second stage reinforced concrete for fixations, if any, will be Class D concrete and will be included in pay item 416.

ITEM 417 POT BEARINGS

417.1 DESCRIPTION

This work shall consist of furnishing and installing replaceable bridge bearings as shown on the plans or as directed by the Engineer.

All special bearing devices shall be of the pot type, either fixed, slided or guided. Movement and restraint characteristics will be shown on the drawings.

The base of pot bearings shall be formed from a single monolithic material such as solid steel plate or cast steel.

The Contractor shall submit to the Engineer well in advance details of bearings he intends to use for approval. Then the Contractor is required to submit one sample and detail drawings on all types of bearings and installation procedures for approval by the Engineer. Bearing shall be installed according to the manufacturer's recommendation and as agreed with the Engineer, by competent personal who are well trained in the installation procedures of the bridge bearings.

417.2 MATERIAL REQUIREMENTS

The Contractor shall submit to the Engineer details of all the bearings he proposes to use in the works along with their specifications. Also, one sample of such bearings shall be submitted, which will form the basis for a tentative approval of the bearings prior to the carrying out of the detailed examination and field tests.

All bearings shall be provided with all fittings, fixtures, bolts and/or shear keys required either for installation of to ensure satisfactory in-service operation.

Bearings shall be delivered in protective packaging and shall be so handled and stored that they remain free from any physical damage or dust accumulation.

Epoxy mortar shall be delivered in ready-to-use packs in the manufacturer's original sealed containers, labeled clearly with the manufacturer's name, product identification and batch number. The size of the packs shall be such that batches of materials for mixing shall be in whole number multipliers of packs. The re-use of the portion of a used pack will not be permitted. The packs shall be stored in dry, weather-proof condition away from the affects of hot sun.

417.3 TESTING

Before approval is given, at least one of each type of bearing shall be tested for material quality, load capacity and friction characteristics. Then the Engineer shall demand bearings selected by him at random which will be similarly tested.

The testing shall be carried out in the country of origin from where pot bearings are procured in the presence of the Engineer and structural Designer. All expenses shall be borne by the Contractor.

i) Vertical Test

Load deformation test to a maximum of one and one-half ($11/_2$) times rated load, with the load applied in equal increments and decrements in equal increments and equal decrements to obtain a load cycle. Two such load cycles for each test shall be performed. At maximum load in the first cycle, the load shall be held for six (06) hours. At maximum load in the second cycle, the load shall be held for fifteen (15) minutes.

ii) Guide Test

This test shall be carried out at constant vertical loads of ten (10) and one hundred percent of rated load. The horizontal load shall be applied in ten equal increments to a maximum of designated horizontal load. Two load cycles for each test shall be performed. Where required by the Engineer, electrical strain gauges shall be installed on the base plate at thirty (30) degrees spacing on one-quarter of the base plate to measure the stress occurring at the rim/base junctions.

All steel elements of the bearing load tested shall be tested for mechanical strength and chemical compositions and where rolled steel sheets are used, the mechanical strength test shall be carried out in the directions both of rolling and perpendicular to rolling.

PTFE sheets used in metal bearings shall comply with BS 3784: 1973, Grade B and shall be tested for hardness, tensile strength, elongation and specific gravity in accordance with ASTM D 2240, ASTM D638 and ASTM D792 respectively. Additionally, the arrangements and shapes of grease pockets, if used, shall be surveyed and tested.

417.4 CONSTRUCTION REQUIREMENTS

The fixing of all bearings shall comply with the manufacturer's recommendations and be approved by the Engineer.

The maximum allowable value of the coefficient of friction between sliding surfaces of metal bearings shall be three-hundredths (0.03).

The manufacturer shall inscribe on the top of each bearing the longitudinal axis and transverse axis of the bearing.

All bearings shall be indelibly marked with the appropriate type number clearly marked top and bottom. Bearings shall be clearly identified by "pier number/bearing number," "abutment number/bearing number."

For each type of bearing, the Contractor shall furnish detailed calculations and drawings to demonstrate the adequacy of the bearings and that they can be properly installed, maintained and replaced if necessary. Manufacture of bearings should not commence until the Engineer and Designer have approved the design calculations and shop drawings.

Bearings shall not be dismantled. Any transit bolts, straps or other temporary fixing shall not be removed until the bearing is fixed in its final position and the structure immediately above the bearing is in place. Care shall be taken to ensure that all transit bolts, straps or other temporary fixing are finally removed.

Bearings which incorporate low friction material, such as Polytetrafluroethylene (PTFE), shall not be opened up to expose the surface of the low friction material. Should this happen accidentally, bearing surfaces are to be cleaned and regreased and assembled as required by the manufacturer and to the satisfaction of the Engineer.

All bearings shall be set horizontal in both directions and all bearings shall be positioned so that the inscribed longitudinal axis is parallel to the structure axis at point of support, unless otherwise noted on the drawings.

All metal bearings must have positive fixing such that the bearing is subsequently removable without excessive jacking. Horizontal forces shall be transferred from the superstructure to the bearings and from the bearings to supports by means of shear keys or fixing bolts.

The longitudinal movements listed for metal bearings may require presetting the top plates with respect to the bottom plates and also variable orientation of the bearings with respect to the pier axis. Such preset and orientation angles shall be marked on each bearing by the manufacturer before shipment. Full installation drawings of all bearings shall be submitted by the Contractor for approval.

Any devices such as steel packs used to hold bearings level whilst being fixed, must be removed finally, so that the bearing seats only on its dry pack mortar bedding.

Metal bearings shall be set in position on steel wedges to within plus or minus five (± 5) mm of the specified level. The location of theses wedges beneath the bearings shall be agreed with the bearing manufacturer prior to installation.

The gap between the underside of bearing and substructure shall be fixed with steel-rammed dry pack mortar epoxy mortar as specified by the Engineer which have a minimum of twenty-eight (28) day cylinder strength of three hundred ten (310) kilograms per square centimeter (Kg/sq. cm) and the resulting voids filled with dry pack mortar or with an approved epoxy mortar. Construction of the bridge super-structure may then proceed. The supporting false work and formwork of the bridge superstructure shall not be removed not permit the transfer of load to the bearings prior to removal of temporary supporting wedges.

Bearings shall be maintained in their correct position during placing of bridge deck. Mating surfaces of bearings shall be kept clean from contamination and after the deck has been completed; each bearing and the area around it shall be left clean and tidy, to the satisfaction of the Engineer. No bearing shall be accepted on site or be allowed to be installed until approval of the Engineer is obtained in respect of shop drawings material and load tests, installation drawings and installation trials.

ITEM 418 STEEL RAILING

418.1 DESCRIPTION

The work covered by this section of the special provision consist of furnishing all plant, labor, equipment, appliances and materials and of performing all operation in connection with construction of Steel Railing of Reinforced Concrete, Steel Pipes or Steel angles etc. over bridges, structures or on New Jersey Barriers, in strict accordance with these specifications, drawings and as directed by the Engineer.

418.2 MATERIAL REQUIREMENTS

418.2.1 Concrete

Quality requirements of all materials for concrete class A1 shall be in accordance with Item 401.

418.2.3 Reinforcing Steel

Quality of steel reinforcement shall be in accordance with the material requirements of Item 404.

418.2.4 Zinc Coated Steel Pipe (G.I. Pipes)

Zinc coated steel pipe (G.I. Pipes) shall be galvanized and threaded and shall conform to ASTM A53 Grade B.

418.2.5 Fitting and Specials for Zinc Coated Steel Pipes (G.I. Pipes)

Fittings and specials for zinc coated steel pipe (G.I. Pipes) shall be galvanized and threaded and shall conform to the applicable requirements of relevant ASTM Specifications.

418.2.6 M.S. Pipe and Square Bars

M.S. pipe / steel tube shall conform to ASTM A501 or ASTM A53 Grade B, square bars shall conform to the requirements of ASTM A36 and MS Sheet shall conform to ASTM A569 and as approved / directed by the Engineer.

418.2.7 Nuts and Bolts

Nuts and bolts shall conform to ASTM A307 Grade A and washers shall conform to Federal Specifications FA-W-92, Type A, Grade 1 and as approved/directed by the Engineer.

418.2.8 Steel Supports for Pipe Railing

The steel supports for pipe railing shall be constructed from MS Sheets properly cut to shape as shown on the drawings. The whole assembly shall be of welded construction and shall be galvanized or painted as per Specifications.

418.3 WELDING

All welding shown on the drawing shall be of size and shape as shown on the drawings and shall be carried out in accordance with the clause 413.2.7 “welding” of these Specifications.

418.4 PAINTING

Painting of steel supports or pipe railing, if shown on the drawing or as directed by the Engineer, shall be carried out in accordance with the clause 413.2.10 “Painting” of these Specifications.

418.5 GALVANIZING

Galvanizing the steel supports and pipes railing (if not pre galvanized) shall be in accordance with the clause 413.2.8 “Galvanizing” of these Specifications.

418.6 CONSTRUCTION REQUIREMENTS

Steel pipe railing shall be installed in the manner and at locations shown on the Drawings. Fixed and removable railings and safety chains shall be furnished and installed in the locations indicated on the Drawings. The steel supports shall be constructed from MS Sheets according to shape and dimensions as shown on the Drawing. All shop and field connections shall be welded unless otherwise indicated on the Drawings. All welds shall be ground smooth. All railings and their supports shall be galvanized after fabrication, if pre galvanized pipes are not used. Galvanized coatings damaged in the field shall be repaired or replaced as directed by the Engineer. Railings shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length.

ITEM 419 EXPLORATORY DRILLING

419.1 DESCRIPTION

This work shall consists of performing all the operations in connection with drilling, sampling and subsequently the laboratory testing in accordance with latest relevant ASTM Standards, specifications and/or as instructed by the Engineer.

419.2 MATERIALS/EQUIPMENT

Necessary equipments required for drilling, sampling and testing shall conform to the requirements of relevant ASTM Standards.

419.3 DRILLING AND SAMPLING

Drilling work shall include drilling of boreholes to a depth specified by the Engineer, performing Standard Penetration Test (SPT) at specified interval, extraction of undisturbed soil samples as and when specified by the Engineer with some suitable sampler, preservation of the soil samples recovered and transportation of these samples to Engineer's approved laboratory in accordance with latest relevant ASTM standards.

419.4 LABORATORY TESTING

Laboratory testing of the samples transported to an approved laboratory for classification, strength and settlement characteristics shall be performed under prevailing ASTM standards.

DRAINAGE AND EROSION WORKS

ITEM 500 GENERAL

The Contractor shall so schedule the construction of drainage works that the discharge of runoff from rain or other sources, both during and after construction, is properly provided for.

To avoid damage to works in course of construction, the Contractor shall provide adequate means of protection, including all necessary temporary outlet ditches, dams or diversion channels, culverts, 'ditches or other drainage works for the discharge of runoff water during construction and which shall be kept clear of all obstructions that might impede the flow of water.

These requirements shall be met without additional payment and all costs thereof shall be included in the bid prices for any items under the contract.

Drainage structures shown on the Drawings and their estimated total quantities are not to be taken as final. The Engineer, who will inform the Contractor of them in writing, will decide the final quantities.

ITEM 501 REINFORCED CONCRETE PIPE CULVERTS

501 DESCRIPTION

This work shall consist of the construction, reconstruction or repair of culverts and, water drainage structures in accordance with these specifications, and in conformity with the lines, grades and dimensions shown on the Drawings or ordered by the Engineer.

The work shall include the furnishing and laying of the pipe and the construction of such joints and connection to other pipes, catch basins, or other structures as may be required to complete the work as shown on the Drawings or as required by the Engineer.

The work shall also include the removal and disposal of existing culverts and structures except such portions as may be required or permitted by the Engineer to be left in place.

The Engineer reserves the right to inspect and test the pipe after its delivery to the work. Injurious defects revealed subsequent to acceptance of pipe and prior to its installation in the work shall be cause for rejection.

The Contractor shall not order and deliver the pipes for any work until the Engineer has approved a list of sizes and lengths.

501.2 MATERIAL REQUIREMENTS

The pipes shall meet the requirements of the AASHTO M-170 Class II and IV as called for in the Bill of Quantities.

Cement, sand and water shall conform to the requirements specified in item 401-Concrete, except that the grading of sand shall meet the requirements of AASHTO M-45.

Steel reinforcement shall conform to the requirements specified in Item 404 of these specifications.

Rubber ring gaskets for rigid pipe, if required, shall conform to the requirements of AASHTO M-198.

501.3 MANUFACTURING REQUIREMENTS

Reinforced concrete pipe culverts shall conform to the requirements of AASHTO M-170.

501.3.1 Dimensions and Strength Test Requirements

Shell thickness, the quantity of circular reinforcement and the strength per linear meter for the various sizes of pipe shall conform to the minimum requirements listed in related Table as per AASHTO M-170 latest addition.

501.3.2 Reinforcement

Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 diameters for bars and 40 diameters for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than three thousand seven hundred (3,700) Kgf / Sq. cm. The spacing centers of adjacent rings of circumferential reinforcement (pitch) shall not exceed 10 cm. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of +

six (6) mm.

501.3.3 Joints

The ends of reinforced concrete culvert pipes shall be the ogee or spigot and socket types and of such design that when laid the joints shall form a continuous conduit with a smooth and uniform interior surface.

501.3.4 Tolerances

Variations in internal diameter and wall thickness shall not exceed the limit specified in relevant "Table for Allowable Tolerances" for reinforced concrete pipes in these Specifications.

501.3.5 Absorption

The water absorption of the concrete pipe shall not exceed eight (8) per cent of the dry weight as determined in AASHTO designation T-33.

501.3.6 Curing

Pipes shall be subjected to any one of the methods of curing described in the following paragraphs or to any other method or combination of methods, approved by the Engineer's Representative that will give satisfactory results, provided that no pipe shall be used within a period of fourteen (14) days after curing. All pipes shall be marked with the date of casting.

a) Steam Curing

Pipes shall be placed in a curing chamber, free from outside draughts, and cured in a moist atmosphere, maintained at a temperature between thirty eight (38) and fifty four (54) degree C by the injection of steam for a period of not less than twenty four (24) hours or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. When a curing chamber is not available, pipes may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature -and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipes shall be entirely moist at all times.

b) Water Spray Curing

Under the conditions of enclosure prescribed in (i) above, pipes may be cured by subjecting them to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less that twenty one (21) degree C for a period of not less than seventy two (72) hours, or such additional time as may be necessary to meet the -strength requirements.

c) Saturated Cover Curing

The sides and top of each pipe may be covered with heavy Hessian or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than twenty one (21) degree C for seventy two (72) hours, or such additional time as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than twenty one (21) degree C, the curing period shall be increased as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe.

501.3.7 Workmanship and Finish

All pipes shall be substantially free from fractures, large or deep cracks, honeycombing, open texture, spells and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

501.3.8 Inspection

The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, test and approval at the place of manufacture. The Contractor shall make the necessary arrangements with the manufacturer to set aside in a separate area all pipes for which he desires approval.

a) Test Specimens

Pipes for the purpose of tests shall be furnished free of cost by the Contractor and will be selected at random by the Engineer. The number of sections required for test will not be more than two (2) percent except that at least one of every size will be selected. Pipes for tests shall conform to these specifications.

b) Test Equipment

If the manufacturer has equipment for conducting the crushing strength test, the Contractor shall make the necessary arrangements to have the required tests conducted in the presence of the Inspector designated by the Engineer. If the testing facilities are not available at the point of manufacture, the Contractor shall make the necessary arrangements for furnishing & testing, at no cost to the Employer, the pipe sections selected by the Inspector to a laboratory approved by the Engineer.

c) Re-test

Should any of the test specimens provided in accordance with the requirements listed in paragraph (1) above fail to meet the test requirements, the Contractor will be allowed a re-test on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all the these retested specimens meet the strength requirements.

501.3.9 Rejection

Pipes shall be subject to rejection on account of failure to conform to any of the above specification requirements or on account of any of the following:

1) Fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joints exists in more than ten (10) per cent of the pipes inspected, however, the defective pipes shall be rejected.

2) Defects that indicate imperfect mixing and molding.

3) Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.

4) Spalls deeper than one half the depth of the joint or extending more than ten (10) cm around the circumference. If spalls not deeper than one half of the joint or extending not more than ten (10) cm around the circumference exist in more than ten (10) per cent of the pipes, however, the defective pipes shall be rejected.

5) Misplaced reinforcement already exposed or verified by checking with an approved concrete reinforcement cover meter.

501.4 CONSTRUCTION REQUIREMENTS

501.4.1 Excavation

A trench shall be excavated to the depth and grade established by the Drawings. The bottom of the trench shall be shaped to conform to the shape of the pipe for at least twenty (20) percent of its outside diameter. The width of the trench shall not be greater than two (2) times the pipe diameter, to permit satisfactory jointing and thorough tamping of the bedding material specified in item 502 under and around the pipe. Recesses shall be excavated for any bells involved. Where rock or hardpan is encountered the trench shall be excavated to a depth at least (30) centimeters below the grade established for the bottom of the pipe. This excess depth shall be refilled with approved material and thoroughly compacted.

Where in the opinion of the Engineer, the natural foundation soil is such as to require stabilization, such material shall be replaced by a layer of suitable material. Where an unsuitable material (peat. mulch, etc.) is encountered at or below invert elevation during excavation, the necessary subsurface exploration and analysis shall be made and corrective treatment shall be as directed by the Engineer.

501.4.2 Placing Pipe

The pipe shall be laid carefully, bell up-grade, ends fully and closely Jointed, and true to the elevations and grades given. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench. Each section shall be securely attached to the adjoining sections by the method specified for the type of joint used. All joints, unless otherwise specified, shall be filled with stiff mortar composed of one part Portland cement and two parts sand. The mortar shall be placed so as to form a durable, watertight joint around the whole circumference of the pipe. After each section of pipe is laid and before the succeeding section is laid the lower portion of the bell shall be plastered thoroughly on the inside with mortar to such depth as to bring the inner surface of the abutting pipe flush and even. After the section is laid, the remainder of the joint shall be filled with mortar and sufficient additional mortar shall be used to form a bead around the outside of the joint. The inside of the joint shall then be wiped and finished smooth. After the initial set, the mortar on the outside shall be protected from the air and sun with a cover of thoroughly wetted earth or burlap. Any pipe, which is not true in alignment or which shows any undue settlement after being laid, or is damaged, shall be taken up and relaid or replaced without extra payment. All joints, including any connections, shall be capable of transferring the required shear across the point.

501.4.3 Backfilling

After the pipe has been installed and the mortar joints sufficiently set, granular material (sand) and / or selected material from roadway excavation or borrow shall be placed alongside the pipes in layers not exceeding twenty (20) cms in depth and compacted to minimum ninety five (95) percent of the maximum dry density determined as per AASHTO T-180 Method, so that on each side of the pipe there shall be thoroughly compacted material at least as wide as the external diameter of the pipe except insofar as undisturbed material obtrudes upon this width. Each layer shall be moistened, if dry, and then compacted by tamping with mechanical hammers or by hand tamping with heavy iron tampers to the densities as specified under item 108.3.1 -Formation of Embankment with Common Material. This method of filling and compacting shall be continued until the embankment has reached an elevation of twenty (20) cms above the top of the pipe. When construction calls for placing a high embankment over the pipes, special instructions regarding the method of back filling shall be given by the Engineer.

501.4.4 Construction Plant

Movement of Construction equipment, over a culvert shall be at the contractor's risk. Any pipe injured thereby shaft be repaired or placed at the contractor's cost.

501.4.5 Headwalls

Where indicated on the Drawings, the ends of the pipe culverts shall be protected by concrete or masonry headwalls constructed as shown on the Drawings. When headwalls are constructed, the ends of the pipe shall be neatly cutoff flush with the outside face of the headwalls.

ITEM 502 BEDDING OR ENCASEMENT OF CONCRETE PIPE CULVERTS

502.1 DESCRIPTION

This work shall consist of furnishing and placing granular material or concrete as specified in bedding and around concrete pipe culverts.

502.2 MATERIAL REQUIREMENTS

502.2.1 Granular Material/Sand

Granular material shall have grading requirement as per clause 107.2.2 (a) and for sand as per clause 107.2.2 (b).

502.2.2 Concrete

Concrete Class B shall be as specified in Item 401.

502.3 CONSTRUCTION REQUIREMENTS

The bedding material as specified in Items 502.2.1 and 502.2.2 shall be laid to the dimensions shown on the drawings for the types specified or directed by the Engineer; the top surface of which shall be accurately shaped by template to fit the surface of the concrete pipe culvert for at least twenty (20) percent of its outside diameter.

Granular material shall be deposited in layers not exceeding twenty (20) cms and shall be compacted to at least ninety-eight (98) percent of maximum dry density in accordance with AASHTO T-180, Method D. However sand shall be compacted to 74% of relative density as per ASTM D 4253/4254.

Concrete Class B shall be mixed, placed, finished and cured all in accordance with Item 401.

ITEM 503 UNDER DRAIN

503.1 DESCRIPTION

The work shall consist of furnishing and installing under drains complete in accordance with these specifications and to the width shown on the typical cross-sections or drawings.

503.2 MATERIAL REQUIREMENTS

503.2.1 Perforated Concrete Pipe

This pipe shall conform to the requirements of AASHTO M 175 or to ASTM C 444 for the specified diameters and strength classes.

503.2.2 Porous Concrete Pipe

This pipe shall conform to the requirements of AASHTO M 176 for the specified diameters.

503.2.3 Granular Backfill

Granular backfill for bedding and surrounding under drains shall be aggregate conforming to the requirements of Item 107.2.2 - Granular Backfill.

In order to avoid intrusion into the granular material of the in place surrounding earth material, it shall be required that the ratio:

$$\frac{D_{15}\text{ (Granular Material)}}{D_{85}\text{ (Surrounding Earth)}}$$ shall be less than 5

503.3 CONSTRUCTION REQUIREMENTS

503.3.1 Trench and Bedding

Trenches shall be excavated to the width, line and grade as shown in the Drawings; Unless shown otherwise on the Drawings, the depth shall vary from 0.7 to 1.4 meters below the bottom of a gutter or ditch when under drain is situated under a gutter or ditch, and to depths required for proper drainage, as determined by the Engineer. A bed of granular backfill, ten (10) cm thick, shall be spread, and compacted in the bottom of the trench throughout its entire length.

503.3.2 Placing Pipe and Backfilling

The pipe shall be embedded firmly in the bedding material, bells upgrade, ends fully entered in the adjacent bells and spot mortared to provide for centering of the pipe, but the joint shall not be closed to allow infiltration of water.

Perforated pipe shall be laid with the perforated length of the pipe on its underside.

After the pipe has been placed and approved by the Engineer, granular backfill as specified in Item 503.2.3 shall be placed around the drain for a thickness of at least thirty (30) cm and care shall be taken that no pipe is displaced. The upper portion of the trench shall then be filled with approved fine soil selected from structural, common or borrow excavation. All filling material shall be thoroughly compacted, to the satisfaction of the Engineer.

ITEM 504 HEADWALLS, WING-WALLS, PARAPETS, APPROACH SLABS, APRONS AND SIPHON INLETS/OUTLETS

504.1 DESCRIPTION

This work shall consist of construction of sections as mentioned in the Items above in concrete, brickwork or stone work for concrete pipe and other culverts and bridges shown on the Drawings.

504.2 MATERIAL REQUIREMENTS

504.2.1 Formwork

Formwork shall be in accordance with the requirements of design or as directed by the Engineer.

504.2.2 Steel Reinforcement

Quality of Steel reinforcement shall be in accordance with the material requirements of Item 404.

504.2.3 Concrete

Quality requirements of all materials for Concrete (plain and reinforced) of Class A_1, Class A_2, Class A_3, Class D, Class Y, Class B or lean concrete as specified on the Drawings and shall be in accordance with the material requirements of Item 401.

504.2.4 Brickwork

Quality of brick and other materials shall be in accordance with the requirements of Item 410.

504.2.5 Stone Work

Stone work shall be in conformity with item No. 412.

504.3 CONSTRUCTION REQUIREMENTS

504.3.1 Excavation

Excavation shall be in accordance with Item 107.3.1 and in conformity with the Drawings.

504.3.2 Granular Backfill

Granular backfill, if ordered in writing by the Engineer, shall be furnished, placed and compacted in accordance with Item 107.3.3.

504.3.3 Formwork

Formwork shall be supplied and fixed in the positions required for the concrete to be cast as shown on the Drawings and shall be erected and removed as directed by the Engineer.

504.3.4 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the Drawings. Furnishing, bending and fixing shall be in accordance with item 404.

504.3.5 Concrete

Concrete Class A_1, Class A_2, Class A_3, Class D, Class Y, Class B or lean concrete shown on the Drawings shall be supplied, placed, finished, and cured, as specified in Item 401.

504.3.6 Brickwork

Brickwork as shown on the drawings shall be supplied, placed and finished as specified in Item 410.

504.3.7 Stone Work

Stone work shall be constructed in conformity with item No. 412. 504.4.

ITEM 505 MANHOLES

505.1 DESCRIPTION

The work shall consist of the furnishing and erecting pre-cast or cast in situ concrete manholes of sizes shown in drawings with the necessary frames and covers constructed in accordance with these specifications and the specifications for the other work items involved and in conformity with the dimensions, lines, elevations and design shown in the Drawings.

505.2 MATERIAL REQUIREMENTS

505.2.1 Precast Concrete Units.

These units shall be cast to the dimensions shown on the drawings. Structural concrete shall be Class A_1 in accordance with Item 401. Reinforcement shall be used as per design drawings. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units shall not exceed seven (7) percent.

A sufficient number of cylinders shall be cast to permit compression tests at seven (7) and twenty-eight (28) days, and to allow for at least two cylinders for each test. If the strength requirement is met at seven (7) days, the units will be certified for use fourteen (14) days from date to casting. If the strength requirements are not met at 28 days, all units made from that batch will be rejected.

Cracks in units, honeycombed or patched areas in excess of two hundred (200) square centimeter, excessive water absorption, and failure to meet strength requirements will be cause for rejection.

505.2.2 Steel Reinforcement

Steel reinforcement shall be in accordance with the requirements of Item 404.

505.2.3 Frames, Grates and Covers, and Ladder Rungs

Metal units shall conform to the dimensions shown on the Drawings and to the following requirements for the designated materials.

Gray iron castings shall conform to the requirements of AASHTO M 105. Strength class shall be optional unless otherwise specified.

Carbon steel casting shall conform to the requirements of AASHTO M 103. Grade shall be optional unless otherwise specified.

Structural steel shall conform to the requirements of AASHTO M 193 or ASTM A 283, Grade B or better.

Grey iron items shall conform to AASHTO M 105.

Galvanizing, where specified for these units, shall conform to the requirements of AASHTO M 111.

Malleable iron castings shall conform to the requirements of AASHTO M 106. Grade shall be optional unless otherwise specified.

505.2.4 Mortar

Mortar shall be composed of one part Portland cement and two parts of fine aggregate, by volume unless otherwise specified and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Fine aggregate for mortar shall conform to requirements as specified in ASTM C-144.

505.2.5 Concrete

In case of cast in situ concrete manholes, concrete shall be of Class A_1 unless otherwise shown on the Drawings or as directed by the Engineer, and shall conform to the requirements prescribed for that particular class of concrete in Item 401. Forms of approved quality shall be used to give reasonable fair finish from inside, while rough form work may be allowed for outside finish. All other specifications shall be followed as per Item 401.

505.3 CONSTRUCTION REQUIREMENTS

505.3.1 Excavation

Excavation shall conform to the requirements of Item 107.

505.3.2 Backfill

Backfill shall conform to the requirements of Item 108, unless where granular backfill as specified in Item 107 is required by the Drawings or is specified in writing by the Engineer.

505.3.3 Concrete

Concrete construction shall conform to the requirements of Item 401.

505.3.4 Steel Reinforcement

Bending and fixing of steel shall conform to the requirements of Item 404.

505.3.5 Pre-cast Concrete Units

Pre-cast concrete units shall be erected in the positions shown on the Drawings, or as required by the Engineer.

During erection of the units outside of the manhole shall be finished smooth and the joints flushed full with mortar.

505.3.6 Connections

Sections of connection pipe shall be incorporated into the construction and placed at the elevation/direction and grade required. The inner ends of the pipe shall be flush with the inner faces of the walls.

505.3.7 Metal Frames

Metal frames shall be set oh full mortar beds or otherwise secured as shown on the Drawings and the frames, covers, and gratings shall be accurately set true to the line and elevation required to fit the adjoining surface as approved by the Engineer.

505.3.8 Cleaning

Upon completion each manhole - shall be thoroughly cleaned of any accumulation of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulations until final acceptance of the work.

ITEM 506 DROP INLETS AND CATCH BASINS

506.1 DESCRIPTION

This work shall consist of constructing concrete catch basins, and drop inlets including the furnishing of metal frames, grates and lids, and the necessary excavation and backfill in accordance with these specifications and the specifications for other work items involved and in conformity with the dimensions, elevations and design shown on the Drawings.

506.2 MATERIAL REQUIREMENTS

506.2.1 Steel Frames, Grates and Lids

Steel frames, grates and lids shall conform to the requirements of AASHTO M-105.

506.2.2 Concrete

Concrete shall be Class A_1.

506.2.3 Masonry

When so indicated on the plans or approved by the Engineer, brick or concrete block masonry may be used in lieu of concrete for the walls of catch basins or drop inlets as specified in Item 410, "Brick Masonry".

506.2.4 Steel Reinforcement

Quality of reinforcing steel if used in construction of catch basins shall be in accordance with the material requirements of item 404.

506.3 CONSTRUCTION REQUIREMENTS

506.3.1 Excavation and Backfill

Excavation and backfill shall conform to the requirements of Item 107 or 108 as the case may be.

506.3.2 Concrete Construction

Concrete of the specified class shall be supplied, placed finished and cured as specified in Item 401.

506.3.3 Connections

Inlet and outlet tile, sewer pipe and conduit for connections with such structures shall be of the same size, type and class as the tile, sewer pipe, and conduit with which connections are made and shall conform to the pertinent requirements therefore.

Pipe placed in concrete for inlet or outlet connections shall extend from the inside surface of the walls and beyond the outside surface of the walls a minimum distance of forty five (45) centimeters distance to allow for connections with conduits or sewers, and the concrete shall be carefully constructed around them so as to prevent leakage around their outer surface.

506.3.4 Frames, Grates and Lids

All frames shall be set on full mortar beds or otherwise secured as shown on the Drawings. Grates and lids shall be fitted or secured to the frames so that rocking or chattering will be eliminated.

The frames, grates and lids shall be accurately set so that the complete installation will be at the correct elevation required to fit the adjoining surface, the grates and lids shall not be in place while the adjoining concrete is struck-off and finished.

506.3.5 Cleaning

All catch basins and drop inlets shall be thoroughly cleaned of any accumulations of silt, debris, or foreign matter of any kind, and shall be kept clear of such accumulations until the final acceptance of the work.

ITEM 507 GABIONS

507.1 DESCRIPTION

This work shall consist- of wire-mesh gabions, furnished and placed in accordance with these specifications, and the specifications for the other work items involved, and at the locations and in conformity with the lines and grades shown on the Drawings. The work in general, covers gabions used for river and stream stabilization work, such as bank revetments, jetties, groins-deflectors, scour protection and retaining structures.

The complete unit of Gabion plus rock filled therein shall be called as “Mattress Cage Riprap-Gabions”.

507.2 MATERIAL REQUIREMENTS

507.2.1 General

Gabions shall be enclosed by galvanized steel wire mesh, which shall be supplied folded flat to facilitate transport and handling.

Gabions shall be furnished in accordance with the various lengths, widths and heights required by the Drawings, or as directed by the Engineer. If not otherwise required, all gabions shall be one meter in width. The lengths shall be multiples of 2, 3 or 4 times the width of the gabion and heights shall be three tenth (0.3), one half (0.5) or one (1) meter.

507.2.2 Wire

All wire shall be a good commercial quality of steel and size as per Drawings coated with a prime western speller or equal (AASHTO M 120) applied at a rate of not less than 0,8 ounces per square foot (0.25_Kg/Sq. M) of uncoated wire.

Uniformity of coating shall withstand ten (10) one-minute dips by the Preece Test in accordance with AASHTO T-66. "Uniformity of Coating by the Preece Test (Copper Sulphate Dip) on Zinc Coated (Galvanized) Iron or Steel Articles". Wire mesh snail withstand 220 hours of exposure before failure by rusting of any part when subjected to a salt spray test in accordance with ASTM B 117.

The tensile strength of the wire shall be in the range of four thousand (4,000) to six thousand (6000) kg. / sq. cm. and shall have an elasticity to permit elongation of the mesh equivalent to a minimum of ten (10) % without reducing the gauge or tensile strength of the wire.

The minimum size of the wire used in fabrication of the gabion baskets shall be as follows:

	Diameter (mm)	**US Steel Wire Gauge**
Body Wire	2.3	**11**
Selvedge or Perimeter Wire	2.8	**9**
Tying and Connecting Wire	1.95	**13**

507.2.3 Fabrication

Gabions shall be in the form of rectangular baskets of the required dimensions and shall

be manufactured from wire as specified above. Gabions shall be made of steel wire triple twisted forming a uniform hexagonal mesh pattern with openings eight (8) cm by ten (10) cm or by twelve (12) cm. The edges shall be formed into securely connected selvedges adequate to prevent raveling. Individual basket ties and connections shall be made by using a quantity of wire not less than 8 percent of the weight of each basket.

When the gabion length exceeds its width, it shall have securely tied diaphragms connected at all edges to form individual cells of equal length and width. Diaphragms shall be of the same material and manufacture as specified above for the gabions.

Four cross-connecting wires shall be provided in each cell having a height of one half the width or less, and eight (8) cross-connecting wires shall be provided in each cell having a height greater than one half the width.

All the characteristics, values and figures given in the above specifications are subject to the tolerance of plus or minus five (5) percent.

507.2.4 Rock Fill

Fill for gabions shall consist of hard, durable rock pieces that will not deteriorate when submerged in water or exposed to severe weather conditions. Rock pieces shall be generally uniformly graded in sizes ranging from ten (10) cm to twenty (20) cm. Filled gabions shall have a minimum density of one thousand three hundred sixty (1,360) kg per cubic meter. Void spaces shall be evenly distributed and shall not exceed a maximum of thirty (30) percent.

The rock shall meet the requirements of AASHTO M 63 except that the Sodium Sulphate Soundness Loss shall not exceed nine (9) % after five (5) cycles.

507.3 CONSTRUCTION REQUIREMENTS

Installation shall be performed in a workmanlike manner as approved by the Engineer. Beds for gabions shall be suitably level. Gabions fanning elements of structures shall be securely connected along the complete length of top contact edges by means of the above specified tying and connecting wire.

Before the rock fill is placed the gabions shall be stretched in such manner as will permit proper shape, alignment and compaction of fill.

Rock fill for exposed faces of gabions walls shall be carefully selected for uniformity or size, and the pieces shall be hand placed to provide a neat appearance as approved by the Engineer.

The vertical joints of gabion baskets shall be staggered as in running bond brickwork.

“Working drawings” according to AASHTO-Standard Specifications for Highway Bridges (2002) - Division II - Section 22 will be submitted to the Engineer for approval, before fabrication and installation.

ITEM 508 BRICK PAVING

508.1 DESCRIPTION

This item shall consist of one or more layers of bricks laid over thin layer of spread sand and the joints filled with sand with suitable bonding, over prepared shoulder or embankment slopes.

508.2 MATERIAL REQUIREMENTS

508.2.1 Bricks

Quality of bricks shall meet the Material Requirements as specified in Item 410 or as approved by the Engineer.

508.2.2 Sand

Sand used in this work for bed or joints shall be medium to fine sand.

508.3 CONSTRUCTION REQUIREMENTS

508.3.1 Shoulder

The shoulders shall be properly leveled as directed by the Engineer before commencement of work on this item.

508.3.2 Embankment Slopes

These shall be cut and dressed to dense slopes according to specified line and grade as per Item 108, or as directed by the Engineer before commencement of this item.

508.3.3 Stacking of Bricks

The bricks shall be delivered at site in stacks of ten courses high and two bricks thick for the convenience of proper inspection.

508.3.4 Placing of Bricks

A thin layer of sand, at least 1" (25 mm) in thickness, shall be spread over dressed shoulder or slope to facilitate. neat dressing of bricks. The bricks shall be laid closely packed in parallel rows transverse to the center line and/or as directed by the Engineer at site. The bricks shall be laid on edge, in one (1) or two (2) courses as called for in the plans. If more than one (1) course is to be laid the joints in the successive courses will be staggered. Each course shall be properly rolled and joints filled with sand or approved local soil before laying the next course.

ITEM 509 RIPRAP AND REINFORCED CONCRETE SLOPE PROTECTION

509.1 DESCRIPTION

This work consists of furnishing and placing a protective covering of erosion resistant material as riprap or reinforced concrete slope protection on the locations shown on the plans for slopes or pier foundation protection. The work shall be done in accordance with the specifications and conformity with the lines, grades, thickness and typical cross-sections shown on the plans.

The areas to receive riprap or slope protection of any kind shall be dressed smooth to the slopes or shapes called for on the plans and shall be free from stumps, organic matter, or waste material. A filter blanket should be provided where it is anticipated that there may be migration of fines through the riprap. Toe trench and/or filter blanket is to be constructed, as directed by the Engineer.

All materials, regardless of type or kind, shall be placed as per lines and levels called for on the Drawings.

509.2 MATERIAL REQUIREMENTS

509.2.1 Stones

Stone for riprap shall consist of field stone or rough unhewn quarry stone as nearly rectangular in section as is practical, except that riprap of Class A shall consist of round natural stones. The stones shall be sound, tough, durable, dense, resistant to the action of air and water, and suitable in all respects for the purpose intended. Samples of the stone to be used shall be submitted to and approved by the Engineer before any stone is placed. The minimum apparent specific gravity shall be two and half (2.5) and water absorption shall not exceed six (6) percent for stones to be used in riprap. The stone shall not have an abrasion loss greater than forty five (45) percent when subjected to five hundred (500) revolutions in a Loss Angeles Abrasion test.

Stones for riprap shall be one of the following classes as shown on the Drawings or determined by the Engineer:

Class A: Stones ranging in weight from a minimum of fifteen (15) Kg to a maximum of twenty five (25) Kg, with at least 50 percent by weight of the stones weighing more than twenty (20) kg.

Class B: Stones ranging in weight from a minimum of thirty (30) kg to a maximum of seventy (70) kg, with at least fifty (50) percent by weight of the stones weighing more than fifty (50) kg.

Class C: Stones ranging in weight from a minimum sixty (60) kg to a maximum of one hundred (100) kg, with at least 50 percent by weight of the stones weighing more than eighty (80) kg.

Sound pieces of broken concrete obtained from the removal of bridges culverts, and other structures may be substituted for stone upon approval by the Engineer.

509.2.2 Filter Material

The grading of the filter material shall be as specified on the drawings or in the Special Provisions. If not otherwise specified, it will be required that D15 of the filter is at least 4 times as large as D15 for the underlying embankment materials, and not more than 4 times the D85 for the embankment material.

Where: D15 and D85 are the particle diameters corresponding to fifteen (15) percent and

eighty five (85) percent respectively, passing (by weight) in a grain size analysis.

509.2.3 Portland Cement

Portland cement shall conform to the requirements of AASHTO M 85.

509.2.4 Fine Aggregates

Fine aggregates for mortar shall conform to the requirements of AASHTO M 45.

509.2.5 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the drawings. Furnishing, bending and fixing shall be in accordance with Item 404.

509.2.6 Concrete

Concrete of specified Class shown on the Drawings shall be supplied, placed, finished and used as indicated in item 401.

509.2.7 Water

Water for concrete and mortar of ratio 1:3 shall conform to Item 401.2.7.

509.3 CONSTRUCTION REQUIREMENTS

509.3.1 Excavation

The bed for the riprap shall be excavated to the required depths and compacted, trimmed and shaped to the entire satisfaction of the Engineer or as shown on the plans.

The riprap shall be set in a toe trench as shown on the Drawings. The toe trench shall be filled with stone of the same class as the one specified for the riprap, unless otherwise specified. All toe trenches and excavations shall be approved by the Engineer with firm sub-grade or base prior to placement of stones. Stones shall be placed so as to provide minimum of voids. Larger stones shall be placed in the toe trench and on the outside surface of the slope.

509.3.2 Placing

Stones placed below water line shall be distributed so that the minimum thickness of the riprap is not less than that specified.

Stones above the water line shall be placed by hand. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. The stones shall be laid perpendicular to the slope with ends in contact. The riprap shall be thoroughly compacted as construction progresses and the finished surface shall present an even, tight surface. Interstices between stones shall be chinked with spalls firmly rammed into place.

Unless otherwise provided, riprap shall have the following minimum thickness, measured perpendicular to the slope:

Class A: 20 cm

Class B: 45 cm

Class C: 60 cm

The surface of riprap placed above the water line shall not vary from the theoretical surface by more than 8 cm at any point.

509.3.3 Loose Riprap

The loose riprap shall be placed in layers manually or other methods approved by the Engineer, all to secure a stable mass. Surface irregularities of the slope shall not vary more than eight (8) centimeters along the intended slope. After the completion and approval of the riprap placement, the surface voids of the riprap in the footing trench and on the lower portions of the slope shall be filled with excavated material and dressed to the satisfaction of the Engineer.

509.3.4 Grouted Riprap

Grouted Riprap shall be placed over a bedding of five (5) centimeter thick cement sand (1:3) mortar placed on embankment slope specified for protection as shown on the Drawings and or as directed by the Engineer

Stone for this purpose shall, as for as practicable, be selected of the size and shape so as to secure fairly large, flat surfaced stone which will lay up with a true and even surface and a minimum of voids. The stones shall be placed first and roughly arranged in close contact, the larger stones being placed near the base of the slope, the spaces between the larger stones shall be filled with stones of suitable size, leaving the surface smooth, reasonably tight, and conforming to the contour required. In general, the stone shall be laid with a degree of care that will ensure for plane surfaces a maximum variation from a true plane of not more than three (3) percent. Warped and curved surfaces shall have the same general degree of accuracy as specified above for plane surface.

As each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with grout consisting of one (1) part of Portland Cement and three (3) parts of fine aggregates, and one-fifth (1/5) part of hydrated lime with sufficient water to produce a plastic mix and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface, and ensuring that each stone is carefully and firmly bedded laterally. Mortar shall not be placed in temperature lower than five (5) degree C. During hot, dry weather the work shall be protected from the sun and kept moist for a minimum of 3 days after placement. Stones shall be kept wet during placing of the mortar.

After the work has been completed as above described, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints shall then be roughly pointed up either with flush joints or with shallow, smooth raked joints.

Weep holes shall be provided through the riprap cover as shown on the plans or as directed by the Engineer.

509.3.5 Reinforced concrete slope protection

The slopes with suitable material shall be prepared with appropriate compaction to form a sub-grade approved by the Engineer and formwork shall be completed accordingly.

After furnishing and fixing the steel reinforcement, reinforced concrete slope protection "shall be constructed after light spray of water at the locations shown on the plans or where directed by the Engineer. Placing and finishing of concrete shall conform to the requirements specified in Item 401.

ITEM 510 DISMANTLING OF STRUCTURES AND OBSTRUCTIONS

510.1 DESCRIPTION

This work shall consist of dismantling, removal, wholly or in part and satisfactory disposal of broken material from buildings, fences, bridges, culverts, drainage facilities at different locations and any other obstructions which are not designated or permitted to remain on those sections of existing highways except for the obstructions to be removed and disposed of under other items in the contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, pits and ditches,

510.2 CONSTRUCTION REQUIREMENTS

General

Engineer shall specify the extent of dismantling for each structure and the contractor shall raze, remove and dispose of all remains of all those dismantled structures and other obstructions any portion of which are on the right of way, except utilities and those for which other provisions have been made for removal. All designated useable material shall be removed, without unnecessary damage, in sections or pieces, which may be readily transported, and shall be stored by the contractor at specified places with in the project limits. Unusable perishable material shall be destroyed. Non-perishable material may be disposed of outside the limits of view from the project with written permissions of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by structural removal shall be filled to the level of the surrounding ground and, if within the prism of construction shall be compacted to the required degree of compaction designated on the plans for roadway embankment and as specified in Item 108.3.1.

Salvaged pipe, reinforcements, steel/metallic, structural items from culverts and or other structures shall be stored at designated and accessible points on the project as approved by the Engineer and shall be the property of the client. Dismantling shall be carried out either manually or with approved equipments. Structures to be dismantled may include plain or reinforced concrete, brick, stone masonry or any other such construction item.

The Contractor shall be responsible for watch and ward of removed and dismantled material under this item and safe custody up to two months for its final disposal as directed by the Engineer/Employer's representative.

510.2.1 Removal of Bridges, Culverts and other Drainage Structures

Concrete Bridges, culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. Unless otherwise directed, the sub-structures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed thirty (30) centimeters below ground surface. Where such portions of existing structures are wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure. Steel bridges and wood bridges as designated on the plans, shall be carefully dismantled without unnecessary damage. Steel members shall be match marked, unless such match marking is waived by the Engineer. All -salvaged material shall be stored as previously specified.

Blasting or other operations necessary for the removal or dismantling of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work.

510.2.2 Removal of Pipes

Unless otherwise directed all pipes shall be carefully removed and every precaution taken

to avoid breaking or damaging the pipe. The contractor shall be held responsible for the satisfactory removal of such structures in a usable condition. In case these provisions are violated, due to the Contractor's negligence, all material to be salvaged which is damaged in dismantling / removal to impair its future use will be charged to the contractor at sixty (60) percent of the current quoted price, delivered to the project, of an equal amount of new material. This amount of money shall be deducted from any money due or to become due to contractor.

510.2.3 Fences, Boulders, Stone Piles

Stones, fences, piles of stones or boulders of size greater than one-quarter (1/4) cubic meter in volume which lie within the limits of the work as shown on the plans, or which fall within the approved cross sections shall be removed and disposed of as directed.

When fences enclosing pasture land or farm land are to be removed, the Contractor shall notify the property owner sufficiently in advance to permit the owner reasonable time to construct supplemental fences or make other arrangements.

510.2.4 Wells

Existing wells, abandoned or active, which lie within the limits of the Work as shown on the plans, or which fall within the approved cross sections or as directed by the Engineer shall be dismantled, backfilled and compacted. The Contractor shall carefully remove all salvageable material and store it at a location on site designated by the Engineer. Unless otherwise noted or directed, all salvageable material shall become the property of the Client. Wells shall be filled to the level of the surrounding ground and, if within the prism of construction, shall be compacted to the type of compaction within the moisture range designated on the plans for roadway embankment and as specified in Item 107. No dismantling or backfilling of a well shall be done by the Contractor without the prior approval of the Engineer.

No separate payment for dismantling or backfilling wells shall be made, the costs being considered subsidiary to other items listed in the Bill of Quantities, except that the compacted backfill required for wells will be paid for as per applicable item of backfill material.

510.2.5 Removal and disposal of existing Sign Boards

Existing Sign Boards shall be carefully removed and every precaution taken to avoid breaking or damaging the sign boards. The removed material shall be handed over to the Employer and stocked at designated location and or disposed of as directed by the Engineer.

ITEM 511 STONE PITCHING

511.1 DESCRIPTION

Where shown on the Drawings, this work shall consist of furnishing hand-set pitching laid dry or grouted to stabilize slopes or as a protection against water or other erosion to form a flat or cured surface as directed by the Engineer. All materials regardless of type or kind shall be placed as per the lines and levels called for on the plans.

511.2 MATERIAL REQUIREMENTS

511.2.1 Stones

The stones shall comprise good, hard and durable broken boulders or pieces of rock. These shall be sound, dense, resistant to the action of air and water and suitable in all respects for the purpose intended. Stones of class I or II shall be used in pitching, shall conform to the following specifications. The depth of the stones and their weight shall be as under:

Class I

Stones ranging in weight from a minimum of fifteen (15) Kg to a maximum of twenty five (25) Kg with at least fifty (50) percent by weight of the stones weighing more than twenty (20) Kg. The depth of the stones shall generally be from twenty (20) cm to twenty five (25) cm and shall be used for heavy pitching to culvert or bridge ends and approaches, Wadi diversions, protection for structures, revetment to slopes and where directed.

Class II

Stones ranging in weight from a minimum of ten (10) Kg to a maximum of fifteen (15) Kg with at least fifty (50) percent by weight of the stones weighing more than twelve (12) Kg. The depth of the stones shall vary from fifteen (15) cm to twenty (20) cm and shall be used for lighter pitching where directed to ditches, beams, dykes etc.

511.2.2 Portland Cement

Portland cement shall conform to the requirements of AASHTO M 85.

511.2.3 Fine Aggregates

Fine aggregates for mortar shall conform to the requirements of AASHTO M-45.

511.2.4 Water

Water for cement sand mortar shall be as specified in Item 401.

511.3 CONSTRUCTION REQUIREMENTS

511.3.1 Dry Pitching

The bed upon which pitching shall be laid, shall be firm or compacted of approved granular material of specified thickness and to the required grades and lines as shown on the plans or as directed and approved by the Engineer. The stones shall comprise roughly dressed and shaped, set on their edges with their longest dimension at right angles to the flow of water. These shall be securely bedded, breaking bond closely packed with any interstices locked and filled by selected stone spalls hammered in. The loose pitching specified in plans shall be placed by dumping and spreading in layers by hand or other methods approved by the Engineer all to secure a stable mass. The ends

of pitched areas shall be protected from undermining by the use of edge stones at least twice the general size and weight set on end. In large or slope areas of pitching, key stones shall be provided at the rate of one per square meter, at least one and a half times the general size and weight, set on end.

The pitching to the batters of the earth works and diversions of waterways shall be carried down in trench to such a depth as will ensure a sound footing for the lowest course. Subsequent to pitching the trench shall be backfilled to normal ground level with approved, well compacted suitable material.

511.3.2 Grouted Pitching

Specified stones shall be arranged in such a way that the largest stones are at the base of the slope. The surfaces of the rock shall be cleaned of adhering dirt and clay and shall be moistened. Stone in the bottom courses and to a vertical height and thickness as per plans shall be carefully arranged by hand to interlock and so as to yield true and even surface with minimum voids and conforming to the contour required. Pitching laid in cement mortars of 1:3 shall be furnished in panels with weep holes, the joints between panels being approximately two (2) cm in thickness and extending the full depth of the pitching. The joints shall be filled with sand bitumen mixture consisting of approximately one part by weight of bitumen heated as necessary to two parts by weight of a clean sharp sand. The dimensions of the panels shall be approximately two meters square but the precise dimensions in any instance and the spacing of the weep holes shall be as required by the Engineer. In laying the pitching the lines of the panel joints shall be picked out with a straight fillet laid on the face of the earth works and the stones set up carefully to the edge of the fillet. Subsequent to laying the pitching the fillet shall be removed and the joint caulked with the sand bitumen mixture as above. The exposed surface of the stones shall project not less than four (4) centimeters and not more than eight (8) centimeters of the grout surface. The grouted stone pitching shall be cured by an approved method for a minimum period of four (4) days and after expiration of the curing period, the exposed surfaces shall be cleared of all curing mediums.

ITEM 512 DITCH LINING AND WASH CHECKS

512.1 DESCRIPTION

This work shall consist of the construction of stone or concrete ditch and/or wash checks, in accordance with the specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

512.2 MATERIAL REQUIREMENTS

Material shall conform to the requirements specified in the following items.

512.2.1 Concrete

Concrete for ditch lining and wash checks shall be as specified in item 401.

512.2.2 Reinforcing Steel

Reinforcing steel shall be as specified in Item 404.

512.2.3 Stone and Mortar

Stone and mortar for grouted stone ditch lining or grouted stone wash checks shall be as specified in Item '509 for Riprap and reinforced concrete slope protection.

512.3 CONSTRUCTION REQUIREMENTS

512.3.1 Excavation

The sub-grade for the ditch lining or wash checks shall be excavated to a smooth surface parallel to the proposed finished surface and to a depth sufficient for the full thickness of the lining or wash checks as shown on the drawings. Unstable sub-grade material shall be removed and replaced with suitable materials as approved by the Engineer.

512.3.2 Concrete Ditch Lining and Wash checks

Concrete ditch lining and wash checks shall be constructed of Class A_1 concrete. The composition, consistency, proportioning, mixing, and protection of the concrete shall conform to the requirements of item 401. Placement of concrete for ditch lining shall begin at the lower end of the portion of the ditch to be lined and progress toward the upper end.

If shown on the plans, the concrete shall be reinforced with the type of reinforcement and in the manner indicated. Contraction or construction joints shall be spaced and formed as indicated in the plans.

The surface shall be finished with a wooden float. Bridges for Workmen shall be used to avoid walking in the freshly laid concrete.

Immediately after the finishing operations are completed, the concrete shall be protected and cured in a manner as approved by the Engineer.

512.3.3 Stone Ditch Lining and Stone Wash Checks

a) Stone Ditch Lining

The stones shall be placed in rows transversely to the centerline of the ditch in the

manner indicated on the plans. The stones shall be placed with ends and sides abutting and the joints between stones in each row breaking with the joints in the preceding row. The larger spaces between stones shall be filled with spalls. The stones shall be rammed or compacted to give them firm bearing and stability.

b) Stone Wash Checks

The stones for wash checks shall be laid to form a structure of the dimensions shown on the plans. The sides and ends of the stones shall be in contacts much as the sizes and shapes of the stones will permit. Spalls shall be rammed into the larger spaces between stones to form a solid wall. Joints between stones in one row shall break with joints between stones in the adjacent rows.

Stone wash checks may be substituted with concrete wash checks, constructed by class A concrete, if approved by the Engineer at no extra cost to the contractor or client.

c) Grout

After the surface has been inspected and approved, the spaces between stones shall be completely filled with a grout composed of one (1) part of Portland cement and three (3) parts of fine aggregate mixed with sufficient water to produce a plastic mortar. The grout shall be brushed or broomed into the spaces to ensure proper filling.

The grout shall be cured in the manner as provided for "Grouted Riprap" in Item 509, "Riprap and Reinforced Concrete Slope Protection."

ANCILLARY WORKS

ITEM 600 G E N E R A L

This section shall consist of items of work which are ancillary or incidental to the other parts of the General Specifications. Such works shall include general items, precast concrete posts and Right of Way markers, traffic control devices, side walks, guard rails, detours, traffic signs, pavement marking, reflectors, fencing and brick edging, wire rope safety fence for median, rumble strips, weigh stations, toll plazas, ETC System, emergency median openings, police hut, rest areas and lay-bys etc., in accordance with these specifications and in conformity with the lines, grades sections dimensions and locations in the plans or as required by the Engineer.

This section deals with those items of work in which small elements of construction employ construction items such as concrete, brick work, stone masonry, steel reinforcement or structural steel. These items of work have been separately quantified so that contractor can price them by assessing size of each element and extra effort which is essential in addition to the specification requirement of the parent item.

Manufactures of items such as Metal guard rails, traffic road signs and safety devices, pavement markings, reflectorised pavement studs, and other such fixtures shall meet the requirements of ISO - 9001 for which certificates of manufacturers and supplies shall be produced.

ITEM 601 CONCRETE KERBS, GUTTERS AND CHANNELS

601.1 DESCRIPTION

This work shall consist of kerb, gutter, channel, or combination of kerb and gutter or channel; constructed of the following materials and in accordance with the specifications at the location and of the form, dimensions and designs shown on the Drawings or as directed by the Engineer. The kerb, gutter, channel or in combination may be constructed by one of the following methods:

i) Cast in place concrete kerbing.
ii) Precast concrete kerbing.
iii) Extruded concrete kerbing.

601.2 MATERIAL REQUIREMENTS

The concrete for cast in place concrete kerbs, gutters and channels shall be Class "A_1" or as indicated on the Drawings and shall conform to the requirements of that particular class prescribed under item 401.1.1 "Classes of Concrete". An air entraining agent, if required, shall be added during mixing an amount to produce five (5) to eight (8) percent air by volume in the mixed concrete.

Precast concrete kerbing units shall consist of Class "A_1" concrete conforming to the requirement of item 401 and to lengths, shape and other details shown on the Drawings. Kerbing which shows surface irregularities of more than five (5) mm when checked with three meter straight edge or surface pits more than fifteen (15) mm in diameter will be rejected.

Forms to hold the concrete shall be built and set in place as described under item 403-Formwork.

Forms for at least sixty meters of kerb or combination of kerb and gutter or channels shall be in place and checked for alignment and grade before concrete is placed. Curved sections shall have forms of either wood or metal and shall be accurately shaped to radius of curvature shown on the Drawings. Steel Reinforcement if required shall conform to item 404 "Steel Reinforcement".

Expansion joint filler shall be either the performed type conforming to requirement of AASHTO-M 153 or shall be precast fiber board packing.

Joint filler shall consist of one part cement and two parts of approved sand with sufficient quantity of water necessary to obtain the required consistency. The mortar shall be used within thirty (30) minutes after preparation.

The Bonding compound when used shall conform to AASHTO M-200.

601.3 CONSTRUCTION REQUIREMENTS

All types of Kerbs, gutter, channel or combination thereof shall be placed to line, level and grade as shown on the plans or/and directed by the Engineer. The allowable tolerance shall not be more than 12 mm in line (plan-horizontal alignment) and not deviate at any location from a straight edge by more than 3mm in three meters.

601.3.1 Cast-in-Place

Cast-in-place concrete kerb shall be used for radii 12 m or less.

a) Excavation and Bedding

Excavation shall be made to the required depth and the base upon which the kerb or combination of kerb and gutter is to be set shall be compacted to a minimum density of ninety five (95) percent of the maximum dry density as determined by AASHTO T-180 Method. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Where directed by the Engineer, a layer of cinders or clean sand and gravel, or other approved porous material having a minimum compacted thickness, of fifteen (15) cm shall be placed to form a bed for the kerb or combination of kerb and gutter.

b) Placing Concrete

Concrete may be placed in the gutter to the full depth required. The top of the kerb or combination of kerb and gutter shall be floated smooth and the edges rounded to the radii shown on the Drawings. Before finishing, the surface of the gutter shall be tested with a three (3) meter straight-edge and any irregularities of more than five (5) mm in three (3) meters shall be eliminated. In finishing concrete only mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

c) Joints

The kerb and gutter shall be constructed in uniform sections of not more than twenty five (25) meters in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints of the concrete pavement or for closures but no section shall be less than two (2) meters long. The sections shall be separated by sheet templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately five (5) mm in thickness, of the same width as that of the kerb or kerb and gutter and not less than five (5) cm greater than the depth of the kerb or kerb and gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. When pre-cut fiber-board packing is used in the expansion joints it may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber 6oard shall be pre-cut to the shape of the kerb so that its outer edge will be flush with the abutting kerb.

Expansion joints shall be formed in the kerb and gutter at intervals of six (6) to ten (10) meters in order to coincide with the expansion joints of cement concrete pavement or as shown on the Drawing.

d) Dowels at Expansion Joints in Channels

At expansion joints in channels and in the channel portion of kerbs and channel built monolithically, painted dowel bars with slip sleeve shall be provided as a load transfer medium at locations shown on the Drawings.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the gutter and accurately at right angles to the expansion joint.

e) Contraction Joints

Transverse contraction joints shall be provided opposite to all contraction joints in abutting concrete pavement and other locations shown on the Drawing spaced to a maximum of four (4) meters.

The contraction joints shall be provided by forming grooves in the face and surface of

structure at right angle to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section, five (5) cm deep by five (5) cm wide. The grooves shall be formed in the top of all kerbs and in the exposed roadway face of kerb and in the channel surface of monolithic type kerb and channels and in the surface of channels. The edges of the joints shall be tooled and the joints shall be left clean, neat and of specified width and depth.

f) Removal of Forms and Finishing

The forms shall be removed within twenty four (24) hours after concrete has placed except that the. form used against the face of the kerb in a combination of kerb and gutter shall be removed as soon as the concrete has set sufficiently to hold its shape. Minor defects shall be repaired with mortar containing one part of Portland cement and two parts of the fine aggregate. Plastering shall not be permitted on the face of a kerb or kerb and gutter and all rejected kerb or gutter shall be removed and replaced without additional compensation. All surfaces which will be exposed in the finished construction of the kerb and gutter shall be finished, while the concrete is still "green" by wetting a wood block of float and rubbing the surface until they are smooth.

g) Curing

During seventy two (72) hours following placing of concrete, the kerbs, channels and gutters shall be protected against premature drying by covering with suitable cotton or Hessian mats and by frequent sprinkling with water, with liquid forming compounds or with waterproof paper or by any other method as mentioned in section 401.3.8-Curing Concrete and approved by the Engineer.

h) Backfilling

After forms have been removed and concrete has been cured as specified, the excavation of kerbs, gutters or channels shall be backfilled with suitable earth or granular material tamped into place in layers of not more than fifteen (15) cms each until firm and solid.

601.3.2 <u>Precast</u>

a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with a suitable material acceptable to the Engineer.

Bedding shall consist of Lean Concrete conforming to the requirements of Item 401 and shall be to the section and dimension shown on the Drawings.

b) Placing

The precast concrete kerbs shall be set in 1:3 of cement sand mortar 20 mm thick to the line, level and grade as shown on the Drawings or as directed by the Engineer.

c) Joints

Joints between consecutive kerbs shall be three (3) to five (5) mm wide and filled with cement mortar to the full section of the kerb.

d) Back-filling

Backfilling shall meet the requirements of Item 601.3.I (h).

601.3.3 Extruded Concrete Kerbing and Channels

a) Excavation and Bedding

Excavation and bedding shall conform to the requirements as described under Item 601.3.1(a).

b) Placing

Concrete shall be fed to the machine at a uniform rate. The concrete shall be of such consistency that after extrusion it will maintain the shape of the kerb section without support and shall contain the maximum amount of water that will permit this result. The machine shall be operated under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete which requires no further finishing other than light brushing with a brush filled with water only.

The forming tube portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the kerb being placed and the established kerb grade as indicated by an offset guide line.

The top end face of the finished kerb shall be true and straight and the top surface of the kerb shall be of uniform width, free from bumps or surface pits larger than fifteen (15) mm in diameter. When a straight-edge three (3) meters long is laid on the top or face of the kerb. or surface of the gutter, the surface shall not be more than five (5) mm from the edge of the straightedge except at grade changes or curves.

Where adhesive is used to bond the kerb to an existing pavement, the surface shall be first thoroughly cleaned of all dust, loose material and oil, the cost of which shall be included in other items of work.

c) Joints

Expansion joints shall be constructed by sawing through the kerb section to its full depth. The width of the cut shall be such as to admit the joint filler with a tight fit. Preformed joint filler shall conform to the provisions of Item 601.2 and shall be inserted and mortared in place.

If sawing is performed before the concrete has hardened, the adjacent portion of the kerb shall be supported firmly with close fitting shields and the operations of sawing and inserting the joint filler shall be completed before curing the concrete.

Alternatively pre-cut joint fillers shall be permitted to be placed at the location of the expansion joints prior to the placing of the extruded kerb with the approval of the Engineer. The joint fillers shall be set firmly in place in a vertical position to the line and grade of the kerb profile.

d) Curing and Backfilling

Curing and backfilling shall be as described in Items 601.3.1(g) and 601.3.1(h).

ITEM 602 ASPHALT CONCRETE AND CEMENT CONCRETE SIDEWALK

602.1 DESCRIPTION

This work shall consist of the construction of sidewalks which can be asphalt concrete, plain Portland cement concrete, or precast Portland cement concrete slabs (450x450) mm or smaller or interlocking concrete blocks all in accordance with these specifications and to the line, grade, levels and dimensions shown on the Drawings or as required by the Engineer.

602.2 MATERIAL REQUIREMENTS

602.2.1 Cement Concrete

The Concrete shall be Class A_1 as indicated on the drawings and in accordance with Item 401.1.1.

602.2.2 Asphalt Concrete

Asphaltic concrete shall conform to the requirements of Item 305 - Asphalt Concrete Wearing Course - for Class B mixture.

602.2.3 Expansion Joint Filler

Unless otherwise directed the joint filler shall have a thickness of five (5) mm and conform to the requirements of Item 601.2.

602.2.4 Forms

Forms shall be of wood or metal as approved by the Engineer and shall extend to the full depth of the concrete. All forms shall be straight, free from warp and of adequate strength to resist bending.

602.2.5 Bed Course Material

Bed course material shall consist of cinders, sand, slag, gravel, crushed stone or other approved materials of such gradation that all particles will pass through a 1/2" (12.5 m) sieve.

602.2.6 Asphaltic Prime Coat

Asphaltic prime coat material shall conform to the requirements of Item 301 for Cut-back/Emulsified Asphalt.

602.3 CONSTRUCTION REQUIREMENTS

602.3.1 Asphalt Concrete Sidewalk

a) Excavation

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms The foundation shall be shaped, and compacted to minimum ninety five (95) percent of the maximum dry density as determined by AASHTO T-180 Method. The surface shall be even conforming to the section shown on the drawings. All soft material shall be removed and replaced with acceptable material.

b) Placing of Bed Course Material

The bed course material shall be compacted in layers not exceeding ten (10) • cm, to the depth shown on the drawings and to the line and grade of the finished sidewalk surface.

c) Priming the Bed Course Material

The prepared bed course material shall receive an application of prime coat in accordance with the requirements of. Item 302 and approved by the Engineer.

d) Placing the Asphalt Concrete

The asphalt concrete shall be placed on the previously primed prepared bed only when, in the opinion of the Engineer the bed is sufficiently dry and .weather conditions are suitable. The mixture shall be placed on one or more courses of uniform thickness as shown on the Drawings. Each course shall be smoothed by raking or screeding and shall be thoroughly compacted by rolling with a hand operated roller or a type satisfactory to the Engineer. After compaction, the surfacing shall be of the thickness and section shown on the Drawings, shall be smooth, even and of a dense and uniform texture. Forms, if used, shall be removed and the shoulders shaped and compacted to the required section.

602.3.2 Cement Concrete Sidewalk

a) Excavation

Excavation shall meet the requirements of Item 602.3.1 (a).

b) Placing of Bed Course Material

Where indicated on the drawings the bed course material shall be placed in accordance with Item 602.3.1 (b).

c) Forms and Expansion Joints

All forms shall be staked securely in position at the correct line and elevation.

Expansion joint filler shall be set in the position shown on the Drawings before the placing of the concrete is started. The joint filler shall be placed 5 mm below the top surface of the finished sidewalk.

d) Placing the Cement Concrete Material

The mixing, placing, finishing, and curing of concrete shall be as provided under Item 401-Concrete.

Before the concrete has set, the surface of the concrete shall be trawled until it is of uniform smoothness and is true to the lines, elevations, and surface required.

The surface shall be cut through to a depth of one (1) cm with a trowel at intervals of one (1) meter or where required, in straight lines perpendicular to the edge of the sidewalk. The surface shall then be brushed. The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges to a one and half ($1^1/_2$) centimeters radius.

e) Precast Elements

Precast concrete slabs or interlocking concrete blocks shall be set on the bed course material where indicated on the drawings or as directed by the engineer to provide a smooth top surface without ridges or lumps at joints.

Precast concrete units shall be fair faced cast to the sizes and dimensions as indicated on the drawings.

The concrete used for pre-cast unit shall conform to the specifications laid down in item 401-Concrete. The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer. All pre-cast units shall strictly conform to the approved sample.

A pre-cast unit cracked or damaged before, during or after erection shall be removed from the works and replaced by the Contractor at his own expense. All pre-cast units shall be smoothly finished to the required lines, grades angles etc. Holes, grooves, pockets, hooks shall be provided as shown or as directed by the Engineer.

The units shall be properly stacked on a platform without causing any cracks or damage. Curing of all the pre-cast units shall be done in accordance with item 401.

ITEM 603 BRICK EDGING

603.1 DESCRIPTION

This item shall consist of brick installed on vertical edge between the pavement structure and shoulders in such a manner that the brick is laid on compacted shoulders and top of brick is flushed with the slope of road pavement

603.2 MATERIAL REQUIREMENTS

603.2.1 Bricks

Quality of Bricks shall meet the material requirement as specified under item 410.

603.3 CONSTRUCTION REQUIREMENTS

A trench of appropriate dimensions shall be excavated to accommodate brick on vertical edge, so that top of the brick becomes flushed with the top of road pavement and to ensure that one face of the brick remains in contact with the pavement structure. The cavities on the other face of the brick shall be refilled with the excavated shoulder material and properly compacted. The brick shall be laid in accordance with the line and grade of the road pavement. It shall be ensured that bricks are installed in vertical positions.

ITEM 604 METAL BEAM GUARD-RAIL

604.1 DESCRIPTION

This item shall consist of metal beam Guard rail constructed in accordance with these specifications at the locations and in conformity with the dimensions, and design shown on the Drawings or as directed by the Engineer.

604.2 MATERIAL REQUIREMENTS

604.2.1 Metal Beam Guard Rail

The rail elements shall be galvanized corrugated steel beam conforming to the requirements of AASHTO M-180 of the designated type and class.

The mechanical properties of the base metals for beams shall conform to the following requirements:

Yield Point	-	3500 kg / sq. cm. (Minimum)
Tensile Strength	-	4900 kg / sq. cm. (Minimum)
Elongation	-	not less than 12 percent in a 2 inch (5.08 cm) gauge length when tested in accordance with ASTM E-8

In addition to the above, the rail shall withstand a cold bend without cracking of one hundred eighty (180) degree around a mandrel of a diameter equal to two and half (2.1/2) times the thickness of the plate.

604.2.2 End or Buffer Sections

The end or buffer sections shall be formed from open hearth, electric furnace or basic oxygen steel. The section shall be of the same or superior class and type used for the beam to which it is attached.

604.2.3 Connections and Splices

All connections or splices shall be formed with oval shoulder button - headed bolts to minimize projections on the side of the guard. All bolts and nuts for beams shall conform to or exceed the requirements of ASTM A 307 and shall be galvanized as specified in ASTM A 153. The bolted connection of the rail element to the post shall withstand a two thousand two hundred seventy (2270) kg pull at right angles to the line of the railing.

604.2.4 Guard Rail Posts

Posts shall be of either steel or concrete as specified. Only one type of post shall be used for any one continuous Guard rail, except at Junctions between bridges and approach embankments.

a) Steel posts shall be galvanized and of the section and length specified or as shown on the Drawings. They shall conform to the requirements of ASTM A 36/A 36M-08 for the grade specified.

b) Precast reinforced concrete posts shall be of a section and length as specified or as shown on the Drawings. The concrete shall be Class B as specified in Item 401.1.1. Reinforcement shall conform to the requirements of AASHTO M 31 or M 53. All bars shall be of the deformed type, conforming to AASHTO M 31 or M 42.

604.2.5 Wooden Spacer Blocks

Wooden spacer blocks between the Guard rail and the posts shall conform to AASHTO M-133 and M-168 and be constructed to the section and length specified or as shown on the Drawings.

604.2.6 Post Foundation Blocks

Where required or as ordered by the Engineer, post foundation blocks shall be constructed in Class A_1 concrete as specified in Item 401.1.1, to the section and length specified or as shown on the Drawings.

In order to facilitate the removal of posts damaged by vehicle impact, posts shall be set in galvanized tubular steel sockets cast into foundation blocks. The sockets shall be of internal dimension (s) after galvanizing such that there is a clearance of 3 to 5 mm between the socket and the guard rail post. Following erection of guardrails, the space between posts and sockets shall be filled with epoxy mortar.

604.3 CONSTRUCTION REQUIREMENTS

All posts shall be set vertically in the position shown on the Drawings and where embedded in a concrete foundation block shall remain undisturbed for a minimum of forty eight (48) hours. The space around the post or post foundation blocks shall be backfilled to the ground line, with selected earth containing no rocks, in layers of not exceeding ten (10) cm and each layer shall be moistened and thoroughly compacted. Where steel posts are driven into the ground no buckled post or deformed head shall be accepted.

604.3.1 Erection of Rail

All metal work shall be fabricated in the shop and no cutting or welding shall be done in the field unless otherwise ordered by the Engineer. Rail elements shall be lapped so that the exposed ends will not face approaching traffic. Terminal sections shall be installed in accordance with the manufacturer's recommendation.

ITEM 605 CONCRETE BEAM GUARD RAIL

605.1 DESCRIPTION

This item shall consist, of concrete beam Guard rail constructed in accordance with these specifications at the locations and in conformity with the dimensions, and design shown on the Drawings.

605.2 MATERIAL REQUIREMENTS

605.2.1 Concrete Beam Guard Rail

The rail shall be of concrete Class A_1 as specified in item 401.1.1 "Structures". Reinforcing steel shall conform to requirement as specified in item 404. Concrete beam Guard rail shall be of size 125 mm x 300 mm, whereas reinforcing steel shall be provided at the rate of one hundred twenty (120) Kg per cubic meter.

605.2.2 Connections and Splices

Bolts, nuts, washers, sleeves and other fittings shall conform to ASTM Designation A 325 (AASHTO M 614) and shall be zinc coated in accordance with the requirement of ASTM Designation A 153 (AASHTO M 232).

605.2.3 Guard Rail Posts

Post shall be of concrete Class A_1 as specified in item 401.1.1 of these Specifications.

Precast reinforced concrete posts shall be of a section 250 mm x 250 mm. Reinforcement shall conform to the requirements of AASHTO M 31 or M 53. All bars shall be of the deformed type conforming to AASHTO M 137. Reinforcing Steel shall be provided at the rate of one hundred twenty (120) Kg per cubic meter.

605.2.4 Post Foundation Blocks

Where required or as ordered by the Engineer, post foundation blocks, shall be constructed in concrete Class C as specified in Item 401.1.1 to the section and length specified or as directed by the Engineer.

605.3 CONSTRUCTION REQUIREMENTS

605.3.1 Formwork

Formwork shall be supplied and fixed in the position required for the concrete to be cast as shown on the Drawings, or as required by the Engineer, and shall be supplied, erected and removed as specified in Item 403.

605.3.2 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the Drawings, or where required by the Engineer, and its furnishing, bending and fixing shall be in accordance with Item 404.

605.3.3 Concrete

Concrete as shown on the Drawings or as required by the Engineer shall be supplied, placed, finished and cured as specified in Item 401.

ITEM 606 BRIDGE RAILING

606.1 DESCRIPTION

This work consists of the supply and erection of concrete railing for bridges and other structures in accordance with these specifications and to the details shown on the Drawings.

Where metal beam Guard rails form part of the Bridge Railing, the Guard rail beam and connections shall conform to the requirements of item 604 and shall be paid for under that item.

606.2 MATERIAL REQUIREMENTS

606.2.1 Formwork

Formwork where necessary, shall conform to Item 403.

606.2.2 Steel Reinforcement

Steel reinforcement shall be as specified in Item 404.

606.2.3 Concrete

Concrete shall be class D_1 as specified in item 401.1.1 or as shown on the Drawings.

606.3 CONSTRUCTION REQUIREMENTS

606.3.1 Formwork

Formwork shall be supplied and fixed in the position required for the concrete to be cast as shown on the Drawings, or as directed by the Engineer, and shall be supplied, erected and removed as specified in Item 403.

606.3.2 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the drawings or where directed by the Engineer and its furnishing, bending, and fixing shall be in accordance with the Item 404.

606.3.3 Concrete

Concrete class D_1 as shown on the drawings or as directed by the Engineer shall be supplied, placed, finished and cured, as specified in Item 401.

ITEM 607 TRAFFIC ROAD SIGNS AND SAFETY DEVICES

607.1 DESCRIPTION

This work shall comprise furnishing, installing traffic signs and delineators, permanent safety devices and post assemblies in accordance with these specifications and to the details shown on the Drawings. All sign faces and lettering shall be in accordance with NHA/ NTRC sign standards or as shown on plans. Prior to manufacture and fabrication of the signs the contractor shall submit to the Engineer for approval detailed drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per specifications, drawings or as directed by the Engineer. Unless otherwise shown on the Drawings, all signs shall be lettered in both Urdu and English. In case of any discrepancy between MUTCD requirements and these Specifications, the requirements of MUTCD shall govern.

607.2 MATERIAL REQUIREMENTS

Materials shall be of new stock unless otherwise shown on the Drawings or directed by the Engineer and shall conform to the following requirements:

607.2.1 Sign Panels

Sign panels for regulatory, warning and informatory signs shall be manufactured from aluminum alloy conforming to ASTM B 209, alloy 6061-T6 or 5052 - H38 plates of three (3) mm thickness as shown on the drawings.

The blanks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting and punching before preparing the blanks for application of reflective material.

The blanks shall be cleaned, degreased, and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

607.2.2 Reflective Sheeting

Reflective sheeting used on road sign made of flexible white or colored, wide angle retroreflective sheeting (herein after called sheeting), and related processing materials designed to enhance nighttime visibility. The sheeting shall consist of optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface.

The sheeting shall have either a precoated pressure sensitive adhesive or a tack-free adhesive activated by heat applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting.

The sheeting manufacturer must provide documented evidence to the satisfaction of the Engineer that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

a) Color Requirements: Color shall be specified and conform to the requirements of Table 1.

Table I

COLOR SPECIFICATION LIMITS* AND REFERENCE STANDARDS

	1		2		3		4		Reflectance Limit (Y)		** Munsell
Colour	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**	**Min.**	**Max.**	**Paper**
White	0.303	0.287	0.368	0.353	0.340	0.380	0.274	0.316	27.0	-	5PB 7/1
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	15.0	40.0	1.25Y 6/12
Red	0.613	0.297	0.708	0.292	0.636	0.364	0.558	0.352	2.5	11.0	7.5R 3/12
Blue	0.144	0.030	0.244	0.202	0.190	0.247	0.066	0.208	1.0	10.0	5.8PB 1.32/6.8
Orange	0.550	0.360	0.630	0.370	0.581	0.418	0.516	0.394	14.0	30.0	2.5YR 5.5/14
Brown	0.430	0.340	0.430	0.390	0.550	0.450	0.610	0.390	3.0	9.0	5YR 3.6
Green	0.30	0.380	0.166	0.346	0.286	0.429	0.201	0.776	3.0	8.0	10G 3/8

* The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colormeteric system measured with standard illumination Source C

** Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218. Catalog No. MCP-90040.

b) Coefficient of Retroreflection. The coefficients of retroreflection shall conform to the minimum requirements of Table II.

Table II
MINIMUM COEFFICIENT OF RETROREFLECTION
(CANDELAS PER FOOT CANDLE PER SQUARE FOOT)

Observation Angle (°)	Entrance Angle (°)	White	Red	Yellow	Green	Blue	Brown	Orange
0.2	-4	250	45	170	45	20.0	12.0	100.0
0.2	+30	150	25	100	25	11.0	8.5	60.0
0.5	-4	95	15	62	15	7.5	5.0	30.0
0.5	+30	65	10	45	10	5.0	3.5	25.0

For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 70% of the values for corresponding color in the above table.

The sheeting manufacturer shall provide a test report from British Standards Institution (BSI) or any internationally recognized laboratory stating that the sheeting meets the requirements according to BSI 873 Part 6 or FP 92 of FHWA.

The brightness of the reflective sheeting totally wet by rain shall be at least ninety (90) % of the above values.

The reflective sheeting shall be sufficiently flexible as to permit application over and adhesion to a moderately embossed surface. It shall not show damage when bent ninety (90) degree over a fifty (50) mm diameter mandrill.

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty five (25) mm diameter steel ball from a height of two (2) meters onto its surface.

For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty eight (48) hours after application, at temperatures of up to ninety (90) degree Centigrade.

The reflective material shall be weather-resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and not less than seventy five (75) % of the specified wet or dry minimum brightness values when exposed to weathering for five (5) years.

c) Performance Requirements and Obligation. The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retroreflective signs meets all requirements listed herein.

Sheetings processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table III of this specification. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retroreflection is less than the minimum specified for that sheeting during that period listed in Table III.

Table III
MINIMUM COEFFICIENT OF RETROREFLECTION CANDELAS PER FOOT CANDLE PER SQUARE FOOT (0.2° OBS, AND -4° ENTRANCE)*

Sheeting Color	Minimum Coefficient of Retroreflection (7 Years) •	Minimum Coefficient of Retroreflection (10 Years)
White	212	200
Yellow	144	136
Green	38	36
Red	38	36
Blue	17	16
Brown	10	9

For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 50% of the values for the corresponding color in the above table.

All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

Where it can be shown that retroreflective traffic signs supplied and used according to the sheeting manufacturer's recommendations have not met the performance requirements above the sheeting manufacturer shall cover restoration costs as follows for sheetings shown to be unsatisfactory during:

1) The entire seven years the sign manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

2) In addition, during the first five years sign manufacturer and sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to the Employer for materials and labor.

Samples of the reflective sheeting shall be approved by the Engineer prior to the Contractor placing his order.

607.2.3 Metal Posts

Wide flange of 10 x 10 centimeters metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A 283 Grade D.

In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty three (63) mm and seventy five (75) mm respectively conforming to the specifications of ASTM A 501.

All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive priming paint and two coats of grey paint. Length of the posts shall be such that their top flushes with the top of the sign penal, where as bottom of sign panel is at least hundred and eighty (180) centimeters above shoulder level.

607.2.4 Plates

a) Plates shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate otherwise.

It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty seven and half (37.5) mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

b) The High Intensity Grade sheeting for the background should cover the, whole area of the sign plate.

c) Prior to application of the High Intensity Grade reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.

d) The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weather-proof.

607.2.5 Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10) mm dia (G.I.) or aluminium alloy. The bolt heads to be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanized according to ASTM A 153.

607.2.6 Rubber Washer

All rubber washers shall have thick walls and shall not get dry and brittle when exposed to weather at the site after they are in position during the life of the sign. Thickness of rubber washer is as given below:

On top	3 mm
On Bottom	2 mm

607.2.7 Caps over the Pipes

These can be of heavy plastic or of aluminium well fitted so that they cannot be removed; any good adhesive can be used.

607.2.8 General

a) Very large signs need not be made of one piece; in that case extended Aluminium panels shall be used or the various pieces of sheet shall be joined by angle-irons in anticorodal materials, and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded in the concrete as directed by the Engineer.

b) All the nuts and bolts and metal washers must be heavily galvanized, or may be of stainless steel of high quality.

c) Relevant holes to receive ten (10) mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.

d) After the plates are fixed with nuts and bolts, the nuts shall be TACK WELDED to the bolts against pilferage.

607.2.9 Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class A_1 in accordance with Item 401.1.1 and shall of the size 450 x 450 x 650 mm for category 1 & 2 and 600 x 600 x 750 mm or as shown on the Drawings or as directed by the Engineer for category 3.

607.2.10 Road Posts and Hazard Markers

The road posts and hazard markers used as permanent safety devices shall conform fully, with the requirements of the statutory instruments, current British standards and chapter four (4) of the Traffic signs manual. The safety devices shall consist of delineators and detours of verge master, flex master, edge master, passing place post, and chevroflex etc. and will be manufactured from highly durable tough plastic material withstanding vehicular impact. These shall be of High Intensity Grade reflective sheeting for maximum visibility by both day and night and consequently be resistant to impact, damage and vandalism.

607.3 CONSTRUCTION REQUIREMENTS

607.3.1 Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawing.

Backfilling shall be carried out by using the surplus excavated material if approved by the Engineer and shall be compacted in layers not exceeding fifteen (15) cm in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer.

Concrete shall be placed against the undisturbed excavated faces, except that the top fifteen (15) centimeters of each footing shall be formed. Forming of the entire footing will not be permitted unless approved by the Engineer. Concrete shall be thoroughly rodded and spaded so as to eliminate all voids. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger.

Backfill shall be thoroughly compacted by mechanical tampers, and care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished ground line. Pipe post bases and/or posts set in concrete shall be firmly supported, plumb, vertical and at the proper elevation.

In case precast concrete foundations are used, these shall be of the concrete class 'A1' and of the sizes as shown on the drawings.

607.3.2 Erection of Posts

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting process of the concrete. The posts shall be located at the positions shown on the Drawings.

607.3.3 Sign Panel Installation

Sign panels shall be installed by the Contractor in accordance with the details shown on the Drawings. Any chipping or bending of the sign panels shall be considered as sufficient cause to require replacement of the panels at the Contractor's expense.

The exposed portion of the fastening hardware on the face of the sign shall be painted with enamels matching the background colour.

All newly erected traffic road signs shall be covered with burlap or other material until their uncovering is ordered by the Engineer.

607.3.4 Categories of Signs

Traffic road signs shall be of three categories according to type of construction

a) Warning Signs

Constructed with single post and sign of equilateral triangle shape, as shown in drawings, category 1.

b) Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the drawings, category 2.

c) Informatory Signs

These signs shall be rectangular in shape and constructed with one, two **or** three numbers of posts or as shown on the drawings. Dimensions may vary according to the requirements; however total area of sign shall be as under:

Category 3 a = One Sq. meter
Category 3 b = Two Sq. meter
Category 3 c = As shown on drawings

d) Additional panel

If any panel is required to be installed, it shall be of the sizes 60x30 cm **or** 90x30 cm.

607.3.5 Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed / portable safety barriers and hazard markers e.g. verge-master, flex-master chevroflex, bigmax, edgemaster and passing place post and other etc., shall be installed in accordance with the techniques and methods laid down in the manufacturer's manual or guide and in

conformity to the line and level and locations shown on the drawings or as directed by the Engineer to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

607.3.6 Sign faces

a) Design

All sign faces shall be of the type, colour, design and size as shown in the plans. Size and spacing of letters shall be as under:

1	The Urdu writing shall be in "Persian" character.	
2	The Urdu and English writing shall be about the same in length, width and spacing.	
3	English letters are to be in smalls except the first letter of the word, which is to be in Capital.	
4	Height of capital letters	35 cm
5	Height of small letters	25 cm
6	Stroke Width and Width of border	10 cm
7	Space between words and border (at least)	5 cm
8	Space between Words	5 cm
9	Space one line will occupy	4 cm
10	Space between digits of numerals	2.3 cm
11	Height of numerals same as capital letters	35 cm
12	Space between lines (at least)	5 cm
13	Height of letters for Km	K-23 cm m-8 cm
14	Width of letters for Km including spacing	K-8 cm m-9.6 cm
15	Width of dividing line	2.0 cm
16	The size and spacing for Urdu letter and Words will generally conform to the dimensions shown above for English letters.	
17	The spelling of place names in Urdu and in English shall be as written in the Survey of Pakistan maps.	

b) Shop Drawings

The contractor shall submit to the Engineer for approval, three (3) copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/or arrangement and spacing of both the Urdu and English sign messages. Official town names and their spelling shall be as provided by the Engineer. Size and style of lettering shall be as shown on the plans or as otherwise approved by the Engineer.

607.3.7 Storage of Signs

'Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer. Any signs damaged, discolored or defaced during

transportation, storage or erection shall be rejected

607.3.8 Painting

The rear sign face of all signs shall be painted with two (2) coats priming paint pigmented with chromates of chromes (excluding lead chromes) plus two (2) coats of weather-resisting dull silver gray paint. Where connection of large aluminum sheet signs to a steel stiffening frame is required, the studs or screws, bolts and washers shall be painted to properly match the color of the surrounding material.

All painting shall conform to the requirements of Section 413 of General Specifications.

607.3.9 Placement and Orientation

The Engineer will approve and mark the longitudinal location of each sign on the working drawings submitted by the Contractor.

The sign shall be laterally positioned from the shoulder or curb as shown on the approved drawings or directed by the Engineer.

The Contractor shall stake the location of each sign support and shall get its approval from the Engineer prior to carrying out excavation for foundations. The Engineer may order change in location due to site constraints. No separate payment shall be made to the Contractor on account of such change if the change is made before fixing of the sign support in concrete block.

The Contractor shall be responsible for the proper elevation, off-set, level and orientation of all signs he erects. He shall exercise due care on the preservation of stakes for his and the Engineer's use. If any stakes are lost, damaged, displaced, or removed, the Contractor shall have them reset at his own expense.

Unless otherwise shown on the Drawings all signs shall be erected so that the edge and face of the sign are truly vertical and face is at an angle of ninety three (93) degrees to the centerline; that is, facing slightly away from the centerline of the lane which the sign serves. Where lanes divide or are on sharp curves, the Contractor shall orient sign faces as indicated on the Drawings or by the Engineer so that they will be most effective both during day and night and so as to avoid specular reflection and glare. All sign supports shall be plumbed.

607.3.10 Sign Posts

Lengths of posts shown on the Drawings for signs are for bidding purposes only. When progress of the Work permits, the Engineer will authorize the location of each sign, with the station and offset distance from the edge of pavement. The Contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the Drawings. Field cutting of posts shall be performed by sawing.

"Sign Post Support Assemblies" shall be fabricated as detailed on the drawings. Test specimens for pipe shall be taken at least fifteen (15) centimeters from one (1) end of the pipe, instead of at the ends as specified in ASTM A 53, Grade B. When Galvanizing is specified assemblies shall be hot-dip galvanized after fabrication. All welds shall be mechanically cleaned before Galvanizing. Galvanized materials on which the Galvanizing has been damaged in transporting, handling, or erection will be rejected or may, with the approval of the Engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjacent areas on which the Galvanizing has been damaged shall be galvanized by this same method. The zinc alloy stick shall be cast from zinc, tin, and lead in combination with fluxing ingredients. The compound shall be completely liquid at a temperature not lower than two hundred and forty six (246) degrees C. The area to be re-galvanized shall be thoroughly cleaned, including the removal of slag on welds. The surface shall be heated with an oxyacetylene torch to approximately three hundred and fifteen (315) degrees C, and the alloy stick rubbed over the surface to fix a deposit. While

the alloy is still liquid, a clean wire brush shall be used to smooth the deposit evenly over the entire area being re-galvanized. If a heavy deposit or build-up is required to match the original coating, more alloys shall be added immediately to the initial bond deposit and spread with a paddle or brush until the required thickness is obtained. Edges of drilled holes shall be coated with commercially available zinc-rich paint. Shop drawings will not be required for pipe posts.

The Contractor shall furnish to the Engineer, fabricators' certifications in triplicate certifying that the material supplied conforms to all of the requirements specified.

607.3.11 Fastening Signs to Sign Posts

Signs shall be fastened to sign supports in accordance with the requirements of the Drawings, the recommendations of the sign manufacturer and to the satisfaction of the Engineer.

After installation of signs on their supports all bolt heads, screw heads, and washers which are exposed on the face of the sign shall be painted. The color of the paint used shall be as nearly as practical the same as the color of the background or message area at the point where the bolt, screw, or washer is exposed.

Where steel signs are mounted with aluminum hardware or on steel posts, approved asphalt, nylon, or neoprene insulation shall be installed at all points where dissimilar metals might come in contact.

607.3.12 Erection of Delineators and Reflectors

Delineators shall be erected at locations shown on the Drawings and set at elevations such that the Delineator reflectors will be at the indicated height above the ground surfaces. Unless otherwise noted in the Drawings or authorized by the Engineer, holes for posts shall be of the depth and size shown on the Drawings. Posts shall be set plumb and to the established lines and grades and shall be encased in concrete class "B" unless otherwise shown on the Drawings. The cost of all excavation and concrete will be considered subsidiary to the bid item (s) for Delineators.

When noted on the Drawings or authorized by the Engineer, the posts shall be erected by driving, either by hand or with approved mechanical devices. The method of driving shall not substantially alter the cross- sectional dimensions of the posts or materially damage the coating. Battered tops will not be permitted. Posts which, in the opinion of the Engineer, are bent or otherwise damaged during or after erection shall be removed from the site and replaced at the Contractor's expense. After driving, the portion of the posts above ground shall be plumb and the posts shall be firm in the ground.

Reflectors shall be attached to the posts as detailed on the Drawings or according to the manufacturer's specifications.

607.3.13 Sign Gantry Structures

All work in respect of the furnishing, construction of foundation and erection and finishing of sign gantry structures shall conform to the drawings and to the relevant requirements of General Specifications Section 401 "Concrete", Section 404 "Steel Reinforcement" and Section 413 "Steel Structures".

ITEM 608 PAVEMENT MARKING

608.1 DESCRIPTION

This work shall consist of furnishing retro-reflective thermoplastic spray paint material, for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications.

The paint shall be applied in conformance to the size, shape and location of the marking as shown in the Drawings.

608.2 MATERIAL REQUIREMENTS

Retro-reflectorized thermoplastic lines shall consist of a mixture of binder, white or yellow pigment, glass spheres, filler, and other materials in granular form such as light colored silica sand or quartz specifically compounded for traffic paint that is to be applied to the pavement in a molten state by mechanical means with surface application of glass beads. Upon cooling to normal pavement temperature, this material shall produce an adherent Retroreflectorized paint line of specified thickness capable of resisting deformation by traffic.

The minimum softening point of the material shall exceed ninety-two degrees Celsius (92^{o} C).

The Manufacturer's Certification is to be provided by the Contractor, for each batch/ consignment backed up by all the specified tests for approval prior to start of work.

608.2.1 Ingredient Materials

a) The composition of the Mix shall be as per AASHTO M 249, Table 1.

TABLE 608-1 COMPOSITION

COMPONENT	WHITE	YELLOW
Binder	18.0 min	18.0 min
Beads	30-40	30-40
Titanium dioxide	10.0 min	-----
Calcium carbonate & inert fillers	42.0 max	See Note*
Yellow pigments	-----	See Note*

*NOTE 1: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, provided all other requirements of this specification are met.

b) Binder. The binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature. The solid resin shall be a hydrocarbon or alkyd resin. The total binder content of the thermoplastic compound shall be well distributed throughout the compound. The binder shall be free from all foreign objects or ingredients that would cause bleeding, staining, or discoloration.

c) Pigment. The pigment used for the white thermoplastic compound shall be a high-grade pure (minimum 93 percent) titanium dioxide($Ti0_2$). The white pigment content shall be uniformly distributed throughout the thermoplastic compound.

The pigments used for the yellow thermoplastic compound shall be non-toxic, heat resistant, and color-fast yellows, golds, and oranges, which shall produce a compound meeting the requirements of the current US Federal Highway Color Tolerance Chart, PR Color No. 1. The medium chrome yellow pigment content shall be not less than four percent by weight and shall be uniformly distributed throughout the thermoplastic compound, subject to manufacturer's formulation recommendations (See foot Note 1 in the Table).

d) Filler. The filler to be incorporated with the resins as a binder shall be a white calcium carbonate, silica, or an approved substitute. Any filler which is insoluble in 6N hydrochloric acid shall be of such particle size as to pass a No. 100 (150 µm) sieve.

e) Glass Beads. The intermix glass beads shall be as specified in 608.2.3 hereunder.

608.2.2 Thermoplastic Compound

These are to meet the AASHTO M 249 requirements, unless specified otherwise.

a) Physical Condition

1) In the plastic state, the material shall not give off fumes that are toxic or otherwise injurious to persons or property. The manufacturer is to supply safety data sheets.

2) The temperature versus viscosity characteristic of the plastic material shall remain constant and the material shall not deteriorate in any manner during reheating processes. There shall be no obvious change in color of the material as a result of repeated heating or from batch to batch.

3) It shall provide a stripe of uniform color and thickness throughout its cross section and have the density and character to provide a sharp edge of the line.

4) After drying, It shall remain free from tack, and shall not lift from the pavement under traffic conditions within a road temperature range of -29 to 66 °C. The stripe shall maintain its original color, dimensions and placement.

b) Drying Time. With application temperature of 211±7 ºC and thickness of 3.2 to 4.8mm, the maximum drying time shall not be more than ten (10) minutes at 32 °C air temperature.

c) Daylight Reflectance and Color (AASHTO M 249). The thermoplastic compound after heating for four hours ± five minutes at 218.3 ±2 ºC and cooled at 25 °C shall meet the following requirements for daylight reflectance and color, when tested, using a color spectrophotometer with 45 degree circumferential/zero degree geometry, illuminant C, and two degree observer angle. The color instrument shall measure the visible spectrum from 380 to 720 nm with a wavelength measurement interval and spectral bandpass of 10 nm.

- White: Daylight Reflectance ……75 percent min.
- *Yellow: Daylight Reflectance …..45 percent min.

d) Specific Gravity of White and Yellow Material. 2.15 maximum after heating the thermoplastic for four hours ± five minutes at 218.3 ±2 ºC, when determined according to ASTM D 792, Method A, using kerosene as the immersion liquid.

e) Water Absorption of Plastics. The material shall have not more than 0.5 percent by weight of retained water when tested by ASTM D 570, "Water Absorption of Plastics," Procedure (a).

f) Softening Point. When tested in accordance with ASTM D 36, the material shall have a softening point between 102.5 ±9.5 ºC.

g) Flowability-extended heating. Tested as per AASHTO T-250, after heating as specified, the maximum flowability shall be:

- White thermoplastic…..18%
- Yellow thermoplastic….21%

h) Yellowness Index. After heating the thermoplastic for four hours± five minutes at 425 ±3 ºF (218.3 ±2 ºC), the white thermoplastic material shall not exceed a yellowness index of 0.12 when tested in accordance with ASTM D 1925.

i) Impact Resistance. Tested as per T-250, it shall be a minimum of 1.13J (10 in-lb)

j) Storage Life. The material shall maintain a granular free-flow condition in dry storage for a minimum of one year, consistent with the work site temperatures. The thermoplastic must also melt uniformly with no evidence of skins or unmelted particles and meet all requirements of this specification for one year after delivery.

608.2.3 Glass Beads

The glass beads shall conform to AASHTO M 247, except as specified otherwise as under:

a) Gradation

1) Pre-mix glass spheres: The beads used in the thermoplastic material compounding shall conform to the requirements of AASHTO M 247, Type II, except the gradation which shall conform to the following:

Standard Sieve Size	Percent Passing by Weight
0.600mm (No. 30)	100
0.425mm (No. 40)	95-100
0.300mm (No. 50)	50-75
0.212mm (No. 70)	15 maximum
0.180mm (No. 80)	0-5

2) Surface application glass spheres: The Drop-on beads shall conform to the requirements of AASHTO M 247, Type I, except the gradation which shall conform to the following:

Standard Sieve Size	Percent Passing by Weight
1.70mm (No. 12)	100
0.85mm (No. 20)	85-100
0.60mm (No. 30)	45-100
0.30mm (No. 50)	10-45
0.18mm (No. 80)	0-20
0.15mm (No. 100)	0-5

b) Roundness

A minimum of seventy-five percent (75%) shall be true spheres when tested in accordance with ASTM D 1155. Not less than seventy percent (70%) of the spheres of each sieve size shall be free from imperfections of all types, including film, scratches, pits, clusters and opaqueness.

c) Crushing Resistance

When tested as per ASTM D 1213, it shall be 133N (30 lbs) minimum for material retained on No. 40 sieve.

e) Refractive Index

The glass spheres shall have a minimum refractive index of not less than one and fifty hundredths (1.50) when tested by the liquid immersion method at twenty-five degrees Celsius (25ºC).

e) Moisture Resistance Flow Characteristics

When tested as specified in AASHTO M-247 the beads shall not absorb moisture in storage. They shall remain free of clusters and shall flow freely from dispensing equipment.

f) Floatation

When tested as specified in AASHTO M 247, a minimum of 90% beads shall float in xylene.

g) Chemical Resistance

The glass spheres shall withstand immersion in water and acids without undergoing noticeable corrosion or etching, and shall not be darkened or otherwise noticeably decomposed by sulfides.

The tests for chemical resistance shall consist of one (1) hour immersion in water and in corrosive agents followed by microscopic examination. A three (3) to five (5) gram sample shall be placed in each of three (3) glass beakers or porcelain dishes and one (1) covered with distilled water, one (1) with a three (3) N solution of sulfuric acid and the last with a solution of fifty percent (50%) sodium sulfide, forty-eight percent (48%) distilled water, and two percent (2%) Aerosol 1B or similar wetting agent. At the end of the one (1) hour immersion, no darkening, hazing or other evidence of instability shall be noticeable when examined microscopically.

h) Silica Content

The silica content (SiO_2) of the spheres shall be sixty percent (60%) plus or minus five percent (5%) when tested in accordance with U.S. Federal Test Method 141a.

i) Packing and Marking

These shall be packed in moisture proof bags. Containers are to be guaranteed to furnish dry and undamaged beads. Each package shall show manufacturer's name, shipping point, trademark/name, glass beads, this specification number (608.2.3), weight, lot / batch number, month and year of manufacture.

608.2.4 Sampling and Testing

Unless otherwise provided, all materials shall be sampled and tested in accordance with the latest published standard methods of the ASTM/ AASHTO/ or other equivalent recognized standardizing agencies as specified. All sample sizes shall be as per AASHTO M 249. The testing is to be as per AASHTO T 250.

a) Sampling

All paint products and other materials designated by the Engineer shall be sampled for testing. Sampling shall be performed by the Contractor in the presence of the Engineer.

All materials shall be shipped to the job site in undamaged, sealed original packaging, clearly identifying each material as to name, color, manufacturer, batch number, and date of manufacture. All materials shall be accompanied by certified test results verifying compliance with all physical and chemical requirements of these Specifications.

Materials shall be sampled in their original containers, except that bulk shipments may be sampled and resealed as approved by the Engineer. All samples shall be packaged for shipment as approved by the Engineer. Samples shall be transported to the laboratory (ies) approved and or designated by the Engineer. No materials shall be used until approved by the Engineer.

For thermoplastic, at least three randomly selected containers (4L each) shall be obtained from each lot.

All sampling and acceptance testing shall be done in presence of the Engineer. The testing shall be at least 30 days in advance of the pavement marking operations.

The Contractor shall be responsible for the cost of all sampling and testing including those tests designated by the Engineer to be performed at an independent laboratory.

b) Inspection

The right is reserved to inspect the material either at the place of manufacture or at the destination or at both places. If inspected at the place of manufacture, the Contractor shall furnish such facilities as may be required for collecting and forwarding samples, and shall also furnish facilities for testing the material during the process of manufacture, if required.

Random check samples besides the sampling frequency described in 608.2.4 (a) above, may be taken at the job site at the discretion of the Engineer.

c) Material Acceptance/ Testing.

Final acceptance of a particular lot of thermoplastic will be based on the following:

1) Compliance of ingredient materials with the Specifications.

2) Compliance of thermoplastic material with the Specifications.

3) Manufacturer's test results for each lot of thermoplastic have been received. The manufacturer shall perform tests on a minimum of one sample per 10,000 lb (4,500 kg) of thermoplastic produced. Manufacturer's test results shall be submitted along with the thermoplastic sample to the Engineer. The manufacturer shall retain the test sample for a minimum period of 18 months.

4) Identification requirements are satisfactory.

608.2.5 Manufacture, Packing and Storing of Paint

a) Manufacture

The paint shall be produced in a plant owned and operated by the manufacturer following a process which has been used by the manufacturer for at least five (5) years to produce paint. The equipment for mixing and grinding shall be clean, modern, and in good condition.

b) Packing

1) The thermoplastic material shall be packaged in suitable sealed containers which will not adhere to the product during shipment and storage.

2) Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorisation (if applicable), colour, chemical type of binder and maximum safe heating temperature.

c) Storing

The material shall be stored in accordance with the manufacturer's instructions and any material that is in damaged containers of which the seal has been broken, shall not be used.

The material shall maintain a granular free-flow condition in dry storage for a minimum of one year, consistent with the work site temperatures. The thermoplastic must also melt uniformly with no evidence of skins or unmelted particles and meet all requirements of this specification for one year after delivery.

Any material not meeting the specification requirements shall be replaced by the Contractor at his expense, including handling and transportation charges.

608.2.6 Certification

The Contractor shall furnish a certificate from manufacturer that the

material he proposes to use has the required properties and satisfies the specified performance requirements, stating the maximum and minimum properties and grading of the constituents, the acid value of the binder, the setting time, the maximum safe heating temperature, the temperature range of the apparatus and the proposed method of laying.

608.3 CONSTRUCTION

608.3.1 Application Equipment

The application equipment shall be especially designed for placing the plastic material in a hot molten state on the pavement, utilizing either an extrusion or spray method. Equipment shall have the capability of providing continuous mixing and agitation of the material while maintaining the material at the proper placement temperature in a continuous stripe of uniform thickness and width. The use of direct flame heat will not be allowed in any heating operation.

A glass sphere top dressing shall be applied to the completed thermoplastic stripe by an automatic glass sphere dispenser attached to the stripping machine in such a manner that the spheres are applied to the molten thermoplastic material immediately after it has been applied. The sphere dispenser shall utilize pressure type spray guns which will embed the spheres into the stripe surface to at least one-half (1/2) the sphere diameter. The sphere dispenser shall be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

The truck mounted equipment shall ensure smooth, straight application and shall be capable of maintaining a continuous operating speed of at least 5 km/hr. The application equipment shall be capable of automatically placing intermittent and continuous lines of the various widths and colors of pavement marking lines specified.

The equipment shall have a metering device to register the accumulated installed quantities for each gun, each day. Each vehicle shall include at least one operator who shall be a technical expert in equipment operations and thermoplastic application techniques.

Hand equipment shall be permitted for small jobs and where only a limited quantity of lane and edge lining is required. Also it may be used only for markings, including arrows, crosswalks, stop bars, symbols, and legends, and have a capacity to hold a minimum of 55 Kg of molten material and be as maneuverable as required. For the purpose of these Specifications, "hand-operated" shall also include any riding units not particularly considered as "truck-mounted. A mechanical beader approved by the Engineer shall be used.

The heating vessel is a pressure vessel and thus the contractor must provide its latest certification of safety.

Pumping equipment capacity shall be checked to be within calculated pumping requirement. All Measuring gages shall be in working order.

Certification of equipment shall be provided prior to undertaking construction.

Accurate temperature measuring device shall be provided, capable of measuring the pavement temperature prior to installation of the thermoplastic and the temperature of the molten thermoplastic material

during application.

608.3.2 Preparation

a) Surface Preparations

1) Thermoplastic material shall not be applied to a new bituminous concrete pavement before it has been exposed to at least fourteen (14) days of use.

2) The material shall not be laid over old flaking markings of paint or thermoplastic material.

3) For areas with previous road marking, check its compatibility. Thermoplastic material placed over cold applied plastic and waterborne paints, alkyds (with significant thickness) are likely to fail due to non-compatibility.

4) No conditions shall exist that, in the opinion of the Engineer, would displace, damage, or reduce bonding of the material to pavement surface.

5) The pavement surface shall be scrubbed clean, free of any loose dust, grease, oil etc, and dried with no moisture on the pavement surface. The surface shall be cleaned with mechanical broom or other device as approved by the Engineer.

b) Traffic Management

1) Do not apply unless traffic management programme has been set up at site with adequate non-passing zones for the working area.

2) Do not apply under dusty traffic conditions.

c) Climatic Environment

1) Humidity shall be measured in the air which shall be less than 80%.

2) Do not apply in misty and rainy weather condition.

3) Do not apply on moist surfaces. Check surface dryness through a field test.

4) Measure the surface temperature of the pavement which shall be more than ten degrees Celsius (10ºC).

5) No Wind or other conditions to exist that cause a film of dust deposited on the surface after cleaning and before installation.

d) Field Testing Equipment

All necessary equipment required for field measurements such as Thermometers, Test Plates, weighing arrangements, thickness gauges, measuring tapes etc. shall be made available.

e) Setting Out

The edge of a center line or lane line shall be offset a minimum distance of 50 mm from a longitudinal crack or joint. Edge lines shall be approximately 50 mm from the pavement edge.

Pavement marking words and symbols shall conform closely to the dimensions and spacing specified in the plans.

Existing pavement markings, if any, shall be removed. The area removed shall be no wider than the width of the existing pavement markings. The Contractor shall notify the Engineer 72 hours prior to the placement of the thermoplastic markings.

f) Preparation of thermoplastic material on site

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating will be avoided. The temperature of the mass shall be within the range specified by the manufacturer, and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer.

608.3.3 Application

The compound shall be installed in a molten state in temperature range of 211ºC and 225ºC. Scorching or discoloration of material will be cause for rejection by the Engineer.

Thermoplastic shall be applied only when the pavement temperature is greater than 13ºC

a) Laying

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by the self propelled machine. Other marking may be laid by hand, hand propelled machine or self propelled machine as approved by the Engineer. The surface produced shall be uniform in texture and thickness and appreciably free from blisters and streaks.

b) Reflectorization By Surface Application

The glass beads (ballotini) at the rate of about 400 g/m^2 to 500 g/m^2 from the machine shall be applied by pressure concurrently with the laying of the line with sufficient velocity and pressure to ensure retention in the surface of the line. The ballotini so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

The glass beads shall be about half its size penetrated into the thermoplastic.

Ballotini dispensed on the surface of the markings shall conform to the grading specified above at 608.2.3 (i) b.

Unless specified or shown otherwise on the Plans, the thermoplastic material shall be applied at a thickness of not less than 3.2 mm but no greater than 4.8 mm as per specified in AASHTO M 290. Finished lines shall be within 6 mm of the width specified in the plans.

Thermoplastic markings shall be placed with drop on glass beads according to uniformly applied pressure. It shall be the Contractor's responsibility to use a compatible combination of thermoplastic material and beads to preclude the surface beads from sinking deeply into the thermoplastic.

Thickness Conformance

The thickness of the markings will be measured above the pavement surface at random points as selected by the Engineer, to determine conformance as under:

a) If the measurements show the overall thickness of the markings over the pavement surface is substantially in conformance with the thickness requirements, payment will be made at 100 percent of the Contract unit prices involved.

b) If the overall thickness at a given location is less than the minimum specified 3.2mm, additional measurements will be taken on each side of the location by the Engineer to determine the extent of the deficient portion of the marking. The payments shall be made for the deficient portion computed for the area, as under:

1) If the Average thickness is less than 3.2 mm but more than 2.50 mm the adjusted unit price shall be 50 percent.

2) If the Average thickness is less than 2.50 mm, then remove the surface of the deficient portions of the markings sufficiently to reduce the average thickness to about 2.0 mm or less. The Contractor shall then apply additional thermoplastic material and beads to bring the thickness of the markings to at least 3.8 mm and the reflectivity to the minimum required values.

608.3.4 Trial Section

In no case shall the Contractor proceed with the work until the equipment, method of application and rate of application conforming the required thickness (as established by a test section) have been approved by the Engineer.

The objective is:

a) To demonstrate the capability of the Contractor's equipment and operators to produce acceptable lines of given cross-section, alignment, markings and workmanship.

b) Finalize the rate of application of the paint and the drop-on beads to achieve the objective of durability, uniformity and retro-reflectance backed up by tests and observations.

c) The specified drop-on beads are to embed into the stripe surface to at least one-half (1/2) the diameter, by utilizing pressure type spray guns and the sphere dispenser-equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic.

d) Drop-on beads Check: The quantum of the beads shall be measured and tested, excluding any loose beads to conform to the specified requirements.

e) Thickness Check: The actual achieved thickness in any randomly selected section shall be checked with computed thickness (as measured volume of material applied divided by the measured area of application.

f) Check the overall retro-reflective thermoplastic spray performance vis-à-vis the required performance requirements.

608.3.5 Application Site Records

Daily site record of the thermoplastic Application shall be maintained and submitted by the Applicator/ Contractor which shall include but not limited to the following:

a) Name of applicator
b) Type of equipment used
c) The thermoplastic batch numbers used
d) Location of the marking
e) Details of work such as white/ yellow Lines, Arrows etc (Miscellaneous small markings may be grouped, provided the location is identified.)
f) Details of any surface preparation carried out
g) For thermoplastic, note time the material is loaded into pre-heater, quantities added and the total time that material has been held at the application temperature
h) Thickness measurement

608.3.6 Inspection

If the final inspection discloses any work, in whole or in part, which does not meet the inspection requirements, the Contractor shall, within 30 calendar days, completely repair or replace such work to the satisfaction of the Engineer.

ITEM 609 REFLECTORIZED PAVEMENT STUDS

609.1 DESCRIPTION

This item shall consist of furnishing and installing reflectorized pavement studs set into the traveled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer.

609.2 MATERIAL REQUIREMENTS

609.2.1 Reflectorized Studs

Reflectorized Studs shall be "cat-eyes" either the 'Flush Surface' type or Raised Profile' type having the following characteristics.

a) 'Flush Surface' Type

The 'Flush Surface' reflector shall be the short base type having a maximum base area of 18 cm x 14 cm or as shown on the Drawings.

The base shall be formed in cast-iron with adequate webbing to ensure a firm key to the road when installed.

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated life of at least five (5) years. The pad shall be so designed as to produce a self whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass and shall be hermetically sealed into a copper socket.

b) 'Raised Profile' Type

The 'Raised Profile' reflectors shall consist of an acrylic plastic shell filled with an adherent epoxy compound molded from methyl methacylate into the shape of a shallow frustum of a pyramid having base dimension of approximately 15 cm x 15 cm and thickness not more than two (2) cm or as shown on the drawings.

The shell shall contain one or two prismatic reflector each inclined at an angle of thirty (30) degree to the horizontal and having an area not less than twenty (20) square cm or as indicated on the plans.

The reflectors shall attain **the** following standards for their photometric and physical qualities:

i) Photometric Requirements

The reflectors shall have the following minimum Specific Intensity values (S.I) expressed as candle power per foot candle of illumination at the reflector on a plane perpendicular to the incident light.

	COLOUR		
	Crystal	**Yellow**	**Red**
Divergence Angle (in Degree)	**0.20 S.I.**	**0.20 S.I.**	**0.20 S.I.**
Incidence Angle			
0	**3.00**	**1.80**	**0.75**
20	**1.20**	**0.72**	**0.30**

The reflector for testing shall be located with the center of the reflecting face at a distance of one and half (1.5) m from a uniformly bright light source having an effective diameter of half (0.5) centimeter.

The width of the photocell shall be 1.27 cms and shall be shielded from **stray** light. The distance from the centers of the light source and photocell shall be 0.53 cms.

Failure of more than four (4) % of the reflecting faces shall be cause for rejection of the lot.

ii) Strength Requirement

The reflectors shall support a vertical load of 1000 kg when **tested in the** following manner.

A reflector shall be centered horizontally **over** the open end of a vertically positioned hollow metal cylinder seventy five (75) mm internal diameter, twenty five (25) mm high and wall thickness of six (6) mm. The load shall be applied to the top of the reflector through a six (6) mm diameter by six (6) mm high metal plug centered on top of the reflector.

Failure shall constitute either breakage or significant **deformation of the** marker at any load less than one thousand (1000) kg.

609.2.2 Adhesive

When 'Raised Profile' type of reflectors are used, a two-part adhesive having the following ingredients shall be applied to the stud for bonding to the pavement surface.

Package A	**Kg/ Litre**
Epoxy Resin	0.94
Titanium Dioxide	0.07
Colloidal Silica	0.05
Talc	0.345

Package B	**Kg/ Litre**
Modified Asphaltic Amine Hardener (Reinchold 2611)	0.24
Modified Asphaltic Amine Hardener (Reinchold 2613)	0.472
Carbon Black	0.0022
Colloidal Silica	0.04
Talc	0.65

Equal volumes of Package A &-B should be mixed together until a uniform colour is obtained. No more than one quart of adhesive shall be prepared at one time.

609.2.3 Cement Mortar

Cement mortar shall consist of one (1) part Portland cement to three (3) parts of fine aggregates.

609.3 CONSTRUCTION REQUIREMENTS

603.3.1 Flush Surface Type

The stud shall be installed into the pavement in accordance with the manufacturer's instructions but shall also comply with the following requirements:

Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one (1) cm around the stud base. The longitudinal center line axis of the cavity shall be the same as that required for the pavement stud when laid to correct line and direction.

The walls of the cavity shall be splayed back at an angle of approximately thirty (30) degree to the vertical to facilitate a "dove-tail" joint after the mortar has set.

The bottom of the cavity shall be leveled with asphalt concrete prior to placing the stud base. which shall be pounded into position with Pounder Foot attached to a pneumatic drill.

The depth of the cavity shall be such that when the stud base and reflectors have been installed the elevation of the floor of the lens socket shall not be greater than two (2) mm or less than one (1) mm above the pavement surface.

The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in Item 609.2.3 above when the studs are installed into a cement concrete pavement.

609.3.2 Raised Profile Type

The pavement studs shall be installed in accordance with the manufacturer's instructions or to the requirements of the Engineer.

ITEM 610 PRECAST CONCRETE POSTS AND MARKERS

610.1 DESCRIPTION

The work shall consist of furnishing and placing precast concrete Kilometer, Ten Kilometer, Guide Posts and Right of Way Markers, complete including painting and lettering in accordance with the Drawings and specifications or as directed by the Engineer.

610.2 MATERIAL REQUIREMENT

610.2.1 Concrete

Precast concrete post and markers shall consist of Class A_1 Concrete conforming to the requirements of Item 401 and to the lengths, shapes and other details shown on the Drawings.

610.2.2 Reinforcing Steel

Reinforcing steel shall conform to Item 404.

610.3 CONSTRUCTION REQUIREMENTS

a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Bedding shall be to section and dimension shown on the Drawings or as directed by the Engineer.

b) Placing

The precast concrete posts and markers shall be set in two (2) cm of cement mortar to the level and grade as shown on the Drawings or as directed by the Engineer.

c) Back-filling

After the placing of precast concrete posts and markers in the excavated areas and subsequent setting in with cement mortar, the same will be refilled to the required elevation with suitable earth or granular material, which shall be tamped in layers of not more than fifteen (15) centimeters each until firm and solid.

ITEM 611 FENCING

611.1 DESCRIPTION

This work shall consist of constructing post and barbed wire fence or chain link fence in accordance with the details and at the locations shown on the Drawings or as directed by the Engineer.

611.2 MATERIAL REQUIREMENTS

611.2.1 Barbed Wire

Barbed wire shall conform to the requirements of ASTM A 121, Class I. The barbed wire shall consist of two (2) strands of twelve and half (12.5) gauge wire, twisted with two (2) points, fourteen (14) gauge barbs spaced 10 cm apart.

611.2.2 Chain Link Fabric

Chain link fabric shall be fabricated from nine (9) gauge galvanized wire conforming to AASHTO M 181 and shall be of the type shown in the Drawings. Before ordering the chain link fabric the Contractor shall submit a sample of the material to the Engineer for his approval.

611.2.3 Concrete Posts

Concrete post and prestressed concrete post shall be of concrete Class A_1 and D_1 respectively or as shown in the drawings, in accordance with item 401.

611.2.4 Steel Posts

Steel posts shall be of the section length as specified or as shown on the Drawings. The posts shall be of copper bearing steel and shall conform to the requirements of ASTM A 36/A36M for the grade specified.

611.2.5 Steel Reinforcement

Steel reinforcement for the concrete posts shall be deformed steel bars conforming to the provisions of Item 404.

611.2.6 Hardware

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM A153.

611.3 CONSTRUCTION REQUIREMENTS

611.3.1 Erection of Posts

The posts shall be erected vertically in position, inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during,, the setting process of the concrete. The posts shall be erected to the height and location shown on the Drawings or as directed by the Engineer.

611.3.2 Installation of Chain Link Fabric

The chain link fabric shall be set to line and elevation and pulled tight between each post

before spot welding or other method of fixing is carried out.

Where splicing of the fabric is necessary or at joints the lapping of the chain link fabric shall be a minimum of ten (10) cm and shall occur only at the concrete post. No horizontal splicing will be permitted.

The fabric shall be fixed to the concrete post as shown on the Drawings.

ITEM 612 FURNISHING AND PLANTING TREES, SHRUBS AND GROUND COVER

612.1 DESCRIPTION

Under this work, the contractor shall furnish and plant trees, shrubs, vines, ground covers and other plants in addition to preparing and finishing planting beds and shall perform maintenance and planting operations in a workmanlike manner according to the provisions of these specifications and to accepted horticultural practice.

Trees, Shrubs, Vines, ground covers and other plants will herein be referred to collectively as "Plants" or "Plant Material"

The kinds, sizes and quantities of plants to be furnished and planted and the locations at which they are to be planted shall be as called for on the Drawings or as designated by the Engineer.

612.2 MATERIAL REQUIREMENTS

612.2.1 General

All plant material shall comply with the local laws with respect to inspection for plant diseases and infestation, and such inspection certificates as are required by law shall be filed with the Engineer's representative. All plants shall be first-class representative of their normal species or varieties and shall have average or normal well-developed branch or cane systems together with vigorous root systems. Plant cut back from larger sizes to meet specified sizes will not be acceptable. Plants shall be free from disfiguring knots, sun sealed, abrasions of bark, wind or freezing injury or other disfigurements. Plants shall show the appearance of normal health and vigour and shall bear evidence of proper top and .root pruning. Unless otherwise indicated on the Drawings all plants shall be nursery grown.

612.2.2 Trees

Trees shall have straight trunks, well-branched with symmetrical top and intact leader. They shall have no cuts of limbs over two (2) centimeter in diameter which have not completely healed over. Each tree shall possess the characteristics for its variety and growth typical of such trees in the region.

612.2.3 Shrubs

Each shrub shall possess the characteristics of the variety and growth typical of such shrubs in the region.

612.2.4 Vines, Ground Cover and Other Plants

Vines, ground cover and other plants, such as perennials, which are furnished in pots or other containers and which have been acclimatized to outside conditions will be provided they are equal to field grown stock.

612.2.5 Collected Plants

Collected wood grown or natural seeding plants if permitted for use by indication on the Drawings shall conform in quality, size and grade with the respective requirements herein given for nursery grown stock. In all cases such collected wood grown or natural seeding plants shall be of recognized first quality, clean sound stock free from decayed or decaying stumps and free from fire injury.

612.3 HANDLING & TRANSPORTING

All plants shall be dug, handled, prepared and packed for transportation to site with care and skill in accordance with recognized standard practice for the kind of plant concerned and in compliance with the following provisions from 612.3.1 to 612.3.4.

612.3.1 General

The root systems of all plants shall not be permitted to dry out any time and they shall not be exposed to artificial heat or to freezing temperatures. During transportation, all plants shall be packed adequately to insure protection from the sun, wind and climatic or seasonal injuries. Tarpaulins or other covers shall be placed over plants when they are transported by trucks or in open freight cars for considerable distances. All bare-root plants shall have their root systems protected by wet shingle, tow, moss or other suitable material. All earth balls shall be firm and intact and none shall be "made" balls. All balled and Hessian covered plants shall at all times be handled by the ball, and not by the plant.

612.3.2 Trees

All evergreen trees shall be balled and Hessian covered, except that small trees will be acceptable in suitable containers. The ball shall be firm and the Hessian shall be sound at the time of delivering and placing the tree on the project.

Deciduous trees supplied in bare-root condition, shall have had their root systems puddled in a clay solution of sufficient density as to adhere to all parts of the root system. Deciduous trees may be supplied earth placed and Hessian covered or in containers if the contractor so desires.

The head of each tree shall be carefully tied to prevent fracture of branches.

612.3.3 Shrubs

All evergreen shrubs shall be earth balled and Hessian covered or in suitable containers as above provided for evergreen trees. Deciduous shrubs may be supplied bare root, earth balled and Hessian covered or in suitable containers as provided above for deciduous trees.

When collected wood grown natural seeding stock or other non-nursery grown shrubs are permitted or called for on the Drawing or as directed by the Engineer, they will be specified as "Clumps" of various classifications. Collected plants shall be taken from soil, which has produced a fibrous root system typical of the nature of the plant. The clumps shall be dug with earth and incidental vegetation adhering to the roots of the soil or habit of the root growth in such that the roots are not adequately protected, the root system shall be unwrapped in Hessian or other suitable material.

612.3.4 Vines, Ground Covers, Perennials etc.

Vines, ground covers perennials and other similar plant material supplied in pots, tins and other suitable containers will be referred to collectively as pot grown plants. The root systems must be well protected and the plant supplied in accordance with the specification of quality and protection set forth above. Pot grown plants shall be well developed and sufficient roots to hold the earth together intact after removal from the containers and at the same time not be root bound.

612.4 LABELING OF PLANT MATERIAL

Legible labels shall be attached to each plant, which is delivered to the site as a separate unit, and to each box, bundle, bale or container containing one or more plants. The labels shall give the approved horticultural name, size, age or other detailed data required to identify the plant as conforming to specification and, when not attached to separate plants, the label shall show the quantities of each specified plant contained in the box, bundle, bale or container.

612.5 INSPECTION AND REJECTION

All plants intended for use on the project shall be subject to inspection by the Engineer's Representative at any place and at any time. The Contractor shall inform the Engineer at the earliest practicable date as to the sources of plant materials to be furnished on the project, and shall give the Engineer at least 48 hours notice prior to delivery of plant material at the site of the planting operation.

After arrival at the site of the work and prior to the time of planting, each plant will be inspected by the Engineer's Representative for conformance to the Specification and Drawings, and such plants as do not conform thereto will be marked or otherwise identified as "rejected". All rejected plant material shall be removed from the project and shall be replaced by the Contractor with plant material conforming to all specified requirements, all at the Contractor's expense.

612.6 SUBSTITUTION OF PLANTS

No substitutions of plants material will be permitted unless it is proved to the satisfaction of the Engineer that specified plants are not available during the normal planting season occurring within the Contract period. If substitution of plant materials is thus permitted, it shall be made only with prior approval of the Engineer and shall be subject to adjustment, either for or against the Contractor, in such amount as the Engineer may consider fair and equitable.

612.7 TEMPORARY STORAGE

After being dug and prior to planting on the project, all plant material shall be properly protected against injury at all times. Plants which are not planted or which are not to be planted within one day after arrival on the project shall be given special protection as follows:

- Bare-root plants shall be "heeled-in" in trenches with the bundles opened, the plants spaced separately, and all roots covered and kept moist.
- Earth-balled and Hessian-covered plants shall have their balls protected by earth, straw or either suitable material which shall be kept damp or wet to prevent drying out of root systems.

All plants shall be protected from excessive heat or cold and shall be stored in a well ventilated and shaded place, protected from wind and sun.

612.8 CONSTRUCTION REQUIREMENTS

612.8.1 Layout of Planting Areas

Plant locations and outlines of planting areas shall be marked out and staked by the Contractor. The planting layouts will be subject to the approval of the Engineer prior to commencement of the planting operations.

612.8.2 Preparation of Areas for Planting

Areas on which planting is to be done shall be brought to pleasing contour and to the lines and grades directed by the Engineer, after which they shall be cultivated to a depth of fifteen (15) cm. All weeds and other vegetation growth, large clods, rocks and other debris encountered in the cultivating work, and any excess shall be removed and disposed of in a manner approved by the Engineer.

Excavation or pits for individual plants shall be made in accordance with provision (i) to (iv) which follow:

i) General

Topsoil shall be kept separate from subsoil and shall be rendered loose and friable. Alkaline soil, gravel, stones or other materials or matter encountered in the excavations and which are detrimental to plant growth shall be separated from the soil and disposed of at locations approved by the Engineer.

ii) Trees

Pits for trees shall be at least forty five (45) cm greater in dimension than the diameter of earth ball, or the spread root system of bare-root trees. Depths of pits for trees shall be not less than eighty (80) cm deep and as much deeper as may be necessary to provide a depth of at least twenty (20) cm below the bottom of earth ball or root system of the tree when placed at the proper level.

iii) Shrubs

Pits for shrubs shall be at least thirty (30) cm greater in dimension than the diameter of earth ball or the spread root system of bare-root shrubs. Depths of pits for shrubs shall be not less than thirty (30) cm and as much deeper as may be necessary to provide a depth of at least fifteen (15) cm below the bottom of the earth ball or root system of the shrub when placed at the proper level.

iv) Vines, Ground Covers and Other Plants

Pits, pockets or trenches for vines, ground covers and similar types of plant materials shall be of such dimensions as will provide space for the spread root systems of the plants. In general, the pits, pockets or trenches shall be wider and deeper than the actual space required, as above provided, by such amount as the Engineer may determine as being necessary to provide a space of not less than fifteen (15) cm around and beneath the root systems, in which space good quality topsoil and plant nutrient shall be in place at the time of planting.

612.8.3 Planting

All planting work, including backfilling, shall be performed by experienced workmen and in accordance with the recognized best horticultural practice. Plants shall be set plumb and at such a level of elevation that after settlement they will bear the same relation to the level of the surrounding ground as they bore to the ground from which they were dug. All plants shall be planted on and in good quality topsoil to which fertilizers and soil conditioners shall be added and uniformly mixed. The prepared topsoil used in filling under and around the plant and in backfilling the planting holes, pits or trenches shall be thoroughly and properly conditioned and settled by careful tamping and watering. For spring planting, a shallow saucer capable of holding water shall be formed about each plant on the surface of the completed backfill.

Earth-balled and Hessian-covered plants shall have all cloth, ropes, etc. removed from the top of the earth balls, but no cloth shall be pulled out form under the bails. Prepared topsoil shall be carefully tamped around and under the base of each ball to fill all voids.

Bare-root plants shall have their roots spread out in a natural position and the prepared top soil shall be carefully placed under and among them to fill all voids. Any roots, which are broken or frayed, shall be cleanly cut off from the plant.

In removing plants from containers, especially those of metal, care shall be taken to prevent disturbance of the root systems or ball of earth therein.

If topsoil of suitable quality is not obtainable for planting area preparation in sufficient quantity for the planting work, the Contractor shall make up any deficiency. Insofar as such is available and can be taken without detriment to the highway development, the Contractor will be permitted to obtain suitable topsoil from areas within the jurisdiction of the Employer, subject to the directions of the Engineer as to the location, depth, line and grade to which excavation thereof shall be made. The right to take materials from sources not under the

jurisdiction of the Employer shall be acquired by the Contractor at his own expense.

Subsoil, and topsoil in excess of the amounts required for filling and backfilling work on the planting areas shall be disposed of by the contractor in a manner satisfactory to the Engineer.

612.8.4 Pruning, Guying and Staking

After being planted, all plant materials shall be pruned in conformance to the best horticultural practice appropriate to the type of plant. Pruning shall be such that it removes injured twigs and branches and compensates for loss of roots during planting operations. Pruning shall produce clean cuts without bruising or tearing the bark, shall be in living wood and where the wound can heal over properly. Cuts over 2 cm in diameter shall be painted with an approved tree-wound paint.

All deciduous trees over two (2) meter in height shall be staked or guyed at time of planting. The stake shall be placed in the plant excavation and driven securely into the ground prior to planting operations. The tree shall be placed not to exceed ten (10) cm from the stake and fastened tightly to the stake at a point approximately two thirds the height of the tree by means of two and half (2.5) mm wire. At the point of contact with the tree, the wire shall be covered with a length of rubber hose adequate to protect the bark from chafing and injury. The tie wire shall cross between the tree and stake and be securely fixed at the specified height.

Deciduous trees over two and half (2.1/2) M high, but less than 4 M high, shall be staked in a similar manner. In all cases, the stakes shall be cut off to present a uniformly pleasing appearance as directed by the Engineer.

Trees of four (4) M or greater height shall be guyed with guy cables, each consisting of two (2) strands of two and half (2.5) mm or heavier wire extending from approximately two thirds the height of the tree to a stake or deadman anchored securely in the ground at a distance from the trunk of about three-quarters the height of fastening. The tree shall be protected by rubber hose or similar means. Evergreen trees or other Hessian covered shrubs over half (1/2) M in height shall also be guyed with three (3) cables in a similar manner.

612.8.5 Cultivation of Planting Areas

An area having a diameter of not less than Ninety (90) cm and lying around each planted tree and shrub and an area having a diameter of not less than 30 cm and lying around each planted vine or ground cover shall be loosened and brought to friable condition for a depth of not less than 8 cm. Where plant materials are planted in groups in which the plants are so closely spaced as to justify treatment of the area as a unit, the entire area so occupied and extending 60 cm beyond the outer ends of the branches or canes shall be cultivated as above provided.

Prior to any planting operations, the planting areas shall be brought to the lines, grades and cross-sections indicated on the Drawings or as directed by the Engineer. If the areas are to have mulching material placed thereon, as indicated on the Drawings, grades shall be adjusted and established to provide space for the mulch. At the edges of walks, pavements and driveways the finished surface shall be approximately three (3) cm below the surfaces thereof. At edges of lawn areas, the finished surface shall be approximately five (5) cm above the normal height of grass. The edges of adjoining lawn shall be neatly trimmed with a sharp edging tool.

The cultivating work shall include the removal of weeks, the breaking up or removing of clods, the removal of objectionable stones, litter and debris, as well as the removal and disposal of excess soil. Disposal of these materials shall be in a manner satisfactory to the Engineer.

If mulching is required, as indicated on the Drawings the planting areas may be left in a reasonably smooth condition and with irregularities in surface grade and cross-section not exceeding three (3) cm.

612.8.6 Mulching

Planting areas shall be mulched after cultivation with materials of the approved quality and placed to the depths indicated on the Drawings. Mulch materials shall be spread uniformly over the areas to be mulched and shall be finished to a smooth and uniform surface.

612.8.7 Fertilizers and Soil Conditioners

Fertilizers and soil conditioners shall be mixed with topsoil used in the planting operations and used elsewhere as directed by the Engineer. Mixing of these materials with soil, mulch and other materials shall be thorough and complete. They shall be incorporated in the work as directed by the Engineer.

Fertilizer shall consist of an approved compound containing not less then:

10 percent Nitrogen
15 percent Phosphoric Acid
10 percent Potash

or similar approved composition

The Contractor may add with the approval of the Engineer any additional plant nutrients, which he considers the constitution of the soil to warrant.

612.8.8 Maintenance and Protection

Until such time as all work to be done in the Contract is completed by the Contractor and has been finally accepted by the Engineer, the Contractor shall maintain all plant materials and all planting areas efficiently. Maintenance shall consist of keeping plants in a healthy, growing condition by watering, pruning, spraying and other necessary operations. Maintenance shall also include the keeping of planting areas free from weeds, grass, litter and debris, as well as keeping the area smooth, neat and attractive.

In the event of an infestation from insects or disease, the plants shall be treated by preventive or remedial measures approved for good horticultural practice.

If "heeled-in" plant materials have to be held over until a later planting season, such plant materials shall be lifted and replanted in nursery rows. Such emergency storage and maintenance of held-over stock shall be at the sole risk and expense of the Contractor.

All plant and material shall be protected from stray animals or theft or damage by any element during the specified period of maintenance at the expense of the contractor.

612.8.9 Guarantee and Replacement

Until such time as all work to be done under the Contract is completed by the Contractor and during a specified maintenance period after acceptance of the planting, the life and satisfactory condition of all plants furnished by the Contractor shall be guaranteed by the Contractor.

During this period, all plants, which, in the opinion of the Engineer are in an unhealthy or badly impaired condition, shall be replaced with satisfactory material. After the conclusion of the planting operation and prior to the completion of all normal work to determine the condition of the plantings, all plants then not in a healthy growing condition will be noted for replacement and shall be promptly removed by the Contractor. As soon as seasonal conditions permit, all plants to be replaced shall be replaced by the Contractor with the same kinds and sizes and in the same manner as originally specified and at no extra cost to the Employer.

ITEM 613 SPRIGGING AND SODDING

613.1 DESCRIPTION

These works shall consist of furnishing top soil and planting sprigs or laying grass sods in accordance with the specifications, at the location shown on the drawings, or as required by the Engineer.

613.2 MATERIAL REQUIREMENTS

613.2.1 Top Soil

Top soil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable subsoil, refuse, or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 5 cm in diameter, noxious woods, tall grass, bush sticks, stubble, or other litter, and shall have been cultivated from a healthy growth of crops, grasses, trees or other vegetation that is free draining and non-toxic.

613.2.2 Sprigs

Sprigs shall be healthy living stems (stolons or rhizomes) with attached roots of perennial turf-forming grasses harvested with adhering soil, and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of detrimental materials will be cause for rejection.

613.2.3 Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass.

The grass sod shall be cut into uniform squares approximately 30 cm by 30 cm or in rolls of uniform width of approximately 39 cm and shall have a minimum thickness of 5 cm (excluding grass blades).

613.3 CONSTRUCTION REQUIREMENTS

613.3.1 Top Soil

a) Source of Material

The Contractor shall notify the Engineer at least 5 days before he intends **to** start top soil stripping operations. After inspection and approval by the Engineer and prior to stripping any top soil, the Contractor shall remove noxious weeds and tall grass, bush roots and stones larger than 5 cm in diameter.

b) Placing the Sod

The earth bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after having been cut.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards. When placing sod scour checks or similar construction, the length of the strips shall be laid at right angles to the direction of flow of the water.

As the sod is being laid, it shall be lightly tamped with suitable wooden tampers,

sufficiently to set or press the sod into the underlying soil.

As the sod is being laid, it shall be lightly tamped with suitable wooden tampers, sufficiently to set or press the sod into the underlying soil.

At points where it is anticipated that water may flow over a sodded area, the upper edges of the sod strips (e.g. top of embankment) shall be turned into the soil to be below the adjacent area, and a layer of earth shall be placed over this juncture, and thoroughly compacted.

At the limits of sods areas, the end strips shall be turned in and treated as described above.

c) Staking the Sod

On all slopes steeper than one meter vertical to four meters horizontal the sod shall be pegged with stakes, 20-30 cm in length, spaced as needed by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until flush with bottom of the grass blades.

d) Top Dressing

After the staking has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of top soil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

e) Maintenance of Sodded Areas

The Contractor shall regularly water and maintain sodded areas in a satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

ITEM 614 DUCTS FOR UTILITY SERVICES

614.1 DESCRIPTION

This work shall consist of furnishing and laying of UPVC pipes and concrete surround for future services in accordance with these specifications and the specifications for other work items involved and in conformity with the lines and dimensions shown on the Drawings or ordered by the Engineer.

614.2 MATERIAL REQUIREMENTS

UPVC pressure pipes shall conform to the requirements of class 2 or 3 ASTM D 1785 or BS 3506.

The internal and external surfaces of the pipe shall be smooth, clean and reasonably free from grooving and other defects that would impair its performance in service. The end shall be clearly cut, square with the axis of the pipes and suitably protected from damage.

The pipes shall be provided with approved joints

Each duct shall be provided with wooden stopper at each end and draw cord of approved quality for the full length of duct placed in position.

Concrete surround shall be of Concrete Class B and shall conform to relevant requirements of Item 401. Minimum thickness of surround all around shall be as per Drawings and or as directed by Engineer.

Concrete Markers, where ever placed as shown in the Drawings and or as directed by the Engineer shall be paid under relevant pay item No. 401.

614.3 CONSTRUCTION REQUIREMENTS

All pipes shall be laid accurately to line and grade as detailed in the drawings and shall have a full, firm and even bearing at each joint and along the entire length of pipe. Movement of any construction equipment, vehicles or other loads over or adjacent to any pipe shall be at the Contractor's risk.

Pipe shall be handled and assembled in accordance with the manufacturer's instructions except as modified on the drawings or by the Engineer's written instructions.

Backfilling for pipes shall conform to the requirements of Item 107 of these Specifications.

ITEM 615 DISMANTLING/REMOVAL OF WALKWAYS, KERBSTONES AND PAVING TILES

615.1 DESCRIPTION

The work shall consist of dismantling and removal of walkways, Kerbstones and paving tiles includes disposal and stock piling of suitable dismantled materials to suitable location approved by the Engineer. The kerbstones and paving tiles, if suitable and thus salvaged shall be stockpiled at a designated place and handed over to the Engineer. All other items against dismantling shall be removed and disposed off to designated place as approved by the Engineer. The Contractor shall be responsible for watch and ward of removed and dismantled material under this item and the safe custody up to two months till its final disposal by the Engineer's/Employer's Representative.

ITEM 616 PAVING TILES

616.1 DESCRIPTION

This work shall consist of the construction of solid paving tiles, all in accordance with the specifications and in conformity with the lines, grades and typical section shown on the Drawings or as established by the Engineer.

616.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements of Item No. 401 "Concrete" as specified herein.

Solid concrete tiles as provided in the drawings or directed by the Engineer shall be constructed of mortar and concrete in two layers as follows:

a) An upper layer formed of one cm thickness of 1:1 cement: sand mortar by volume.

b) A lower layer formed of five cm thickness of concrete Class A_1 conforming to the requirement of Item No. 401 "Concrete". Combined aggregates shall conform to the following gradation, unless otherwise approved by the Engineer:

ASTM SIEVE	% Passing by Weight
1/2"	100
3/8"	84-100
No. 4	60-86
No. 8	40-60
No. 16	28-45
No. 30	18-32
No. 50	9-20
No. 100	3-10
No. 200	0-3

616.3 CONSTRUCTION REQUIREMENTS

616.3.1 Casting of Tiles

All elements shall be pre-cast by hydraulic pressing, in an approved machine using concrete produced in a full automatic batching plant.

616.3.2 Testing

Tests shall be carried out on the concrete mix prior to commencement of manufacture to verify that the specified strength and surface finish requirements will be met. If the required strength and surface finish are not achieved, the Engineer may instruct adjustment in the mix proportions, etc. in order to achieve the specified requirements. Mix design changes and any other work considered necessary shall be considered subsidiary to the manufacture of the elements.

Prior to approval of elements of commercial manufacture, cores shall be taken from a random sample and tested to determine the compressive strength, which shall not be less than specified.

616.3.3 Dimensions

Elements shall be manufactured to the dimensions shown on the Drawings and/or as instructed by the Engineer. For horizontal curves or radius less than ten meters, elements shall be manufactured to the radius shown and in no circumstances with straight elements or portions of straight elements be permitted.

616.3.4 Surface Finish

The finished elements shall be of sound appearance with clean plane faces, free from segregation, honeycombing, pits, broken corners and other defects. There shall be no evidence of external rendering.

Bull noses and curved faces shall be of constant radius with a smooth change from radius to plain face.

Manufacturing tolerances shall be three mm in any one, dimension and end faces shall be truly perpendicular to the base.

616.3.5 Joints

Between kerbs and paving tiles, the joints shall have a width of four (4) mm and shall be filled with 1:1 cement: sand mortar with one fifth part hydrated lime and sufficient water to make the mixture plastic and easily, smoothed and finished. Joints between paving tiles shall be filled by sand.

616.3.6 Bedding

Paving tiles to be laid on top of RCC cover slab of drains, shall be placed on a bed of 2cm thick 1:3 cement:sand mortar.

Tiles shall be laid on a foundation compacted to 95% of MDD, AASHTO T-180.

ITEM 617 PAVING TILES WALKWAYS

617.1 DESCRIPTION

This work shall consist of construction of solid Paving Tiles walkways, lay-bys etc in accordance with plans, lines, grades and detail shown in drawings. Bed course shall be of subbase material and tiles shall be laid on a foundation of sand cushion as specified in the drawings. The work consists of furnishing of all plant, equipment, material and labor and performing all operations for excavation and backfill, strictly in accordance, with all the relevant sections of these Specifications.

617.2 MATERIAL REQUIREMENTS

617.2.1 Paving Tiles

Paving Tiles shall conform to the item 616 of these Specifications.

617.2.2 Concrete

Concrete shall conform to the item 401 of these Specifications. .

617.2.3 Bed Course Material

Bed Course Material shall be subbase material.

617.2.4 Precast Concrete Kerb

Precast Concrete Kerb shall conform to the item 601 of these Specifications.

617.3 CONSTRUCTION REQUIREMENTS

617.3.1 Casting of Tiles

All elements shall be precast by hydraulic pressing, in an approved machine, using concrete produced in a fully automatic batching plant.

617.3.2 Bedding

Tiles shall be laid on a foundation of sand cushion 3 cm thick, unless shown otherwise on the drawings.

ITEM 701 PROVISIONS OF SURVEY TEAMS AND INSTRUMENTS

DELETED

ITEM 702 PROVIDE, EQUIP AND MAINTAIN OFFICE FACILITY AND RESIDENCE FOR THE ENGINEER (BASE CAMP FACILITY) AND CLIENTS REPRESENTATIVE

DELETED

ITEM 703 PROVIDE, EQUIP AND MAINTAIN LABORATORY FOR THE PROJECT

DELETED

ITEM 704 MAINTENANCE OF WORKS FOR ONE YEAR AFTER COMPLETION, DEFECT LIABILITY PERIOD (PERIOD OF MAINTENANCE)

DELETED

ITEM 705 TEMPORARY ROAD WORKS FOR TRAFFIC DIVERSION

705.1 DESCRIPTION

The Contractor is allowed to carry out rehabilitation work on half carriageway and direct the traffic on the other half. However if he opts to divert the traffic on temporary road for ease in construction, he shall provide, maintain and remove on completion of the works for which they are required, all Temporary Road Works such as, detours, sleeper tracks over unstable ground and bridges over streams and shall make them safe and suitable in every respect for maintaining two way diverted traffic. Such temporary diversion structures shall be constructed to the satisfaction of the Engineer.

705.2 MATERIALS

Materials used in the construction of Temporary Road Works shall provide reasonably smooth and strong surface to carry the traffic, as approved by the Engineer

705.3 CONSTRUCTION AND MAINTENANCE REQUIREMENTS

Before constructing Temporary Road works, the Contractor shall make all necessary arrangements, including payment if required, with the public authorities or land owners concerned, for the use of the land and he shall also obtain the approval of the Engineer. Such approval will not, however, relieve the Contractor of his contractual obligations. Upon completion of the Works, the Contractor shall clean up and restore the land to the satisfaction of the Engineer or the landowner concerned, which shall be very near to original condition, unless otherwise allowed in writing.

705.3.1 Construction requirements for Temporary Road

Works shall be carried out by the Contractor as per requirement of items used in construction or as directed by the Engineer. Length of diversion shall not exceed more then 20 percent of project length unless otherwise authorized by Engineer.

705.3.2 Maintenance of Temporary Road

Works shall be performed periodically and to such an extent as to cause no delays or interruption to the normal flow of traffic. Such work shall include, but not limited to, immediate repair of potholes, regular grading to maintain smoothness of the road surface, cleaning of culverts to ensure proper drainage, repair of damaged portions which may affect traffic flow.

ITEM 706 CONTROL AND PROTECTION OF TRAFFIC

706.1 DESCRIPTION

706.1.1 General

The Contractor shall keep open to traffic half a portion of any existing road during the performance of the rehabilitation work on the other half provided that when such a maintenance of traffic is not possible for any reason the Contractor will construct a temporary road as provided under item 705.

The Contractor shall take necessary care at all times to ensure the convenience and safety of residents along and adjacent to the Highway.

Any failure of the Contractor in the performance of these works will entitle the Engineer to carry out such work as he deems to be necessary and to charge the Contractor with the full cost thereof, which sum will be deducted from any money due or which may become due to the Contractor under the Contract.

706.1.2 Temporary Traffic Control

In order to facilitate traffic movement through or around the works, or wherever ordered by the Engineer, the Contractor shall erect and maintain at prescribed points on the works and at the approaches to the work, traffic signs, signals, illumination, flares, barricades and other facilities as required by the Engineer for the direction and control of traffic.

Where required, or where directed by the Engineer, the Contractor shall furnish and station competent flagmen, whose sole duty shall consist of directing the movement of traffic through or around the work.

706.1.3 Single-Lane Traffic Control

In all cases where single-lane traffic becomes necessary over a particular length of the works or over the approaches thereto, the Contractor, in maintaining through traffic, shall provide a single lane at least three and a half (3.5) meters wide on the roadway or embankment to be kept open to traffic.

The Contractor shall so conduct his operations as to offer the least possible obstruction, inconvenience and delay to traffic and shall be responsible for the adequate control of the traffic using the width, of single lane above specified.

At places where such single-lane traffic is in operation, and when ordered by the Engineer, the movement of the Contractor's equipment from one portion of the work to another shall be subject to such single-lane traffic control. Spillage resulting from haulage operations along or across the roadway shall be removed immediately at the Contractor's expense.

706.1.4 Project Information Signs

The Contractor shall within the mobilization period, erect project information signs at all main roads crossing the project area and at the beginning and end of the contract. The size of the project information signs and the message thereon shall be determined by the Engineer.

706.2 MATERIALS

Materials of which road posts, hazard markers, warning tapes, traffic signs, flashing amber lights, signals, barricades, diversion cones, big cones, bollards, detours (Chevron) etc; shall conform to current BS or ASTM standards or as approved by the Engineer.

706.3 CONSTRUCTION REQUIREMENTS

Traffic signs, signals, barricades, warning tapes, road posts, hazard markers, cones, bollards etc. shall be so placed as to be easily and opportunely visible to oncoming traffic to ensure drivers will know immediately what instructions they are to follow.

ITEM 707 REMOVAL/ RELOCATION OF UTILITIES

707.1 DESCRIPTION

This work shall consist of carrying out relocation of various types of services falling within the Right of Way. The quantum of work shall be as directed by the Engineer.

707.2 MATERIAL REQUIREMENTS

All materials, if required for the relocation of services shall conform to the Specifications of the relative department whose utilities are being shifted.

707.3 CONSTRUCTION REQUIREMENTS

The construction requirement such as alignment, level and general workmanship shall conform to the applicable requirements of relative departments.

ELECTRICAL WORKS

ITEM 800 G E N E R A L

800.1 DESCRIPTION

The work under this Contract consists of supplying, storage at site, installing, testing and commissioning of all materials and services comprising poles, lighting fixtures, lighting control panels, distribution transformers, cables, earthing, conduits and pipes etc., as specified herein, shown on the Drawings and given in the Bill of Quantities. Small items which are not expressly specified but which are necessary for completion of work shall be supplied by the Contractor without extra cost. The supply connection for lights etc. shall be obtained from the nearby WAPDA source. The work shall be complete in every respect for satisfactory operation as per specifications and standards give hereinafter.

The Contractor shall co-ordinate with the Engineer at site with respect to other services for exact location and position of all electrical equipments.

800.2 GENERAL

The location of the lighting fittings, poles, distribution boards, lighting control panels, distribution transformers and cables etc. are tentatively shown on the drawings. The Contractor shall ensure the exact position and location of poles and cable routes etc. in coordination with other services as per site requirement. The Contractor shall be responsible for proper light distribution on the road/underpass surface from the proposed luminaires and other equipment after installation and commissioning. He shall be fully responsible during maintenance period of the works.

The road/underpass lighting work shall be installed as per requirements of BS-5489 or other similar international standards. The Contractor shall also comply with the regulations of Pakistan Electricity Act and requirements of Water and Power Development Authority (WAPDA), wherever applicable.

The quality of equipment shall be of the best grade for each type, even though such quality may not be stated specifically in the specifications. All materials and products shall be new and manufactured by well known firms. Furthermore, these shall be sound and uniform in quality, size, shape, colour and texture and free from cracks, wrapage or other defects.

Component parts of each electrical system or piece of equipment shall be the latest standard product of a single manufacturer unless otherwise specified and provided sub-components, manufactured by different manufacturers are of specified standards design and dimensions and interchangeability is possible and shall normally have been satisfactory in service for at least two years.

The design criteria for road lighting are based on the following parameters;

Luminance (L) cd/m^2	1.5 cd/m^2
Overall Uniformity (Uo) (Uo = L min. /L avg.)	0.4
Uniformity of Each lane (UI) (UI = L min. /L max.)	0.5 – 0.7
Threshold increment not exceeding	≤ 10

Road surface characteristics as per IEC classification is type R2 with qo = 0.07.

The contractor shall be responsible and confirm in writing that his selection of equipment will ensure on the road surfaces luminance level and uniformities equal or better than those defined in the lighting design criteria.

Within six (6) weeks after award of the contract, the contractor shall submit the technical details of the luminaries and other equipment and having obtained conditional approval thereof submit in duplicate, full detail of the calculated results for the level and uniformity of luminance and illumination on all road surface .These detail should be submitted in the format as described in the relevant IEC publication and after initial approval by the engineer.

800.3 APPLICABLE REGULATIONS AND STANDARDS/CODES

The latest edition of the following standards & codes shall be applicable for the materials within the scope of this work.

IEC - International Electro-technical Commission

IEEE - Institute of Electrical and Electronics Engineers U.S.A.
(IEEE Wiring Regulation UK).

BSS - British Standard Specifications

VDE - Verband Deutscher Electro-technical (Association of German Electrical Engineers)

NEMA - National Electrical Manufacturers Association, U.S.A.

PSI - Pakistan Standards Institution

CIE - Commission Electro-technique International

800.4 TESTING

800.4.1 Factory Tests

a. General

All type and routine tests on switchgear and all other equipment shall be performed at the manufacturer's works in the presence of the Engineer or his representative. Type tests may be waived off in case test certificates as certified by an approved standard laboratory of international repute are provided by the Contractor and approved by the Engineer. Submission or merely producing the type test certificates shall not relieve the Contractor to carry out the required standard/routine tests.

The Contractor shall arrange at his own cost factory visit(s) for pre-shipment inspection/testing for all major electrical equipment offered. Airfare to and from inspector's home town (two persons), boarding, lodging and transport shall be Contractor's, responsibility and all costs in this respect shall also be borne by the contractor.

In addition, for all pre-shipment inspections carried abroad, the Contractor shall provide (for two persons) daily allowance @ 200 US$ per day for out of pocket expenses, at per diem rate per person currently recommended by Chamber of Commerce and Industry for foreign travelers on business visa. The number of days shall be actual days spent in travel from and to the home town of the concerned inspector but not less than five (5) days. The 200 US$ per day per person in cash shall be provided before start of travel from hometown.

For all pre-shipment inspections carried out within Pakistan, the Contractor shall provide (for two persons) daily allowance of Rs. 2,000 for out of pocket expenses, at per diem rate

per person. The amount shall be provided in cash before start of travel from hometown for the entire duration of the visit.

The Contractor shall inform the Engineer about the date and time of test of each equipment at least two weeks in advance. The witnessing of test by the Engineer or his representative shall not absolve the Contractor from his responsibility for the proper functioning of the equipment, and for furnishing the guarantees. All test results shall be supplied in triplicate.

b. Insulation Resistance Test

Insulation resistance test shall be made on all Electrical equipment by using a meggar of 500 volts for circuits upto 250 volts and 1000 volts for circuits between 250 and 500 volts.

The insulation resistance values of cables, switchgear, etc., shall be as per BSS, IEC and Pakistan Electricity Rules.

800.4.2 <u>Field Tests</u>

a. General

Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Engineer for the purpose of demonstrating equipment or system compliance with Specifications. The Contractor shall submit for Engineer's approval complete details of tests to be performed describing the procedure, test observations and expected results.

The Contractor shall furnish all tools, instruments, test equipment, materials etc. and all qualified personnel required for the testing, setting and adjustment of all Electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the Contractor shall be responsible for adequate protection of all personnel and equipment during such tests.

The Contractor shall record all test values of the tests made by him on all equipment. Three (3) copies of all test data and results certified by the Engineer shall be given to the Engineer for record purposes. These shall also include details of testing method, testing equipment, diagrams etc.

b. Earth Resistance Test

Earth resistance test shall be made by the Contractor on the earthing system, separating and reconnecting each earth connection.

If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer will determine the extent of such corrective measures.

The Electrical resistance of the ECC together with the resistance of the earthing leads measured from the connection with earth electrode to any other position in the complete installation shall not exceed five ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earth electrodes are installed, the earth resistance test of each electrode shall be measured by means of resistance bridge instrument.

c. Switchgear Test

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams furnished by the manufacturer.

The Contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses disconnect switches, number of interlocks, indicating lights, alarms and remote control devices shall be in accordance with approved manufacturer drawings. Name plates shall be checked for proper designation of equipment served.

ITEM 801 POLES FOR ROAD LIGHTING

801.1 SCOPE OF WORK

The work under this section consists of designing, manufacturing, supplying, installation testing and commissioning of the street lighting poles and accessories as specified herein, or as shown on the Tender Drawings and given in the Bill of Quantities.

The Contractor shall discuss the electrical layout with the Engineer and coordinate at site with other services for exact location and position of the electrical poles.

The poles with accessories shall also comply with the General Specifications for Electrical Works Section-8001 and with other relevant provisions of the Tender Documents.

801.2 APPLICABLE STANDARDS/CODES

The latest editions of the following standards/codes shall be applicable to the material specified within the scope of this Section:

ASTM A36 -	Steel for Pole and Base Plate	
ASTM A307-	Anchor Bolts	
BS EN ISO 1461	-	Galvanization
ASTM A123 & A385	-	Galvanization

801.3 CONSTRUCTION OF POLES

The galvanized steel poles shall be of mild steel as shown on drawing from base plate to lantern connection, well proportioned and neatly finished. The height of the pole from the centre line of the spigot for lantern connection to the ground line and out-reach of each arm from the vertical centre line of the pole to the tip of the spigot for lantern attachment shall be as shown on Drawing. Approval of the Engineer shall be obtained before ordering the poles for manufacturing.

The pole (vertical portion) alongwith base plate shall preferably be in one piece. But if manufacturing in one length is not possible, it can be in two or three pieces with force fit lap joint.

The steel poles after fabrication shall be galvanized by hot dip process (inside and outside) as per applicable standards -Hot Dip Galvanized Coatings on Iron and Steel Articles'. The poles shall be prepared before galvanizing by removing grease, burs and slag etc. so that zinc coating is adherent, dense, smooth, continuous and uniform. The Contractor shall ensure before placing of order that the firm has adequate facility for hot dip galvanizing process as per standard practice. The steel used in the manufacture of poles shall be made by open hearth or electric furnace process.

The straight portion of the pole shall be truly vertical and no deviation more than 100 mm in the entire length shall be accepted.

Other tolerances shall be as follows:

- Outside diameter = +/- 1%
- Wall thickness = +/- 10%
- Overall length of pole = +/- 0.5%

- Weight = - 0.3%
  + not limited.

The pole and the bracket shall be so designed that when subjected to wind at a velocity of 160 km/hour on the full projected area of pole, bracket and the lantern a factor of safety of 3 on minimum tensile strength of the material shall be obtained. In addition, the temporary horizontal deflections at the lantern position shall not exceed 1/40 of the length of the pole above ground at aforementioned wind velocity.

The poles shall have a base compartment, designed to accommodate a loop-in services cutout for 4 core PVC/SWA/PVC cables of given sizes. A 8 mm stainless steel stud complete with nut and washers shall be provided in the base compartment of the pole for earthing purpose.

The edges of the door opening on the pole shall be reinforced with a 10 mm thick M.S. square bar to reinstate the strength of pole at this location. The opening cover shall consist of weather proof hinged door. The door shall be provided with a heavy duty non-rusting lock.

Flag brackets shall be fitted to poles if shown on the drawing and shall be as approved by the Engineer.

801.4 CONSTRUCTION REQUIREMENTS

Lighting poles shall be handled/transported and erected in such a way so as to avoid any damages. Any damage to pole or galvanizing shall be made good to the satisfaction of the Engineer.

The lighting poles shall be stored clear of soil, ground water or other rust producing materials. The fixing of poles shall be carried out in accordance with manufacturer's instructions and good engineering practice.

The poles shall be erected in a true vertical position.

Where lighting poles are to be installed in the vicinity of overhead power lines, the Contractor shall inform the Engineer and act as directed. He shall maintain clearances as per WAPDA requirements from the power lines.

The Contractor shall number all the poles with high quality paint using stencil for 50 mm high lettering. The numbering shall be at 1200 mm from the bottom of pole towards the road. The numbering shall be in a manner as directed by the Engineer.

Earth backfill around pole foundation shall be done in 150 mm thick layers and shall be well rammed and compacted to provide full lateral support.

801.4.1 Data to be Submitted

Before manufacturing, the Contractor shall submit for approval of the Engineer, the shop drawing of the pole anchor bolts, base plate and pole bracket together with details of the base compartment, cover and the means adopted for making it waterproof and tamperproof. Design calculation sheets for the poles from manufacturer shall also be submitted by the contractor to show that poles/foundations are safe for all specified stresses.

801.4.2 Tests

801.4.2.1 General

The poles shall be tested and the results recorded for each test by the manufacturer in the presence of an authorized representative of the Owner or Engineer as stated below.

801.4.2.2 Inspection

Prior to inspection, checklist shall be submitted pertaining to fabrication of each pole lot duly filled in by the manufacturer.

The material, weight and dimensions of poles as specified shall be certified by the manufacturer. The poles shall be inspected and in case being found below the limits of tolerance as aforementioned, shall be rejected.

801.4.2.3 Sample Test

Sample of poles shall be selected at random basis from each lot of high masts and poles and shall be checked in accordance with the project specific requirements, BoQ, relevant construction drawings and applicable manufacturing standards. Factory routine test certificates shall be submitted by the manufacturer for each type of high masts/poles.

801.4.2.4 Galvanizing

Weight, uniformity of coating and other requirements shall be strictly inspected in accordance with applicable standards.

801.4.2.5 Service Cutouts

Each pole shall be provided with a waterproof and dust tight loop-in-service cutout accommodated in the base compartment of the pole.

The junction box shall comprise two (2) 2A MCB, for double arm poles and one (1) 2A MCB in accordance with IEC 60947 for single arm poles, a solid neutral link and an earthing terminal. It shall incorporate arrangements for looping "IN" and "OUT" for 4 core up to 25 mm^2 PVC/SWA/PVC cable having copper/aluminium conductor. The earth terminals, nuts and washers shall be adequately sized to take the earth continuity conductors with tight connections.

Dimensional drawings and details of the junction cutout box of pole shall be submitted for approval to the Engineer.

801.5 MEASUREMENT AND PAYMENT

801.5.1 Measurement

Measurement shall be made for the number of poles including all accessories and foundation block acceptably supplied and installed by the Contractor as shown on the drawing.

801.5.2 Payment

Payment shall be made for the number of units measured, as provided above, at the contract unit price each, and shall constitute full compensation for supplying, installing, connecting, testing and commissioning of each pole including junction cutout box.

The galvanized steel poles shall be of mild steel as shown on drawing from base plate to lantern connection, well-proportioned and neatly finished. The height of the pole from the centre line of the spigot for lantern connection to the ground line and out-reach of each arm from the vertical centre line of the pole to the tip of the spigot for lantern attachment shall be as shown on Drawing. Approval of the Engineer shall be obtained before ordering the poles for manufacturing.

ITEM 802 LUMINARIES

802.1 Description of Scope of Contract

Manufacturing, supply, installation, testing and commissioning of Light Emitting Diode (LED) Road Lighting Fixtures of make/model of Philips, GE or equivalent, conforming to the international standards, suitable for ME 1, ME 2 and ME 3 roads, with built-in flexibility in the optical system for each of the wattage groups as specified:

802.2 Major Contract Components

The major contract components are the lighting design calculations for project specific requirements, design & manufacturing, type testing (or test reports from independent laboratories on similar fixtures), factory acceptance testing, supply/transportation to site, installation at site, site acceptance testing & commissioning and maintenance & local support during Four (04) years warranty period of LED Road Lighting Fixtures after defect liability period of one year and the associated equipment/hardware thereof.

802.2.1 Lighting Installation Period

The installation period may vary as per project specific requirements. However, the delivery schedules are defined in the Tender Documents.

802.2.2 Specifications

802.3 General Requirements

802.3.1 Housing

The fixture shall have a full die cast aluminum housing providing adequate rigidity, strength and heat dissipation. Bidder to provide the manufacturing standard details.

The housing shall have integrated driver and LED lamp compartments for better heat dissipation and convenience in maintenance at the site, and shall feature multilayer optic with highly reflective components to increase light output.

The optical LED compartment shall have thermally hardened (Tempered) glass cover and high quality silicon gaskets. The glass shall be extra-white for maximum light transmission. The glass cover shall be tightly secured with the housing.

The bidders/supplier/manufacturer shall submit the samples of each wattage/type/model of the fixture being offered along with its submittal.

802.3.2 Optics

The fixtures for the project shall have flexible optical systems for the wattage range in the respective group.

The fixture shall use high efficiency (greater than or equal to 90%) LED and optics system.

The Light Output Ratio (LOR) shall not be less than 85%.

The fixture shall offer composite system efficiency above 110 lumen/Watt (tolerance of +/- 5%).

The lens system design and high efficiency LED shall facilitate maximum spacing between the road lighting poles and coverage of wider roads.

The multilayer optics design shall ensure adequate luminance and illuminance uniformity in the unlikely event of an individual LED failure.

The fixture shall offer choice of narrow, medium and wide beam light distribution.

The optical lens system shall feature long life with no discoloration (UV protection), highest possible light transmission and having high reflectivity for maximum light output.

802.3.3 Surge Protection

The lighting fixture shall have surge protection to protect the electronic driver and LED system. Minimum surge protection rating shall be 10 kV.

SPD should comply to IEC 61347-2-11 and should be listed in Luminaire IEC 60598-2-3

802.3.4 IP Protection / Impact Resistance

The complete fixture including lamp and gear compartments shall have minimum ingress protection class IP66 for Road Lights and IP65 for Flood/tunnel Lights for long reliable performance and minimal maintenance requirement and an Impact Resistance of IK08 or above (Road Lights) and IK07 or above (Flood/tunnel Lights). No chemical glue shall to be used as that may cause breakdown of water-proof and dust-proof seal. All Synthetic material shall be 100% UV stable and scratch resistant.

802.3.5 <u>Design of Fixture w.r.t Maintenance</u>

Both the driver and LED compartments shall be designed to be easily accessible for maintenance. Whatever method of i.e clamps/screws for securing/assembling of fixture is used, it is to be ensured that the fixtures are designed in a manner so that frequent opening/closing at site during maintenance does not compromise its ingress protection (IP) rating and the various components like terminal blocks, LED drivers etc. are not dislocated from their designated position.

Gaskets are to be properly secured in special groves made for the same and must not be fixed to the body by any adhesive material.

The components inside the gear compartment like LED drivers, terminal blocks etc. must be easily detachable by using plug and play connectors/terminals to ensure ease of replacement at site and to be secured in the body of the fixture making special mounting arrangements so that the same are not dislodged/dislocated from their designated position.

802.3.6 Mounting

The mounting of the fixture shall be in axial orientation through suitable sized sidearm. The means for attaching the luminaire or external part to its support shall be appropriate to the weight of the luminaire or external part.

802.3.7 Future Compatibility

The fixture shall be fully compatible with future LED upgrades when they become available. It shall have a modular design to upgrade / replace with new LED modules or LED drivers at site conveniently with minimum effort. All electronic components/ drivers shall be mounted in a manner so that they are easily accessible and replaceable during

maintenance. Lamp compartment shall have an easy access for opening and closing at site.

802.4 LED Driver/Electronic Control Gear for LED Modules

The LED driver shall be designed to operate large array of high powered LEDs through current controlled output. The driver shall be suitable for 230V, +10%, -15%, 50Hz, single phase mains AC supply.

The LED driver shall have an efficiency of at least 90%.

The LED driver shall have energy saving/dimming options. So, that the driver can be easily programmed at site in a manner that different output wattages are available from the same fixture as per requirements. In the late night mode the fixture can thus be operated at various reduced wattages as per traffic conditions to have an energy efficient use.

The LED driver shall be of Philips, Meanwell, GE, Schwabe or Lightech Make or equivalent (duly type tested as specified and in full conformance to the technical requirements/specifications).

The driver shall have Power Factor (PF) >0.90 at maximum load.

802.5 LEDs

The LED chip shall be Philips Lumiled, Cree, Nichia or Osram make or equivalent (duly type tested as specified and in full conformance to the technical requirements/specifications).

The LEDs shall:

- Be designed for lumen maintenance of L70 or 70% at the end of useful life at ambient temperature of 35 ºC.
- Have a useful life of 50,000 burning hours at 50 ºC.
- Have a minimum color rendering index (Ra) of 70 (+10/-10) and a color temperature above 5000K.
- Have a color consistency within 7 SDCM (standard deviation of color matching) as defined by MacAdam.

The bidder shall submit the exact details w.r.t the model number, binning efficacy, CRI/CCT, LM 21 calculations of LED chip/wafer being used in the fixtures manufactured by them.

802.6 Thermal Management

Managing thermal properties in LED fixtures is most critical to ensure optimum performance of LEDs and reliability of the system.

The housing under the circuit board shall be specially designed to ensure perfect contact between the board and the fixture housing for efficient heat dissipation.

PCBs used shall maximize the heat transfer process and to offer reinforced electrical insulation via dielectric layer. The PCB shall be mounted on the housing using a highly efficient thermal interface material. Use of Silicon glue is not acceptable. The PCB used shall be from a reputed PCB manufacturer offering fully traceability of the product along with its serial number/identification numbers to ensure quality of the product.

The housing shall have additional ribs and shall also have adequate surface area to ensure fast heat dissipation.

802.7 Photometrics

Fixtures shall have Illumination Engineering Society (IES) Type II or III distribution pattern, with short or medium longitudinal distribution.

LM-80 LED and photometric test reports and IES files from a third party testing Laboratory/authenticated source shall be available.

Photo Biological Safety:

Ensure luminaries comply with Photo biological Safety of lamps and lamp systems in accordance with the requirements of BS EN 62471:2008 or ANSI/IESNA RP-27. 3-0.

Provide proof of testing and compliance to the standards along with certification provided to prove the fixture is classed as “Exempt” or Risk one. (The main target is to show up passed for blue rays toxic effect on retina)

Required Lighting Levels:

Unless otherwise mentioned, LED street lighting suppliers shall follow CIE115, including M1, M2, M3, M4 lighting levels as per applications and given parameters.

A maintenance factor of 0.75 shall be used on all lighting calculations, provided that the supplier need to submit lighting calculations at MF of 1 represents the day one measurements shall be submitted along with 0.75 calculations.

802.8 Warranties

Warranties & Maintenance

The complete fixture including all accessories shall have at least four (04) years warranty, after one year of Defect Liability Period (DLP), against any manufacturing defects and failures.

The LED manufacturer /authorized agent/assembler shall not only be responsible for 5 years of warranty but also during the warranty period maintenance of the fixtures including free of cost replacements of any/all defective components/parts against manufacturing defects with the genuine products/components through the manufacturer/authorized agents under the supervision of the contractor/ maintenance agency.

The involvement of the manufacturer/authorized agent for maintenance/replacement of components is considered important because the warranty of the manufacturer becomes void if genuine product/manufacturer recommended methodology/components installation is not followed. In addition to this it is also necessary that genuine branded products those offered at the time of supply with the fixtures are provided for the 5 years of warranty / component replacement period.

Undertaking in this regard shall be submitted by the contractor as well as manufacturer/authorized agent/assembler to the Client.

Further, if required, the manufacturer/authorized agent/assembler through contractor shall provide the proof of genuineness from the manufacturer for various components provided/installed in the fixtures after fulfilling the technical requirements

The road light supplier/manufacturer shall be bound to make on site measurements to the Client's representatives wherever, applicable (i.e., where a dedicated & proper lighting network has been designed) if required, by the client for cd/m^2 (Luminance) on annual basis to ensure the compliance of the desired output light levels in accordance with CIE 140 with Luminance meter. In this manner the light output depreciation and useful life of the LEDs (50,000 burning hours) shall be compared accordingly. In case, the lighting output depreciation is not within the limits prescribed by the standard as well as any other non-compliance/mal-operation of any component is noted, the contractor/ road lighting manufacturer shall be responsible for replacement of any/all component free of cost during the warranty period. The undertaking in this regard shall be submitted through the contractor on manufacturer's letter head to the Client.

An undertaking shall be submitted by the contractor/supplier on manufacturer's letter head clearly confirming that the submitted reports are original and test values/results mentioned in the reports are authenticated.

Contractor/supplier/manufacturer shall confirm that the LED chip/wafers, drivers, SPDs used are genuine and shall furnish the undertaking of LED chip/wafer, drivers & SPDs manufacturers on its letter head where applicable for use of LED chips/wafers, driver & SPDs in the fabrication/manufacturing of LED light fixture.

The Contractor shall have an active team in consultation with the Client responsible to check the nonoperational lights on daily basis and shall rectify within two (02) days on self-response basis (pertaining to his scope only) during DLP and uptil warranty after DLP, otherwise the penalty @ of PKR 200 per day of delay for each non-operational light will be charged from the Contractor. In case the fault is not on his part he will promptly notify the same to the concerned authority.

802.9 Applicable Standards and Codes

The fixtures shall conform to the following latest standards and codes. It shall be the mandatory requirement that the bidder shall submit detailed type test reports from certified international testing agency / laboratory / body to establish its conformance to the specified international standard.

- IEC 60598-1
- IEC 60598-2-3 (Road & Tunnel Lights)
- IEC 60598-2-5 (Flood Lights)
- LM-79 for the luminaries being offered (Model/Wattage specific)
- LM-80 for LED chip being used
- LM-82-12 (Model/Wattage specific)
- IEC 62471 (For the complete fixtures being offered as well as for the LED Chips)
- EN 55015 : 2006 and 2007 – Limits and methods of measurement of radio disturbance characteristics of electrical lighting
- EN 61547 : 1995 / +A1 : 2000 – Equipment for general lighting purpose EMC immunity requirements
- EN 61000-3-2 : 2006 – Limitation of harmonic current emission
- EN 61000-3-3 : 2008 – Limitation of voltage fluctuation and flicker
- EN 62493- Assessment of lighting equipment related to human exposure to electromagnetic field (environmental friendly)
- Thermal management test (UL 1598) (Model/Wattage specific)
- IP Degrees of protection provided by enclosures (IP Code)
- Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

The LED driver shall conform to following latest standards and codes:

- EN61347-1: Lamp control gear general and safety requirements
- EN61347-2-13: particular requirements for DC or AC supplied electronic control gear for LED modules

- EN62384: DC or AC supplied electronic control gear for LED modules performance requirements
- Technical and descriptive data and drawings.

802.10 Technical and Descriptive Data and Drawings

Technical and descriptive data and drawings to be submitted shall include but not be limited to the following:

- Technical data of fixtures and driver
- IES photometric file (absolute photometric data)
- LM-79 test report for each of the fixture type/wattage being offered.
- LM-80 test report of LED used
- LM-82-12 (test report) of the fixture type/wattage being offered.
- Thermal management test report (UL 1598) of the fixture type/wattage being offered.
- EN 62493- Test report
- IK rating test report
- Lumen depreciation test report at 1000, 2000, 3000, & 6000 burning hrs.
- 3rd Party IEC 60598 test reports.
- Vibration test report
- EMC test report
- Salt spray test report
- Photo- biological safety test report
- Customer testimonials
- Factory ISO certificate
- Reports of other type tests stipulated in the respective standards/codes
- Country of origin, Manufacturing works/ factory details, premises & QA & QC procedures, in-house testing procedures, routine testing procedures/protocols with traceability mechanism on light fixtures being manufactured and testing equipment details w.r.t make/model & calibration available at premises shall be provided.

Contractor/Supplier shall be bound to furnish (if required) the original test reports for onward confirmation/verification/authentication of the relevant parts/results/calculations of the test reports as required from the testing Laboratory.

Supplier/manufacturer shall be bound to arrange for the third party testing of the LED lights from approved accredited laboratory by third party of international repute prior to placement of order.

802.11 International Independent Laboratories

For the specified requirements of type tests and type test reports by an independent authority/independent laboratory (specific to their status/approval for performance of specific test(s) on the fixtures as defined in the project), the following laboratories shall be considered as independent laboratories:

- DEKRA (KEMA) Labs, Holland.
- CESI Labs, Italy.
- CRIEPI Labs, Japan.
- Any other laboratory accredited by EA (European Co-Operation for Accreditation) or a member thereof.
- Any other laboratory accredited by ILAC (International Laboratory Accreditation Cooperation) or a member thereof.
- Any other laboratory accredited by IAF (International Accreditation Forum) or a member thereof.
- Any other laboratory accredited by STL (Short-Circuit Testing Liaison) or a member thereof.

ITEM 803 PVC PIPES

803.1 DESCRIPTION

When cables cross road, paved area or other services, they shall be laid in protective pipes of required size. The pipe ends after installation of cable shall be plugged to make them watertight by means of bituminized hesian or equivalent material.

Conduits/ pipes/ ducts for electrical cables shall be properly sealed with the water proofing material “Plastic Polyurethane Foam” as per relevant ASTM standard to avoid rain water entry to the conduits. The contractor shall also provide the technical data of the sealant material before the execution of the work.

803.2 GENERAL

The extent of works shown on the drawing does not indicate the exact position of conduits and pipes. The Contractor shall ensure exact location and route of conduit and pipes in coordination with other services drawings, as per site requirements and as directed by the Engineer

803.3 STANDARDS FOR PVC PIPE/ACCESSORIES

Latest editions of the following standards / codes shall be applicable for the materials in scope of this Section:

BS 6099	-	PVC conduits and accessories.
BS 3595	-	PVC pipes & accessories.
BS 4346	-	Cement Solvent for jointing

803.4 MATERIAL

803.4.1 PVC Conduits and Accessories

The heavy gauge PVC conduits and accessories conforming to BS6099 shall be generally used. The PVC conduits and accessories of light gauge may be used on the project with the concurrence of the Engineer.

The PVC bends, sockets, elbows, couplings, etc. shall conform to the same specifications as for the conduits. The PVC bends shall have enlarged ends to receive conduit without any reduction in the internal diameter at joint. Manufactured smooth bends shall be used where conduit changes direction. Bending of conduits by heating or otherwise will not be allowed in any situation. The use of sharp 90-degree bends and tees will not be allowed for concealed wiring.

The round PVC junction boxes for ceiling light or fan points shall have minimum dimensions of 63-mm diameter and depth. The junction boxes for wall light points shall have minimum dimensions of 63-mm diameter and 38 mm deep. Round junction boxes shall be provided with one piece PVC cover plate fixed to the box by means of brass screws.

803.4.2 PVC Pipe and Accessories

The PVC pipe shall be rigid. All pipes shall be minimum Class D, unless otherwise stated on drawings or bill of quantities. The buried PVC pipe should be able to withstand the external load acting upon it by continuous movement of heavy duty vehicles such as trucks. Cranes, forklift, etc. Where pipe change direction, manufactured smooth bends

shall be used. Bending of pipes by heating or otherwise will be allowed in special cases only. Bending of pipes by heating shall be carried out by first filling the pipe with sand inside and then immediately removing the sand. The use of sharp 90-degree bends and tees will not be allowed. The bends shall conform to same specifications as given for PVC conduits. for joining of pipe all precautions and procedures recommended by manufacturer shall be followed.

803.5 INSTALLATION

803.5.1 Concealed Conduits

Where concealed conduit system as stated on drawings, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid underfloor only where specifically stated.

When concealed the conduit shall have a minimum of 32-mm cover of concrete measured from the top of conduit to finished surface. In the reinforced cement concrete (RCC) work the conduit shall be laid before pouring of Concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and Accessories after pouring of concrete. The conduit shall be supported on top of bottom reinforcement of slab. All outlet boxes to be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed an cement concrete (CC) work after concreting or in block masonry chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the cement concrete work or block masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from the Engineer before starting chasing and cutting.

The termination of conduits at or near the equipment switchboard as shown diagrammatically on the drawings. The exact locations of the termination shall be coordinated with the equipment/switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends pointing upwards or downwards shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against falling with concrete. At all terminations of conduit sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wire or cables during pulling through the conduits.

Under floor conduit shall be installed at a minimum depth of 2 inches from the finished floor level or as shown on the drawings. The conduits shall be installed empty before finishing of floor or in RCC work with a 18 SWG steel wire drawn through the conduit for pulling cable. No conduits shall be laid under floor in bathroom.

The entire conduit system shall be installed and checked before wiring as carried out. Any obstruction found shall be cleared before the installation of cable. Pull boxes and adaptable boxes shall be provided an conduit runs wherever required to facilitate pulling operation. The drawings are diagrammatic and do not indicate the position and spacing of pull boxes or adaptable boxes. However, these shall meet the following requirements.

- Pull boxes
- For straight runs the spacing shall not be more than 180 feet
- For runs with one 90degree bend the spacing shall not be more than 90feet
- For runs with two 90degree bends the spacing shall not be more than 40feet
- Adaptable boxes
- For conduit upto 1-inch dia. the boxes shall be 2 inch in depth

- For conduit upto 1-1/2 inch dia. the boxes shall be 2-1/2 inch in depth

- For conduit upto 2-inch dia. the boxes shall be 3-1/2 inch in depth

The rectangular inspection boxes or pull boxes shall be 18 SWG heavy gauge sheet steel of suitable design to receive conduits. The box shall be painted inside and outside with black enamel paint over a base coat of red oxide primer paint. The minimum length of inspection box shall not be less than four times the cable manufacturer's recommended Bending radius of the cable. All concealed type pull boxes shall have a white plastic sheet of appropriate size fixed to the box by means of galvanized screws.

Adaptable boxes shall be 18 SWG sheet steel and painted and finished to the same quality as the Lighting distribution boards.

Wherever the conduit lengths cross the expansion joint either along the columns or slab suitable arrangement shall be provided so that when the conduit lengths in the expansion joint are stressed the conduit shall not crack or break.

803.5.2 PVC Pipe

Rigid PVC pipes shall be installed under roads and paved areas, at crossing with other services and at cable entering building as shown on the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe:

a) Under roads and paved surface 900 mm below the finished surface

b) When crossing other services for the crossing length. 250-mm vertical clearance. 500 mm horizontal clearance with CC protective cover.

The trench of required dimensions shall be excavated and the bottom of trench cleaned and leveled. A Four-inch thick bed of fine sand shall be provided over which the PVC pipes installed after proper alignment. Where two or more pipes are installed in the same trench the clearance between pipes shall not be less than Two inches. After laying of pipe the trench shall be backfilled with clean-screened earth in layer of Four inches. Each layer shall be properly compacted.

Where underground cables enter connection terminal boxes the PVC pipe shall be installed on surface by means of PVC clamps at a maximum interval of Eighteen inches.

After installation, the ends of the pipe shall be plugged with material impervious to water and chemicals. All joints shall be sealed adequately to prevent entry of foreign elements.

The installation of pipes shall be completed in all respects including its fixing at terminations, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be thorough cleaned of dirt and dust from inside. the pipes shall be installed in proper co-ordination with other works.

803.6 MEASUREMENT AND PAYMENT

803.6.1 General

The Contractor's bid amount against each Bill of Quantities item as given below shall include supplying, installation and completion for all work specified herein and as shown on the Tender drawing related to the item.

803.6.2 PVC Conduits

803.6.2.1 Measurement

Measurement shall be made for the number of running feet or running meters of conduits acceptably supplied and installed by the Contractor as a complete unit.

803.6.2.2 Payment

Payment shall be made for the total numbers of units measured, as provided above, at the Contract unit price each. The payment shall constitute full compensation for supplying, installing and completion of the laying of the conduits including jointing materials and accessories. The complete work wherever applicable shall include cutting/ chasing of civil work, for concealed conduit system, excavation and backfilling of ground for underground pipes painting, plugging, bitumen coating, etc., as applicable for each type of work.

803.6.3 PVC Pipes

803.6.3.1 Measurement

Measurement shall be made for the number of running feet or running meters of pipes acceptably supplied and installed by the Contractor as a complete unit.

803.6.3.2 Payment

Payment shall be made for the total numbers of units measured, as provided above, at the Contract unit price each. The payment shall constitute full compensation for supplying, installing and completion of the laying of the PVC pipes including jointing materials and accessories.

ITEM 804 LT CABLES

804.1 DESCRIPTION

The cable manufacturer shall be certification holder of ISO-9002 and shall be approved by the Engineer. The cables for road lighting shall be PVC insulated and PVC sheathed, 600/1000 Volt grade, designed, manufactured and tested in accordance with IEC-60502 or other equivalent international standards.

For lighting system, the cables shall be single or multicore as required with stranded copper or aluminum conductors and polyvinyl chloride heat and moisture-resistant insulation of the thickness listed in IEC or British Standard.

The route of the cables shall be as shown on the drawing. Any change in route required due to site conditions shall be made in relation with other service layout and with the approval of the Engineer.

804.2 MATERIAL REQUIREMENTS

The cable shall be suitable for operation at conductor temperature upto 70^{o} C under normal conditions.

Conductors shall be of high purity electrolytic annealed copper or aluminum wires and shall conform to the requirement of the following BS or equivalent standard.

If armoring is required, it shall consist of galvanized steel wires complying with BS 1442 and shall provide conductivity not less than 50% of the phase conductor.

BS 6746: - PVC insulation and sheath of electric cables

BS 6360: Copper or Aluminum conductors in insulated cables and cords

IEC 60228: - Conductors of insulated cables

804.2.1 Cable Sizes

The sizes of LT copper conductor cables shall be as shown on the drawings. Care shall be taken so that voltage drop at the far end of the cable does not exceed 5% of the nominal voltage. Cables manufactured by the reputed firms shall be used, provided they fulfill all the requirements of the specifications.

804.2.2 Phase Identification

All cables shall have phase identification colour on the insulation of each core. The colour code of three phase circuits shall be red, yellow and blue for phase conductors and black for neutral conductor. From pole junction box upto lantern green or green and yellow striped PVC insulated wire shall be used as earth continuity conductor (ECC).

For all cables, to be supplied and installed, the Contractor shall submit complete technical data, including conductor material, insulation material, current carrying capacity, Voltage grade, weight for 100 meters etc. and all such data shall be supported by test certificates, current and temperature rise curves etc. for approval of Engineer.

804.2.3 Cable Accessories

All accessories shall be provided without additional cost for the complete cabling and wiring system. These shall include but not be limited to items such as clamps, fixing channels,

connectors, cable joints (where necessary and as approved by the Engineer), clips, lugs, tapes, solders, identification tags, bushes & glands etc.

804.2.4 DATA TO BE SUBMITTED

The Contractor shall submit the following for approval of the Engineer before execution:

- Manufacturer
- Country of Origin
- Catalogue with indication of equipment proposed
- Detailed Specification
- Construction drawings

Compliance of the following shall be required:

1) In–process testing and tests after manufacturing (each size/type) to be supplied, as per national and international standards (as applicable) specified particularly for the project for which the cable will be ordered, including but not limited to:

   a) Single / Multi-core Cable Manufacturing as per applicable BS or IEC standards schedule of testing.

   b) Tests on completed cables in accordance with BS standard 6004 & BS 6346 or equivalent IEC standard / codes.

2) Routine tests shall be carried out from independent laboratory in the presence of Client / Consultant representatives. Review/approval of these test reports shall be carried out by the Client/Consultants.

3) In advance availability of sources / supporting documents with regard to material sources vis-à-vis imported Copper (in accordance with the mandatory requirements of imported copper laid down in the market input rates of material, Finance Department, Government of the Punjab), PVC used in the manufacturing of the cables ordered for a particular project including sales tax invoices from the respective material source and reconciliation quantity of the material procured with the manufactured cables. The import documents of material should consist of the following:

   - Bill of exchange.
   - Commercial invoice.
   - Packing list.
   - Beneficiary certificate.
   - Test report of Material (Copper Rod).
   - Shipment advice.
   - Bill of lading.
   - The vendor from which imported copper is purchased should be approved / registered with LME

4) Certificate of Registration from the client shall be submitted.

5) Cable inspection test protocol/procedure shall be furnished.

6) Pre-shipment / delivery inspection shall be carried out at Manufacturing Works of the cable manufacturers.

7) The samples from the cable drums supplied at site shall be taken and collected by the contractor in the presence of Client/consultant representatives for testing of same from UET or PCSIR Lahore in line with applicable standards / codes and test report of the same shall be submitted accordingly.

804.3 CONSTRUCTION REQUIREMENTS

Power supply to the poles at the road crossing shall be with PVC insulated PVC sheathed cable passing through pipe as specified and as shown on the drawings. Individual pole

connections shall be by means of the power supply cable looping between poles. The cable from lighting control box shall enter first lighting unit at its three phase and neutral service cut-out and then similarly looped to the next. The luminaries on each pole shall be connected alternately to each of the three phases.

Cable routes shall consist of trenches or 100 mm PVC pipe as suitable or as shown on the drawings. The cable if laid in trench shall be at least 500 mm below the general ground and 750 mm below road (class-1) level, with sand cushion around cable and a layer of 230 mm wide bricks over sand along the entire route of cable. The bricks shall be laid in such a way to provide equal margin of cover on both sides of the cable.

Slack shall be left in cables for which purpose the cut lengths of cables shall allow about 3% more in the measured length between terminations (Engineer will verify the lengths of cables). At junction boxes, ample slack shall be left to prevent straining of cable joints due to settlement of cable trench.

For underpass luminaries PVC insulated, PVC sheathed, SWA cable shall be pulled through already laid/buried PVC pipes in underpass slabs. The pulling of cables through pipes shall be started only after the conduit (PVC) system is completely installed and all outlet boxes, junction boxes etc. are fixed in position. The cable shall be pulled in PVC pipes with care, preferably without the use of any lubricant. Where necessary, and after approval of Engineer, the cable manufacturers recommended lubricant shall be used. Use of any kind of oil or soap will not be permitted.

The wiring shall be continuous between terminations and looping-in system shall be followed throughout. Any joint in cables shall not be allowed. Slack shall be left in cables for which purpose the cut lengths of cables shall allow about 3% more in the measured length between terminations (Engineer will verify the lengths of cables). At junction boxes, ample slack shall be provided to facilitate repairs in future.

Cables, whether installed in bare ground or in pipes shall not be bent to a radius less than that recommended by the cable manufacturers.

Upon completion of cable installation, the Contractor will be required to undertake testing as approved by the Engineer or the concerned department and shall comply with IEE wiring regulations. The copies of test results shall be supplied to the Engineer.

Conduits/ pipes/ ducts for electrical cables shall be properly sealed with the water proofing material “Plastic Polyurethane Foam” as per relevant ASTM standard to avoid rain water entry to the conduits. The contractor shall also provide the technical data of the sealant material before the execution of the work.

804.4 MEASUREMENT AND PAYMENT

804.4.1 Measurement

Measurement shall be made for the number of running meters for each size and type of cable complete with required accessories acceptably supplied and installed by the Contractor. For 2.5 mm^2 cable from junction box to lighting fitting lamp holder through hollow of pole, it shall be on each cable basis.

804.4.2 Payment

Payment shall be made for the number of running meters of each size of cable measured as provided above, at the contract unit price each and shall constitute full compensation for supplying, installing, connecting and commissioning, of the cables. Payment for 2.5 mm^2 cable from junction box to lighting fitting lamp holder shall be lump sum on each cable basis.

ITEM 805 LIGHTING CONTROL PANEL

805.1 DESCRIPTION

The lighting control/distribution panel shall be of 14 SWG sheet steel fabricated, cubical type, totally enclosed, dust tight and vermin proof. These shall be complete in all respects with material and accessories, factory assembled, tested and finished all according to the specifications and to the normal requirements. The panel with all components and accessories shall be suitable for front operation and shall;

- be provided with adequate clearance from live parts so that flashovers cannot be caused by switching, vermins, pests etc.
- have all components rated for insulation class of 600 Volt minimum.
- have the components mounted so as to facilitate ease of maintenance from the front.
- be suitable for mounting on concrete foundation.

The lighting control panel shall be complete with detachable steel base frame for embedding in concrete foundation on site.

805.2 MATERIAL REQUIREMENTS

The road lighting control box shall be of 14 SWG, G.I. sheet and equipped with the following:

- One-set of three phase, neutral and earth busbars of rating as specified (site rating).
- One incoming molded-case circuit breaker, breaking capacity & rating as specified.
- Outgoing circuit breakers, breaking capacity & rating as specified.
- Magnetic contactors as per rating specified.
- Photo-electric cell switches dust and water proof type and as per BS 5972 or WAPDA Specifications P-102 with upto date amendments.

One photo electric cell unit shall be provided to switch ON/OFF every contactor for control of lights. Photo-electric unit shall include a delay device to prevent the switching of lamps during transient changes in voltage. Each lighting circuit shall be equipped with Auto/Manual selector switch and ON/OFF push buttons for maintenance purpose without interference with the photo cell and the whole to be enclosed in the dust and vermin proof case. Since the lighting control panel is installed on road side, therefore its outer cover shall be plain, without electrical components. A brass batten holder with ON/OFF switch and 60-watt incandescent lamp shall be provided at suitable location in the panel to facilitate maintenance during night time. Doors with hinges shall be provided so as to give maximum access for cabling and maintenance and shall be fitted with lock. Three sets of keys shall be supplied along with road lighting control box.

All necessary interconnecting wiring within the control panel shall be carried out in the factory.

Cable glands and lugs shall be provided. Three sets for incoming outgoing 4-Core up to

35 mm^2 Copper conductor PVC/SWA/PVC cables.

A suitable earthing terminal shall be provided inside the box.

Crimping type lugs for incoming and outgoing copper cables shall be provided.

805.2.1 Moulded Case Circuit Breakers

Molded Case Circuit Breakers shall be provided for each distribution feed circuit. The circuit breakers shall be in accordance with IEC 60947-2. The three phase fault level shall be in accordance with the circuit requirements. The I_{cu} of all MCCBs shall be equal to 100% of I_{cs}. All MCCBs shall be capable of operating at 50 ^oC.

Each circuit breaker shall have integral thermal overload and magnetic type short-circuit trip devices. The thermal release shall provide inverse time overload tripping and the magnetic release shall provide instantaneous tripping or short time delay tripping where necessary, to achieve discrimination with downstream protective devices during short circuit conditions.

805.2.2 Magnetic Contractors

The contactors shall be triple pole, 400 V continuous duty type. The main contacts shall be silver tipped, but type with double break per pole. Each contactor shall be provided with 230 V AC single phase operating coil, and minimum two normally open and two normally closed auxiliary contacts wired upto terminals. But if more number of working auxiliary contacts are required then, these shall be provided according to the system requirements.

805.2.3 Indicating Lamps

Indicating lamps shall be suitable for flush mounting, complete with base and shall have rosettes of suitable colour.

805.2.4 Line-up Terminals

Line-up terminals wherever provided for control & power circuits shall be suitable for voltage and size of conductors as indicated on drawing.

The line-up terminals for controls shall be suitable for channel mounting. All necessary accessories such as end-plates, fixing clips, transparent label holder caps and label sheets with marking shall be provided.

805.2.5 Data to be Submitted

The Contractor shall submit the following for approval of the Engineer before execution;

- Manufacturer
- Country of Origin
- Catalogue with indication of equipment proposed
- Detailed Specification
- Construction drawings
- General arrangement and proposed foundation details.
- Details of materials used for weather and dust proofing.

805.3 CONSTRUCTION REQUIREMENTS

The road lighting control panel box shall be installed near transformer at location shown on the drawing. The Contractor shall ensure coordination with the civil contractor to avoid damage to the completed works. The Contractor shall provide foundation bolts and grout them in cement concrete with the approval of the Engineer. All installation material required for the satisfactory erection, such as bolts, nuts, washers, supporting steel etc.

shall be provided and installed by the Contractor. The panel shall be installed upright and in level and shall be firmly and rigidly fixed on the concrete supports. Panel shall be erected as per manufacturer's instructions and as approved by the Engineer.

Loose parts dispatched by the manufacturer, shall be installed and connected as per assembly drawing. Any safety locking of metres, relays etc. provided by the manufacturer, for safe transport shall be released only after the panel is installed in position. The Lighting Control Panel shall be tested and commissioned in the presence of the Engineer.

Panel openings for cables shall be properly sealed with the water proof material "Plastic Polyurethane Foam" as per relevant ASTM standard to avoid rain water/animal entry to the panel. The contractor shall also provide the technical data of the sealant material before the execution of the work.

805.4 MEASUREMENT AND PAYMENT

805.4.1 Measurement

Measurement shall be made for each panel complete with all components and accessories as given in bill of quantities acceptably supplied and installed by the Contractor as completed job.

805.4.2 Payment

Payment shall be made for the number of panels measured as provided above at the contract unit price each and shall constitute full compensation for supplying, installing, connecting, testing and commissioning of panels including bolts, supporting steel base, nuts, washers, tapes and earthing etc.

ITEM 806 EARTHING

806.1 DESCRIPTION

Earthing system as shown on the drawing shall be installed by the Contractor. The earthing system shall give earth resistance, including the resistance of soil, earth leads and ECC, equal to or less than one ohm.

806.2 MATERIAL REQUIREMENTS

806.2.1 Earthing by Earth Rods

The earth rod shall be of steel and shall be protected against rusting by a thick exterior layer of copper (not less than 0.33 millimeter), permanently molted or electrolytically deposited on a high strength steel core which shall provide rigidity for easy driving without bending. The earth rod shall have nominal dia of 16 mm with chamfered head of 2x45 mm (chamfer). The overall length of the rod shall be 3000 $\pm$5 mm.

806.2.2 Earthing Lead

The copper conductor used for earth wire shall conform to the latest revision of IEC 228, IEC 228A. The size and number of individual conductor shall be as specified in the applicable standards.

806.2.3 Earth Continuity Conductor

Earth continuity conductor (ECC) shall be hard drawn bare copper wire, or single core PVC insulated copper conductor cable of given size. The earth continuity conductor shall be connected at one end to the earth rod through switch clamp/eye bolts as shown in the drawings at the other end to the relevant equipment to be protected as mentioned in the specification, BOQ and shown on drawing.

The specifications for single core PVC insulated cables used as ECC shall be same as those in relevant sections of technical specifications.

806.2.4 Data to be Submitted

The Contractor shall submit the following for approval of the Engineer before execution;

- Manufacturer
- Country of Origin
- Catalogue with indication of equipment proposed
- Detailed Specification
- Construction drawings

806.3 CONSTRUCTION REQUIREMENTS

806.3.1 General

For earthing of equipment proper size copper or brass thimbles or lugs shall be used to which the copper wire shall be connected by copper brazing. The soldering of copper wire at joints or terminations shall not be allowed. All tee-off connections shall be by copper brazing using suitable socket and clamps. After brazing, the jointed surface shall be protected by oxide inhibiting compound of low electrical resistance. For connections to metallic body, the surface shall be thoroughly cleaned before bolting the lug or socket.

The earth continuity conductor shall, in general, run in cable trench or in conduits/pipes. Where laid along underground cables, these shall be laid directly underground in unpaved

areas and in pipe under paved areas.

806.3.2 Earth Continuity Conductor

The body of all lighting control panels shall be connected to earth by specified size of ECC. All other metal work shall also be connected to earth by suitable size of ECC so that earth resistance is less than five ohm.

At joints or terminations, the ECC shall be connected using proper accessories. No connection shall be made by twisting of earth conductors.

806.3.3 Earth Resistance Test

Earth resistance tests shall be done on the earthing system by separating and reconnecting conductor. The resistance of earthing leads in the installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements.

806.4 MEASUREMENT AND PAYMENT

806.4.1 Measurement

For earth continuity conductors (ECC) measurement shall be made for each size of copper wires on per running meter basis acceptably supplied and installed by the Contractor.

806.4.2 Payment

Payment for copper rod type earth point shall be made for each point and provided as above at the Contract Unit price each and shall constitute full compensation for supplying, installing, connecting and testing including earth rod, excavation, backfilling, civil work for inspection chamber, etc. as shown on the drawings. Payment of earth continuity conductors (ECC) shall be made for the number of running meters measured at the Contract unit price and shall constitute full compensation for supplying, installing & connecting including all installation accessories.

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION/ MEDIUM SIZE PROJECTS	MAINTENANCE PROJECTS
101	Clearing & Grabbing	1 Bulldozer (160 H. P) or Grader (140 H. P) 2 Dumper (10 T)	-	-
102	Removal of Tree	1 Excavator (0.3 CM)	-	-
103	Stripping	1 Grader (140 H. P.)	-	-
104	Compaction of Natural Ground.	1 Static Tandem Roller (8-12 T) 2 Water Tanker (Tow Type)	-	-
105	Roadway Excavation.	1 Bull Dozer (160-200 H.P.) 2 Front End Loader (2-3 CM) 3 Dump Truck (10-18T)	1 Bull Dozer (160 H.P.) 2 Tractor/Trolley (50 H.P.)	-
107	Structural Excavation and Backfill	1 Excavator (0.3 CM) 2 Plate Compactor	Plate Compactor	Plate Compactor.
108	Formation of Embankment.	1 Grader (140-165 HP) 2 Combination/sheep-foot or pneumatic Roller (8-12T) 3 Water Tanker (Bowser Type)	Grader (140 HP) Combination/ sheep foot or Pneumatic Roller (8-12T) Water Tanker (Bowser Type)	1 Heavy Duty Tractor with Blade (80 H.P.) 2 Static Roller (8-12T) 3 Water Tanker (Tow-Type).
109 110 111 & 112	Sub-grade Preparation.	1 Grader (140-165 HP) with scarifier. 2 Water Tanker (Tow-Type) 3 Combination Roller (10-12T)	-	-
113	Bitumen Stabilized Sub-grade.	1 Grader (140-165 HP) with scarifier 2 Asphalt Distributor. 3 Tandem Roller (10-12T)	-	-
114	Dressing and Compaction of Berms.	-	1 Tractor with Blade (50-80 HP) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)	1 Tractor with Blade (50 H.P.) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)
201	Granular Sub-Base.	1 Power Broom /Air Compressor 2 Grader With Scarifier (140 H.P.) 3 Water Bowser. 4 Combination Roller (10-12T)	1 Heavy Duty Tractor with Blade. 2 Water Tanker (Tow type) 3 Static Roller (10-12T)	1 Tractor / Trolley with Blade (50 H.P.) 2 Water tanker (Tow Type) 3 Static Roller (10-12T)

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION/ MEDIUM SIZE PROJECTS	MAINTENANCE PROJECTS
202 & 211	Base Course	1 Power Broom / Air compressor. 2 Front End Loader (2-3 CM) 3 Pugmill (50-100T/ Hour) 4 Dumper (10-15T) 5 Base Paver (4M wide) 6 Combination Roller (10-12T)	1 Grader (140 H.P.) with Articulated Blade. 2 Water Tanker (Tow type) 3 Combination Roller (10-12T)	1 Heavy Duty Tractor / Trolley with Blade (80 H.P.) 2 Water Tanker (Tow Type) 3 Static Roller (10-12T)
204	Soil Cement Stabilized Sub-base / base.	1 Concrete Batching and forced mixing plant (30 CM/Hour). 2 Dumper (10-15T) 3 Base Paver (4M wide) 4 Tandem Roller (10-12T)	Same Equipment as for major project.	—
212	Bitumen Stabilized i) Sub-base. Bitumen Stabilized ii) Base.	1 Grader with scarifier (140 H.P.) 2 Asphalt Distributor 3 Combination Roller (10-12T)	1 Heavy Duty Tractor with Blade. 2 Combination Roller (10-12T)	—
	(a) Cold Mix	1 Grader with Scarifier (140-165 H.P.) 2 Bitumen Distributor (Auto/Tow Type) 3 Tandem Static Roller (10-12T)	Same Equipment as for major projects.	
	(b) Hot Mix	Equipment mentioned as per Item 203.	Equipment mentioned as per Item 203.	
213	Recycling of Road Pavement Structure/ Soil Stabilization.	—	1 Cold Mix Recycler. 2 Grader (140 HP) Water Tanker 3 (Tow Type) Vib. Combination 4 Roller (10-12T)	—
203 & 305	Asphaltic Base Course/ Wearing Course Plant Mix.	1 Power Broom / Air-Compressor. 2 Front End Loader(2-3 CM) 3 Asphalt Plant(80-120T) 4 Paver (4 M wide) 5 Dumper (10-18T) 6 P.T.R (9 Wheeler 21 T) 7 Tandem Vibratory Roller (10-12T)	1 Front End loader (1.50-2.50 CM) Asphalt Plant (20-240T) 2 Dumper (10T) 3 Paver 4 (4M wide) P.T.R. 5 (9 Wheeled) 18-T. Tandem Vibratory Roller (8-1 OT)	1 Bitumen Aggregate Mixer (1 CM) 2 'Wheel Barrow (0.5 CM) 3 Tandem Vibratory Roller (8-1 OT) 4 Tractor/ Trolley (50 H.P.)
308	Re-cycling of Asphalt Concrete	—	1 Recycling Machine. 2 Bitumen Bowser plus all equipment for Asphaltic Concrete under Item 305	—

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION/ MEDIUM SIZE PROJECTS	MAINTENANCE PROJECTS
115& 306	Shoulder Treatment.	1 Grader (140 H.P.) 2 Dumpers (10T) 3 Water Tanker (Tow type) 4 Combination Roller (10-12T)	1 Heavy Duty Tractor / Trolley with Blade. 2 Water Tanker (Tow type) 3 Static Roller (10-12T)	1 Tractor/ Trolley with Blade (50 H.P.) 2 Water Tanker (Tow type) 3 Static Roller (8-10T)
309	Cold Milling	—	1 Cold Milling Machine(1 M wide) 2 Dumpers (10T) 3 Water Tanker (Tow type)	1 Cold Milling Machine (1 M wide) 2 Dumpers (10T) 3 Water Tanker (Tow type)
302 & 303	Bituminous Prime Coat / Tack Coat.	1 Power Broom / Air-Compressor. 2 Engine Operated Bitumen pressure distributor (Auto-Type)	1 Manual Operated Bitumen pressure distributor (Tow Type)	Manually Operated Bitumen Pressure Distributor (Tow Type)
304	Bituminous Surface Treatment.	1 Power Broom/ Air-Compressor. 2 Aggregate Spreader. 3 Engine Operated Bitumen pressure distributor (Auto- Type) 4 Dump Truck (10 T) 5 Rubber Mounted Tandem Roller or P.T.R (9 Wheeled-18T)	1 Aggregate Spreader (3-4 M wide) 2 Bitumen Distributor Auto or Tow-Type. 3 Dump Truck (10T). 4 Static Tandem Roller (8-10T).	1 Tractor/ Trolley (50 H.P.) 2 Bitumen Sprayer (manual) Static Tandem Roller (18T).
310	Concrete Pavements.	Concrete Batching Plant (30 CM/H). Concrete Paving Machine (4 M wide) Front End Loader(2-3 CM) Concrete Transit mixer (6 CM)	—	—
401	Concrete	1 Concrete Batching Plant (30 CM/H) 2 Front End Loader(2-3 CM) 3 Concrete Transit Mixer (6 CM) 4 Crane (20-45T). 5 Vibrator (40 mm – 50 mm). 6 Concrete Finisher.	1 Concrete Static Mixer (1 CM) 2 Tractor Trolley (50 H.P.) 3 Crane (20T) 4 Water Tanker (Tow Type) 5 Vibrator (40mm-50mm).	1 Concrete Static Mixer (½-1 CM). 2 Tractor/ Trolley (50 HP). 3 Vibrator 4 Wheel Borrows.
405	Prestressed Concrete Structures	1 Prestressing Equipment plus all equipment contained in Item No. 401. 2 Heavy Duty Crane or Beam launching Truss.	—	—

ITEM NO.	DESCRIPTION	CONSTRUCTION MACHINERY FOR		
		MAJOR PROJECTS	REHABILITATION/ MEDIUM SIZE PROJECTS	MAINTENANCE PROJECTS
407	Piling.	Piling Equipment plus all those equipment mentioned in Item 401, for major projects.	—	—
608	Pavement Marking	Road Marking Machine	Manual	Manual