2022

Standard Specifications For Road And Bridge Construction

Communication and Works Department
Government of Punjab

Punjab Communication and Works Department

To

The Secretary
Communication and Works Department
Lahore.

Subject: **REVIEW OF REVISED SPECIFICATIONS**

Vide Notification No. SOH-II(C&W)3-39/2017 Dated June 1st, 2022 committee was constituted for review of Draft Specifications prepared by consultants in 2016. After detailed review and deliberations the Road and Bridges Specifications are finalized. A number of changes were made to bring pay items in line with Market Rate System so that gaps are not encountered in implementation of new specifications. Further improvements in Chapters were made to bring the sections on Asphalt and Bridges up to date and commensurate with the latest practices in field. Adoption of new General Specifications will be a stepping stone for better practices and improved quality of work. Committee agrees to the fact that General Specifications is a live book and needs to be updated in an ongoing process, therefore the Committee recommends that a standing committee may be notified for review every year and an office may be nominated as custodian of specifications.

Committee expresses its gratitude towards contribution and services rendered by Engr. Mohd. Naseem Ashraf, Superintending Engineer, Engr. Hafiz Shoaib, Engr. Sarfraz Bhatti and Mr. Sajjad Ahmad, Circle Draftsman.

Final Draft is submitted herewith duly recommended for approval and notification.

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GENERAL REQUIREMENTS OF HIGHWAY CONSTRUCTION

1-1 SECTION – GENERAL REQUIREMENT OF HIGHWAY CONSTRUCTION

1-1.1 PREAMBLE

The Specifications in vogue in the Punjab Highway Department have been updated for the construction of roads and bridges construction keeping in view that the following types of activities are being carried out in the Department.

i. Construction of Link Roads, Access Roads, Farm To Market Roads, New Highways, Bridges and allied works.

ii. Rehabilitation and Improvement of existing road network.

All the aspects of construction and rehabilitation have been covered in these Specifications. This chapter describes the broad outlines of the essentialities which are obligatory upon the contractor for the construction of a road project. Efforts have been made to summarize these requirements in short paragraphs as below.

1-1.2 STANDARDS

The requirements and procedures for execution of work items to achieve required workmanship and quality have been adequately described in these specifications. The materials to be used and the quality of the finished product 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 (BS) as indicated in their latest editions. Sampling of materials for laboratory analysis and their subsequent approval shall be accomplished according to these references.

1-1.3 MANPOWER

Contractor shall also provide skilled manpower in sufficiently adequate number, who can execute the work with quality and workmanship in accordance with the requirements of the work item.

1-1.4 EQUIPMENT AND MACHINERY

Number and kind of Equipment and Machinery required for different items of work shall be deployed by the contractor keeping in view the quality and workmanship required by a particular item and the quantity of finished item required to be carried out in specified manner and period. 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 completion of project.

1-1.5 ALTERNATE EQUIPMENT

While a 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 will be encouraged.

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

The Engineer before considering or accepting such request may require the Contractor to furnish, at contractor's his own expense, evidence to satisfy him that the equipment and machinery 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, to that which can be produced by the equipment specified. Upon withdrawal of such permission by 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 own expense, any defective or unsatisfactory work produced with the alternative equipment.

Neither the Employer nor the Contractor shall have any claim against each other, for either the withholding or the granting of permission to use alternative equipment, or for the withdrawal of such permission for guidance of the contractor, the list of the equipment and machinery is given in Section 1-4 and Annex-I.

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.

1-1.6 STORAGE OF MATERIALS

Articles or materials to be supplied for utilizing in the work shall be stored in such a manner as to ensure the preservation of their quality and fitness for the work, and to facilitate inspection, with no or minimum hazard to road users.

1-1.7 MATERIALS NOT CONFORMING TO THE REQUIREMENTS OF THE SPECIFICATIONS

All materials which the Engineer has determined as not conforming to the requirements of the drawings and specifications will be rejected whether in place or not. The defective material shall be removed immediately from the site of the work. No rejected material, the defects of which have been subsequently corrected, shall be used in the work, unless approval in writing has been given by the Engineer. Upon failure of the Contractor to comply with any order of the Engineer made under the provisions in this clause, the Engineer shall have authority to cause the removal of rejected material and to deduct the cost thereof from any payments due or to become due to the Contractor.

1-1.8 QUARRY MATERIALS

Quarry material is rock, sand. gravel, earth, or other mineral material, other than local borrow or selected material, obtained on the project. Quarry material does not include materials such as cement, lime, marble powder etc. obtained from established commercial sources.

Quarry Materials shall be furnished by the Contractor from any source he may select, except that when mandatory local sources of certain materials are designated in the Special Provisions, the Contractor shall furnish material from such designated mandatory sources.

The furnishing of quarry materials from any source is subject to the provisions of "Laboratory analysis as to whether it fulfills the requirements of, Specifications of the particular item of Work".

Unless approved in writing by the Engineer, material sources shall not be excavated at locations where the resulting scars will present an unsightly appearance from any highway. No payment will be made for material obtained in violation of this provision.

The Contractor shall, at his expense, make any arrangements necessary for hauling over local public and private roads from any source.

Full compensation for furnishing all labour, materials, tools, equipment, and incidentals, and for doing all the work involved in conforming to the provisions in this clause, for furnishing and producing materials from any source shall be considered as included in the price paid for the contract item of work involving such material and no additional compensation will be allowed therefore.

1-1.9 TRADE NAMES AND ALTERNATIVES

For convenience in designation on the plans or 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.

- 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.
- 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 quality of the material or article proposed. Such request shall be made well in time to permit approval without delaying the work.

1-1.10 FREQUENCY OF TESTS & TEST DESIGNATION

Frequencies of tests for the items of construction have been given in subsequent chapters. Test designation and procedure will be used as given in the latest version of relative publications of AASHTO and ASTM or BS Schedule for sampling and testing of various materials is given in the relative section of each component and summarized in Chapter 2.

1-1.11 TESTING

Unless otherwise specified, all tests shall be performed in accordance with the methods used by AASHTO/ASTM/BSS and shall be arranged by the contractor under the supervision of the Engineer or his designated representative at site or in laboratory.

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 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 who 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.

1-1.12 CONSTRUCTION STAKES, LINES AND GRADES

The Engineer will furnish design survey data and jointly locate with contractor, all points of intersection and of tangents and basic benchmarks. The plans indicate the properties of horizontal and vertical curves, together with rates of super elevation where required. The contractor shall set construction stakes establishing lines, slopes, and continuous profile-grade in road work, and center line and bench marks for bridge work, culvert work, protective and accessory structures and appurtenances 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.

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 modification and the Contractor will revise the stakeout for further approval. No change in bid unit price will be made for such modifications.

The profiles and cross sections on the plans indicate the elevation of the top of road surface or as otherwise noted on the plans. The contractor shall be responsible for the preservation of all stakes and marks, and if any of the construction stakes or marks has been destroyed or disturbed, the Contractor will replace them at his own expense.

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

1-1.13 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.

1-1.14 SAFETY OF 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.

1-1.15 SAFETY PRECAUTIONS

The Contractor shall adequately provide for the safety, health and welfare of persons and for the prevention of damage to works, materials and equipment for the purpose of or in connection with the Contract.

1-1.16 INSPECTION

The Engineer shall, at all times, have safe access to the work during its construction, and shall be furnished with every reasonable facility for ascertaining that the materials and the workmanship are in accordance with the requirements and intentions of these Specifications, the Special Provisions, and the plans/drawings. All works done and all materials furnished shall be subject to inspection by Engineer.

The inspection of the work or materials shall not relieve the Contractor of any of his obligations to fulfill his contractual obligation as prescribed. Work and materials not meeting such requirements shall be made good and unsuitable work or materials may be rejected, notwithstanding that such work or materials have been previously inspected by the Engineer or that payment therefor has been included in a progress estimate.

1-1.17 REMOVAL OF REJECTED AND UNAUTHORIZED WORK

All works, which have been rejected, shall be remedied, or removed and replaced by the Contractor in an acceptable manner and no compensation will be allowed to him for such removal, replacement, or remedial work.

Any work done beyond the lines and grades shown on the plans or established by the Engineer, or any extra work done without written authority will be considered as unauthorized work and will not be paid for. Upon order of the Engineer, unauthorized work shall be remedied, removed, or replaced at the Contractor's expenses.

Upon failure of the Contractor to comply promptly with any order of the Engineer made under this section, the Employer may cause rejected or unauthorized work to be remedied, removed, or replaced and to deduct the costs from any payment due or to become due to the Contractor.

1-1.18 ALTERNATE METHODS OF CONSTRUCTION

Whenever the plans or specifications provide that more than one specified methods of construction or more than one specified type of construction equipment may be used to perform portions of the work and leave the selection of the method of construction or the type of equipment to be used up to the Contractor. it is understood that the Employer does not guarantee that every such method of construction or type of equipment can be used successfully throughout all or any part of any project. It shall be the Contractor's responsibility to select and use the alternative or alternatives, which will satisfactorily perform the work under the conditions encountered.

In the event some of the alternatives are not feasible or it is necessary to use more than one of the alternatives on any project, full compensation for any additional cost involved shall be considered as included in the contract price paid for the item of work involved and no additional compensation will be allowed thereof

1-1.19 CONFORMITY WITH CONTRACT DOCUMENTS AND ALLOWABLE DEVIATIONS

Work and materials shall conform to the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown on the plans or indicated in the specifications. Although measurement, sampling and testing may be considered evidence as to such conformity, the Engineer shall be the sole judge as to whether the work or materials deviate from the plans and specifications, and his decision relating to any allowable deviations there from shall be final.

1-1.20 TRIAL SECTION

Contractor shall submit complete methodology of trial section for approval of the Engineer. Trial sections shall be prepared for each type of road pavement layer. Inspite of the approval of Engineer for trial section, contractor shall be responsible for the quality of work. Contractor will provide minimum of following information’s in the methodology.

Equipment to be used

i. Layer thickness adopted

ii. Per day production

iii. Field Test Results

1-1.21 CONTRACTUAL FRAMEWORK OF STANDARD SPECIFICATIONS

The Standard Specifications is a part of contract documents which shall be read in conjunction with the following additional documents which are mutually explanatory to one another and mentioned hereunder. These additional documents are also part of the contract documents

i. Contract Agreement (Latest Edition)

ii. Addenda.

iii. Letter of acceptance

iv. Supplementary conditions

v. Additional conditions

vi. Drawings.

vii. Specifications.

viii. The bid and Appendices

SECTION – 1-2

DEFINITION OF TECHNICAL TERMS

1-2 SECTION - DEFINITION OF TECHNICAL TERMS

Whenever in these specifications or in other documents pertaining to the contract, the following terms and abbreviations appear, their intent and meaning shall, unless specially stated otherwise, be interpreted as given below:-

Accepted	Completion of the work Item to the Engineer's satisfaction
Addendum	A written amendment or revision to the Contract Documents or plans issued to bidders prior to the Final date and time for submission of Tenders in The "Instruction To Tenderers"
Aggregate	Inert material such as sand, shingle, broken stone, or broken bricks which, when bound together by an added matrix, forms a conglomerated mass, as in concrete or bituminous paving mixtures. The term coarse aggregate is employed for aggregate retained on US Standard Sieve No. 4 (4.75 mm) for concrete and sieve No. 8 (2.38 mm) for bituminous paving mixtures.
Alignment	The position and direction given to the centerline of a road in plan or profile.
Alignment (Horizontal)	The position and direction of centerline of a road in plan.
Alignment (Vertical)	The position and direction of centerline of a road in profile.
Alignment (Re-alignment)	The alteration to the alignment of an existing road.
Amenities	Recreational facilities and similar items provided to improve living conditions at site-characteristics conducive to pleasantness
Apron	A layer or layers of concrete brick or stone masonry or stone, placed at the entrance or outlet of culvert or waterway or along the toe of an embankment etc, to prevent scour.
Asphalt	A dark brown to black cementations material in which the predominating constituents is bitumen which occur in nature or are obtained in petroleum processing
Asphalt Base Course	The lowermost layer of specified thickness of an asphalt concrete pavement which may include an asphalt leveling course
Asphalt Concrete	High quality, thoroughly controlled hot mixture of aspalt cement and well-graded, high quality aggregate, thoroughly compacted into a uniform dense mass

Asphalt Concrete Pavement	All courses of asphalt aggregate mixtures placed above the layer of base course, sub base or improved subgrade. When placed directly on the subgrade, it is called full- depth asphalt pavement
Auxiliary Lane	That portion of the roadway adjoining the traveled way for speed change or other purposes supplementary to through traffic movements
Axle Load	The total load transmitted by all wheels whose centers may be included between two parallel transverse vertical planes 1.02 meter (40 inches) apart extending across the full width of the vehicle.
Back Fill	Material used to replace or the act of replacing material removed during construction, also may denote material placed or the act of placing material at the back of abutments, retaining walls or similar structures.
Ballast	Gravel, Broken stone, Broken Brick etc.
Base Course	The layer or layers of specified or selected material placed in designated thickness on a sub-base or subgrade to support a surface course.
Batching Plant	The mechanical equipment for measuring either by weight or by volume, the quantities of different ingredients required to make up each complete charge of mixer.
Bid/Tender Price	It is priced offer by the contractor to accomplish specific items of work or the entire project, in accordance with terms and conditions of the contract documents.
Bid Schedule	It is a priced bill of quantities containing rates offered by the contractor for completion of various items according to drawings and specifications of the projects.
Bill of Quantities	A list showing work quantities and specifying unit price and/or lump sum for specific items of work
Binder	A material used for the purpose of holding solid particles together as a coherent mass.
Binder Course	A mix of graded aggregate and bituminous material mixed in a plant which constitutes the lower layer of the surface course.
Bitumen	The by-product of the distillation of or evaporation of crude petroleum either by natural process or in a refinery; the basic constituents of an Asphalt essentially consist of hydro-carbons. It is characteristically solid to semi solid, black to dark brown in colour, is adhesive, and melts or softens on the application of heat.
Bitumen	Bitumen obtained after the final stage of distillation of

(Straight Run)	petroleum of suitable type.
Bitumen (Cut Back)	Bitumen whose viscosity has been reduced by the addition of some suitable volatile diluents.
Bitumen (Emulsion)	An emulsion in which bitumen is suspended in a state of minute sub-divisions in water or in an aqueous solution with the aid of suitable emulsifying agents.
Bituminous Concrete	A designed combination of dense graded mineral aggregate, filler and straight run bitumen mixed in a central plant, laid and compacted while hot.
Bleeding (of bituminous roads)	A road condition in which free binder exudes in liquid form from the surface of a bituminous road in hot weather.
Blinding	The application of a loose layer of specified fine material to reduce bleeding.
Blinding Layer	A layer of concrete or other material(generally thin) covering the surface of excavated ground or fill, forming a stable surface on which work may be constructed
Borrow Material	Suitable material used primarily for road embankment.
Borrow area	A place, outside the right of way, unless otherwise specified, from which fill material will be obtained for construction of embankment etc.
Box culvert	A culvert constructed of rectangular cross-section.
Bridge	A structure designated to secure passage over an obstacle or waterway of more than 6 meters (20 linear feet)
Breast wall	A retaining wall on the hill side.
By-pass road	A road so constructed as to enable through traffic to avoid congested areas or other obstructions to movement.
Calendar day	Every day shown on the calendar.
C.B.R. (California Bearing Ratio)	An empirical measure of the bearing capacity of a sub-grade, sub-base, base or pavement expressed as a percentage of the bearing capacity of a standard sample of crushed stone.
Camber	The convexity given to the curved cross-section of a carriage way or foot path.
Carpet	See bituminous concrete.
Carriage way	That portion of a highway intended primarily for vehicular traffic.
Catchment Area	The watershed or area which contributes runoff to a drain or other drainage basin

Causeway	A paved waterway slightly raised above normal bed of the water channel.
Chipping	Crushed angular stone fragments of single size materials having nominal size between 2 mm (0.08 in) and 25 mm (1 inch)
Contract and Contract Documents	The written agreement between the Department and the contractor setting forth the obligations of the parties there under, including, but not limited to, the performance of the work, the furnishing of labour and materials, and the basis of payment. The Contract Documents include the invitation for tenders, the tender, notice of award, form of contract, contract bond, general conditions and special conditions, general specifications, supplemental specifications, special specifications plan, addenda, directives, change orders and supplemental agreements that are required to complete the Work, all of which constitute one instrument.
Contract Item (Pay Item)	A specifically described unit of work for which a unit price is provided in the tender.
Contract time	The number of working days or calendar days allowed for completion of the contract, including authorized time extensions. In case a calendar date of completion is shown in the tender, in lieu of the number of working in calendar days the work contemplated shall be completed by that date.
Contractor	The person, firm or corporation with whom the contract has been made by the employer, or to whom the contract has been assigned.
Compaction	**a) General:** The process of inducing a closer packing of particles by mechanical means. **b) Soil:** The process whereby soil particles are constrained by rolling or other mechanical means to pack more closely together reducing air voids, and increasing the dry density of the soil.
Crown	The highest part of a curved surface such as an arch, or a carriage way in cross section commonly at or near the center.
Culvert	A structure designed to secure passage over an obstacle or waterway of not more than 6 meters (20 linear feet)
Department	The Highway Department, Government of the Punjab unless otherwise specified.
Detour(Diversion)	A temporary road, adequately maintained, for the use of the traveling public through the project area.
Drain	A trench cut in the ground for the purpose of receiving and conducting drainage water.

Dry Density	The weight of material after drying it to constant weight at 105°C (221°F) contained in a unit volume.
Dry Density (Maximum)	The dry density of soil obtained by a specified amount of compaction at the optimum moisture content.
Dual Carriageway	A road in which there are two physically separated carriage ways reserved for up and down traffic separately.
Engineer **Or Engineer**	The duly authorized representative of the Employer/Government as Incharge of the work at site/acting directly or through his designated representative who is responsible for supervision of the work. (Where the term “The Engineer” is used in this document, it should be taken to mean Engineer).
Embankment	The work built above the natural ground by the deposition of material to support pavement structure.
Equipment	All machinery and equipment, together with the necessary supplies for up keep and maintenance, and also all tools and apparatus necessary for the proper construction and acceptable completion of work.
Expansion Joint	A space between two rigid parts of the same structure, formed to allow small relative movements to occur without the development of serious stresses, with or without provision of means to preserve functional continuity
Extra work	An item of work not provided for in the contract as awarded but found essential to the satisfactory completion of the work within its intended scope.
Filler	A finely divided mineral powder mostly passing 75-micron sieve, added to bitumen or the like, or to a mixture containing the same.
Final Hand Over	The final acceptation of the work by the Department, as authorized by the General conditions of the contract.
Flexible Pavement	A form of road construction, which, for the purpose of design, is assumed to have no flexural rigidity.
Forms or Formwork	Suttering including supports and false work.
Force Majeure	An unexpected and disruptive event, which may operate to excuse a party from a contract or part thereof.
Free Haul	The maximum distance upto which excavated material is transported without extra charge.
Frustration of Contract	Rendered impossible of performance by external cause beyond the contemplation of the parties

Gallon	Unless otherwise specified, the word "gallon" used in the specifications designates the imperial gallon (4.546 litres) and not U.S. gallon (3.785 litres).
Grade	The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centre-line of the road bed. Profile grade means either elevation or gradient of such trace accordingly
Graded Material	Material having particle sizes within the limits specified.
Gradient	The rate of rise or fall with respect to the horizontal plane along the centerline of a road or bridge.
Grading	a) The proportions by weight, of particle sizes in a granular material. b) The operation of bringing the profiles to the required grades.
Gravel	Waterborne stones of irregular shape and size occurring in natural deposits, with or without some finer material.
Gravel Road	A road constructed with layers of gravel with or without the addition of sand or clay.
Grubbing	Uprooting small trees, hedges, brushwood etc.
Guarantor	A financial institution approved by the Government which provides the guarantees called for in the contract documents.
Haul (Lead)	The total distance through which material is transported.
Interchange	A grade separated intersection with one or more turning roadways for travel between intersecting legs.
Intersection	The general area where two or more roads join or cross, within which are included the roadway and roadside facilities for traffic movements in the area.
Island	A central or subsidiary area in a roadway generally at road junctions, shaped and placed so as to constrain and control the movement of traffic.
Joint filler	A strip of compressible material used to fill the space in an expansion joint.
Kerb (Web)	A border of bricks, stone, concrete or other rigid material formed at the edge of a roadway.
Laybys	Areas for the parking of motor vehicles off the roadway other than the shoulders.
Litre/ Liter	One thousandth part of a cubic meter (1000 ml)
Loam	Soil consisting of a natural mixture of clay, sand and silt.

Macadam	A layer of coarse graded, angular mineral aggregate with a filler of fine aggregate interlocked by compaction.
Maintenance period	The period during which a contractor may be required to maintain at his own expense the contract works after completion.
Major road	A road which has, or to which is assigned a priority of traffic movement over that of other roads.
Minor road	A road which has, or to which is assigned, lesser priority for traffic movement than that of a major road.
Median	The portion of a divided highway or street separating the carriageways for traffic movement in opposite directions.
Overhaul	The distance of the Haul in excess of the free Haul.
Pavement or Pavement structure	The combination of sub-base, base and surface course placed on a sub grade to support the traffic load and distribute it over the subgrade.
Paving	A wearing course laid upon a prepared foundation consisting of units fitted closely together or of a layer of bitumen coated macadam, concrete or the like.
Penetration macadam (Bitumen macadam)	Macadam constructed with application of bitumen by penetration process.
Potholes	Bowl shaped holes in the pavement resulting from localized disintegration.
Prime coat	An application of low viscosity bitumen to an absorbent surface.
Profile grade	The grade intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadbed.
Retaining wall	A wall constructed to resist lateral pressure from the adjoining ground, or to maintain in position a mass of material usually the road embankment.
Revetment (Pitching)	A facing of stone or other material laid on a sloping face of earth to maintain the slope in position or to protect it from erosion.
Right of way (ROW)	The land acquired or secured or reserved for development, improvement and construction of all structures pertaining to a road.
Road bed	The graded portion of a road prepared as a foundation for the pavement structure and shoulders.

Road Formation	The width of a road on top consisting of pavement and shoulders.
Roadway	That portion of right of way which includes the road formation, slopes of embankment and road side ditches (infilling) or full width from back to back of retaining or breast walls.
Safety Fence	a) A fence erected to prevent vehicles from leaving the carriageway at a dangerous place. b) A fence erected for the safety of pedestrians c) A fence on a highway to prevent any specified type of traffic from leaving the part of highway appropriate to its use.
Scarifying	The systematic disruption and loosening of the top of a road or of natural ground by mechanical or other means.
Screening	Fine material to fill voids or interstices in a layer of macadam base course.
Seal coat	A thin treatment consisting of bituminous material, usually with coarse aggregate, applied to a surface course to close the voids with the object of rendering the surface water proof.
Section (Cross)	A vertical section at right angles to the center line, showing the elevation of the ground.
Section (Longitudinal)	A vertical section showing the elevation of the ground usually along the center line.
Service road	A temporary road with reasonably good riding surface constructed parallel to main road for the transportation of machinery and construction material etc.
Shingle	Round or water-worn stones of irregular size and shape as occurring in natural deposits and substantially free from sand
Shoulders	The portion of the road formation adjacent to and level with the pavement but generally of local soil or of lighter construction, to provide an opportunity for vehicles to leave the pavement for passing or parking or to provide lateral support to the pavement.
Sidewalk	That portion of the roadway primarily constructed for the use of pedestrians.
Site	The land and other places provided by the Department for the execution of the work.
Site Engineer	The onsite representation of the contractor duly authorized to receive and execute all instructions of the Engineer and to supervise and direct all of the contractors, construction operations in all phases of the work.

Soil	Any naturally occurring loose or soft deposit, forming part of the earth's crust and resulting from weathering or break down of rock formations.
Special specifications	Additions and revisions of the General and Supplemental Specifications covering conditions peculiar to an individual project
Specifications	A general term applied to all directions, provisions and requirements pertaining to the performance of the work.
Stabilized soil	Any natural material which has been modified to improve and maintain its load carrying capacity and resistance to weathering.
Structures	Bridges, culverts, catch basins, catch pits, drop in lets, retaining walls, cribbing manholes, end walls, buildings, sewers, service pipes, under drains, foundation drains and other features which may be encountered in the work and not otherwise classified herein.
Sub-contractor	An individual firm or corporation to whom the contractor sublets part of the work.
Sub-grade surface	The top surface of a road-bed upon which the pavement structure and shoulders are constructed.
Subgrade surface limit	The limits of the road-bed which are included in the designation sub-grade, shall be taken as extending to full embankment width in fills and to full formation width in cuts to a depth of 30 cms (1 foot) below sub base.
Sub-Base	A layer of material provided between the subgrade and the base, for a special purpose e.g. drainage or to add strength to the pavement.
Substructure	All of that part of the structure below the bearings of simple and continuous spans, skewtacks of arches and tops of footings of rigid frames, together.
Superstructure	The entire structure except the substructure.
Supplemental specifications	Additions and revisions to the General specifications that are adopted subsequent to issuance of the printed book.
Super elevation	The inward tilt or transverse inclination given to the cross section of a carriageway throughout the length of a horizontal curve to reduce the effect of centrifugal force on a moving vehicles.
Surety	The corporation, partnership or individual, other than the Contractor, executing a Tender Guarantee furnished by the Contractor.

Surface course	One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion and the disintegrating effects of climate.
Surface dressing	The surfacing process consisting of the application of bituminous binder and cover aggregate to an existing road surface.
Surface treatment	One or more applications of bituminous binder and cover aggregate on a prepared base course.
Tack coat	A very light application of bitumen to an existing bituminous or Portland cement concrete surface to provide bond to a super-imposed course.
Tender	The bid or offer made by a bidder, on the prescribed form, to perform the works and to furnish the labour and materials at the prices quoted.
Tender documents	The approved form on which the Department requires Tenders to be prepared and submitted for the work.
Tender guarantee	The security furnished with a Tender to guarantee that the bidder will enter into a contract if his Tender is accepted, and includes the specified forms on which the Contractor shall furnish required information and to his ability to perform and finance the work.
Ton	The word “Ton” used in the specifications designates the long ton of 2240 lbs.
Tonne (Metric ton)	Equivalent to 1000 Kilograms (2204 lbs)
Traffic Lane	A unit of carriage way width sufficient to accommodate a single line of vehicular traffic with provision for slight lateral movement.
Wall	**a) Curtain:** A thin wall used as a shield or protection (as distinct from retaining wall) **b) Head:** A retaining wall formed at the termination of a culvert or pipe. **c) Toe:** A low retaining wall formed at the termination of a culvert or pipe. **d) Wing:** A wall in extension of an abutment, as in a bridge or a culvert for retaining the side slopes or earth filling.
Water Bound Macadam	A form of road construction consisting of crushed stone or crushed gravel, compacted in the presence of water, the binding agent used being stone screenings or approved material.

Water table	The level at which ground water would finally stand in an un-pumped borehole, well or other depression, when equilibrium has been reached.
Wearing course	The top layer of the bituminous concrete, which carries the traffic, resists skidding, surface abrasion and the disintegrating effects of climate.
Weep hole	A small aperture or pipe through a retaining wall or abutment which, by using as a drain, prevents the accumulation of water.
Work	The work shall mean the furnishing of all labour, materials, equipment and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the Contract.
Working day	A working day shall be any day on which the Contractor can physically and legally execute the work.
Working drawings	Stress sheets, shape drawings, execution plans, work plans, framework plans, plans for bending of reinforcing steel, or any other supplementary plans, or similar data which the contractor is required to submit to the Engineer for approval.
Zone (safety)	A raised pavement or platform, or a guarded area so situated in a carriageway as to divide the stream or traffic and to provide a safety area for pedestrians.

SECTION – 1-3
ABBREVIATIONS

1-3 SECTION - ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials.
ASTM	American Society for Testing and Material
AWG	American Wire Gauges.
AWPA	American Wood Preservers Association
BS	British Standard Code of Practice.
ACI	American Concrete Institute.
FHWA	U S Federal Highway Administration.
PCA	Portland Cement Association.
Wt	Weight.
Lb	Pound
R.L.	Reduced level.
R.O.W.	Right of Way
in.	Inch
ft.	Foot
Yd.	Yard
Ltr.	Liter.
Mm	Millimeter
Cm	Centimeter
m	Meter
Km	Kilometer
m^2	Square Meter
m^3	Cubic Meter
Ha	Hectare (10,000 m^2)
Kg	Kilogram
N	Newton
^oC	Degree Centigrade
^oF	Degree Fahrenheit
Psi	Pounds per Square inch
Kg/cm^2	Kilogram per Square Centimeter

SECTION - 1-4

CONSTRUCTION MACHINERY AND EQUIPMENT GENERAL REQUIREMENTS

1-4 SECTION - CONSTRUCTION MACHINERY AND EQUIPMENT GENERAL REQUIREMENTS

1-4.1 GENERAL

Unless restricted by the Specifications, Plans, Special Provisions or the Engineer, to a specific type or types of the machinery, equipment, tools, plants, combination and number of units etc to be used on the work shall be such as the contractor selects.

However the equipment to be used on the work shall be such as to give the specified and required results conforming to specifications.

1-4.2 EQUIPMENT CONDITION AND APPROVAL

All equipment required to be used in construction of the project or in any stipulated portions of a project, shall be on the site in perfect working condition and shall have been approved by the Engineer before construction of any particular item of work is started. The number of units, the sizes, etc. of all equipment shall be adequate to ensure completion of work within the time specified in the contract. No equipment shall be removed from the site without 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. Any plant or equipment or portion thereof, which becomes worn or defective shall be immediately repaired or replaced to the satisfaction of the Engineer.

1-4.3 CATEGORIES OF CONSTRUCTION EQUIPMENT

Various categories of construction equipment shall include but not limited to the items listed below:

A. Earth Moving Equipment

1. Scrapers
2. Bulldozers / Angle dozers
3. Tractors fitted with front blades
4. Motor graders
5. Excavator
6. 1-Scraper

B. Compacting Equipment

1. Tamping or sheep foot rollers.
2. Two axle/three axle Tandem steel rollers.
3. Three Wheeled steel rollers.
4. Trench rollers.

5. Self-propelled pneumatic tire rollers.
6. Pull type pneumatic tire rollers.
7. Vibrating compactors.
8. Water Tanker.
9. Vibratory Road Rollers.
10. Controlled water distribution equipment. equipped with spray bars (water lorries).

C. Hauling and Weighing Equipment

1. Trucks
2. Tractor trolleys.
3. Dump trucks.
4. Platform scales

D. Cement Concrete Equipment

1. Cement concrete paving equipment
2. Batching plant and equipment
3. Concrete Mixers.
4. Concrete Spreaders.
5. Finishing machine
6. Longitudinal Finisher.
7. Concrete saw
8. Joint compound hearing & placing equipment
9. Concrete vibrators.
10. Transit mixer.

E. Asphaltic Construction Equipment

1. Asphalt plant
2. Equipment for heating bituminous material
3. Bitumen distributor.
4. Paving machine
5. Self propelled aggregate spreader
6. Air Compressor.
7. Mechanical Brooms

1-4.4 SPECIAL EQUIPMENT

Where a special type of plant or equipment is specified for a particular operation, the Contractor may, with the written approval of the Engineer, use alternative equipment provided that he satisfies the Engineer at his own risk and cost that he can achieve the required results within the time schedule. If the Contractor does not achieve the result to the satisfaction of the Engineer, the Engineer will require him to revert to the originally specified special equipment for the satisfactory completion of the work.

1-4.5 RECOMMENDED MAJOR EQUIPMENT FOR DIFFERENT CONSTRUCTION OPERATIONS

For general guidance of the Executing Agencies the Recommended major construction equipment is given at Annex-I.

1-4.6 CONTRACTOR'S RESPONSIBILITY

The approval of number of units, the sizes or particular types, by the Engineer does not absolve the Contractor of the responsibility of timely and satisfactory completion of the work.

SECTION – 1-5

FIELD TEST LABORATORY FOR QUALITY CONTROL

1-5 SECTION - FIELD TEST LABORATORY FOR QUALITY CONTROL

1-5.1 GENERAL

Every Contractor employed on the construction or improvement of roads, bridges or other road structures shall be required to provide and maintain during execution of work (for quality control) a field test laboratory properly equipped with approved equipment and furniture to carry all the tests indicated in the relevant sections of these specifications. Contractors shall also be required to employ necessary qualified technical staff as approved by the Engineer to carry out the specified tests and maintain its record in a manner approved by the Engineer. The laboratory shall be provided with equipment specified in the quality control manual of the Punjab Highway Department or annexed with Tender Documents for various tests. The contractor shall also make arrangements of electric power supply, water supply and drainage for the field test laboratory.

1-5.2 LOCATION

The laboratory shall be located in the project area at the site of work, approved by the Engineer. It shall be housed in a temporary building or a double fly tent, spacious enough to accommodate laboratory equipment and furniture and allowing enough space for preservation of samples performing tests, upkeep of test result record and convenience in conducting the tests and supervision by the Engineer's representative. Laboratory housing arrangement will be such that the samples, equipment and the record are not susceptible to damage due to weathering effects.

1-5.3 COST MEASUREMENTS AND PAYMENTS

1-5.3.1 Payment

a. Providing Material Testing Laboratory with Equipment

Contractor will provide at his own cost furnishing, accommodation with appropriate power, water supply and sanitary arrangements and testing equipment for testing in the laboratory and at site, temporary labour for site activity, materials & equipment for pit excavation and related site activity, incidentals etc. as approved by the Engineer for proper testing of the road materials and finished product as specified and according to AASHTO and ASTM standard procedures.

b. Maintenance of Laboratory

The contractor will bear the cost for the maintenance of Laboratory which includes, the cost of all materials/chemicals required for testing, the salary of laboratory technical staff and labour, cost of stationery etc. The contractor shall allow the Engineer or his staff to use the field test laboratory for carrying out quality control tests.

SECTION – 1-6

CONTROL, PROTECTION AND MAINTENANCE OF TRAFFIC

1-6 SECTION - CONTROL, PROTECTION AND MAINTENANCE OF TRAFFIC

1-6.1 DESCRIPTION

The work specified in this section consists of maintaining traffic in a manner approved by the Engineer within the limits of the project and for the duration of the construction period including any temporary suspensions of the work. The Contractor shall keep open to traffic half 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 It shall, thus, include the construction and maintenance of any necessary detour facilities and making of any special arrangements for the maintenance of traffic, as shown or indicated on the Drawings or as directed by the Engineer.

The Contractor shall take necessary care at all times to ensure the convenience and safety of the residents along and adjacent to the road. Any failure of the Contractor in 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 to or which may become due to the Contractor under the contract.

1-6.2 GENERAL REQUIREMENTS

The Contractor’s responsibility for maintenance of traffic shall begin on the day he starts work on any component of the project. Or on the first day contract time is changed, whichever is earlier.

All lanes that are being used for the maintenance of traffic, including those on detours and temporary facilities, shall be adequately maintained with a substantial surface under all weather conditions. The lanes shall be kept free of dust and, when necessary to accomplish this, they shall be sprinkled with water or some other dust palliative.

The contractor will be required to maintain two way traffic except as other-wise provided for in the special provisions or herein. Where one-way traffic is permitted, traffic is to alternate in direction so that it will not be delayed beyond a reasonable time.

The contractor shall provide competent flagmen during the day and proper and adequate lights during the night to direct all one-way or otherwise restricted traffic, and to direct traffic at all restricted bridges and other hazardous location unless relieved of the requirement in writing by the Engineer or his authorized representative.

The contractor will not be permitted to block any road or street, which intersects or crosses the project, unless otherwise specifically permitted. Detours for intersecting or crossing traffic shall be provided and maintained, in accordance with provisions of Section 1-6.3

Where, in the opinion of the Engineer, traffic over the base or surface course would be injurious to such work, all traffic passageways along the project shall be outside the pavement area.

When traffic is specified to be detoured over other roads or streets, the contractor will not be required to maintain such roads or streets, and all posting including those at the intersections with the project, will be done by the Department.

The contractor will not be permitted to isolate residences or places of business. Access shall be provided to all residences and all places of business whenever construction interferes with the existing means of access.

Barricaded, warning lights, warning and detour signs are to be erected by the Contractor wherever necessary, in accordance with provisions of section 1-6.4 to ensure that traffic does not deviate from the established usable road way limit.

1-6.3 DETOURS OR DIVERSIONS

On all construction works where the contractor is required to maintain traffic, he will be required to construct and maintain detour facilities wherever it becomes necessary to divert from any existing roadway or wherever construction operations block the flow of traffic. The minimum lane width shall be 3.65 meters (12 feet)

All detours are to be planned, constructed and maintained in such a manner that they will be capable of conveniently carrying the traffic volume throughout all conditions of weather. It will be the contractor’s responsibility to provide all detour facilities with adequate drainage to meet this requirement.

The contractor will generally be required to provide all materials, labour and equipment for the construction and maintenance of all detours except that where the plans call for the Department to provide borrow or other material pits and the contractor will be allowed to obtain material from these pits for detour unless otherwise shown no separate payment shall be made for detours material from these pits.

In general, the requirements of the Standard Specifications pertaining to construction and material details shall not apply to detour construction, and it will be the responsibility of the contractor to select and to use construction methods and materials that will satisfactorily provide a stable detour facility of sufficient durability to remain in good condition as supplemented by his maintenance for as long a period as it is necessary to utilize the detour. Detours shall be removed by the contractor after completion of the project.

1-6.4 BARRICADES, WARNING LIGHTS, WARNING AND DETOUR SIGNS

The contractor shall furnish, erect and maintain all necessary barricades, suitable and sufficient warning lights, danger signs and warning signs, and flares and shall also provide sufficient number of watchmen to direct the traffic and shall take all necessary precautions for the protection of work and safety of the public. Roads closed to traffic shall be protected by effective barricades on which shall be placed appropriate warning signs. The contractor shall erect and maintain the proper warning and directional signs at all closures and intersections and along the detour routes, directing the traffic around the closed road or portions of the road, and such that the temporary detour route shall be indicated clearly throughout its entire length. All barricades and obstructions shall be illuminated at night and all lights shall be kept burning from sunset until sunrise.

Materials of which road posts, hazard marker, warning tapes, traffic signs, flashing amber lights, signals, barricades diversion cones, big cones bollards etc shall conform to current BS or ASTM standards or as approved by the ENGINEER.

During the entire period of construction operations at railway crossings, it shall be the Contractor's responsibility to erect & maintain, during day & night and in a satisfactory and clearly legible condition, the advance warning signs which are normally installed by the Railway. Wherever such signs are not installed by Railways, the Contractor shall install and properly maintain adequate temporary advance warning signs, which will be furnished to him by the Department.

1-6.5 WATERING

The contractor shall sprinkle the surface with adequate amount of water where so required to keep down the dust.

1-6.6 MEASUREMENT AND PAYMENT

The item for maintenance of traffic at all points affected by the project will be measured in number of months during which the traffic is maintained during the construction period of the project It will include providing and installation of all signs, signals illumination, barricades etc. round the clock and necessary manpower/flagmen as per requirement of the engineer. It will also include construction and maintenance of temporary Detours or Diversion road as directed by the Engineer.

1-6.7 PAYMENT

The unit rate shall be full compensation for all costs of complying with the provisions of this section and includes costs of all materials, labour and machinery etc. per month.

The Payment shall be made for maintenance of Traffic for total months under the construction period of the project.

Pay Item No.	Description	Unit of Measurement
1-6	Maintenance of traffic including Detours or Diversion Road	Per Month

SECTION– 2-1

TABLES FOR SAMPLING AND FREQUENCY

2-1 SECTION – TABLES FOR SAMPLING AND FREQUENCY

2-1.1 SCHEDULE FOR SAMPLING AND TESTING OF EMBANKMENT AND SUBGRADE

Section Nos. - (4-4), (4-5), (4-6), (4-7), (4-8), (4-9). (4-10). (4-11). (4-12).

Material	Test	Designation *	Sampling and Testing Frequency
Soil	Classification	AASHTO M-145	1/2,000 CM
	CBR	AASHTO T-193	1/2,000 M
	Swelling	AASHTO T-193	1/2,000 CM
	Moisture Density(Lab)	AASHTO T-180	1/2,000 M
	or		
	Relative Density	ASTM D-4254-83	1/1,000 M
	Field Density	AASHTO T-191	1/200 M

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.2 SCHEDULE FOR SAMPLING AND TESTING OF MECHANICALLY STABILIZED SOIL AGGREGATE SUB BASE

Section No. (5-2)

Material	Test	Designation *	Sampling and Testing Frequency:
Aggregate	Gradation	AASHTO T-27	3 / Source plus 1/1000 CM
	Plasticity Index	AASHTO T-89 and T-90	3 / Source plus as required base on visual observation
	CBR	AASHTO T-193	3/Source plus as required based on variation in gradation or 1/1000 CM
	Abrasion	AASHTO T-96	3 / Source plus 1/500 CM
	Moisture Density	AASHTO T-180	1/1000 CM
	Field Density	AASHTO T-191 T-238 and T-239	4/layer / 400 M laid, 3 Minimum / layer if less than 400 M laid.
	Sand Equivalent	AASHTO T-176	3 / source plus as required based on visual observation.

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.3 SCHEDULE FOR SAMPLING AND TESTING OF SOIL-CEMENT SUB-BASE AND BASE COURSE

Section No. (5-3)

Material	Test	Designation *	Sampling and Testing Frequency.
Soil	Classification.	AASHTO T-27 and T-89.	3/Borrow Source plus 1/1000 CM
Mixture	Moisture-Density.	AASHTO T-134	1/Soil Class.
	Pulverization.	Note (a)	1/300 m strip
	Field Density.	AASHTO T-191 or T-238 & T-205.	1/300 m strip 1/300 m strip
	Compressive Strength	ASTM D-1633	1/Soil Class
	Wetting & Drying	AASHTO T-135	1/Soil Class

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

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.4 SCHEDULE FOR SAMPLING AND TESTING OF CRACK-RELIEF LAYER

Section No. (5-4)

Material	Test	Designation *	Sampling and Testing Frequency
Aggregate (Crushed)	Gradation	AASHTO T-27	Same as for item 5-7
Aggregate (Asphaltic open-graded plant mix)	Gradation	AASHTO T-27	Same as for coarse aggregate under item 6-6
Asphalt Cement	-	-	Same as for Item 6-6
Mixture	Asphalt Coating	AASHTO T-195	1/day's production or as required based on visual observation

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.5 SCHEDULE FOR SAMPLING AND TESTING OF AGGREGATE BASE COURSE

Section No. (5-7)

Material	Test	Designation *	Sampling and Testing Frequency:
Aggregate	Gradation	AASHTO T-27	3 / Source plus 1/1,000 M
	Plasticity Index	AASHTO T-89 and T-90	3 / Source plus as required based on visual observation
	CBR	AASHTO T-193	3/Source / stock piles as required based on variation in gradation
	Abrasion	AASHTO T-96	3 / Source plus 1/5,000 CM
	Sodium Sulfate Soundness	AASHTO T-104	3/ Source plus 1/5000 CM
	Fracture Faces	Visual	3 / Source plus as required based on visual observation
	Moisture Density	AASHTO T-180	1/1000 CM
	Field Density	AASHTO T-191 T-238 and T-239	4/layer / 400 M laid, 3 Minimum / layer if less than 400 M laid
	Sand Equivalent	AASHTO T-176	3 / source plus as required based on visual observation.

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.6 SCHEDULE FOR SAMPLING AND TESTING OF WATER BOUND MACADUM BASE COURSE

Section No. (5-8)

Material	Test	Designation *	Sampling and Testing Frequency:
Aggregate	Gradation	AASHTO T-27	3 / Source plus 1/1000 CM
	Plasticity Index	AASHTO T-89 and T-90	3 / Source plus as required based on visual observation
	CBR	AASHTO T-193	3/Source plus as required based on variation in gradation or 1/1000 CM
	Abrasion	AASHTO T-96	3 / Source plus 1/500 CM
	Moisture Density	AASHTO T-180	1/1000 CM
	Field Density	AASHTO T-191 T-238 and T-239	4/layer / 400 M laid, 3 Minimum / layer if less than 400 M laid.
	Sand Equivalent	AASHTO T-176	3 / source plus as required based on visual observation.

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.7 SCHEDULE FOR SAMPLING AND TESTING OF ASPHALTIC BASE COURSE PLANT MIX

Section No. (6-6)

Material	Test	Designation *	Sampling and Testing Frequency:
Course Aggregate	Gradation	AASHTO T-27	1/1000 M
	Abrasion	AASHTO T-96	3 / Source / stock piles plus 1/5000 CM
	Sodium Sulfate Soundness	AASHTO T-104	3/ Source plus 1/5000 CM
	Stripping	AASHTO T-182	3 / Source plus 2/5000 CM
	Fracture Faces	Visual	' source plus as required based on visual observation.
	Flat and Elongated Particles	Visual	3 / source plus as required based on visual observation.
	Specific Gravity and Absorption	AASHTO T-85	4 / Source for each size as hot bins of Asphalt Plant
Fine Aggregate	Sand Equivalent	AASHTO T-176	3 / source plus as required based on visual observation.
	Plasticity Index	AASHTO T-89 & T90	2 / 1000 CM
	Specific gravity	AASHTO T-84	4/ Source
	Friable particles	AASHTO T-112	2/5000 CM
Asphalt Cement	Specific gravity	AASHTO T-228	4/ Source
	Penetration	ASSHTO T-49	3 / Week of plant operation Samples taken from heating tank at staggered intervals
Mixture	Extraction Gradation	AASHTO T-164 and T30	2 days Production
	Bulk Specific Gravity	AASHTO T-166 Method B	
	Maximum Specific Gravity	AASHTO T-209	
	Air Voids	AASHTO T-269 and T-90	
Mixture Compacted in Place	Thickness	AASHTO T-230	1 / Layer @100M interval per Lane
	Compaction	AASHTO T-230 ASTM D2950	1 / Layer @ 100 M interval per Lane

Notes: Test location will be selected at random.

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.8 SCHEDULE FOR SAMPLING AND TESTING OF WEARING COURSE PLANT MIX

Section No. (6-8)

Material	Test	Designation *	Sampling and Testing Frequency:
Course Aggregate	Gradation	AASHTO T-27	1/1000 M
	Abrasion	AASHTO T-96	3 / Source / stock piles plus 1/5000 CM
	Sodium Sulfate Soundness	AASHTO T-104	3/ Source plus 1/5000 CM
	Stripping	AASHTO T-182	3 / Source plus 2/5000 CM
	Fracture Faces	Visual	source plus as required based on visual observation.
	Flat and Elongated Particles	Visual	3 / source plus as required based on visual observation.
	Specific Gravity and Absorption	AASHTO T-85	4 / Source for each size as Hot bins of Asphalt Plant
Fine Aggregate	Sand Equivalent or	AASHTO T-176	3 / source plus as required based on visual observation.
	Plasticity Index	AASHTO T-89 & T-90	1/ 1000 CM
	Friable particles	AASHTO T-112	1/5000 CM
Asphalt Cement	Specific gravity	AASHTO T-228	2 / shipment
	Penetration	ASSHTO T-49	3 / Week of plant operation Samples taken from heating tank at staggered intervals
Premix Asphalt	Extraction Gradation	AASHTO T-164 and T-30	2 days Production
	Flow	AASHTO T-245	
	Stability	AASHTO T-245	
	Bulk Specific Gravity	AASHTO T-166 Method B	
	Loss Stability	AASHTO 245	
Mixture Compacted in Places	Thickness	AASHTO T230	1 / Layer @100M interval per Lane
	Compaction	AASHTO T-230 ASTM D2950	1 / Layer @ 100 M interval per Lane

Notes: Test location will be selected at random

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

2-1.9 SCHEDULE FOR SAMPLING AND TESTING OF CONCRETE PAVEMENT

Section No. (7-1)

Material	Test	Designation *	Sampling and Testing Frequency:
Course Aggregate	Gradation	AASHTO T-27	1/1000 M
	Unit Weight	AASHTO T-19	1/ Source plus 1/1000 CM
	Specific Gravity	AASHTO T-85	2 / Source plus 2/1000 CM
	Absorption	AASHTO T-85	1/ Source plus 1/5000 CM
	Abrasion	AASHTO T-96	1/ Source plus 1/5000 CM
	Soundness	AASHTO T-104	1/ Source plus 1/5000 CM
	Deleterious Substance	AASHTO M-80	1/ Source plus 1/5000 CM
Fine Aggregate	Gradation	AASHTO M-6	2/ Source plus 1/1000 CM
	Unit Weight	AASHTO T-19	4/ Source plus 1/800 CM
	Specific gravity	AASHTO T-228	2 / shipment
	Absorption	AASHTO -84	1/Source plus 1/1000 CM
	Organic Impurities	ASSHTO T-21	1/Source plus 1/1000 CM
	Soundness	AASHTO T-104	1/ Source plus 1/5000CM
	Fineness	ASSHTO M-6	1/ Source plus 1/1000 Cm
	Deleterious Substance	AASHTO M-6	1/ Source plus 1/5000 CM
	Petrographic	-	1/Source plus 1/5000 CM
	Yield Test for Cement Content	AASHTO T-121	1/Lot or per 1000 Bags
Cement	Setting Time	AASHTO T-121	1/Lot or per 1000 Bags
	Mortar Strength	AASHTO T-131	1/Lot or per 1000 Bags
Water	Chemical Tests	AASHTO T-26	1/Source
Concrete Mix	Compression (Cube or Cylinder)	AASHTO T-22	6 / Shift or 50 CM (2 sets of 3 each)
	Slump	AASHTO T-119	2 / Shift or 50 CM

** For Details of AASTO/ASTM Standards, Refer Vol. IV of these specifications.*

SECTION – 2-2

TABLES FOR ALLOWABLE TOLERANCES

2-2 SECTION - TABLE FOR ALOWABLE TOLERANCES

2-2.1 TABLE FOR ALLOWABLE TOLERANCES FOR SUBGRADE, SUB BASE, BASE, WEARING COURSEAND CONCRETE PAVEMENTS

Description	Thickness (mm)	Level (mm)	5M Straight-edge (mm)	Cross-fall (%)	Longitudinal Grade in 30 M (%)
Sub-Grade	±20	+0 -40	30	± 0.5	± 0.1
Sub base (Gradation or Stabilized)	+10 -20	+0 -25	20	± 0.3	± 0.1
Base Course (Granular or Stabilized)	+5 -10	+5 -10	6	± 0.2	± 0.1
Asphaltic Base Course	+3 -10	+3 -10	6	± 0.2	± 0.1
Asphaltic Wearing Course	±3	±3	5	± 0.2	± 0.1
Concrete Pavements	+10 -5	+10 -5	5	± 0.2	± 0.1

Note: 1. *Material for stabilization of soil may be cement, lime or bitumen.*

2. *Accumulative tolerance shall be more than that as specified against the final layer.*

2-2.2 ALLOWABLE TOLERANCE FOR CENTRE 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: Reinforcement bars are evaluated on the basis of nominal weights in no case shall the overweight of any bar or lot of bars shall be cause of rejection.

2-2.3 TABLE FOR ALLOWABLE TOLERANCE (REINFORCED CONCRETE PIPES OF CLASS II AND IV)

AS PER AASHTO M-170

Description	Individual 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

Note:

1. *Pipes having localized variations in wall thickness exceeding those specified above shall be accepted, if the three –edge bearing and minimum steel cover requirements are met.*
2. *Pipes having variation in the position of the requirement exceeding those specified above shall be accepted, if the three edge bearing strength requirements on a representative sample are met.*

SECTION – 2-3

REFERENCE GUIDE TABLES FOR THEIR APPLICATION TO THE PARTICULAR SECTION OF THE SPECIFICATIONS

2-3 SECTION - REGERENCE GUIDE TABLES FOR THEIR APPLICATION TO THE PARTICULAR SECTION OF THE SPECIFICATIONS

2-3.1 REFERENCE GUIDE TABLES FOR EARTH WORK AND ALLIED ACTIVITIES

Section	Description	New Construction	Rehabilitation	Maintenance
4	General, Earth Work	°	°	°
3-1	Clearing and Grubbing	°		
3-2	Removal of Trees	°		
3-4	Stripping	°		
4-6	Compaction of Natural Ground	°		
4-5	Roadway / Excavation and Borrow Excavation	°		
3-3	Removal of Existing Structures	°		
4-4	Structural Excavation and Backfill	°	°	
4-8	Formation of Embankment	°	°	°
4-7	Subgrade Preparation	°	°	
4-9	Improved Subgrade	°		
4-10	Soil Cement Stabilized Subgrade	°		
4-11	Lime Stabilized Subgrade	°		
4-12	Bitumen Stabilized Subgrade.	°		
4-13	Dressing and Compaction of Berms	°	°	°
6-10	Reinstatement of Shoulders / shoulder treatment		°	°

2-3.2 REFERENCE GUIDE TABLES FOR SUB BASE AND BASE

Section	Description	New Construction	Rehabilitation	Maintenance
5-1	General,	◦	◦	
5-2	Sub-Base Mechanically stabilized	◦	◦	◦
5-7	Aggregate Base Course	◦	◦	◦
6-6	Asphaltic Base Course Plant Mix.	◦	◦	
5-3	Soil Cement Stabilized Sub base and Base.	◦	◦	
5-4	Crack Relief Layer		◦	◦
5-8	Water Bound Macadam Base.	◦	◦	◦
4-2	Removal of Existing pavement		◦	◦
4-3	Scarification of Existing Road / Breaking of Road Pavement Structure.		◦	◦
5-11	Pavement Widening and Grooving of Existing Surface.		◦	◦
6-13	Hot Recycling of Asphaltic concrete		◦	
6-7	Asphaltic Base / Binder Course		◦	

2-3.3 REFERENCE GUID TABLES FOR BITUMINUS BASE AND SURFACING

Section	Description	New Construction	Rehabilitation	Maintenance
10-3	Asphaltic Materials	°	°	°
6-1	Bituminous Prime Coat	°	°	°
6-2	Bituminous Tack Coat	°	°	°
6-3	Bituminous Surface Treatment and Seal Coat	°	°	°
6-8	Asphaltic Concrete Wearing Course, Plant Mix.	°	°	
6-10	Shoulder Treatment	°	°	°
6-12	Bit-Mac		°	°
6-13	Hot Recycling of Asphalt Concrete		°	
6-11	Cold Milling		°	°
7-2	Concrete Pavements	°	°	°

2-3.4 REFERENCE GUIDE TABLE FOR STRUCTURE

STRUCTURE

Item No.	Description	New Construction	Rehabilitation	Maintenance
8-1	General – Structures	°	°	°
	Bridges and Culverts	°	°	
7-1	Concrete	°	°	°
8-2	False work & Centring for Bridges	°	°	°
	Formwork	°	°	°
8-3	Steel Reinforcement	°	°	°
8-4	Prestressed Concrete Structures	°	°	
8-5	Steel structure	°	°	
8-6	Piling	°		
8-8	Well Foundation	°		
8-8	Brick Masonry	°	°	
8-9	Random and Dressed Uncoursed Stone Masonry	°	°	°
8-10	Dressed Coursed Stone Masonry	°	°	°

2-3.5 REFERENCE GUIDE TABLES FOR ANCILLARY WORKS

ANCILLARY WORKS

Item No.	Description	New Construction	Rehabilitation	Maintenance
9-1	General – Drainage & Erosion Works	∘	∘	∘
9-2	Reinforced Concrete Pipe Culverts	∘	∘	∘
9-3	Bed to Concrete Pipe Culverts	∘	∘	∘
9-4	Underdrain	∘	∘	
9-5	Headwalls, Wingwalls, Parapets, Approach Slabs, Aprons and Siphon Inlets / Outlets.	∘	∘	∘
9-6	Manholes	∘	∘	∘
9-7	Drop Inlets and Catch Basins	∘	∘	∘
9-8	Gabions	∘	∘	∘
9-9	Riprap and Reinforced Concrete Slope Protection.	∘	∘	∘
9-10	Stone Pitching	∘	∘	∘
9-11	Concrete Kerb	∘	∘	∘

2-3.6 REFERENCE GUIDE TABLE FOR ANCILLARY WORKS

ANCILLARY WORKS

Item No.	Description	New Construction	Rehabilitation	Maintenance
9	Drainage Erosion and Ancillary Works	◦	◦	◦
9-11	Concrete Kerbs, Gutters and Channels	◦	◦	◦
9-12	Asphalt Concrete and Cement Concrete Side Walk	◦	◦	◦
9-13	Metal Beam Guard-rail	◦	◦	◦
9-14	Concrete Beam Guard-rail	◦	◦	◦
9-15	Bridge Railing	◦	◦	◦
9-16	Traffic Signs and Safety Devices	◦	◦	◦
9-17	Pavement Marking	◦	◦	◦
9-18	Reflectorized Pavement Studs.	◦	◦	◦
9-19	Precast Concrete Posts & Markers.	◦	◦	◦
9-20	Fencing	◦		

2-3.7 REFERENCE GUIDE TABLE FOR MISCLLANEOUS

MISCELLANEOUS

Item No.	Description	New Construction	Rehabilitation	Maintenance
11-1	Provision of Survey Teams and Instruments	◦	◦	
11-2	Provide, Equip and Maintain Office Facility to the Engineer (Base Camp Facility)	◦	◦	◦
11-3	Provide, Equip and Maintain Laboratory for the Project	◦	◦	
11-4	Maintenance of Works for One Year after Completion (Period of Maintenance)		◦	◦
11-5	Temporary Road Works for Traffic Diversion		◦	◦
11-6	Control and Protection of Traffic		◦	◦

SECTION-2-4
CONVERSION FACTORS TABLES

2-4 SECTION - CONVERSION FACTORS TABLES

LENGTH								
km	**m**	**mm**	**mile**	**Yard**	**ft**	**in**		
1	1000	10^{6}	0.6214	1094	3281	$3.937x10^{4}$		
10^{-3}	1	1000	$6.214x10^{-4}$	1.0936	3.281	39.37		
10^{-6}	10^{-3}	1	$6.214x10^{-7}$	$1.094x10^{-3}$	$3.28x10^{-3}$	$3.937x10^{-2}$		
1.6094	1609.4	$1.609x10^{6}$	1	1760	5280	63360		
$9.144x10^{4}$	0.9144	914.41	$5.682x10^{-4}$	1	3	36		
$3.048x10^{-4}$	0.3048	304.8	$1.894x10^{-4}$	0.3333	1	12		
$2.54x10^{-5}$	0.0254	25.4	$1.578x10^{-5}$	$2.778x10^{-2}$	$8.333x10^{-2}$	1		
AREA								
km^{2}	**m^{2}**	**cm^{2}**	**mm^{2}**	**sq. Mile**	**acre**	**yd^{2}**	**ft^{2}**	**in^{2}**
1	10^{-6}	10^{10}	10^{12}	0.38612	247.11	$1.196x10^{6}$	$1.076x10^{7}$	$1.550x10^{9}$
10^{-6}	1	10^{4}	10^{6}	$3.86x10^{-7}$	$2.471x10^{-4}$	1.196	10.764	1550
10^{-10}	10^{-4}	1	100	$3.86x10^{-11}$	$2.471x10^{-8}$	$1.16x10^{-4}$	$1.076x10^{-3}$	0.155
10^{-12}	10^{-6}	10^{-2}	1	$3.86x10^{-13}$	$2.471x10^{-10}$	$1.196x10^{-6}$	$1.076x10^{-5}$	$1.550x10^{-3}$
2.59	$2.59x10^{6}$	$2.59x10^{10}$	$2.59x10^{12}$	1	639.96	$3.097x10^{6}$	$2.788x10^{7}$	$4.01x10^{8}$
$4.047x10^{-3}$	4047	$4.047x10^{7}$	$4.047x10^{9}$	$1.563x10^{-3}$	1	4840	43560	$6.273x10^{6}$
$8.36x10^{-7}$	0.8361	8361	$8.36x10^{5}$	$3.228x10^{-7}$	$2.066x10^{-4}$	1	9	1296
$9.29x10^{-8}$	$9.29x10^{-2}$	929	92900	$3.587x10^{-8}$	$2.296x10^{-5}$	0.1111	1	144
$6.45x10^{-10}$	$6.45x10^{-4}$	6.4516	645.16	$2.491x10^{-10}$	$1.594x10^{-7}$	$7.716x10^{-4}$	$6.944x10^{-3}$	1
VOLUME								
m^{3}	**dm^{3} (litre)**	**cm^{3} (ml)**	**yd^{3}**	**ft^{3}**	**in^{3}**	**UK gallon**	**US gallon**	
1	10^{3}	10^{6}	1.3079	35.311	6102	219.97	264.17	
10^{-3}	1	10^{3}	$1.308x10^{-3}$	$3.53x10^{-2}$	61.02	0.22	0.2642	
10^{-6}	10^{-3}	1	$1.308x10^{-6}$	$3.531x10^{-5}$	$6.102x10^{-2}$	$2.199x10^{-4}$	$2.642x10^{-4}$	
0.7646	764.6	$7.646x10^{5}$	1	27	46650	168.19	201.99	
$2.832x10^{-2}$	28.32	$2.832x10^{-4}$	$3.704x10^{-2}$	1	1728	6.229	7.481	
$1.639x10^{-5}$	$1.639x10^{-2}$	16.387	$2.144x10^{-5}$	$5.787x10^{-4}$	1	$3.605x10^{-3}$	$4.329x10^{-3}$	
$4.546x10^{-3}$	4.546	$4.546x10^{3}$	$5.946x10^{-3}$	0.1605	277.42	1	1.2008	
$3.785x10^{-3}$	3.785	$3.785x10^{3}$	$4.951x10^{-3}$	0.1337	231	0.8327	1	
WEIGHT								

Tonne (Mg)	kg	g	UK ton	US ton	cwt	lb	Oz	
1	1000	10^{6}	0.9842	1.1011	19.66	$2.205x10^{3}$	$3.527x10^{4}$	
10^{-3}	1	1000	$9.842x10^{-4}$	$1.101x10^{-3}$	$1.966x10^{-2}$	2.2046	35.274	
10^{-6}	10^{-3}	1	$9.842x'10^{-7}$	$1.101x10^{-6}$	$1.966x10^{-5}$	$2.204x10^{-3}$	$3.527x10^{-2}$	
1.016	1016	$1.016x10^{6}$	1	1.12	20	2240	35840	
0.9081	908.1	$9.08x10^{5}$	0.8928	1	17.856	2000	32000	
$5.085x10^{-2}$	50.85	$5.085x10^{4}$	0.05	0.0560	1	112	1792	
$4.536x10^{-4}$	0.4536	453.6	$4.46x10^{-4}$	$5x10^{-4}$	$8.92x10^{-3}$	1	16	
$2.835x10^{-5}$	$2.835x10^{-2}$	28.349	$2.79x10^{-5}$	$3.125x10^{-5}$	$5.580x10^{-4}$	$6.25x10^{-2}$	1	

PRESSURE, STRESS AND MODULUS OF ELASTICITY

MN/m^2 MPa	kN/m^2 kPa	kp Kgf/cm^2	Ton/ft^2	psi lbf/in^2	psf lbf/ft^2
1	1000	10.197	9.320	145.04	20886
0.001	1	$1.019x10^{-2}$	0.0093	0.14504	20.886
$9.807x10^{-2}$	98.07	1	0.9139	14.223	2048.1
0.1073	107.3	1.0942	1	15.562	2240
$6.895x10^{-3}$	6.895	$7.031x10^{-2}$	$6.426x10^{-2}$	1	144
$4.788x10^{-5}$	$4.788x10^{-2}$	$4.883x10^{-4}$	$4.464x10^{-4}$	$6.944x10^{-3}$	1

DENSITY

Tonne/m^3 Mg/ m^3 g/cm^3	Kg/ m^3	Lb/in^3	UK ton/yd^3	US ton/yd^3	pcf Lb/ft^3
1	1000	0.03613	0.75247	0.8428	62.43
10^{-3}	1	$3.613x10^{-5}$	$7.525x10^{-4}$	$8.428x10^{-4}$	$6.243x10^{-2}$
27.680	27680	1	20.828	23.328	$1.728x10^{3}$
1.3289	$1.328x10^{3}$	$4.801x10^{-2}$	1	1.12	82.955
1.1865	$1.186x10^{3}$	$4.287x10^{-2}$	0.8929	1	74.074
$1.602x10^{-2}$	16.019	$5.787x10^{-4}$	$1.205x10^{-2}$	$1.35x10^{-2}$	1

FORCE AND WEIGHT

MN	KN	N	Kgf	Tonf	lbf
1	1000	10^{6}	$1.0196x10^{5}$	100.4	$2.248x10^{5}$
10^{-3}	1	10^{3}	101.96	0.1004	224.82
10^{-6}	10^{-3}	1	0.10196	$1.004x10^{-4}$	0.2248
$9.807x10^{-6}$	$9.807x10^{-3}$	9.807	1	$9.842x10^{-4}$	2.2048
$9.964x10^{-3}$	9.964	9964	1016	1	2240
$4.448x10^{-6}$	$4.448x10^{-3}$	4.448	0.45455	$4.464x10^{-4}$	1

TEMPERATURE

Kelvin (K)	=	$(t_F + 459.67) / 1.8$
	=	(tc + 273.15
Celsius (C)	=	$(t_F - 32) / 1.8$
Fahrenheit (F)	=	(tc x 1.8) + 32

POWER

1 hp (horse power)	=	745.700 W (J/s)
1 lbf/s	=	1.35582 W

VISCOSITY, KINEMATIC

1 m^2 / s	=	10.7639 ft^2 /s
1 cSt (Centistokes)	=	5.58001 $in^{2/}h$
	=	1 mm^2/s
	=	10^{-6} m^2/s
1 $ft^{2/}h$	=	0.092903 m^2/h
1 in^2/s	=	645.16 mm^2/s
	=	

DENSITIES (at 20^{o}C) g/cm^3

Pure Water	=	0.99820
Sea Water	=	1.04
Mercury	=	13.564
Kerosene (approx):	=	0.80
Paraffin wax (m.p. 52-52^{o}C	=	0.912
Microcrystalline wax (m.p. 60-63 ^{o}C)		0.915

SECTION – 3-1

CLEARANCE AND GRUBBING

3-1 SECTION - CLEARING AND GRUBBING

3-1.1 DESCRIPTION

This work shall consist of removing to a specified depth, as upto 10 cm (4 inches) grubbing of all surface objects and disposing off all vegetation, bushes, stumps, roots trees with less than150mm girth, rubbish debris and all other objectionable material within the limits of the road formation including slopes both in filling and cutting, easement areas and areas where road structures are to be constructed except such objects as are designated by the Engineer to remain or are to be removed in accordance with other sections of these specifications.

3-1.2 REQUIREMENT OF ALL CLEARING AND GRUBBING

3-1.2.1 General

The contractor shall demarcate limits of the road formation including slopes and the Engineer will designate all trees, shrubs, plants and other objects to remain and the Contractor shall preserve all such things designated by the Engineer to remain.

3-1.2.2 Work Included.

A. Timber and Crops

Clearing and grubbing shall consist of the complete removal and disposal as directed by the Engineer of all surface objects, shrubs, roots, stumps and other protruding obstructions not designated to remain in roadway cut areas, all surface objects to a depth of 30 cm(12 inches) below subgrade level all surface objects need to be removed.

In roadway fill areas, where clearing and grubbing is required, same shall be carried out to the depth of 30cm (12inches) below the NSL (Natural Surface Level)

B. Sub-Surface Facilities

It also includes removal of all structures and other such obstruction such as underground septic tanks and building foundations and satisfactory disposal of all debris It also includes removal and disposal of water supply pipeline or sewer lines; except that removal of such obstacles which are covered to be removed or realigned in other sections of these specifications

C. Removal of Structures other than buildings

It includes temporary structures such as huts, abandoned electric poles, and structures other than buildings or designated not to be removed, causing obstruction in the right-of-way. The removal of Existing Structures / Buildings is described in Section 3-3

3-1.2.3 Work not Included

A. PROPERTY OBSTRUCTION AND UTILITIES

Property obstructions which are to remain in place, such as buildings, sewers, drains, water gas pipe, conduits, railroads, poles, walls, posts, bridges, etc. are to be carefully protected from injury and are not to be displaced except as might be directed by the Engineer for unusual cases. Such property obstructions as have to be moved and reset or rebuilt shall generally be moved at the expense and risk of the owner, and the Department will be responsible for arranging for their removal. The Department, however, shall not be responsible for any delay which may be caused to the Contractor due to the non – removal of such obstructions, whether or not they are shown on the plans except for any extension of time for completion, as specified in the Contract.

B. ABANONED WATER WELLS

1. GENERAL: All water wells which are found within the right of way (including borrow pits and lateral ditches) and which are not required to remain in service shall be filled or plugged as specified or directed by the Engineer.
2. PLUGGING OF WELLS: Wells will be filled with material approved by the Engineer and capped with concrete, clay or other material which will prevent the flow of water down the well.

C. LANDSCAPE AREAS:

The work of clearing and grubbing shall include the careful preservation of any trees, vegetation, etc., outside the limits of construction and within any areas designated for being conserved.

3-1.2.4 Protection and Restoration

The Contractor shall prevent damage to all pipes, conduits, wires, cables or structures above or below ground which are designated to be preserved. 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 operations shall immediately be rectified by him at his own expense

3-1.3 STANDARD CLEARING AND GRUBBING

3-1.3.1 Scope of Work

Standard Clearing and Grubbing shall consist of the complete removal and disposal as directed by the Engineer, of all buildings, timber, brush, stumps, roots, grass weeds, sawdust, rubbish and all other obstructions resting on or protruding through the surface of the existing ground and the surface of excavated areas.

3-1.3.2 Area Covered in General

Unless otherwise shown on the Plane, Standard Clearing and Grubbing shall be done within the following areas:

All areas where excavation will be done, including borrow pits, lateral ditches, right of way ditches etc.

All areas where roadway embankments will be constructed.

All areas where structures will be constructed, including pipe culverts and other pipelines.

3-1.3.3 Roots, Stumps, etc-Depth of Removal

In all areas where excavation is to be done and where the excavated material is to be used in the construction of roadway embankment or roadway base or pavement; also in all areas where roadway embankments will be constructed; all stumps, roots, and other debris shall be removed to a depth of at least one foot below the ground surface or finished subgrade level as explained in Section 3-1-2.2. Holes left by stumps and roots shall be back – filled with suitable material and compacted to the satisfaction of the Engineer.

All trees having a girth less than 150 mm (6 inches) and stems upto 600 mm height and situated within the format width and marked to be removed shall be filled and 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 acceptable condition shall be responsibility of the contractor for which no extra payment other than notified under clearing and grubbing will be made the trees, stump and roots remains the property of the client and these will be delivered at the designated place.

3-1.3.4 Trees to be Trimmed etc

As an exception to the above provisions, where so directed by the Engineer trees within the roadway area shall be trimmed, protected and left standing. Branches of trees extending over the area occupied by the Roadway shall be trimmed as directed, to give a clear height of 15 feet above the Roadway.

3-1.3.5 Boulders

All loose boulders lying on the surface of the ground shall be removed and placed in neat piles along (but inside) the right of way line.

3-1.3.6 Leveling Terrain

Within the areas between the limits of construction and the outer limits of clearing and grubbing all holes and other depressions shall be filled, all mounds and ridges cut down, and the area to sufficiently uniform countour that the Department’s subsequent moving and cutting operations will not be hindered by irregularity of terrain.

3-1.4 DISPOSAL OF MATERIALS

3-1.4.1 General Disposal

Any useless timber, stumps, brush, roots, rubbish and objectionable material resulting from clearing and grubbing shall be disposed of within the limits of the right of way by burning; however, as an exception to this requirement, such materials may be disposed of on private property provided, the engineer is furnished with a written notice from the owner of the property giving permission for the disposal of the materials on his or their property. Areas provided by the Contractor for disposal of the debris, etc., shall be out of sight of the project and at least 300 feet from the nearest roadway right of way line of the project, unless such materials are buried, in which case the requirement that the areas be 300 feet distant will be waived.

3-1.4.2 Blocking Waterways

Natural waterways or irrigation channels shall not be blocked in the disposal of debris from clearing and grubbing operations.

3-1.5 MEASUREMENTS AND PAYMENTS

3-1.5.1 Measurements

Clearing and Grubbing will be measured for payment only on areas so designated in writing by the Engineer or shown on the drawings. The quantity to be paid for shall be the number of square meters or 100 sqft. satisfactorily cleared and grubbed Any tree having girth less than 150 mm (6 inches) and stems of trees measured 600 mm above ground level shall fall under this item.

Engineer shall ensure that a minimum of 500 SM area is designated for clearing and grubbing in any stretch of roadway for the sake of ease to construction activities. Clearing and Grubbing carried out by the contractor in borrow pits shall not be measured for payment

When the bill of quantities includes the item of clearing and grubbing and provides for payment for the work to be paid for, shall be measured in square meters or 100 square feet and the unit of measurement shall be square meter or 100 square feet. The measurement shall be limited to those locations designated on the plans or locations designated in writing by the Engineer.

3-1.5.2 Payment

The unit rate for clearing and grubbing shall be full compensation for all the work specified in this section and shall include all necessary hauling, furnishing and operation of equipment, disposal of debris, and cost of furnishing and compaction of material required for back filling of holes left by stumps and other obstructions removed. It shall also include the cost for preserving all things designated to remain.

Where separately called for in the tender documents, the payment shall be made under:

Pay Item No.	Description	Unit of Measurement
3-1	Clearing and Grubbing	Lumpsum.

SECTION – 3-2

REMOVAL OF TREES

3-2 SECTION - REMOVAL OF TREES

3-2.1 DESCRIPTION

This work shall consist of the removal of trees having girth of more than 150 mm (6 inch) and stems more than 600 mm (24”) above ground along with their roots to a depth, to ensure complete removal of roots and stumps and their disposal as provided in Special Provision or as directed in writing by the Engineer.

3-2.2 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 an inventory prepared showing girth of the tree stem.

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.

Hole or loose earth resulting from the removal of trees shall be filled and re-compacted to a degree of compaction of adjoining area. Any extra material required for such purpose shall not be measured for payment.

3-2.3 GENERAL REQUIREMENTS

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-ground or over-ground property damaged by the contractor shall be immediately repaired by the contractor at his own expense.

3-2.4 MEASUREMENT AND PAYMENTS

3-2.4.1 Measurement

Engineer and Contractor shall jointly measure the girth and number of trees to be removed under this item. Any tree having a girth of less than 150mm (6 inch) measured less than six hundred (600)mm /(24 inch) above ground level shall not be measured under this item, as the same shall be removed under Section “Cleaning and Grubbing”.

3-2.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price for the pay item mentioned below and shown in the Bill of Quantities which price shall be deemed to include all cost of labour equipment and incidental related to the respective Section.

Pay Item No	Description	Unit of Measurement

3-2 a	Removal of trees, or stems of Girth 301 – 600 mm (12 to 30”)	Each
3-2 b	Removal of trees or stems of Girth above 600mm (30”)	Each

SECTION – 3-3

REMOVAL OF EXISTING STRUCTURES

3-3 SECTION - REMOVAL OF EXISTING STRUCTURES

3-3.1 DESCRIPTION

The work specified in this section consists of the removal and disposal of the materials from existing structures. The structures to be removed shall be: (1) those structures, or portions of structures, shown on the plans to be removed; (2) those found within the limits of the area to be cleared and grubbed, and directed by the Engineer to be removed and (3) those structures or portions of structures which, in the opinion of the Engineer are necessary to be removed in order to construct the new structures.

3-3.2 REMOVAL

The existing structures designated for removal shall be removed in such a way as to avoid damage to the materials and to leave no obstructions to any proposed new structures and any waterways. All pilling shall be pulled or cut, or shall be broken off one meter (3.3 ft) below the finished excavation surface or the original ground surface. Structural steel members shall be marked as directed, for identification. Where a portion of the existing structure is to remain in place, explosives shall not be used to remove reinforced concrete. Underground structures, abandoned wells and chambers shall be demolished to the depth shown on the drawings and shall be properly cleared out, closed or filled with suitable material and compacted to the specified density as directed by the Engineer.

On concrete bridges to be partially removed and widened, concrete shall be removed by manually or mechanically operated pavement breakers, concrete saws or chipping hammers. Wherever concrete is to be removed to confine required dimensions, the outlines of the work shall first be made with small trenches or grooves about 25 mm (1 inch) deep cut in the existing concrete surface. Care shall be taken to confine the breakage to the correct outline.

3-3.3 DISPOSAL

All waste materials shall be disposed off, as directed by the Engineer within meters (3000 ft) unless otherwise specified in the Bid Schedule. All usable materials, as determined by the Engineer shall be stacked in neat piles along (but inside) the right of way line.

3-3.4 MEASUREMENT AND PAYMENT

3-3.4.1 Measurement

The unit of measurement for removal of existing structures will be job item, for the area of the project designated in the contract.

3-3.4.2 Payment

The lump sum rate shall be full compensation for costs of all materials, Labour and machinery etc.

Payment shall be made under:

Pay Item No	Description	Unit of Measurement
3-3	Removal of Existing Structure	Lump sum

SECTION – 3-4

REMOVAL OF UNSUITABLE SOIL / STRIPPING

3-4 SECTION - STRIPPING

3-4.1 DESCRIPTION

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

3-4.2 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 (4inches) in depth. Which in turn is covered under Section 3-1 (clearing & Grubbing) The removed topsoil shall be transported, deposited in stock piles 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, before such a decision.

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 top soil removed from places other than that directed by the Engineer. The Engineer shall, however identify the soil as unsuitable through laboratory tests, before such a decision.

3-4.3 MEASUREMENT AND PAYMENT

3-4.3.1 Measurement

Measurement shall be made by multiplying the length, breadth and depth of layer approved by the Engineer in cubic meter or 100 cubic feet of material removed and disposed as directed by the Engineer. However space thus created shall be filled by the material as directed by the Engineer and paid separately under relative item.

3-4.3.2 Payment

The payment under this item shall be made for at the contract unit price per cubic meter or 100 cubic feet of stripping measured as above, for removal of material to a depth approved by the Engineer including its disposal at designated place and in the manner as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
3-4	Removal of Unsuitable Material / Stripping	Cubic meter or 1000 cubic feet

SECTION 4-1

EARTHWORK

4-1 SECTION - GENERAL TREATISE OF EARTH / ROAD EXCAVATION AND FILLING

4-1.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of earth, 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 byes, 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.

4-1.2 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 prevailing site conditions. 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 and rock, its quantity, locations and suitability to meet the specified requirements, 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.

4-1.3 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.

4-1.4 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Items 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 or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item exists for such features. The details of such items are covered under the respective clause of the relevant section.

4-1.5 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 for earthwork or construction of road ways or embankments shall be included in the bid price 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 affect 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.

4-1.6 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 started 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 in the bid schedule no separate payment will be made for the excavation of side ditches, interception ditches, inlet and outlet ditches.

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.

4-1.7 EXCAVATION FOR CULVERTS

Except where otherwise specified excavation and backfill for culvert and drainage pipes, except granular backfill or underfill to under drains, pipes or behind the abutment walls 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 or pipes etc.

4-1.8 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 the bid schedule or in the relevant Item of these specifications as the case may be.

4-1.9 SURVEY AND LEVELING PRIOR TO COMMENCEMENT OF EARTHWORK

The Contractor shall be responsible for the setting out of the work in accordance with the relevant Clause 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.

4-1.10 MEASUREMENT AND PAYMENT

The quantities of the various classes of excavation or embankment to be measured for payment under the contract shall be limited to the lines and level as taken under clause 4-1.1 above. However if the levels so taken differ appreciably from design levels the matter shall be referred to the client.

Excavation and filling beyond the lines and level shown on the drawings, approved profiles and cross-sections will not be paid for. The Engineer will decide the angle of the slope of cuts and fills as the work proceeds on the basis of evaluation of the soil characteristics. The actual lines of the cuts and fills as made will be duly measured and recorded by the Contractor. The Engineer will check these records and will approve the measurements, if correct, as a basis of payment. Excess of excavation shall be backfilled, as directed by the Engineer, with sub base materials or better fill material without extra payment to the Contractor; excess of fill may be either left in place or removed as required by the Engineer. The quantities of excavation, backfill and earthwork to be paid shall be covered under the respective section and shall be the number of cubic meters or 1000 / cubic ft. as the case may be and given in the respective section. The material shall be measured by the average end- area method, except where the error may exceed plus or minus five percent as compared with the prismoidal formula in which case the Engineer will authorize the use of the more accurate method. However, the Contractor shall request such authority before he submits his quantities for approval. Quantities measured on the average end-area basis, once they have been submitted and approved, shall not be subject to review for the purpose of applying a more accurate method.

SECTION – 4-2

REMOVAL OF EXISTING PAVEMENT

4-2 SECTION - REMOVAL OF EXISTING PAVEMENT

4-2.1 SCOPE AND DESCRIPTION

4-2.1.1 Scope

The Scope of work envisage dismantling the pavement structure as a whole upto the top of the subgrade level for the reach or stretch of the road as designated on the drawings or identified by the ENGINEER

4-2.1.2 Description

The work specified in this section consists of removing and storing for re–use if so designated by the Engineer or otherwise disposing of all existing pavement materials such as bituminous surfacing, crushed rock or bricks, comprising the sub base , road edging / sidewalk, curb and gutter or flexible road surface where it is shown on the plans or ordered by the Engineer to be removed or where required to be removed by the construction operations.

4-2.2 CONSTRUCTION METHODS

The method of dismantling or breaking of the pavement structure as a whole including removal of road edging, sidewalks, curb or gutter etc. shall be proposed by the Contractor along with the machinery or equipment to be employed and approved by the Engineer in accordance with requirements under the conditions. Except where specifically directed otherwise the contractor shall store all materials for use where directed by the Engineer. The Contractor shall be responsible for the materials until finally disposed of.

4-2.3 MEASUREMENT AND PAYMENT

4-2.3.1 Measurement

The item for removal of existing pavement designated on the plans will be measured in superficial area. The unit of measurement will be one hundred square feet. The quantity shall be determined by actual measurement before removal.

4-2.3.2 Payment

The unit rate shall be full compensation for all costs of complying with the provisions of this Section and includes costs of all materials, labour and machinery etc.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
4-2	Removal of Existing Pavement	Per cu meter / or 100 cft.

SECTION – 4-3

SCARIFICATION OF EXISTING ROAD / BREAKING OF ROAD PAVEMENT LAYERS

4-3 SECTION - SCARIFICATION OF EXISTING ROAD / BREAKING OF ROAD PAVEMENT LAYERS

4-3.1 DESCRIPTION AND SCOPE

4-3.1.1 Description

i. The scope of work under this section envisage breaking and removing a part or a layer of the existing pavement structure and removing of the dismantled material so that a new layer is placed after ensuring the specified compaction of the lower layer which has been left to be intact

ii. The second method of improvement of a damaged road stretch is to scarify or scrapping the sub base or base course layer and compacting the same after fulfilling the gradation and thickness requirements. Payment for the fulfillment of the gradation / thickness and compaction requirement will be made separately under the relevant subhead.

4-3.1.2 Scope

This work 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 freshly laid base-course or surfacing layer. The surface on which the new base course or surface layer is to be constructed, shall be approved and accepted by the Engineer prior to placing the crushed stone base aggregate.

4-3.2 CONSTRUCTION REQUIREMENTS

After the existing pavement structure broken off, the material shall be removed and disposed off outside the right of way, according to the satisfaction of the Engineer. The surface obtained after scarification or breaking the existing pavement shall be compacted to the density prescribed under the relevant section of this specification. Payment of such compaction shall be included in the contract price for this item of work

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. The compaction of the lower un-scarified layer according to the prescribed limits shall be the responsibility of the contractor who has scarified the upper layers, the price of which is included in the scarification.

4-3.3 MEASUREMENT AND PAYMENT

4-3.3.1 Measurement

a. The quantity for a layer of the pavement structure broken and removed, to be paid for, shall be measurement in cubic meter or 100 cub. ft to a depth as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

b. The quantity for road pavement structure scarified or scrapped, to be paid for shall be measured in Sq. meter or 100 sq. ft. as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

4-3.3.2 Payment

The quantities as measured above shall be paid for at the contract unit price per cubic meter/cft of breaking of road pavement structure and per Sq. meter/sft of scarification of existing road pavement structure, for carrying out the works mentioned above including cost of labour, equipment, tools and incidentals necessary to complete these items.

Pay Item No	Description	Unit of Measurement
4-3 a	Breaking of a layer of Existing Road Pavement Structure	CM or 100 c.ft.
4-3 b	Scarification of Existing Road Pavement	SM or 100 s.ft.

SECTION – 4-4

STRUCTURAL EXCAVATION AND BACKFILL

4-4 STRUCTURAL EXCAVATION AND BACKFILL

4-4.1 DESCRIPTION

The work specified in this Section consists of the excavation for bridge foundations, box culverts, pipe culverts, storm sewers and all other pipe lines, retaining walls, headwalls for pipe culverts and drains, catch basins, drop inlets, manholes and similar structures not otherwise provided in these specifications and in accordance with the Drawings or as directed by the Engineer. It shall also include furnishing of all necessary equipment for (1)the construction and removal of cofferdams, sheeting, bracing etc., (2) pumping or otherwise unwatering the foundation; (3) the removal and disposal of any existing structures or portions of structures not covered by other items in the Contract, including the foundations, abutments, piers, wings, and all other materials, obstructions, etc., found necessary to clear the site for the proposed work; (4) backfilling, disposing of surplus material which is not required for backfill, in a manner and at locations as directed in writing by the Engineer and final cleaning, as may be necessary for the proper execution of the work.

4-4.2 EXCAVATION CLASSIFICATION

All materials excavated shall be classified and considered according to section 4-5.2 as common soil, gravel, soft rock and hard rock excavation according to the material encountered.

4-4.3 CONSTRUCTION REQUIREMENTS

4-4.3.1 General

All substructures, where practicable, shall be constructed in open excavation and, where necessary, the excavation shall be shored, braced, or protected by cofferdam in accordance with approved methods. In case, the contractor has excavated additional volumes than specified the contractor shall at his expense backfill the volume with approved material as directed by the Engineer

4-4.3.2 Depth of Excavation

All excavation shall be carried out to foundation level satisfactory to the Engineer, All excavation located in the bed of a stream or canal shall be carried to a depth of a least four feet below the permanent bed of the stream, or as shown on the plans based on the designed scour depth or otherwise a firm footing is established on solid rock before such depth is reached, and to such additional depth as may be necessary to eliminate any danger of scouring or undermining. Wherever rock bottom is encountered, the excavation shall be done in such manner as to allow the solid rock to be exposed and prepared in horizontal beds for receiving the masonry. All loose and disintegrated rock or thin strata shall be removed. All foundations shall be inspected and approved by the Engineer prior to placing of masonry.

4-4.3.3 Preparation of Foundation for Footing

i. The foundation pits shall be excavated to permit the placing of the full widths and lengths of footings shown on the Plans, with full horizontal beds. Corners or edges of footings shall not be rounded or undercut.

ii. All rock or other hard foundation material shall be free from all loose material, cleaned and cut to firm surface,

iii. COMPACTION: The bottom of the trench shall in all cases be compacted to 95% Standard AASHTO Max. Dry density. Where the bottom of the trench is under cut and back filled with selected material, this material shall be compacted to at least 95% Standard AASHO dry density or to such other value as the Engineer may direct.

4-4.4 PRESERVATION OF CHANNEL

Unless otherwise shown on the Plans no excavation shall be made outside of caissons, cribs, cofferdams, or sheet pilling, and the natural stream bed or canal adjacent to the structure shall not be disturbed unless so permitted by the Engineer. If any excavation or dredging is made at the site of the structure before caisson, cribs or cofferdams are sunk in place, backfill all such excavations to the original ground surface or river bed with material satisfactory to the Engineer.

Materials deposited within the stream area from foundation excavation or otherwise, shall be removed and the stream left in its original condition, unless otherwise shown on the Plans or ordered by the Engineer.

4-4.5 COFFER DAMS AND CRIBS

i. General

For substructure work, the Contractor shall submit drawings showing his proposed method of construction of coffer dam. Contractor shall not start work until the Engineer has approved such drawings

ii. Construction

Wherever practicable all foundations shall be constructed by open excavation and the foundation openings shored, braced, or protected by cofferdams in accordance with approved methods. Cofferdams or cribs for foundation construction shall in general be carried well below the bottom of the footings and shall be well braced and as watertight as practicable. The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors and to pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of linking shall be righted or enlarged so as to provide the necessary clearance and this shall be solely at the expense of the Contractor

iii. Green concrete protection

Cofferdams shall be so constructed as to protect green concrete against damage from a sudden rising to the water and to prevent damage by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure masonry except where might be so permitted, in writing, by Engineer.

iv. Depth

For placing footings in the dry, the Engineer may require cofferdam sheeting to be driven to an elevation six feet below the elevation of the bottom of the footings and require sufficient pumping equipment to dewater and maintain the cofferdam in a comparatively dry condition.

v. Additional Requirements

When conciliations 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 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 placement of foundation seal, the elevation of the water inside the cofferdam shall be controlled to prevent any flow through the seal, and if the coffer dam is to remain in place, it shall be vented or ported at low water level.

vi. Contractor's Drawings

For sub- structure work, the Contractor shall submit upon request, drawings showing his proposed method of cofferdam construction and other details left open to his choice or not fully shown on the Engineer's drawings. The type and clearance of cofferdams, in so far as such details affect the character of the finished work, will be subject to the approval of the Engineer, but other details of design will be left to the Contractor, who will be responsible for the successful construction of the work.

vii. Removal

Unless otherwise provided, cofferdam or cribs, with all sheeting and bracing, shall be removed by the Contractor after the completion of substructure. The removal shall be effected in such manner as not to disturb or mar the finished masonry.

4-4.6 DISPOSAL OF SURPLUS MATERIAL

The excavated materials shall generally be used for backfilling and in constructing embankments over and around the structure. All excavated material not used for backfilling shall be disposed of as directed by the Engineer. When suitable, this material, in general, shall be used in the construction of roadway embankments, but material that is unsuitable or not required for this purpose shall be disposed of in such a manner as not to impair the appearance or utility of either the roadway or the waterway. In no case shall it be placed in the channel of the stream.

4-4.7 PUMPING

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping shall be done during the placing of concrete, or for a period of at least 24 hours thereafter, unless it is done from the suitable sump separated from the concrete work by a watertight wall. Pumping to unwater a sealed coffer dam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

4-4.8 INSPECTION

After each excavation is completed the Contractor shall inform in writing to the Engineer and no masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

4-4.9 BACKFILLING

4-4.9.1 General

Backfill material shall be made with the following material

a. Common backfill material from structural excavation or brought from outside

b. Granular backfill of selected material from structural excavation or brought from outside

c. Rock material of small size shall be permitted in the backfilling of structures or walls subject to the approval of methodology by the Engineer Material shall be either from the structural excavation or brought from outside

4-4.9.2 Specifications for Materials and Laying

i. Common Back fill Material obtained from the structural excavation or brought from outside

Common material 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) cm /eight (8) inches in depth to the density,95 percent of maximum dry density as per AASHTO T-180(D)

ii. Granular Backfill material

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/eight(8) inches in thickness to 100 percent of Maximum dry density as per AASHTO T-180(D).In case of water logged areas, the thickness of the layer shall not exceed fifty (50) cm / twenty (20) inches in depth or as directed by the Engineer to the density as mentioned above.

If the material satisfying the requirements of coarse sand falling under soil classification A-3(AASHTO) is used, it shall be ensured that the same is confined properly as approved by the Engineer.

iii. Rock Material from structural excavation or brought from outside

The rock material whose individual sizes are not more than 30cm/12 inches shall be placed in the position to the required depth as specified and the voids shall be filled in layer with 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 (60) sixty cm./24 inches.

Rock backfills will not be placed within two meters from concrete faces of any structure

4-4.9.3 Specified Requirements for Backfill Locations

a. All spaces excavated and not occupied by abutments, piers or other permanent works 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 back fill shall be thoroughly compacted up to the satisfaction of the Engineer and generally top surface properly leveled

b. The fills behind the abutment walls of all bridges and culverts which act as subgrade of approach roads should be of granular material fulfilling the requirement of coarse sand falling under the classification A-3(AASHTO) The width should not be less than 1½ meter or 5 ft meter along the road alignment or as directed by the Engineer or shown on the drawings ,The granular backfill shall start from the natural ground surface and end upto the top of the subgrade level and in no case be less than one meter or 3ft.

c. 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.

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

e. 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 equipment to ensure compaction in restricted areas, Engineer may allow backfill with sand saturation method, at no extra cost to the Client.

Adequate provision shall be made for the through drainage of backfill. Weep holes. With perforated PVC drainage pipes 19 mm or ¾" diameter will be provided along the slopes and the spacing will be decided by the Engineer.

No backfill shall be placed against concrete or masonry structure before fourteen (14) days of placement and backfilling shall be carried out on both sides of the structure simultaneously.

4-4.9.4 General Requirements for All Structures

i. Backfilling to the original ground surface of openings made for structures, with a sufficient allowance for settlement shall be a part of the work of excavation, although the Engineer may require that the material used in making the backfill be obtained from a source entirely apart from the structure. All material used for backfill shall be of quality acceptable to the Engineer and shall be free from large lumps, wood, or other extraneous material.

ii. In case of backfilling of a road cut for bridge or culvert abutments as mentioned in Section 4-4.9.3(b), if the excavated material from the structural excavation does not fulfill the specified requirement of coarse sand, the same material shall be brought from outside and paid separately

4-4.10 REPLACING OF PAVEMENT REMOVED FOR CONSTRUCTION OR CULVERTS SEWERS ETC

Where existing pavement, kerb, gutter, sidewalk, or valley gutter is removed only for the purpose of constructing or removing box culverts, pipe culverts, storm sewers, inlets, manhole etc., such pavement etc., shall be replaced and restored to as good condition, as determined by the Engineer, as before removal and without direct compensation there from, the replaced pavement etc., shall be of the same or similar type as the removed except where permission is given by the Engineer for the use of other type.

4-4.11 CLEANING UP

Upon completion of the work, the Contractor shall leave the structure and all adjacent areas affected by these operations in a neat and presentable condition and shall remove and clear up all temporary structures, rubbish and surplus material and leave the space under the structure unobstructed and in such shape that drift will not collect nor scour be induced. All material from existing structures that have been removed by him shall be piled neatly on the bank or otherwise disposed of as directed by the Engineer. False work pilling shall in general be pulled, except that, when permitted by the Engineer, they may be cut or broken off two feet below the ground line or stream bed.

4-4.12 METHOD OF MEASUREMENT

Excavation will be measured in its original position by the cross section method to determine the amount of material removed and will be that material actually removed below the original ground line or stream bed, but not including that shown on the plans to be paid for as Regular Excavation, (Section 4-5). No measurement will be made for material removed in excavation for footings of foundations outside of an area which is bounded by vertical planes one foot outside of the limits of the footing and parallel thereto.

When excavation for material below plan grade is called for on the Plans or authorized by the Engineer, the measurement shall include both the material excavated below grade and the material used for back fill.

4-4.13 MEASUREMENT AND PAYMENT

4-4.13.1 Measurement

The work of Excavation for Structures will be measured by volume. The unit of measurement shall be one cubic meter or hundred cubic feet and the backfill coarse sand material if brought from outside will also be measured accordingly

4-4.13.2 Payment

The unit rate shall be full compensation for all costs of complying with the provisions of this Section and includes costs of unwatering of foundations, removal and disposal of surplus material, back – filling and final cleaning as may be necessary for the proper execution of the work.

Pay Item No.	Description	Unit of Measurement
4-4 a	Excavation for Structure in Ordinary / Common Material including backfilling and disposal of surplus material	Cub meter – 1000 cu.ft
4-4 b	Excavation for Structure in Hard / Very Hard Material including backfilling and disposal of surplus material	Cub meter – 1000 cu.ft
4-4 b	Excavation for Structure in Rock Material including backfilling and disposal of surplus material	
	i. In Shingle Gravels whether above or below Water Level Rate Per CM / Per100Cft	CM / Per 1000Cft
	ii. In Soft Rock whether above or below Water Level Rate Per CM / Per100Cft	CM / Per 1000Cft
	iii. In Medium Rock whether above or below Water Level Rate Per CM / Per100Cft	CM / Per 1000Cft
	iv. In Hard Rock whether above or below Water Level Rate Per CM / Per100Cft	CM / Per 1000 Cft
4-4 c	Back filling behind abutments with borrowed coarse sand	Per CM/100 Cft

SECTION – 4-5

ROADWAY EXCAVATION/BORROW EXCAVATION

4-5 SECTION - ROADWAY EXCAVATION/BORROW EXCAVATION

4-5.1 DESCRIPTION

The work specified in this Section consists of excavation of materials of whatever nature, encountered within the limit required for the proposed work, excluding structural excavation and shall include the removal, utilization and disposal of such materials, as required. It shall also include all excavation, haulage filling and placing, compaction, shaping and sloping necessary for the construction of all embankments, subgrades, shoulders and special backfills, in accordance with the required alignment, grade and cross sections shown on the plans. Free haul for the carriage of material for the construction of embankment which is considered to be included in the rate of roadway excavation or borrow excavation is 900m (3000ft).The work covered in this section includes:

1. Roadway Excavation
2. Borrow Excavation
3. Making Road Embankment

4-5.2 CLASSIFICATION OF EXCAVATED MATERIAL

All material excavated shall be classified as under:-

a. Ordinary / Common Soil

Clayey, silty and sandy soils including small quantities of stone fragments, or gravel.

b. Gravel

Soil containing predominantly water borne stones of rounded shape of irregular size, occurring naturally.

c. Soft Rock

Rock formation requiring pick and crow bar operation or any rock that can be removed with blade of 200 HP bulldozer.

d. Medium Rock

Rock that cannot be removed with a blade of 200 HP. Bulldozer But can be removed by the Rippers

e. Hard Rock

All other rock formations requiring blasting. Because it cannot be removed with Rippers of a 200 HP Bulldozer

For the purposes of making embankment, common soil and gravel are to be considered as “COMMON MATERIALS” and soft rock, medium and hard rock as “ROCK MATERIALS”

4-5.3 CLASSIFICATION OF ROADWAY/BORROW EXCAVATION

Roadway Excavation shall further be classified as “Common Excavation” or “Rock Excavation” (common excavation shall include all the materials of whatever nature encountered but not rock excavation).

i. COMMON EXCAVATION

Common excavation shall consist of the removal and satisfactory disposal of all Aeolian, alluvial and residual materials, in place unaltered and un weathered strata which are not firm or rigid enough to possess all the characteristics of “Rock Excavation” Boulders of less than one quarter (1/4) cubic meter volume shall also be classified as “Common Excavation”. Aeolian and alluvial materials consist of gravel, shale, volcanic ash, loess dunes and loams, sands and clays or any combination of these materials and termed as Common Excavation

ii. ROCK EXCAVATION

Rock excavation includes firm and rigid igneous, metamorphic and sedimentary rocks. boulders larger than (i/4) cubic meter volume will also be considered as “Rock Excavation”, provided these are firm and stable lying in continuous bed more than 50% by volume as compared to other type of materials in the total mass The term Hard, Medium or Soft rock is described as above in Para 4-5.2

4-5.4 TYPES OF EXCAVATIONS

- Roadway Excavation
- Borrow Excavation

4-5.4.1 Roadway Excavation

Road Excavation shall comprise all excavation that is not classified as structural excavation carried out within the limits of roadway including permanent drainage ditches and side slopes in cut

a. **General:** It shall consists of the excavation for the road in “cutting section” and utilization of all useful materials necessary for the construction of the roadway in “fill section”. It shall also include the excavation and disposal of muck, clay, rock or any other material that is unsuitable in its original position within the limits of the roadway including the removal of all suitable material lying within the roadway limits which is necessary to remove in order to excavate the unsuitable material.

b. **Protection of Work:** While the excavation is being done and until the work is finally accepted, the contractor shall take the necessary steps to protect the work to prevent loss of material from the roadway, due to action of wind or water. During construction of the roadway, the subgrade shall be maintained in such condition that it will be well drained at all times.

c. **Removal of Trash:** Vegetation etc. On previously graded roadways, where no clearing and grubbing of the roadway is called for on the plans, all vegetation, bushes, shrubs, saplings etc. and including any trees for which removal is specifically called for in the plans, shall be removed as provided in Section Clearing and Grubbing, as a part of the work, under this Section.

4-5.4.2 Borrow Excavation

a. General: Borrow shall consist of the material obtained from the authorized borrow pits. It shall include only material that is suitable for the construction of roadway embankments or other work of constructing embankments covered by the contract, and also unsuitable material that is necessary to excavate, as determined by the Engineer, to obtain suitable material.

Borrow shall be resorted to only when sufficient quantities of suitable material are not available, as herein prescribed, from roadway excavation, to properly construct the embankment, subgrade and shoulders and to complete the backfilling of structures. In no case shall material be borrowed until so ordered by the Engineer, and then only from the designated borrow pits. No borrow pits shall be opened until the Engineer has approved their location and, where borrow is to be measured in pits, their surface have been cross sectioned.

Unless otherwise indicated on the plans, the right of way for all borrow areas necessary for the completion of the work will be furnished by the department.

b. Borrow Area Furnished by the Contractor – At the option of the Contractor in lieu of obtaining borrow from areas furnished by the Department, he may obtain borrow from other areas furnished by him, provided the Engineer determines the material from such areas meets the Departments standards, and other requirements for suitability for use in the particular sections of the work in which it is placed, and further provided that any increase in hauling or other costs shall be absorbed by the Contractor.

No borrow material shall be obtained from any substitute areas until the Contractor has requested, in writing, permission to use such areas, and the Engineer has approved, in writing, the use of the particular areas and has cross sectioned the surface. Upon such written approval by the Engineer, the substitutes areas shall be considered as designated borrow areas.

c. Excavation Requirements – When borrow material is to be measured, if needed, the borrow pits shall be excavated neatly and the bottom and edges so shaped that accurate measurement are taken. Where the plans show the depth and width of excavation, such depth and width shall be considered approximate only and shall be subject to variation as directed. In borrow pits furnished by the Department; no material shall be excavated within three feet of the adjacent property lines.

d. Provisions for Drainage – Where shown on the plans the ditches for drainage of the borrow pits or roadway shall be constructed. The excavation of such drains shall be classified as borrow, and suitable material thus obtained, used, where required, on the works.

e. Sequence of construction – If the plans indicate section within which a significant quantity of borrow is required in order to establish a balance within the limits of such sections, then except as might be permitted otherwise in writing by the Engineer, the Contractor shall construct first those sections showing no borrow, such that all suitable surplus material therein will be utilized. In order to meet this requirement if the Contractor is required to haul a distance greater than the distance indicated on the plans overhaul be paid for as specified in the Section OVERHAUL OF EXCAVATION

4-5.5 HAUL ROADS

The Contractor shall provide and maintain at his own expense all necessary service roads necessary for hauling the material over the shortest practicable route as determined by the Engineer, to the points where it is to be used for doing all operations pertinent to the execution of work covered under this section. The Department will obtain any necessary property easements for haul roads leading to the pits furnished by it.

4-5.6 CONSTRUCTION REQUIREMENTS

All suitable material excavated within the limits and scope of the project shall, unless provision is expressly made to the contrary in these specifications, be used in the most effective manner for the formation of the embankment, for widening the road formation, for backfill, or for other work included in the contract.

Any material surplus to this requirement or any materials declared in writing by the Engineer to be unsuitable shall be disposed off and leveled in layers by the Contractor outside the right of way or as directed by the Engineer. The material unsuitable common material is that material who's soaked CBR (96 hours) is less than five (5) percent or it falls under A-6 OR A-7 AASHTO soil classification

When unsuitable material is ordered to be removed and replaced, the soil left in place shall be compacted to a depth of 20 cm (8in) to the density prescribed under the relevant "compaction" paragraph of the chapter MAKING EMBANKMENT. Payment for such compaction shall be included in the contract prices for the excavation of unsuitable materials.

If the unsuitable material which is to be removed is below standing water level and the replacement material is gravel or a similar self-draining material of at least 30 cm (1 ft.) in depth, the compaction may be dispensed with, if approved by the Engineer

4-5.7 MEASUREMENT AND PAYMENT

4-5.7.1 Measurement

Only material which is surplus to the requirements of the component of the project or is declared in writing by the Engineer to be unsuitable will not qualify for payments under pay items No.4-5-a, 4-5-b, 4-5-c and 4-5-d as the case may be.

The cost of excavation of material which is used/utilized anywhere in the project shall be deemed to be included in the pay items relating to the parts of the work where the materials is used.

The under mentioned pay items No.4-5-a to 4-5-b shall include the cost of obtaining the consent of the owner or tenant of the land where the disposal of surplus or unsuitable materials is made.

Unsuitable or surplus material shall be measured in its original position and its volume shall be calculated in cubic meters or cubic feet.

4-5.7.2 Payment

The unit rate shall be full compensation for all costs or complying with the provisions of this section regarding roadway excavation in accordance with Drawings and as directed in writing by the Engineer.

The quantities determined as provided above shall be paid for, at the contract unit price respectively for each particular pay items listed below and shown in the bill of Quantities which prices and payment shall constitute full compensation for all costs involved in the proper completion of the work prescribed in this item.

Pay Item No	Description	Unit of Measurement
4-5 a	Excavate Unsuitable Ordinary / Common Material	m^3 or 1000 Cft.
4-5 b	Excavate Unsuitable Rock Material	
	i. Soft Rock Material	m^3 or 1000 Cft
	ii. Medium Rock Material	m^3 or 1000 Cft
	iii. Hard Rock Material	m^3 or 1000 Cft
4-5 c	Excavate Surplus Common Material	m^3 or 1000 Cft.
4-5 d	Excavate Surplus Rock Material	
	a. Soft Rock Material	m^3 or 1000 Cft
	b. Medium Rock Material	m^3 or 1000 Cft
	c. Hard Rock Material	m^3 or 1000 Cft

SECTION – 4-6

COMPACTION OF NATURAL GROUND

4-6 SECTION - COMPACTION OF NATURAL GROUND

4-6.1 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.

4-6.2 CONSTRUCTION REQUIREMENTS

4-6.2.1 Under Normal Conditions

Up to a depth of twenty (20) cm (8 inches) below the natural ground, all sods and vegetable matters shall be removed and clear surface shall be broken up by ploughing and scarifying to compact to the degree as defined below:-

For height of Embankment below sub grade level	Percent of Maximum Dry Density as determined by AASHTO T-180
0 to 30 cm	95
30 to 75 cm	93
Over 75 cm	90
Below the foundation of structures	95

4-6.2.2 Compaction of Original Ground Surface in Areas of High Water Levels and Salinity

Compaction of the natural ground surface in such areas will be difficult if not impossible. See relative Items etc. under Formation of Embankment for construction requirements under these conditions, where compaction of Natural Ground shall not be carried out.

4-6.3 MEASUREMENT AND PAYMENT

4-6.3.1 Measurement

The measurement shall be made by multiplying the length and breadth of the area approved in writing by the Engineer to be paid under this item. The measurement of the item shall be in Square meter.

Any subsidence of levels of Natural Ground due to compaction under this item shall not be measured for payment; the contractor is expected to take care of such factors while bidding.

4-6.3.2 Payment

The payment under this item shall be made for at the contract unit price for Square meter of compaction of (natural) ground measured as above and shall be deemed to include cost of scarification, watering, mixing, leveling, rolling, labour, equipment, tools, and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
4-6	Compaction of Natural Ground	Sq,ft or SM

SECTION – 4-7

SUBGRADE PREPARATION

4-7 SECTION SUBGRADE PREPARATION

4-7.1 DESCRIPTION

The sub-grade preparation shall be that part of the work which is to be carried out by compaction of the defined thickness/depth of material to prepare such surface on which the sub-base is placed or, in the absence of sub-base, it acts as the base of the pavement structure. It shall extend to the full width of the road bed including the .shoulders and laybys as indicated on the Drawings or as specified herein.

4-7.2 CONSTRUCTION REQUIREMENTS

4-7.2.1 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 (12 inches) of existing sub-grade 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 work herein described has been approved by the Engineer.

4-7.2.2 Compaction Requirement

All materials down to a depth of 30cm(12 inches) below the subgrade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method "D (Modified).or corresponding Relative Density as per D-4254-83(ASTM)

4-7.2.3 Subgrade Preparation in Earth Cut

In case bottom of subgrade level is within sixty (60) cm (24 inches) of the natural ground, the surface shall be scarified, broken up, adjusted to moisture content and compacted to minimum density of Ninety Five (95) percent of the maximum dry density as determined by AASHTO T-180 Method-D. Subsequent layer of approved material shall be incorporated to ensure that the depth of subgrade layer is sixty (60) cm (24 inches.)

In case, the bottom of subgrade is below the natural ground by more than sixty (30) cm, (12 inches.) the material above the top of subgrade shall be removed and subsequent layer of thirty (30) cm (12 inches.) shall be scarified, broken up, adjusted to moisture content and compacted to the same degree of compaction as described above.

Subgrade preparation process shall be carried out in multi layers of fifteen (15) cm (6 inches) each.

In case, unsuitable material is encountered at the sub-grade level within the depth of thirty to sixty (30 – 60) cm, (12 - 24 inches) the same shall be removed and replaced by the approved material. The contractor shall be paid for removal and disposal of unsuitable material as per pay item

4-7.2.4 Sub-grade Preparation in Rock Cut

Execution in solid rock shall extend to the subgrade level or as shown on drawing. Rock shall be under cut nearly to required elevation and sections shown on the plans or as directed by the Engineer. Transverse and longitudinal profile checked by template shall be accurate to the specification. Cuts below subgrade level shall be backfilled with selected sub base material and compacted to at minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO-T-180, method "D" at Contractor's cost.

No rock shall be higher than two centimeters (0.75 inches) above the undercut section elevation. The undercut material shall be placed in embankment or disposed off at the direction of Engineer.

4-7.2.5 Sub-grade 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 centimeters (12 inches) below subgrade level shall meet compaction requirement as mentioned in the relevant section. soils of A-1-a, A-1-b and A-2-4 classification having a minimum value of CBR of seven percent and swell value of not more than 0.3 percent shall be used in case the design allows otherwise. Unsuitable material if encountered within the formation layer as per laboratory specified test, shall be removed, disposed off and replaced by suitable one as per discretion of Engineer of which the payment will be made under relevant items of work.

Rollers and other equipment 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.

Performance of this item of work shall not be paid for under this section but shall be covered by the contract price for the relative pay item of the Section 4-8 MAKING/FORMATION OF EMBANKMENTS as the case may be.

4-7.2.6 Sub-grade 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 sub base 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. Scarification shall include disposal of any surplus material in the adjacent embankment or elsewhere as may be ordered by the Engineer.

In case, the design level of subgrade is within 30cm (12 inches) of the existing ground/road, then the item shall be measured and paid accordingly.

4-7.2.7 Sub-grade Reinforcement

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the sub base or base to be placed upon it, the Engineer may order to strengthen and support the sub base 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 replacement 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 the relative pay item of the Chapter MAKING/FORMATION OF EMBANKMENTS as the case may be.

If declared unsuitable it shall be disposed of and paid as provided in the chapter ROAD EXCAVATION. The compaction and the finished compacted surface of the subgrade shall be as specified in the above sections item

4-7.2.8 Protection of Completed Work

Any part of the subgrade that has been completed shall be protected and 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 admitted to 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 amount of subgrade preparation to an area easily maintained with the equipment available. Subgrade preparation and sub base or base placing shall be arranged to follow each other closely. The subgrade, when prepared too soon in relation to the placing of the sub base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or re-compact the subgrade as may be necessary to restore it to the state specified herein.

4-7.2.9 Templates and Straight Edges

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. For tolerances, referred to the “Table for Allowable Tolerances” in these specifications.

4-7.3 MEASUREMENT AND PAYMENT

4-7.3.1 Measurement

The quantity to be paid for shall be the number of square meters or square feet of sub-grade prepared as herein before prescribed and accepted. Subgrade in rock cuts and on embankment not consisting of the existing road surface in fill area shall not be measured for direct payment.

Sub-grade preparation on “Existing Surface” shall only be measured for payment when ordered by the Engineer.

4-7.3.2 Payment

The quantities, determined as provided above, shall be paid for at the contract unit price for the pay item listed below and shown in the Bill of Quantities which prices and payment shall be full compensation for furnishing of material, water, equipment, tools, labour, and all other items incidental to and necessary for completion of this work.

Pay Item No	Description	Unit of Measurement

4-7 (a)	Subgrade preparation in Earth Cut	m^2 or 100 sft
4-7 (b)	Subgrade preparation in Existing Road	
	i. Subgrade preparation Without any fill	m^2 or 100 sft
	ii. Subgrade preparation With fill less than 30 cms	m^2 or 1000 sft.

SECTION – 4-8

MAKING/FORMATION OF EMBANKMENT

4-8 SECTION – MAKING / FORMATION OF EMBANKMENT

4-8.1 DESCRIPTION

This work shall consist of the 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 these specifications and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as directed by the Engineer

4-8.2 MATERIAL REQUIREMENTS

Material for embankment such as common soil, gravel, soft or hard rock shall consist of suitable material obtained from structural excavation, roadway excavation or borrow excavation as approved by the Engineer. Borrow material however, shall only be used when there is no suitable material available from structural excavation or roadway excavation.

The material under this item shall conform to the following specification.

a. Contractor shall use AASHTO Class A-1, A-2, A-3, A-4, A-5 or A-6 soil as specified in AASHTO M-145 or other material approved by the Engineer.

b. CBR of the material shall not be less than Eight (8) percent, corresponding to the degree of compaction required for the corresponding layer.

c. 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. In case sandy material is used for embankment formation, it shall be properly confined at no extra payment with a material and to the extent as approved by the Engineer and sandy material shall not be used on slopes of embankment.

d. 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.

4-8.3 CONSTRUCTION REQUIREMENTS

4-8.3.1 Formation of Embankment with Common Material

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 (8 inch) thick.

The material placed in all embankment layers and the material scarified to the designated depth shall be compacted to the density specified as below.

TABLE – 4-8.3

SPECIFIED DENSITY FOR EMBANKMENT/SUBGRADE

Depth below sub-grade level	Percent of maximum dry density as applicable AASHTO T-180*
0 to 90 cm(0 to 3 ft)	95
over 90 cm (over 3 ft)	90

NOTE:- *Method "B" or "D" of AASHTO-T-180 whichever is applicable may be adopted. In road sections constructed of uniformly graded sands, or gravel the compaction shall preferably be determined by "Relative Density Method"*

In place density determinations of the compacted layers shall be made in accordance with AASHTO T-191 (Sand Cone Method) or other approved methods. For all soils, with the exception of rock fill materials, containing more than 10% oversize particles (retained on 19 mm (3/4 inch sieve), the in-place density thus obtained shall be adjusted to account for such oversize particles as directed by the Engineer. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted to desired standards and accepted by the Engineer

Material for embankment at points inaccessible to normal compaction equipment shall be placed in horizontal layers of loose material not more than 15 centimeters (6") thick and compacted to the densities specified above by the use of mechanical tampers, or other appropriate equipment.

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

Embankment material that does not contain sufficient moisture to obtain the required compaction shall be given additional moisture to attain the optimum moisture content by means of approved sprinklers and mixing. Material containing more than the amount of moisture necessary to obtain the required compaction 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 and disking or other approved methods.

When materials of widely divergent characteristics, such as clay and chalk or sand, drawn from different source are to be used in the embankment, they shall be deposited in different layers (with individual layer of the same material) over the full width of the embankment to depths and sequence of material to be laid as approved by the Engineer . Lumps of clay or other similar material shall be broken down, and no accumulation of lumps or boulders in the embankment will be permitted. No surplus material shall be permitted to be left at the toe of embankment or at the top of cut sections.

Side slopes shall be neatly trimmed off to the lines and grades shown on the Drawings or as directed by the Engineer and the finished work shall be left in a neat and acceptable condition.

The Contractor shall be responsible for the stability of all embankments made by him and shall replace at his own expense any portions which in the opinion the Engineer have been displaced due to any cause whatsoever. The Contractor shall remain responsible for the stability of the embankment in the position fixed in the drawings till the work has been finally measured and the period of maintenance has not expired

4-8.3.2 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 meter width of fill rating 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
2600 - 4300	600	5
4300 - 500	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 spells, shale, earth, sand, gravel, to form a solid mass. After placing 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 than 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. Compaction test will be made whenever the Engineer determines they are feasible and necessary. Each layer must be approved by the Engineer before the next layer is placed

When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding fifty (50) percent of the thickness of the layer being placed

4-8.3.3 Formation of Embankment on Steep Slopes and over pipes and Structures

- Where embankments are to be constructed on steep slope, hill sides 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 the time, the original slope of the hill side, of existing pavement or adjacent to half width of embankment shall be cut in steps of twenty (20) centimeters(8inches) depth. Benching shall be of sufficient width to permit operation of equipment possible during placing and compaction of material.

  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.

- Embankments over and around pipes, culverts, arches and bridges shall be made with the selected material and compacted in such a manner as to avoid undue strain upon the structure

4-8.3.4 Formation of Embankment on Existing Roads

Before fill is placed and compacted on an existing carriageway, the existing embankment and or pavement may be leveled by cutting, rooting or scarifying by the 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 by the Engineer, either suitable or unsuitable for use in the construction of embankment/sub base. In the first case it shall be used in the adjacent embankment as directed by the Engineer, and payment shall be made as per relative pay item. In the second case the material shall be disposed off as provided in section 4-3 and 4-4 payment shall be made as per the relevant item.

Scarified material removed from the existing road surface may be placed in the embankment in thin layers in strict compliance with the instructions of the Engineer No. extra compensation shall be allowed for the storing and re-handling of such material.

4-8.3.5 Formation of Embankment in Water Logged Areas

Where embankments are to be placed in water logged areas and which are inaccessible to heavy construction equipment, a special working platform shall be first established, consisting of a blanket of fill material placed on top of the soft layer. The material of the working table shall consist of normal or processed granular fill, obtained from borrow excavation. This material shall conform to the following specifications:

Sieve Description	Percentage of Weight Passing Mesh Sieve, AASHTO-T-27
3 inch (75 mm)	100

The remaining grading shall be such as to avoid intrusion into the working platform material of subgrade or natural ground surface material. For this, condition to be met it will be required that the ratio.

D_{15} (Working Platform Material)

D_{85} / D_{15} is less than 5.

D_{85} (Natural Ground Material)

D_{85} and D_{15} mean the particle diameters corresponding to 85% and

15%, respectively, passing (by weight) in a grain size analysis.

Construction of this working table shall proceed from one edge of the soft area by using the fill as a ramp for further material transport.

The thickness of the working table as prescribed above shall be approximately 0.5 meter unless directed otherwise by the Engineer, and the width shall be that of the embankment. The placement and compaction of the working table shall be carried out by use of light equipment, as directed by the Engineer

4-8.3.6 Trial Section

Before starting the formation of the embankment the Contractor shall construct a maximum of three trial sections of 200 meter (660 feet) each for each soil type proposed to be used for compaction as directed by the Engineer. The soil 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 equipment that the contractor will use for the main work and that has been accepted by the Engineer.

The object of these trials will 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, as it is a subsidiary obligation of the contractor under the relevant pay items of this section

4-8.3.7 Excavation in Embankment for Structures

Unless otherwise specified in the Special Provisions, the Contractor may choose with the approval of the Engineer to make excavation for road structures, culverts, and pipe culverts after the embankment has been constructed. Any space remaining after the placing of such structures of culverts and deducting for specified bed or backfill, shall be filled with GRANULAR material approved by the Engineer and compacted as follows:-

Layers not more than 20 cm (8inches") in loose thickness shall be placed and compacted in succession, with mechanical tampers or tyres or tracks of motor driven equipment operated transversely to the roadway, to the densities specified in the relevant section. Moisture content shall be adjusted as directed by the Engineer.

The excavation in embankment and the placing of backfill for the purposes described above shall not constitute any claims for payment but shall be covered under the contract unit price paid for other works in which the operation is involved. Granular backfill when specified by the Engineer shall be paid under the relative pay item.

4-8.3.8 Miscellaneous Requirements

To avoid interference with the construction of bridge abutments and wing walls the contractor shall, at points to be determined by the Engineer suspend work on Embankment and/or in cuts forming the approaches to any such structure until such time as the construction of the latter 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 upto or over bridges, culverts or pipe drains, 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.

When as result of settlement, an embankment requires the addition of material upto 20 cm (8”) 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 placed, and no extra payment shall be made 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. Embankment material which may be lost or displaced as a result of natural causes such as storm, 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 at all times. When unsuitable material has been placed in the embankment by the contractor he shall remove it without extra payment.

4-8.4 MEASUREMENT AND PAYMENT

4-8.4.1 Measurement

The quantities to be paid for shall be the number of cubic meters or 1000 cubic ft. calculated on theoretical designed lines and grades and the ground levels as established under the relevant clause, compacted in place, accepted by the Engineer:

i. Formation of Embankment from Borrow Excavation

Measurement shall be made as under: -

Formation from Borrow = Total Embankment Quantity (minus) Roadway excavation Quantity (Minus) structural excavation Quantity

ii. Formation from Structural Excavation

This quantity shall be the same as calculated for structural excavation irrespective of its haulage distance except that declared unsuitable by the Engineer.

iii. Formation from Roadway Excavation

This quantity shall be the same as calculated for Roadway Excavation. The contractor will be supposed to use material from Roadway Excavation irrespective of haulage distance. However if contractor, for his own convenience, uses the material from borrow, the payment will still be made under the respective item.

In the measurement of "Formation of Embankment on steep slopes" no allowance will be made for the benching or volume of material cut out from the hill side or from the first half width fill to accommodate the compacting equipment but will be calculated only on the net volume of fill placed against the original hill sides, the old embankment or the first half width fill.

4-8.4.2 Payment

a. Formation from Borrow Excavation

The quantity to be paid for shall be the number of cubic meters or 100 cft. placed in embankment, measured as provided above for material from borrow excavation and such a payment will be deemed to include cost of excavation, payment of royalty, levies and taxes of Local, Provincial and Federal Government, cost of free hauling including all lead and lift, reflected in the Bid Schedule, spreading, watering, Rolling, labour, equipment, tools and incidental necessary to complete this item.

b. Formation from Structural Excavation.

The quantity to be paid for shall be the number of cubic meters 100 cft placed in embankment and measured as provided above for material from structural excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

c. Formation from Roadway Excavation

The quantity to be paid for shall be the number of cubic meters 100 cft placed in embankment and measured as provided above for material from roadway excavation and such payment will be deemed to include cost of excavation, hauling, dumping, spreading, watering, rolling, labour, equipment, tools and incidental necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
4-8 a	Formation of Embankment from Roadway Excavation in Ordinary / Common Material	CM or 1000 cft
4-8 b	Formation of Embankment from Roadway Excavation in Rock Material.	CM or 1000 cft
4-8 c	Formation of Embankment from Borrow Excavation from Rock Excavation within free haul.	CM or 1000 cft
4-8 d	Formation of Embankment from Borrow Excavation in Ordinary / Common Material.	CM or 1000 cft
4-8 e	Formation of Embankment from Structural Excavation in Common Material	CM or 1000 cft
4-8 f	Formation of Embankment from Structural Excavation in Rock Material	CM or 1000 cft

SECTION – 4-9
IMPROVED SUBGRADE

4-9 SECTION - IMPROVED SUBGRADE

4-9.1 DESCRIPTION

This work shall consist of the formation of top thirty centimeters of the roadbed, under sub base or base course as the case may be, with an approved blend of materials, uniformly mixed, compacted, shaped and finished to the lines, grades and typical cross-sections shown on the Drawings.

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.

4-9.2 MATERIAL REQUIREMENTS

The major component of improved subgrade shall consist of material conforming to the specifications mentioned in the relevant item of the Chapter MAKING/FORMATION OF EMBANKMENTS

The blending material shall be any soil that classifies as A-1, A-2, A-2-4 or A-3 according to AASHTO M-145.with PI of not more than 6

The blended mixture when compacted to Ninety five percent(95%) of the maximum dry density determined by AASHTO-T-180-D Method, shall exhibit a laboratory soaked CBR (96 hours) not less than 20, or as specified in the drawings.

4-9.3 CONSTRUCTION REQUIREMENTS

4-9.3.1 Preparation

The surface of the roadbed on which the improved subgrade is to be constructed shall be compacted to the density specified in section MAKING/FORMATION OF EMBANKMENTS

4-9.3.2 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 mixture along with 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.

4-9.3.3 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. 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 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-sections. 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 pug mill. 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.

c. Road Mix Method

The materials shall be transported to the site and spread on the roadbed in the quantities required to produce the specified blend. After the materials for each lift have been spread, the materials shall be mixed by motor graders and other approved equipment until the mixture is uniform throughout.

During mixing operation, water shall be added as necessary to bring the moisture content to the proper percentage.

4-9.3.4 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 (8 inches). Each layer shall be compacted to the density conforming to the requirements specified in item. “Construction Requirements” of the Chapter MAKING/FORMATION OF EMBANKMENTS

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

4-9.3.5 Trial Sections

Prior to the formation of the improved subgrade, the Contractor shall construct three trial sections of 200 meter or 650ft length, one 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 numbers 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. 4-8-

4-9.3.6 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 admitted to 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 re-compact the improved subgrade as may be necessary to restore it to the state specified herein.

4-9.3.7 Templates and Straightedges

The contractor shall provide for the use of 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.

4-9.3.8 Tolerance

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

4-9.4 MEASUREMENTS & PAYMENT

4-9.4.1 Measurement

The quantity of improved subgrade to be paid for shall be measured in cubic meter or 100 cubic feet by the theoretical volume in place as shown on the Drawings, placed and accepted in the completed improved subgrade.

4-9.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter or per 100 cft of improved subgrade for the pay item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, mixing, placing in layers, watering and compacting, labour equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
4-9	Improved Subgrade	m^3 or 1000 Cft.

SECTION – 4-10

SOIL CEMENT STABILIZED SUBGRADE

4-10 SECTION - SOIL CEMENT STABILIZED SUBGRADE

4-10.1 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.

4-10.2 MATERIAL REQUIREMENTS

4-10.2.1 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

Liquid Limit (Max).	45%
Plastic Limit (Mas).	20%
P.H. Value	Not less than 12
Soluble Sulphate Content max.	4%
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:

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

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

4-10.2.2 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 Cement shall conform to requirement of AASHTO M-85 while sulphate resistant cement shall conform to requirement of AASHTO M-74.

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.

4-10.2.3 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.

4-10.2.4 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.

i. 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.

ii. 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.

iii. Maximum permissible tolerance of cement and water content during construction shall be as under:-

Cement Content: Tolerance of: 1.0 percent of that given in the mix design.

Water Content: 0 to (+) 2% of that given in the mix design.111.2.6

4-10.2.5 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 (426 psi) 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.

4-10.3 CONSTRUCTION REQUIREMENTS

4-10.3.1 Mix in Place Method

The field equipment 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.

4-10.3.2 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 within 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.

4-10.3.3 Compaction

Any modification to meet the specification shall be completed together with compaction, within one and a half (1½) 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 five (95) % as tested in accordance with modified 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 maintain 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.

4-10.3.4 Tolerance

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

4-10.4 MEASUREMENT AND PAYMENT

4-10.4.1 Measurement

The unit of measurement for payment shall be cubic meter of 100 cft. of completed and accepted subgrade as measured in place. Measurement shall not include any areas in excess of that shown on the drawings, except the areas authorized by the Engineer in writing. Measurement of cement content used shall be the number of metric Ton used to stabilize subgrade. This quantity of Cement consumed shall not exceed the theoretical percentage established in the laboratory.

4-10.4.2 Payment

The measured quantity of stabilized subgrade determined as above shII be paid for at the contract unit price per cubic meter or 100 cft. for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment, handling, mixing manipulating, placing, shaping, compacting, including necessary water for compaction, rolling, finishing; correcting unsatisfactory areas and unsatisfactory material; maintenance including protection of stabilized layers; and incidentals necessary for completion of work except cement consumed which shall be paid separately as measured above.

Pay Item No.	Description	Unit of Measurement
4-10-a	Soil Cement stabilized Sub-grade	CM or 1000 cft.
4-10-b	Cement content type	Ton / cwt

SECTION – 4-11
LIME STABILIZED SUBGRADE

4-11 SECTION - LIME STABILIZED SUBGRADE

4-11.1 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.

4-11.2 MATERIAL REQUIREMENTS

4-11.2.1 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 section 4-9.2 (Cement stabilized silty, clay soils with texture mentioned in that section)., "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.

4-11.2.2 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.

SPECIFICATION REQUIREMENT FOR LIME

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

4-11.2.3 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 ($S0_4$). Water from doubtful sources shall not be used until tested as specified in AASHTO- T-26 and approved by the Engineer.

4-11.2.4 Mix Design in Laboratory

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

i. The percentage of lime and water (optimum content and tolerances)

ii. The field density of lime stabilized mixture to minimum ninety five (95) percent of laboratory density established with modified AASHTO T-134 test.

iii. The required results of the compressive strength in laboratory at 7 days shall not be less than ten (10) Kg/sq. cm.(142 psi)

4-11.2.5 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 (1975).

As a 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 and the quantity of lime required per 100 Kg. of soil should be established through detailed laboratory before actual utilization at site.

4-11.3 CONSTRUCTION REQUIREMENTS

4-11.3.1 Stationary Plant Method

The construction requirements of this clause shall conform to as specified in clause 4-9.3 of Section Cement Stabilization.

4-11.3.2 Mix in Place Method

The requirements of construction under this clause shall be in accordance with sub item 4-9.3.1 of Section Cement Stabilization.

4-11.3.3 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.

4-11.3.4 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 95% as determined by modified 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 determined in the laboratory. Dry density of compacted layers shall not be less than Ninety five (95) % 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 (1½) hours after mixing. Contractor will be responsible for any removal of or making good to deficient area without any extra payment. No vehicle or equipr.1ent shall be allowed to move over stabilised subgrade before initial setting of 7 days.

4-11.3.5 Tolerance

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

4-11.3.6 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.

4-11.4 MEASUREMENT AND PAYMENT

4-11.4.1 Measurement

The unit of measurement for payment shall be the cubic meter or 100 Cft of the compacted and accepted subgrade as measured in place. Measurement shall not include any area in excess of that shown on the drawings, except the areas authorized by the Engineer in writing. Measurement of lime consumed shall be the number of metric Ton used to stabilize subgrade. This quantity of lime consumed shall not exceed the theoretical percentage established in the laboratory.

4-11.4.2 Payment

The measured quantity of stabilized subgrade determined as above shall be paid for at the contract unit price per cubic meter for a particular item listed below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment; handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance including protection of stabilized layers; and incidentals necessary for completion of work except lime consumed which shall be paid separately as measured above.

Pay Item No.	Description	Unit of Measurement
4-11-a	Lime Stabilized Subgrade	CM or 1000 Cft.
411-b	Lime	Metric Ton / cwt

SECTION – 4-12

BITUMEN STABILIZED SUBGRADE

4-12 SECTION - BITUMEN STABILIZED SUBGRADE

4-12.1 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.

4-12.2 MATERIAL REQUIREMENTS

4-12.2.1 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.

4-12.2.2 Bitumen

Bituminous material used for subgrade stabilization shall comply with the requirement as per relevant tables specified in section. "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 relevant tables of "Asphaltic Materials".

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

<u>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.</u> 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.

4-12.3 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 un-compacted 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.

4-12.3.1 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 (3 inches to 8 inches) 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, AASHTO - T-205 or AASHTO - T-238 and shall be minimum ninety five (95) % modified AASHTO 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.

4-12.3.2 Tolerance

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

4-12.3.3 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.

4-12.4 MEASUREMENT AND PAYMENT

4-12.4.1 Measurement

The unit of measurement for payment shall be cubic meters or 100 cft. of a given thickness of compacted and accepted subgrade as measured in place. Measurement shall not include any areas in excess of that shown on the drawings, except the areas authorized by the Engineer in writing.

Measurement of bitumen binder used shall be the number of metric Ton used to stabilize subgrade. This quantity of bitumen consumed shall not exceed the theoretical percentage established in the laboratory.

4-12.4.2 Payment

Measured quantity of stabilized subgrade determined as above shall be paid for at the contract unit price per cubic meter or 100 cft. for a particular item listej below and shown on the bill of quantities, which payment shall be full compensation for furnishing all labour, material, tool, plant, equipment; handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsuitable areas and unsatisfactory material; maintenance including protection of stabilized subgrade layer and incidentals necessary for completion of work except bitumen consumed which shall be paid separately as measured above.

Pay Item No.	Description	Unit of Measurement
4-12 (a)	Bitumen Stabilized Subgrade	CM or 1000 cft.
4-12 (b)	Bitumen Binder, Type	Metric Ton / cwt

SECTION – 4-13

DRESSING AND COMPACTION OF BERMS

4-13 SECTION - DRESSING AND COMPACTION OF BERMS

4-13.1 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.

4-13.2 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.

4-13.3 CONSTRUCTION REQUIREMENTS

4-13.3.1 Dressing of Berms without the use of Extra Material

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

4-13.3.2 Dressing of Berms with the Use of Extra Material

In case the difference of elevation of existing berms 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.

4-13.3.3 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 Depth in cm per AASHTO T-180 (D)
0 - 15 (Top layer)	95% for common earth material
0 - 15 (Top layer)	100% for Sub base material

4-13.3.4 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.

4-13.4 MEASUREMENT AND PAYMENT

4-13.4.1 Measurement

Measurement under this item shall be made in square meter of berms dressed or compacted in accordance with theoretical lines, or sections shown on the drawings, or as per existing edge of road.

In case partial fresh material is used to compensate for shortage of material in the top layer the quantity of such material shall be measured by survey levels of existing ground and designed lines, grades or sections shown on the drawing.

The quantity of material thus measured shall be paid under other items of works of formation of embankment / sub base.

4-13.4.2 Payment

The payment of this item shall be made for at the contract unit price per square meter of dressed and compacted berm measured as above, for scarification watering, mixing, rolling, labor, equipment, tools and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
1.13 a	Dressing of berms without extra material	CM or 1000 cft.
1.13 b	Dressing of berms with extra material	CM or 1000 cft.

SECTION – 4-14

OVERHAUL OF EXCAVATION

4-14 SECTION - OVERHAUL OF EXCAVATION

4-14.1 DESCRIPTION

Overhaul shall consist of necessary hauling of excavated material a distance beyond that defined herein as the free haul distance. Unless otherwise shown on the Plans overhaul shall apply only to borrow material; and for these materials, only when called for on the Plans or as provided hereinafter.

As far as practicable all the excavated material shall be disposed of, as directed by the Engineer, within the free haul limits.

4-14.2 FREE HAUL

4-14.2.1 When Bid Schedule Shows an Item for Overhaul

When the Bid Schedule shows as item and approximate quantity for Overhaul, the free haul distance shall be 3,000 feet, provided that when the Plans indicate the bid item to be applicable only to a certain class of excavation, all hauling of other classes of excavation shall be considered as free haul, subject, however to the provision of 4-13 – 2..2; and further provided that, should material on which overhaul is to be allowed be obtained from substitute pits furnished by the Contractor, any increase in length of the haul due to such change also shall be considered free haul and any decrease in length of haul shall not reduce the specified free haul distance.

4-14.2.2 When Bid Schedule Does Not Show an Item for Overhaul

When Bid Schedule does not show an item and approximate quantity for Overhaul, all hauling shall be considered as free haul except as follows:

i. When the location of a proposed borrow material pit is changed by the Engineer from that shown on the original plans, and such change entails the hauling of material a distance greater than the length of haul indicated on the original plans, the haul distance indicated on the original plans for such material shall be considered as the free haul distance and the necessary hauling of such material beyond this free haul distance shall be classed as overhaul.

ii. The Engineer may direct the Contractor to use selected material occurring within the right of way or in borrow pits within the free haul distance to be placed to form the top 1 to 2 ft. of the embankment. The cost of this will be considered as covered under Section 406- Making / Formation of Embankment.

4-14.3 MEASUREMENTS AND PAYMENTS

4-14.3.1 Measurement

The quantity of Overhaul to be paid for shall be determined by the mass diagram method. The pay quantity shall be computed as the product of the remaining number of 1000 cubic feet of material from any excavated area after proper deduction has been made for material placed within the free haul limits, multiplied by the distance (unit of one half KM) such material is hauled in excess of the free haul distance. The distance such material is hauled will be taken as the distance between the center of volume of such remaining excavation and the center of volume of the corresponding embankment. The distance between centers of volume shall be measured along the centerline of construction except in the case of borrow, when it along the centerline of construction except in the case of borrow, when it shall be measured along the shortest practical line of haul, as determined by the Engineer.

4-14.3.2 Payment

When the Bid Schedule shows as item and approximate quantity for overhaul, the quantity, determined as provided in 4-14-3 and under the conditions of 4-14-2.1, shall be paid for at the unit price per half-KM for carriage of 1000 cft., as established by the Contractor's bid, which price shall be full compensation for complying with the provisions of this Section and includes cost of all labour, machinery, tools etc.

When overhaul is encountered under the conditions set forth in 4-14-2.2, and such overhaul is not covered by a bid item, the quantity of such overhaul, determined as provided above, shall be paid for at the rate agreed upon in the contract.

One half KM 100 cft. or (one Cubic Meter) Shall equal 100 cubic feet or one cubic meter of excavated material hauled one half KM in excess of the free haul distance.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
4-14 a	Overhaul when the bid schedule shows an item for overhaul	Cub meter or 1000 cft.
4-14 b	Overhaul when the bid schedule does not show an item for overhaul	Carriage of one cub meter or 1000 cft. earth per half KM

SECTION – 5-1

SUB BASE AND BASE GENERAL

5-1 SECTION - SUB BASE AND IN GENERAL PERSPECTIVE

5-1.1 DESCRIPTION

Under this section an over view of finishing, spreading and compacting graded sub base, base, asphaltic base course, layers constructed on a prepared bed are described.

5-1.2 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 the respective section of these specifications.

5-1.3 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 sub base, 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 requirement, at no additional cost to the Client.

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). 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".

5-1.4 SELECTION OF PLACE FOR SAMPLING

The selection of representative samples for testing shall be by "Random Sampling Method 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.

5-1.5 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.

5-1.6 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" (Chapter 2) 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 one item. 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.

5-1.7 TOLERANCES

The allowable tolerances for the subgrade prior to placing the overlying courses, together with the allowable tolerances for the sub base and base are as specified in "Table for Allowable Tolerances" in these specifications (Section 2-2 of Chapter 2)..

5-1.8 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.

5-1.9 TRIAL STRIPS

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

a. Maximum thickness of loose layer, which can be laid.
b. Type of equipment to be used.
c. Watering and mixing procedures.
d. Number of passes required to satisfactorily compact the layer to required level.
e. Any other requirement ordered by the Engineer.

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

SECTION – 5-2

SUB-BASE COURSE MECHANICALLY STABILIZED SOIL AGGREGATE

5-2 SECTION - SUB-BASE COURSE MECHANICALLY STABILIZED SOIL AGGREGATE

5-2.1 DESCRIPTION

This item shall consist of furnishing, spreading in one or more layers and compacting granular sub base of either naturally occurring materials or blended materials consisting of gravel, crushed stone and fines whichever is specified in the bid schedule conforming to the specified grading requirements placed and compacted on the prepared sub-grade in accordance with these specifications and drawings inconformity with the lines, grades, thickness and typical cross section shown on the drawings and as directed by the Engineer.

5-2.2 MATERIAL REQUIREMENTS

Granular sub base material shall consist of natural or processed aggregates such as gravel, sand or stone fragment 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, stable sub base.

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

a. The sub base material shall have a gradation curve within the limits for grading A or B, given below. However grading A may be allowed by the Engineer in special circumstances.

Grading Requirements for Sub base Material					
Sieve Designation		Mass Percent Passing Grading			
		For Compacting 6 in Layer		For Compacting 4 in Layer	
mm	Inch	A	B	C	D
60.0	(2½)	100			
50.0	(2)	90-100	100	100	
25.0	(1)	50-80	55-85	75 – 95	100
9.5	(⅜)	--	40-70	40 – 75	50 – 85
4.75	No.4	35-70	30-60	30 – 60	35 – 65
2.0	No. 10	--	20-50	20 – 45	25 – 50
0.425	No.40	--	10-30	15 – 30	15 – 30
0.075	No. 200	2-8	5-15	2 – 20	5 – 15

The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis, curve.

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 hundred (100) percent of the maximum dry density determined according to AASHTO T-180 Method-0.

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 (45) percent.at 500 revolutions

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

   Where 85 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 6 or less.

f. If over-size is encountered, screening of material at source, shall invariably be done, no hand picking shall be allowed, however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass.

g. Sand equivalent for all classes shall be 25 min.

5-2.3 CONSTRUCTION REQUIREMENTS

5-2.3.1 Spreading

Granular sub base 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.

Granular sub base 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 sub base 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 cm (6 inches) 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 (10) centimeters (4 inch) 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 uncompacted thickness of one layer shall not exceed 15 cm (6 inches). All subsequent layers shall be spread and compacted in a similar manner. It should be preferred that layer of more thickness should be overlaid with layer of lesser thickness.

Sub base 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 sub base material.

5-2.3.2 Compaction Trials

Prior to commencement of granular sub base 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 sub base 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. For details, refer to clause 1-1.20 (General - trial Section) of these specifications.

5-2.3.3 Compaction

The moisture content of sub base material shall be adjusted prior to compaction, by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the specified compaction.

The sub base material shall be compacted by means of approved vibratory rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the center, 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.(4 inches)

If the layer of sub base material or parts thereof does not conform to the required mesh, 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 sub base 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 sub base has been approved by the Engineer.

5-2.3.4 Compaction requirements

The relative compaction of each layer of the compacted sub base shall not be less than Hundred (100) 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 (No 4 sieve) AASHTO Method T-224 shall be used.

5-2.3.5 Moisture Content Determination

As it is customary in the project laboratories that small samples of materials are placed in ovens for moisture determination for proctor, following precautions are necessary to ensure proper compaction results.

Same size of sample is placed in oven for moisture determination in case of laboratory density (Modified Proctor) and field density.

Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve. (No 4 sieve)

5-2.3.6 Tolerance

The sub base shall be compacted to the desired level and cross slopes as shown on the drawings. The allowable tolerance shall be according to the "Table for Allowable Tolerances" in these specifications.

5-2.4 MEASUREMENT AND PAYMENT

5-2.4.1 Measurement

The quantity of sub base to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed granular sub base course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross sections.

5-2.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter or per 100 cubic ft. of granular sub base or Crushed Aggrgate Sub-base for the Pay Item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all material hauling, placing watering; rolling, labor, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
5-2 (a)	Gravel Sub base course of the specified thickness	Per CM Per 100 Cft
5-2 (b)	Crushed Aggregate Sub-base Course of specified Thickness	Per CM Per 100 Cft

SECTION – 5-3

SOIL CEMENT STABILIZED SUB BASE AND BASE

5-3 SECTION - SOIL CEMENT STABILIZED SUB BASE AND BASE

5-3.1 DESCRIPTION

The work shall consist of performing all operations inconnection with the construction of one or more cources of cement stabilized sub base or base and all incidentals in accordance with the specifications in conformitywith the lines,grade; thickness and typical cross sections shown on the plans or as directed by the Engineer.

5-3.2 MATERIAL REQUIREMENTS

5-3.2.1 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 sub base 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 sub base material.

Fraction passing 0.075 mm (No. 200) shall not be greater than two-third (2/3) 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%

5-3.2.2 Cement

Cement shall conform in all respect to requirement specified under section 10-1.

5-3.2.3 Water

Water used for cement stabilized base course or sub base shall conform in all respect to requirements specified under section 10-10.

5-3.2.4 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 approval, and shall fulfill the following requirements:

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/cm² (327 psi)for sub base and thirty (30) kg/sq. cm (427 psi)for base respectively.

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

Maximum variation during constructions shall be as given below.

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

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

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

Type	Applicable Specifications
Rapid Curing Cutback Asphalt	AASHTO M-81
Medium Curing Cutback Asphalt	AASHTO M-82
Slow Selling Emulsified Asphalt	AASHTO M-140
Road	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.

5-3.2.5 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/cm² (711 psi)for sub base and eighty (80) kg/cm² (1137 psi)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 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.

5-3.3 CONSTRUCTION REQUIREMENTS

5-3.3.1 Stationary Plant Method

Equipment, tools, machines used for the performance of cement stabilized sub base; base shall be subject to the approval of Engineer and shall be maintained in satisfactory working condition of 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 without cement lumps.

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

The mixture shall be placed on moist subgrade and /or sub base 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.

5-3.3.2 Mix in Place Method

Cement stabilized sub base/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.

5-3.3.3 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 areas 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 remixing. 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.

5-3.3.4 Compaction

The thickness of layer shall be as shown on the Drawings but in no case shall be less than eight (8) centimeters or 3 inches. If thickness of each layer does not exceed twenty centimeters, (8 inches) it shall be constructed as one layer. If thickness of layer exceeds twenty (20) centimeters, (8 inches) it shall be constructed in two or more layers each within the range of eight (8) to twenty (20) centimeters (3 inch to 8 inch) 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 sub base/base is uniformly compacted to maximum density of 95% as tested according to procedure outlined in 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.

5-3.3.5 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 compacting effort.

In place density determination will be made using AASHTO T-191 or AASHTO T-205& T-238 Method.

5-3.3.6 Curing/Maintenance

After compaction the stabilized sub base/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 Sub base/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 notraffic period of seven (7) days.

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

5-3.3.7 Tolerance

The surface of each sub base/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 Sub base/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. The Tolerance limits are described in section 2-2 of Chapter 2.

5-3.4 MEASUREMENT AND PAYMENT

5-3.4.1 Measurement

Unit of measurement for the payment shall be cubic meter of the compacted and accepted Sub base/Base material as measured in place. Measurement shall not include any areas in excess of that shown on the drawings except the areas authorized, in writing, by the Engineer.

Measurement of cement content used shall be the number of metric Ton consumed to stabilize sub base/base. This quantity of cement used shall not exceed the theoretical percentage established in the laboratory.

Bituminous curing material shall be measured by the metric Ton. The Contractor shall furnish in duplicate certified weight tickets from the batch scales of commercial plants.

5-3.4.2 Payment

Measured quantity of stabilized sub base/base determined as provided above shall be paid for at the unit price per cubic meter or 100 Cub.ft. for a particular item listed below and shown on the Bill of Quantities, which payment shall be full compensation for furnishing all labor, material, tool, plant, equipment, handling, mixing, manipulating, placing, shaping, compacting including necessary water for compaction, rolling, finishing; correcting unsuitable area and unsatisfactory material; maintenance including protection of stabilized sub base/base layer and incidentals necessary for completion of work except cement consumed which shall be paid separately as measured above. Payment for bituminous curing material shall include all labor, material, heating (if required) equipment, spreading and protection from traffic as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
5-3 (a)	Cement Stabilized Sub base	m^3 or 100 cft
5-3 (b)	Cement Stabilized Base	m^3 or 100 cft
5-3 (c)	Cement content	Metric Ton
5-3 (d)	Rapid Curing Cut Back Asphalt	Metric Ton
5-3 (e)	Medium Curing Cut Back Asphalt	Metric Ton
5-3 (f)	Emulsified Asphalt for curing seal	Metric Ton

SECTION – 5-4
CRACK RELIEF LAYER

5-4 SECTION - CRACK - RELIEF LAYER

5-4.1 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.

5-4.2 MATERIAL REQUIREMENTS

5-4.2.1 Aggregates

i. Material for a layer of graded crushed aggregate

Material for graded crushed aggregates shall in all respects conform with 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 1O 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.

ii. Material for a layer of asphaltic open graded plant mix

Aggregates for the asphaltic open-graded plant mix shall conform to the requirements of Clause 6-6.2.1 of Section Asphaltic Base-course with the following exceptions:

a. Fine aggregates and mineral filler will be required.

b. Sand equivalent and plasticity requirements are not applicable.

5-4.2.2 Asphaltic Material

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

5-4.2.3 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	1 ½	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.

5-4.3 CONSTRUCTION REQUIREMENTS

Prior to construction of the crack-relief layer (CRL) the completed soil- cement base course shall be duly accepted by the Engineer.

5-4.3.1 Graded Crushed Aggregate

Construction of this layer shall conform in all respects to the requirements specified under Item 5-7.3 (Construction Requirement of Aggregate Base Course).

5-4.3.2 Asphaltic Open-Graded Crack Relief Layer

Construction of this layer shall conform in all respects to the requirements specified under Item 6-6.3 (construction Requirements for Asphaltic Base Course Plant Mix), 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 (Crack Layer Relief) 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 time 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.

5-4.4 MEASUREMENT AND PAYMENT

5-4.4.1 Measurement

The quantity of graded crushed aggregate crack-relief asphaltic open graded layer to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the

Engineer, placed and accepted in the completed graded crushed aggregate crack-relief layer.

The quantity of asphaltic open graded crack relief layer shall be measured in cubic meters or 100 cubic ft. by taking out cores as detailed for Base Course Asphalt under item 6-6.5.1 of section 6-6 (Asphaltic Base Course Plant Mix.

The quantity of Asphaltic material is included in the mixture and will not be measured separately.

5-4.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all costs necessary for the proper completion of the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
5-4 (a)	Graded Crushed Aggregate Crack-Relief Layer	CM or 100 cft.
5-4 (b)	Asphaltic Open-Graded Plant Mix Crack Relief Layer	CM or 100 cft.

SECTION – 5-5

SUB BASE COURSE-BRICK PAVED

5-5 SECTION SUB BASE COURSE BRICK PAVED

5-5.1 DESCRIPTION

The work specified in this section shall consists of providing and constructing one or more layers of brick courses laid on edge or flat as called for in the Bid Schedule or shown on drawings The bricks will be laid over a sand cushion 3.28 cm (1 inch) thick and with the joints filled with sand with suitable bonding, over a prepared sub grade .Compacted upto 95% modified density in all the sections of Chapter 4. of these specifications

5-5.2 MATERIALS

5-5.2.1 Bricks

The size of bricks shall be as per Section 10-8 of chapter 10 (Materials) these shall be, slightly over burnt without being vitrified. They shall be of uniform colour with reasonably square corners and parallel faces. They must be homogenous in texture and emit a clear ringing sound when struck. 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. These shall be free from lime, air pockets, and marked laminations. They shall not absorb more than 1/6the of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 140 kg/cm^{2}or 2000 lbs. / sq. in. when tested in accordance AASHTO- T 32.

They shall be moulded or burnt from suitable soil which shall not contain detrimental quantities of salts.

5-5.2.2 Sand

The sand on which the bricks are bedded shall be free flowing and show no plasticity. And shall conform to gradation and plasticity requirements as follows.

a. Filling of joints will be filled with silty sand

b. Gradation

The grading of bedding soil shall conform to the following limits.

Sieve Designation	Mass Percent Passing
1” (25 mm)	100
⅜” (9.5 mm)	80-100
No. 10	50-85
No. 200	15-35

Note: - Coarser than 1” (25 mm) size material may be allowed upto five (5) percent by the Engineer.

c. Physical Requirements

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

1.	P.I value.	6.0% max.
2.	Swelling Value.	0.20% max.
3.	Soaked C.B.R. (96 hours)	20% min.

5-5.3 CONSTRUCTION REQUIREMENTS

5-5.3.1 Sub-Grade

The sub-grade shall be constructed in accordance with the Section 4-5 and 4-4, 4-7.

5-5.3.2 Stacking of Bricks

The bricks shall be delivered at site in stacks ten courses high and two bricks thick for the convenience of proper inspection.

5-5.3.3 Placing of Bricks

The prepared and compacted sub-grade as per section 4-5, 4-6, and 4-7 shall be covered by 2.58 cm (1inch)" of sand cushion over which the bricks shall be laid closely packed in parallel rows transverse to the center line with string courses 25 ft. apart along the length and on each side, or as may be directed by the Engineer at site. The bricks shall be laid on edge or flat, in one or two courses as called for in the plans or bid schedule. If more than one 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 before laying the next course.

As provided in Section 6-10 suitable material as provided in the bid schedule should then be placed on the shoulder and the shoulders compacted at the same time as the brick pavement is rolled.

5-5.4 MEASURMENT AND PAYMENT

5-5.4.1 Measurement

Brick sub base course of brick pavement when laid and finished to the required thickness and grade line and accepted in place by the Engineer shall be measured by volume The quantity shall be worked by superficial area multiplied by the nominal thickness of brick layer/layers. The unit of measurement shall be cubic meter or 100 cft. one hundred cubic feet.

5-5.4.2 Payment

The unit rate for brick sub base course or brick pavement of specified thickness shall be full compensation for preparing and shaping the subgrade, by removing the undulation or replacement of unstable sub–grade, provision and laying of the approved sand, provision and laying of the bricks, filling the voids with sand and rolling the whole width for proper compaction and includes material, labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
5-5 (a)	Sub base course of brick laid on edge including sand cushion, 1” thick	Cubic meter or 100 cubic feet.
5-5 (b)	Brick Pavement laid flat of specified thickness including sand cushion 1” thick	Cubic meter or 100 cubic feet

SECTION – 5-6

DRAINAGE LAYER UNDER SHOULDERS

5-6 SECTION - DRAINAGE LAYER UNDER SHOULDERS

5-6.1 DESCRIPTION

The work specified in this section shall consist of providing a layer of crushed bricks, crushed stone aggregate or naturally occurring gravel of specified gradation over a prepared and well compacted subgrade over the whole shoulder width so as to provide a free drainage layer where the sub base does not cover the full width of the sub – grade The drainage layer of specified thickness shall be provided only if shown other plans and x-sections.

5-6.2 MATERIALS

Slightly or well over burnt crushed bricks or other crushed stone aggregate or naturally occurring gravel shall be used. The gradation shall be as follows:

Sieve Designation	Percentage Passing by Wt. Passing Through the Mash Square Sieve.
25mm (1")	100%
19mm (¾")	70-100 %
0,15mm (No. 100)	0-10%

5-6.3 CONSTRUCTION

A layer of drainage materials of specified thickness as described in the previous paragraph shall be laid over the well prepared and compacted sub-grade outside the sub-base to the width shown on the Plans adjoining the sub base on either side with a four percent cross slope and rolled dry with two coverages of an 8 – 10 ton smooth wheel roller. Over this layer, the required material for the shoulders should be spread and compacted in layers to the dsired degree of compaction and conforming to remaining thickness of the sub –base and base course as shown on the plans and drawings. The drainage layer shall be provided only when shown on the Plans.

The final surface shall be graded to the correct levels and cross fall and shall be within the following tolerances:

Under crown template	± 12.5mm. or.+/-½ inch"
Under 3 meter (10ft)' straight edge along the road	+/-9.5mm or +/-3/8 inch

5-6.4 MEASURMENT AND PAYMENT

5-6.4.1 Measurement

The item of drainage layer under shoulders when completed to the actual thickness and to the clear lines shown on the plans for width and length shall be measured by superficial area. The unit of measurement will be one cubic meter or one hundred cubic feet of the completed work.

5-6.4.2 Rate

The unit rate shall be full compensation for furnishing and placing all materials including all labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

5-6.4.3 Payment

Payment shall be made under:

Pay Item No	Description	Unit of Measurement
5-6 a	Crushed Brick Drainage Layer of the Specified thickness	Cubic meter / 100 cub.ft
5-6 b	Crushed Stone Aggregate Drainage Layer of the specified thickness	Cubic meter / 100 cub.ft
5-6 c	Gravel Drainage Layer of the specified thickness	Cubic meter / 100 cub.ft

SECTION – 5-7
AGGREGATE BASE COURSE

5-7 SECTION - AGGREGATE BASE COURSE

5-7.1 DESCRIPTION

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

5-7.2 MATERIAL REQUIREMENTS

5-7.2.1 Coarse Aggregate

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, 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 and within the envelope limits for Grading A or B given below.

Grading Requirements for Aggregate Base Material			
Sieve Designation		**Mass Percent Passing Grading**	
mm	**Inch**	**A**	**B**
50.0	2”	100	100
25.0	1”	70-95	75-95
9.5	3/8”	30-65	40-75
4.75	No. 4	25-55	30-60
2.00	No. 10	15-40	20-50
0.425	No. 40	8-20	12-25
0.075	No. 200	2-8	5-10

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

b. Crushed Aggregate (material retained on sieve NO. 4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

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

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

e. The sand equivalent determined according to AASHTO T-176 shall not be less than 45 and the material shall have a Liquid limit of not more than twenty five (25) and a plasticity Index of not more than 6 as determined by AASHTO T-89 and T-90:

f. The material passing the 19 mm sieve shall have a CBR value of minimum eighty (80%) percent, tested according to the AASHTOT -193. The CBR value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

g. Laminated material shall not exceed 15% of total volume of Aggregate Base Course.

5-7.2.2 Filler for Blending

If filler, in addition to that naturally present in the 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
No. 4	85-100
No. 100	10-30
Plasticity Index (AASHTO T-90)	6 maximum
Sand Equivalent (AASHTO T-176)	30 minimum

However the combined aggregates prepared by mixing the coarse material and filler shall satisfy the requirements as mentioned in clause 2.3 2 above.

5-7.3 CONSTRUCTION REQUIREMENTS

5-7.3.1 Preparation of surface for Aggregate base course

In case crushed aggregate base is to be laid over prepared sub base course, the sub base course shall not have loose material or moisture in excess to Optimum Moisture Content.

Spreading shall conform in all respects to the requirements specified under this heading Section 5-2.3 Construction Requirement of Sub base

5-7.3.2 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in Section 5-2.3.3 of sub base compaction.

5-7.3.3 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than100 percent to the maximum dry density determined according to AASHTO T-180, Method D (Modified). 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,(No 4 sieve) AASHTO Method T-224 shall be used .

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.

5-7.3.4 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under clause 5-1.3.5 for sub base.

5-7.3.5 Trial Sections

Prior to commencement of aggregate base course operations, a trial section of two 1600 ft. hundred (200) meters minimum (about 600 ft.), 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. For details refer to clause 1-1.20 (General) of these specifications.

5-7.3.6 Tolerance

The completed base course shall be tested for required thickness and smoothness before acceptance. Any area having waves, irregularities in excess of one (1) cm in three (3) M Or two (2) cm in fifteen (15) M shall be corrected by scarifying the surface, adding approved material, reshaping, re compacting and finishing as specified. Skin patching of an area without scarifying the surface to permit proper bonding of added material shall not be permitted. The allowable tolerances shall be according to the "Table for Allowable Tolerances" in these specifications.

5-7.3.7 Acceptance, Sampling and Testing

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

5-7.4 MEASUREMENT AND PAYMENT

5-7.4.1 Measurement

The quantity of aggregate base to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed crushed aggregate base course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross sections.

5-7.4.2 Payment

The accepted quantities measured as above shall be paid for at the contract unit price per cubic meter of aggregate base, for the item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labor, equipment, tools and incidentals necessary to complete this item.

Pay Item No.	Description	Unit of Measurement
5-7	Aggregate Base	CM or 100 cub. ft

SECTION – 5-8

BASECOURSE WATER BOUND MACADUM

5-8 SECTION - WATER BOUND MACADAM BASE

5-8.1 DESCRIPTION

This work shall consist of furnishing and placing one 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, sub base, or existing pavement in conformity with the lines. Grades and cross-sections shown on the drawings. Unless otherwise directed by the Engineer this item of work may be applied to road structure or shoulders.

5-8.2 MATERIAL REQUIREMENTS

5-8.2.1 Gradation Requirements

a. Coarse aggregate

Coarse aggregates either crushed or broken stone shall conform to the quality requirements as specified hereunder, except that no CBR testing will be required. The gradation curve of the coarse aggregate shall be within the envelop limits given below. Gradation of class A is generally recommended.

Sieve Designation		Percent Passing by weight		
mm	Inch	Class A	Class B	Class C
102	(4")	100		
89	(3 ½")	90 - 100		
76	(3")	–	100	
63.5	(2 ½ ")	25 – 60	90 - 100	100
50	(2")	–	25 - 75	90 - 100
37.5	(1 ½ ")	0 - 15	0 - 15	35 - 70
25	(1")	–	–	0 - 15
19	(¾")	0 - 5	0 - 5	0 - 5
12.5		–	–	–

b. Fine Aggregate or Filler Material

Fine aggregate (filler material or screenings) shall consist of crushed stone screenings or any other fine material approved by the Engineer. It shall be free from clay lumps, dirt and other objectionable material. The fine aggregate shall be of the following gradation.

Sieve Designation		Percent Passing by weight
mm	Inch	
9.5	3/8	100
4.35	No.4	85-100
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 six (6).

c. Binding Material

Binding material to prevent reveling of water bound.

5-8.2.2 Physical Requirements

The additional physical requirements of coarse aggregates for water bound macadam will satisfy the following limits:-

a. Loss Angeles Abrasion Value Max 45%

b. Flakiness Index Max 15%

c. The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T-104) shall be less than twelve (12).

5-8.2.3 Quantities

Sufficient coarse aggregate and screenings shall be used to make a compact dense mass of the required thickness as indicated on the Plans.

5-8.3 CONSTRUCTION

5-8.3.1 Preparation of Previously Constructed Subgrade or Sub base

All loose or foreign materials shall be removed. Any ruts or soft yielding places that appear on the subgrade or sub base course shall be corrected and rolled until firm. Necessary sub – grade or sub base course material shall be added to conform to proper grade and cross section.

Subgrade or sub base course shall be rolled to even, firm foundations.

5-8.3.2 Weather limitations

Water Bound Macadam work shall not be constructed during freezing weather or on a wet or frozen subgrade or sub base course.

When temperature is below 40o F. complete base course shall be protected against freezing, until it dries out, by a sufficient covering of straw, hay, or other approved material.

5-8.3.3 Thickness of Layers

The base course shall be constructed in complete layers of not less than 77 mm (3”) or more than 116 mm (4 ½”) compacted thickness. The compacted thickness of layer more than 116 mm (4 ½") may be allowed if the Contractor can demonstrate that he can achieve the specified densities throughout the depth of the course tot eh satisfaction of the Engineer by using special rolling equipment. When it is necessary to construct the base in more than one layer to conform to the required finished thickness, each layer shall be constructed as described below:

5-8.3.4 Spreading Coarse Aggregate

Sufficient coarse aggregate shall be uniformly spread to give the required thickness for each layer when compacted.

All patches or areas of fine or undersized aggregate shall be removed and replaced with suitable aggregate.

The thickness of each layer shall be set by the use of depth blocks.

Coarse aggregate shall not be spread more than 15000 sq. ft. and never more than 500 lin. ft. in advance of rolling and application of screenings.

5-8.3.5 Compaction:

Immediately after the spreading of the coarse aggregate, it shall be compacted to the full width by rolling with a power roller weighing at least 10 tons. The rolling shall begin with the outside rear wheel covering equal parts of shoulder and coarse aggregate and the roller shall be run forward and backward until the shoulder and coarse aggregate are firmly bound together.

When shoulders and edges of the base course have been firmly rolled, the rolling shall progress gradually from the edges to the center, each preceding rear – wheel track being uniformly lapped by one – half the width of such track, and shall continue until the entire area of the course has been rolled by the rear wheels. Rolling shall be continued until the aggregate is well keyed and does not creep ahead of the roller and until the surface is firm, even and true to line, grade, and crown. Places inaccessible to roller shall be compacted by mechanically operated or hand tampers or as directed by the Engineer.

5-8.3.6 Applying Screenings

Immediately after the compaction of the coarse aggregate, sufficient clean, dry screenings shall be uniformly applied, to fill all voids. Dry rolling shall be continued while screenings are being applied. Hand brooms shall be used if the roller is not equipped with a broom. Screening shall be spread in thin layers at a uniform and slow rate to insure filling all voids.

Spreading screenings, brooming, and rolling shall be continued until the voids are completely filled.

5-8.3.7 Sprinkling

Immediately after the voids of a layer have been filled with screenings, the macadam shall be sprinkled with water, the sprinkler being followed by the roller. All excess screenings forming in piles or cakes on the surface shall be scattered by light sweeping. The sprinkling and rolling shall continue, and additional screenings shall be applied where necessary, until all voids are completely filled and the coarse stone firmly set and bonded. The quantity of screenings and water shall be sufficient to completely fill and bond the entire depth of the coarse aggregate and to produce a granular surface.

Provision shall be made by the Contractor for furnishing water at the site of the work by equipment of ample capacity and of such design as to assure uniform application.

5-8.3.8 Density Requirements

As soon as proper conditions of moisture are attained the density tests shall be performed in accordance with AASHTO T191 modified to include only material passing a ¾ inches sieve. If the density is less than 100 percent of the maximum density as determined by AASHTO T180 (Modified Proctor), the contractor shall perform additional rolling as may be necessary to obtain that density.

5-8.3.9 Tolerances

The surface shall be true to the established grade. The surface shall not vary more than stipulated in section 2-2 of Chapter 2.

5-8.3.10 Reconstructing Damaged Base Course

Should the subgrade or sub base at any time become soft or churned up with the base – course material the contractor shall, without additional compensation remove the mixture from the affected portion, reshape and compact the subgrade or sub base, and replace the removed section in accordance with the foregoing requirements.

5-8.3.11 Maintenance and Protection of Base Course:

The surface of any layer shall be maintained in its finished condition until the succeeding layer or pavement is placed.

5-8.3.12 Quality Control Testing

Tests for compliance with the quality control requirements will be made as often as deemed necessary and according to sequence of testing as stipulated in Section 2-1.4 of Chapter-2.

5-8.4 MEASUREMENT AND PAYMENT

5-8.4.1 Measurement

The quantity of Water Bound Macadam Base to be paid for shall be measured by the theoretical volume in place, as shown on the Drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed Waterbound Macadam Base Course. No allowance will be given for materials placed outside the theoretical limits shown on the cross-sections.

5-8.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the contract unit price per cubic meter or per 100 cubic ft of Water Bound Macadam Base, for the pay items listed below and shown in the Bill of

Quantities, which price and payment shall constitute full compensation for furnishing all materials, hauling, placing, watering, rolling, labour, equipment, tools and incidentals necessary to complete this item.

Pay Item No	Description	Unit of Measurement
5-8 (a)	Water Bound Macadam Base with Coarse Agg: Class A, B, C	CM or 100 cft.

SECTION – 5-9

INTERLOCKING CONCRETE PAVING BLOCKS

5-9 SECTION - INTERLOCKING CONCRETE PAVING BLOCKS

5-9.1 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.

5-9.2 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:

5-9.2.1 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 blastfurnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146 Part 2.

5-9.2.2 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 : 1983 (except grading requirements in clause 5)
Air Cooled blast furnace slag	BS 1047 : 1083 (except grading requirements in 4.8)
Pulverized fuel ash	BS 3892 : Part-1 or Part-2
Ground granulated blastfurnace slag	BS 6699

5-9.2.3 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 µ m sieve.

5-9.2.4 Water

The water shall be of drinking quality or in accordance with the recommendations of appendix A of BS 3148 : 1980.

5-9.2.5 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

5-9.2.6 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.

5-9.2.7 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.

5-9.3 SIZES AND TOLERANCES

5-9.3.1 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.

5-9.3.2 Tolerances

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as follows:

Length	±	2 mm
Width	±	2 mm
Thickness	±	2 mm

Where a paving block includes profiled sides, the profile shall not deviate from the manufacturer's specification by more than 2 mm.

5-9.4 STRENGTH REQUIREMENTS

5-9.4.1 Compressive strength

The compressive strength of paving blocks shall be not less than 49 N/mm2 (7000) and the crushing strength of any individual block shall be not less than 40 N/mm^2 (6000).

5-9.4.2 Sampling and Testing

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.

5-9.5 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 1986 or latest revision.

5-9.6 CONSTRUCTION REQUIREMENTS

5-9.6.1 Laying the Concrete Blocks

The total area to be covered with paving block shall be prepared by:

Compaction of subgrade

Laying of sub base in a thickness specified

Laying of crushed aggregate base or lean concrete in thickness as per typical section

5-9.6.2 Tolerance

Tolerance of these layers shall be as per applicable requirement of each item of this specifications.

Payment for each of the above item shall be made under the relative item of work.

The total area will thereby be divide with nylon strings into sectors of not more than 1.5 square meters or 10 sft. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

5-9.7 MEASUREMENT AND PAYMENT

5-9.7.1 Measurement

The area to be measured shall be bound by lines shown on the drawings or as directed by the Engineer. Unit of measurement shall be square meter measured in horizontal plane.

5-9.7.2 Payment

The quality determined as provided above shall be paid for the unit price of contract for each square meter of paving block installed including sand cushion and sand filling in joints and all other work related for installing paving blocks. Cost shall include all labour, materials and equipment for proper campletion of work.

Pay Item No.	Description	Unit of Measurement
5-7-a	Installation of paving blocks 50 mm (2) inches thick	SM or 100 sft.
5-7-b	Installation of paving blocks 60 mm (2 ½) inches thick	SM or 100 sft.
5-7-c	Installation of paving blocks 80 mm 3 inches thick	SM or 100 sft.
5-7-d	Installation of paving blocks 100 mm 4 inches thick	SM or 100 sft.

SECTION – 5-10

BRICK EDGING

5-10 SECTION - BRICK EDGING

5-10.1 DESCRIPTION

This item shall consist of a 9 inch wide brick on edge layer, contiguous to the pavement edge and in line with the finished profile of the base course, in combination with a 3 inch wide brick on end course so as to make 12 inches wide brick edging. The bricks shall be laid with close joints over one inch sand cushion and sand grouted.

5-10.2 MATERIAL

5-10.2.1 Bricks

The size of bricks shall be as per section 1041. They shall be slightly over burnt without being vitrified. They shall be slightly over burnt without being vitrified. They shall be of uniform colour with reasonably square corners and parallel faces. They must be homogenous in texture and emit a clear ringing sound when struck. They shall be free from lime, air pockets, and marked laminations. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no sings of efflorescence on drying. Compressive strength shall not be less than 2000 1b/sq. in. when tested in accordance AASHO T – 32.

They shall be burnt from suitable soil which shall not contain detrimental quantities of salts.

5-10.2.2 Sand

The sand on which the bricks are bedded and for filling the joints shall be free flowing and show no plasticity.

5-10.2.3 Construction Requirements

Except for the top most layer of the base course, all other layers of sub base and base course shall be laid and compacted without laying edging but after completion of the consecutive layers of earthen shoulders at the same level as the pavement layer as the pavement layer to be rolled. If considered necessary, for each layer ordinary bricks may be used as form work on both sides to be removed after comp[acting the adjacent layers of sub base and base course.

While laying the top most layer of the base course 9 inch wide brick on edge layer shall be laid over 1 inch sand cushion with close joints and sand grouted. The top of these bricks after rolling shall be in line with the finished profile of the base course. The brick layer shall be rolled simultaneously with the final layer of base course after completion of the earthen shoulders.

There in. wide brick on end course shall be laid after excavating the earthen shoulders contiguous to the 9 inches wide brick layer with top of the end course at the same level as that of the brick on edge course. The brick on end course shall be laid with close joints over 1 inch sand cushion and sand grouted.

5-10.3 MEASUREMENTS AND PAYMENTS

5-10.3.1 Measurements

Brick edging when laid and finished in accordance with the provisions of this section shall be measured in linear units. The Unit of measurement shall be one meter or one hundred feet of the brick edging.

5-10.3.2 Payment

The unit rate of brick edging shall be full compensation for provision of materials and completion of the work as specified in this section.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
5-10	Brick Edging	One meter or per foot

SECTION – 5-11

PAVEMENT WIDENING

5-11 SECTION PAVEMENT WIDENING

5-11.1 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.

5-11.2 MATERIALS

Materials for the construction of "Pavement Widening" shall conform to the requirements specified in relevant items of Sub base and Base course in these specifications.

5-11.3 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-191 method. If the plans do not call for a specific type of compaction, the subgrade, sub base 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

5-11.4 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.

Reflector zed 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."

5-11.5 MEASUREMENT AND PAYMENT

5-11.5.1 Measurement

"Pavement Widening" shall be measured by the unit of sq. or 100 sft. and shall include all excavation, trimming, disposal and compaction of subgrade and subsequent layers of sub base and base course.

The removal of edge kerb if exists, will not be paid for separately but will be considered subsidiary to the item of "Pavement Widening".

Water, ordered by the Engineer or added with the consent of the Engineer, which is necessary to obtain satisfactory compaction of the foundation treatment will not be paid for separately, but will be considered subsidiary to the item of "Pavement Widening". No measurement will be made of unauthorized areas or for extra width or thickness.

5-11.5.2 Payment

The amount of completed and accepted · Work, measured as provided above, will be paid for at the unit price bid in the Bill of Quantities for which price shall be full compensation for furnishing materials, such as sub base, base course and water etc., for all labour, equipment, tools, supplies, and all other items necessary for the proper completion of the Work. Full compensation will be considered included in all payment items and not separately compensated.

SECTION – 6-1

BITUMINOUS PRIME COAT

6-1 SECTION – BITUMINOUS PRIME COAT

6-1.1 DESCRIPTION

This work shall consist of furnishing all plant, labor, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated earth subgrade, water bound base course, crushed aggregate base course, tops of roadway shoulders, and as otherwise shown on the plans in strict accordance with the specification and in conformity with the lines shown on the drawings.

6-1.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of the Section 10-3 “Asphaltic Materials", either cutback or Emulsified Asphalt, whichever is specified in the Bill of Quantities. However, the bituminous materials used for prime coats should have high penetrating qualities. After curing it should leave a high viscosity residue in the voids of the upper portion of the base course. The suitable material for this purpose is liquid asphalt (Cut-back) or road tar (RT) of low viscosity. Rapid curing (RC) grades are not generally used because of their rapid increase in viscosity after application. Medium curing (MC) grades are most widely used which best serve the purpose. The grade and rate of application will be governed by the condition of the existing surface, and the following guidelines need to be followed.

a. Bituminous Materials

Bituminous materials shall be of the type and grade called for in the bid schedule and shall conform to the requirements of Section 10-3 Medium curing (MC) grades are most widely used which best serve the purpose.

b. Rate of Application

MC-70 Grade is generally suited for priming non-bituminous aggregate base and rate of application shall be 0.65 litre to 1.75 litres/m^2 (13 Lbs to 35 Lbs/100 sft). A quantity of 1 litre/m^2 (20 Lbs/100 sft) is usually recommended.

The ideal rater of application of a primer is the maximum that will under favourable weather conditions be completely absorbed by the base course aggregate particles within 24 to 48 hours from the time of application.

c. Blotter Materials

Generally a prime coat should be touch dry within 2 to 4 hours and completely dry in 24 to 48 hours. If it is necessary to use blotter materials because the section has to be opened to traffic or for other reasons, the blotter material shall be clean and dry sand passing 4.75 mm (No. 4) sieve. .

6-1.3 CONSTRUCTION REQUIREMENTS

6-1.3.1 Weather Limitations

Prime coat shall be applied only when the surface to be treated is dry or slightly damp and drying when the atmospheric temperature in the shade is above 13°C (55°F) and rising or above 16°C (60°F) if falling, and it shall not be applied in rain or a dust storm. The temperature requirements may be waived, but only when so directed by the Engineer.

6-1.3.2 Clearing of Surface

Prior to the application of the prime coat, all loose dirt and other objectionable materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and/or 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. If the Engineer so requires the surface shall be slightly bladed and rolled immediately prior to the application of bituminous materials, a light application of water shall be made just before the application of the bituminous material, if directed by the Engineer. Prior to the application of prime coat on bridge decks and concrete pavements, the surfaces shall be cleaned of all loose material. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer.

6-1.3.3 Areas to be Primed

Areas to be primed will be classified as under:

i. The top of earth surface or water bound base courses from a point 20 centimeters outside the edge of the pavement line to 20 centimeters outside the line on the opposite side of the roadway.

ii. The top of the shoulders from the intersection of embankment slope and top layer to the edge of the pavement line.

iii. The bridge wearing surface from curb to curb and end to end of bridge wearing surface.

iv. Other surfaces as shown on the plans or ordered by the Engineer. Primed surface shall be kept undisturbed for at least 24 hours, so that the bituminous material travels beneath and leaves the top surface in non-tacky condition. No asphaltic operations shall start on a tacky condition.

6-1.3.4 Equipment

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 1000 liter (220 Imperial Gallon) capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed 100 kg/cm width of tyre. It shall be of recognized manufacturer.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid up to 180°C. The heating device shall be so that overheating will not occur consequently; the flames must not touch directly on the casting of the tank containing the asphaltic liquid or gases there from. 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 the drop in temperature when the tank is filled and not heated will be less than 2°C per hour. A thermometer shall be fixed to the tank in order to be able to control 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 contents. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The distributor shall be able to vary the spray width of the asphaltic liquid in steps of maximum 10 cm, to a total width of 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

The distributor shall have a pump for spraying the liquid driven by a separate motor, or the speed of the pump shall be synchronized with the speed of the distributor. The pump shall be furnished with an indicator showing the performance in liters per minute. At the suction side the pump shall have a filter easily exchangeable. 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 the speed in meter per minute. The tachometer shall be visible from the driver's seat. The function of the distributor shall be so exact that the deviation from the prescribed quantity to be spread on any square meter does not exceed 10%. The distributor shall be equipped with a device for hand spraying of the bituminous liquid, to cover any irregular area or covering the area improperly sprayed.

6-1.3.5 Application of Asphaltic Material

Immediately before applying prime coat, the full area of surface to be treated shall be swept with a power broom to remove all dirt and other objectionable material. If required by the Engineer, the surface shall be made moist but not saturated. Asphaltic Materials shall be applied at temperature stated in Section 10-3 by approved pressure distributors operated' by skilled workmen:

The spray nozzles 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.

The rate for application of asphaltic material (cut back/emulsified) shall be as under:

TYPE OF SURFACE	LITRES PER SQUARE METER	
	Minimum	Maximum
Subgrade, Sub base, Water bound base course, and Crushed stone base course.	0.65	1.75
Bridge, Wearing Surface, Concrete Pavement	0.15	0.4

However, the exact rate shall be specified by the Engineer determined from field trials.

The test methods shall be determined by the Engineer and performed by the Contractor in the presence of Engineer.

6-1.3.6 Maintenance of Opening of Traffic

The prime coat shall be left undisturbed for a period of at least 24 hours, and shall not be opened to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. 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 sand or similar treatment. All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

The surface of structures and trees adjacent to the area being treated shall be protected in such manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to ½ the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area. Work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for traffic.

6-1.4 MEASUREMENT AND PAYMENT

6-1.4.1 Measurement

The unit of measurement shall be as below as actually covered by prime coat in accordance with these specifications. No measurement or payment will be made for the areas primed outside the limits specified, herein, shown on the plans or designated by the Engineer.

Blotting material will not be measured for payment and shall be considered subsidiary to the prime coat.

6-1.4.2 Payment

The payment for area primed measured as stated above, shall be made for the unit price per m², or 100 sft. Which payment shall be full compensation for furnishing all labor, material, tools, equipment and incidentals and for performing all the work involved in applying prime coat, complete in place in accordance with these specifications:

Pay Item No.	Description	Unit of Measurement
6-1	Bituminous Prime Coat.	m² or 100 sqf.

SECTION – 6-2

BITUMINOUS TACK COAT

6-2 SECTION - BITUMINOUS TACK COAT

6-2.1 DESCRIPTION

The work covered by this section shall consist in furnishing all plant, labor, equipment and applying asphaltic material on a previously prepared asphaltic layer, in addition to performing all operations in connection with the application of Bituminous tack coat complete in accordance with these specifications and to the width shown on the typical cross sections of applicable drawings. The purpose of laying tack coat is to provide bond between the previously prepared bituminous base or road surfaces with the super imposed courses.

6-2.2 MATERIAL REQUIREMENTS

Bituminous material shall be of the type and grade called for in the bid schedule and shall conform to the requirements of Section 10-3. However, materials commonly used for tack coats include the bitumen of 80/100, or lighter grades, or emulsified asphalt of SS-1 or SS-1h grades.

6-2.3 CONSTRUCTION REQUIREMENTS

6-2.3.1 Weather Conditions

Tack coat shall be applied only when the surface to be treated is dry. It shall be carried out when the atmospheric temperature in the shade is above 12°C (55° F) and rising or above 16°C (60°F) if falling and it shall not be carried out in rain or dust storm. The temperature requirement can be waived, but only when so directed by the Engineer.

6-2.3.2 Cleaning of Surface

Immediately 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. The tack coat shall be applied only when the surface is dry, however for emulsified asphalt, application may be made on a reasonable moist surface. Application of tack coat 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 bituminous binder and no tack coat will be applied until the surface has been approved.

6-2.3.3 Equipment

Equipment shall conform in all respect to the respective provision under 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. The equipment should contain a hand power spray attachment to a bitumen pressure distributor or other container having an independently operated bitumen pump, pressure gauge, thermometer for determining the temperature of the asphalt tank contents and a hose connected to a hand power spray suitable for applying the Bituminous tack coat in the amounts specified. All to be such as to meet the approval of the Engineer.

6-2.3.4 Application of Asphaltic Material:

Immediately after cleaning the surface, bituminous material shall be applied at the rate directed by the Engineer. When straight run bitumen 80/100 or lighter grades are used for tack coat, it shall be applied as “spatter” coat of not more than 0.25 litre/m^2 (5 Lbs/100 sft).

The actual rate of application of tack coat shall be decided by the Engineer.

The tack coat shall be applied on cleaned surface and only when it is dry.

When emulsified asphalt is used, it shall be diluted with an equal amount of water and applied at the rate of 0.25 to 0.70 litre/m^2 or 5 lbs to 14 lbs/100 sft, of the diluted asphalt emulsion.

The surface of structures and trees adjacent to the areas being treated shall be protected in such manner as to prevent their being spattered or marred. No bituminous material shall be discharged into a borrow pit or gutter.

The surface shall be allowed to dry until it is in a proper condition of tackiness to receive the surface course. Tack coat shall be applied only so far in a advance of surface course placement as is necessary to obtain this proper condition of tackiness. Until the surface course is placed the Contractor shall protect the treated area from damage.

Care shall be taken that the application of asphaltic material is not in excess of the specified quantity; any excess asphalt shall be blotted by sand or similar treatment. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structure and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one half the roadway widths at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the treated area work shall not be started on the portion of the road not covered by previous application until the surface previously covered has dried and is ready for paving.

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 or otherwise shall be cleaned by Contractor at his own cost before the next course is applied.

6-2.4 MEASUREMENT AND PAYMENT

6-2.4.1 Measurement

The quantities of Bituminous Tack Coat shall be measured in square meter for the actual area Tacked with asphaltic material on the prepared surface in accordance with this specification.

6-2.4.2 Payment

The payment of bituminous Tack coat, measured as stated above shall be paid for at the unit price per square meter, or 100 sft. Which payment shall be full compensation for furnishing all labor, materials, tools, equipment and incidentals and for performing all the work involved in applying Tack Coat complete in place, as shown on the Drawings and in accordance with these specification.

Pay Item No.	Description	Unit of Measurement
6-2	Bituminous Tack Coat	m^2 or 100 sft.

SECTION – 6-3

BITUMINOUS SURFACE TREATMENT AND SURFACE DRESSING

6-3 SECTION - BITUMINOUS SURFACE TREATMENT AND SURFACE DRESSING

6-3.1 DESCRIPTION

The work specified in this section shall consist of furnishing and applying bituminous material of the type and grade specified and the cover material of specified size (s) as detailed in these specifications.

6-3.2 MATERIALS

6-3.2.1 Bituminous Binders

Bituminous binders will be of the type and grade as specified taking into consideration climatic conditions and the intensity of traffic, and will be in accordance with the requirements of the quantities of bituminous binders recommended in 6-3.1 and 6-3.1 are for penetration grade asphalts. The quantities of cutbacks and emulsified asphalts shall be based on the amount of asphalt residue or as directed by the Engineer.

6-3.2.2 Aggregate

The aggregate shall be of the specified nominal size in conformity with the grading and shape given in table 6-3.2 (A) and 6-3.2 (B). Crushed gravel or crushed stone shall consist of clean, tough, durable fragments, free from dirt or other deleterious substances and shall not have a percentage of Los Angles wear greater than 35% at 500 revolutions as determined by AASHTO T-96. The quantities of aggregates recommended in Table 6-3.1 (A) and 6-3.1 (B) are for Triple Surface Treatment and Surface Dressing/resurfacing respectively**.**

TABLE-6-3.1(A)

QUANTITIES OF MATERIAL (BINDER AND AGGREGATE) FOR SURFACE TREATMENT

SURFACE TREATMENT		NOMINAL SIZE		RATE OF SPREADING OF AGGREGATE		RATE OF APPLICATION OF BITUMEN	
Type	Application	Standard	Alternate	Cubic meter /100 sq meter	Cubic feet per /100 sq. ft	Kilogram (kg)/100 sq meter	Pounds (lbs)/ 100 sq. Feet
Triple (Heavy)	Ist COAT	25.00 mm	1”	1.68	5.50	1.95	40
Heavy (Listed)	2nd COAT	12.50 mm	½”	0.84	2.75	122	25
	3rd COAT	06.30 mm	¼”	0.46	1.50	68	14

TOTAL FOR THREE COATS.				2.98	9.75	385	79
Triple	1st Coat	19.00 mm	¾"	1.22	4.00	171	35
Light	2nd Coat	09.5 mm	⅜"	0.61	2.00	88	18
	3rd Coat	06.30 mm	¼"	0.46	1.50	68	14
TOTAL FOR THREE COATS				2.29	7.50	327	67

TABLE-6-3.1(B)

QUANTITIES OF MATERIAL (BINDER AND AGGREGATE) FOR SURFACE TREATMENT

Surface treatment		**Nominal size**		**Rate of spreading of Aggregate**		**Rate of application of Bitumen**	
Type	**Application**	**Standard**	**Alternate**	**Cubic meter /100 sq meter**	**Cubic feet per /100 sq Feet.**	**Kilogram (kg)/100 sq meter**	**Pounds (lbs)/ 100 sq. Feet**
Resurfacing (Heavy)	Single coat	19.00 mm	¾"	1.06	3.5	107	22
Resurfacing (Light)	Single coat	12.50 mm	½"	0.67	2.50	98	20

TABLE 6-3.2(A)
GRADING SPECIFICATIONS FOR SINGLE SIZE CHIPPING.

Nominal Nominal size	Specified size			Over size			Under size			Maximum Permissible Flakiness Index (Bs-812)
	Passing Sieve	Retained sieved	Minimum proportion of specified size percent	All to pass sieve	Max of nominal size retaining on sieve percent	Passing sieve	Max of nominal size retaining on sieve percent	Passing sieve	Maximum Fins Percent	
25.0 mm (1”)	25.0 mm (1”)	19.0mm (3/4”)	60	37.5 mm (1-½”)	15	12.5 mm (1/2”)	7	2.38 mm (No.8)	2	35
19.0 mm (3/4”)	19.0 mm (3/4”)	12.5 mm (1/2”)	65	25.0mm (1”)	15	9.5 mm (3/8”)	7	2.38 mm (No.8)	2	35
12.5mm (1/2”)	12.5mm (1/2”)	9.5mm (3/8”)	55	19.0mm (3/4”)	15	6.3 mm (1/4”)	7	2.38 mm (No.8)	2	35
9.5mm (3/8”)	9.5mm (3/8”)	6.3 mm (1/4”)	60	12.5mm (1/2”)	15	4.75 (mm) (No.4)	10	2.38 mm (No.8)	2	35
6.3 mm (1/4”)	6.3 mm (1/4”)	3.3mm (1/8”)	70	09.5mm (3/8”)	15	02.38 mm (No.8)	10	0.60 mm (No.8)	2	35

TABLE 6-3.2(B)
ALTERNATE GRADING (SINGLE SIZE CHIPPING)

Nominal size	Sieve Size									Maximum permissible flakiness index (BS-812)
	37.5 mm 1-½”	25 mm 1”	19 mm ½”	12.5 mm ½”	9.5 mm ⅜”	6.3mm ¼”	4.75 mm No.4	2.38 mm No.8	0.075 mm No.200	
Percentage Passing By Weight										
25 mm (1”)	100	85-100	0-40	0-7	-	-	0-1	-	0-0.5	35
19 mm (3/4”)	-	100	95-100	0-20	0-5	-	-	-	0-05	35
12.5mm (1/2”)	-	-	100	95-100	0-30	0-5	-	-	0-0.5	35
9.5 mm (3/8”)	-	-	-	100	95-100	0-40	0-5	-	0-0.5	35
6.3 mm (1/4”)	-	-	-	-	100	85-100	0-30	0-10	0-0.5	35
4.75mm (No.4)	-	-	-	-	-	100	95-100	0-40	0-0.5	35

6-3.3 CONSTRUCTION REQUIREMENTS AND DETAILS

6-3.3.1 Temperature and Weather Limitations

Bituminous material shall be applied only when the atmospheric temperature in the shade is above 10 ^{0}C(50 ^{0}F) and rising or above of 16 ^{0}C (60 ^{0}F) if falling and it shall not be carried out in rain or dust storm.

6-3.3.2 Preparation of the Surface for Treatment

The surface of the base course to be treated will be cleaned of all loose dust and deleterious materials using mechanical broom and /or mechanical blower. Hand brooms may be approved by the Engineer if sufficient labour is available. All necessary patching on old black top surface shall be carried out in a way as to bring the surface of the patch to match the texture of the remaining road as closely as possible, at least ten days ahead of surface treatment. The surface of the old black top road shall also be cleaned before application of bituminous materials. The non-bituminous base shall be primed if so required. However priming of WBM can be invariably avoided if it is properly water bound and cleaned to create mosaic stony surface, to the satisfaction of the Engineer.

6-3.3.3 Application of Bituminous Binder

The bituminous material shall be applied when the surface to be treated is dry through a distributor at the rate of spread in general conformity with Table 6-1.1 (A or B) or as may be specified by the Engineer and at the appropriate temperature range for the particular bituminous binder. Successive widths of spray shall overlap by an appropriate amount to give a clean start and stop, blotting paper will be spread across the road and the spray started and stopped on this. The paper will be disposed off as directed by the Engineer. If the spray bar is not protected by hood to prevent the binder being blown out care shall be taken to protect such objects.

6-3.3.4 Spreading the Cover Aggregate

The cover aggregate for each layer of bitumen will be spread within 2 minutes of the application of bitumen, the rate of spread will be sufficient to give complete shoulder to shoulder coverage of chipping and in general conformity with Table 6-3.2 (A) & (B). Any bare spots will be covered up by hand or brushing. The aggregate shall be cleaned/screened to the satisfaction of Engineer so as to conform to required specification before application.

6-3.3.5 Rolling

Rolling may be done by a self-propelled pneumatic tyred roller (Min. weight ¾ ton per wheel with 40 psi tyre pressure or 6-8 ton three wheel rollers. The first rolling of the cover aggregate shall be completed within 15 minutes after it has been spread. Rolling should not be continued when the chippings show sign of crushing. After 24 hours, or longer period, the surplus aggregate shall be removed by brushing and the subsequent layers be applied in the same manner, as specified above.

6-3.3.6 Opening of Traffic and Traffic Control

During the execution of work of surface treatment or surface dressing, diversion shall be provided and sufficient control exercised to prevent traffic coming on the treated road till the bituminous material has dried, and in the opinion of the Engineer will not picked up under traffic.

6-3.3.7 Stockpiling (Stacking)

When indicated on the drawings and called for in the Bid Schedule, cover aggregate shall be furnished and stockpiled (stacked) in the required quantity and at the locations, as approved by the Engineer and in accordance with Section 1031.

6-3.4 MEASUREMENT AND PAYMENT

6-3.4.1 Measurement

Surface treatment or surface dressing of a specified type shall be measured by superficial area. The unit of measurement shall be one square meter or per 100 Sq. ft.

When indicated on the drawings and called for in the bid schedule cover aggregate of the specified size (s) shall be stock piled (Stacked0 in the required quantity and at the locations approved by the Engineer. The unit of measurement shall be one cubic meter or one hundred cubic feet.

6-3.4.2 Payment

The unit rate shall be full compensation for furnishing and applying bituminous material and aggregate in the specified quantities including all labour, materials, equipment, tools and incidentals to complete the work prescribed in this section.

When called for in the bid schedule, the unit rate for stockpiling of aggregate of the specified size (s) shall be full compensation for procurement, supply and stacking of specified quantity of aggregate. Separate rates shall be quoted by the Contractor for aggregates required for each coat of surface treatment and surface dressing.

Payment shall be made as under:-

Pay Item No.	Description	Unit of Measurement
6-3	Triple Surface Treatment using the specified quantities of Bitumen and Aggregate	
	a. Triple Surface Treatment Heavy	Per sq.m or per 100 sft
	b. Triple Surface Treatment Light	Per sq.m or per 100 sft
6-3	Surface Dressing (Re-surfacing) using the specified quantities of Bitumen and Aggregate	

	a. Surface Treatment Heavy	Per sq.m or per 100 sft
	b. Surface Treatment Light	Per sq.m or per 100 sft
6-3	Supplying aggregate of specified size for triple surface i. For Heavy Treatment ii. For Light Treatment	Per cubic meter (m^3) or per 100 cubic feet (ft^3) Per cubic meter (m^3) or per 100 cubic feet (ft^3)
6-3	Supplying aggregate of specified sizes for Resurfacing i. For Heavy Treatment ii. For Light Treatment	Per cubic meter (m^3) or per 100 cubic feet (ft^3)

SECTION – 6-4
SEMI GROUT SURFACING

6-4 SECTION - SEMI GROUT SURFACING

6-4.1 DESCRIPTION

This work shall consist of furnishing and placing three courses of graded aggregate and two applications of bituminous binders, with a bituminous seal coat and chip covering, constructed on a prepared surface, by the penetration method, in accordance with these specifications in reasonably close conformity with the lines, grades thickness and typical cross sections shown on the plans or established by the Engineer. The Specification of this section are applicable if the item exists the bid schedule.

6-4.2 MATERIALS

6-4.2.1 Bitumen

The type of bituminous material will be specified in the contract and the grade designated by the Engineer. The bituminous material furnished shall meet the requirement is of Section 10-3.

6-4.2.2 Aggregate

Aggregate shall consist of crushed clean, hard, tough and durable fragments of stone or gravel, free from soft and disintegrated pieces, organic impurities and other injurious material. Coarse aggregate shall be free from an excess of flat or elongated pieces. The flakiness index shall not exceed 35 percent.

Screenings to fill the voids in the coarse aggregate shall be of crushed stone, quarry waste or any other suitable material having same cementing properties as per gradation in table 6-.4.1.

6-4.2.3 Gradations

Gradation of coarse aggregate (essentially single sized), key aggregate and cover aggregate shall conform to the requirements of Table 6-4.1 Aggregate Gradation. The nominal size of the coarse aggregate shall not be less than one half or more than 3/4 of the thickness of layer. Quantities of materials shall be in accordance with Table 6-4.2 – (Quantities of Material for 50 mm or 2” thick semi grout surfacing).

TABLE 6-4.1: AGGREGATE GRADATION

	Percent Passing By Weight					
	Coarse Aggregate		**Key Aggregate**	**Cover Aggregate**	**Seal Aggregate**	**Screening**
	No. (1)	No. (2)				
75mm	100					

63mm	90-100	100					
50mm		90-100					
38mm	15-35						
25mm	0-10	15-35	100				
19mm		0-10	55-100	100			
12.5mm			0-15	90-100	100		
9.5mm			-	-	85-100	100	
4.75mm			0-2	10-30	10-40	80-100	
2.38mm				0-3		-	
0.15mm						10-30	

TABLE 6-4.2: QUANTITIES OF MATERIALS FOR 50mm THICK SEMI GROUT SURFACING

QUANTITY OF MATERIALS PER Sq. m					
	Bitumen kgs.	**Coarse Aggregate Cu. m.**	**Key Aggregate Cu. m.**	**Cover Aggregate Cu. m.**	**Seal Aggregate Cu. m.**
First Application	- -	- -	0.06	- -	- -
First Application	2.44	- -	- -	- -	- -
Second Spreading	- -	- -	0.005	- -	- -
Second Application	0.32	- -	- -	- -	- -
Third Spreading	- -	- -	- -	0.0028	- -
Third Application	0.18	- -	- -	- -	- -
Seal Spreading	- -	- -	- -	- -	0.0012

Note: The quantities of first spreading of aggregate and the first application of bitumen may be proportionately increased depending upon the thickness of the course. There will be no change in the subsequent operations.

6-4.3 CONSTRUCTION REQUIREMENTS

6-4.3.1 Weather Limitations

Semi grout surfacing shall not be done on any wet surface, when the air temperature is below 15 degree (60 °F) C or when weather conditions otherwise would prevent the proper construction of the pavement.

Note: Dates may be established by the Engineer between which no bituminous layer shall be placed except with written approval.

6-4.3.2 Equipment

The equipment to be used shall include a power broom (hand brooms may be used if sufficient labour is available), or a power blower, (8 – 12 ton) rollers, spreader as may be approved by the Engineer for spreading coarse aggregates, a bituminous binder distributor, and equipment for heating bituminous material.

6-4.4 CONSTRUCTION METHODOLOGY

6-4.4.1 Placing and Compacting Coarse Aggregate capital

Immediately before placing coarse aggregates the surface upon which the pavement is to be constructed, a layer of screenings @ 0.018 cu. Meter per square meter or 6 cubft / 100 sft. .shall be placed in a uniform thickness.

Coarse aggregate shall be placed in the required amount by approved stone spreaders, or by other approved methods. All areas of non – uniformly graded aggregate shall be removed and replaced with suitable material before the rolling begins. These corrections shall be made by hand picking whenever necessary and shall be continued after initial rolling until the appearance and texture of the aggregate are uniform and all irregularities are corrected.

The coarse aggregate shall be dry rolled until the aggregate does not creep or wave ahead of the roller. Rolling shall be parallel to the road center line and shall start at the outer edges of the road, overlap equal portions of aggregate and shoulder and progress toward the center, overlapping on successive passes by at least one – half the width of the roller except that on super – elevated curves rolling shall progress from the lower to the upper edge. Finally sufficient water shall be added to make slurry with the screening under the roller and rolling continued till the surface is even and firm.

Material which crushes under the roller or becomes segregated in such manner as to prevent free and uniform penetration of the bituminous material shall be removed and replaced with the suitable aggregate. Any irregularities in the surface profile shall be made good by raking or filling.

Along curbs, headers, and walls, and at all places not accessible to the roller, the aggregate shall be tamped thoroughly with mechanical tampers or with hand tampers. Each hand tamper shall weigh not less than 13.60 kg, and have a face area of not more than 650 square cm.

Aggregate in any course that becomes coated or mixed with dirt or clay prior to the application of the bituminous material shall be removed and replaced with clean aggregate, and the area shall be rerolled. Any dust or vegetable matter shall completely be removed and the slurry within 9.5mm – 25mm of the surface shall be cleaned and removed by coir brushes.

Prior to application of the bituminous material, the surface of the aggregate will be tested by the Engineer using a 3.048 m straight edge at selected location. The variation of the surface from the testing edge of the straight edge between any two contacts with the surface shall at no point exceed 4.75mm. All humps or depression exceeding the specified tolerance shall be corrected by removing defective work and replacing it with new material as specified.

6-4.4.2 Application of Bituminous Materials

Bituminous material shall be uniformly applied by distributor at the rate specified. The bituminous binder shall be heated at the specified temperature for the grade of the bitumen used. Successive spray widths shall be overlapped by an amount sufficient to give a uniform rate of spread over the joint. During the application of bituminous material care shall be taken to prevent spattering adjacent pavement, structures and trees. The distributor shall not be cleaned or discharged into ditches, borrow pits or the shoulders or along the right of way.

6-4.4.3 Application of Key Aggregate

Immediately following the first application of bituminous material, key or choke aggregate shall be spread and worked into the voids of the coarse aggregate by broom dragging and rolling. Additional key aggregate shall be spread as required, broom dragged and rolled until the course is uniformly filled and compacted. If the layer of penetration is more than 75mm compacted the process outlined above in sub section 3.3 to 3.5 shall be repeated for successive layers.

6-4.4.4 Cover and Seal Coat

Before a cover and a seal coat is applied the loose stone the surface shall be brushed off, and the surface sprayed with the quantity of bitumen specified in Section 3-4. The cover aggregate of the size specified shall be spread within 15 minutes of applying the bitumen and rolled with a steel tyred roller or pneumatic tyred roller. Rolling shall not be continued if the aggregate shows excessive crushing. The surface may be opened to traffic after this treatment if no rain is anticipated for unto 3 months or otherwise the seal coat shall be provided at the earliest.

6-4.4.5 Seal Coat

Seal coat forms an essential part of semi grout surface course which should not be delayed for more than 6 months and in any case should be provided before the first rainy season.

Before applying the final seal coat, all loose chipping or foreign matter shall be removed with brooms or flowers. The bitumen specified shall then be sprayed at the specified rate of spread and covered with seal aggregate within 15 minutes. The surface shall be rolled and surplus aggregate removed after 7 days.

6-4.4.6 Stockpiling

Stockpiling of aggregate shall be carried at points specified on the plans or approved by the Engineer in accordance with specifications of course aggregate for concrete.

6-4.5 MEASUREMENT AND PAYMENT

6-4.5.1 Measurement

Semi grout surfacing of specified thickness shall be measured by superficial area. The unit of measurement shall be square meter or 100 sq.ft.

6-4.5.2 Payment

The unit rate shall be full compensation for furnishing and applying the bituminous material and aggregates in the specified quantities (in all the 3 courses), including all materials, labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section. Payment shall be made under

Pay Item No.	Description	Unit of Measurement
6-4	Semi Grout Surfacing of Specified Thickness	m^2 100 sqt.

SECTION – 6-5
PENETRATION MACADAM

6-5 SECTION - PENETRATION MACADAM

6-5.1 DESCRIPTION

This work shall consist of furnishing and placing one or more courses of graded aggregate and one or more applications of bituminous binders, with a bituminous seal coat and chip covering, constructed on a prepared surface, by the penetration method, in accordance with these specifications in reasonably close conformity with the lines, grades, thickness and typical cross sections shown on the Plans or established by the Engineer. The specifications of this section are applicable only if the item exists in the bid schedule

6-5.2 MATERIALS

6-5.2.1 Bitumen

The type of bituminous material will be specified in the contract and the grade designated by the Engineer. The bituminous material furnished shall meet the requirements of Section 10-1.

6-5.2.2 Aggregate

Aggregate shall consist of crushed clean, hard, tough and durable fragments of stone or gravel, free from soft and disintegrated pieces, organic impurities and other injurious material. Coarse aggregate shall be free from an excess of flat or elongated pieces. The flakiness index shall not exceed 35 percent.

6-5.2.3 Gradations

Gradation of coarse aggregate (essentially single sized), key aggregate and cover aggregate shall conform to the requirements of Table 6-5.1 Aggregate Gradation. The nominal size of the coarse aggregate shall not be less than one half or more than ¾ of the thickness of layer. Quantities of materials shall be in accordance with Table 6-5.2 and 6-5.3.

TABLE 6-5.1
AGGREGATE GRADATION

	PERCENT PASSING BY WEIGHT			
	Coarse Aggregate	Key Aggregate	Cover Aggregate	Seal Aggregate
75mm	100			
63mm	90-100			
50mm	35-70			
38mm	0-15	100		
25mm		90-100		
19mm		40-75	100	
12.5mm		15-35	90-100	100

9.5mm		0-5	40-75	85-100
4.75mm		0-5	5-25	10-40
2.38mm		-	0-10	0-10
1.18mm		-	0-5	-

TALE 6-5.2

QUANTITIES OF MATERIALS FOR 75mm THICK PENETRATION MACADAM

Sequence of Operation	QUANTITY OF MATERIALS PER Sq. m.				
	Bitumen kgs.	Coarse Aggregate Cu. m.	Key Aggregate Cu. m.	Cover Aggregate Cu. m.	Seal Aggregate Cu. m.
First Spreading	- -	0.09	- -	- -	- -
First Application	7.33	- -	- -	- -	- -
Second Spreading	- -	- -	0.02	- -	- -
Second Application	1.71	- -	- -	- -	- -
Third Spreading	- -	- -	- -	0.011	- -
Third Application (Seal)	0.68	- -	- -	- -	- -
Seal Spreading	- -	- -	- -	- -	0.004

TABLE 6-5.3
QUANTITIES OF MATERIALS FOR 50mm THICK PENETRATION MACADAM

Sequence of Operation	Bitumen kgs	Coarse Aggregate	Key Aggregate Cu. m.	Cover Aggregate Cu. m.	Seal Aggregate Cu. m.
First Spreading	- -	0.061	- -	- -	- -
First Application	4.88	- -	- -	- -	- -
Second Spreading	- -	- -	0.015	- -	- -
Second Application	1.71	- -	- -	- -	- -
Third Spreading	1.22	- -	- -	0.010	- -
Third Application (Seal)	0.68	- -	- -	- -	- -
Seal Spreading	- -	- -	- -	- -	0.046

6-5.3 CONSTRUCTION REQUIREMENTS AND DETAILS

6-5.3.1 Weather Limitations

Penetration macadam shall not be placed on any wet surface, when the air temperature is below 18.9^{o}C or when weather conditions otherwise would prevent the proper construction of the pavements.

NOTE: Dates may be established between which no bituminous penetration macadam pavement shall be placed except with written approval.

6-5.3.2 Equipment

The equipment to be used shall include a power broom (Hand brooms may be used if sufficient labour is available), or a power blower, (8 – 12 ton) rollers, spreader as may be approved by the Engineer for spreading coarse aggregates, a bituminous binder distributor, and equipment for heating bituminous material.

6-5.3.3 Placing and Compacting Coarse Aggregate

Immediately before placing coarse aggregates the surface upon which the pavement is to be constructed shall be swept clean.

Coarse aggregate shall be placed in the required amount by approved stone spreaders, or by other approved methods. All areas of non – uniformly graded aggregate shall be removed and replaced with suitable material before the rolling begins. These corrections shall be made by hand picking whenever necessary and shall be continued after initial rolling until the appearance and texture of the aggregate are uniform and all irregularities are corrected.

The coarse aggregate shall be dry rolled giving two coverage of 8 – 12 ton roller. Rolling shall be a parallel to the road center line and shall start at the outer edges of the road, overlap equal portions of aggregate and shoulder and progress toward the center, overlapping on successive passes by at least one – half the width of the roller except that on super elevated curves rolling shall progress from the lower to the upper edge.

Material which crushes under the roller or becomes segregated in such manner as to prevent free and uniform penetration of the bituminous material shall be removed and replaced with the suitable aggregate. The compacted coarse aggregate shall have a firm, even surface and any irregularities in the surface profile shall be made good by raking or filling.

Along curbs, headers, and walls, and at all places not accessible to the roller, the aggregate shall be tamped thoroughly with mechanical tampers or with hand tampers. Each hand tamper shall weigh not less than 13.60 kg, and have a face area of not more than 645 square cm.

Aggregate in any course that becomes coated or mixed with dirt or clay prior to the application of the bituminous material shall be removed and replaced with clean aggregate, and the area shall be rerolled.

Dry rolling shall be stopped when the surface of the coarse aggregate will support the distributor and before the voids are closed to prevent the free uniform, penetration to the bituminous material.

Prior to application of the bituminous material, the surface of the aggregate will be tested by the Engineer using a 3m straight edge at selected location.

The version of the surface from the testing edge of the straight edge between any two contacts with the surface shall at no point exceed 4.75mm. All humps or depression exceeding the specified tolerance shall be corrected by removing defective work and replacing it with new material as specified.

6-5.3.4 Application of Bituminous Material

Bituminous material shall be uniformly applied by distributor at the rate specified. The bituminous binder shall be heated at the specified temperature for the grade of the bitumen used. Successive spray widths shall be overlapped by an amount sufficient to give a uniform rate of spread over the joint. During the application of bituminous material care shall be taken to prevent spattering adjacent pavements, structures and trees. The distributor shall not be cleaned or discharged into ditches, borrow pits on the shoulders or along the right of way.

6-5.3.5 Application of Key Aggregate

Immediately following the first application of bituminous material, key or choke aggregate shall be spread and worked into the voids of the coarse aggregate by broom dragging and rolling. Additional key aggregate shall be spread as required, broom dragged and rolled until the course is uniformly filled and compacted. If the layer of penetration is more than 75mm. compacted the process outlined above in Sub Section 6-5.3.3 to 6-5.3.5 shall be repeated for successive layers.

6-5.3.6 Cover and Seal Coat

If the penetration macadam is to be opened to traffic, a cover and a seal coat shall be applied. The loose stone on the surface shall be brushed off, and the surface sprayed with the quantity of bitumen specified in the manner outlined in Sub Section 6-5.3.4. The cover aggregate of the size specified shall be spread within 15 minutes of applying the bitumen and rolled with a steel tyred roller or pneumatic tyred roller. Rolling shall not be continued if the aggregate shows excessive crushing. The surface may be opened to traffic after this treatment if no rain is anticipated for upto 3 months or otherwise the seal coat shall be provided at the earliest.

Before applying the final seal coat, all loose chipping or foreign matter shall be removed with brooms or blowers. The bitumen specified shall then be sprayed at the specified rate of spread and covered with seal aggregate within 15 minutes. The surface shall be rolled and surplus aggregate removed after 7 days.

6-5.4 STOCKPILING

Stockpiling of aggregate shall be carried at points specified on the plans or approved by the Engineer in accordance with specifications of course aggregate for concrete.

6-5.5 MEASUREMENT AND PAYMENT

6-5.5.1 Measurement

Penetration macadam in one or more courses for the specified thickness shall be measured by superficial area. The unit of measurement shall be square meter.

6-5.5.2 Payment

The unit rate shall be full compensation for furnishing and applying the bituminous material and aggregate in the specified quantities, including all material, labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section

Pay Item No	Description	Unit of Measurement
6-5	Penetration macadam in one or more courses of specified thickness	m^2 or 100 sft.

SECTION – 6-6

ASPHALTIC BASE COURSE PLANT MIX

6-6 SECTION - ASPHALTIC BASE COURSE PLANT MIX

6-6.1 DESCRIPTION

This work shall consist of furnishing of plant, labor, equipment and material and performing all operations in connection with the construction of an asphaltic plant mix base course on a previously constructed and accepted subgrade, sub base or base course, subject to terms and conditions of the Contract, and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer.

6-6.2 MATERIAL REQUIREMENTS

6-6.2.1 Mineral Aggregate

Mineral aggregates 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 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 at least ninety five (95) percent by weight of material retained on AASHTO No. 4 sieve shall consist of pieces with at least two (2) mechanically fractured faces, and when tested for stability of bituminous mix shall show satisfactory stability.

Fine aggregate which is material passing 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 No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. 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 gradations.

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 applicable requirements.

a. The Percentage of wear by the Los Angeles Abrasion test (AASHTO T

96) shall not be more than forty (40).

b. The loss when subject to five cycles of the Sodium Sulfate Soundness test (AASHTO T 104) shall be less than twelve percent.

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

d. Fine aggregates shall have a liquid limit not more than twenty five (25) and a Plasticity Index of not more than six (6) 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 = 2.5:1).

f. Stripping test shall be performed on coarse aggregates as described under AASHTO T-182 and only that material shall be allowed which qualifies the test.

g. The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behavior so that their affinity with the bitumen to be used is verified.

h. Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

6-6.2.2 Asphaltic Material

Asphalt binder to be mixed with the aggregate to produce asphaltic base shall be asphalt cement having penetration grade 40-50, 60-70 or 80-100 as specified: by the Engineer. Generally it will meet the requirements of AASHTO M -20.

However, if specified specifically performance grade is to be used, then it will meet requirement of AASHTO M-320 as specified.in Bid Schedule. A sample sop of asphalt binder supply from approved source to asphalt plant is attached as Annexure-B.

6-6.2.3 Asphalt Concrete Base Course Mixture

The composition of the asphaltic concrete paving mixtures for base course shall conform to Class A and/or Class B shown in the following table:

TABLE 6-6.2.1: COMBINED AGGREGATE GRADING REQUIREMENTS

Mix Designation	Class A	Class B
Use	Leveling/Base.	Leveling/Base
Compacted Thickness	70 - 90 mm	50 - 80 mm
U.S. Standard Sieve Size Percent passing by weight		
2" (50 mm)	100	
1½" (38 mm)	90-100	100
1" (25 mm)	—	75- 90
¾"(19mm)	56-75	65-80
½" (12.5 mm)	—	55-70

3/8" (9.5 mm)	—	45-60
No. 4 (4.75 mm)	23-40	30-45
No.8(2.38mm)	15-30	15-35
No. 50 (0.300 mm)	4-10	5-15
No. 200 (0.075 mm)	3 - 6	2- 7
Asphalt Content weight percent of total mix	3 (Minimum)	3 (minimum)

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

Compaction, number of blows each end of specimen	75
Stability	1000Kg/(Min.)
Flow, 0.25 mm (0.01 in.)	8-14
Percent air voids in mix	4-6
Percent voids in mineral aggregates	According to Table.-5.3 MS-2 Asphalt institute, sixth edition 1993.
Loss in Stability	25 percent (max.)

Mixes composed of larger size aggregates with maximum size up to 38 mm (1.5 inches) will be prepared according to modified Marshall Method as per MS-2 Asphalt institute, sixth edition, 1993 or the latest edition. The procedure is basically the same as the original method except for following differences that are due to the larger specimen size used:

a. The hammer weighs 10.2 kg (22.5 lb.) and has a 149.4 mm (5.88 inches) flat tamping face. Only mechanically operated device is used for the same 457 mm (18 inches) drop height.

b. The specimen has a 152.4 mm (6 inches) diameter by 95.2 mm (3.75 inches) height.

c. The batch weights are typically of 4 Kg.

d. The equipment for compacting and testing (molds and breaking heads) are proportionately larger to accommodate the larger specimens.

e. The mix is placed in the mold in two approximately equal increments, with spading performed after each increment to avoid honey combing.

f. The number of blows needed for the larger specimen is 1.5 times (75 or 112 blows) of that required for the smaller specimen (50 or 75 blows) to obtain equivalent compaction.

g. The design criteria shall be modified as well, the minimum stability shall be 2.25 times and the range of flow values shall be 1.5 times normal sized specimens.

h. Similar to the normal procedure, following values shall be used to convert the measured stability values to an equivalent value for a specimen with a 95.2 mm (3.751nches) thickness, if the actual thickness varies:

Approximate Height		Specimen volume	Correlation
mm	(inches)	(Cubic cm)	Ratio
88.9	(3 1/2)	1608 to.1626	1.12
90.5	(3 9/16)	1837 to 166	1.09
92.1	(3 5/8)	1666 to 1694	1.06
93.7	(3 11/16)	1695 to 1723	1.03
95.2	(3 3/4)	1724 to 1752	1.00
96.8	(3 13/16)	1753 to 1781	0.97
98.4	(3 7/8)	1782 to 1810	095
100.0	(3 15/16)	1811 to 1839	0.92
101.6	4	1840 to 1968	0.90

6-6.2.4 Job-Mix Formula

At least one (1) week prior to production, a Job-Mix Formula (JMF) for the asphaltic base course to be used for the project, shall be established jointly by the Engineer and the Contractor in the project laboratory. Job mix formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

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), sixth edition 1993, or the latest Edition.

The JMF, with the allowable tolerances shall be within the range specified in Item. 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.

The ratio of weight of filler (passing sieve No. 200) to that of Bitumen shall range between 1.5:1 for hot climate areas with 7 days average temperature more than 40°C.

After the 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.

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

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 60 degrees centigrade for 20 minutes shall not exceeds twenty five (25) percent. If the mixture fails to meet this criterion, JMF shall be modified or an anti-stripping agent shall be used.

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 make it necessary, a new Job Mix Formula will be required.

6-6.3 CONSTRUCTION REQUIREMENTS

6-6.3.1 Bituminous Mixing Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M 156 or ASTM Designation D995-617, and of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Plant shall have minimum three cold bins and at least 3.5 decks of hot sieves.

6-6.3.2 Preparation of Aggregates

Before being fed to the dryer, aggregates for the asphaltic 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 sized that eighty (80) percent will be retained on Sieve No. 4. Should fine material be incorporated in the mix, separate bin shall be provided in addition to 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.

Asphalt cement shall be heated within a temperature range of hundred and thirty five to hundred and sixty three (135-163)° degrees centigrade at the time of mixing. Asphalt cement heated above maximum temperature shall be treated as 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°) degrees centigrade below the temperature of the aggregate, at the time, the two materials enter into the pugmill.

For placing the materials in bins or in moving them from bins to the dryer, any method which causes segregation or uncontrolled combination of materials of different grading, shall be discontinued and the segregated or degraded materials shall be prescreened for reuse.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty three (163), degrees centigrade, If aggregate contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of hundred and sixty three (163) degrees centigrade, they shall be removed from the bins and returned to their respective stock piles. In no case, shall the temperature of asphaltic mix exceed 163 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.

Asphalt plant shall have minimum three and half (3½) sieve decks to effectively control the gradation of hot bins.

6-6.3.3 Transportation and Delivery of Mixtures-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 thirty (130°) degree C. Drivers of dump trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

6-6.3.4 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 and operates 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 malfunctioning 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.

6-6.3.5 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.

6-6.3.6 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 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.

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.

6-6.3.7 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.

The longitudinal joint in one layer shall offset to that in the layer immediately below, by approximately 15.0 cm; however, the joint in the top layer shall be at the centerline of the pavement if the roadway comprises two lanes of width, or at lane lines if the roadway is more than 2 lanes in width.

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 thirty (130°C) degree centigrade 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°C and 190°C be mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

6-6.3.8 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 to proceed longitudinally, parallel to the road centerline, each trip overlapping one half (½) 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°C) degree.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. The rolling speed should remain between 3 to 6 km/h. Too many passes with vibration can cause harmful loosening of material and disturbances in the structure. 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 asphaltic material obtained for daily Marshall Density is achieved.

A approximate approach to achieve desired compaction and no pf roller passes is as below:

Thickness of the Asphalt Layer d(cm)	**Number of passes with vibration with various tandem vibratory rollers**		
	4t	**7t**	**10t**
2	2-4	1-2 (K)	1-2 (K)
4	4-6	2-4 (K)	2-4 (K)
6	4-8	4-6 (K)	2-4 (K)
10	6-8	4-8 (K, G)	4-6 (K, G)
14		6-8 (G)	4-6 (G)
18		6-8 (G)	4-8 (G)
Chip mastic d=2 d=4 porous asphalt d=4		1-2 (K) + stat pass 4-6 (K) + stat pass	1-2 (K) + stat pass 4-6 (K) + stat pass 1-2 (K) + stat pass

K = low amplitude

G= high amplitude

Assumption Compaction temperature> 100C

4t = Machines are with one amplitude only.

1 pass = 1 pass in forward or in reverse direction

Fig: Typical values for the number of vibratory passes

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 wails 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 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.

Sequence of laying and compaction of premix shall be so managed, that a long time does not elapse between successive dump trucks, which may cool down the un-compacted premix, between paver and compacted asphalt below 120°C.

6-6.4 QUALITY CONTROL

6-6.4.1 Frequency of Testing for Cores

One core shall be taken for each 100 linear meter of each lane of Asphaltic 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 behavior 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.

6-6.4.2 Surface Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) meters straightedge by Engineer at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts with the surface shall at no point exceed six (6) millimeters when placed either parallel or perpendicular to centerline of roadway. However, if specified in contract requirement profilometer may be asked for a IRI determinations as specified in bid for surface tolerance.

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 asphaltic base course without additional cost to the Employer.

6-6.4.3 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".

6-6.4.4 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.

6-6.4.5 Weather Limitations

Hot asphaltic mixtures 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.

6-6.4.6 Trial Section

Contractor shall prepare a trial section before the start of work in light of procedure given in clause 1.20 (General).

However, record of asphalt laying will be kept for weekly record on proforma attached as Annexure-A.

6-6.5 MEASUREMENT AND PAYMENT

6-6.5.1 Measurement

The quantities for asphaltic leveling / base course will be measured by surface area per inch compacted in place. Measurement shall be based on the dimension as shown on plan or as otherwise directed or authorized by the Engineer. No measurement shall be made for unauthorized areas or for extra thickness.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of liquid asphalt, wasted or remaining on hand after completion of the work shall not be measured or paid for.

Payment will be subject to determination of Bitumen / Binder quantity based on extraction test determined in a qualified laboratory and paid according to Bid Schedule. If quantity is determined less than specified but within JMF tolerance limits, then will be paid according to extraction tests. But if determined quantity is above Bid Schedule but within JMF band will be paid according to specified in BOQ.

6-6.5.2 Payment

The quantities determined as provided above shall be paid for at the, contract unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full work prescribed in this item. Asphalt additive or anti–stripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items of Asphaltic Base Course.

Pay Item No.	Description	No. of Measurement
6-6	Asphaltic Base Course Plant Mix (with % of bitumen)	100 Sft per inch or mm

SECTION – 6-7

ASPHALTIC CONCRETE BINDER COURSE

6-7 SECTION - ASPHALTIC CONCRETE BINDER COURSE

6-7.1 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.

6-7.2 MATERIAL REQUIREMENTS

6-7.2.1 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, e.g. 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 cuboid 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 30%.

b. The loss when subject to five cycles of the Sodium Sulfate Soundness test (AASHTO T-140) 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 45.

d. All aggregates shall have a liquid limit of net 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 = 2:5:1).

6-7.2.2 Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce asphaltic 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.

6-7.2.3 Asphalt Concrete Binder Course Mixture

The composition of the asphaltic 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
mm	**Inch**	**Weight**
25	1	100
19	¾	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 25 %
Loss of stability	25 % (Max.)
Filler/Bitumen ratio	1-1.5 applicable to hot climate (>45°C

6-7.2.4 Combined Aggregates Gradation

TABLE NO.2

COMBINED AGGREGATE 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.	± 0.3%

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.

6-7.2.5 Job Mix Formula

At least one week prior to production, a Job Mix Formula (JMF) for the asphaltic 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), May 1992 Edition.

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 2.5.2.4 of these specifications.

6-7.3 CONSTRUCTION REQUIREMENTS

Construction requirements for this item shall conform to the same construction requirements specified for Asphaltic Concrete Base Course Plant Mix under Item 2.4.3, except as modified in the following sub items.

6-7.3.1 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.

6-7.3.2 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 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.

6-7.4 MEASUREMENT AND PAYMENT

6-7.4.1 Measurement

The quantities of asphaltic binder course shall be measured per cubic meter basis. The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of liquid asphalt, wasted or remaining on hand after completion of the work shall not be measured or paid for.

6-7.4.2 Payment

The quantities determined, as provided above, shall be paid for at the contract unit price respectively for each of the particular pay item listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
6-7	Asphaltic Concrete Binder Course	CM

SECTION – 6-8

ASPHALTIC CONCRETE WEARING COURSE – PLANT MIX

6-8 SECTION - ASPHALTIC CONCRETE WEARING COURSE - PLANT MIX

6-8.1 DESCRIPTION

This work shall consist of furnishing aggregates and asphalt binder at a central mixing plant, to a specified mixing temperature, transporting, spreading and compacting the mixture in an approved manner on primed or tacked base, sub base, subgrade, 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 oras directed by the Engineer.

6-8.2 MATERIAL REQUIREMENTS

6-8.2.1 Mineral Aggregates

The Aggregates shall consist of coarse aggregates, fine aggregates and filler material, if required and shall be clean, hard, tough, durable and sound particles of uniform quality, geology, petrology and free from decomposed material, vegetable matter, soil, clay, lumps and other deleterious substances.

Coarse aggregate which is the material retained on an AASHTO No. 4 Sieve, shall consist of 100percent crushed rock or crushed gravel having 2 faces mechanically crushed. The type of source shall be uniform throughout the quarry location from where such a material is obtained. The coarse aggregates shall be free from an excess of flat or/and elongated particles.

Fine aggregate which is the material passing from AASHTO No. 4 sieve, shall consist of 100% crushed material from rock or boulder. Fine aggregate shall be stored separately, and 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 AASHTO No. 200 sieve, mineral filler material shall be added as approved by the Engineer. The filler shall consist of finely divided mineral matter such as rock dust, hydrated lime, hydraulic, calcined dust cement or other suitable mineral matter free from lumps, balls or other deleterious material and shall conform to the following gradation:

Sieve Designation		Percent Passing by Weight
mm	Inch	
0.600	No. 30	100
0.300	No. 50	95–100
0.075	No. 200	70–100

The coarse and fine aggregates shall meet the following requirements:

a. The percent of wear by the Los Angeles Abrasion Test (AASHTO T-96) shall not be more than 30.

b. The loss when subjected so five cycles of the Sodium Sulfate soundness fest (AASHTO T-104) shall be less than 12 percent.

c. The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement shall 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 aggregates retained on the 9.5 mm sieve shall not contain more than10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension should be 2.5:1).

f. Stripping test shall be performed on crush aggregates as described under AASHTO-182 and only that material shall be allowed which qualifies the test.

g. The coarse aggregates shall be checked if desired by the Engineer for cationic and anionic behavior so that their affinity with the bitumen to be used is verified.

h. Petrographic examination of the coarse aggregate shall be conducted if so directed by the Engineer.

The percentage of particles having certain proportions between their largest and smallest dimensions (i.e. between the largest distance the particles can fill out between two parallel planes that will permit the particle to pass), shall be determined in the following way:

i. Form sample of coarse aggregates, all particles passing No. 4 sieve are eliminated. The sample shall be of sufficient quantity that at least 100 particles remain.

ii. By means of a sliding caliper, the largest and smallest dimensions, as defined above, are determined for each particle and its proportion calculated (with one decimal).

iii. The total weights of particles having the proportions 2.5 or less and 3 or less, are determined and their percentage in relation to the total sample are calculated.

6-8.2.2 Asphaltic Material

Asphaltic binder, to be mixed with me aggregate to produce asphaltic base shall be asphalt cement penetration grade 40–50, 60–70 or 80–100 as specified by the Engineer. Generally it will meet the requirement of AASHTO M-20.

However, if specified specifically performance grade is to be used, then it will meet requirement of AASHTO M-320 as specified.in Bid Schedule. A sample sop of asphalt binder supply from approved source to asphalt plant is attached as Annexure-B.

6-8.2.3 Asphalt Concrete Wearing Course Mixture

The composition of the asphaltic concrete paving mixture for wearing course shall conform to Class A and/or Class B shown in the following table:

TABLE 6-8.1
ASPHALT CONCRETE WEARING COURSE REQUIREMENTS

Mix Designation		**Class A**	**Class B**
Compacted Thickness		50–80 mm	35–60 mm
Combined Aggregate Grading Requirements			
Sieve Designation		**Percent Passing by Weight**	
mm	**Inch**		
25	1	100	–
19	3/4	90–100	100
12.5	1/2	–	75–90
9.5	3/8	56–70	60–80
4.75	No. 4	35–50	40–60
2.38	No. 8	23–35	20–40
1.18	No. 16	5–12	5–15
0.075	No. 200	2–8	3–8
Asphalt Content weight percent of total mix		3.5 (Min.)	3.5 (Min.)

The asphalt concrete wearing course mixture shall meet the following Marshal Test Criteria:

Compaction, number of blows each end of specimen	75
Stability	1000 kg (Min)
Flow, 0.25 mm	8–14
Percent air voids in mix	3–5
Percent voids in mineral aggregates	According to Table 5.3 MS-2 (Asphalt Institute – USA), sixth addition, and 1993.
Loss of Stability	20% (Max.)

6-8.2.4 Job Mix Formula

At least one week prior to production, a Job Mix Formula (JMF) for the asphaltic wearing 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 Marshall Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993 or the latest Edition. (or if otherwise specified in Bid Schedule Superpave(R) Method of Mix Design shall be used)

The JMF with the allowable tolerances shall be within the master range specified in Table.608-1. Each JMF shall indicate a single percentage of aggregate passing each required sieve and a single percentage of bitumen to be added to the aggregates.

The ratio of weight of filler (Passing No. 200) to that of asphalt shall range between 1-1.5 for hot climate areas with temperature more than 40 °C.

After the JMF is established all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform there to the following ranges of tolerances:

Combined aggregates gradation

Retained No. 4 and larger ± 7.0%

Passing No. 4 to No. 100 sieves ± 4.0%

Passing No. 200 ± 1.0%

Asphalt Content.

Weight percent of total mix ± 0.3%

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 specimen in water at 60°C for 24 hours as compared with the stability measured after immersion in water at 60°C for 20 minutes shall not exceed 20 percent. If the mixture fails to meet this criterion, the JMF shall be modified or an anti-stripping agent shall be used.

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 make it necessary a new Job Mix Formula will be required.

6-8.3 CONSTRUCTION REQUIREMENTS

Construction requirements for this Section shall conform to the same as specified for Asphaltic Concrete Base Course Plant Mix, except as modified in the following sub–items.

6-8.3.1 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 coat, if directed by the Engineer

6-8.3.2 Pavement Thickness and Tolerances

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 ± 3mm from the desired thickness shown on the drawings. For determination of thickness 1 core per hundred meters of each lane will be taken. If the thickness so determined is deficient by more than 3 mm, but not more than 10 mm, payment will be made at an adjusted price as specified in Table 6-8.1of this specification.

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 5 millimeters. The cross fall (camber) shall be within ± 0.2 percent of that specified, and the level at any point shall be within ± 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.

However, if specified surface will be checked with laser profilometer for IRI as specified in Bid Schedule.

6-8.3.3 Acceptance Sampling and Testing

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 " in these specifications.

6-8.3.4 Trial Section

Contractor shall prepare a trial section before the start of work in light of procedure given in clause 1.20 (General).

However, record of asphalt laying will be kept for weekly record on proforma attached as Annexure-A.

6-8.4 MEASUREMENT AND PAYMENT

6-8.4.1 Measurement

The quantities of Asphaltic wearing course shall be measured by surface area in sq.m-/Sft laid and compacted in place. Measurements shall be based on the dimensions as shown on plans or as otherwise directed or authorized by the Engineer. A tolerance of ± 3 mm shall be allowed in compacted thickness of wearing course. However, any asphalt in excess of 3 mm shall not be paid and any layer deficient by more than 3 mm but not exceeding 10 mm shall be paid.

The quantity of bitumen material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities of Bitumen or asphaltic concrete wasted or remaining on hand after completion of the work shall not be measured or paid for.

Payment will be subject to determination of Bitumen / Binder quantity based on extraction test determined in a qualified laboratory and paid according to Bid Schedule. If quantity is determined less than specified but within JMF tolerance limits, then will be paid according to extraction tests. But if determined quantity is above Bid Schedule but within JMF band will be paid according to specified in BOQ.

6-8.4.2 Payment

The quantity determined as provided above shall be paid for at the unit price respectively for each of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or anti-stripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items of Asphaltic wearing course.

Price adjustment: If the thickness determined as per clause 6-8.3.2 of this specification is deficient by more than 3mm, but not more than10 mm, payment will be made at an adjusted price as specified in following Table.

Deficiency in thickness as determined by cores	Proportional Rate of contract Price allowed.
0.0 mm to 3.0 mm	100%
3.1 mm to 5.0 mm	90%
5.1 mm to 10.0 mm	80%

When wearing course is more than 10 mm deficient in thickness, the Contractor shall remove such deficient areas and replace them with Wearing course of an approved quality and thickness or the Contractor may opt to place an additional layer of wearing course asphalt, grading with a minimum thickness of 35 mm. The Contractor will receive no compensation for the above additional work.

Alternately, the Contractor may choose to overlay the area in a thickness of 30 mm (min.) with smooth transition as approved by the Engineer on either side with no extra compensation.

Pay Item No.	Description	Unit of Measurement
6-8 b	Asphaltic Concrete for Wearing Course (with specified % of Bitumen Binder)	Sqm per mm / 100 Sft per in

SECTION – 6-9

ASPHALT. CONCRETE WEARING COURSE (PLANT MIX) WITH CELLULOSE FIBER.

6-9 SECTION – ASPHALT CONCRETE WEARING COURSE (PLANT MIX) WITH CELLULOSE FIBER

6-9.1 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, sub base, 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.

6-9.2 MATERIALS REQUIREMENTS

6-9.2.1 Mineral Aggregates

a. Coarse Aggregates

Coarse Aggregates shall be crushed, non-absorptive stones and unless otherwise stipulated, shall conform to the following quality requirements of AASHTO M 283 for class A aggregates:

1.	Los Angeles abrasion, AASHTO T 96	30%
2.	Flat and Elongated Particles, ASTM D 4791, Comparing length to thickness (measured on material retained above the No. 4 sieve) 2.5 : 1	15% max.
3.	Sodium sulfate soundness loss (5 cycles), AASHTO T 104	15% max
4.	Particles. retained on the No. 4 sieve	
	shall have at least one fractured face, two fractured faces	 100% min. 75% min.
5.	Absorption, AASHTO T 85	2% max.
6.	Coarse and fine durability index, AASHTO T 210	40% max.

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. It shall conform to the quality requirements or AASHTO M 20. The sodium sulfate soundness loss in 5 cycles shall not exceed 15 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 6-9.1 below.

TABLE 6-9.1: (PERCENTAGE BY WEIGHT PASSING SIEVES, AASHTO T 27 & T 11)

Sieve Designation		Percentage Passing
3/4 in.		100 %
1/2		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.*

6-9.2.2 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.

6-9.2.3 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 MSHTO M 17.

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.

6-9.2.4 Cellulose Fiber

Fiber stabilizer, cellulose fiber is to be utilized. Dosage rates 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 6-9.2 utilizing the listed test procedures.

TABLE 6-9.2: 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. 20 Sieve	70% (+/-10%)
No. 20 Sieve	70% (+/-10%)
2. Ash-Content:	18% (+/- non-volatiles)
3. pH:	7.5 (+/- 0)
4. Oil Absorption:	5.0 (+/- 1.0) (Time fiber weight)
5. Moisture Content:	< 5%

1. 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 11 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 fibers 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.

6-9.2.5 Design Mix Requirements

Design parameter shall be 1n accordance with Hot Mix Asphalt Design by Marshal Method utilizing AASHTO T-245.

Sr. No.	Test	Parameter	Designation
	VTM percent	3-4	T-166, T-209, T-269 of total mix.
	Asphalt Content %	6.0 min.	
	Stability (Kg)	1000 min	Marshall Method
	VMA percent	17 min	MS-2
	Flow 0.01 inch.	8-14	Marshall Method
	Compaction No. of blows on each side of specimen.	50	Marshal Method
	Drain Down test, percent.	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 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 wt. in total mix.	± 0.03%

6-9.3 CONSTRUCTION REQUIREMENTS

6-9.3.1 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 fibers to ensure 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.

6-9.3.2 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.

6-9.3.3 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.

6-9.3.4 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.

6-9.3.5 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.

6-9.3.6 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 moist 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.

6-9.4 QUALITY ASSURANCE

6-9.4.1 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.

6-9.4.2 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.

6-9.4.3 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.

6-9.5 MEASUREMENT AND PAYMENT

6-9.5.1 Measurement

The quantities of Asphaltic wearing course shall be measured by volume in CM. laid and compacted in place. Measurements shall be based on the dimension as shown on plans or as otherwise directed or authorized by the Engineer. A tolerance of three (3) mm shall be allowed in compacted thickness of wearing course. However, any asphalt in excess of 3 mm shall not be paid and any layer deficient by more than 3 mm may be rejected unless rectified by overlaying additional layer at no extra cost, approved by the Engineer.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately.

Quantities Bitumen, wasted or remaining on hand after completion of the work, shall not be measured or paid for.

The quantity of cellulose fiber shall be measured in Kg. and paid separately.

6-9.5.2 Payment

The quantity determined as provided above shall be paid for at the contract unit price respectively for each 'of the particular pay items listed below and shown in the Bill of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
6-9 (a)	Asphaltic Concrete for Wearing Course of Specified Thickness	SM 100 sft.
6-9 (b)	Cellulose fiber	SM 100 sft.

SECTION – 6-10
SHOULDER TREATMENT

6-10 SECTION - SHOULDER TREATMENT

6-10.1 DESCRIPTION OF WORK

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.

6-10.1.1 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.

6-10.2 MATERIAL REQUIREMENTS

6-10.2.1 Earth Shoulders

The material used for Earth Shoulders shall consist of suitable materials from roadway or structural excavation supplemented by additional suitable material from borrow excavation or as designated on the plans and shall be obtained from sources approved by the Engineer.

6-10.2.2 Aggregate Shoulders

Material used for “Aggregate Shoulders” shall be of class designated on the plans and shall conform to all the requirements.

6-10.2.3 Soil Cement Stabilized Shoulders

Material for soil cement shoulders shall conform to all the requirements of Section 5-3, “Soil Cement Stabilized Sub base or Base”.

6-10.2.4 Asphaltic Materials

Materials for surface treatment of shoulders shall be liquid asphalts, emulsified asphalts or asphalt cement as specified or shown on the drawings requirements of Section 10-1 for the type specified.

6-10.3 CONSTRUCTION REQUIREMENTS

6-10.3.1 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.

6-10.3.2 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.

6-10.3.3 Earth Shoulders

Earth shoulders shall be constructed in accordance with the applicable paragraphs under this specification.

6-10.3.4 Aggregate Shoulders

Aggregate shoulders shall be constructed in accordance with the requirements of these specifications whichever is shown on the drawings.

6-10.3.5 Soil Cement Stabilized Shoulders

Soil cement stabilized shoulders shall be constructed in accordance with the requirements of Section 5.3.

6-10.3.6 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 in Section 4, 5 and 6.

6-10.4 MEASUREMENT AND PAYMENT

The quantities for shoulder materials and treatment shall be measured and paid for as specified under the particular pay items in the work listed below.

The quantities of different items of work as mentioned below shall be added to relative items of the bill of quantities.

Pay Item No.	Description	Unit of Measurement
6-10 (a)	Formation of Embankment from Roadway Excavation in Common Material	Cub.ft or CM

6-10 (b)	Formation of Embankment from Borrow Excavation in Common Material	Cub.ft or CM
6-10 (c)	Formation of Embankment from structural Excavation in Common Material.	Cub.ft or CM
6-10 (d)	Granular Sub Base.	Cub.ft or CM
6-10 (e)	Water Bound Macadam Base Course	Cub.ft or CM
6-10 (f)	Asphaltic Base - Plant Mix. Class	Cub.ft or CM
6-10 (g)	Cement Stabilized Sub base	Cub.ft or CM
6-10 (h)	Cement Stabilized Base	Cub.ft or CM
6-10 (i)	Cement content	Ton
6-10 (j)	Liquid Asphalt for curing seal, type	Ton
6-10 (k)	Emulsified Asphalt for curing seal, type	Cub.ft or CM
6-10 (l)	Bituminous Surface Treatment and Seal Coat.	Sq.ft or SM
6-10 (m)	Asphalt Concrete Wearing Course Plant Mix. As specified.	Cub.ft or CM

SECTION – 6-11
COLD MILLING

6-11 SECTION - COLD MILLING

6-11.1 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 Special Provision or as directed by the Engineer.

6-11.2 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 two (2) mm.

iii. Scraper bars and belt conveyor system shall ensure picking and loading of milled material in a truck.

6-11.2.1 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 string line 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 Special Provision or as directed by the Engineer.

Milled surface shall be cleaned by wire brushes or compressed air for subsequent operation.

6-11.3 MEASUREMENT AND PAYMENT

6-11.3.1 Measurement

The quantity of cold milling to be paid shall be measured by the number of square meters of area milled and cleaned as described above, as per drawings or as directed by the Engineer. No allowance will be given for milling outside the approved limit. Any such area milled beyond approved limits, shall be reinstated by the Contractor at his own expense.

6-11.3.2 Rate

6-11.3.3 Pavement

The accepted quantity measured as provided above shall be paid at the contract unit price per square meter of cold milling for the pay items as listed below and in the B.O.Q., which price and payment shall constitute full compensation for labour, equipment and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
6-11 a	Cold Milling 0-25 mm (1 inch)	Sft, / Sq.m
6-11 b	Cold Milling 0-50 mm (2 inch)	Sft, / Sq.m
6-11 c	Cold Milling 0-75 mm (3 inch)	Sft, / Sq.m

SECTION – 6-12

BIT MAC

6-12 SECTION – BIT MAC

6-12.1 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, sub base 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.

6-12.2 MATERIAL REQUIREMENTS

6-12.2.1 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 of crushed rock crushed boulder, or crushed gravel. It shall be clean, hard, tough, sound, durable and free from decomposed stones, organic matter, shale, 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 are 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.

6-12.2.2 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 3.2.2.

6-12.2.3 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 3.8.2 (A), must be carefully selected considering average thickness of .patches.

Design sheet under table No. 3.8.2 (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. 3.8.2 (B) is suitable for open graded wearing course having rough surface texture with good skid resistance thus having minimum bleeding tendency.

6-12.3 CONSTRUCTION REQUIREMENTS

6-12.3.1 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 150-160 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.

TABLE 6-12 (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	REMARKS
Sieve Size Inch/No.	200	No. 8	No. 4	3/8"	1/2"	3/4”	1"	USED	
(mm)	(0.075)	(2.36)	(4.75)	(9.5)	(12.5)	(19)	(25)		
Specification Range	4-12	43-56	55-75	90-100				4% by Weight of Mix	Minimum Layer Thickness 20 mm, Aggregate max. size 9 mm, Rate of Aggregate Application: 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% by Weight of Mix 4	Minimum Layer Thickness: 30mm, Aggregate Size: 12mm, Rate of Aggregate Application: 70Kg/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% by Weight of Mix	Minimum Layer Thickness: 50mm, Aggregate Size: 20mm Down Rate of Aggregate Applied:115 Kg/SM
Allowed % Passing	8	38	53	73	82	100			
% by Weight	46%		54%						
Qty. by Proportion.	3		4						
Specification Range	4-12	24-37	34-47	49-61	57-70	70-87	88-100	3.5% by Wt. of Mix.	Minimum Layer Thickness: 50mm, Aggregate size: 20mm Down, Rate of Aggregate Application: 150 Kg/SM.
Allowed % Passing	8	30	40	54	62	76	100		
% by Weight	46%		54%						
Qty. by Proportion.	3		4						

TABLE 6-12 (B):

DESIGN SHEETS FOR OPEN GRADED HOT MIX: FOR WEARING COURSE AND RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE.

AGGREGATE IN MIX.	FILLER	FINE AGGREGATE	COARSE AGGREGATES					BITUMEN USED.	REMARKS
Sieve Size Inch	200.	No. 8	No. 4	3/8"	1/2"	3/4"	1"	4% by Wt. of Mix.	Minimum Layer Thickness: 20mm, Size 9 mm, Rate of Aggregate Application: 50 Kg/SM.
(mm)	(0.075)	(2.36)	(4.75)	(9.5)	(12.5)	(19)	(25)		
Specification Range	2-10	24-37	40-50	88-100					
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% by Weight of Mix.	Minimum Layer Thickness: 30mm, Aggregate Size 12mm, Rate of Aggregate Application: 70Kg/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% by Weight of Mix.	Minimum Layer Thickness: 50mm, Aggregate size 20mm Down, Rate of Aggregate Application: 110 Kg/SM.
Allowed % Passing	6	20	32	50	65	100			
% by Weight	26%		74%						
Quantity by Proportion			3						
Specification Range	2-10	12:25	20-35	36-51	45-60	65-81	82-100	3.5% by Weight of Mix.	Minimum Layer Thickness: 60mm Aggregate size 25mm Down, Rate of Aggregate Application 135 Kg/SM.
Allowed % Passing	6	17	26	41	52	72	100		
% by Weight	23%		77%						
Quantity by Proportion	1		3						

6-12.3.2 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 string line shall be used to check riding quality and the alignment of the patch.

6-12.3.3 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 liters per square meter of A.0 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 string line to check the riding quality of the leveling course.

6-12.3.4 Wearing Surface

6-12.3.5 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.

6-12.3.6 Preparation of aggregates

Aggregates shall be stored and handled as discussed under item 3.8.2, Material Requirement.

6-12.3.7 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.

6-12.3.8 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 3.3. The rate of application of prime coat shall be 0.8-1.5 liters per square meter. Tack coat shall be done in a manner as described in item 3.4. The rate of application of tack coat shall be 0.2-0.4 liters per square meter. When surface of existing pavement or old base is irregular if 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.

6-12.3.9 Spreading and Finishing

Bit Mac mixture shall be placed on approved surface, stack 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.

6-12.3.10 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.

6-12.4 MEASUREMENT AND PAYMENT

6-12.4.1 Measurement

Unless otherwise shown on the plans or directed by the Engineer, quantity of BIT-MAC shall be measured by theoretical volume of compacted mix, in place, in cubic meters. Measurement will be based on the dimensions as shown on plans or as directed by the Engineer. No measurement will be made for unauthorized areas or for extra thickness than specified. Minimum quantity for pot hole shall be 0.05 cubic meters.

6-12.4.2 Payments

The accepted quantities measured above shall be paid for at the contract unit price per cubic meters of BIT-MAC for the Pay Item listed below and shown in the Bill of Quantities; which price and payment shall constitute full compensation for slurry seal, priming and tack coat, furnishing all materials, hauling, placing, rolling, labor, equipment, tools and incidentals necessary to complete the item.

Pay Item No	Description	Unit of Measurement
6-12 a	Dense Graded Hot BIT-MAC	CM
6-12 b	Open Graded Hot BIT-MAC.	CM

SECTION – 6-13

HOT RECYCLING OF ASPHALT CONCRETE

6-13 SECTION - HOT RECYCLING OF ASPHALT CONCRETE

6-13.1 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.

6-13.2 MATERIAL REQUIREMENTS

Material spedtications for coarse and fine aggregates and asphalt binder shall correspond to the specification requirements elaborated under relative sections of this chapter 6.

6-13.3 CONSTRUCTION REQUIREMENTS

6-13.3.1 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.

6-13.3.2 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. Scarifies shall be controlled by electronic devices to ensure removal of materials to a specified depth and grade.

6-13.3.3 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.

6-13.3.4 Addition of Fresh Asphalt Concrete

Fresh asphalt concrete of specified design prepared as per Item “Asphalt Base Course Plant Mix” or “Asphaltic Concrete Wearing Course” 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 c!djustable 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.

6-13.3.5 Laying 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.

6-13.4 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.

6-13.5 MEASUREMENT AND PAYMENT

6-13.5.1 Measurement

The quantity of recycled asphalt shall be measured in cubic meters of asphalt concrete removed and relayed after mixing of other ingredients such as asphaltic binder or fresh wearing course asphalt.

Measurement and payment of fresh wearing course asphalt or asphaltic binder shall be made in tons and paid under applicable item of work separately.

6-13.5.2 Payment

The quantity measured as provided above shall be paid at the contract unit price per cubic meter as shown in B.O.Q., acceptably laid and compacted in place, which payment shall be deemed to include full compensation for furnishing all materials, Labour, equipments, tools and incidentals necessary to complete the item.

Payment for asphaltic binder or fresh asphalt wearing course shall be made separately under relative item of work as given below

Pay Item No.	Description	Unit of Measurement
6-13a	Recycling of Asphalt Concrete (0-60 mm Thick)	CM / cft
6-13b	Bitumen Binder Grade (40-50, 60-70, 80-100)	Ton / cwt
6-13c	Freshly Prepared Wearing Course Asphalt Concrete of specified quality, mixing, layout and compaction	Ton / cwt

SECTION – 6-14
PROOF ROLLING

6-14 SECTION - PROOF ROLLING

6-14.1 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 or natural surface. 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.

6-14.2 CONSTRUCTION REQUIREMENTS

1. 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 for which payment shall be deemed to be included within this item.
2. The equipment required for compaction may be any of the following or combination thereof:
   a. Combination vibratory roller - min. 10 tons capacity.
   b. Pad foot vibratory roller - min. 10 tons capacity.
   c. Pneumatic type roller 9 wheeler - 21 tons capacity.

6-14.3 MEASU REMENT AND PAYMENT

6-14.3.1 Measurement

Proof rolling shall. be measured by the unit of square meter in the areas as designated on the drawings or directed by the Engineer.

6-14.3.2 Payment

The quantity of completed and accepted work, measured as provided above will be paid at the unit price quoted by the contractor for furnishing all equipments,. Labour, and other items necessary for the completion of the work

Pay Item No.	Description	Unit of Measurement
6-14	Proof Rolling	SM

Annex-A

WEEKLY RECORD OF BITUMINOUS PAVING
[DIVISION]

Proj.____________
District____________________________
Date____________________________

Location.____
Condition of Base Surface____
____
Type of Paver_______________________________ Sensor Calibration_______________
Type of Roller_________________________ Weight Tandem / Vibratory _________Roller's Surface_______________
Vibration Frequency__________

Date.__________________________
____

Prime Coat

Type/ Grade_________________________________ Quantity Used ____
Widht_______________________________________ Rate of Application_________________________________

Surface Course AWC

Type_____AWC______ Width__12 ft.__Thickness of Mat _2 in

Source of Materials

Bituminous Material____ Aggregate________________________

Date	Time	Section / RD	Truck ticket #	Length of Haul	Mix temp. at Plant	Mix Temperature behind Paver			Air Temperature			Weather Condition *	Tandem Roller Passes	PTR Passes	FINISH ROLLING
						Minimum	Maximum	Average	Minimum	Maximum	Average				

Remarks____

___________________________________Address

Note: i. Mixing temperature at Plant should not exceed 165 C.
ii. Rolling of asphalt should start above 130 °C of mix temperature.
iii. No rolling should be allowed to continue if the Temperature of Surface drops below 85 °C
iv. Variation in laying temperature of Asphalt should not vary more than +/- 5 °C
v. Paver speed for 2 in layer should not exceed 38 ft /min
vi. Static/Vibratory Roller speed should be adjusted according to type of Roller and weight
vii. Pneumatic Roller Speed should be adjusted according to type and weight of roller

QA / Consultants Certificate

	Limits	On site	Remarks
Straightedge Used to Check Joints and Mat by QC (Contractor) & QA (RE)	<3 mm		
Tandem Roller Pattern Established	3-9 km/hr		
Number of Rollers			
Vibratory Rollers	3-6 kmph		
Vibration Frequency and Amplitude Established?			
Control Strip Established and Density Passed?	97%		
Provide Random Density Test Locations?			
Density Core/Plug Holes Tacked and Patched?			
Correct striping and temperature requirement met.			
Daily extraction tests performed on daily production	min 2		
Marshall Density for G_{mm} and G_{mb}			

ANNEXURE - B

SOP OF ASPHALT BINDER SUPPLY FROM APPROVED SOURCE TO ASPHALT PLANT

1. SCOPE

This Standard Operating Procedure (SOP) covers the procedure to ensure that Asphalt Binder procured from the approved source is used in Asphalt Plant for laying of Hot Mix Asphalt in project.

2. PROCEDURE

2.1 After commencement of Contract, the Contractor will submit the request for the approval of Asphalt Binder Source / refinery. The supplier / refinery provides following but not limited to:-

a. All necessary certified test reports of Asphalt binders as per contract requirement and required by the Engineer Incharge.

b. Asphalt Binder samples / specimen as required by the Engineer / Engineer's Representatives to ascertain Asphalt binder properties.

2.2 After ascertaining the asphalt binder properties and examining all necessary documentations, consultant will convey the comments to the Project Authorities (Superintending Engineer & Executive Engineer) on the quality of Asphalt binder obtained from the source. The approval of source does not relieve the contractor from responsibility of conforming Asphalt binder properties as per contract specification.

2.3 After truck tankers of Asphalt Binder reaches at Asphalt Plant, the supplier will provide the certified testing results of asphalt binder of each batch to the Engineer Incharge / Engineer's Representative and Project Authorities.

2.4 As the consignment of Asphalt Binder will start from the Plant warehouse, Supplier will provide the necessary documents that include following record for each truck tanker but not limited to.

A. Quality Certificate

a. Asphalt Binder Grade
b. Complete list of Test and Conformance report therof.

B. Delivery Documents

a. Producers / refinery name and location or Delivery point
b. Plant Warehouse location
c. HMA Plant location
d. Project name / identification
e. Date and time of Delivery
f. Expected date and time of reaching at HMA Plant
g. Delivery invoice number
h. Truck number

i. Asphalt quantity by weight or calculated volume based on direct measurement

C. Sealing Certificate

a. Sealing Certificate signed and embossed by Authorized representative of Plant Warehouse.
b. Sealing of truck by numbered seals.

D. Tracking Record

a. Engineer Incharge / Engineer's Representative will demand Tracking of route of Trucks supplying Binder.
b. Keep record of tracking ensuring no abnormal stopovers and delays.
c. Project Authorities and the Engineer / Engineer Representative will ensure that Asphalt binder must be transported through truck tankers and is not allowed to transport through drums. The supplier / refinery is responsible for the haulage and transportation of Asphalt Binder till, the Asphalt binder is unloaded from Truck Tankers to HMA plant location Storage Tanks.

2.5 After truck tanker reaches at Asphalt Plant, the Engineer Incharge / Engineer's Representative will verify each test report by obtaining reasonable samples from each truck tanker to evaluate the Asphalt binder properties as required in Contract Specification. In this regard, Contractor will establish proper laboratory at Asphalt Plant and Project site to perform asphalt Binder terms as per Contract Specification. Invoices submitted will be got verified from source / refinery.

2.6 The Engineer / Engineer Representative will prepare the detailed Performa with the approval of Project Authorities to maintain proper record and archiving of supply and usage of Asphalt Binder incorporating following information but not limited to:-

a. Original Invoice of Refinery.
b. Truck tanker arrival date and time with truck number.
c. Check all relevant record is provided by the supplier as mentioned above for the truck tanker reaches at Asphalt Plant.
d. Note down the gauge of Asphalt plant storage tank before and after unloading of Asphalt Binder from each Truck Tanker supplied by Supplier / refinery.
e. Date and time of each entry of record mentioned in para 2.4b, 2.4c and 2.4d;
f. The Engineer Incharge / Engineer's Representative will submit the duly signed completely filled daily record approved Performa to Project Authorities positively

2.7 The Engineer Incharge / Engineer's Representative will also ensure that Asphalt binder cannot be removed from the Storage tank at Asphalt Plant without permission of the Engineer / Engineer Representative and Project Authorities. In this regard, Engineer / Engineer's Representative prepares strict security mechanism duly approved by project authorities.

2.8 All activities at plant will be monitored through video recording of plant storage tanks and testing of binders.

3. Responsibilities

- Quality Control is main responsibility of Contractor.
- Quality Assurance is responsibility of Engineer's Representative i.e Supervision Consultants. It will be the responsibility of Consultant's that invoice will be got verified from source refinery and record shall be kept intact and handed over to client at end of project.

SECTION – 7-1
CONCRETE

7-1 SECTION - CONCRETE

7-1.1 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 the special Provisions and to the approval of the Engineer.

7-1.1.1 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 the Special Provisions. The following requirements shall govern unless otherwise shown on the Drawings.

Class A_l 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/cu m 22ls/cft of concrete with a slump between ten (10) / 4” and fifteen (15) cm /6”.

Concrete placed for piles shall be class A_3 with minimum cement content of four hundred (400) kg/cu m 24.3 lbs / cft.

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 the Special Provisions 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 the Drawings.

Class Y concrete shall be used as a filler in steel grid bridge floors, in thin reinforced sections, or as otherwise specified in the Special Provisions.

Lean Concrete (Plain Cement concrete) shall be used in thin layers underneath footings and when called for on the Drawings or directed by the Engineer.

The recommended limits of Module of course aggregate for all concrete classes would be ranges 6.95 ~ 7.6 Kg/m^3 except class whose module range is 6.3 to 6.9.

The concrete of the various classes shall satisfy the requirements shown in Table 7-1-1.

Table 7-1-1 Portland Cement Concrete Requirements

Class of Concrete	Mix. Design ratio (Tentative)	Max. Size of Coarse Aggregate	Min. Cement	28 days' Compressive Strength (min) (Cylinder)		Consistency (Range in Slump)	Permissible Maximum Water-Cement Ratio
		(mm)	(Kg/m^3)	Psi	(kg/cm^2)	Vibrated (mm)	
A_1	1:2:4	20	300	3000	210	25~75	0.58
A_2	1:1.5:3	25	350	3500	245	100~150	0.58
A_3	1:1.5:3	38	400	4000	280	100~150	0.58
B	1:3:6	51	250	2400	170	25~75	0.65
C	1:2:4	38	275	3000	210	25~75	0.58
D_1	1:1:2	25	450	5000	350	50~100	0.40
D_2	1:1:2	25	500	6000	425	50~100	0.40
D_3	1:1:2	25	550	7000	500	50~100	0.40
Y	1:2:4	13	400	3000	210	25~75	0.58
Lean Concrete	1:4:8	51	175	1400	100	-	-

7-1.1.2 Types of Concrete Works

Under Ground Concrete

Concrete poured below Natural Surface Level with or without shuttering and shoring.

On Ground Concrete

Concrete poured by erecting formwork with necessary bracings on ground.

Elevated Concrete

Concrete poured by erecting props, bracing and towers to support the formwork at higher levels.

7-1.2 MATERIAL REQUIREMENTS

7-1.2.1 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 the 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 M 85 (ASTM C 150). The type of the cement to be used, unless otherwise shown on the Drawings, shall be type 1.

Sampling of cement shall be in accordance with AASHTO 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 the work of concreting 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 item of construction unless authorized by the Engineer, after preparing new mix design.

7-1.2.2 Fine Aggregate

The fine aggregate shall consist of sand, stone screenings or other approved inert materials with similar characteristics, or a combination thereof, 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) % of material passing the No. 200 sieve by washing nor more than one percent of clay lumps or one (1) % of shale. The use of beach sand is prohibited without the written consent of the Engineer.

For exposed work, the fine aggregate shall be free from any substance that will discolor the concrete surface.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO T 11 and T 27 shall meet the following grading requirements as shown in Table 7-1.2:

TABLE 7-1.2: GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight
3 / 8 inch (9.5mm)	100
No. 4 (4.75mm)	95~100
No. 16 (1.18mm)	45~85
No. 50 (0.3mm)	10~30
No. 100 (0.15mm)	2~10
No. 200 (0.075mm)	0~3

In case if fine aggregates fail under Fineness Modulus or Gradation however material passing No. 4 in combined aggregate, qualifies for these requirements, then the material can be accepted.

Fine aggregates shall be of such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO T 71, shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.3 to 3.1. Natural aggregates if required shall be thoroughly and uniformly washed before use. Sand equivalent (AASHTO T 176) shall be 75 % min.

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.

7-1.2.3 Coarse Aggregate

The coarse aggregate shall consist of crushed or broken stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, 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.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 7-1.3 and when tested in accordance with AASHTO T 11 & T 27 shall meet the following grading requirements.

TABLE 7-1.3: GRADING OF COARSE AGGREGATES

Designated Sizes	Percentage by Weight Passing Laboratory Sieves, in inches, Having Square Openings							
	2 ½	2	1 ½	1	¾	½	3/8	No. 4
½" to No. 4	-	-	-	-	100	90~100	40~70	0~15*
¾" 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" to¾"	-	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) % shall pass No. 8 sieve.

Coarse aggregate gradation should conform to the requirements of ASTM C 33. Coarse aggregate shall contain not be more than one (1) % by weight of material passing the No. 200 sieve by washing and not more than five (5) % of soft fragments.

It shall have an abrasion loss of not more than forty (40) % at five hundred (500) revolutions, when tested in accordance with AASHTO T 96.

When tested in accordance with AASHTO T 104, for five cycle, the loss with the sodium sulphate soundness test shall be not more than 12 percent.

Natural aggregates shall be thoroughly washed before use. Testing of coarse aggregate is specified under Section 7-1.10 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. In case the Contractor proposes to use the aggregate having the alkaline/siliceous characteristics with the intention to use it with Blast Furnace Slag Cement, he will undertake to carry out the job without any extra cost and shall arrange to conduct the necessary tests as directed by the Engineer.

7-1.2.4 Combined Aggregate

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

7-1.2.5 Water

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall contain not more than one thousand (1,000) parts per million of chlorides nor more than one thousand three hundreds (1,300) parts per million of sulfates (SO_4). 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) % nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) % when compared to the result obtained with distilled water.

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 discoloration 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 T 26 wits its P-H Value 6 to 8.

7-1.2.6 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.

7-1.2.7 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 weather-proof 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 that, 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 re-cleaning and as approved by the Engineer.

7-1.3 CONSTRUCTION REQUIREMENTS

The manufacturing, transport, handling and placing of concrete shall conform to the requirements given hereinafter.

Unless otherwise specified, ordinary Portland cement shall be used for all types of concrete. When sulphate resisting cement or other type of cement is required, it will be specified on the Drawings or in Bill of Quantities or ordered by the Engineer. Sulphate resisting cement will be used at least in foundations under saline conditions.

7-1.3.1 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. A tentative mix design ratio for each concrete class is provided in Table 7-1.1.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various material 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 7-1.11 "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.

7-1.3.2 Consistency

The consistency of the concrete shall be such that, taking into consideration the nature of the work, it shall be sufficiently workable to provide a dense and homogeneous concrete of the specified strength. The degree of workability shall be altered if so required by the Engineer who may order slump or other tests to be carried out in order to control the consistency.

Consistency of concrete (slump test) shall be determined as specified in AASHTO T 119 (ASTM C 143). The Consistency of concrete at the time of delivery shall be as shown in Table 7-1.1 or as designated by the Engineer.

7-1.3.3 Water Cement Ratio

The quantity of water introduced into mixes shall be regulated and arranged so as to ensure that the water-cement ratio shall be the minimum required to produce the concrete specified.

In general, the mix design shall provide for water-cement ratios by weight with aggregate at saturated surfaces dry condition, which will be determined on the basis of producing concrete having suitable workability, density, impermeability, durability and the required strength without the use of excessive amount of cement. The maximum permissible water cement ratio for each concrete class is shown in Table 7-1.1.

7-1.4 MIXING CONCRETE

a. Mixing 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) % 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 ($\pm$ 1/2) %. 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 movements of other operating equipment do not effect 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) % for cement, one and a half ($1^1/_2$) % for any size of aggregate, or one (1) % for the total aggregates in any batch.

Where volumetric measurements are authorized by the Engineer, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowances shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregates. Boxes or similar containers of the exact volume required shall be filled and struck off. Measurement by wheel barrow volumes will not be permitted.

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 a half ($2^1/_2$) cm 1” 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) % 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-two (32) °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 that 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 a 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 be neither 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) °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 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.

h. Temperature Control

No mixing or pouring of concrete will be allowed at ambient temperatures higher than 35 °C, without prior approval of the Engineer for satisfactory measures made by the Contractor for keeping the concrete mix cool at the time of placing. The temperature of mixed concrete immediately before placing shall not be more than 30 °C. The Contractor shall take all specific precautions according to AASHTO-SS-Division II 8.6.3 to achieve this target for which no extra payment shall be made.

7-1.5 HAULING AND DELIVERY OF MIXED CONCRETE

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. 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) °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) °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) °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 re-handling and without damage to the structure of the concrete.

c. Re-tempering

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 re tempered or remixed.

7-1.6 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 Section 7-1.5 “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 a half ($1^1/_2$) m 5 feet 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.

Before concreting in any section, reinforcement shall have to be completely cleaned and free from all contaminations, including concrete which may have been deposited on it from previous operations. Concreting will take place only after the Engineer has inspected the placing of the reinforcement and given his approval.

The Contractor will allow the Engineer eight (8) working hours after the reinforcement is in place to conduct the inspection.

The Contractor shall make available all the records of concrete placing to the Engineer.

These records, in a form as agreed to by the Engineer, shall be kept by the Contractor containing all details of every pour of concrete placed. These records shall include Class of concrete, location of pour, weather conditions, 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.

The Contractor shall supply to the Engineer two copies of these records each week covering work carried out the preceding week. In addition, he shall supply to the Engineer monthly histograms of all twenty-eight (28) days' cylinder strengths together with accumulative and monthly standard deviations and any other information which the Engineer may require concerning the concrete placement 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 the Special Provisions 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_2 concrete with a minimum cement content of three hundred fifty (350) kg/cu m 22 lbs/cft. of concrete.

The slump of concrete shall be maintained between ten (10) and fifteen (15) cm 6”. 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 twenty-five (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 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) cm 10” 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 three (3) cm 1⅛” 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 either in the forms or in troughs/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.

7-1.7 CASTING SECTIONS AND CONSTRUCTION JOINTS

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 wall, an inset formwork shall be used to produce an edge thickness of not less than fifteen (15) cm 6" in the succeeding layer. Work shall not be discontinued within fifty (50) cm 20" of the top of any face, unless provision has been made for a coping less than fifty (50) cm 20" 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 Special Provisions, 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 a quarter ($1^1/_4$) m 4" 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 a quarter ($1^1/_4$) m 4 feet 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 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 the Special Provisions.

Concrete in girder haunches less than one (1) m 3¼ feet 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) m 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.

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 4”-6” in cross-section and having a length of ten (10) cm 6” 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) cm 12” 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 twenty-four (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 in the drawings. If so, this requirement shall be subjected to the Engineer’s agreement. If the stresses distribution in the structure are changed by the new construction joints, new calculations can be asked from the Contractor for checking the reinforcement. If the quantities of steel and formwork are increased, no extra payments shall be made. Elsewhere, on visible faces, aesthetical treatment of construction joint will be provided without any extra payment.

f. Provisional openings for removal of formwork

The Contractor may require provisional openings for removal of formwork, in location and sizes. This requirement shall be subjected to the approval of the Engineer.

The quantity of additional steel due to these openings will not be paid.

Elsewhere, on visible faces, aesthetical treatment of construction joint will be provided by the Contractor without any extra payment.

g. 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) cm 24” 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) cm 6” of concrete and no stone shall be closer than thirty (30) cm 12” to any top surface nor any closer than fifteen (15) cm 6” to any coping. For walls or piers greater than one (1) m 3’-3”in thickness, larger stone (50 kg 110 lbs or more) may be used. Each stone shall be surrounded by at least thirty (30) cm 12”of concrete and no stone shall be closer than sixty (60) cm 24” to any top surface or closer than twenty (20) cm 8” to any coping.

h. Concrete Exposed to Sea Water

Unless otherwise specifically provided, concrete for structures exposed to seawater 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 ten (10) cm. The concrete shall be mixed for a period of not less than two (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 seawater 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.

i. 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) cm, 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.

a. Protection of Concrete from Environmental Conditions

i. 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 Contractor’s risk and any damaged concrete shall be removed and replaced at the Contractor’s expense.

ii. 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.

iii. Work in Hot Weather

The temperature of concrete shall not exceed thirty-two (32) °C at the time of laying, unless the Contractor incorporates in the mix a plasticizer, 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:

1. 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.
2. Cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled shall be uniform.
3. 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.

4. Night work provided that (1), (2) and (3)above 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 item.

b. 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) °C, nor resumed until an ascending air temperature in the shade and away from artificial heat reaches two (2) °C. In such cases, the mixing water and/or aggregates shall be heated to not less than twenty-one (21) °C nor more than sixty-six (66) °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) °C, nor more than twenty-seven (27) °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.

7-1.8 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

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 (3)-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.

i. 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 strike 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) m 10” ahead of strike 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 strike 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 a half ($2^1/_2$) m 8½ feet nor more than three and a half ($3^1/_2$) m.11½ feet 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 33 feet 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 one and eight-tenths (1.8) m 6 feet or less shall be followed by two (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 two (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 planning 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 (1/2) 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 a half ($3^1/_2$) to five (5) m 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 a half ($2^1/_2$) cm 1” thick and from ten (10) cm 6” to twenty (20) cm 8” wide. Adjusting screws spaced as not to exceed

60 cms 24” 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 701.3.8 “Curing Concrete” hereinafter.

The finished surface of the concrete shall be tested by means of a three (3) m ⅛” long straightedge. The surface shall not vary more than three (3) mm ⅛” from the lower edge of the straightedge. All high areas in the hardened surface in excess of three (3) mm ⅛” 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 a half ($2^1/_2$) cm 1” or more in thickness, the surface of the concrete shall not vary more than nine (9) mm ⅜” from the lower edge of the three (3) m 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.

ii. 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 ¼” under a three (3)-meter 10 feet straightedge and the finished surface shall be free of blemishes

iii. Ordinary Surface Form Finish

Ordinary surface form finish will follow AASHTO-SS-8.12.2. Non-shrinkable 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.

iv. Class 1 Surface Form Finish

Class 1 surface form finish will follow the AASHTO-SS-8.12.3.

Metal, fiber or plywood forms in good conditions will be used exclusively.

Class 1 surface finish shall systematically be required to be applied as the final finish for the following surfaces, unless otherwise directed by the Engineer:

- All form finish surfaces of bridge super-structures, except the under surfaces between girders.
- All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three-tenths (0.3) m 1 feet below finished ground.
- All surfaces of railing/barrier.

b. Surface Rendering

All faces of concrete that 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.

7-1.9 CURING CONCRETE

a. General

All newly placed concrete shall be cured in accordance with these Specifications, unless otherwise directed by the Engineer.

b. Method of Curing

The curing method shall be one or more of the following as described hereinafter:

i. 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.

ii. 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 colorless liquid. The use of any membrane forming compound that will alter the natural color 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. 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 or 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 talks 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 / liters 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.

iii. Reinforced Water Proof 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 seventy-two (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 fiber.

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 4".

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.

iv. 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) cm 2" 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.

v. 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) °C.

vi. 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) cm 12" 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 Section 7-1.9 "Methods of Curing".

The curing compound method may be used on concrete surfaces that are to be buried underground and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform color 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 eighty (80) % of strength achieved, at the option of the Contractor. Steam curing for precast members shall conform to the following provisions:

i. After placement of the concrete, members shall be held for a minimum four (4) hours pre-casting period.

ii. 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.

iii. 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.

iv. 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) °C per hour. The curing temperature throughout the enclosure shall not exceed sixty-five (65) °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.

v. 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) m of continuous bed length will be required for checking temperature.

Curing of precast concrete will be considered completed after termination of the steam curing cycle.

e. Curing Precast Concrete Piles

All newly placed concrete precast piles, both conventionally reinforced and pre-stressed shall be cured by the “Water Method” as described in Section 7-1.9 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 Section 7-1.9 “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.

7-1.10 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 & ASTM methods:

i)	Sampling aggregates	T 2
ii)	Sieve analysis	T 27
iii)	Amount of material passing No. 200 sieve	T 11
iv)	Organic impurities	T 21
v)	Mortar Strength	T 71
vi)	Sodium-sulphate soundness	T 104
vii)	Friable particles	T 112
viii)	Abrasion loss	T 96
ix)	Specific Gravity	T 84
x)	Absorption	T 85
xi)	Production of Plastic Fines	T 210
xii)	Fineness Modulus	T 27
xiii)	Sand Equivalent	T 17
xiv)	Potential Reactivity of Carbonate Rocks for Concrete Aggregate (Rock Cylinder Method)	ASTM C 586
xv)	Potential Alkali Reactivity of Cement Aggregate Combinations (Mortar-Bar Method)	ASTM C 227
xvi)	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.

7-1.11 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 that must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 7-1.1.

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 T 22.

A set of six (6) cylinders shall be taken from each fifty (50) cu m 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 twenty-eight (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) % 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 the specifications of AASHTO T 24.

Test results of the cores shall meet the following requirements:

i. Average test result of the cores shall not be less than the minimum required twenty-eight (28) days' strength.

ii. No individual core shall show strength less than ninety-five (95) % 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) % of the twenty-eight (28) days' strength (in case of type-I cement), 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 twenty (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. Equipment used for trial batches will be the one that would be used on that specific job.

7-1.12 MEASUREMENT AND PAYMENT

7-1.12.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic meters cubic feet concrete of the various classes complete in place and accepted.

In measuring the volume of concrete to be paid for, the dimensions to be applied shall be those shown on the Drawings except where others ordered by the Engineer in writing.

Deductions from the theoretical volume of concrete shall be made for the volumes of draining holes, weep holes, pipes, conduits etc. in case where their cross-sectional areas exceed five hundred (500) sq cm sq. inch.

The measurement shall not include any concrete used in 80 sq. inch the construction of cofferdams or false work.

The volume involved in fillets, scorings, or chamfers ten (10) sq cm 1.6 sq. inch in cross-sectional area or less shall be disregarded when measuring the quantity of concrete to be paid for.

Concrete for railings, pipe culverts etc. is not to be measured under this item, but under separate items.

Any lost formwork not retrieved shall not be paid for.

7-1.12.2 Payment

For all concrete structures or portions, thereof, no separate measurement or payment shall be made for false work, centering, formwork or any other temporary work to complete the concrete structure or portion thereof, payment for all such temporary works shall be deemed to be included in the Contract price paid under various items of concrete work.

The accepted quantity measured as provided above shall be paid for at the Contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which price and payment shall be full compensation for such works as curing, surface finishing and/or rendering as required, formation of construction joints and any such work and incidentals necessary to complete the work prescribed in this Section except works that are paid for under other pay items:

Pay Item No.	Description	Unit of Measurement
7-1 a	Concrete Class A_1	
	i. Under Ground	Cub.ft or CM
	ii. On Ground	Cub.ft or CM
	iii. Elevated	Cub.ft or CM
7-1 b	Concrete Class A_2	Cub.ft or CM
	i. Under Water	Cub.ft or CM
	ii. Under Ground	Cub.ft or CM
	iii. On Ground	Cub.ft or CM
	iv. Elevated	Cub.ft or CM
7-1 c	Concrete Class A_3	Cub.ft or CM

	i. Under Ground	Cub.ft or CM
	ii. On Ground	Cub.ft or CM
	iii. Elevated	Cub.ft or CM
	iv. Concrete for Pile Works	Cub.ft or CM
7-1 d	Concrete Class B – to be used where specified	Cub.ft or CM
7-1 e	Concrete Class C to be used for Cribbing or as specified	Cub.ft or CM
	i. Under Ground	Cub.ft or CM
	ii. On Ground	Cub.ft or CM
	iii. Elevated	Cub.ft or CM
7-1 f	Concrete Class D_1 to be used for pre-stressed or post-tensioning	Cub.ft or CM
7-1 g	Concrete Class D_2	Cub.ft or CM
7-1 h	Concrete Class D_3	Cub.ft or CM
7-1 i	Concrete Class Y to be used as filler in concrete girders	Cub.ft or CM
7-1 j	Lean Concrete	Cub.ft or CM
7-1 k	Precast Concrete, Class	Cub.ft or CM
	i. Precast Concrete Class A_1	Cub.ft or CM
	ii. Precast Concrete Class A2	Cub.ft or CM
	iii. Precast Concrete Class A3	Cub.ft or CM
	iv. Precast Concrete Class C	Cub.ft or CM

SECTION 7-2

CEMENT CONCRETE PAVEMENT

7-2 CEMENT CONCRETE PAVEMENT

7-2.1 DESCRIPTION

The work specified in this section consists of construction of Cement Concrete Pavement, constructed in one course on a prepared sub-grade and under course in accordance with these specifications and in conformity with the lines and cross sections shown on the drawings. The concrete for pavement construction shall be of specified quality and shall be reinforced with steel bars, or steel mesh, where called for in contract and in accordance with the details shown on the drawings.

7-2.2 MATERIALS

a. Concrete

Materials needed to make the cement concrete of the specified type for pavement construction shall conform to specifications as contained in Section 7-1(Concrete).

b. Reinforcing steel

Reinforcing steel bars shall conform to specifications as contained in section 8-3.

c. Joint Filler

Materials for filling of joints shall be as specified on drawings and approved by the Engineer.

Joint filler shall consist of cane or other suitable long fibers of a cellular nature uniformly impregnated with asphalt. The asphalt content of the joint material shall be between thirty and fifty percent. 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 $\pm$ two (2) mm for thickness and $\pm$ twelve (12) mm for depth are to be rejected. All damaged strips are to be rejected too

d. Joint Sealing Compound

Joint sealing compound is to be as BS 2499 (1973) type A1 or A2, or as approved by the Engineer.

The compound is to be impermeable, 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.

e. 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 center to center 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.

f. Expansion Caps

Expansion caps for dowel bars in expansion joints shall consists 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.

g. 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 power to be added to the mixing water, or as a self-dispersing power 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 power 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.

h. 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.

7-2.3 PLANT AND EQUIPMENT

Plant and equipment needed for making the required concrete shall be in accordance with Section 7-1.

7-2.4 CONSTRUCTION DETAILS

7-2.4.1 Proportions of Ingredients

This shall conform to specifications contained in Section 7-1, provided that the mix shall be designed on minimum fourteen (14) days flexural strength which shall not be less than 35 Kg/cm^2 (500 Psi) and having 28 days compressive strength not less than 316 Kg/cm^2 (4500 Psi)

7-2.4.2 Mixing and Testing Concrete

The concrete shall be mixed in accordance with specifications under Section 7-1.4 and tested according to specifications under Section 7-1.11.

7-2.4.3 Pavement Subgrade (Embankment)

The subgrade (embankment) for the concrete pavement where required shall be constructed in accordance with Section 4-8.

7-2.4.4 Pavement Base Course

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.

7-2.4.5 Forms

Unless as may otherwise be directed by the Engineer, the forms shall be made of steel, of an approved section with a base width of at least 200 mm (8 inches), and the depth shall be equal to the thickness of the pavement at the edge. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than 3 mm in 3 meters (1/8 inch in 10 feet) from a true plane surface on top of the form, and the inside face shall not vary more than 6 mm (1/4 inch) from a plane surface.

Before placing forms, the underlying materials shall be excavated to the required grade if necessary and shall be firm and compact. The forms shall have full bearing 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. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than 3 mm (1/8 inch) from the proper elevation.

Forms shall be set to the required lines and grades well ahead of placing concrete preferably not less than 150 m (500 ft).

Forms shall not be removed for at least 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.

Forms shall be thoroughly cleaned and oiled each time they are used.

7-2.4.6 Consistency

The slump of the pavement concrete shall be from 25 mm to 75 mm (1 to 3 inches) or as directed by the Engineer. The slump shall not vary more than 25 mm (One inch) from batch to batch.

7-2.4.7 Placing of Concrete and Steel

- **Concrete**

Concrete shall be placed on the prepared and moistened under-course in such a manner as will require as little re-handling as possible to avoid segregation of materials and in accordance with specifications under section 7-1.6.

If required by the Engineer the forms shall be wetted immediately prior to the placing of concrete.

- **Steel 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 t)e 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 o(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 without 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 pla1aed in one (1) layer.

Where two (2) layers of wire mesh reinforcement are required, as at bridge approaches, the bottom layer shall be supported in the required position with bar chairs. 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.

All other properties and other operations for fabrication and laying of steel bars will be according to Section 8-3.

7-2.4.8 Re-tempering

After placing and vibration of concrete, re-tempering that is remixing with or without additional material or water will not be permitted.

7-2.5 JOINTS

General Requirements

Joints shall be constructed exactly in accordance with the details shown on the drawings and the 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 types 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 50 mm (2 inch) 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 drawings, 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 drawings 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 6 mm (1/4 inch) in the horizontal alignment from a straight line. No plugs of concrete shall be permitted anywhere within the expansion space.

A PVC slip sleeve of the dimensions shown on the drawings 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 drawings. Any excess grease on the dowel holder shall be removed.

The joints shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure that 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 section 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 depressions caused by this operation shall immediately be filled with fresh concrete, responded 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 of the tamper and each screed, in turn; the screed may be operated over the joint.

b. Contraction Joints

Contraction joint shall be of the type and dimensions and at the spacing shown on the drawings.

Sawed contraction joint shall be cut by means of an approved concrete saw. The joints shall not be sawed until the concrete has hardened.

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 drawings. Guidelines or devices approved by the Engineer shall be provided to insure 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 combination of air and water applied under pressure immediately after the joint has been cut, and before filling with joint compound.

When the drawings specify that dowels be installed through contraction joints the under course 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 centerline of the joint.

Each dowel shall be painted and thoroughly coated with hard grease, or lubricant, in accordance with the directions given on the drawings 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 drawings and shall be installed in such a position that the centerline of the joint assembly is perpendicular to the centerline 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 drawings 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 drawings. When the fabricated steel strip is specified, it shall be held rigidly in place with an adequate number of pins driven into the sub grade to insure 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, and 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 insure cutting the longitudinal joint on the true line as shown on the drawings. 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 drawings. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination or 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 day’s 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 50 mm (2 inch), a width of not less than the thickness of the pavement and a length of not less than the width of the 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 the centre of the header there shall be fastened a trapezoidal piece of metal or wood for the full length of the header 50 mm (2 inch) wide and at least twenty five (25) mm (one inch) depth to for a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars herein after 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 insure an interlocking joint.

Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the drawings. Tie bars as provided for the longitudinal joint, and spaced at forty five (45) centimeter (18 inch), shall be placed across the joint in a plane parallel to the surface of the pavement approximately midway between the top and bottom surface of the pavement. The edges of the joint shall be grooved, edges, and sealed with the material used for sealing expansion and contraction joints.

No construction joint shall be placed within three (3) meters (10 feet) of an expansion, contraction, or other construction joint.

e. Sealing Joints

i. Materials: Joints shall be sealed with material of the type designated on the plans.

ii. Hot Poured Joints: The joints shall be sawed as provided in sub item 310.3.?(b) and covered as provided in sub item 310.3.?(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 pressure, wire brushes or in extreme cases the joint shall, when directed by the Engineer, be reviewed 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.

iii. Cold Poured Joints: The joints shall be sawed as provided in sub- item 310.3.?(b) & 310.3. (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 glassline or heavy craft is suitable. The paper shall remain on the joint until it weathers or wears off.

iv. 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.

7-2.6 CONSOLIDATING AND FINISHING

a. By Mechanical Means

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. The forward 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 corner of the slab shall not be disturbed.

b. Hand Finishing

Unless otherwise specified, hand finishing methods will not be permitted except under the following conditions:

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.

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.

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 screened. 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.

c. 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.

7-2.7 PROTECTING AND CURING CONCRETE PAVEMENT

i. 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.

ii. 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.

7-2.8 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 not 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.

7-2.9 TESTS FOR THICKNESS OF PAVEMENT AND DEGREE

i. 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:

a. One 15cm 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.

b. 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.

c. 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 s8tisfaction of the Engineer.

d. The removal and replacements of pavements shall extend transversely the full width each lane in which such deficiency is found.

e. All pavements within two (2) meters of the deficiency spot shall be removed, except that hen any joint is more than two (2) meters, all pavements shall then be removed to the next joint.

f. Sections of pavement which are deficient in thickness, as determined by measurement of cores in accordance with MSHTO 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 %

ii. 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.

iii. 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.

7-2.9.1 Replacement

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 joint.

7-2.9.2 Concrete

"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."

7-2.10 MEASUREMENT AND PAYMENT

7-2.10.1 Measurement

Cement concrete pavement shall be measured by the volume of cement concrete laid on the pavement according to the thickness and cross section shown on the drawings. The length shall be measured along the actual surface at the pavement and width from outside of completed pavement. The unit of measurement shall be one cubic meter (m^3) or one cubic feet (cft).

7-2.10.2 Rate

The unit rate for cement concrete laid for concrete pavement shall be full compensation for the work specified in this section completed, cured with water, finished and accepted including cost of furnishing all materials, labour, tools and equipment and operations necessary to complete the work as specified in this section, including construction joint, contraction joints and longitudinal joints. The rate for the concrete does not include steel fabrication which is paid separately under pay item 7-2 (e).

7-2.10.3 Rate Adjustment

Where the average thickness of concrete pavement is deficient by more than 5mm, but not more than 25mm, payment will be made at an adjusted rate as given in Table hereunder:

Deficiency in thickness (mm)	Percentage of price paid
0.0 to 5.0	100
5.1 to 8.0	80
8.1 to 10.0	72
10.1 to 13.0	68
13.1 to 19.0	57
19.1 to 25.0	50

7-2.10.4 Payment

Payment shall be made under: -

Pay Item No.	Description	Unit of Measurement
7-2 (a)	Plain Cement Concrete Pavement of specified strength	Per Cu.m. (m^3) or Per 100 cft (ft^3)
7-2 (b)	Reinforced Cement Concrete Pavement of specified strength	Per Cu.m.(m3) or Per 100 cft (ft 3)
7-2 (c)	Concrete Lug Anchors	Per meter or Per foot
7-2 (d)	Furnishing, Fabrication and planning of steel deformed bars of Grade 40	Per Metric Ton
7-2 (e)	Furnishing, Fabrication and planning of steel deformed bars of Grade 60	Per Metric Ton

SECTION – 8-1
STRUCTURES GENERAL

8-1 SECTION – STRUCTURES GENERAL

8-1.1 DESCRIPTION

This section 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, pre-stressed 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 the Engineer. This section works shall also include construction of certain structural features and incidental which are either common to all types of structures or which may apply to any of them.

8-1.2 MATERIALS

The materials used shall be those prescribed for several Contract items that are to constitute the complete structure.

8-1.3 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 3-1 “Clearance 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’s 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 Engineers 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. 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.

f. Concreting

The concrete of Bridges or culverts shall be poured and surface finished and cured as per requirements conforming to Section 7-1.

g. 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, headwalls and on embankment slopes. Bridge decks and sidewalks shall be left in clean and workman like condition. No specific payment for clearing up shall be made but the cost shall be included in other items shown on the Bill of Quantities.

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.

i. Opening to Traffic

Bridges or slab or box culverts having decks constructed with Portland 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) °C. When temperatures are below ten (10) °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.

8-1.4 MEASUREMENT AND PAYMENT

8-1.4.1 Measurement

The quantities of various pay items which constitute the completed and accepted structures shall be measured for payment according to the plans and specification for the several pay items appearing in the Bill of Quantities and in term of the prescribed units provided for the several pay items. Only accepted work shall be included for payment and the measured quantity shall be based on the dimension of component as shown on the plans or as directed in writing by the Engineer.

8-1.4.2 Payment

The quantities measured as provided above shall be paid for at the unit prices bid for the several pay items appearing in the Bill of Quantities which payment and prices shall be full compensation for furnishing, preparing, fabricating, transporting, placing and erecting all material for the complete structure; for all labor, equipment, tool and all other items necessary for the completion of work. Such payment shall constitute full payment for completed structure and no allowance will be made for cofferdam construction, form lumber, false work and other incidental expenses.

SECTION – 8-2

FALSE WORK, FORMWORK AND CENTERING FOR BRIDGES

8-2 SECTION - FALSE WORK AND CENTERING FOR BRIDGES

8-2.1 DESCRIPTION

This work shall consist of the designing, providing, erecting supplying, construction and removing of false work / formwork of sufficient strength with all necessary bracings, fasteners etc. 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.

Alternative

The Contractor may require for formwork of "in-situ" concreted slabs, the use of the alternative (not shown on drawings) solution "lost formwork" such as precast reinforced concrete slabs or fiber-cement planks. In that case, the Contractor shall have to submit the materials and his method statement to the Engineer for approval. This requirement will be accompanied by a calculation note. Any extra steel or extra-foundation to be added due to this proposal should be carried out without any extra payment to the Contractor.

8-2.2 MATERIAL REQUIREMENTS

Timber and lumber to be used for false work / formwork shall be of sound lumber and comply with the requirement in AASHTO M 168.

Structural steel to be used for false work / formwork shall comply with the requirements of Standard Specifications for Structural Steel AASHTO M 183. Reinforcing steel if it is to be used for false work / formwork shall comply with the requirements of AASHTO M 31-82. Concrete when used shall conform to section 7-1 of these Specifications.

Forms 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.

8-2.3 CONSTRUCTION REQUIREMENTS

8-2.3.1 False work Design and Drawings

Detailed working drawings and backup calculations of the false work / formwork shall be furnished by the Contractor to the Engineer. No false work / formwork 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 false work / formwork design and in no case shall be less than one (1) week.

The Contractor may revise the false work / formwork 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 false work / formwork shall include but not be limited to the following:

a. For designing false work / formwork and centering, a weight of two thousand four hundred (2,400) kg/cu m shall be assumed for green concrete. All false work / formwork 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 a certain strength.

c. False work, which cannot be founded on a satisfactory footing, shall be supported on piling, which shall be spaced, driven and removed in an approved manner. The loading used on timber piles shall not exceed the bearing value for the piles and in no case exceed ten (10) tons per pile.

d. Soil bearing values and soil conditions (wet and dry) shall be designated by the Contractor on the false work / formwork drawings. False work / formwork footings shall be designed to carry the loads imposed upon them without exceeding estimated soil bearing values or allowable settlements.

e. False work / formwork 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 pre-stressed, the false work / formwork shall be designed to support any increased or readjusted loads caused by the pre-stressing forces.

i. Joints supporting slabs and overhangs shall be considered as false work / formwork and designed as such.

For the construction of false work / formwork over and adjacent to road ways where false work / formwork openings are required for maintaining traffic, the Contractor shall provide any additional features for the work needed to ensure that the false work / formwork will be stable if subjected to impact by vehicles.

The false work / formwork 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 false work / formwork cap or framing.

ii. Adequate bracing shall be used during all stages of false work / formwork construction and removal over or adjacent to public traffic.

iii. False work / formwork members shall be at least thirty (30) cm clear of temporary protective railing members.

The false work / formwork 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 false work / formwork drawings shall show any pedestrian openings, which are required through the false work.

Anticipated total settlements of false work / formwork and forms shall be indicated by the Contractor on the false work / formwork drawings. These should include false work / formwork footing settlement and joint take-up. Anticipated settlements over two (2) cm 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 false work / formwork 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 false work / formwork shall be the sum of therefore mentioned cambers.

8-2.3.2 False work / Formwork Construction

The false work / formwork shall be constructed to conform to the false work / formwork drawings. The materials used in the false work / formwork construction shall be of the quantity and quality necessary to withstand the stresses imposed. The workmanship used in false work / formwork construction shall be of such quality that the false work / formwork will support the loads imposed on it without excessive settlement or take-up beyond that shown on the false work / formwork drawings.

False work / formwork shall be founded on footings, capable of supporting the loads imposed on it.

When false work / formwork is supported on piles, the piles shall be driven to a bearing value, equal to the calculated pile loading as shown on the false work / formwork drawings.

Suitable jacks or wedges shall be used in connection with false work / formwork to set the forms to their required grade and to take up any excessive settlement in the false work / formwork 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 plus two (+2) cm from those indicated on the false work / formwork drawings, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of these Specifications, the placing of concrete shall be discontinued until corrective measures are provided to entire satisfaction of the Engineer. In the event, satisfactory measures are not taken to correctness of excessive settlements, the Contractor shall not be relieved of responsibility for conforming to the requirements of these Specifications.

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 the Drawings or required by the Engineer and with the surface finish as specified.

Forms for exposed surfaces shall preferably be lined with metal, plywood, or other approved material, or may with the Engineer's permission be made of dressed lumber of uniform thickness. Forms shall be filled at all sharp corners (Minimum two (2) cm 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. 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) cm from the face without injury to the concrete.

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 color. 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.

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 commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolor the concrete. All exposed surfaces of similar portions of a concrete structure shall be formed with the same forming material or with materials that produce similar concrete surface textures, color 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 three (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, satisfactory to the Engineer have been made. 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.

8-2.3.3 Removing False work

In the determination of the time for the removal of false work 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.

Unless otherwise shown on the drawings, or permitted by the Engineer, false work / formwork supporting any span of a simple span bridges shall not be released before fourteen (14) days after the last concrete, excluding concrete above the bridge deck, has been placed. False work / formwork supporting any span of a continuous or rigid frame bridge shall not be released before fourteen (14) days after the last concrete, excluding concrete above the bridge deck, has been placed in that span and in the adjacent portions of each adjoining span where false work / formwork is to be released.

False work / formwork supporting deck overhangs and deck slab between girders shall not be released until seven (7) days after the deck concrete has been placed.

In addition to the above requirement, no false work / formwork for bridges shall be released until the supported concrete has attained a compressive strength of at least eighty (80) % of the required twenty-eight (28) days' strength.

False work / formwork for cast-in-place prestressed portions of structures shall not be released until after the pre-stressing steel has been tensioned.

All false work / formwork materials shall be completely removed. False work / formwork piling shall be removed at least sixty (60) cm below the surface of the original ground or stream bed. When false work / formwork piling is driven within the limits of ditch or channel excavation areas, the false work /

formwork piling within such areas shall be removed to at least sixty (60) cm, 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.

If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the temperature is below five (5) °C, for removal of forms and supports shall be used as a minimum subject to the approval of the Engineer:

Arch Center	14 days
Centering Under Beams	14 days
Supports under Flat Slabs	14 days
Floor Slabs	14 days
Vertical Wall Surfaces	24 Hours
Columns	24 Hours
Side of Beams	12 Hours
Top Slabs R.C. Box Culverts	14 days

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 false work / formwork 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.

8-2.4 MEASUREMENT AND PAYMENT

For all concrete structures, pre-stressed concrete structures or portions thereof, no separate measurement or payment shall be made for false work / formwork supporting such structures. All false work / formwork costs shall be considered as included in the Contract prices paid (cost/CM or LM of structural members or lump-sum) for the various items of concrete work and no additional compensation will be allowed thereof.

SECTION 8-3

STEEL REINFORCEMENT

8-3 SECTION - STEEL REINFORCEMENT

8-3.1 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.

8-3.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given, whichever is applicable. 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

h. The plain rounds smaller than 9.5mm (3/8”) in diameter (steel wires) ASTM A510.

8-3.3 TENSILESTRENGTH, YIELD STRENGHT AND ELONGATION REQUIREMENT (AASHTO M31)

The tensile properties of round bars of grade 40 and 60 shall satisfy the requirements as shown in following Table.

TABLE 8-3.1: TENSILE REQUIREMENTS

	Grade-40	Grade-60
Tensile strength, min. MPa (psi)	500 (70,000)	620 (90,000)
Yield strength, min. MPa (psi)	300 (40.000)	420 (60.000)

The percentage of Elongation in 200mm (8inch) shall be as shown in the Table below:-

TABLE 8-3.2: ELONGATION REQUIREMENTS

Bar Designation No. (Diameter in mm)	Grade-40	Grade-60
3 (10)	11mm	9mm
4,5,6 (13,16,19)	12mm	9mm
7,8 (22,25)	-	8mm
9,10,11,14,18 (29,32,36,43,57)	-	7mm
Grade 40 bars are furnished only in sizes 3 through 6 (10 through 19)		

8-3.4 YIELD POINT

The yield point of mild steel of 40 Grade and 60 Grade will be 276 MPa (18 tons/square inch) and 414 MPa (27 ton/square inch) for the bar sizes as shown in Table 8-3.2

8-3.5 COLD BEND TESTS

For bend tests, except in the case of round bars 25mm (1 inch) in diameter and under, the test piece when cold shall stand, from hammer until the internal radius is not greater than 1-1/2 times the thickness of the test piece and the sides are parallel. In the cases of round bars 25mm (1 inch) in diameter and under, the internal radius of bend shall not be greater than the diameter of the bar. Bend test requirement are shown in Table 8-3.3

TABLE 8-3.3: BEND TEST REQUIREMENTS

Bar Designation No. (Diameter in mm)	Pin Diameter for Bend Test	
	Grade-40	Grade-60
3,4,5 (10,13,16)	3.5d	3.5d
6 (19)	5d	5d
7,8 (22,25)	-	5d
9,10,11 (29,32,36)	-	7d
14,18 (43,57) (90°)	-	9d

i. Test bends 180° unless noted otherwise

ii. dnominal diameter of specimen.

8-3.6 YOUNG'S MODULUS (E)

The value of the E for steels used in structural works shall be of the order of 21 x 10^4 MPa (30 x 10^6 Lbs. Per square inch).

8-3.7 UNIT WEIGHT

The unit weights to be used for measurement of quantities of steel shall be as shown in the following Table 8-3.4

DEFORMED BAR DESIGNATION NUMBERS, NOMINAL WEIGHTS,

TABLE 8-3.4: NOMINAL DIMENSIONSAND DEFORMATION REQUIREMENT

Bar No. (Bar designation)	Nominal Wt. lb/f (nominal mass kg/m)	Nominal Dimension			Deformation Requirements, in. (mm)		
		Diameter, in (mm)	Cross-section area, in.^{2} (mm^2)	Perimeter, in. (mm)	Max. Average spacing	Min. average height	Max. gap (Chord of 12.5% of nominal perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	1.043 [1 552]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	0.437 [111]	0.028 [0.71]	0.239 [6.1]
6 [19]	1.502 [2.235]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	2.044 [3.042]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [127]	0.383 [9.7]
9 [29]	3.400 (5.0601	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [142]	0.431 [10.9]
10 [32]	4.303 (6.404]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	5.313 [7.907]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [25811	7.09 [180.11	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

8-3.8 CONSTRUCTION REQUIREMENTS

8-3.8.1 Fabrication of Bent Bars

a. Order Lists

Before the all materials / steel reinforcement steel is set to be procured by the contractor, all order / lists along-with bending diagrams shall be furnished by the Contractor for the approval of 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 will be provided to the Engineer for approval, according to AASHTO-SS Section II-9.3. These documents shall be given to the Engineer at least one month before placing the steel. All grade sixty (60) bars shall be brought to the Site in straight bars.

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 to the shapes shown on the Drawings or required by the Engineer. Bars shall be bent around a pin having the following diameters(D) in relation to the diameter of the bar (d):

a) Stirrups & column tie bars — D = 4 x d

b) Other bars having:

- i) d <3.5 cm ($1^3/_8$", No. 11 bar):
  - 1) Grade 40 — D = 5 x d
  - 2) Grade 60 — D = 8 x d
- ii) d $\geq$3.5 cm ($1^3/_8$", No. 11 bar) — D = 10 x d

For deformed bars grade 60, bending will be made only mechanically.

8-3.8.2 Placing and Fastening

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 M.S. bars of 1” (25 mm) dia. spares).

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 inform the Engineer well in advance 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.

i. Tolerances

Tolerances on bars placing will be plus twenty (+20) mm in any direction parallel to a concrete face and plus ten (+10) mm at right angle to a face.

ii. Control of Formwork before Placing the Steel

No reinforcement shall be placed before the Engineer has inspected the formwork and given his approval. The Contractor shall allow the Engineer at least four (4) working hours after the form is finished to conduct the inspection.

c. Splicing

All reinforcement shall be furnished in the full lengths indicated on the Drawings unless otherwise permitted. Splicing of bars, except where shown on the Drawings, will not be permitted without the written approval of the Engineer. 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. The Contractor may require the use of mechanical couplers splices. This requirement will have to be met according to AASHTO-SS-9.7.4.

Unless otherwise shown on the Drawings, bars shall be lapped with a minimum overlap of forty (40) 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 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 2" (5cm). In work exposed to the action of sea water the minimum covering shall be ten (10) cm / 4".

8-3.9 MEASUREMENT AND PAYMENT

8-3.9.1 Measurement

The quantity to be paid for shall be measured for different sized m.s. bars separately dia-wise in running foot / running meter and then multiplied by its theoretical unit weight of the relevant bars in lbs / kg provided, their tested weight is within permissible variation limit of $\pm$ 6% and if the tested weight difference is more than + 6%, the weight will be arrived at the theoretical weight and if the tested weight is more than +6% then the actual tested weight will be considered for payment as shown in table 8-3.5:

TABLE 8-3.5: BAR SIZES AND THEIR WEIGHT

Size mm (inch)	Weight Kg/m (lb/ft)
6 (¼")	0.222 (0.149)
8 (2.5/8 ")	0.395 (0.265)
10 (⅜")	0.560 (0.376)
13 (½")	0.994 (0.668)
16 (⅝")	1.552 (1.043)
19 (¾")	2.235 ()1.502
22 (⅞")	3.042 (2.044)
25 (1")	3.973 (2.670)
29 (1 ⅛")	5.060 (3.400)
32 (1 ¼")	6.404 (4.303)

36 (1 ⅜”)	7.907 (5.313)
43 (1¾”)	11.38 (7.65)
57 (1 ½”)	20.24 (13.60)

When laps are made for splices, other than those shown on the Drawings or required by the Engineer and for convenience of the Contractor, the extra steel shall not be measured for payment.

When continuous bars are shown on the drawings, without the splices being shown the necessary steel in the splices will be paid for on the basis of the individual bars not being shorter than twelve (12) m.

For bent bars, the length along center line of bar will be paid.

8-3.9.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price as entered in the contract agreement and includes procurement straightening, cutting bending, wastage, hoisting, binding wire, chairs, spacers, labour charges and T&P etc.

Pay Item No.	Description	Unit of Measurement
8-3 (a)	Deformed Mild Steel Reinforcement as per (AASHTO M31 Grade 40)	100 kg / per cwt
8-3 (b)	Deformed Mild Steel Reinforcement as per (AASHTO M31 Grade 60)	100 kg / per cwt
8-3 (c)	Deformed Steel Wire for Reinforcement of Concrete as per (AASHTO 225 M)	100 kg / per cwt
8-3 (d)	Welded Plain Steel Wire Fabric for Concrete Reinforcement as per (AASHTO M 55)	100 kg / per cwt
8-3 (e)	Steel Bar Mats for Concrete Reinforcement as per (AASHTO M 54)	100 kg / per cwt
8-3 (f)	Cold Drawer Steel Wire for Concrete Reinforcement as per (AASHTO M 32)	100 kg / per cwt
8-3 (g)	Welded Deformed Steel Wire Fabric for Concrete Reinforcement as per (AASHTO M 221)	100 kg / per cwt
8-3 (h)	Reinforcement (Structures Shapes) as per (ASTM A-36 221)	100 kg / per cwt

SECTION – 8-4

PRESTRESSED CONSTRUCTION

8-4 SECTION - PRESTRESSED CONSTRUCTION

8-4.1 DESCRIPTION

This work shall consist of pre-stressing precast or cast-in-place concrete by furnishing, placing and tensioning of pre-stressing steel in accordance with details shown on the plans and as specified in these Specifications or as directed by the Engineer.

This work shall also include the furnishing and installation of any appurtenant work necessary for the particular pre-stressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

8-4.2 MATERIAL REQUIRMENTS

8-4.2.1 Pre-stressing Reinforcement Steel

Prestressing reinforcement shall be high-strength seven-wire strand or high-strength steel wire or high-strength alloy bars of the grade and type called for in the contract documents / mentioned by the Engineer in plans and shall conform to the requirements of the following Specifications.

8-4.2.1.1 — Strand

Uncoated seven-wire strand shall conform to the requirements of AASHTO M 203M/M 203 (ASTM A416/A416M).

8-4.2.1.2 — Wire

Uncoated stress-relieved steel wire shall conform to the requirements of AASHTO M 204M/M 204 (ASTM A421/A421M).

8-4.2.1.3 — Bars

Uncoated high-strength bars shall conform to the requirements of AASHTO M 275M/M 275 (ASTM A722/A722M). Bars with greater minimum ultimate strength, but otherwise produced and tested in accordance with AASHTO M 275M/M 275 (ASTM A722/A722M), may be used provided they have no properties that make them less satisfactory than the specified material.

The steel shall be free from injurious defects and shall have a smooth surface. Material, which shows injurious 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 pre-stressing steel, in case, he is not satisfied with the source of manufacture. Relaxation for pre-stressing steel shall be measured over a period of thousand (1,000) hours stressed at seventy (70) % of its ultimate tensile strength giving less than six (6) % elongation.

8-4.2.2 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 selection of samples shall be made at the manufacturer's plant by the Engineer or his representative. The Contractor shall furnish for testing the following samples selected from each lot as ordered by the Engineer:

i. Pre-Tensioning Method

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.

ii. Post-Tensioning Method

1. Samples of the following lengths shall be furnished: For wires, sufficient length to make up one parallel-lay cable one and a half ($1^1/_2$) m long consisting of the same number of wires as the cable to be furnished. For strands, one and a half ($1^1/_2$) m length shall be furnished.
2. For bars to be furnished with threaded ends and nuts, one and a half ($1^1/_2$) m between threads at ends.

iii. Anchorage Assemblies

Two anchorage assemblies of each size of anchorage to be used shall be furnished, complete with distribution plates.

8-4.2.3 Concrete

The materials for concrete shall conform to the requirements of Section 7-1. The concrete shall be Class D as shown in Table 7-1.1 unless otherwise shown on the plans.

8-4.2.4 Reinforcement Steel

Reinforcement steel shall conform to the requirements of Section 8-3.

8-4.3 CONSTRUCTION REQUIREMENTS

General

Unless otherwise ordered by the Engineer, the Contractor shall certify for the Engineer's approval that a technician skilled in the approved pre-stressing or post tensioning method will be available to the Contractor to give aid and instruction in the use of the pre-stressing equipment to obtain the required results. The contractor will use either Freyssinet System or strong hold system of pre-stressing post tensioning and will get approval of the particular system from the Engineer before start 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 pre-stressing 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.

8-4.3.1 Pre-stressing Method

The method of pre-stressing to be used shall be optional with the Contractor, provided he introduces no change in the position of centroid of the total pre-stressing force over the length of the member and in the magnitude of the final effective pre-stressing force as prescribed in the Drawings. The pre-stressing 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 pre-stressing system to be applied, the following points have to be ensured:

a. The safety of the anchorage of the pre-stressing 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 pre-stressing.

c. The suitability of the proposed steel for the chosen pre-stressing system.

d. The length of transmission of the force to the concrete and the minimum strength of the latter necessary for pre-stressing in systems, where the pre-stressing elements are fully or partially anchored to the concrete through bond and friction.

e. The suitability of measures taken to protect pre-stressing 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 pre-stressing operations. Such detail shall outline the method and sequence of stressing, complete specifications and details of the pre-stressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures and all other data pertaining to the pre-stressing operation, including the proposed arrangement of the pre-stressing units in the members.

An agreement certificate for the pre-stressing 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.

8-4.3.2 Pre-stressing 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. All devices, whether hydraulic jack gauges or otherwise, shall be calibrated so as to permit the stress in the pre-stressing 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 pre-stressing steel or the slipping of the grips during the pre-stressing process. All equipment 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.

8-4.3.3 Enclosures

Enclosures for pre-stressing steel shall be accurately placed at locations shown on the plans or approved by the Engineer.

All enclosures shall be of ferrous metallic material and shall be completely mortar-tight with the exception that the Contractor, at his option, with the approval of the Engineer, may form the enclosures by means of cores or ducts composed of rubber or other suitable material that can be removed prior to installing the pre-stressing reinforcement. 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 wires, 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 pre-stressing operations have been completed.

8-4.3.4 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.

8-4.3.5 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 pre-stressing 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.

8-4.3.6 Pre-Tensioning

The pre-tensioning 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 hundred 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 minimum.

8-4.3.7 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 pre-stressing 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 pre-stressing reinforcement shall be stressed by means of jacks to the required tension and stress transferred to the end anchorages. 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 pre-stressing 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 pre-stressing steel shall be determined by the formula:

$Ft = 2(F_1 - a\ c\ E)$

Where:

Ft = total friction loss

F_1 = Observed tension at the jack

a = cross-sectional area of the pre-stressing 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 that will not affect the strength of the stressed tendon, with particular care if the use 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 within 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.

8-4.3.8 Grouting of Bonded Steel

Post-tensioned pre-stressed bridge members preferably shall be of the bonded type in which the tensioned steel is installed in holes or flexible metal ducts cast in the concrete and bonded to the surrounding concrete by filling the tubes or ducts with grout. The grout shall be a mixture of cement and fine sand (passing a No. 30 sieve) in the approximate proportion of one part cement to 0.75 part sand, the exact proportions to be adjusted to form a grout having the proper consistency and under no circumstances, shall the water cement ratio exceed 0.45. The compressive strength of the hardened grout shall not be less than one hundred seventy (170) kg/sq cm after seven (7) days at a temperature of eighteen (18) °C, when making preliminary trials for quality. The grout shall be mixed for a minimum of two (2) minutes and until a uniform consistency is obtained.

All pre-stressing reinforcement to be bonded shall be free of dirt, loose rust, grease, or other deleterious substances. Before grouting, the ducts shall be free of water, dirt or any other foreign substance. The ducts shall be blown out with compressed air until no water comes through the duct. For long members with draped strands an open tap at the low point of the duct may be necessary.

The grout shall be fluid (consistency of thick paint) but proportioned so that free water will not separate out of the mix. Unpolished aluminum powder may be added in an amount per sack of cement as approved by the Engineer. Commercial plasticizer used in accordance with the manufacturer's recommendation may be used provided they contain no ingredients that are corrosive to steel. Sufficient pressure shall be used in grouting to force the grout completely through the duct, care being taken that rupturing of the ducts does not occur.

8-4.3.9 Making Good Recesses

After completing all grouting operations, the various grout holes shall be neatly plugged and recesses at the anchorages shall be made good with properly placed and compacted with Portland cement concrete Class D as shown in Table 7-1.1 unless otherwise shown on the plans.

8-4.3.10 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 damaged by improper storing or handling shall be replaced by the Contractor at his expense.

Pre-stressed 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.

8-4.3.11 Manufacture of Pre-stressed Members off the Site

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 the Site until the tests have been satisfactorily completed.

8-4.3.12 Sampling and Testing

a. Testing of Pre-tensioned Beams

i. 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 borne by the Contractor.

ii. 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.

iii. Loads shall be measured with an accuracy of plus two (+2) % or fifty (50) kg and deflections with an accuracy of plus one-half (+1/2) mm.

iv. 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) % 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) %of the maximum deflection recorded during the second test.

v. 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.

vi. 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 Modulus of Elasticity (E).

vii. 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 Pre-stressing 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) %.

8-4.3.13 Curing Concrete

a. General

For all pre-stressed 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 section 7-1

8-4.4 MEASUREMENT AND PAYMENT

8-4.4.1 Measurement

Measurement and payments for the various items in prestress concrete work shall be made in accordance with appropriate items of relevant sections, as depicted in the Drawings.

8-4.4.2 Payment

a. Precast Prestressed Concrete Member

The quantity to be paid for shall be the number of pre-stressed concrete structural members of the several types and sizes, constructed and installed in place as per Drawings completed and accepted. Each member shall include the concrete, reinforcement and pre-stressing steel, enclosures for pre-stressing steel, anchorage, plates, nuts, formwork, shuttering including its removal and centering if required and other such material contained within or attached to the unit.

b. Cast-in-Place Prestressed Concrete

The work to be paid for under this section will be the concrete of specified class, pre-stressing work as specified here and shown on the Drawings or required by the Engineer and shall include supply and installation of pre-stressing high tensile steel, spacers, enclosures, anchorages plates, nuts and other such material deemed necessary to complete the work. Steel reinforcement, concrete, will be measured and paid for accordingly.

Pay Item No., Description and Unit of Measurement for Precast Pre-stressed Concrete Members and Cast-in-Place Pre-stressed Concrete will be covered, under specified BOQ item number provided in Special Provisions, as per Drawings and other related documents for following items separately:

Pay Item No.	Description	Unit of Measurement
8-4 (a)	Lifting, transporting and placing beams, diaphragms, slabs. Pre-stressed Hardware Including Sheets etc. i. Beams upto 50 ft ii. Beams 50-75 ft iii. Beams 75 – 100 ft. iv. Beams 100 – 150 ft v. Beams above 150 ft.	Cubic M or100 Cft.
8-4 (b)	Pre-stressed High Tensile Metallic ropes strand of specified quality including pre-stressing etc. including Pre-stressing arrangement including Hardware sheets, male female cone and Anchorage arrangement required under Freysinet or Stronghold pre-stressing or post tensioning system	100 kg
8-4 (c)	Pre-stressed High tensile Metallic Wires of specified quality including pre-stressing arrangement including Hardware sheets, male female cone and Anchorage arrangement required under Freysinet or Stronghold pre-stressing or post tensioning system	100 kg

SECTION 8-5
STEEL STRUCTURES

8-5 SECTION - STEEL STRUCTURES

8-5.2 DESCRIPTION

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 labor, 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.

8-5.3 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.

8-5.4 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. Certified mill test reports for steels with specific impact values shall include, in addition to other test results, the results of Charpy V-Notch (CVN) 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.

8-5.5 SHIPPING, HANDLING AND STORING MATERIALS

Members weighing more than two and a half (21/2) 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.

8-5.6 FALSE WORK

False work used for the erection of structural steel shall conform to the provisions in Section 8-2 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 false work.

False work 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) cm 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.

8-5.7 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 Section.

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 position.

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 corrected.

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 for this steel.

8-5.8 MATERIAL REQUIREMENTS

8-5.8.1 Description

The various materials shall conform to the specifications of ASTM as listed in the following with certain modifications and additions as specified:

TABLE 8-5.1: MATERIAL REQUIREMENTS

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	A 48, 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) Grade B; A 106 Grade B; or A 139 Grade B	A 53, Type E or S
Stud connections through 1020 either semi- or fully skilled	A 108, grades 1010

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 these specifications.

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 CVN 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 A 514. CVN impact values shall be determined in accordance with ASTM E 23.

CVN impact values shall conform to the following minimum requirements shown in Table 8-5.2.

TABLE 8-5.2: CVN IMPACT VALUES REQUIREMENTS

Material	Impact Value ft-lb at Temp. (kg-m at Temp.)
A 36	15 at 40 °F (2.07 at 4.45 °C)
A 441	15 at 40 °F (2.07 at 4.45 °C)

A 572*	15 at 40 °F (2.07 at 4.45 °C)
A 588* 2" and under in thickness (50.8mm & under in thickness)	15 at 40 °F (2.07 at 4.45 °C)
A 588* Over 2" to 4" in thickness (Over 50.8mm to 101.6rnm in thickness)	20 at 40 °F (2.77 at 4.45 °C)
A 514 $2^1/_2$" & under in thickness (63.5mm & under in thickness)	25 at 0 °F (3.46 at -17.8 °C)
A 514 Over $2^1/_2$" to 4" in thickness Over 63.5mrn to -101.6mm in thickness)	35 at 0 °F (4.84 at -17.8 °C)

**If the yield point of the material exceeds 65,000 psi (4,569.5 kg/sq cm), the temperature for the CVN impact value for acceptability shall be reduced to 15 °F. (-9.45 °C) for each increment of 10,000 psi (703 kg/sq cm) above 65,000 psi (4,569.5 kg/sq cm).*

Stud connectors 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, cracks, 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 as shown in Table 8-5.3

TALE 8-5.3: STRENGTH REQUIREMENTS OF STUD CONTRACTORS

Tensile Strength	Elongation	Reduction of Area (min)
(min) 60,000 psi (4,218 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.

8-5.8.2 Structural Steel

Unless otherwise specified or shown on the plans, all structural steel plates, shapes and bars shall conform to ASTM 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 thickness of flange plates, shall be approved in writing by the Engineer prior to fabrication.

When stud type shear connectors longer than twenty (20) cm 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 these specifications.

c. The strength classification of the material shall not be reduced.

8-5.8.3 Castings

Steel, gray iron and malleable iron castings shall be provided with adequate continuous fillets cast in place in all reentrant 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 ($1^1/_4$) cm.

The dimensions of the finished casting shall not be less than the specified. Castings shall not be more than seven and a half ($7^1/_2$) % overweight. Large castings shall be suspended and hammered over their entire area. No cracks, flaws or other defects shall appear after such hammering.

8-5.8.4 Unidentified Stock Material

Unidentified stock material, consisting of material that cannot be identified with certified mill test reports, may be used subject to the requirements in this Section.

When unidentified stock material is proposed for use, the Engineer may, at his discretion, select random test specimens from each piece. 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 this Contract.

Unidentified stock material shall be segregated from all other materials to be used in the work.

8-5.8.5 Welding

1. 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.

2. Surfaces and edges to be welded shall be smooth, uniform, clean and free of defects, which would adversely affect the quality of the weld. Edge preparation shall be done in accordance with the current ANSI/AASHTO/AWS D1.5 Bridge Welding Code.
3. The presence of any of the following defects will result in rejection of the weld:
   i. Cracks, regardless of length or location.
   ii. Overlaps, lack of penetration or incomplete fusion.
   iii. Inclusions of slag, porosity and other deleterious materials less than 1.5 mm in size, unless well dispersed.
   iv. Inclusions outside the size limits given in Table 8-5.4.
   v. Any line of inclusions in a length of 12T that have an aggregate length greater than T.

TABLE 8-5.4

WELD DEFECT LIMITS

Welded plate thickness (T) (mm) / Inch	**Maximum allowable defect dimension (mm) / Inch**
19 or less ¾”	6.5 ¼”
19-57 ¾” - 2/¼”	T/3
Greater than 57 / 2/¼”	19 ¾”

Defects pointed out by the Inspector/the Engineer shall be removed by mechanical means or by oxygen grooving as per given instructions after which the joints shall be re-welded.

8-5.8.6 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.

8-5.8.7 Cleaning

All steel works shall be blast cleaned after fabrication in accordance with the Drawings and to the satisfaction of the Engineer. Steel work that is to be in contact with concrete shall be, after fabrication, wire brushed and cleaned to remove all loose rust, dirt and grease.

8-5.8.8 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 a red lead paint as specified for the shop coat, tinted light brown as required with lamp black in an amount not to exceed thirty (30) gm/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 Color

Steel shall be painted with one shop or prime coat and with not less than two field coats. The color shall be as specified or determined by the Engineer. Coats shall be different in color 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. The 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.

8-5.9 CONSTRUCTION AND FABRICATION REQUIREMENTS

8-5.9.1 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 that 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.

8-5.9.2 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.

The plates, angles, other shapes, and built-up members shall be straightened without fracturing or injuring the metal. Mechanical means to straighten distorted members by applying limited, localized heat. Heat straightening of AASHTO M 270M/M 270 Grades 70W, 100, and 100W (485W, 690, and 690W) steel members will be performed only under rigidly controlled conditions subject to approval. The temperature values shall not exceed as specified in Table 8-5.5

TABLE 8-5.5: MAXIMUM STRAIGHTENING TEMPERATURE

Material to Be Straightened	Maximum Temperature (°C)
Grade 485W > 150 mm from weld	565
Grade 485W < 150 mm from weld	480
Grade 690 and 690W > 150 mm from weld	595
Grade 690 and 690W < 150 mm from weld	510

The maximum straightening temperature for all other steels is 1,200°F (650°C). Temperature shall be measured by using temperature-indicating crayons, liquids, or bimetal thermometers. The Engineer will reject material heated in excess of the specified limits unless testing verifies material integrity.

The Engineer will ensure that parts to be heat-straightened are free of stress and external forces, including stresses from mechanical means used to apply the heat.

8-5.9.3 Abutting Joints.

Mill or saw cut abutting ends in compression members of trusses and columns to provide a square joint and uniform bearing. The maximum opening in unfaced joints is 3/8 in. (10 mm).

8-5.9.4 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.

8-5.9.5 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.

The surface shall be finished for bearing, base plates, and other bearing surfaces that contact each other or concrete as specified in Table 8-5.6.

TABLE 8-5.6: SURFACE ROUGHNESS VALUES

Bearing Surface	Surface Roughness Value in. × 10–6 (μm)
Steel slabs	2000 (50)
Heavy plates in contact in shoes to be welded	1000 (25)
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 (12.5)
Bridge rollers and rockers	250 (6)
Pins and pin holes	125 (3)
Sliding bearings	125 (3)

8-5.9.6 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.

8-5.9.7 Plates

a. Direction of Rolling

Steel plates for main members shall be cut and fabricated for main members and shall be spliced for flanges and main tension members so the primary direction of rolling is parallel to the main tensile and/or compressive stresses.

b. Plate Cut Edges.

The plates shall be planed, milled, ground, or thermal cut to a depth of 1/4 in. (6 mm) the sheared edges of plates more than 5/8 in. (16 mm) thick that carry calculated stress.

i. Oxygen Cutting.

Oxygen cutting shall conform the requirements of AASHTO/AWS D1.5M/D1.5 Bridge Welding Code.

ii. Visual Inspection and Repair of Plate Cut Edges.

Shall conform the requirements of AASHTO/AWS D1.5M/D1.5 Bridge Welding Code.

c. Bent Plates

Plates to be bent shall be taken from the stock plates to ensure the bend line is at right angles to the direction of rolling. Cold bent ribs for orthotropic deck bridges shall be bent with the bend lines in the direction of rolling only with approval. Before bending, The plate corners shall be rounded to a 1/16-in. (1.5mm) radius where the bend are placed.

i. Cold Bending

The plate shall be cold bended steel without cracking. The minimum bend radii specified in Table 8-5.7 shall be used, measured to the concave face of the metal.

TABLE 8-5.7: MINIMUM BEND RADII

Plate Thickness, in. (mm)	Bending Radius (for all grades of structural steel)
Less than 1/2 (12)	2*t*
Over 1/2 to 1 (12 to 25)	2.5*t*
Over 1 to 11/2 (25 to 38)	3*t*
Over 11/2 to 21/2 (38 to 60)	3.5*t*

ii. Hot Bending

Bend radii smaller than the minimum specified for cold bending with the plates at a temperature less than 1,200°F (650°C), excluding AASHTO M 270M/M 270, Grades 70W, 100, and 100W (485W, 690, and 690W) steel. Plates shall be requenched and tempered Grades 100 and 100W (690 and 690W) steel when the steel to be bent is to be heated higher than 1,100°F (595°C).

8-5.9.8 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.

8-5.9.9 Finished Members

Finished members shall be true to line and free from twists, bends and open joints.

8-5.9.10 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).

8-5.9.11 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.

8-5.9.12 Finish

Portions of the work exposed to view shall be finished neatly. Shearing, flame cuffing 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.

8-5.9.13 Bolted Connections

Bolted connections unless otherwise shown on the Drawings shall be made with high-strength steel bolts conforming to ASTM 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.

8-5.9.14 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 Section 8-5.9 “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 a half ($1^1/_2$) 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) % of the holes for each connection. All holes shall pass a pin four and a half ($4^1/_2$) 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 A 26 where the material is thicker than two and a quarter ($2^1/_4$) cm 7/8” will not be permitted. Punching or sub-punching of high strength structural steel where the material is thicker than two (2) cm 0.63” 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 materials that are to be reamed shall not consist of both sub-punched and sub-drilled holes and holes punched or drilled full size.

8-5.9.15 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) cm in diameter, a hole not less than four and three quarters ($4^3/_4$) cm 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 eight-tenths (0.8) mm.

The diameter of the holes for pins shall not exceed that of the pins by more than half (1/2) mm for pins thirteen (13) cm or less in diameter, or eight-tenths (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.

8-5.9.16 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 wedged 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 (5,000 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 not show any expansion after seven days when tested in accordance with AASHTO T 160.

When air temperature is below four (4) °C, the Contractor shall provide adequate cold weather protection to maintain a minimum air temperature of four (4) °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) °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 (½) inch (13 mm) above the nut and shall be threaded to approximately half (½) 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 (1/2) 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 (1/2) 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) °C or as indicated on the Drawings.

8-5.10 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 that 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 labor, 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:

i. Departure from overall plan dimensions at any level ....ten (10) mm.

ii. Departure from theoretical centers of adjacent beams or girders in any floor or roof ....five (5) mm.

iii. Departure from the true alignment of any plate girder relative to the associated setting out geometry shown on the Drawing ... five (5) mm.

iv. Departure from the true vertical center line or any girder throughout its length of height ....five (5) mm.

v. 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 Section 8-5.7.8. 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 subjected 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 (24) 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

All paints shall be applied in accordance with the manufacturer's instructions and as specified under Section 8-5.7.8.

Damaged areas of paintwork 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

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.

All parts of the Works done on the Site will be subjected 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.

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.

8-5.11 MEASUREMENT AND PAYMENT

8-5.11.1 Measurement

The quantity to be paid for shall be measured for different sized (cross-section) members separately in running foot / running meter and then multiplied by its theoretical unit weight of the relevant steel section in lbs / kg if there tested weight is within permissible variation limit of $\pm$ 6% and if the tested weight difference is more than 6%, the weight will be arrived at the actual weight if in minus and if the tested weight is more than +6% then the theoretical weight will be considered. Including the weight (mass) of heads, nuts, single washers and threaded stick-through of all high tensile strength bolts, both shop and field, and the basis of Table below:

8-5.11.2 Payment

The pay item shall include fabrication, erection and protective coating (painting). The measurement shall be the total weight of the finished member comprising plates, rolled sections, shear connectors, stiffeners, cleats, packs, splice plates and all incidentals necessary to complete the item, without allowance for tolerance for rolling margin and other permissible deviations from standard weights and excluding the weights of welds, fillets, bolts, nuts, washers and protective coatings. No deductions shall be made for notches, holes and the like each less than decimal zero one (0.01) sq m measured in area.

Fabrication shall include:

a. Preparation and supply of shop drawings.

b. Examining and checking steel plates for segregation, laminations, cracks and surface flaws and carrying out any remedial measures required by the Engineer in respect of such defects.

c. Cutting, marking off, drilling, notching, machining, form fitting, edge preparation and cambering.

d. Welding, riveting, bolting as the case may be, assembling and pre-heating.

e. Bolts, nuts and washers required to fabricate the steelwork and to complete the erection and installation of steelwork on Site, together with spares and service bolts, drifts, draw-up cleats and the like.

   The measurement will include the weight (mass) of heads, nuts, single washers, and threaded stick-through of all high tensile strength bolts, both shop and field, on the basis of Table 8-5.8:

TABLE 8-5.8

MASS PER 100 BOLTS(SI UNITS)

Designation	Bolt Diameter	Mass/100 Bolt Kg (lbs)	Over Size Limit Inch (mm)
M16	¼" (6mm)	14.4 (31.74)	0.016 (0.4)
M20	5/16" - 3/8" (8mm) to (10mm)	23.8 (52.46)	0.017 (0.43)
M22	7/16" - ½" (10.5 mm) to (13mm)	36.5 (80.45)	0.018 (0.45)
M24	9/16" – ¾" (13.5 mm) to (20mm)	53.0 (116.81)	0.020 (0.50)
M27	7/8" (22 mm)	75.0 (165.3)	0.022 (0.55)
M30	1.0" - 1¼" (25 mm) to (31.25 mm)	96.4 (212.46)	0.024 (0.60)
M36	1 3/8" - 1 ½" (34 mm) to (38 mm)	127.3 (280.57)	0.027 (0.67)

f. Welding shear connectors to steel members either at the place of fabrication or on Site and preheating as per Table 8-5.9.

TABLE 8-5.9: MASS OF FILLET WELDS

Fillet Weld	Mass Lb/ft (kg/m)
3/16" (5mm)	0.08 (0.12)
¼" (6mm)	0.14 (0.21)
5/16" (8mm)	0.22 (0.33)
⅜" (10mm)	0.30 (0.45)
½" (12mm)	0.55 (0.82)
⅝" (16mm)	0.80 (1.19)
¾" (20mm)	1.10 (1.64)
⅞" (22mm)	1.49 (2.23)
1" (25mm)	2.00 (2.98)

g. Approval testing of welders.

h. Production tests of welding during fabrication including non destructive testing.

i. Marking members for identification and delivery in matching sequence.

Permanent Erection shall include:

i. Temporary bracing or stays to prevent displacement including the provision and removal of temporary attachments.

ii. Approval testing of welders.

iii. Permanent bolted and welded connections required on Site including the provision of preheat and shelters for welding.

iv. Production tests of Site welding including non-destructive testing.

Protective Coating shall include:

1. Specimen panels of blast cleaning.
2. Paint samples and dispatching to testing authority.
3. Paint application procedure trials.
4. Testing.
5. Masking and other measures to protect adjacent untreated steelwork.
6. Joint fillers and sealing of bolted joints.
7. Preparing materials for application.
8. Preparation of surfaces and painting of steelwork at the place of fabrication and on Site.
9. Complying with any special requirements in respect of ambient conditions for the application of protective treatment and for intervals between successive operations and applications.
10. Strip coats.

Pay Item No.	Description	Unit of Measurement
8-5	Structural Steelwork	100 kg / cwt

SECTION 8-6

DRIVEN FOUNDATION PILES

8-6 SECTION - DRIVEN FOUNDATION PILES

8-6.2 DESCRIPTION

This work shall consist of furnishing and driving foundation piles of the type and dimensions designated on the plans or in the special provisions including cutting off or building up foundation piles when required. This specification also covers providing test piles and performing loading tests. Piling shall conform to and be installed in accordance with these specifications, and at the location, and to the elevation, penetration, and bearing capacity shown on the plans or as directed by the Engineer.

Any improperly driven, broken, or otherwise defective pile shall be corrected to the satisfaction of the Engineer by removal and replacement, or the driving of an additional pile, at no extra cost.

Except when test piles are required, the Contractor shall furnish the piles in accordance with dimension shown on the plans or special provisions. When test piles are required, the pile lengths shown on the plans are for estimating purposes only and the actual lengths to be furnished for production piles will be determined by the Engineer after the test piles have been driven. The lengths given in the Engineer's order list will include only the lengths anticipated for use in the completed structure. The Contractor shall, without added compensation, increase the lengths shown or ordered to provide for fresh heading and for such additional length as may be necessary to suit the method of operation.

8-6.3 MATERIALS

8-6.3.1 Steel Piles

The structural steel used for foundation piling shall conform to the Specification for Structural Steel for Bridges, AASHTO M 270 (ASTM A 709) Grades 36, 50, or 50W, or to the Specification for Piling for Use in Marine Environment, ASTM A 690.

8-6.3.2 Castings for Steel Piles Shoes

The castings used for castings shall conform to AASHTO M103M/M103, Grade (70-36).

8-6.3.3 Painting

Unless otherwise provided, when steel piles or steel pile shells extend above the ground surface or water surface they shall be protected by the paint system specified for painting new steel in a high pollution or coastal environment. This protection shall extend from an elevation 0.6m below the water or ground surface to the top of the exposed steel.

8-6.3.4 Concrete Piles

Concrete piles shall consist of either precast concrete piles or cast-in-place concrete piles cast in steel shells. Portland cement concrete shall conform to the requirements in Section 7-1, "Portland Cement Concrete," and unless another class is shown on the plans or specified, concrete shall be class D_2. Reinforcing steel shall conform to the requirements of Section 8-3, "Steel Reinforcement," and pre-stressing shall conform to the requirements of Section 8-4, "Prestressed Construction."

Steel shells for cast-in-place concrete piles shall be of not less than the thickness shown on the plans. The Contractor shall furnish shells of greater thickness if necessary to provide sufficient strength and rigidity to permit driving with the equipment selected for use without damage, and to prevent distortion caused by soil pressures or the driving of adjacent piles. The shells shall also be watertight to exclude water during the placing of concrete. The shells may be cylindrical or tapered, step-tapered, or a combination of either, with cylindrical sections.

8-6.4 CONSTRUCTION REQUIREMENTS

a. Location and Site Preparation

Piles shall be used where, indicated on the Drawings or as directed by the Engineer.

All excavations for the foundation in which the piles are to be driven shall be completed before the driving is begun, unless otherwise specified or approved by the Engineer. After driving is completed, all loose and displaced materials shall be removed from around the piles by hand excavation, leaving clean solid surfaces to receive the concrete for foundations.

b. Determination of Pile Length

The criteria for pile length and bearing capacity will be determined by the Engineer according to the results from test piles and load tests. The piles shall be driven to such depths, that the bearing loads indicated on the Drawings are obtained.

The criterion for pile length may be one of the following:

i. Piles in sand and gravel shall be driven to a bearing value determined by use for the pile driving formula or as decided by the Engineer.

ii. Piles in clay shall be driven to the depth ordered by the Engineer. However, the bearing value shall be controlled by the appropriate pile driving formula if called for by the Engineer.

iii. Piles shall be driven to refusal on rock or hard layer when so ordered by the Engineer.

The Contractor shall be responsible for correct pile lengths and bearing capacities according to the criteria given by the Engineer.

c. Pile Driving

All piles shall be driven accurately to the vertical or the batter as shown on the Drawings. Each pile shall, after driving, be within fifteen (15) cm from the theoretical location underneath the pile cap or underneath the superstructure in the case of pile bents. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

Piles shall be used only in places where a minimum penetration of three (3) m in firm materials, or five (5) m in soft materials, can be obtained. Where a soft stratum overlies a hard stratum, the piles shall penetrate to hard material upto a sufficient distance to fix the ends rigidly.

d. Pile Driving Equipment

The Engineer shall submit the necessary pile driving equipment information at least 30 days prior to driving piles, using the form shown in Data Sheet 8-6.1attached with this Section.

e. Pile Hammers

The Contractor will provide the technical specifications and operating instructions related to hammer equipment to the Engineer. The energy of the driving equipment, as submitted for approval on the Pile and Driving Equipment Data Form, will be rated by the manufacturer at or above the appropriate minimum energy level corresponding to the ultimate pile capacity as shown in Table:8-6.1

Table 8-6.1: Minimum Pile Hammer Requirements

Ultimate Pile Capacity (kN)	Minimum Manufacturer's Rated Hammer Energy (Joules)
800 and under	12,000
800 to 1,350	20,000
1,351 to 1,850	27,000
1,851 to 2,400	32,000
2,401 to 2,650	35,000
2,651 and over	Wave Equation Required

i. Drop (Gravity) Hammers

Drop (gravity) hammers shall not be used for concrete piles or for piles whose design load capacity exceeds 30 tons. When gravity hammers are permitted, the ram shall weigh between 900 and 1600 kg and the height of drop shall not exceed 4.5m. In case shall the ram weight of gravity hammers be less than the combined weight of the drive cap and pile. All gravity hammers shall be equipped with hammer guides to insure concentric impact on the drive head or pile cushion.

ii. Air and Steam Hammers

The weight of the striking part of air/steam hammers used shall not be less than 1/3 the weight of pile and drive cap, and in no case shall the striking part weighs less than 1250kg. The plant and equipment furnished for air/steam hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer.

iii. Diesel Hammers

Open-end (single acting) diesel hammers shall be equipped with a device to permit the Engineer to determine hammer stroke at all times during pile driving operations. A chart from the hammer manufacture equating stroke and blows per minute will be provided to the Engineer. Closed-end (double acting) diesel hammers shall be equipped with a bounce chamber pressure gauge, in good working order, mounted near ground level so as to be easily read by the Engineer. A correlation chart of bounce chamber pressure and delivered hammer energy shall be provided by the Contractor.

iv. Hydraulic Hammers

A power plant having sufficient capacity to maintain, under working conditions, the volume and pressure specified by the manufacturer will be used. The power plant and equipment will be equipped with accurate pressure gauges that are easily accessible to the Engineer.

v. Non Impact Hammers

Non –Impact hammers, such as vibratory hammers or driving aids such as jets, followers and pre-bored holes shall not be used unless either when specifically allowed by the Special Provisions or in writing by the Engineer. Except when pile lengths have been determined from load test piles, the bearing capacity of piles driven with vibratory hammers shall be verified by re-driving the first pile driven in each group of 10 piles with an impact hammer of suitable energy to measure the pile capacity before driving the remaining piles in the group.

f. Drive System Components and Accessories

i. Hammer Cushion

All impact pile driving equipment except gravity hammers shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure the uniform driving behavior. Hammer cushions shall be made of durable, manufactured materials, which will retain uniform properties during driving. Wood, wire rope, and asbestos hammer cushions shall not be used. A striker plate shall be placed on the hammer cushion to insure uniform compression of the cushion material. The hammer cushion shall be inspected in the presence of the Engineer when beginning pile driving at each structure or after each 100 hours of pile driving, whichever is less. The hammer cushion shall be replaced by the Contractor before resuming pile driving whenever hammer cushions compressed to less than 75 percent of the original thickness.

ii. (Helmet) Pile Drive Head

Piles driven with impact hammers shall be fitted with an adequate drive head to distribute the hammer blow to the pile head. The helmet shall be axially aligned with the hammer and the pile. The drive head shall be guided by the leads and not be free-swinging. The drive head shall fit around the pile head in such a manner as to prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

For steel and timber piling, the pile heads shall be cut squarely and a drive head provided to hold the longitudinal axis of the pile in line with the axis of the hammer.

For precast concrete and prestressed concrete piles, the pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

For special types of piles, appropriate driving heads, mandrels or other devices shall be provided so that the piles may be driven without damage.

iii. Pile Cushion

The heads of concrete piles shall be protected by a pile cushion made of plywood, hardwood or composite plywood and hardwood materials. The minimum thickness of pile cushion placed on the pile head prior to driving shall not be less than 100mm. A new pile cushion shall be provided if, during driving, the cushion is either compressed more than one-half the original thickness or begins to burn. The pile cushion dimensions shall be matched with the cross sectional area of the pile top.

iv. Leads

Pile driving leads which support the pile and the hammer in line and position throughout the driving operation shall be used. Leads shall be constructed in a manner that affords freedom of movement of the hammer while maintaining alignment of the hammer and the pile to ensure concentric impact for each blow. The leads shall be of sufficient length to make the use of a follower unnecessary and shall be so designed as to permit proper alignment of battered piles.

v. Followers

Followers shall only be used when approved in writing by the Engineer, or when specifically allowed in the special provisions. When a follower is permitted, in order to verify that adequate pile penetration is being attained to develop the desired pile capacity, the first pile in each bent and every 10th pile driven thereafter shall be furnished sufficiently long and shall be driven full length without a follower. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full length piles.

vi. Jets

Jetting shall only be permitted if approved in writing by the Engineer or when specially allowed in the special provisions. When jetting is not required, but approved after the Contractor's request, the Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall be responsible for all damage to the site caused by jetting operations. When jetting is specifically required in the special provisions, the jetting plant shall have sufficient capacity to deliver at all times a pressure equivalent to at least 700kPa at 19mm jet nozzles. In either case unless otherwise indicated by the Engineer, jet pipes shall be removed when the pile tip is a minimum of 1.5m above prescribed tip elevation and the pile shall be driven to the required bearing capacity with an impact hammer. Also, the Contractor shall control, treat if necessary, and dispose of all jet water in a manner satisfactory to the Engineer.

vii. Pre-boring

When required by the special provisions, the Contractor shall pre-bore holes at pile locations to the depths shown on the plans, specified in the special provisions, or allowed by the Engineer. Pre-bored holes shall be smaller than the diameter or diagonal of the pile cross section and sufficient to allow penetration of the pile to the specified depth. If subsurface obstructions, such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension which is adequate for pile installation. Any void space remaining around the pile after completion of driving shall be filled with sand or other approved material. The use of spuds (a short strong driven member which is removed to make a hole for inserting a pile), shall not be permitted in lieu of pre-boring, unless specifically allowed by the special provisions or in writing by the Engineer.

viii. Pile Shoes and Lugs

Pile shoes used to protect all types of piles when hard driving is expected and pile lugs used to increase the bearing capacity of steel piles shall be of the types shown on the plans and shall be used at the locations specified or ordered by the Engineer. Steel pile shoes shall be fabricated from cast steel conforming to ASTM A 27.

Such pile shoes or lugs used at the option of the Contractor shall be of a type approved by the Engineer.

g. Pile Driving Formulae

Pile driving formulas may be used to determine the number of blows of hammer per unit of pile penetration needed to obtain the specified bearing capacity for piles driven in the sub-soils at the Site. Piles shall be driven to a final resistance as indicated on the plans determined by the following formula:

For drop hammer:

Q_{all} = WH/[6(S+2.5)]

For single-acting steam or air hammers and for diesel hammers havingunrestricted rebound of rams:

Q_{all} = WH/[6(S+0.25)] (Use when driven weights are Smaller than striking weights)

Q_{all} = WH/[6{S+0.25(WD/WS)}] (Use when driven weights are larger than striking weights)

For double-acting steam or air hammers and diesel hammers having enclosed rams:

Q_{all} = E/[6(S+0.25)] (Use when driven weights are smaller than striking weights)

Q_{all} = E/[6{S+0.25(WD/WS)}] (Use when driven weights are larger than striking weights)

In the above formulas:

Q_{all} = Allowable pile load in kilograms

W = Weight of striking parts of hammer in kilograms

H = Height of fall in centimeters for steam and air hammers and the observed average height of fall in centimeters, of blows used to determine penetration for diesel hammers with unrestricted rebound of hammer

S = Average net penetration per blow in centimeters for the last 10 to 20 blows of steam, air, or diesel hammer; or for the last 15 cm of driving for a drop hammer

E = Actual energy delivered by hammer per blow in kg-cm

WD = Driven weights in kilograms

(Note: Ratio of driven weights to striking weights should not exceed three)

WS = Weight of striking parts in kilograms

Modifications of basic pile driving formula:

i. For piles driven to and seated in rock as high capacity end-bearing piles:

   Drive to refusal (approximately four (4) to five (5) blows for the last 0.625 cm of driving). Re-drive open end pipe piles repeatedly until resistance for refusal is reached within two and a half ($2^1/_2$) cm of additional penetration.

ii. For piles driven through stiff compressible materials unsuitable for pile bearing to an underlying bearing stratum:

   Add blows attained before reaching bearing stratum to required blows attained in bearing stratum.

iii. For piles into limited thin bearing stratum:

   Drive to predetermined tip elevation and determine allowable load by load test.

The bearing power as determined by the appropriate formula in the foregoing list will be considered effective only when it is less than the crushing strength of the pile. Other recognized formula for determining pile bearing power may be used when given in special specification. However, it shall be understood that the relative merits and reliability of any of the pile formula can be judged only on the basis of comparisons with the results of load tests.

8-6.5 DRIVING OF TEST PILES

Test piles and piles for static load tests, when shown on the plans, shall be furnished to the lengths ordered and driven at the locations and to the elevations directed by the Engineer before other piles in the area represented by the test are ordered or driven. All test piles shall be driven with impact hammers unless specifically stated otherwise in the special provisions or on the plans. In general, the ordered length of test piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions. The driving equipment used for driving test piles shall be identical to that which the Contractor proposes to use on the production piling. Approval of driving equipment shall conform to the requirements of these Specifications. Unless otherwise permitted by the Engineer, the Contractor shall excavate the ground at each test pile to the elevation of the bottom of the footing before the pile is driven.

Test piles shall be driven to a hammer blow count established by the Engineer at the estimated pile toe elevation. Test piles which do not attain the hammer blow count specified above at a depth of 300mm above the estimated pile toe elevation shown on the plans shall be allowed to “set up” for a period of from 12 to 24 hours, as determined by the Engineer, before being re-driven. The hammer shall be warmed up before redriving begins by applying at least 20 blows to another pile. If the specified hammer blow count is not attained on re-driving, the Engineer may direct the Contractor to drive a portion or all of the remaining test pile length and repeat the “set up” redrive procedure. When ordered by the Engineer, test piles driven to plan grade and not having the hammer blow count required shall be spliced and driven until the required capacity is obtained.

8-6.6 TEST PILES

Test piles which are shown on the Drawings or ordered by the Engineer shall conform to the requirements for piling as specified and shall be so located that they may be cut-off and become a part of the completed structure.

Test piles to be load tested shall be driven or cast-in-situ in locations determined by the Engineer. These piles shall not be utilized in the structure unless otherwise directed.

Test piles driven or cast-in-situ by the Contractor for his own use in determining the lengths of piles to be furnished may be so located and they may be cut-off and become a part of the completed structure provided that such test piles conform to the requirement for piling in these Specifications.

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.

Test piles shall generally be driven with the same equipment that is to be used for driving foundation piles. When required, the ground shall be excavated to the elevation of the bottom of the footing before the test pile is driven.

When diesel hammers are to be used for driving end bearing piles, or friction piles where the bearing capacity shall be checked by pile driving formulas, the Contractor shall in advance carry out test piling or load tests to determine the energy developed by the hammer. The Contractor may elect one of the following methods for the calibration:

a. By test driving the same type of piles successively with diesel hammer and gravity or single acting hammer, or by driving two different piles with diesel hammer and gravity or single acting hammer respectively.

b. By driving test piles to a depth determined by the Engineer and load testing the same piles.

c. Calibration tests shall be made at least at two different sites until the results are satisfactory to the Engineer.

Calibration of diesel hammers may not be required if the hammer has been previously calibrated under soil conditions and for the same size and type of pile, provided that the calibration data is accepted by the Engineer.

8-6.7 LOAD TESTING OF PILE

The load testing of the driven pile shall be done in accordance with the Section 8-7.4.

8-6.8 SPLICING OF PILES

8-6.8.1 Steel Piles

Full-length piles shall be used where practicable. If splicing is permitted, the method of splicing shall be as shown on the plans or as approved by the Engineer. The arc method of welding shall be preferred when splicing steel piles. Welding shall only be performed by certified welders.

8-6.8.2 Concrete Piles

Concrete piles shall not be spliced, other than to produce short extensions as permitted herein, unless specifically allowed by the plans, the special provisions, or by the Engineer in writing.

Short extensions or "build-ups" may be added to the tops of reinforced concrete piles to correct for unanticipated events. After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcing steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary form-work shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of not less than the quality used in the pile. Just prior to placing concrete, the top of the pile shall be thoroughly flushed with water, allowed to dry, then covered with a thin coating of neat cement, mortar, or other suitable bonding material. The forms shall remain in place not less than 7 days and shall then be carefully removed and the entire exposed surface of the pile finished as previously specified.

8-6.9 DEFECTIVE PILES

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete, injurious splitting, splintering and brooming of the wood or excessive deformation of the steel. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged by reason of internal defects or by improper driving or driven out of its proper location or driven below the butt elevation fixed by the plans or by the Engineer shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question:

The pile shall be withdrawn and replaced by a new and, if necessary, a longer pile.

A second pile shall be driven adjacent to the defective or low pile. The pile shall be spliced or built up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

All such remedial materials and work shall be furnished at the Contractor's expense.

8-6.10 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 equal to at least (40) times the diameter of the main reinforcing bars. 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 precast concrete pile, steel shell, pipe or 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 Section 7-1, if approved by the Engineer.

8-6.11 MEASUREMENT AND PAYMENT

8-6.11.1 Measurement

The quantities to be paid for shall be the number of linear meters of piles, completed and accepted, measured from the pile tip elevation to the bottom of pile caps, footings or bottom of concrete superstructure in the case of pile bents. In case the bottom of pile caps or footing or bottom of pile bent is above N.S.L and method of fabrication is such that the work above N.S.L is done as that of column, the same shall be measured as concrete and steel for column. No allowance shall be made for cut-offs or the required length of concrete or reinforcement steel placed into the concrete structure as called for on the Drawings. Any additional pile lengths that may be necessary to suit the Contractor's method of operation or for any other reason shall not be included in the measurements.

For cast-in-situ piles, helical and vertical steel will be measured in Tons. Pile casing wherever provided will be measured in linear meters. Measurement shall be made for permanently placed pile casing as shown on the Drawings. If the Contractor likes to use temporary casing for the convenience of preparing of boreholes, the same shall not be measured whether left in place or withdrawn after completing the boreholes.

Test piles when ordered by the Engineer, whether or not utilized as service piles in the structure shall not be included in the above measurements. Accepted test piles will be measured separately as the number of linear meters.

Pile shoes when called for on the Drawings or by the Engineer shall be measured by the number accepted in place.

Splicing of piles if not shown on the Drawings will not be allowed except that the length of reinforcement is to exceed twelve (12) m in which case the splicing will not be measured or paid directly but the cost thereof shall be considered as included in the unit price for piling.

Load tests shall be counted as the number of complete and accepted load tests.

Concrete footings or pile caps shall be measured and paid for as provided under Section 8-1, "Structures". Additional quantities of concrete, reinforcement and formwork caused by incorrect location of piles or additional piles necessary to replace defective piles shall be to the Contractor's expense.

The measurement for the work specified for drilling of bore holes at the sites of bridges and structures including collection of disturbed, undisturbed and rock core samples, performing the field and laboratory testing and compilation and presentation of reports shall be done.

8-6.11.2 Payment

The quantities of piling left in place in the accepted structure measured as provided above shall be paid for at the Contract unit price per linear meter of piles of the different types listed below and shown in the Bill of Quantities.

For cast-in-situ piles, rate per linear meter will include all items except for helical and vertical reinforcement, which will be paid as per steel reinforcement Section 8-3.

For precast piles, the cost of steel shall be included in the rate per linear meter.

Pile casing will be paid at the Contract unit price per linear meter for pile casing.

Test piles whether or not used in the completed structure or constructed adjacent to structure as per requirements of the Contract Documents shall be paid for at the Contract unit price for pile installation.

Load tests shall be paid for at the Contract unit price for pile load Tests, either one and a half ($1^1/_2$) times or two (2) times the design load. The unit price for test loading to three (3) times the design load shall include the total load test with all load increments.

Payment for tubular steel piles left in place shall include the cost of the concrete core of the specified class of concrete and the steel reinforcement of the said concrete core.

The payment for the work specified for drilling of bore holes at the sites of bridges and structures including collection of disturbed, undisturbed and rock core samples, performing the field and laboratory testing and compilation and presentation of reports shall be paid as per the items listed below and given in the BOQ.

Such prices and payment shall be considered full compensation for furnishing all materials, performing standard penetration and all other relevant laboratory tests, labor, equipment, tools, fuel, welding, if needed and other incidental expenses including splicing, caging, providing covers etc. necessary to complete the work prescribed in this Section or as directed by the Engineer.

Pay Item No.	Description	Unit of Measurement
8-6 (a)	Furnishing and Placing Pre-Cast Pile of Reinforced concrete of specified strength and specified dimensions including casting, curing furnishing etc.	Rft. or Meter
8-6 (b)	Pre-Cast Pile Driving including Pre-boring, getting to facilities Pile driving also includes pile driving Equipment for pile driving	Rft. or Meter
8-6 (c)	Steel Reinforcement of specified Grade including fabrication etc. for Test pile and Driven piles.	M. Ton
8-6 (d)	Furnishing and Placing Pre-Cast Test Pile of RCC of specified strength and specified dimensions including casting, curing furnishing.	Rft. or Meter
8-6 (e)	Driving of Pre-Cast Test Pile including Pre-boring, getting to facilitate Boring. It also includes Pile Driving Equipment for pile driving.	Rft. or Meter
8-6 (f)	Load Tests of Driven Pre-cast Test Pile of	Each

	Prescribed load and in prescribed manner.	
8-6 (g)	Splices.	Rft. or Meter
8-6 (h)	Pile Shoes.	Each
8-6 (i)	Pile Lugs.	Each
8-6 (j)	Cement Concrete of Class (Specified) for Pile Caps	Cu.ft (m^3)
8-6 (k)	Steel Reinforcement for Pile Cap of specified Grade	100 kg /cwt

Data Sheet: 8-6.1 Pile and Driving Equipment Data Form

Contract No.:____________

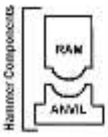
Structure Name and/or No.:____________________________________

Project:________________

Pile Driving Contractor or Subcontractor:____________________________ (Piles driven by)

County:________________

Hammer



Manufacturer:_______________ Model No.:________________

Hammer Type: Serial No.:_______________________________

Manufacturer's Maximum Rated Energy:_____________(Joules)

Stroke at Maximum Rated Energy:_________________ (meters)

Range in Operating Energy: __________to __________(Joules)

Range in Operating Stroke: __________ to __________(meters)

Ram Weight:______________________(kg)

Modifications:____
____

Striker Plate

Weight: _________________ (N) Diameter: _________(mm)

Thickness: ______________(mm)

Hammer Cushion

Material # 1	Material # 2 (for composite Cushion)
Name: _____________________	Name: ______________
Hammer Area: __________(mm^2)	Area: ___________(mm^2)
Cushion Thickness / Plate:__(mm)	Thickness/Plate: ___(mm)
No. of Plates: ________________	No. of Plates: _________

Total Thickness of Hammer Cushion: _____________________

Helmet (Drive Head)

Weight: _________________(kN)

Pile Cushion

Material: ________________________________

Area: ________________($mm.^2$) Thickness/Sheet: ___(mm)

No. of Sheets: _______________

Total Thickness of Pile Cushion: _____________________(mm)

Pile

Pile Type: ________

Wall Thickness:__________(mm) Taper: _______________

Cross Sectional Area:______(mm^2)

Ordered Length: ___________(m)

Design Load: _____________(kN)

Ultimate pile Capacity: _____(kN)

Description of Splice: _________________________________
____

Driving Shoe/Closure Plate Description: ___________________
____

Submitted By: _______________ Date: ________________

Telephone No. _______________ Fax No.: ______________

SECTION – 8-7

BORED CONCRETE PILES

8-7 DRILLED / BORED PILES

8-7.1 DESCRIPTION

This work shall consist of constructing drilled/bored foundation piles, with or without bell footings, including the placing of reinforcing steel and concrete all in accordance with the plans, these specifications and the special provisions.

8-7.2 MATERIALS

8-7.2.1 Concrete

Concrete shall conform to the requirements of Section 7-1. The concrete shall be class A_3 unless otherwise specified.

The concrete mix for drill/bored piles shall be fluid, consolidate under self-weight, be resistant to segregation, and have a set time that will assure that fluidity is maintained throughout the shaft concrete placement, and removal of temporary casing. The time for initial set of the shaft concrete should generally not exceed 12 hours.

8-7.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirements of 8-3 "Steel Reinforcement".

8-7.2.3 Casing

Casing which are required to be incorporated as part of the permanent work shall conform to the requirements of Section 8-5, "Steel Structures" Steel shall be AASHTO M 183 (ASTM A 36), AASHTO M 270 (ASTM A 709) Grade 36, or ASTM A 252, Grade 2 or 3 unless otherwise specified.

8-7.3 CONSTRUCTION REQUIREMENTS

8-7.3.1 Protection of Existing Structures

All precautions shall be taken to prevent damage to existing structures and utilities. These measures shall include but are not limited to, selecting construction methods and procedures that will prevent excessive caving of the piles excavation, monitoring, and controlling the vibrations from the driving of casing or sheeting, drilling of the piles or from blasting, if permitted.

8-7.3.2 Construction Sequence

Where drilled/bored piles are to be installed in conjunction with embankment placement, they shall be constructed after the placement of the fill and completion of any specified settlement periods unless shown otherwise in the plans.

8-7.3.3 General Construction Methods

Excavations required for piles and bell footings shall be constructed to the dimensions and elevations shown on the plans. The methods and equipment used shall be suitable for the intended purpose and materials encountered. Generally either the dry method, wet method, temporary casing method, or permanent casing method will be used as necessary to produce sound, durable concrete foundation piles free of defects. The permanent casing method shall be used only when required by the plans or authorized by the Engineer. When a particular method of construction is required on the plans, that method shall be used. If no particular method is specified for use, the Contractor shall select and use the method, as determined by site conditions, subject to approval of the Engineer that is needed to properly accomplish the work.

The excavation shall be completed in a continuous operation. If the excavation operation is stopped, the pile cavity shall be protected by installation of a safety cover. It shall be the Contractor's responsibility to ensure the safety of the piles excavation, surrounding soil and the stability of the side walls. A temporary casing, slurry or other methods approved by the Engineer shall be used if necessary to ensure such safety and stability. Excavations shall not be left open overnight unless cased full depth.

The Contractor shall use appropriate means such as a cleanout bucket or air lift to clean the bottom of the excavation of all piles. When unexpected observations are encountered, the Contractor shall notify the Engineer promptly. The removal of such obstructions and the construction of excavation shall be as directed by the Engineer.

8-7.3.4 Dry Construction Method

The dry construction method shall be used only at sites where the groundwater table and site conditions are suitable to permit construction of the pile in a relatively dry excavation, and where the sides and bottom of the pile remain stable without any caving, sloughing or swelling and may be visually inspected prior to placing the concrete. The dry method consists of drilling the pile excavation, removing accumulated seepage water and loose material from the excavation, and placing the pile concrete in a relatively dry excavation.

The Engineer will only approve use of the dry construction method when the trial pile excavation demonstrates the following:

less than 300 mm of water accumulates above the base over a [1]-hour period when no pumping is allowed;

the sides and bottom of the hole remain stable without detrimental caving, sloughing or swelling over a [4]-hour period immediately following the excavation; and

any loose material and water can be satisfactorily removed prior to inspection and prior to placing concrete.

If the above criteria are not met, wet construction method or the casing construction method shall be used.

8-7.3.5 Wet Construction Method

The wet construction method shall be used at sites where a dry excavation cannot be maintained for placement of the pile concrete. This method consist of using water or mineral slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage and pile concrete. Exterior casings shall be extended from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of concrete, where drilled shafts are to be located in open water areas. Exterior casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that no piping of water or other materials occur into or from the shaft excavation.

8-7.3.6 Temporary Casing Construction Method

The temporary casing construction method shall be used at sites where the stability of the excavated hole and / or the effects of groundwater cannot be controlled by other means.

Temporary casing may be installed by driving or vibratory procedures in advance of excavation to the lower limits of the caving material.

Temporary casings shall be removed while the concrete remains workable (i.e., a slump of 4 inches or greater). As the casing is being withdrawn, a 5 foot minimum head of fresh concrete in the casing shall be maintained so that all the fluid trapped behind the casing is displaced upward without contaminating the pile concrete. The required minimum concrete head may have to be increased to counteract groundwater head outside the casing. Movement of the casing by rotating, exerting downward pressure and tapping to facilitate extraction or extraction with a vibratory hammer will be permitted. Casing extraction shall be at a slow, uniform rate with the pull in line with the pile axis.

8-7.3.7 Permanent Casing Construction Method

The permanent casing construction method shall be used only when required by the plans. This method generally consists of driving or drilling a casing to a prescribed depth before excavation begins. If full penetration cannot be attained, the Contractor may either excavate material within the embedded portion of the casing or excavate a pilot hole ahead of the casing until the casing reaches the desired penetration. The pilot hole shall be no larger than one-half the diameter of the pile and shall be centered in the pile. Over reaming to the outside diameter of the casing shall not be performed unless specifically stated in the Plans or Special Provisions.

The casing shall be continuous between the elevations shown on the plans. Unless shown on the plans, the use of temporary casing in lieu of or in addition to the permanent casing shall not be used.

After the installation of the casing and the excavation of the pile is complete, the reinforcing steel shall be placed, followed by the placement of the pile concrete. After the permanent casing has been filled with concrete, any voids between the pile excavation and the casing shall be pressure grouted with cement grout. The method of pressure grouting the voids shall be submitted to the Engineer for approval.

Pressure grouting is required to assure contact (bearing) between the casing and any surrounding soil layer that is utilized for lateral support.

8-7.3.8 Excavation

The bottom elevation of the bored pile shown on the plans may be adjusted during construction if the Engineer determines that the foundation material encountered during excavation is unsuitable or differs from that anticipated in the design of the drilled pile.

When specified or shown in the plans, the Contractor shall take soil samples or rock cores to determine the character of the material directly below the pile excavation. The Engineer will inspect the samples or cores and determine the final depth of required pile excavation.

Excavated materials which are removed from the pile excavation and any drilled/bored fluids used shall be disposed of in accordance with the special provision and in compliance to the directions of Engineer.

When bell footings are shown in the plans they shall be excavated to form a bearing area of the size and shape shown.

8-7.3.9 Casings

Casings shall be metal, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified diameter of the pile. The inside diameter of the casing shall not be greater than the specified diameter of the pile plus 6 inches unless otherwise approved by the Engineer. Where the minimum thickness of the casing is specified in the Plans, it is specified to satisfy structural design requirements only. The Contractor shall increase the casing thickness as necessary to satisfy the casing strength requirements for handling and driving stresses.

Temporary casings may be corrugated and non-watertight if conditions permit.

8-7.3.10 Bentonite Slurry

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 sub-clause (vii) hereof shall include details of the slurry. These shall include inter-alia:

1. The source of the bentonite
2. The constitution of the slurry
3. Specific gravity, viscosity, shear strength and pH value of slurry
4. The methods of mixing, storing, placing, removal and recirculating the slurry and
5. 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.

- **Manufacturer’s Certificate**

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.

- **Tests on Bentonite Slurry**

The Contractor shall carry out tests 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 13B-1, Section -1 and 2.2.

Prior to placing pile concrete, the contractor shall use an approved sampling tool to take slurry samples from the bottom and at mid height of the pile. Any heavily contaminated slurry that has accumulated at the bottom of the pile shall be eliminated. The bentonite slurry shall be within specified requirements immediately before pile concrete placement. If the physical properties of any bentonite slurry deviate outside the agreed limits, it must be replaced with new bentonite slurry with the correct physical properties, regardless of how long it has been used.

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.

Adequate time shall be allowed for proper hydration to take place, consistent with the method of mixing, before using slurry in the Works.

A minimum of four sets of tests during the first 8 hours of slurry use shall be conducted. When the results show consistent behavior, the Contractor shall decrease the testing frequency to one set for every four hours of slurry use. Tests are performed when the slurry temperature is above 40°F (4.5°C). The requirement for mineral slurry should be as shown in Table 8-7.1

TABLE 8-7.1: REQUIREMENTS FOR MINERAL SLURRY (SODIUM BENTONITE OR ATTAPULGITE IN FRESH WATER)

Property	At Time of Slurry Introduction	In Hole at Time of Concreting	Test Method
Density[a]	64.3 to 69.1 lb/ft^3 (10.1 to 10.8 kN/m^3)	64.3 to 75.0 lb/ft^3 (10.1 to 11.8 kN/m^3)	Density Balance
Viscosity[b]	28 to 45 sec/quart	28 to 45 sec/quart	Marsh Funnel
pH	8 to 11	8 to 11	pH paper, pH meter

a. Increase by 2 lb/ft^3 (0.31 kN/m^3) in salt water.

b. Standard measurements are in seconds per quart, not seconds per liter. 1 sec/quart is equivalent to 1.06 sec/L, but 1 quart, not 1 liter, of slurry should be used in the test.

- **Precautions**

The Contractor shall control the bentonite slurry so that it does not cause a nuisance either on the Site or adjacent waterways or other areas. After use it shall be disposed in a manner to the approval of the Engineer.

The level of the slurry in the bentonite shall be maintained so that the 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.

Where pile bores contain water or drilling fluid, a cleaning process shall be employed before concrete is placed. Large debris and/or accumulated sediment shall be removed from bottom of the bore hole using appropriate approved methods, which shall be designed to clean while at the same time minimizing ground disturbance at bore hole tip level. Water or drilling fluid shall be maintained at such levels throughout and following the cleaning operation so that the stability of the bore is preserved.

Before placing concrete, measures shall be taken in accordance with the above para to ensure that there is no accumulation of silt or other material at the base of the boring, and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the hole. The bore hole should be washed thoroughly before placement of concrete.

Concrete to be placed under water or drilling fluid shall be placed by tremie and shall not be discharged or dropped freely into the water or drilling fluid. Pumping of concrete may be approved where appropriate.

A sample of the 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. In this event the Contractor shall modify or replace the bentonite as approved to meet the Specifications.

8-7.3.11 Removal of Soil From Boreholes

The soil and debris from inside the pile boreholes shall be removed by bucket, augur 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 sub soil stratum to the satisfaction of the Engineer and shall lengthen the pile if necessary and cost of any such lengthening shall be paid as per this Contract.

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. In any case, a pile shall not remain unfilled with concrete for period exceeding eighteen (18) hours after completion of 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.

8-7.3.12 Samples and Tests

The Contractor shall take soil samples or as directed by the Engineer to the designed tip elevation of the pile and shall carry out in-situ Standard Penetration tests within and ahead of borehole on the line of vertical axis of the pile at these locations after one and a half (1 1/2) m interval. In addition to these samples, the Contractor shall also keep a complete borehole log with a visual soil classification supported by an adequate number of samples preserved in sealed and adequately labelled glass jar, for at least two pile boreholes for each pier and each abutment. An adequate number of samples shall mean not less than one sample for every 5 feet of borehole and in addition, not less than two samples at every significant change in the soil strata.

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).

8-7.3.13 Bore Hole Inspection

After temporary casing has reached its final penetration and otherwise made ready to receive reinforcement and thereafter concrete, the contractor shall inform the Engineer or his representative who shall personally check the actual penetration achieved, the amounts and directions, if any, by which the borehole is out-of-position and/or out-of-plumb or out-of-rake. Final shaft depth shall be measured after final cleaning.

No more than ½ inch of loose or disturbed material shall be present at the bottom of the shaft just prior to placing the concrete for end bearing shafts. No more than 2 inches of loose or disturbed material shall be present for side friction shafts. End bearing shafts shall be assumed unless otherwise noted in the Plans. The excavated shaft shall have the approval of the Engineer prior to proceeding with construction.

8-7.3.14 Reinforcing Steel Cage Construction and Placement

The reinforcing steel cage consisting of the steel shown on the plans plus cage stiffener bars, spacers, centralizers, and other necessary appurtenance shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted and prior to shaft concrete placement. The reinforcing cage shall be rigidly braced to retain its configuration during handling and construction. Individual or loose bars shall not be used. The Contractor shall show bracing and any extra reinforcing steel required for fabrication of the cage on the shop drawings.

The reinforcement shall be carefully positioned and securely fastened at a suitable spacing in such a manner as to ensure that the concrete cover listed below is maintained throughout and that the reinforcement cage is not displaced in the casing during placement of the concrete.

The contractor may prefer to lower the reinforcement cage assembly into the borehole in two or three sections. In that case he has to observe the same lapping requirements as for assembly on ground, namely, that the main longitudinal reinforcement shall be lapped for not less than 40 bar diameter and the spiral reinforcement shall be double over these laps.

Place bars as shown in the contract plans with concrete cover as shown in the table below:

Concrete Cover			
Shaft Diameter	**Uncased**	**Casing Remains**	**Casing Withdrawn**
2'.0" or less	3"	3"	4"
3'.0"	3"	3"	4"
4'.0"	4"	4"	4"
5'.0" or larger	6"	6"	6"

Rolling spacers for reinforcing steel shall be used to minimize disturbance of the side walls of the shaft and to facilitate removal of the casing during concrete placement.

Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals not exceeding 5 feet along the shaft to ensure concentric location of the cage within the shaft excavation. When the size of the longitudinal reinforcing steel exceeds one inch diameter, the maximum spacing of the spacing devices may be increased to 10 feet (maximum). Approved non-corrosive bottom supports shall be provided for the rebar cage to assure that the reinforcing is the proper distance above the base.

Other types of spacers may be used if approved by the Engineer. The Contractor shall submit details of the proposed reinforcing cage spacers along with the shop drawings. Shaft excavation shall not be started until the Contractor has received approval from the Engineer for the Contractor proposed spacers.

8-7.3.15 Concrete Placement, Curing and Protection

Concrete placement shall commence immediately after completion of excavation, inspection and setting of the reinforcing cage, and shall continue in one operation, to the top of the shaft, or to a construction joint identified on the plans. An unforeseen stoppage of work may require a horizontal construction joint during the shaft construction. For this reason, an emergency construction joint method shall be submitted to the Engineer for approval prior to starting shaft construction.

For concrete to be placed in water slurry shall be placed through a tremie using methods specified in Section 701, "Underwater Placement." Before placing any new concrete against concrete deposited in water, the Contractor shall remove all scum, laitance, loose gravel and sediment on the upper surface of the concrete deposited in water and chip off any high spots on the upper surface of the existing concrete that would prevent any subsequent shaft reinforcing from being placed in the position required by the Plans.

Concrete to be placed in dry shafts shall be placed and consolidated as specified.

The Contractor must have a proper light accessible at all times prior to the placing of the concrete into the driven well for the inspection of each shell throughout its entire length.

No concrete shall be placed until all driving within a radius of 15 feet of the pile has been completed, or all driving within the above limits shall be discontinued until the concrete in the last pile cast has set at least 5 days.

Concrete for cast-in-place piles shall be dense and homogeneous. Vibration or rodding of concrete for cast-in-place piles will only be required to a depth of 5 feet below the ground surface.

Concrete shall be placed for each pile in a single continuous operation with the flow of concrete directed down the center of the pile so as to consolidate the concrete by impact. Accumulations of water in shells shall be removed before the concrete is placed. Concreting shall continue until the concrete has reached an elevation 3 feet higher than the bottom of the future pile cap. After the concrete has hardened, the top surface shall be cut back to remove laitance to the final elevation of the top of the piles which is 3 inch above the bottom of the future pile cap exposing the length of pile reinforcement required for lapping and bond within the pile cap.

For shafts less than 8 feet in diameter, the elapsed time from the beginning of concrete placement in the shaft to the completion of placement shall not exceed 2 hours unless a shaft concrete retarder is approved by the Engineer. For shafts 8 feet and greater in diameter, the concrete placing rate shall be not less than 30 feet of shaft height per each 2-hour period providing a 4 inch minimum slump is maintained throughout the concrete placement based on tests of a trial mix. The concrete mix shall be of such design that the concrete remains in workable plastic state throughout the 2-hour placement limit.

When the top of shaft elevation is above ground, the portion of the shaft above ground shall be formed with a removable form or with a permanent casing, when specified.

The shaft concrete shall be vibrated or rodded to a depth of 5 feet below the ground surface except where soft uncased soil or slurry remaining in the excavation will possibly mix with the concrete.

After placement, the temporarily exposed surfaces of the shaft concrete shall be cured in accordance with the provisions in Section 701, "Cement Concrete."

For at least 48 hours after shaft concrete has been placed, no construction operations that would cause soil movement adjacent to the shaft, other than mild vibration, shall be conducted. Mild vibration is defined as operation of light construction equipment adjacent to the shaft.

Portions of drilled shafts exposed to a body of water shall be protected from the water by leaving the forms in place for a minimum of seven days after concrete placement or until the shaft concrete reaches a minimum strength of 2500 psi, whichever occurs first.

8-7.3.16 Construction Tolerances

The following construction tolerances shall be maintained in constructing bored piles:

Piles shall be constructed so that the center at the top of the Pile is within the following tolerances:

Pile Diameter	Tolerance
2’.0” or less	2”
3’.to 4’	3”
4’.to 5’	4”
5’.0” or larger	5”

Piles shall be within 1% of plumb. For rock excavation, the allowable tolerance can be increased to 1.5% max.

After all the pile concrete is placed, the portion of the pile reinforcing steel cage embedded in the pile shall be no more than 1 inch above no more than 3 inches below plan position, and shall be at least 1 inch below the top the pile.

The minimum diameter of the drilled/bored pile shall be the diameter shown on the plans for diameters 24 inches or less and not more than 1 inch less than the diameter shown on the plans for diameters greater than 24 inches. The maximum pile diameter shall be the diameter shown in the plans, plus 6 inches.

The bearing area of bells shall be excavated to the plan bearing area as a minimum. All other dimensions for the bells shall be as shown on the approved working drawings.

During drilling or excavation of the pile, the Contractor shall make frequent checks on the plumbness, alignment, and dimensions of the pile. Any deviation exceeding the allowable tolerances shall be corrected with a procedure approved by the Engineer.

Drilled/bored pile excavations constructed in such a manner that the concrete pile cannot be completed within the required tolerances are unacceptable. Correction methods shall be submitted by the Contractor for the approval. Approval will be obtained before continuing with the drilled/bored pile construction.

Materials and work necessary to effect correction for out-of-tolerance drilled/bored pile excavations shall be furnished at no additional cost to the Department.

8-7.3.17 Integrity Testing

When called for in the special provisions, the completed pile will be subjected to nondestructive testing to determine the extent of any defects that may be present in the pile.

Work and materials required for testing which are to be furnished by the Contractor shall be as shown on the plans or special provisions.

In the event testing discloses voids or discontinuities in the concrete which, as determined by the Engineer, indicate that the drilled pile is not structurally adequate, the pile shall be rejected. The Contractor shall repair, replace or supplement the defective work in a manner approved by the Engineer. The construction of additional drilled piles shall be discontinued until the Contractor demonstrates the adequacy of the pile construction method and any subsequent method changes to the satisfaction of the Engineer. Any additional work required as a result of pile defects shall be at no additional cost to the Department.

8-7.4 TEST LOADING OF PILES

8-7.4.1 PURPOSE OF LOAD TESTS:

The load tests stipulated in this Section of the specifications are intended for the purpose of adjusting in the field the penetration of piles actually required to obtain an ultimate load bearing capacity of the piles of not less than 2 x Dead Load + 2 x Live Load or such higher factor of safety as the Engineer may stipulate at his discretion. A secondary objective of these pile loading tests is to establish whether any significant pile settlements are likely to occur up to the design load values.

8-7.4.2 PILES TO BE TESTED

The test piles shall be located in the bed as instructed by the Engineer in the vicinity of the bridge. The penetration of piles shall be down. to specified elevation and the effective embedment of these piles shall be limited to the specified level by means or device approved by the Engineer, for example, by leaving in place a sufficient portion of the steel. casing, all in a manner calculated to simulate as closely as possible the actual conditions which may occur with maximum local, scour.

8-7.4.3 TIME OF TESTING:

Not less than 14 (fourteen) days shall elapse between the end of all concreting operations on any test pile and the application of any test loads.

8-7.4.4 METHOD OF READING SETTLEMENT:

A reference bolt shall be set in the top of each test pile and two bench marks shall be established on permanent objects near the location of the test piles and not less than 30 feet from the nearest test pile. The bench marks should be so located as to allow cross bearing on all the test piles and, if necessary, a third bench mark shall be established for this purpose, provided that only two bench marks are used for observations on any one test pile. Observations of settlements shall be made with reference to these two bench marks for each test pile by readings taken on these bench marks and on the reference, bolt set in the top of each test pile.

8-7.4.5 METHOD OF LOADING PILES:

The apparatus for the application of test loads should be capable of applying known vertical loads to the top of the test pile without including any horizontal thrust, twist or moment in the pile. Any loading apparatus used shall be so designed as to allow the direct placing of a surveyor's target rod on top of the reference bolt referred to above set in the top of the pile, without any interference, Adequate precautions shall be taken by the contractor to avoid accidents owing to toppling over of the test load, sudden pile settlements or any other reason. The contractor would furnish details of the method of loading proposed to be adopted for approval by the Engineer.

8-7.4.6 LOADING AND UNLOADING TEST PILES:

The first increment of load applied to the test pile shall be 25% of the pile design load. The load on the pile shall be increased to the test load by applying additional load in increments amounting to 50, 75,100,125,150,175 and 200 per cent. A minimum period of two hours shall intervene between the applications of each increment of load except that no increment shall be added until a settlement of less than 0.005 of an inch is observed for a 15-minute interval under the previously applied increment. The settlement just after application of each load increment is applied, and at 15-minute intervals thereafter, shall be recorded. If there is a question as to whether the test pile will support the test: load, the load increments shall be reduced by 50 per cent 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 hours. During the application of each increment of load, the load shall be kept constant by jacking if required. For each application of the load the total settlement of the top of the pile, while under load, shall be recorded, then the load shall be released for a period of 15 minutes and the total permanent settlement of the top of the pile, with no load, shall be recorded. All settlement measurements shall be referred to the original top elevations of the test pile. If, after release, the full test load has caused more than one-quarter inch of permanent settlement in a period of forty-eight hours of continuous application of the test load, the test pile will be considered to have failed the test, indicating that longer piles are required. If the pile does not fail under the test load, the load shall be released and readings continued to check rebound at 15-minute intervals until no further movement: of the pile is observed. The test pile shall then again be loaded with the test load, and that load will be increased in 10-sklp increments to determine the test piles ultimate load capacity which is the maximum load on the test pile which does not cause a total settlement with load of more than one inch or a permanent settlement in excess of one-quarter inch when the load is maintained for forty-eight hours, and then released.

8-7.4.6 LOAD TEST REPORT:

A load test report: shall, be submitted in triplicate and shall contain the following information:

a) Exact location of the test piles with reference to previously established monuments or other permanent features, drawn. In a plan. to a suitable scale. This plan shall also indicate the penetration of the top of the each of test piles in plan as well as the direction and amount of bow iv. test pile, if any., in as far as those data be ascertained.
b) A. borehole log for the test piles showing reduced levels of the existing ground levels of the top of the pile, and of the ground water table, and showing also the thickness and reduced levels of various soil strata encountered during boring as well as their visual classification.
c) A time-load settlement graph. for each pile plotting the time in hours on the horizontal axis, the load in tons and the recorded settlements in thousandths of a foot being plotted to a suitable scale of the vertical axis respectively above and below the common time axis.
d) A load-settlement graph with the load in tons plotted on the horizontal axis and the corresponding settlement in thousandths of a foot plotted downwards on the vertical axis, all to a suitable scale and annotated with descriptions of settlement: variation with time at critical or otherwise important load values.
e) A report giving a general description of each load test and copies of the

load test log for each test pile in tabular form with observations of loads, settlements and times for each load test: and remarks concerning any unusual. or noteworthy occurrences during the entire operation. Measurement and Payment

8-7.3.18 Measurement

a. Drilled/Bored Pile

Drilled piles, complete in place, will be measured by the linear foot for each size of pile listed in the schedule of bid items. Measurement will be along the centerline of the pile based on the tip and pile cut-off elevations shown on the plans or as ordered by the Engineer.

b. Bell Footings

Bell footings will be measured by the cubic yard, computed by using the dimensions and shape specified on the plans or as revised by the Engineer. The bell shall consist of the volume outside the plan or authorized dimensions of the pile, which will extend to the bottom of the bell for the purpose of measurement.

c. Test Piles

Test Piles of the specified diameter will be measured from the elevation of the ground at the time drilling begins, by the linear foot of acceptable test pile drilled.

d. Test Bells

Test bells will be measured by the cubic yard computed by using the dimensions.

e. Exploration Holes

Exploration holes will be measured by the linear foot measured from the bottom of pile elevation to the bottom of the exploration hole, for each authorized hole drilled.

f. Permanent Casing

Permanent casing will be measured by the linear foot for each size of casing authorized to be used. Measurement will be along the casing from top of casing or top of pile, whichever is lower, to the bottom of the casing at each pile location where permanent casing is authorized and used.

g. Load Tests

Load tests will be measured by the number of load tests performed for each designated pile load capacity.

8-7.3.19 Payment

a. Drilled/Bored Pile

Drilled/Bored Piles will be paid for at the contract price per linear foot for drilled/bored pile of the diameter specified. Such payment shall be considered to be full compensation for all costs involved with pile excavation, disposal of excavated material, and the furnishing and placing of concrete, including all labor, materials, equipment, temporary casing, and incidentals necessary to complete the drilled/bored piles, except for steel reinforcement.

b. Steel Reinforcement

Steel reinforcement will be paid at the contract price per kilogram.

c. Bell Footings

Bell footings constructed to the specified or authorized dimensions will be paid for at the contract unit price per cubic yard for bell footings. Such payment shall be full compensation for excavation, and concrete beyond the diameter of the drilled/bored pile including all labor, materials, equipment and incidentals necessary to complete the bell footings.

d. Test Piles

Test piles of the specified diameter will be paid for at the contract unit price per linear foot for test piles. Such payment shall be full compensation for excavation and concrete or backfill material including all labor, materials, equipment, and incidentals necessary to complete the test piles, except cost of steel reinforcement.

e. Test Bell

Test bells for the diameter and shape specified or authorized and approved will be paid for at the contract unit price per cubic meter or cubic foot for test bells. Such payment shall be full compensation for excavation and concrete or backfill material including all labor, materials, equipment, and incidentals necessary to complete the test bells.

f. Exploring Holes

When specified or shown in the plans, exploration holes for soil samples or rock cores will be paid for at the contract unit price per linear meter or foot for exploration holes. Such payment shall be full compensation for drilling or coring the holes, extracting and packaging the samples or cores and delivering them to the Department and all other expenses necessary to complete the work.

g. Permanent Casing

Permanent casing will be paid for at the contract unit price per linear foot for permanent casing. Such payment shall be full compensation for furnishing and placing the casing above the costs attributable to the work paid for under associated pay items.

h. Load Tests

Load tests will be paid for at the contract unit price for each load test. Such payment shall be full compensation for all costs related to the performance of the load tests including load test report.

Pay Item No.	Description	Unit of Measurement
8-7 a	Cast in place piles of Reinforced concrete of specified strength and specified diameter including drilling of bore holes, Temporary casing, Bore Logs, Bill Footings etc.	Ft / m

8-7 b	Steel Reinforcement of specified Grade----- including fabrication, lowering of cage etc for permanent piles and test pile.	100 kg / cwt
8-7 c	Load Test of Test Piles according to the Prescribed Load and Procedure static or Dynamic as specified.	Metric Ton / cwt
8-7 d	Permanent casing of specified dimensions and quality.	kg / cwt

SECTION 8-8
WELL FOUNDATION

8-8 SECTION - WELL FOUNDATION

8-8.1 DESCRIPTION

This Section 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 comprise the following five separate main operations:

a. the casting of well kerb in proper position

b. the erection of well steening by stages

c. the sinking of the erected kerb and well steening to the required elevation

d. the proper plugging of the well and

e. the construction of the transom slab all in accordance with Specifications and the Drawings or as directed by the Engineer.

8-8.2 MATERIAL REQUIREMENTS

8-8.2.1 Structural Steel

Structural steel shall conform to the requirements of AASHTO M 183 (ASTM A 36 unless otherwise specified).

8-8.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirements under Section 8-3 “Steel Reinforcement”.

8-8.2.3 Structural Concrete

Structural concrete shall conform to Class A concrete requirements as specified under Section 7-1 “Concrete”.

8-8.2.4 Brickwork

Brickwork shall conform to the requirements as specified under Section 8-11 “Brick Masonry”.

8-8.2.5 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.

8-8.3 CONSTRUCTION REQUIREMENTS

8-8.3.1 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.

8-8.3.2 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 Section 8-7. 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.

8-8.3.3 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.

i. Positioning

Each well kerb shall be correctly positioned in place and approved by the Engineer before commencement of further work.

ii. Support

Well kerb shall be adequately supported to prevent shift or tilt during the initial operation arid on excavation and sinking whether the well has been started on made up ground or in water in excavation.

iii. 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.

iv. 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 labor will remain the responsibility of the Contractor.

v. 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.

vi. 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 effects 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.

vii. 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.

viii. 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 depositing concrete of the required strength.

i. Concrete Under Water:

The concrete deposited under water shall have ten (10) % 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.

ii. 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.

8-8.4 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 a half ($1^1/_2$) m 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) m below that elevation before he is allowed to plug the well.

8-8.5 MEASUREMENT AND PAYMENT

8-8.5.1 Measurement

a. General

For the various items of work constructed under this Section, measurement shall be made as narrated under the respective items. The quantity to be paid for shall be the original plan quantity measured as provided for respective items, except where changes have been made by the Engineer and order has been given in writing.

No measurements for or other allowances will be made for work or materials for forms, false works, supports, bracings, kentledge or pumping.

b. Structural Steel

The quantity of structural steel entering into and becoming a part of the completed structure and accepted by the Engineer shall be the computed weight in metric tons of this material entering into the completed structure of item of work.

The unit of measurement of structural steel work shall be metric tons.

The weights of the rolled shapes, bars, plates and pipe railing shall be computed on the basis of nominal weight as given in the manufacturer's hand books, using the dimensions shown on the Drawings. The weight shall be computed on the basis of dimensions and ordered overall lengths for all structural shapes. No deductions from the computed weight of rolled steel shall be made for caps, clips, sheared edges, punching borings, drillings, milling or planing and no allowance shall be made for the weight of weld metal or for overrun in weight.

c. Reinforcement Steel

For well kerb, steening and transom slab reinforcing steel shall be measured and paid for according to the requirements of Section 8-5.

d. Structural Concrete

For well kerb, steening, plugging of well and transom slab construction, concrete shall be measured and paid for according to the requirements under Section 7-1. The unit rate includes the cost of ten (10) % extra cement to be used where required.

e. Brick Work

In 1:3 (cement: sand) mortar for steening shall be measured and paid for according to the requirements of Section 8-11.

f. Well Sinking

For any item of work carried out under this head, measurement shall be made per linear meter of twin or single well of specified external diameter, sunk below the bed level shown on the Drawings. The unit of measurement shall be one linear meter. The unit rate for sinking twin or single well shall include excavation, pumping, supports, bracings, kentledge, tilt correction soil samples, all according to the requirements given in Section 8-8.3.3 and 8-8.4.

g. Fill Sand

The well hole shall be measured as the volume of well hole required to be filled. The unit of measurement shall be cubic meters.

8-8.5.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all material, equipment, labor, delivery of materials to Site, handling and storage and all incidentals necessary to complete the work prescribed in this Section:

Pay Item No.	Description	Unit of Measurement
8-8 a	Structural Steel Work for Cutting Edge	100 kg / cwt
8-8 b	Furnishing and Placing Deformed Reinforcing Steel Bars of Specified Grade for Well Curb Steining and Transom Slab	100 kg / cwt
8-8 c	Cement Concrete of Specified Strength for Well Curb Plugging of Well, Well Steining or Transom Slab	100 Cft or M^3
8-8 d	Well Sinking	Rft or M
8-8 e	Sand Filling in Well Holes	100 Cub.ft or M^3

SECTION – 8-9
BRICK MASONRY

8-9 SECTION - BRICK MASONRY

8-9.1 DESCRIPTION

The work specified in this section shall consist of providing all materials, equipment and labour required for constructing brickwork. All brickwork shall be first class and finished in a workman like manner, true to dimensions and grades shown on the drawings according to these specifications.

8-9.2 MATERIALS

8-9.2.1 Bricks.

The size of bricks shall be standard size 22.9 cm x 11.4 cm x 7.6 cm (9”x 4 ½ ” x 3”). 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 homogenous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. Shall show no signs of efflorescence on drying. Brick masonry construction shall conform to the Specifications AASHTO M114 (ASTM C62).

8-9.2.2 Portland Cement

Portland cement shall conform to the requirements for Portland cement as contained in Section 7-1.

8-9.2.3 Sand

Sand for mortar used in brickwork shall conform to the requirement for the fine aggregate specified in Section 10-6.

8-9.2.4 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 written approval of the Engineer.

8-9.3 TOOLS AND SCAFFOLDING

All equipment used for mixing mortar, transporting it and for laying bricks shall be clean and free from set mortar, dirt, or other injurious foreign substances. It shall be thoroughly cleaned at the end of each day’s work.

The contractor shall provide all scaffolding, staging, and ladders, necessary for the work. All walls or others brickwork shall be securely braced and protected against damages by wind and storm during the construction period. No extra rate shall be paid for this item.

8-9.4 BOND

Unless otherwise specified, all brickwork shall be laid in English Bond with frogs upward.

8-9.5 CONSTRUCTION REQUIREMENT

8-9.5.1 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.

8-9.5.2 Brick Laying

Brick work 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 corners, 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) m 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.

8-9.5.3 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.

8-9.5.4 Progress

Brickwork shall be carried up in a uniform manner. No portion shall be raised more than one meter (3 feet) above another at the same time. Temporary spaces left during construction shall be raked and not toothed. The brick layer shall be provided with measuring rods or straight edge having courses marked on them with saw and the height of courses shall be checked all over, during from time to time so as to keep all courses level.

8-9.5.5 Putlogs

Only headers shall be left out to allow a putlog to be inserted and not more than one brick shall be left out for each putlog. Under no circumstances shall putlogs be made immediately under or next to the impost or skew back of arches.

8-9.6 JOINTS

Horizontal points shall be parallel and truly level.

Vertical joints in alternate courses shall come directly over one another. Thickness of joints, unless otherwise specified, shall not be less than 6.3 mm (1/4”) and shall not be more than 9.5 mm (3/8’). The height of 4 courses and 3 joints as laid shall not exceed more than 25 mm (1 inch) the height of 4 bricks as piled dry one upon the other.

8-9.6.1 Jointing Works

When fresh masonry is to join masonry that has partially or fully set, the exposed joining surface of the set masonry shall be cleaned, roughened and wetted so as to affect the best possible bond with the new work. All loose bricks and mortar shall be removed.

8-9.6.2 Striking of Joints

Where in the case of brickwork in cement mortar, pointing of plastering to the face work is not provided as a separate item the joints in face work shall be struck. This operation shall be paid for separately.

8-9.6.3 Ranking Joints

The joints of brickwork, which is to be pointed or plastered, shall be raked out with a hook to a depth of 12.5 mm (1/2’). The raking shall be done before the mortar sets each day.

8-9.7 CORNERS

At all corners alternate courses of bricks shall be laid header wise and stretcher-wise so as to bond the two walls together.

Where particularly required, cut or mould bricks shall be used in jambs, arches and projecting corners, so as to eliminate sharp angles from the inside of a building. This shall be included in the unit rate if the radius of the finished (Plastered) corners does not exceed 19 mm (3/4 of an inch). In case it exceeds 19 mm (3/4 of an inch) extra payment shall be made by marking linear measurements.

8-9.8 ROUND PILLARS

Round pillars shall be built with quadrant shaped bricks, if the pillars are of considerable height flat circular discs of stone or cement concrete of the same diameter as the pillar and about 75 mm (3 inches) thick shall be introduced at every 1.0 m to 2 m (3 to 6 feet) as bond stone. The cost of this operation will be included in the unit rate.

8-9.9 PLUMB BOBS AND STRAIGHT EDGES

All brickwork shall be truly plumbed and each set of 4 brick course shall be checked with plumb bob and straight edge.

8-9.10 FACE WORK

All face work shall be finished with neat drawn joints and pointed out if it has not be plastered. If it has to be plastered the joints shall be raked out before any plaster is laid on. For face work the bricks shall be of true edges, uniform colour and correct dimensions. If specially required, face work shall be laid up with pressed bricks. It shall be measured and paid for separately. All brick courses shall be proportioned that they will work out evenly with the height of windows and doors.

8-9.11 CUT BRICK WORK

Bricks shall be cut, dressed or grooved, as required for architectural features. Corners shall be made with cut bricks.

8-9.12 FIXTURES

Holdfasts and similar fixtures shall be built in with the surrounding brickwork in their correct position in specified mortar. They shall be built in as the work progresses and not inserted later on into space left for them.

8-9.13 BED PLATES

Bed plates of concrete or stone shall be provided under each beam and joint. They shall conform to the dimensions given in the drawings and shall be carefully laid in specified cement mortar to correct level.

8-9.14 CENTERING

Centering for all openings shall be strong enough to support the lintels of arches spanning the opening. They shall be subject to the approval of the Engineer Incharge and shall remain in position till the brickwork has set. No additional payment will be made to the contractor for this item of work.

8-9.14.1 Coping, Bridge Seats and Backwalls

The tops of retaining walls, abutment wingwalls and similarly exposed brick work shall be provided, in general, with either a stone or concrete coping. The underside of the coping shall have a batter or drip bead, at least 25mm (1 inch) beyond the face of the brick work wall. The coping upon an abutment backwall will commonly have no projection beyond its bridge seat face. No coping shall be less than 0.1 m thick.

Unless otherwise specified, the top courses of all plinths, parapets, stops etc., shall be built in brick on edge in specified mortar. In case of parapet walls the outside half of the brick shall be weathered and throated. The corners shall be made by cutting selected bricks or by special bricks to given a radiated and keyed joint.

8-9.15 BRICK WORK IN ARCHES

The brickwork in arches shall conform to specifications for first class brickwork, but shall not commence till abutments have been built to their full width and upto the level of skew backs. Arch work shall be carried up evenly from both abutments and as soon as the arch is complete, masonry shall be built up evenly on both sides to the heights of crown so as to load the haunches.

8-9.16 MEASUREMENT AND PAYMENT

8-9.16.1 Measurement

Brickwork shall be measured by volume. The unit of measurement shall be 1 cubic meter. The measurement of cut bricks shall be in number. The unit of measurement shall be 1000 bricks. The item of coping shall be measured by length. The unit of measurement shall be one linear meter or one linear foot.

8-9.16.2 Payment

The unit rate shall be full compensation for carrying out 1st class brickwork including the cost of bricks mortar and any other material required, including curing and protection as per above specifications. It shall further include the cost of providing using and removing scaffolding, shuttering, centering, staging, ladders, supports and other tools and plants, required for carrying out 1st class brickwork.

Payment shall be made under: -

Pay Item No.	Description	Unit of Measurement
8-9 (a)	1st class brick work in Cement Mortar as Specified. a. Circular Masonry b. Straight Masonry	100 Cft or M^3
8-9 (b)	Coping in Specified Cement Concrete of Specified Strength	100 Cft or M^3
8-9 (c)	Brick work in Arches	100 Cft or M^3
8-9 (d)	Cut Bricks	Nos.
8-9 (e)	Cement Sand Plaster of Specified Ratio	Sq. or M^2

SECTION – 8-10

RANDUM AND DRESSED UNCOURSED STONE MASONRY

8-10 SECTION - RANDUM AND DRESSED UNCOURSED STONE MASONRY

8-10.1 DESCRIPTION

The Section shall consist of Random and Dressed uncoursed Stone Masonry with or without mortar. Dimensions of such masonry may vary as per the Drawings or as directed by the Engineer.

8-10.2 MATERIAL REQUIREMENTS

8-10.2.1 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.

8-10.2.2 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 Section 7-1 & Section 10-10.

8-10.3 CONSTRUCTION REQUIREMENTS

8-10.3.1 Stone Size and Shape

Individual stones shall have a thickness of not less than twenty (20) cm and a width of at least one and a half ($1^1/_2$) times the thickness and length of at least 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.

8-10.3.2 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) cm. Vertical joints of face stone shall be fine finished and full to the square for a depth of not less than twenty-five (25) cm.

Exposed surfaces of face stone shall be according to the plans, with edges pitched to true lines and exact batter, chisel drafts four (4) cm 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.

8-10.3.3 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 (90) cm. Stone masonry in cement mortar shall be cured for at least seven (7) days.

8-10.3.4 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) cm 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) cm. Header shall hold in the heart of the wall spaced not further apart than two and a half ($2^1/_2$) m center to center, There shall be at least one header to every two stretchers.

8-10.3.5 Cores 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) cm thick. Concrete used for cores and backing shall conform to the requirements specified in Section 7-1. 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.

8-10.3.6 Stone

It shall conform to the requirement as specified in Section 8-13.

8-10.3.7 Arches

Refer to Section 8-13.

8-10.4 MEASUREMENT AND PAYMENT

8-10.4.1 Measurement

The quantity of stone masonry to be paid for shall be the number of cubic meters measured in the completed work and the limiting dimensions shall not exceed than those shown on the Drawings or fixed in writing by the Engineer.

Class C or lean concrete shall be measured separately as per dimensions shown on the Drawings or as directed by the Engineer. No separate measurement shall be made for stuck pointing which is deemed to be included in stone masonry with mortar, however roll pointing shall be measured separately in square meter.

8-10.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for labor, materials, equipment and incidentals necessary to complete the work prescribed in this Section:

Pay Item No.	Description	Unit of Measurement
8-10 (a)	Stone Masonry Random Dry	Cu.ft or M^3
8-10 (b)	Stone Masonry Random with Mortar	Cu.ft or M^3
8-10 (c)	Stone Masonry Dressed Uncoursed Dry	Cu.ft or M^3
8-10 (d)	Stone Masonry Dressed Uncoursed with Mortar	Cu.ft or M^3
8-10 (e)	Concrete Class C	Cu.ft or M^3
8-10 (f)	Lean Concrete	Cu.ft or M^3
8-10 (g)	Roll Pointing	Sq.ft or M^2
8-10 (h)	Coping in Specified Cement Concrete of Specified Strength	Cu.ft or M^3

SECTION 8-11

DRESSED COURSED STONE MASONRY

8-11 SECTION - DRESSED COURSED STONE MASONRY

8-11.1 DESCRIPTION

This Section shall consist of dressed coursed stone masonry with mortar. Dimensions of such masonry may vary as per the Drawings or as directed by the Engineer.

8-11.2 MATERIAL REQUIREMENTS

8-11.2.1 Stone Size

The individual stones shall be large and well proportioned. They shall not be less than twenty (20) nor more than fifty (50) cm 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.

8-11.2.2 Mortar

Mortar shall conform to the requirement set forth under Section 8-12.

8-11.3 CONSTRUCTION REQUIREMENT

8-11.3.1 Surface Finishes of Stone

For the purpose of this specification the surface finishes of stone are defined as follows:

a. Smooth-finished

Having a surface in which the variations from the pitch line do not exceed decimal one five (0.15) cm.

b. Rough-finished

Having a surface in which the variations from the pitch line do not exceed one and a quarter ($1^1/_4$) cm.

c. Scrabbled

Having a surface in which the variations from the pitch line do not exceed two (2) cm.

d. Rock-faced

Having an irregular projecting face without indication of tool marks. The projections beyond the pitch line shall not exceed seven and a half ($7^1/_2$) cm and no part of the face shall recede back of the pitch line.

8-11.3.2 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.

8-11.3.3 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 a half ($3^1/_2$) times their thickness and not less than ninety (90) cm.

8-11.3.4 Headers

Headers shall be placed in each course and shall have a width of not less than one and a half ($1^1/_2$) times their thickness. In walls having a thickness of one and two-tenths (1.2) m 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) cm or less in height and not less than one and two-tenths (1.2) m 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 two and a half ($2^1/_2$) m center to center. There shall be at least one header to every two stretchers.

8-11.3.5 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 Section 7-1.

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.

8-11.3.6 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 color, 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 a half ($1^1/_2$) minutes. Mortar shall be used within forty-five (45) minutes after mixing. Retempering of mortar will not be permitted.

8-11.3.7 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 cannot 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 not less than one (1) cm nor more than one and a 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 four and a half ($4^1/_2$) 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 Section 7-1. However, the puddling and compacting of concrete adjacent to the ashlar 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.

8-11.3.8 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) cm below the top bed of any course of masonry.

8-11.3.9 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.

8-11.3.10 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.

8-11.3.11 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 six-tenths (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.

8-11.3.12 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 that shall be trawled smooth to receive the waterproofing.

Arch centering, waterproofing, drainage and filling shall be as specified for concrete arches.

8-11.3.13 Pointing

Pointing shall not 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 three (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.

8-11.4 MEASUREMENT AND PAYMENT

8-11.4.1 Measurement

The quantity of stone masonry to be paid shall be the number of cubic meters measured in the completed work and the limiting dimensions shall not exceed than those shown on the Drawings or fixed by the Engineer.

Concrete Class C or lean shall be measured separately as per dimensions shown on the Drawings or as directed by the Engineer, No separate measurement shall be made for stuck pointing, which is deemed to be included in stone masonry with mortar, however roll pointing shall be measured separately in square meters. No separate measurement will be made for dowels and cramps.

8-11.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for labor, materials, tools, equipment, dowels, cramps and incidentals necessary to complete the work prescribed in this Section:

Pay Item No.	Description	Unit of Measurement
8-11 (a)	Stone Masonry Dressed Coursed with Cement Sand Mortar of Specified Mix	Cu.ft or M^3
8-11 (b)	Concrete Class C	Cu.ft or M^3
8-11 (c)	Lean Concrete	Cu.ft or M^3
8-11 (d)	Roll Pointing	Sq.ft or M^2
8-11 (e)	Coping in Specified Cement Concrete of Specified Strength	Cu.ft or M^3
8-11 (f)	Stone Masonry in Arches	Cu.ft or M^3

SECTION – 8-12

BRIDGE BEARINGS

8-12 SECTION – BRIDGE BEARINGS

8-12.1 DESCRIPTION

The work specified in this Section consists of furnishing and fixing in final position bridge bearing as specified in this Section and according to the lines, dimensions and note shown on the Drawings.

8-12.2 TYPES OF BEARINGS

8-12.2.1 Metal Bearing Devices

Unless otherwise directed by the Engineer or provided in the Special Provisions, the requirements for metal bearings shall conform to the following:

a. AASHTO M 107 for bronze bearing

b. AASHTO M 108 or rolled copper alloy bearings

c. ASTM B 438 for sintered metal powder bearings

d. AASHTO M 160 for galvanized steel bearings

8-12.2.2 Elastomeric Bearing Pads

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 laminations and elastomer for bearing pads shall conform to the requirements of AASHTO M 251-06.

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 twelve plus or minus three (12±3 mm) thickness. Variation in thickness of an individual elastomer lamination shall not exceed three (3) 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 three (3) 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 three (3) mm.

The length and width of a pad shall not vary more than three (3) 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 Engineer, 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) % 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 one hundred twenty-five (125) kg/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) % by volume of the total compound.

The elastomer, as determined from test specimens, shall conform to the requirements as shown in Table 8-12.1:

TABLE 8-12.1: REQUIREMENTS FOR ELASTOMER

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 °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 ± 5 points
Ozone resistance 20% strain, 100 hours at 38 °C + 100 + 20 parts 1 °C	D 1149	(except No Cracks per 100,000,000)
Low temperature stiffness, Young's Modulus at 35 °C, kg/sq cm	D 797	350 max
Low temperature brittleness, 5 hours at - 40 °C	D 736	Passed

After accelerated aging in accordance with ASTM D 573 for seventy (70) hours at hundred (100) °C, the elastomer shall not show deterioration changes in excess of the following:

Tensile strength, %	+ 15
Elongation at Break, %	- 50 (but not less than 300% total elongation of the material)
Hardness, points	+ 10
Shear Test (without vertical load)	7 kg/sq cm (min)

Sampling shall be performed in accordance with AASHTO M 251-74 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.

8-12.3 CONSTRUCTION REQUIREMENTS

8-12.3.1 Metal Bearing Devices

Steel bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be constructed in accordance with the details shown on the plans and shall be hot-dip galvanized after fabrication.

Bronze or copper alloy plates, if specified, shall conform to the requirements of the Special Provisions.

The bearing plates shall be set level and the rockers or other expansion devices shall be set to conform to the temperature at the time of erection or to the setting specified.

When bearing assemblies or masonry plates are shown on the Drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding or other approved means to a true level plane which shall not vary perceptibly from a straight edge 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.

8-12.3.2 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 ($1^1/_2$) 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.

8-12.3.3 Asphaltic Felt

The quantity to be paid shall be in square meter of 3 ply rating Fiber/Fabric based asphaltic felt weighing forty-one (41) to forty-five (45) kg per twenty (20) sq m including striking coat/paint coat and flood coat of special industrial bitumen and sand blinding as approved by the Engineer, laid in place as directed by the Engineer.

8-12.4 MEASUREMENT AND PAYMENT

8-12.4.1 Measurement

The quantity to be paid for shall be the number of cubic centimeter of bearing devices either steel bearing or elastomeric bearing pads installed in the work completed and accepted.

8-12.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the pay item listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, labor, equipment, tools and incidentals and any work pertaining to bearings and which is not paid for separately, necessary to complete the work prescribed in this Section:

Pay Item No.	Description	Unit of Measurement
8-12 (a)	Steel or Metal Bearing Devices	KG
8-12 (b)	Elastomeric Neoperene Bearing Pads (According to size and thickness)	Cu. Inches or Cu.Cm
8-12 (c)	Asphalt Felt (3 Ply)	Sq.ft or M^2

SECTION – 8-13

JOINTS AND JOINT FILLERS FOR CONCRETE STRUCTURES

8-13 SECTION – JOINTS AND JOINT FILLERS FOR CONCRETE STRUCTURES

8-13.1 DESCRIPTION

The work covered in this item shall consist of furnishing all plant, equipment, materials and labor in performing all operations in connection with furnishing and placing (in concrete structures) all deck expansion joints and seals of approved type, complete and in accordance with these Specifications, the Drawings and/or as required by the Engineer.

8-13.2 MATERIAL REQUIREMENTS

8-13.2.1 Premolded Expansion Joint Fillers

a. Non Extruding and resilient type

Unless otherwise directed by the Engineer preformed joints filler shall conform to the requirements of AASHTO M 153 (ASTM D 1752)

b. Bituminous fiber type

Unless otherwise directed by the Engineer preformed joints filler shall conform to the requirements of AASHTO M 213 (ASTM D 1751)

c. Preformed Elastomeric Compression Joint Seal

Unless otherwise directed by the Engineer preformed joints filler shall conform to the requirements of AASHTO M 220.

d. Neoprene Rubber Sheet with Bitumastic Seal

Unless otherwise directed by the Engineer, neoprene rubber sheets six (6) mm in thickness, meeting the requirements of Item 921-2.3, shall be used as joint filler covered with a bitumastic seal as shown on the Drawings.

8-13.2.2 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 that shall be in stainless steel.

8-13.2.3 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 physical characteristics in accordance with ASTM D 15, Part B as shown in Table 8-13.1.

TABLE 8-13.1: PHYSICAL CHARACTERISTICS OF ELASTOMER FOR JOINT SEALS

Hardness, Durometer A (ASTM D 2240)	45 ± 5 points
Tensile Strength (ASTM D 412)	127 kg/sq cm min
Elongation at Break	400 % min
Compression Set, 22 Hours at 70 °C (ASTM D 395, Method B)	20 % max
Low Temperature (ASTM D 746)	Not brittle at 40 °C
Ozone Resistance, Exposure to 100 PPHM Ozone for 70 hours at 38 °C. Sample under 20 % (ASTM D 1149)	No cracks
Oil Deterioration - Volume increase after soaking in ASTM oil No. 3 for 70 hours at 100 °C (ASTM D 470)	120 % max

8-13.3 CONSTRUCTION REQUIREMENTS

8-13.3.1 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.

8-13.3.2 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.

8-13.3.3 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.

8-13.4 MEASUREMENT AND PAYMENT

8-13.4.1 Measurement

a. Filled Concrete Joints

The quantity to be paid for shall be in square meters of either expansion joint with preformed joint filler or expansion joint with neoprene rubber sheet six (6) mm thick and covered with bitumastic seal, completed and accepted in work.

b. Steel Joints

The quantity to be paid for shall be the number of kilograms of steel for steel joints fabricated, galvanized and placed in the work completed and accepted.

8-13.4.2 Payment

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing all materials, labor, equipment, tools and incidentals and any work pertaining to joints, which is not paid for separately, necessary to complete the work prescribed in this Section:

Pay Item No.	Description	Unit of Measurement
8-13 (a)	Premoulded Joint filler 12mm thick with Bitumastic Joint Seal	Sq.ft or M^2
8-13 (b)	Neoprene Rubber Joint Filler 12mm thick with Bitumastic Joint Seal	Sq.ft or M^2
8-13 (c)	Steel Expansion Joints	Kg

SECTION - 8-14
WATER STOPS

8-14 SECTION – WATER STOPS

8-14.1 DESCRIPTION

This Section shall consist of furnishing and installing adequate water stops of metal, rubber or plastic in accordance with these specifications at the locations and in conformity with the dimensions and design shown on the Drawings or as ordered by the Engineer.

Where movement at the joint is provided for, the water stops shall be of a type permitting such movement without injury. They shall be spliced, welded or soldered, to form continuous watertight joints.

The water stops shall be of the size and shape shown on the plans. They shall be dense, homogeneous and without holes or other defects.

8-14.2 RUBBER WATER STOPS

Rubber water stops shall be formed from synthetic rubber made exclusively from neoprene, reinforcing carbon black, zinc oxide, polymerization agents and softners. Provide water stops that meet the requirements specified in Table 8-14.1

TABLE 8-14.1: REQUIREMENTS OF RUBBER WATER STOPS

Property	Requirement	
Composition	Neoprene (not less than 70 percent by volume), reinforcing carbon black, zinc oxide, polymerization agents ans softeners	
Durometer hardness	ASTM D 2240	50 to 60
Tensile strength	ASTM D 412	2750 psi (19MPa)
Elongation at break	ASTM D 412	600%
Tensile strength (aged)	65% of original, after 7 days in air at 160^{o}F $\underline{+}$2^{o}F (70^{o}C $\underline{+}$1^{o}C), or after 4 days in oxygen at 160^{o}F$\underline{++}$2^{o}F (70^{o}C $\underline{+}$1^{o}C) and 300psi (2.1 MPa) pressure	

8-14.3 POLYVINYLCHLORIDE WATER STOPS

Polyvinylchloride water stops shall be manufactured by the extrusion process from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride (PVC). The compound shall contain any additional resins, plasticizers, stabilizers or other materials needed to ensure that, when the material is compounded, it will meet the performance requirements given in this specification. No reclaimed PVC or other material shall be used.

The material shall comply with the following physical requirements when tested under the indicated ASTM test method in Table 8-14.2:

TABLE 8-14.1: REQUIREMENTS OF PVC WATER STOPS

Property	Test Method	Requirement
Specific Gravity	ASTM D792	1.35 Max.
Durometer Hardness	ASTM D 2240	75$\pm$5
Tensile Strength	ASTM D 412	1800psi Min.
Elongation	ASTM D 412	350%
Cold Brittleness	ASTM D 746	-35F
Stiffness in Flexure	ASTM D 747	350psi Min.

8-14.4 MEASUREMENT AND PAYMENTS

8-14.4.1 Measurement

The water stops when completed and fixed in position as specified shall be measured in number. The unit of measurement shall be each number.

8-14.4.2 Payment

The unit payment shall be full compensation for water stops of specified type and fixing in position all according this Section and as shown on the Drawings.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
8-14 (a)	Water Stop, Type	Rft / Meter

SECTION – 9-1

DRAINAGE, EROSION AND ANCILLARY WORKS

9-1 SECTION - DRAINAGE, EROSION AND ANCILLARY WORKS GENERAL

9-1.1 DRAINAGE AND EROSION WORKS

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 will inform the Contractor of them in writing and decide the final quantities.

9-1.2 ANCILLARY WORKS

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 works, precast concrete posts and markers, traffic control devices, sidewalks, guard rails, detours, traffic signs, pavement marking, reflectors, fencing and back edging 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 Section.

Metal guard rails, traffic road signs and safety devices, pavement markings, Reflectorized pavement studs, and other such fixtures shall meet the requirements of ISO–9,000 for which certificates of manufacturers and supplies shall be produced.

SECTION – 9-2

REINFORCED CONCRETE PIPE CULVERTS

9-2 SECTION - REINFORCED CONCRETE PIPE CULVERTS

9-2.1 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 as ordered by the Engineer.

The work shall include the furnishing and laying .of the pipe and the construction of such join connection to oilier 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.

9-2.2 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 Section 7-1 Concrete, except that the grading of sand shall meet the requirements of AASHTO M-45.

Steel reinforcement shall conform to the requirements specified in Section 8-5 of these specifications.

Rubber ring gaskets for rigid pipe, if required shall conform to the requirements of AASHTO M-198.

9-2.3 MANUFACTURING REQUIREMENTS

Reinforced concrete pipe culverts shall conform to the requirements of AASHTO M-170.

9-2.3.1 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 confirm to the minimum requirements fisted in related tables per AASHTO M-170.

9-2.3.2 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, not less than three thousand and seven hundred-(3700) Kgf/Sq.cm. The spacing centers of adjacent rings of the circumferential reinforcement (pitch) shall not exceed 10 cm/2”. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of ± six (6) mm/1/4”.

9-2.3.3 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.

9-2.3.4 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.

9-2.3.5 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.

9-2.3.6 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.

i. 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 eighty (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.

ii. 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 than 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.

iii. 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.

9-2.3.7 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.

9-2.3.8 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.

i. 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 numbers of sections are 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.

ii. 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.

iii. 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 retest on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all these retested specimens meet the strength requirements.

9-2.3.9 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:

i. 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.

ii. Defects that indicate imperfect mixing and moulding:

iii. Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.

iv. Spalls deeper than one half the depth of the joint or extending more than ten (10) cm/4” around the circumference. If spalls not deeper than one half of the joint or extending not more than ten (10) cm/4” around the circumference exist in more than ten (10) per cent of the pipes, however the defective pipes shall be rejected.

v. Misplaced reinforcement already disposed or verified by checking with an approved concrete reinforcement cover meter.

9-2.4 CONSTRUCTION REQUIREMENTS

9-2.4.1 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 of be greater than two(2) times the pipe diameter, to permit satisfactory jointing and thorough tamping of the bedding material specified in Section 9-3 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/12” 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. Measurement & Payment will be made and paid accordingly to the relevant section of the specifications of Roads and Bridges Construction.

9-2.4.2 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.

9-2.4.3 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) cm in depth and compacted to minimum ninety (90%) percent of the maximum dry density determined as per AASHTO T-191 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 Section 4-6 "*Formation of Embankment"*. This method of filling and compacting shall be continued until the embankment has reached an elevation of twenty (20) cm/8" 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. Measurement & Payment will be made and paid accordingly to the relevant section of the specifications of Roads and Bridges Construction.

9-2.4.4 Construction Plant

Movement of Construction equipment, over a culvert shall be at the Contractor's risk. Any pipe injured thereby shall be repaired or placed at the contractor's cost.

9-2.5 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.

9-2.6 MEASUREMENT AND PAYMENT

9-2.6.1 Measurement

The quantities to be paid for shall be the number of linear meters/RFT of pipe placed completed and accepted.

Payment shall be made separately under Section 9-3 for furnishing and installing granular material or concrete in the bed of the culvert as shown on the Drawings.

9-2.6.2 Payment

The quantities as measured above shall be paid for at the contract unit price respectively, for each of the particular pay items listed below in the B.O.Q. Payment shall be full compensation for furnishing and placing all materials including mortar for joints, for excavating trenches and backfilling, and. for all other costs necessary or usual to the proper completion of the work prescribed in this Section. Headwalls, wing walls and aprons together with the bedding for the concrete pipe culvert: will be measured and paid for separately.

Pay Item No.	Description	Unit of Measurement
AASHTO M 170, Class II Reinforced Concrete pipe.		
9-2 (a)	Diameter 310 mm/12” inside	M/Rft
9-2 (b)	Diameter 380 mm/15” inside	M/Rft
9-2 (c)	Diameter 460 mm/18” inside	M/Rft
9-2 (d)	Diameter610 mm/24” inside	M/Rft
9-2 (e)	Diameter 760 mm/30” inside	M/Rft
9-2 (f)	Diameter 910 mm/36” inside	M/Rft
9-2 (g)	Diameter 1070 mm/42” inside	M/Rft
9-2 (h)	Diameter 1220 mm/48” inside	M/Rft
9-2 (i)	Diameter 1520 mm/60” inside	M/Rft
AASHTO M 170, Class IV Reinforced Concrete pipe		
9-2 (j)	Diameter 310 mm/12” inside	M/Rft
9-2 (k)	Diameter 380 mm/15” inside	M/Rft
9-2 (l)	Diameter 460 mm/18” inside	M/Rft
9-2 (m)	Diameter 610 mm/24” inside	M/Rft
9-2 (n)	Diameter 760 mm/30” inside	M/Rft
9-2 (o)	Diameter 910 mm/36” inside	M/Rft
9-2 (p)	Diameter 1070 mm/42” inside	M/Rft
9-2 (q)	Diameter 1220 mm/48” inside	M/Rft
9-2 (r)	Diameter 1520 mm/60” inside	M/Rft

SECTION – 9-3

BEDDING OR ENCASEMENT OF CONCRETE PIPE CULVERTS

9-3 SECTION – BEDDING OR ENCASEMENT OF CONCRETE PIPE CULVERTS

9-3.1 DESCRIPTION

This work shall consist of furnishing and placing granular material or concrete as specified for bedding concrete pipe culverts or encasement.

9-3.2 MATERIAL REQUIREMENTS

9-3.2.1 Granular Material

Granular material shall be sand or selected sandy soil all of which passes a 9.5 mm (3/8-inch) sieve and not more than fifteen (15) percent passes No 200 sieve.

9-3.2.2 Concrete

Concrete class B shall be used as specified under Section 7-1 unless otherwise specified on the drawings or as directed by the Engineer.

9-3.3 CONSTRUCTION REQUIREMENTS

The bedding material consisting of granular material as specified in Section 9-3.2.1 shall be laid to the dimensions shown on the drawings. The top surface 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 fifteen 15 cm (6 inches) and shall be compacted to at least ninety five (95) percent maximum dry density in accordance with AASHTO T 180, Method D or at least seventy four (74) percent relative density in accordance with ASTM D 2049, whichever is applicable.

Concrete class B if shown on the drawings shall be mixed placed finished and cured all in accordance with Section 7-1.

9-3.4 MEASUREMENT AND PAYMENT

9-3.4.1 Measurement

The quantities to be paid for shall be the number of cubic meter of granular material, or concrete class B, placed and accepted.

9-3.4.2 Payment

The quantities measured as provided above shall be paid for at the contract unit price, for each of the particular pay items listed below, which prices and payment shall be full compensation for furnishing and placing all materials included for completion of the work prescribed in this Section.

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
9-3 (a)	Granular Materials in Bed to Concrete Pipe Culvert	Per cubic meter (m^3)/ 100 cft.
9-3 (b)	Concrete class B in Bedding and Encasement of Concrete Pipe Culvert.	Per cubic meter (m^3)/ 100 cft.

SECTION – 9-4
UNDER DRAIN

9-4 SECTION - UNDER DRAIN

9-4.1 DESCRIPTION

The work shall consist of furnishing and installing under drains complete in accordance with these specifications and as shown in the Drawings.

9-4.2 MATERIAL REQUIREMENTS

9-4.2.1 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.

9-4.2.2 Porous Concrete Pipe

This pipe shall conform to the requirements of AASHTO M 176 for the specified diameters.

9-4.2.3 Granular Backfill

Granular backfill for bedding and surrounding under drains shall be aggregate conforming to the requirements of Granular Sub base Grading C.

In order to avoid intrusion into the sub base of the in place surrounding earth material, it shall be required that the ratio

$$\frac{D_{15}(Subbase)}{D_{85}(Surrounding\ Earth)} \leq Less\ than\ 5$$

9-4.3 CONSTRUCTION REQUIREMENTS

9-4.3.1 Trench and Bedding

Trenches shall be excavated to the width, line and grade as shown in the Drawings, unless shown other-wise 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 sited under a gutter or ditch, and to depths required for proper drainage, as determined by the Engineer Incharge. A bed of granular back-fill, ten (10) cm (4inch) thick, shall be spread, and compacted in the bottom of the trench throughout its entire length.

9-4.3.2 Placing Pipe and Backfilling

The pipe shall be embedded firmly 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 the desired 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 above shall be placed around the drain for a thickness of at least thirty (30) cm (12inch)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.

9-4.4 MEASUREMENTS AND PAYMENT

9-4.4.1 Measurements

The quantities to be paid for shall be:

1. The number of meters of under drain, of the kind mentioned below, in place and accepted.
2. The number of cubic meters (cubic foot) of granular backfill, in place, and accepted.

9-4.4.2 Payment

The quantities, determined as provided above, shall be paid for at the contact unit price for the pay items lists below. These prices and payment shall be full compensation for furnishing and placing the under drain, for excavating the trench in which the under drain is laid for granular backfill used, for the backfill and all other costs related to the work prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
9-4 (a)	Perforated Concrete Pipe for Under drain, Diameter 150 mm	M/Rft
9-4 (b)	Perforated Concrete Pipe for Under drain, Diameter 200 mm	M/Rft
9-4 (c)	Perforated Concrete Pipe for Under drain, Diameter 380 mm	M/Rft
9-4 (d)	Porous Concrete Pipe for Under drain, Diameter 150 mm	M/Rft
9-4 (e)	Porous Concrete Pipe for Under drain, Diameter 200 mm	M/Rft
9-4 (f)	Granular Backfill to Concrete Pipe under drain.	M^3/100Sft

SECTION – 9-5

HEADWALLS, WINGWALLS, PARAPETS APPROACH SLABS, AND APRONS

9-5 SECTION - HEADWALLS, WINGWALLS, PARAPETS APPROACH SLABS, AND APRONS

9-5.1 DESCRIPTION

This work shall consist of construction of sections as mentioned in the Section above in concrete, brickwork or stone work for concrete pipe and other culverts and bridges shown on the Drawings.

9-5.2 MATERIAL REQUIREMENTS

9-5.2.1 Steel Reinforcement

Quality of Steel reinforcement shall be in accordance with the material requirements of Section 8-5 of these specifications.

9-5.2.2 Concrete

Quality requirements of all materials for Concrete of Class A, Class B, Class C or Lean Concrete as specified on the Drawings and shall be in accordance with the material requirements of Section 7-1, of these specifications.

9-5.2.3 Brickwork

Quality of brick and other materials shall be in accordance with the requirements of Section 8-9 and 10-8 of these specifications.

9-5.2.4 Stone Work

Stone work shall be in conformity with Section 8-10 and 10-9.

9-5.3 CONSTRUCTION REQUIREMENTS

9-5.3.1 Excavation

Excavation shall be in accordance with Section 4-4 and in conformity with the Drawings.

9-5.3.2 Granular Backfill

Granular backfill, if ordered in writing by the Engineer, shall be furnished, placed and compacted in accordance with Section 4-4.

9-5.3.3 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.

9-5.3.4 Steel Reinforcement

Steel reinforcement shall be furnished, bend and fixed as shown on the Drawings. Bending and fixing shall be in accordance with Section 8-3.

9-5.3.5 Concrete

Concrete Class A, B, C or Y shown on the Drawings shall be placed, finished and cured, as specified in Section 701, Standard Specifications for Road and Bridge Construction.

9-5.3.6 Brickwork

Brickwork as shown on the drawings shall be carried out as specified in Section 8-9.

9-5.3.7 Stone Work

Stone work shall be in conformity with Section 8-10, 8-11 and 10-9.

9-5.4 MEASUREMENT AND PAYMENT

a. The formwork in place and accepted shall not be measured for payment and shall be deemed to have been paid under other items.

b. Steel reinforcement in place and accepted shall be measured and paid for as specified in Section 8-3, Standard Specifications for Road and Bridge Construction.

c. Concrete in place and accepted shall be measured and paid for as specified in Section 7-1, Standard Specifications for Road and Bridge Construction.

d. Granular backfill in place and accepted shall be measured and paid for as specified in Section 4-4, Standard Specifications for Road and Bridge Construction.

e. Brickwork in place and accepted shall be measured and paid as specified in Section 8-9, Standard Specifications for Road and Bridge Construction.

f. Stonework in place and accepted shall be measured and paid as specified in Section 8-10, 8-11 Standard Specifications for Road and Bridge Construction.

SECTION – 9-6

MANHOLES

9-6 SECTION - MANHOLES

9-6.1 DESCRIPTION

This 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 these specifications and the specifications for the other work items involved and in conformity with the dimensions, lines, elevations and design shown on the drawings.

9-6.2 MATERIAL REQUIREMENTS

9-6.2.1 Pre-cast/Cast in Situ Concrete Units

These units shall be cast to the dimensions shown on the drawings. Cement concrete shall be Class A2 in accordance with Section 7-1. Reinforcement shall be used as per drawings. The pre-case units shall be cured in accordance with AASHTO M170. Water absorption of individual cores taken from such unit shall not exceed seven (7) percent.

A sufficient number of cylinders/cubes shall be cast to permit compression tests at seven (7) and twenty-eight (28) days, 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 after fourteen (14) days from date of casting. If the strength requirement is not met at twenty eight (28) days, all units made from that batch will be rejected.

Cracks in units, honeycombed or patched areas in excess of 200 sq. cm (30 sq. inches), excessive water absorption and failure to meet strength requirements will be cause for rejection.

9-6.2.2 Steel Reinforcement

Steel reinforcement shall be in accordance with the requirements of Section 8-5.

9-6.2.3 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 requirement of AASHTO M 105. Strength class shall be optional unless other-wise 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.

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.

9-6.2.4 Mortar

Mortar shall be composed of one part Portland cement and two parts of fine aggregate conforming to Section 10-6 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.

9-6.2.5 Concrete

In case of cast in situ concrete manholes, Concrete shall be of Class A unless otherwise shown on the drawings or as directed by the Engineer, and shall conform to the requirements prescribed under Section 7-1. 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 7-1.

9-6.3 CONSTRUCTION REQUIREMENTS

9-6.3.1 Excavation

Excavation shall conform to the requirement of Section 4-4.

9-6.3.2 Backfill

Backfill shall conform to the requirements of Section 4-4, unless where granular backfill as specified under section 4-4 is required by the drawings, or is specified in writing by the Engineer.

9-6.3.3 Cement Concrete

Cement Concrete shall conform to the requirements of section 7-1.

9-6.3.4 Steel Reinforcement

Reinforcing Steel shall conform to the requirements of section 8-3.

9-6.3.5 Pre-cast Concrete Units

Pre-cast concrete units shall be erected in positions shown on the drawings, or as directed by the Engineer.

During erection of the units the outside of manhole shall be finished smooth and the joints flushed full with the mortar.

9-6.3.6 Connections

Sections of connections pipe shall be incorporated in to the construction and placed at the elevation, direction and grade required. The inner ends of the pipes shall be flush with the inner faces of the walls.

9-6.3.7 Metal Frames

Metal frames shall be set on full mortar beds of 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.

9-6.3.8 Cleaning

Upon completion each manhole shall be thoroughly cleaned by any accumulations of silt debris, or foreign matter of any kind and shall be kept clean of such accumulations until final acceptance of the work.

9-6.4 MEASUREMENTS AND PAYMENT

9-6.4.1 Measurement

The quantities to be paid for shall be:

1. The number of concrete manholes, complete with frames and covers and all other relevant components in position and accepted, from one (1) meter to two (2) meters deep/6-1/2 feet.
2. The number of concrete manholes, complete with frames and covers and all other relevant components in position and accepted, more than two (2) meter and up to three (3) meters deep/10 feet.
3. The number of concrete manholes, complete with frames and covers and all other relevant components in position and accepted, greater than three (3) meters in depth//10 feet.

In the determination of the depth of a manhole the distance shall be measured from the top surface of the manhole cover to the under surface of the foundation of the manhole.

9-6.4.2 Payment

The quantities measured as provided above shall be paid for at the contract unit price respectively, for each items listed below and as given in the Bill of Quantities, which prices and payment shall be full compensation for furnishing and placing all materials, and for all other costs necessary for the satisfactory completion of work prescribed in this section.

Excavation & granular back fill shall be paid under Section 4-4.

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
9-6 (a)	Concrete manhole 1 m to 2 m/ 3’-3” to 6’-6” deep	Each
9-6 (b)	Concrete manhole more than 2 m to 3 m/ 6’-6” to 10’ deep	Each
9-6 (c)	Concrete manhole more than 3 m/ 10’ deep	Each

SECTION – 9-7

DROP INLETS AND CATCH BASINS

9-7 SECTION - DROP INLETS AND CATCH BASINS

9-7.1 DESCRIPTION

The 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.

9-7.2 MATERIAL REQUIREMENTS

9-7.2.1 Steel Frames, Grates and Lids

Steel frames, grates and lids shall conform to the requirements of AASHTO M-105

9-7.2.2 Concrete

Concrete shall be as specified in Section 7-1.

9-7.2.3 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 Section 8-9, "Brick Masonry".

9-7.2.4 Steel Reinforcement

Quality of reinforcing steel if used in construction of catch basins shall be in accordance with the material requirements of Section 8-3.

9-7.3 CONSTRUCTION REQUIREMENTS

9-7.3.1 Excavation and Backfill

Excavation and backfill shall conform to the requirements of Section 4-4 as the case may be.

9-7.3.2 Concrete Construction

Concrete of the specified class shall be supplied, placed finished and cured as specified in Section 7-1.

9-7.3.3 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 thereof.

Pipe placed in cement concrete for inlet or outlet connections shall extend from the inside surface of the wall and beyond the outside surface of the walls a minimum distance of forty five (45) centimeters/18" 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.

9-7.3.4 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 is 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 surfaces, the grates and lids shall not be in place while the adjoining concrete is struck-off and finished.

9-7.3.5 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.

9-7.4 MEASUREMENT AND PAYMENT

9-7.4.1 Measurement

The quantities to be measured shall be:

1. The number of drop inlets of the type specified in the construction of Drop inlets, complete in place and accepted.
2. The numbers of catch basins of the type specified complete in place and accepted.

9-7.4.2 Payment

The quantities measured as provided above shall be paid at the contract unit price for each of the pay items listed below. Such prices and payment shall be full compensation for furnishing and placing all materials, and for all other costs relative to the proper completion of the work prescribed.

Granular backfill in place and accepted shall be measured and paid for as specified in Section 4-4.

Pay Item No.	Description	Unit of Measurement
9-7 (a)	Excavation	Per m3/1000 cft.
9-7 (b)	Masonry	Per m3/100 cft.
9-7 (c)	Concrete	Per m3/100 cft.
9-7 (d)	Steel Reinforcement	Per Kg. /Per lb.
9-7 (f)	Steel Frames, Grates	Per Kg/Per lb.

SECTION 9-8
GABIONS

9-8 SECTION - GABIONS

9-8.1 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 lines and grades shown on the drawings or as directed by the Engineer. The work in general, covers gabions used for construction of retaining & breast walls and stream stabilization works.

9-8.2 MATERIAL REQUIREMENTS

9-8.2.1 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 and heights required by the drawings, or as directed by the Engineer. If not otherwise required, all gabions shall be one meter (3.3 feet) in width. The length shall be multiples of 2,3 or 4 times the width of the gabion and heights shall be 0.33 m, 0.66 m or 1.0 m (1.1 ft, 2.2 ft, 3.3 ft).

9-8.2.2 Wire

All wire shall be good commercial quality of steel and size as per drawings coated with a prime western speller or equal (AASHTO M 120)/(ASTM A90) 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 shall 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 (4000) to six thousand (6000) kg./sq.cm. And shall have an elasticity to permit elongation of the mesh equivalent to 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 in Table.

	Diameter mm	**US Steel Wire Gauge**
Body Wire	(2.3)	11
Selvedge or Perimeter Wire	(2.8)	09
Tying and Connecting wire	(1.95)	13

9-8.2.3 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 (3 inches) by ten (10) cm (4 inches) or ten (10) cm by twelve (12) cm (4" x 5"). The edges shall be formed into securely connected salvages 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 connect at all edges to form individual cells of equal length and width. Diaphragms shall be of the same material and manufactured as specified above for the gabions.

Four cross-connecting wires shall be provided in each cell having aheight 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.

9-8.2.4 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 twelve (12) cm (5") to twenty (20) cm (8"). Filled gabions shall have a minimum density of one thousand three hundred sixty (1360) 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 M63 except that the Sodium Sulphate Soundness Loss shall not exceed nine (9) % after five (5) cycles.

9-8.3 CONSTRUCTION REQUIREMENTS

Installation shall be performed in a workmanlike manner as approved by the Engineer. Beds for gabions shall be suitably leveled. Gabions forming elements of structures shall be securely connected along the complete length of top contact edges by means of the above-specified tying and connection 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 of 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.

9-8.4 MEASUREMENT AND PAYMENT

9-8.4.1 Measurement

The quantities shall be measured for payment as under:-

a. Wire Mesh

The galvanized steel wire mesh furnished, placed and accepted shall be the theoretical number of kilograms or pounds calculated from the weight per square meter or per square foot of mesh respectively by the manufacturer. The area of mesh to be measured shall be the net area of the gabion in position.

b. Rock Fill

The rock fill shall be the number of loose cubic meters of rock placed in the gabion with an allowance of maximum thirty (30) % voids and accepted and measured by the width, breadth and length of the gabion constructed.

9-8.4.2 Payment

The quantities determined as provided above shall be paid for at the contract unit price, which shall be full compensation for all necessary excavation, furnishing and placing of materials and all other costs related to completion of the work.

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
9-8 (a)	G.I. Steel Wire mesh for Gabions 15 SWG 10SWG 8 SWG	100 sft
9-8 (b)	Rock Fill in Gabions	Cubic Meter (m^3)/ 100 cft

SECTION 9-9

RIPRAP AND REINFORCED CONCRETE SLOPE PROTECTION

9-9 SECTION - RIPRAP AND REINFORCED CONCRETE SLOPE PROTECTION

9-9.1 DESCRIPTION

This work consists of furnishing, and placing protective covering protective 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 plan 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.

9-9.2 MATERIAL REQUIREMENTS

9-9.2.1 Stones

Stone for riprap shall consist of field stone or rough uneven 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 of sixty (60) Kg to a maximum of 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 maybe substitutes for stone upon approval by the Engineer.

9-9.2.2 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: D 15 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.

9-9.2.3 Portland Cement

Portland cement shall conform to the requirements of AASHTO M 85.

9-9.2.4 Fine Aggregates

Fine aggregates for mortar shall conform to the requirements of AASHTO M 45.

9-9.2.5 Steel Reinforcement

Steel reinforcement shall be furnished, bent and fixed where shown on the drawings. Furnishing, bending and fixing shall be in accordance with Section 4-3.

9-9.2.6 Concrete

Concrete of specified Class shown on the Drawings shall be supplied placed, finished and used as indicated in Section 7-1.

9-9.2.7 Water

Water for concrete and mortar of ratio 1:3 shall conform to Section 7-1 & 10-10.

9-9.3 CONSTRUCTION REQUIREMENTS

9-9.3.1 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 subgrade or base prior to placement of zones stones shall be placed so as to provide minimum of void a larger stones' shall be placed in the toe trench and on the outside surface of the slope.

9-9.3.2 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 waterline 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/8”

Class B: 45 cm/18”

Class C: 60 cm/24”

The surface of riprap placed above the water line shall not vary from the theoretical surface by more than 8 cm/3” at any point.

9-9.3.3 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.

9-9.3.4 Grouted Riprap

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 space all of the spaces or open Logs 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.

9-9.3.5 Reinforced concrete slope protection

The slopes with suitable material shall be prepared with appropriate compaction to form a subgrade 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.

9-9.4 MEASUREMENT AND PAYMENT

9-9.4.1 Measurement

The quantities to be measured for payment shall be the number of cubic meters/cubic feet of completed and accepted work placed to the designated thickness on slopes including the toe wall as shown on Drawings.

A filter layer of granular material, when required, shall be measured separately by the cubic meters, in place and accepted,

The computation of the quantities will be based on the volume within the theoretical limiting dimensions designated on the Drawings.

These works shall include the furnishing of all material, placing and grouting stone riprap, mixing and placing concrete including reinforcement. Excavation, backfilling and slope preparation shall not be measured for payment but will be considered subsidiary to the Section of "Riprap" or "Slope Protection".

9-9.4.2 Payment

The quantities, measured as provided above shall be paid for at the contract unit price, for each of the pay items listed below and shown in the Bill of Quantities. Payment shall be full compensation for furnishing all materials, labor, equipment, tools supplies and all other costs related to completion of the work.

Pay Item No.	Description	Unit of Measurement
9-9 (a)	Riprap, Class A	CM/100 cft
9-9 (b)	Riprap, Class B	CM/100 cft
9-9 (c)	Riprap, Class C	CM/100 cft
9-9 (d)	Grouted Riprap, Class A	CM/100 cft
9-9 (e)	Grouted Riprap, Class B	CM/100 cft
9-9 (f)	Grouted Riprap, Class C	CM/100 cft
9-9 (g)	Reinforced Concrete Slope Protection	CM/100 cft
9-9 (h)	Filter Layer of granular Material	CM/100 cft
9-9 (i)	Steel Reinforcement of Specified Grade for Reinforcement Cement Concrete	kg

SECTION 9-10
STONE PITCHING

9-10 SECTION - STONE PITCHING

9-10.1 DESCRIPTION

Where shown on the Drawings, this work shall consist of furnishing hand set pitching laid dry or grouted to stabilize slopes or as air 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.

9-10.2 MATERIAL REQUIREMENTS

9-10.2.1 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

Class I

Stones shall be ranging in weight from a minimum of fifteen (15) Kg/32 lbs to a maximum of twenty five (25) Kg/55 lbs with at least fifty (50%) percent by weight of the stones weighing more than twenty (20) Kg/43 lbs. The depth of the stones shall generally be from twenty (20) cm/8” to twenty five (25) cm/10” and shall be used for heavy pitching to culvert or bridge ends and approaches, Water diversions, protection for structures, revetment to slopes and where directed.

Class II

Stones are ranging in weight from a minimum of ten (10) Kg/22 lbs to a maximum of fifteen (15) Kg/33 lbs with at least fifty (50) percent by weight of the stones weighing more than twelve (12) Kg/26 lbs. The depth of the stones shall vary from fifteen (15) cm to twenty (20) cm/6” to 8” and shall be used for lighter pitching where directed to ditches, beams, dykes etc.

9-10.2.2 Portland Cement

Portland cement shall conform to the requirements of AASHTO M-85.

9-10.2.3 Fine Aggregates.

Fine aggregates for mortar shall conform to the requirements of AASHTO M-45.

9-10.2.4 Water

Water for cement sand mortar shall be as specified in Section 7-1.

9-10.3 CONSTRUCTION REQUIREMENTS

9-10.3.1 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 wilt 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.

9-10.3.2 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 inter lock 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/3/4” 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 the laying, pitching 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/1-1/2” and not more than eight (8) centimeters/3” 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.

9-10.4 MEASUREMENT AND PAYMENT

9-10.4.1 Measurement

The quantities shall be measured by the square meter of completed and accepted work placed to the designated thickness of slopes including the toe walls as shown on Drawing. Toe walls shall be measured by the height times the length, and no additional payment will be made for the additional thickness of the toe walls when compared to the slope thickness. Measurement shall be based on the dimensions shown on the plans or as otherwise specified by the Engineer. These works shall include the furnishing of all material, placing and grouting stone pitching. Excavation, backfilling and slope preparation shall not be measured for payment, but will be considered subsidiary to the Section of "Stone Pitching".

9-10.4.2 Payment

The amount of completed and accepted work as measured above shall be paid for at the contract unit price for each of the pay items listed below and specified in the Bill of Quantities, which price shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other item necessary for the completion of the work.

Pay Item No.	Description	Unit of Measurement
9-10 (a)	Grouted Stone Pitching	100 cft
9-10 (b)	Dry Stone Pitching	100 cft

SECTION – 9-11

CONCRETE KERB, GUTTERS AND CHANNELS

9-11 SECTION - CONCRETE KERB, GUTTERS AND CHANNELS

9-11.1 DESCRIPTION

This work shall consist of kerb, gutter, or combination of kerb and gutter, 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 or combination of kerb and gutter may be constructed by one of the following ways:

- Cement Concrete Cast in place or
- Pre-cast Cement Concrete

9-11.2 MATERIAL REQUIREMENTS

9-11.2.1 Cement Concrete for Cast in Place Units

The cement concrete for cast-in-place kerb, gutter or combination of kerb & gutter shall be type C and shall conform to the requirements of Section 7-1. The units shall be cast as per details shown on the drawings.

9-11.2.2 Cement Concrete for Pre-cast Units

Cement Concrete for pre-cast kerb, gutter or combination of kerb& gutter shall consist of Type C cement concrete, conforming to the requirements of Section 7-1 and to the length, shapes and other details shown on the drawings.

9-11.2.3 Reinforcing Steel

Reinforcing Steel shall conform to Section 8-3.

9-11.2.4 Joint Filler

Expansion joint filler shall be either the preformed type conforming to the requirements of AASHTO M 153 or shall be pre-cut fiber-board packing.

9-11.2.5 Joint Mortar

Joint mortar shall consist of one part cement and two parts of approved sand with water added to obtain the required consistency.

The mortar shall be used within 30 minutes of preparation. The bounding compound when used shall conform to AASHTO M-200.

9-11.3 CONSTRUCTION REQUIREMENTS

9-11.3.1 Cast in Place Units

a. Excavation and Bedding.

Excavation shall be made to the required depth and the base upon which the kerb gutter, gutter or combination of kerb and gutter is to be set. It shall be compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer. The surplus or unsuitable material resulting from Excavation shall be disposed off as directed by the Engineer. When directed by the Engineer a layer of clean sand and gravel or other approved quarry material, having minimum compacted thickness of 15 cm (6 in) shall be placed to form a bed for the kerb, gutter or combination of kerb and gutter.

b. Forms

i. Forms to hold the cement concrete shall be built and set in place as described under Section 8-4. Forms for at least 60 meters (200 feet) of kerb, gutter or combination of kerb and gutter shall be in place and checked for alignments and grade before concrete is placed. Kerb gutter or kerb and gutter constructed on curves shall have forms of either wood or metal and they shall be accurately shaped the radius of curvature shown on the drawings. Mixing, placing, and curing of concrete shall be in accordance with Section 7-1 and the requirements given below.

ii. Slip form will be used having shape and design as approved by Engineer Incharge. Cement Concrete shall be set in place using mechanical slip form kerber as described under Section 8-4. Alignment will be preset with steel guide lines fixed by surveyor accurately shaped to the radius of curvature shown on the drawings around curves. Alignment will be checked by inspector before commencement of work. Mixing, placing, and curing of concrete shall be in accordance with Section 7-1 and the requirements given below.

a. Placing Cement Concrete

Cement Concrete may be placed to the full depth required. The top of the kerb gutter 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 or kerb or combination of both shall be tested with a 3-meter (10 feet) straight edge and any irregularities of more than 5 mm (3/16 inch) 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.

b. Joints.

The kerb and gutter shall be constructed in uniform sections of 25 meter (82 feet) in length except where shorter sections are required to coincide with the location of weakened plane or contraction joint of the concrete pavement or for closures but no section shall be less than 2 meter (6-1/2 feet) long. The sections shall be separated by approved templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately 5 mm (3/16 inch) in thickness, of the same width as that of the kerb and gutter and not less than 5 cm (2 inch) greater than the depth of the 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 fiberboard packing is used in the expansion joints it may be used in place of the approved template referred to above, on the approval of the Engineer. In this event the fiberboard 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 approximately 25 meter (82 feet) in order to coincide with the expansion joints of cement concrete pavement or as shown on the drawings.

c. 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.

d. 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 5cm 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.

e. Removal of Forms and Finishing

The forms shall be removed 24 hours after concrete has been 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 approved sand. 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 wooden float and rubbing the surface until they are smooth.

f. Curing

Immediately upon the completion of the rubbing down, the surface shall be moistened and kept moist for 3 days. Other methods of curing shall be adopted on the approval of the Engineer. The concrete shall be cured by covering with suitable cotton or Hessian mats and by frequent sprinkling with water with liquid forming compounds subject to approval of Engineer.

g. Backfilling

After the concrete has been cured as specified, spaces on back of the kerb or kerb and gutter excavated for placing the kerb or kerb and gutter shall refilled to the required elevation with suitable earth or granular material, which shall be tamped in layers of not more than 15 cm (6 inch) each until firm and solid.

9-11.3.2 Pre-cast Units

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. The surplus or unsuitable material resulting from excavation shall be disposed off as directed by the Engineer.

Bedding shall consist of Class B Cement Concrete conforming to the requirements of Section 7-1 and shall be to the section and dimensions shown on the drawings.

b. Placing

The pre-cast concrete kerbs shall be set in 2 cm (3/4 inch) of cement mortar to the line level grade as shown on the drawings or as directed by the Engineer. Pre-cast units which show surface irregularities of more than 5 mm (3/16") under a 3 meter (10 feet) straight edge or surface pits more than 12.5 mm (1/2") in diameter will be rejected.

c. Joints

Joints between consecutive units shall be 3 to 5 mm (1/8" to 3/16") wide & filled with cement mortar to the full section of the unit.

d. Backfilling

Backfilling shall meet the requirements as states above.

9-11.4 MEASUREMENT AND PAYMENT

9-11.4.1 Measurement

All kerb, gutter or combination of kerb and gutter shall be measured by the linear meter or foot along the front face of the section at the finished grade elevation. Deductions in length will be made for drainage structures installed in the kerbing such as catch basin and drop inlet, etc.

Bed course material shall be measured by the cubic meter of material compacted in place.

Cement concrete and cement mortar that may be required for bedding to pre-cast concrete kerbs as shown in the drawings shall not be measured for payment as separate items, but the cost shall be included in the contract unit price for pre-cast concrete kerbs.

9-11.4.2 Payment

The accepted quantities of kerb or gutter or combination of kerb and gutter shall be paid for at the contract unit price per linear meter or foot for each of the particular pay items listed below and shown in the Bill of Quantities, which payment shall constitute full compensation for furnishing and placing all materials for concrete, for reinforcing steel if required on the drawings, for expansion joints, materials, forms for drainage opening, excavations bedding, backfilling and dumping and disposal of surplus materials and for all labor equipment, tools and incidentals necessary to complete the work. Compacted bed course material shall be measured in cubic meter and shall be paid separately.

Payment shall be made as under:-

Pay Item No.	Description	Unit of Measurement
9-11 (a)	Cast-in-situ Cement Concrete Kerb	cft / cub m
9-11 (b)	Cast-in-situ Cement Concrete Gutter	cft / cub m
9-11 (c)	Pre-cast Concrete Kerb 12 in 14 in 18 in	Per meter (m) /Rft
9-11 (d)	Pre-cast Concrete Gutter	cft / cub m
9-11 (e)	Combination of Kerb, gutter and channel in place	cft / cub m
9-11 (f)	P/L Kerb block / RCC Barrier using Class D (400 psi) concrete of required size over lean concrete base with fslip form Paver / power kerber machine, and batching plant, excluding cost of additive / super plasticizer steel reinforcement and as specified in drawings complete: i. Kerb block ii. RCC barrier single faced iii. RCC barrier double faced.	Cub m / cft
9-11 (g)	Punjab Standard Drains of PCC laid over Lean concrete 1:6:12 complete i/c rendering exposed surfaces with 1:1 cement sand mortar ¼ in (6mm) thick complete as per drawings of various types.	Per meter (m) /Rft
9-11 (h)	Compacted Bed Course	Per cubic meter (m^3)/ 100 cft.

SECTION – 9-12

ASPHALT CONCRETE AND CEMENTCONCRETE SIDEWALK

9-12 SECTION - ASPHALT CONCRETE AND CEMENTCONCRETE SIDEWALK

9-12.1 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 (450 x 450 mm) 18 x 18 inch. It 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.

9-12.2 MATERIAL REQUIREMENTS

9-12.2.1 Cement Concrete

The concrete shall be either Class A or Class C as indicated on the drawings and in accordance with Section 7-1.

9-12.2.2 Asphalt Concrete

Asphaltic Concrete shall conform to the requirements of Asphalt Concrete Pavement – for Class B mixture.

9-12.2.3 Expansion Joint Filler

Unless otherwise directed the joint filler shall have a thickness of five (5) mm and conform to the requirements of Section 9-11.2.4

9-12.2.4 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.

9-12.2.5 Bed Course Material

Bed course material shall consist of cinders, sand, slag, gravel, crushed stone or other approved material of such gradation that all particles will pass through a 1/2" (12.5 m) sieve.

9-12.2.6 Asphaltic Prime Coat

Asphaltic prime coat material shall conform to the requirements of the Section 6-1for Cut-back Asphalt

9-12.3 CONSTRUCTION REQUIREMENTS

9-12.3.1 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 90% of the maximum dry density as determined by AASHTO T-191 Method. The surface shall be even conforming to the section shown on the drawings. All soft and yielding material shall be removed and replaced with approved material.

b. Placing of Bed Course Material

The bed course material shall be compacted in layers not exceeding 10 cm (4 inch) to the depth and to the line, grade levels dimensions as shown on the drawings.

c. Priming the Bed Course Material

The prepared bed course material shall receive an application of prime coat in accordance with the requirements of Section 6-1and 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 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 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.

9-12.3.2 Cement Concrete Sidewalk

a. Excavation

Excavation shall meet the requirements of Section 4-4.

b. Placing of Bed Course Material

Where indicated on the drawings the bed course material shall be placed in accordance with Section 5-1.

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 5mm 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 Section 7-1.

Before the concrete has set, the surface of the concrete shall be troweled 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 1 cm (3/8”) with a trowel at intervals of 1 meter (3 feet) 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 1.5 cm (5/8") radius.

e. Precast Elements

Precast concrete slabs or intrerlocking 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 Section 7-1.The Contractor shall be required to submit a sample of precast unit for the approval of the Engineer. All precast units shall strictly conform to the approved sample.

A precast 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 precast 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 precast units shall be done in accordance with Section 7-1.

9-12.4 MEASUREMENT AND PAYMENT

9-12.4.1 Measurement

The quantity to be paid for shall be area of asphalt concrete or cement concrete sidewalk complete in place and accepted. The unit of measurement will be square meter.

9-12.4.2 Payment

The quantity as determined above, shall be paid for at the contract unit price per square meter for the pay items listed below and shown in the Bill of Quantities, which price and payment shall constitute full compensation for furnishing and placing all materials, for Portland Cement concrete, expansion joint material, for excavating and compacting the foundation bed, for furnishing and placing any crushed brick, gravel or other porous bed course material, for forms, and for all labour, equipment, tools and incidentals necessary to complete the item.

Pay Item No.	Description	Unit of Measurement
9-12 (a)	Asphalt Concrete Sidewalk per in of given % of bitumen.	(m^2)/100 sft.
9-12 (b)	Cement Concrete Sidewalk (To be paid as per volume of concrete of specified class)	100 Cft / cubm
9-12 (c)	Precast Concrete Interlocking Block Sidewalk	(m^2)/100 sft.

SECTION – 9-13
METAL BEAM GUARD RAIL

9-13 SECTION - METAL BEAM GUARD RAIL

9-13.1 DESCRIPTION

This Section 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 ordered by the Engineer.

9-13.2 MATERIAL REQUIREMENTS

9-13.2.1 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/cm^2 (50,000 Psi) minimum
Tensile Strength	4900 kg/cm^2 (70,000 Psi) minimum
Elongation	Not less than 12 percent in a 5.08 cm (2 inch) gage length when tested in accordance with ASTM E 8

In addition to the above the rail shall withstand a cold bend, without cracking of 180° around a mandrill of a diameter equal to 2 ½ times the thickness of the plate.

9-13.2.2 End of 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. The size of the end or buffer section shall be according to the details given on the drawings or as directed by the Engineer.

9-13.2.3 Connections and Splices

All connections or splices shall be formed with oval shoulder button headed bolts to minimize projections on the side of the guardrail. All bolts and nuts for beams shall conform to or exceed the requirements of ASTM A307 and shall be galvanized as specified in ASTM A 153. The bolted connection of the rail element to the post shall withstand a 2270 kg (5000 lbs) pull at right angles to the line of the railing.

9-13.2.4 Guardrail Posts

Posts shall be of either steel or concrete as specified. Only one type of post shall be used for any one continuous guardrail, except at junctions between bridges and 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 AASHTO M 183 for the grade specified.

b. Pre-cast reinforced concrete posts shall be of a section and length as specified or as shown on the drawings. The concrete shall be Class C as specified under 7-1. Reinforcement shall conform to the requirements of AASHTO M31 or M53. All bars shall be of the deformed type, conforming to AASHTO M 31 or M 42.

9-13.2.5 Wooden Spacer Blocks

Wooden spacer blocks between the guard rail and the posts shall conform to AASHTO M133 and M168 and be constructed to the section and length specified or as shown on the Drawings.

9-13.2.6 Post Foundation Blocks

Where required or as ordered by the Engineer, post foundation blocks shall be constructed in Class A cement concrete as specified under section 7-1 to the size shown on the drawings.

Inorder 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 5mm/1/8" to ¼" between the socket and the guard rail post. Following erection of guard rails, the space between posts and sockets shall be filled with epoxy mortar.

9-13.3 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 48 hours. The space around the posts shall be backfilled to the ground line, with selected earth containing no rocks, in layers of not exceeding 10 cm (4 inches) 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.

9-13.3.1 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 or as shown on the drawings or as directed by the Engineer.

9-13.4 MEASUREMENT AND PAYMENT

9-13.4.1 Measurement

The guardrail shall be measured by the linear meter/feet from center to center of end posts for each completed section fastened in place and accepted.

Post for guardrail and end or buffer sections for guardrail shall be measured by the number erected in place and accepted. Post foundation blocks provided, if required, shall not be paid separately.

9-13.4.2 Payment

The quantities determined as prescribed above shall be paid for at the contract unit price for the pay item listed below and shown in the Bill of Quantities which price shall be full compensation for furnishing, placing all materials, for foundations, for provision and erection of posts, for excavation and backfill, for installation and fastening, and for all costs including labour, tools and incidentals necessary to complete the work prescribed in this Section.

Payment shall be made under:

Pay Item No.	Description	Unit of Measurement
9-13 (a)	W Beam G.I Metal Guardrail Complete including beams, posts, end sections whether fish tail or other as specified including double faced reflector etc.	M/Rft.

SECTION- 9-14

CEMENT CONCRETE BEAM GUARDRAIL

9-14 SECTION - CEMENT CONCRETE BEAM GUARDRAIL

9-14.1 DESCRIPTION

This section shall consist of cement concrete beam guardrail constructed in accordance with these specifications at the locations and in conformity with dimensions, and design shown on the drawings or as directed by the Engineer.

9-14.2 MATERIAL REQUIREMENTS

9-14.2.1 Concrete Beam Guardrail

The rail shall be of Class A cement concrete as specified under section 7-1. Reinforcing steel shall conform to requirements of Section 8-5. Concrete beam Guard rail shall be of size 125mm x 300mm/5” x 12” whereas reinforcing steel shall be provided at the rate of 120Kg/m^3/7.5 lbs per cft.

9-14.2.2 Guardrail Posts

Post shall be of concrete Class A as specified in Section 7-1 of these specifications.

Precast reinforced concrete posts shall be of a Section 7-1 250mm x 250mm. The concrete shall be class A as specified in Section 7-1.Reinforcement shall conform to the requirements of AASHTO M31 or M53. All bars shall be of the deformed type, conforming to AASHTO M137. Reinforcing Steel shall be provided at the rate of 120Kg/cm^3/7.5 lbs per cft.

9-14.2.3 Connections and Splices

Bolts, nuts, washers, sleeves and other fittings shall conform to ASTM Designation A 325(AASHTO M614) and shall be zinc coated in accordance with the requirement of ASTM Designation A 153 (AASHTO M 232).

9-14.2.4 Post Foundation Blocks

Where required, post foundation blocks, shall be constructed in Class C concrete as specified under section 7-1 to the size shown on the drawings.

9-14.3 MEASUREMENT AND PAYMENT

9-14.3.1 Measurement

The guardrail shall be measured by the number from center to center of end posts for each completed unit in place and accepted.

Guardrail end pieces shall be measured by the length completed in place and accepted. Posts for guard rail and guard rail end pieces shall be measured by the number erected in place and accepted.

9-14.3.2 Payment

The quantities, determined as prescribed above shall be paid for at the contract price per unit of measurement for the pay item listed below and shown in the Bill of Quantities which price shall be full compensation for furnishing, placing all materials, for foundations, for provision and erection of posts, for excavation and backfill, for installation and joining with mortar, and for all costs including labor, tools and incidentals necessary to complete the work prescribed in this item.

Pay Item No.	Description	Unit of Measurement
9-14 (a)	Concrete Beam Guardrail, as per drawing and Type complete in all respects.	Per meter/Rft

SECTION – 9-15
BRIDGE RAILING

9-15 SECTION - BRIDGE RAILING

9-15.1 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 Guardrails form part of the Bridge Railing, the Guard rail beam and connections shall conform to the requirements of Section 9-13 and shall be paid for under that section.

9-15.2 MATERIAL REQUIREMENTS

9-15.2.1 Formwork

Formwork where necessary, shall conform to Section 8-2.

9-15.2.2 Steel Reinforcement

Steel reinforcement shall be as specified in Section 8-3.

9-15.2.3 Concrete

Concrete shall be class D1 as specified in Section 7-1 or as shown on the Drawings.

9-15.3 CONSTRUCTION REQUIREMENTS

9-15.3.1 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 Section 8-4.

9-15.3.2 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 Section 8-3.

9-15.3.3 Concrete

Concrete class D1 as shown on the drawings or as directed by the Engineer shall be supplied, placed, finished and cured, as specified in Section 7-1.

9-15.4 MEASUREMENT AND PAYMENT

9-15.4.1 Measurement

Concrete in place and accepted shall be measured as specified in Section 7-1.The formwork in place and accepted shall not be measured separately as specified in Section 8-2.

Steel reinforcement in place and accepted shall be measured for as specified in Section 8-3.

9-15.4.2 Payment

Payment shall be made for the materials utilized, or the rates quoted by contractor and measured as provided above, for following items.

Pay Item No.	Description	Unit of Measurement
9-15 (a)	Concrete Beam Guardrail, as per drawing and Type complete in all respects.	Rft / m

SECTION 9-16

TRAFFIC ROAD SIGNS AND SAFETY DEVICES

9-16 SECTION TRAFFIC ROAD SIGNS AND SAFETY DEVICES

9-16.1 DESCRIPTION

This work shall comprise furnishing and installing traffic signs, 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 (National Highway Authority) / NTRC (National Transport Research Center) / (MUTCD) Manual of Uniform Traffic Control Devices latest edition, 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.

9-16.2 MATERIAL REQUIREMENTS

9-16.2.1 Sign Panels

Sign panels for regulator, 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)/1/8” mm thickness as shown on the drawings.

In Case G.I (Galvanized Iron) is taken in approved estimate for purpose of manufacturing of road signs of any shape , design and thickness / gauge it should confirm specifications ASTM A653 / 653 M and G90(Z275) Zinc coated etc. by the hot dip process to the entire satisfaction of Engineer in charge. Where reflective sheeting is to be applies the contractor may be requested to provide an acknowledgement from the manufacturer of the reflective sheeting that the reflective sheeting is compatible with the metal sheeting. The contractor may also be requested to provide an extended guarantee in relation to the traffic signs.

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.

9-16.2.2 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 pre coated 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 furnish the process links, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of it is specification and hall 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 of material of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic condition for at least three years.

Color Requirements: Color shall be specified and conform to the requirements of Table-9-16.1.

TABLE-9-16.1: COLOR SPECIFICATION LIMITS* AND REFERENCE STANDARDS

									Reflectance Limit (Y)		Munsell **
Color	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**	**Min.**	**Max.**	**Paper**
White	0.303	0.287	0368	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	0.66	0.346	0.286	0.4288	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 colorimetric system measured with standard illumination Source C*

*** Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218. Catalog No. MCP-90040.*

a. Coefficient of Retroreflection:

The coefficients of retro reflection shall conform to the minimum requirements of Table 9-16.2.

TABLE 9-16.2: MIMINUM 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 Table 9-16.2.

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 (5.0) mm/1/4" diameter mandrill.

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty five (25) mm/1" diameter steel ball from a height of two (2) meters/6'-6" onto its surface.

For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty eight (48) hours after application, a 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%) percent of the specified wet or dry minimum brightness values when exposed to weathering for five (5) years.

b. 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.

The retro reflective 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 9-16.3.

Table 9-16.3: MINIMUM COEFFICIENT OF RETROREFLECTION CANDELAS PER FOOT CANDLE PER SQUARE FOOT

(0.2" Om, 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 sheeting shown to be unsatisfactory during.

a. The entire seven years the sign manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

b. 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 NHA for materials and labor.

Samples of the reflective sheeting shall be approved by the Engineer prior to the Contract or placing his order.

9-16.2.3 Metal Posts

Wide flange of 10 x 10 centimeters/4"x4" 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/2-1/2" and seventy five (75) mm/3" 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/7" above shoulder level.

9-16.2.4 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/15". Any trade mark or other printing shall be carefully removed with liquid thinner.

b. Diamond / High Intensity Grade sheeting for the background should cover the whole area of the sign plate.

c. Prior to application of the Diamond / High Intensity Grade reflective sheeting, the sign, plate shall be cleaned and shall be wax free. They shall be degreased by vapor 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.

9-16.2.5 Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10) mm die (G.I) or aluminum alloy. The bolt heath to be such that they do not protrude out too much not show very, much on the front face of the plate a heads should be flush with the plate face and covered with sheeting galvanized according to ASTM A 153.

9-16.2.6 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.

9-16.2.7 Caps over the pipes

These can be of heavy plastic or of aluminum well fitted so that they cannot be removed; any good adhesive can be used.

9-16.2.8 General

a. Very large signs need not be made of one piece; in that case extended Aluminum panels shall be used or the various pieces of sheet shall be joined by angle irons in anti-corroding 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 are 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.

9-16.2.9 Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class A in accordance with Item 401.1.1 and shall of the size 450 x 450 x 650 mm/18”x18”x26” for category 1 & 2 and 600 x 600 x 750 mm/24”x24”x30” for category 3.

9-16.2.10 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 with standing 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.

9-16.3 CONSTRUCTION REQUIREMENTS

9-16.3.1 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/6” in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer.

9-16.3.2 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 the prevent movement of the post during the setting process of the concrete. The posts shall be located at the positions shown on the Drawings.

9-16.3.3 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 color

All newly erected traffic road signs shall be covered with burlap or other material until their uncovering is ordered by the Engineer.

9-16.3.4 Categories of Signs

Traffic road signs shall be of three categories according to type of construction

a. Warning Sings

Constructed with single post and sign of equilateral triangle shape, as shown in drawings, category 1

b. Regulatory Sings

Constructed with single post and sign of circular shape, as shown in the drawings, category 2

c. Informatory Sings

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/10 sft.

Category 3 b = Two Sq meter/20 sft.

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/24”x12” or 90x30 cm/36”x12”.

9-16.3.5 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, 3M 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 a prohibiting car parking on grass verges and protecting herb side areas on public and private roads.

9-16.3.6 Sign faces

a. Design

All sign faces shall be of the type, color, 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" characters.	
2	The Urdu and English writing shall be about the same in length, width and spacing	
3	English letters are to be in italics except the first letter of the word, which shall be in capital.	
4	Height of Capital letters	21 cm/9”
5	Height of italics Letters	17 cm/7”
6	Stroke Width and Width of border	3.5 cm/1-1/2”
7	Space between words and border (at least)	5cm/2”
8	Space between Words	5 cm/2”
9	Space one line will occupy	4 cm/1’1/2”
10	Space between digits of numerals	4 cm/1-1/2”
11	Height of numerals same as capital letters	
12	Space between lines (at least)	
13	Size of letter for km. Height	K-23 cm/9” m-8 cm/3”
14	Width of letters for km including spacing	K-8 cm/3” m-9.6 cm/4”
15	Width of dividing line	2.0 cm/3/4”
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.

9-16.3.7 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, defaced during transportation, storage or erection shall be rejected.

9-16.4 MEASUREMENT AND PAYMENT

9-16.4.1 Measurement

The quantities of traffic road signs and safety devices to be paid for shall be measured in sqft or meter of either round, triangular, or rectangular shape. The vertical posts of G.I pipe of Medium class shall be measured by Rft/m. and installation of lettering and printing and pasting shall be measured by sq m or sft each category of sign sheet of either Diamond Category or High Intensity (HIP) tape supplied and installed at site as directed by the Engineer.

9-16.4.2 Payment

The quantities measured as determined above shall be paid for at the contract unit price for the pay items listed below and as shown in the Bill of Quantities which price and payment shall be full compensation for furnishing all labor, materials, tools, equipment, and for excavation, concreting, backfilling and erection of posts, installation of sign panels and all incidental costs including sheeting/painting necessary to complete the work as prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
9-16 (a)	Lettering and printing of signage / direction board/ road delineators of any color by machine i/c cost of Digital Lettering, lamination and pasting etc. complete. i. High intensity / Prismatic (HIP) Tape ii. Diamond Grade Tape	Sq m / Sft
9-16 (b)	Providing and fixing pole mounted Director board / road delineators of any hape and size with specified sheet and thickness supporte with G.I Channel (excluding cost of post and painting) complete:	Sft / m^2

Pay Item No.	Description	Unit of Measurement
	G.I Sheet 14 SWG Circular / Triangular Rectangular Alloy Sheet 14 SWG Circular / Triangular Rectangular	
9-16 (c)	P/ F Vertical posts comprising of GI Pipe of Medium Class of specified diameter i.c cost of clamping top cover, hold fasts and embed in PCC complete:	Rft / m
9-16 (d)	P F pole mounted mirrors of specified design.	Each
9-16 (d)	P / F Cantilever Gantry of specified portal made 3mm thick GI sheet (Z-275) of size 4000x2400x3mm supported with a frame of MS angle iron frame of size 40x40x5mm all around the sheet with 3no vertical and one no horizontal braces of MS tees of size 40x40x5 mm duly supported on a truss of 2 no chords of MS pipes 273x7 mm x9.27 mtr and 3 no struts of MS pipe of size 143x4.5mm 3.098 mtr duly bolted with a post of MS pipe of size 7500x457.5x12.7 mm thick duly welded with Base plate of 850x850x36 mm with MS stiffners of 18mm thick MS sheet and fixed with anchor bolts in prelaid RCC footing i/c the cost of polyurethane Paint to MS skeleton but excluding the cost of lettering / printing as approved and directed by the Engineer Incharge. i. Single Portal ii. Double Portal	P.Sft/ Sq.m
	P / F full width Gantry comprising of 3mm thick GI sheet (Z-275) fixed over double front and back truss made with Top & Bottom Chords of MS angle iron L-100x100x10 mm, webs and struts of L 65x65x8 mm welded with top and bottom truss of webs and struts of 65x65x8 mm duly supported on specified vertical posts of double columns of MS pipe of size 7500x219x8 mm thick duly welded with Base plate of 600x400x50 mm with MS stiffners of 350x150x15mm thick MS sheet for each column fixed in prelaid RCC footing i/c the cost of polyurethane Paint to MS skeleton but excluding the cost of lettering / printing as	P.Sft/ Sq.m

Pay Item No.	Description	Unit of Measurement
	approved and directed by the Engineer Incharge. a. i. Two Supports ii. Three Lane b. Three Supports i. Four Lane Each	

SECTION – 9-17
PAVEMENT MARKING

9-17 SECTION - PAVEMENT MARKING

9-17.1 DESCRIPTION

The work shall consist of furnishing non reflective or reflective chlorinated rubber based thermoplastic paint material or retroreflective performed pavement marking (tape) whichever is called for in the Special Provisions and shown in the Bill of Quantities, for sampling and packing for the preparation of surface all in accordance with these Specifications.

The paint shall be applied in accordance to the size, shape and location of the markings as shown in the Drawings.

9-17.2 CHLORINATED RUBBER PAINT

9-17.2.1 Material Requirements

A standard and acceptable quality of Chlorinated Rubber based paint shall be used. The paint shall be homogeneous, well dispersed to smooth consistency and shall not cake, live, thicken curdle, gel, settle badly or show any other objectionable properties after period of storage not to exceed six (6) months.

a. Composition

TABLE 9-17.1

WHITE TRAFFIC PAINT REQUIREMENTS

i)	Pigment	Titanium dioxide Rutile and Extenders	100 %
ii)	Vehicle	Modified Chlorinated Rubber Plasticized and Resin Blend	52 ± 4%
		Solvents	45 ± 4%
		Additives: i.e. Flow leveling, adhesion improving agents, anti oxidants, siccatives etc	1-3%
iii)	Paint Composition	Pigments	55 ± 4 %
		Vehicle Solvent and additives	45 ± 5 %

TABLE 9-17.2

YELLOW TRAFFIC PAINT REQUIREMENTS

i)	Pigment	Chrome Yellow and Extenders	100% by Weight
ii)	Vehicle	Same as for white traffic paint	
iii)	Paint Composition:	Pigments	55±4% by Weight
		Vehicle, Solvent and Additives	45+5% by Weight

TABLE 9-17.3

BLACK TRAFFIC PAINT REQUIREMENTS

i)	Pigment	Chrome Yellow and Extenders	100% by Weight
ii)	Vehicle	Same as for white traffic paint	
iii)	Paint Composition:	Pigments	55±4% by Weight
		Vehicle, Solvent and Additives	45+5% by Weight

The volatile material shall be of such character that has a minimum solvent action of asphalt, and such that the resins and non volatile components will be entirely dissolved in the volatile material, and will not precipitate from the solution on standing. The non volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight.

Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer.

9-17.2.2 Ballotini for Reflective Road Paint

The grading of balloting dispersed in the paint shall be as follows in Table 9-17.4:

TABLE 9-17.4

BALLOTINI FOR REFLECTIVE ROAD PAINT

Sieve Sizes	Percentage Retained
No. 12	0
No. 20	30
No. 30	50
No. 50	80
No. 80	100

Glass beads shall conform to AASHTO Designation M-247 At least ninety (90) percent glass beads shall be transparent, reasonable spherical and free from flaws.

The proportion of balloting to paint shall be not less than five hundred (500) grams per litre of paint.

9-17.2.3 Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per meter per requirement surface Coating as follows in Table 9-17.5.

TABLE 9-17.5.

PHOTOMETRIC REQUIREMENTS FOR REFLECTIVE ROAD PAINT

		Color			
		White		Yellow	
Divergence Angle	(Degree)	0.2	0.5	0.2	0.5
Incidence Angles	4(Degree)	237	118	129	75
Incidence Angles	40(Degree)	75	43	43	32

9-17.2.4 Construction Requirements

Traffic markings shall be .applied with approved equipment capable of applying the paint at the specified width and at the specified rate of application. In no case shall the contractor proceed with the work until the equipment, method of application and rate of application as established by a test section have been approved by the Engineer

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labor and traffic paint necessary for the entire work.

The paint shall not be applied during rain, wet weather, when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unfavorable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint firm.

The application of paint shall preferably be carried out by a purpose made machine but where brushes are used only round or oval brushes not exceeding 10 cm. in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at a rate of one (1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving, traffic, till its complete drying and sticking to road surface.

9-17.3 HOT APPLIED THERMOPLASTIC ROAD PAINTS

9-17.3.1 Material Requirements

i. Aggregate

The aggregate shall consist of light colored silica sand, calcite, quartz, calcined flint or other material approved by the Engineer:

ii. Pigment and Extender

a. White Material

The pigment shall be titanium dioxide complying with the requirements of Type A (anatase) or Type R (rutile) of BS 1851.

b. Yellow Materials

Sufficient suitable yellow pigment shall be substituted for all or part of the titanium dioxide to comply with the other requirements of this specification.

c. All Materials

The extender shall normally be whiting (i.e. calcium carbonate prepared from natural chalk) complying with the requirements of BS 1795. The manufacturer may substitute lithopone complying with the requirement of BS 296 for any or all of the whiting.

d. Binder

The binder shall consist of synthetic hydrocarbon resin, or, with the approval of the Engineer, gun or wood resin, plasticized with mineral oil.

e. Composition of mixture

The proportions of the constituents of the mixed material as found on analysis shall comply with the requirements of Table 9-17.6.

TABLE 9-17.6

PROPORTIONS OF CONSTITUENTS OF MIXTURE

Constituent.	Percentage by mass of total mixture	
	Minimum	Maximum
Binder (resin and oil)	18	22
Pigment	6*	--
Pigment and extender	18	22
Ballotini	20+	
Aggregate		--
Pigment Extender and ballotini	78	82

** For Titanium Di-oxide only, no minimum is specified for yellow material.*

Where specified, 10% in the case of material to which surface ballotini is to be applied by pressure application.

The grading of the combined aggregate, pigment, extender and ballotini (where specified) as found on analysis, shall comply with the requirements of Table 9-17.7.

TABLE 9-17.7

TABLE 2, GRADING OF COMBINED AGGREGATE, PIGMENT EXTENDER AND BALLOTINI

Sieve	Percentage by mass passing	
	Screeded	Sprayed
280 µm	100	100
600 µm	--	75–95

9-17.3.2 Sampling and Testing

i. Sampling

For the purpose of carrying out the testing, it is essential that adequate and representative samples be taken in the manner prescribed in specification BS 3262 at following stages.

1. At the manufacturer's plant.
2. After it has been re-melted by the road application contractor.

ii. Testing

The samples shall be prepared and tested in accordance with B.S. Specification 3262 (1976) appendix A to H. The test results shall conform to the following properties

- **Softening Point.**

The softening point measured in accordance with appendix C shall be not less than 65° C.

- **Color and Luminance**

a. White Material.

The luminance factor of white material as delivered by the manufacturer shall be measured in accordance with appendix D and shall not be less than 70 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 65.

b. Yellow Material.

The Color of yellow material shall be approximately BS 381C Color No. 355, Lemon. The luminance factor of yellow material as delivered by the manufacturer shall be not less than 60 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 55.

- **Heat Stability**

a. White Material

When tested in accordance with appendix E, the luminance factor of white material as measured in accordance with appendix D shall be not less than 65

b. Yellow Material

When tested in accordance with appendix E, the luminance factor of yellow material as measured in accordance with appendix D shall be not less than 55.

- **Flow Resistance**

In testing the flow resistance, a cone made and tested in accordance with appendix F, shall not slump by more than 25%.

- **Skid Resistance**

When tested in accordance with appendix G, the skid resistance of a newly laid marking prepared under the stated conditions shall be not less than 45.

9-17.3.3 Manufacturing, Packing and Storing of Paint

i. Manufacturing

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.

ii. Packing

The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination.

Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorization (if applicable) color, chemical type of binder and maximum safe heating temperature.

iii. 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.

9-17.3.4 Certification

The Contractor shall furnish a certificate from manufacturer that the material he proposes to use has the required properties, stating the maximum and minimum proportions 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.

9-17.3.5 Application of Material to the Road

a. Preparation of site

The thermoplastic paint shall only be applied to surfaces, which are clean and dry. Immediately before the application of paint, the surface shall be cleaned with mechanical broom, compressed air or other approved means to remove surplus asphalt, oils, mud, dust and other loose or adhered material. The material shall not be applied if the road surface is at a temperature of less than 5°C.

b. Preparation of material on site

The material shall be melted in accordance with the manufacturer's instructions in heather 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. The molten material shall be used as expeditiously as possible and for thermoplastic material which of as natural resin binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

- After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.
- On concrete carriageway, a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's

instructions prior to the application of thermoplastic material.

c. Laying

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self propelled machine. Other markings 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.

d. Reflectorization by surface application

When surface application of balloting is required, additional balloting (400 g/m2 to 500 g/m2 from the machine) shall be applied by pressure concurrently with the laying of the line with sufficient velocity to ensure retention in the surface of the line. The balloting so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

Balloting dispensed on the surface of the markings shall conform to the following grading as shows in Table 9-17.8.

Sieve	Percentage by mass passing
1.7 mm/1/8”	100
600 µm	80-100
425 µm	45-100
300 µm	10-45
212 µm	0-25
75 µm	0-5

Not less than 90%, by mass of the balloting, shall be of transparent glass, spherical in shape and not more than ten (10) percent shall be ovate in shape or have other flaws. The ballotini shall be made of soda glass.

e. Thickness

Unless otherwise approved by the Engineer, the material shall be laid to the following thicknesses.

a. Sprayed lines other than yellow not less than 1.5 mm.

b. Sprayed yellow edge lines not less than 0.8 mm.

The minimum thicknesses specified are exclusive of surface applied balloting. The method of thickness measurement shall be in accordance with appendix H of BS 3262 (1976).

9-17.3.6 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.

9-17.4 RETRO-REFLECTIVE PREFORMED PAVEMENT MARKINGS

9-17.4.1 Materials Requirements

The preformed markings shall consist of white or yellow films with pigments selected to conform to standard highway colors. Ceramic and glass beads shall be incorporated to provide immediate and continuing retroreflection. Ceramic skid particles shall be bonded to a top urethane layer to provide a skid resistant surface.

The preformed markings shall be capable of .being adhered to asphalt cement concrete (ACC) or Portland Cement Concrete (PCC) by a pre coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The preformed marking film shall mold itself to pavement contours by the action of traffic. The pavement marking film wearing courses during the paving operation shall be approved by the Engineer in accordance with the manufacturer's instructions. Following proper application and tamping, the markings shall be immediately ready for traffic. The bidder, when bidding; shall identify proper solvents and/or primers (where necessary) for proper application, and recommendation for application that will assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

The marking film shall be durable retoreflective plisot polymer pavement marking film for performed longitudinal markings subject to low to medium traffic volumes and moderate wear conditions such as repeated shear action from crossover or encroachment on channelization lines.

The retroreflective pavement marking film shall consist of mixture of high quality pigmented polymeric materials, with a reflective layer of ceramic and glass beads, and a layer of skid resistant ceramic particles bonded to the top urethane wear face, he film shall have a predated pressure Sensitive" adhesive. The edges of the preformed tape shall be clear cut and true.

9-17.4.2 Color

The daytime color of the white film shall provide a minimum initial Luminance factor, Y, of 80, and shall conform to the following: chromaticity requirements: X = 0 290 Y = X = 9: 491 Y=0435; = X 0.512 Y 0.486; X = 0536, Y = 0.463.

Measurements shall be made in accordance with ASTM E 1349, using illuminant "C" and 0/45 (45/0) geometry. Calculations shall be in accordance with ASTM E 308 for the 2° standard observer.

9-17.4.3 Reflectance

The white and yellow films shall have the following initial minimum reflectance values as measured in accordance with the testing procedures 1M ASTM D 4061. The photometric quantity to be measured shall be specific luminance (SL), and shall be expressed as millicandals per square foot per foot candle (mcd. ft^2). Fc^{-1}). The metric, equivalent shall be expressed as millicandals per square meter per lux (mcd. m^2) lx^{-1})

	White	Yellow
Entrance Angle 86.000	86.5°	86.5°
Observation Angle	1.0°	1.0°
Specific Luminance	300	175
SL (mcd. ff 2). fc		

9-17.4.4 Skid Resistance

The surface of the retoreflective films shall provide the initial minimum skid resistance values of 55 BPN as measured by the British Portable Skid Tester in accordance with, ASTM E 303.

9-17.4.5 Patchability

The pavement marking film shall be capable of use for patching worn areas of the same type of film in accordance with the manufacturer's instructions.

9-17.4.6 Reflectance Retention.

To have a good, effective performance life, the ceramic and glass beads must be strongly bonded and not be easily removed by traffic wear. The following test shall be employed to measure reflectivity retention.

9-17.4.7 Taber Abraser Simulation Test

Using a Taber Abraser with an H-18 wheel and a 125 gram load, the sample shall be inspected at 200 cycles, under a microscope, to observed the extent and type of bead facture No more than l5% of the treads shall be lost due to pop out and the predominant mode of failure shall be "wear down" on the beads.

9-17.4.8 Beads

The size, quality and refractive index of the ceramic and glass beads shall be such that the performance requirements for the marking shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched:

9-17.4.9 Bead Retention

The film shall be ceramic and glass bead retention qualities such that when a 2 in x 6 in. (5.08 cm x 15.24 cm) sample is bent over a ½ in. (1.27 cm) diameter mandrel, with the 2 M dimension perpendicular to the mandrel axis. Microscopic, examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

9-17.4.10 Thickness

The film without adhesive shall have a minimum thickness of 0.030 in (0.76mm).

9-17.4.11 Effective Performance Life

The film, when applied according to the recommendations of the manufacturer, shall provide neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and through normal traffic wear shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking throughout its useful life and shall show no significant tearing, roll back or other signs of poor adhesion.

9-17.4.12 Installation

The markings shall be applied in accordance with the manufacturer's instructions.

9-17.5 CEMENTITIONS MARKING COMPOUND

Cementations marking compound shall be used for Concrete, Surface Dressing and Bitumen to provide enhanced night and wet, weather visibility. This compound will be applied at following locations:

- Kerbs Pavements and car park areas.
- Roundabout vertical and sloping faces.
- Traffic Islands vertical edges and bull noses, etc
- Traffic Dividers black and white chevrons.
- Concrete wall and faces on high speed intersections and traffic merging.

9-17.6 MEASUREMENT AND PAYMENT

9-17.6.1 Measurement

The quantity of non-reflective or reflective chlorinated rubber based or thermoplastic pavement marking paint shall be the no. of linear rft / meters of painted: traffic tine for the specified width as indicated in B.O.Q.

The retro reflective preformed pavement markings (tape) shall be measured in square meters. The arrows shall be measured in number.

The measurement shall be made of painted areas completed and accepted. No measurement shall be made of unauthorized areas. Paint that is applied in unauthorized areas shall be completely removed from the surface of the road to the satisfaction of the Engineer and bf Contractor's expense.

9-17.6.2 Payment

The quantities measured as determined above shall be paid for at the Contract unit price respectively for the pay items listed below, which price and payment shall constitute full compensation for furnishing and placing all materials including sampling, packing and testing at approved laboratory. The cost shall also include the preparation of the surface, and for all other costs necessary to complete the work as prescribed in this Section.

Pay Item No.	Description	Unit of Measurement
9-17 (a)	Pavement Marking in reflective CR Paint for Lines of 5 in /12.5 cm width.	M/Rft
9-17 (b)	Pavement Marking in reflective TP Paint: Lines of 5 in / 12.5 cm width. Lines of 6 in / 15 cm width	M/Rft
9-17 (c)	Pavement Marking in reflective TP Paint for 4 M arrows.	Each
9-17 (d)	Pavement Marking by retro reflective Preformed pavement markings (Tape).	SM/Sft

SECTION – 9-18

REFLECTORIZED PAVEMENT STUDS

9-18 SECTION -REFLECTORIZED PAVEMENT STUDS

9-18.1 DESCRIPTION

This section 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.

9-18.2 MATERIAL REQUIREMENTS

9-18.2.1 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/7x5-1/2” or as shown in 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 10 cm x 10 cm and thickness not more than two (2) cm/3/4” 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 as shown in Table 9-18.1

TABLE 9-18.1

PHOTOMETRIC REQUIREMENTS OF REFLECTORS

	COLOUR		
	Crystal	**Yellow**	**Red**
Divergence Angle	0.20	0.20	0.20
(in Degree)	S.I.	S.I.	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 cm and shall be shielded from stray light. The distance from the centers of the light source and photocell shall be 0.53 cm.

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/2240 lbs 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/3” internal diameter, twenty five (25) mm/1” high and wall thickness of six (6) mm/1/4”. The load shall be applied to the top of' the reflector through a six (6) mm/1/4” diameter by six (6) mm/1/4” 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/2240 lbs.

9-18.2.2 Adhesives

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 shown in Table 9-18.2

TABLE 9-18.2

ADHESIVES REQUIREMENTS

Package A	**Kg / Liter/Lbs/Gln.**
Epoxy Resin	0.94/0.46
Titanium Dioxide	0.07/0.03
Colloidal Silica	0.05/0.02
Talc	0.345/0.17

TABLE 9-18.3

ADHESIVES REQUIREMENTS

Package B	Kg / Liter/Lbs/Gln.
Modified Asphaltic Amine Hardener (Reinchold 2611)	0.24/0.11
Modified Asphaltic Amine Hardener (Reinchold 2613)	0.472/0.23
Carbon Black	0.0022/0.001
Colloidal Silica	0.04/0.02
Talc	0.650/0.32

Equal volumes of Package A & B should be mixed together until a uniform color is obtained. No more than one quart of adhesive shall be prepared at one time.

9-18.2.3 Cement Mortar

Cement mortar shall consist of one (1) part Portland cement to three (3) parts of fine aggregates.

9-18.3 CONSTRUCTION REQUIREMENTS

9-18.3.1 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/3/8" 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 socRef"sfia7l softie 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 when the studs are installed into a cement concrete pavement.

9-18.3.2 Raised Profile Type

The pavement studs shall be installed in accordance with the manufacturer's instructions or to the requirements of the Engineer.

9-18.4 MEASUREMENT AND PAYMENT

9-18.4.1 Measurement

The quantity of reflectorized pavement studs to be paid for shall be the number of ‘Flushed Surface' or 'Raised Profile' type provided and installed as mentioned above.

9-18.4.2 Payment

The quantities measured as described above shall be paid for at the contract unit price respectively for the pay items listed below and shown in the Bill of Quantities, which payment shall constitute full compensation for furnishing and placing all materials, excavating cavities, preparation of surfaces, applying adhesive and mortar, for all labor, equipment, tools and incidentals necessary to complete the work.

Pay Item No.	Description	Unit of Measurement
9-18 (a)	Reflectorized Pavement Stud, / Cat eyes of size 4inx4in duly casted of specified material (Flush Surface) nailed with zinc plated steel nail fixed with epoxy: a. Acrylic b. Aluminum Alloy	Each
9-18 (b)	Reflectorized Pavement Stud Raised Profile Type as specified whether unidirectional direction and of specified size.	Each
9-18 (c)	Reflectorized Pavement Stud Raised Profile Type as specified whether bidirectional direction and of specified size.	Each

SECTION – 9-19

PRECAST CONCRETE POSTS AND MARKERS

9-19 SECTION - PRECAST CONCRETE POSTS AND MARKERS

9-19.1 DESCRIPTION

The work shall consist of furnishing and placing precast concrete Kilometer, Ten Kilometer, Guide Post's and Right of Way Markers, complete including painting and lettering in accordance with the Drawings and specifications or as directed by the Engineer.

9-19.2 MATERIAL REQUIREMENT

9-19.2.1 Concrete

Precast concrete post and markers shall consist of Class conforming to the requirements of Section 7-1 and to the lengths, shapes and other details shown on the Drawings.

9-19.2.2 Reinforcing Steel

Reinforcing steel shall conform to Section 8-3.

9-19.3 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/3/4” 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/6” each until firm and solid.

9-19.4 MEASUREMENT AND PAYMENT

9-19.4.1 Measurement

The quantity of each element to be paid for shall be the number of post and marker furnished and installed in place as per drawing or as directed by the Engineer:-.

9-19.4.2 Payment

In accepted quantities of posts and markers shall be paid for at the contract unit price per unit of measurement for the pay items listed below and shown in Bill of Quantities which price shall be compensation for furnishing, excavation, placing, erection, painting, lettering and for all costs including labor, tools, and incidentals necessary to complete the work prescribed in this section:

Pay Item No.	Description	Unit of Measurement
9-19 (a)	Guide Post.	Each
9-19 (b)	Right of Way Marker.	Each
9-19 (c)	Kilometer Post.	Each

SECTION – 9-20
FENCING

9-20 SECTION – FENCING

9-20.1 DESCRIPTION

The work shall consist of constructing concrete or steel 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.

9-20.2 MATERIAL REQUIREMENTS

9-20.2.1 Barbed Wire

Barbed wire shall conform to the requirements of (AASHTO M280) ASTM A 121, Class 1. The barbed wire shall consist of 2 strands of 12.5 gauge wire, twisted with 2 points, 14 gauge barbs spaced 10 cm (4 inch) apart.

9-20.2.2 Chain Link Fabric

Chain link fabric shall be fabricated from 10 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 Incharge for his approval.

9-20.2.3 Concrete Posts

Concrete posts shall be made from Class D1 concrete in accordance with Section 7-1. The posts shall be cast to the length shown on the drawings and shall have a smooth surface finish.

9-20.2.4 Steel Posts

Steel posts shall be of the section and length as specified or as shown on the drawings. The posts shall be of copper bearing steel and shall conform to the requirements of AASHTO M 183 for the grade specified.

9-20.2.5 Steel Reinforcement for Concrete Posts

Steel reinforcement for the concrete posts shall be deformed steel bars conforming to the provisions of Section 8-3.

9-20.2.6 Hardware for Steel Posts

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM 153.

9-20.3 CONSTRUCTION REQUIREMENTS

9-20.3.1 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 at the locations shown on the drawings or as directed by the Engineer.

9-20.3.2 Installation of Chain Link Fabric or Fabric of Barbed Wire

The chain link fabric or barbed wire 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 10 cm (4 inch) and shall occur only at the concrete post.

No horizontal splicing will be permitted.

The fabric shall be fixed to the concrete posts as shown on the drawings.

9-20.4 MEASUREMENT AND PAYMENT

9-20.4.1 Measurement

The quantity to be paid shall be measured in linier feet/meter and multiplied by its theoretical standard weight.

9-20.4.2 Payment

The quantities measured as determined above shall be paid for at the contract unit price for the pay items listed below and shown in the Bill of Quantities which price and payment shall be full compensation for furnishing, placing, excavating, backfilling and erecting all posts for the installation, fixing and welding of the fabric and wire and for all materials, labor, equipment, tools and incidentals necessary to complete the work.

Pay Item No.	Description	Unit of Measurement
9-20 (a)	Chain Link Fabric Fencing	KG/lbs
9-20 (b)	Barbed Wire Fencing	KG/lbs

SECTION – 10-1

PORTLAND CEMENT

10-1 SECTION - PORTLAND CEMENT

10-1.1 DESCRIPTION

These specifications give requirements for the composition, sampling and testing of ordinary and other types of Portland cements normally in use with the Department, and as manufactured according to ASTM, or AASHTO.

10-1.2 TYPES OF CEMENT

According to A.S.T.M. C 150 (AASHTO M 85)

Type-I. For use when the special properties specified for any other type are not required.

Type-IA Air-entraining cement for the same uses as Type-I, where air-entrainment is desired.

Type-II For general use, more especially when moderate sulphate resistance or moderate heat of hydration is desired.

Type-IIA Air-entraining cement for the same uses as Type-II, where air-entrainment is desired.

Type-III For use when high early strength is desired.

Type-IIIA Air-entraining cement for the same uses as Type-III, where air-entrainment is desired.

Type-IV For use when a low heat of hydration is desired.

Type-V For use when high sulphate resistance is desired.

10-1.3 BASIS OF PURCHASE

The purchaser shall specify the desired type or types of Portland cement. When no type is specified, the requirements of Type 1(ASTM C-150) or AASHTO M 85 shall govern.

10-1.4 DEFINITION

10-1.4.1 Portland Cement

Portland cement is a hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as an interground addition.

10-1.4.2 Air-entraining Portland Cement

A hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as an interground addition and with which there has been interground an air-entraining addition.

10-1.4.3 Hydraulic Cement

Cement that sets and hardens by chemical interaction with water and is capable of doing so under water.

10-1.5 QUALITY REQUIREMENTS

Portland cement of the types shown in section 10-1.2 shall conform to the chemical and physical requirements given in Tables 10-1.1 & 10-1.2 respectively, of ASTM Designation C-150, AASHTO M 85 whichever is applicable.

10-1.6 PACKING AND MARKING

When the cement is delivered in packages, the name and brand of the manufacturer and the type shall be plainly identified thereon, except that, in the case of type I cement, the type need not be identified. When the cement is delivered in bulk this information shall be contained in the shipping advices accompanying the shipment. All packages shall be in good condition at the time of inspection.

10-1.7 STORAGE

10-1.7.1 Storage Godowns

The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment and in a suitable weather-tight building that will protect the cement from dampness and minimize warehouse set.

10-1.8 INSPECTION

Inspection of the material shall be made as agreed upon between the purchaser and the seller as part of the purchase contract.

10-1.9 REJECTION

The cement may be rejected if it fails, to meet any of the requirements of this specification.

At the option of the purchaser, retest, before using, cement remaining in bulk storage for more than six months or cement in bags in local storage in the custody of a vendor for more than three months after completion of tests and reject the cement if it fails to conform to any of the requirements of this specification. Cement so rejected shall be the responsibility of the owner of record at the time of resampling for resets.

Packages shall be identified the mass contained as net weight. At the option of the purchaser, packages more than two percent below the mass marked theron shall be rejected. If the average mass of packages in any shipment , as shown by determining the mass of 50 packages selected at random, is less than that marked on the packages, the entire shipment shall be rejected.

10-1.10 METHOD OF SAMPLING AND TESTING

The sampling and testing of Portland cement shall be in accordance with the following related standards of ASTM or AASHTO.

Sr. No.	Test Method	ASTM Designation	AASHTO Designation
1	Sampling and Amount of Testing of Hydraulic cement	C183	T127
2	Compressive Strength of Hydraulic Cement Mortar (Using 50mm cube specimen)	C109	T106
3	Chemical Analysis of Hydraulic Cement	C114	T105
4	Fineness of Portland Cement by the Turbidimeter	C115	T98
5	Autoclave Expansion of Portland Cement	C151	T107
6	Time of setting of Hydraulic Cement by Vicat Needle	C191	T131
7	Early Stiffening of Hydraulic Cement (Paste Method)	C451	T186
8	Air Content of Hydraulic Cement Mortar	C185	T137
9	Heat of Hydration of Hydraulic Cement	C186	Not available
10	Potential Expansion of Portland Cement Mortars Exposed to Sulphate	C452	Not available
11	Expansion of Portland Cement Mortar Stored in Water (Calcium Sulphate in Mortar)	C1038	Not available

10-1.11 PHYSICAL PROPERTIES REQUIREMENTS

Portland cement of each of the eight types shown in Section 10-1.2 shall conform to the respective standard physical requirements as shown in Table-10-1.1.

Table 10-1.1 – Standard Physical Requirements

Cement Type	I	IA	II	IIA	III	IIIA	IV	V
Air content of mortar,[b] volume, percent:								
Max	12	22	12	22	12	22	12	12
Min	–	16	–	16	–	16	–	–
Fineness [c], specific surface, m^2/kg								
(alternative methods):								
Turbidi meter test:								
Average value, min[d]	160	160	160	160	160	–	–	160
Min value, any one sample	150	150	150	150	150	–	–	150
Average value, max[d]	220	220	220	220	220	–	–	220
Max value, any one sample	230	230	230	230	230	–	–	230
Air permeability test:						–	–	
Average value, min[d]	280	280	280	280	280	–	–	280
Min value, any one sample[e]	260	260	260	260	260	–	–	260
Average value, max[d]	400	400	400	400	400	–	–	400
Max value, any one sample[e]	420	420	420	420	420	–	–	420
Autoclave expansion, max, percent	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Strength, not less than the value shown for the ages indicated below								
Compressive strength, MPs (Psi)								
1 day	–	–	–	–	12	10.0	–	–
					(1740)	(1450)		
3 days	12.0	10.0	10.0	8.0	24.0	19.0	–	8.0
	(1740)	(1450)	(1450)	(1160)	(3480)	(2760)		(1160)
			7.0[g]	6.0[g]				
			(1020)	(870)[g]				
7 days	19.0	16.0	17.0	14.0	–	–	7.0	15.0
	(2760)	(2320)	(2470)	(2030)			(1020)	(2180)
			12.0[g]	19.0[g]				
			(1740)	(1310)				
28 days	–	–	–	–	–	–	17.0	21.0
							(2470)	(3050)
Time of setting (alternative methods)[h]								
Gillmore test:								
Initial set, min, not less than	60	60	60	60	60	60	60	60
Final set, min, not more than	600	600	600	600	600	600	600	600
Vicattest:[i]								
Time of setting, min, not less	45	45	45	45	45	45	45	45

Cement Type	I	IA	II	IIA	III	IIIA	IV	V
than								
Time of setting, min, not min than	375	375	375	375	375	375	375	375

a. *Cement Conforming to the requirements for all types are not carried in stock in some areas. In advance of specifying the use of other than Type I cement, determine whether the proposed type of cement, is or can be made available.*

b. *Compliance with the requirements of this specification does not necessarily ensure that the desired air content will be obtained in concrete.*

c. *Either of the two alternative fineness methods may be used at the option of the testing laboratory. However, when the sample fails to meet the requirements of the air-permeability test, the turbidimeter test shall be used and the requirements in this table for the turbidimetric method shall govern.*

d. *Average value shall be determined on the last consecutive five samples from a source.*

e. *The value of any one sample shall be result of a test or average of tests on any one sample.*

f. *The strength at any specified test age shall be not less than that attained at any previous specified test age.*

g. *When the optional heat of hydration or the chemical limit on the sum of the tricalcium silicate and tricalcuim aluminate is specified.*

h. *The purchaser should specify the type of setting-time test required. In case he does not so specify, the requirements of the Vicat test only shall govern.*

i. *The time of setting is that described as initial setting time in T 131.*

10-1.12 CHEMICAL PROPERTIES REQUIREMENTS:

Portland cement of each of the eight types shown in Section 10-1.2 shall conform to the respective standard chemical composition requirements as shown in Table 10-1.2

Table 10-1.2 – Standard Chemical Composition Requirements

Cement Type	I and IA	II and IIA	III and IIIA	IV	V
Silicon dioxide (s_iO_2) min, percent	–	20.0[b,c]	–	–	–
Aluminum oxide ($Al_2 O_3$), max, percent	–	6.0	–	–	–
Ferric oxide ($Fe_2 O_3$), max, percent	–	6.0[b,c]	–	6.5	–
Magnesium oxide (MgO), max, percent	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO_3),[d] max, percent					
When (C_3A)[e] is 8 percent or less	3.0	3.0	3.5	2.3	2.3
When (C_3A) [e] is more than 8 percent	3.5	d	4.5	d	d
Loss on ignition, max, percent	3.0	3.0	3.0	2.5	3.0
Insoluble residue, max, percent	0.75	0.75	0.75	0.75	0.75
Tricalcium silicate (C_3S), [e] max, percent	–	58		35b	–
Dicalcium silicate (C_2S), [e] max, percent	–			40b	–
Tricalcium aluminate (C_3A), [e] max, percent	–	8	15	7b	5
Tricalcium aluminoferrite plus twice the tricalcium aluminate (C_4AF + 2(C_3A)), or solid solution (C_4AF + (C_2F)), as applicable, max, percent	–	–	–	–	25

a) *See Note 1.*
b) *Does not apply when the heat of hydration limit in Table 4 is specified.*
c) *Does not apply when the sulfate resistance limit in Table 4 is specified.*
d) *There are cases where optimum $S0_3$ (using ASTM C 563) for a particular cement is close to or in excess of the limit in this specification. In such cases where properties of a cement can be improved by exceeding the SO_3 limits stated in this table, it is permissible to exceed the values in the table, provided it has been demonstrated by ASTM C 1038 that the cement with the increased S01 will not develop expansion in water exceeding 0.020 percent at 14 days. When the manufacturer supplies cement under this provision, he shall, upon request, supply supporting data to the purchaser.*
e) *The expressing of chemical limitations by means of calculated assumed compounds does not necessarily mean that the oxides are actually or entirely present as such compounds.*
When expressing compounds, C = CaO, S = $Si0_2$. A= Al_20_3, F = Fe_20_3.For example, C_3A = 3Ca0 ·$A1_20_3$ Titanium dioxide and phosphorus pentoxide ($Ti0_2$ and P_20_5) shall not be included with the $A1_20_3$ Content.
When the ratio of percentages of aluminum oxide to ferric oxide is 0.64 or more, the percentages of tricalcium silicate, dicalcium silicate, tricalcium aluminates, and tetracalcium aluminoferrite shall be calculated from the chemical analysis as follows:
Tricalcium silicate= (4.071 x percent C_aO) - (7.600 X percent $Si0_2$) - (6.718 X percent Al_20_3)- (1.430 x percent Fe_20_3)- (2.852 X percent $S0_3$)
Dicalcium silicate = (2,867 x percent $Si0_2$) -(0.7544 x percent C_3S)
Tricalcium aluminate = (2.650 X percent Al_20_3) - (1.692 x percent Fe_20_3)
Tetracalcium aluminoferrite = 3.043 x percent Fe_20_3
When the alumina-ferric ratio is less than 0.64, a calcium aluminoferrite solid solution (expressed as ss(C_4AF + C_2F) is formed. Contents of this solid solution and of tricalcium silicate shall be calculated by the following formula:
ss(C_4AF + C_2F) = (2.100 x percent Al_20_3) + (1.702 x percent Fe_20_3)
Tricalcium silicate·= (4.071 X percent CaO) - (7.600 x percent $Si0_2$)- (4.479 X percent Al_20_3)- (2.89 x percent Fe_20_3)- (2.852 x percent $S0_3$). No tricalcium aluminate will be present in the cements of this composition. Dicalcium silicate shall be calculated as previously shown.
f) *Not applicable.*

10-1.13 MEASUREMENT

10-1.13.1 Measurement and Payment

Cement shall be measured by weight. The unit of measurement shall be one metric ton (Tonne).

10-1.13.2 Rate

The unit rate for supply of cement, at site of work shall be full compensation for cost of cement, unloading from wagons/trucks, transportation to site of work, and its storage in godowns.

10-1.13.3 Payment

Payment for supply of cement, when specifically called for in bid schedule shall be made as under:-

Pay Item No.	Description	Unit of Measurement
10-1	Supply of Portland cement of Specified Quality	metric ton

SECTION – 10-2
LIME

10-2 SECTION - LIME

10-2.1 GENERAL

Lime is obtained by suitable calcination of naturally occurring forms of calcium carbonate in the shape of lime stone or kanker. Lime can be generally divided into two classes, viz. (i) Non-hydraulic Limes and (ii) Hydraulic Limes.

10-2.2 CLASSES OF LIMES

10-2.2.1 Non-hydraulic Limes

The non-hydraulic limes depend upon the absorption of carbon dioxide from atmosphere for setting and hardening and may be of the following two kinds: -

a. High Calcium Lime also called stone, white or fat lime. It contains from 95% upwards of calcium oxide. It exhibits high degree of plasticity and sets and hardens slowly entire on absorption of carbon dioxide from the atmosphere, it is most suitable for plastering. When used for mortar however, it should be gauged with a proportion of cement.

b. Poor Lime.-It is relatively impure lime containing from about·10% to 40% of impurities insoluble in acid. Otherwise it possesses the general properties of rich lime though to a lesser degree.

10-2.2.2 Hydraulic Limes

The hydraulic limes set and harden under water due to the presence of constituents like silica and alumina which enable them to be independent of atmosphere. These limes are obtained from kanker of clay limestones. Properties of hydraulic limes depend upon the proportion of clay present which may vary from 5% to 30 %. The larger the proportion of clay, the more sluggish the slaking and greater the hydraulic property. Hydraulic limes are suitable for works under water and for all positions where strength is required as they have much less tendency to shrink or crack than non-hydraulic limes.

Semi-hydraulic limes contain silica and alumina in proportions intermediate between non-hydraulic and hydraulic limes

10-2.3 CALCINATION

Calcination may be effected by two methods, namely, intermittent burning and continuous burning.

10-2.4 DEFINITION

Unless otherwise stated, Lime shall mean Stone lime or Kanker Lime.

10-2.5 SOURCE OF STONE LIME

Stone, fat or white lime shall be manufactured from limestone containing at least 90% pure carbonate of lime. Limestone shall be obtained from an approved source, as specified in the Conditions of Contract.

10-2.6 CALCINATION OF STONE LIME

The limestone shall be broken into pieces so that it will pass through a ring of 2½ inches/6.25 cm diameter before placing it in the kiln. For firing the kiln, coal, charcoal, wood or screened cinders shall be used (as specified in Conditions of Contract); under no circumstances shall cowdung be used.

The Kanker lime shall be broken up to 2"/5cm gauge and shall be burnt. The kanker, when burnt shall be carefully handpicked so as to exclude all over and under burnt pieces and shall then be ground fine and passed through a screen of 144 meshes per square inch/6.25 sq. cm.

10-2.7 STORAGE

Lime shall be stored in dry and weather-proof sheds, in a compact heap so as to expose as small an area as possible to air to prevent air slaking. Lime shall not be stored for a long period after burning but shall be used as fresh as possible.

10-2.8 MEASUREMENT AND PAYMENT

10-2.8.1 Measurement

Stone lime, freshly burnt shall be measured by weight before slaking. The unit of measurement shall be one mention or tone as specified. Kanker Lime, freshly burnt and ground shall be measured in bulk before slaking. The unit of measurement shall be on metric ton (tone).

10-2.8.2 Rate

The rate shall include furnishing, grinding and screening of lime as per above specifications, delivery, stacking and slaking at Site of Work to be defined in the Conditions of Contract.

10-2.8.3 Payment

The payment will be made as under:

Pay Item No.	Description	Unit of Measurement
10-2	Supply of Lime un slacked	Tonne

SECTION 10-3
BITUMINOUS BINDERS

10-3 SECTION - BITUMINOUS BINDERS

10-3.1 DESCRIPTION

The work covered under this Section consists of supplying bituminous binders of designated grades, in accordance with these specifications and at location designated by the Engineer.

Asphalt Cement shall be oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from cude asphaltic petroleum. it shall be free from admixtures with any residues obtained by the artificial distillation of coal, coal tar or paraffin and shall be homogenous and free from water

Asphaltic cement shall be classified by Penetration and when tested in accordance with standard methods of tests of the AASHTO

10-3.2 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 10-3.1 below gives recommended asphalt grades for various temperature conditions.

Table 10-3.1: SELECTING ASPHALT GRADE

Temperature Condition	Asphalt Grade *
Cold, mean annual air temperature	AC-10
≤7 degree C (45 degree F)	AR-4000
	80 / 100 pen
Warm, mean annual air temperature	AC-20
between 7 deg. C (45 deg F)	AR-8000
and 24 def.0 (75 def. F)	60 / 70 pen.
Hot, mean annual air temperature	AC-40
≥24 deg.0 (75 deg. F)	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 trivial; on structure to be used, and the curing sate.

10-3.3 TYPES OF BITUMINOUS BINDERS

For the purposes of these specifications, the following types of bituminous binder shall be considered.

i. Bitumen (Penetration graded asphalt / straight run)

ii. Cut Back (Cut Back Asphalt)

iii. Emulsions (Emulsified Asphalt)

10-3.3.1 Bitumen

Penetration grade bitumen shall be obtained from crudes by either vacuum distillation or semi blowing or two stage blowing, or fluxing and solvent extraction methods.

The supply order for bitumen shall be designated by its penetration at 25^{o}C (77^{o}F). The grades of bitumen are usually designated by penetration limits such as 200/300, 120/150, 80/100, 60/70, 40/50. Grade specifically required shall be designated.

The Penetration Grade Bitumen shall be homogenous, free from water and shall not foam when heated to 175^{o}C (347^{o}F).

The various grades shall conform to the requirements given in Table-10-3.1 of this Section These requirements are as per AASHTO M20 and ASTM D946/D946M.

10-3.3.2 Cut Backs (Cutback Asphalt)

Cut backs shall consist of penetration grade bitumen mixed with a volatile solvent or flux which shall be either white spirit or Naptha, or a type of Kerosine or type of gas oil

Bitumen when mixed with Naphta or white spirit, produces rapid curing cutbacks, when mixed with a type of kerosene, produces medium curing cutbacks and when mixed with a type of gas oil produces slow curing cutbacks

Thus Cutback Asphalt shall be liquid petroleum products, produced by fluxing an asphaltic base with suitable petroleum distillates, to be used in treatment of road surfaces. The two types of cutback asphalts which are generally in use are as:

i. Rapid Curing Type (RC) &

ii. Medium Curing Type (MC)

Grades of cutbacks are designated by the kinematics viscosity measured at a standard temperature of 60 degree C (140 Degree F). Each grade is named by the lower limit of viscosity and upper limit for the grade is twice that of lower limit.

The Rapid curing and Medium curing cit backs are classified as follow:

- Rapid curing cut backs
    - Rc-70

- Rc-250
- Rc-800
- Rc-3000

- Medium curing cut backs
  - Mc-30
  - Mc-70
  - Mc-250
  - Mc-800
  - Mc-3000

The cutback asphalt shall show no separation or curdling prior to use and shall not foam when heated to the application temperature as shown in Tables 10-3.2 and 10-3.3 of this section.

The required properties of these cut backs are given in AASHTO Tables numbered as AASHTO M-82 and AASHTO M-83 which are reproduced in Tables 10-3.2 and 10-3.3.

10-3.3.3 Emulsions (Emulsified Asphalt)

Asphaltic Emulsions shall be composed of a bituminous base uniformally emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting(RS) or Slow Setting(SS) and shall conform to the requirements specified in AASHTO Tables designated as AASHTO M-140. The emulsified asphalt shall be homogeneous. Within 30 days after delivery and provided separation and making sure that it has not been effected by freezing, the emulsified asphalt shall be homogeneous after thorough mixing.

The requirements for emulsified asphalts as per AASHTO M140 are reproduced in Table 10-3.4.

The bituminous base used in manufacturing RS-1 TYPE EMULSIONS shall be asphalt cement Grade 120-150 or Grade 200-300

The bituminous base used in manufacturing SS1 TYPE EMULSION shall be paving asphalt Grade 60-70 or Grade 120-150

10-3.4 APPLICATION TEMPERATURES FOR VARIOUS BITUMINOUS BINDERS

Various bituminous binders for applications shall be heated to temperatures shown in Table 10-3.5

10-3.5 SUPPLY OF BITUMEN

The agency supplying bituminous binders to the Department shall do so either in tank trucks or in waterproof drums, as called for in the Bid schedule. The drums shall be standard 35/36 Imp. Gallons/156/162 Liters or as specified by the Department made of 24 SW gauge or thicker M.S. sheet as specified and properly welded to make it waterproof. The tank trucks shall be fully insulated. They shall be inspected prior to loading and if necessary they shall be drained and cleared.

10-3.6 METHODS OF SAMPLING AND TESTING

Sampling and testing bitumen shall be in accordance of standard methods of AASHTO / ASTM as under:-

Penetration Grade Bitumen

1. Penetration Grade Bitumen		
Test Method	**AASTO Designation**	**ASTM Designation**
a. Sampling	T 40	D140
b. Penetration	T 49	D5
c. Flash Point (C.O.C)	T 48	D92
d. Ductility	T 51	D113
e. Solubility Trichloroethylene	T 44	D2042
f. Thin Film Oven Test	T 179	D1754
g. Water	T 55	D95
2. Cutback Asphalt		
a. Sampling	T 40	D140
b. Kinematic Viscosity	T 201	D2170
c. Water Content	T 55	D95
d. Distillation	T 78	D402
e. Penetration	T 49	D5
f. Saybolt Furol Viscosity	T 72	D88
g. Ductility	T 51	D113
h. Solubility	T 44	D2042
i. Flash Point	T 79	
3. Emulsions (Emulsified bitumen)		
a. Sampling	T 40	D140
b. Testing	T 59	D244

10-3.7 MEASUREMENT AND PAYMENT

10-3.7.1 Measurement

Bitumen binders shall be measured by weight or by volume as specified. When measured by weight, the unit of measurement shall be one metric ton (Tonne). When measured by volume, the unit of measurement shall be an imperial Gallon or U.S. Gallon or liter.

10-3.7.2 Rate

The unit rate for supply of bituminous binder at site of work shall be full compensation for cost of material, unloading from wagons/trucks, transportation to site of work & its storage in godowns including the cost of metallic drums at the unit rate provided in the Contract Agreement.

10-3.7.3 Payment

Payment for supply of bituminous binder or tar, when specifically called for in bid schedule shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-3	Supply of bituminous binder of specified quality and grade	Metric ton (Tonne)

TABLE – 10-3.1

REQUIREMENTS FOR PENETRATION GRADE BITUMENS

(AASHTO M –20)

		PENETRATION GRADE									
		40-50		60-70		80-100		120-150		200-300	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1.	Penetration at 25^{0}C (77^{o}F)100g, 5 Sec.	40	40	60	70	80	100	120	150	200	300
2.	Flash point, Cleveland Open Cup (F^0)	450	-	450	-	450	-	425	-	350	-
3	Ductility at 25^0 C(77^0 F) 5 cm. Per min, cm	100	-	100	-	100	-	100	-	-	-
4	Solubility in Trichloroethylene percent.	99	-	99	-	99	-	99	-	99	-
5	Thin-film oven test, 1/8 in. (3.2mm), 163^0 C(325^0 F) 5 hour. Loss on heating percent.	-	0.8	-	0.8	-	1.0	-	1.3	-	1.5
6	Penetration of residue, percent of original	58	-	54	-	50	-	46	-	40	-
7	Ductility of residue at 25^{0}C(77^{0}F)5 cm. per min, cm.	-	-	50	-	75	-	100	-	100	-

Properties:

The asphalt cement shall be homogenous, free from water and shall not foam when heated to 175^{0}C (347^{0}F).

TABLE- 10-3.2

REQUIREMENTS FOR RAPID-CURING CUTBACKS
(AASHTO M –81)

		RC-70		RC-250		RC-800		RC-3000	
		Min	**Max**	**Min**	**Max**	**Min.**	**Max**	**Min**	**Max**
1.	Kinematics Viscosity at 60^0C (140^0F) centistokes	70	140	250	500	800	1600	3000	6000
2.	Flash point (tag. Open cup) degree C(F)	-	-	27(80)	-	27(80)	-	27(80)	-
3	Water percent.	-	0.2	-	0.2	-	0.2	-	0.2
4	Distillation test								
	Distillate, percentage by volume of total distillate to 360^0C (680^0F)								
	To 190^0C (374^0F)	10	-	-	-	-	-	-	-
	To 225^0C(437^0F)	50	-	35	-	15	-	-	-
	To 260^0C (500^0F)	70	-	60	-	45	-	25	-
	To 315^0C (600^0F)	85	-	80	-	75	-	70	-
5	Residue from distillation to 360^0C (680^0F) volume percentage of sample by difference.	55	-	65	-	75	-	80	-
6	Test on residue from distillation								
	Penetration, 100g, 5 sec. at 25^0C(77^0F)	80	120	80	120	80	120	80	120
	Ductility, 5 Cm/min. at 25^0C(77^0F) cm	100	-	100	-	100	-	100	-
	Solubility in Trichloroethylene percent	99	-	99	-	99	-	99	-

Note:- As an alternate saybolt-Furol Viscosities may be specified as follows:-

Grade RC-70	*Furol Viscosity at 50^0C*	*(122^0F)*	*60 to 120 Sec.*
Grade RC-250	*Furol Viscosity at 60^0C*	*(140^0F)*	*125 to 250 Sec.*
Grade RC-800	*Furol Viscosity At 82.2^0C*	*(180^0F)*	*100 to 200 Sec.*
Grade RC-3000	*Furol Viscosity At 82.2^0C*	*(180^0F)*	*300 to 600 Sec.*

TABLE-10-3.3

REQUIREMENTS FOR MEDIUM-CURING CUTBACKS
(AASHTO M –82)

		MC-30		MC-70		MC-250		MC-800		MC-3000	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1.	Kinematics Viscosity at 60^{0}C (140^{0}F)(see note 1) centistokes	30	60	70	140	250	500	800	1600	3000	6000
2.	Flash point (tag. Open cup) degree C(F)	38(100)	-	38 (100)	-	66 (150)	-	66 (150)	-	66 (150)	-
3	Water percent.	-	0.2	-	0.2	-	0.2	-	0.2	-	0.2
4	Distillation test										
	Distillate, percentage by volume of total distillate to 360^{0}C (680^{0}F)										
	To 225^{0}C (437^{0}F)	-	25	-	20	-	10	-	-	-	-
	To 260^{0}C (500^{0}F)	40	70	20	60	15	55	-	35	-	15
	To 315^{0}C (600^{0}F)	75	93	65	90	60	87	45	80	15	75
5	Residue from distillation to 360^{0}C (680^{0}F) volume percentage of sample by difference	50	-	55	-	67	-	75	-	80	-
6	Test on residue from distillation										
	Penetration, 100g, 5 sec. at 25^{0}C(77^{0}F)	120	50	120	250	120	250	120	250	120	250
	Ductility, 5 Cm/min. cm (see note 2)	100	-	100	-	100	-	100	-	100	-
	Solubility in Trichloroethylene percent	99	-	99	-	99	-	99	-	99	-

Note 1:- As an alternate say bolt-Furol Viscosities may be specified as follows:-

Grade MC-30	*Furol Viscosity at 25^{0}C*	*(77^{0}F)*	*75 to 150 Sec.*
Grade MC-70	*Furol Viscosity at 500C*	*(1220F)*	*60 to 120 Sec.*
Grade MC-250	*Furol Viscosity at 600C*	*(1400F)*	*125 to 250 Sec.*
Grade MC-800	*Furol Viscosity At 82.20C*	*(1800F)*	*100 to 200 Sec.*
Grade MC-3000	*Furol Viscosity At 82.20C*	*(1800F)*	*300 to 600 Sec*

Note 2. If penetration of residue is more than 200 and its ductility at 25^{0}C (77^{0}F) is less than 100 cm, the material will be acceptable if its ductility at 15.5^{0}C (60^{0}F) is more than 100 cm.

TABLE 10-3.4
REQUIREMENTS FOR EMULSIFIED ASPHALT

	Rapid-setting						**Medium-Setting**					
Type	**RS-1**		**RS-2**		**HFRS-2**		**MS-1**		**MS-2**		**MS-2h**	
Grade	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Tests on emulsions:												
Viscosity, Sayblot Furol at 25^{o}c, SFs	20	100	…	…	…	…	20	100	100	…	100	…
Viscosity, Sayblot Furol at 50^{o}c, SFs	…	…	75	400	75	400	…	…	…	…	…	…
Storage stability test, 24-h %[A]	…	1	…	1	…	1	…	1	…	1	…	1
Demulsibility,35ml, 0.02 N c_acl_2, %	60	…	60	…	60	…	…	…	…	…	…	…
Coating ability and water resistance	…	…	…	…	…	…	…	…	…	…	…	…
Coating dry aggregate	…		…		…		good		good		good	
Coating after spraying	…		…		…		Fair		Fair		Fair	
Coating wet aggregate	…		…		…		Fair		Fair		Fair	
Coating after spraying	…		…		…		fair		fair		fair	
Cement mixing test %	…	…	…	…	…	…	…	…	…	…	…	…
Slave test % [A]	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10
Residue by distillation, %	55	…	63	…	63	…	55	…	65	…	65	…
Oil distillate by volume of emulsion, %	…	…	…	…	…	…	…	…	…	…	…	…
Tests on residue from distillation test:												
Penetration, 25^{o}c, 100g, 5s	100	200	100	200	100	200	100	200	100	200	40	90
Ductility, 25^{o}c, 5 cm/min, cm	40	…	40	…	40	…	40	…	40	…	40	…
Solubility in trichloroethylene, %	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…
Float test, 60^{o}c, s	…	…	…	…	1200	…	…	…	…	…	…	…
	Medium-Setting						Medium-Setting					
Type	HF MS-1		HF MS-2		HFMS-2h		HFMS-2S		SS-1		SS-1h	
Grade	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Tests on emulsions:												
Viscosity, Sayblot Furol at 25^{o}c, SFs	20	100	100	…	100	…	50	…	20	100	20	100
Viscosity, Sayblot Furol at 50^{o}c, SFs	…	…	…	…	…	…	…	…	…	…	…	…
Storage stability test, 24-h % [A]	…	1	…	1	…	1	…	1	…	1	…	1
Demulsibility,35ml, 0.02 N c_acl_2, %	…	…	…	…	…	…	…	…	…	…	…	…
Coating ability and water resistance												

Coating dry aggregate	Good		Good		Good		Good		…		…	
Coating after spraying	fair		fair		fair		fair		…		…	
Coating wet aggregate	fair		fair		fair		fair		…		…	
Coating after spraying	fair		fair		fair		fair		…		…	
Cement mixing test %	…	…	…	…	…	…	…	…	…	2.0	…	2.0
Slave test % [A]	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10	…	0.10
Residue by distillation, %	55	…	65	…	65	…	65	…	57	…	57	…
Oil distillate by volume of emulsion, %	…	…	…	…	…	…	…	…	…	…	…	…
Tests on residue from distillation test:												
Penetration, 25°c, 100g, 5s	100	200	100	200	40	90	200	…	100	200	40	90
Ductility, 25°c, 5 cm/min, cm	40	…	40	…	40	…	40	…	40	…	40	…
Solubility in trichloroethylene, %	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…	97.5	…
Float test, 60°c, s	1200	…	1200	…	1200	…	1200	…	…	…	…	…

a. *This test requirement on representative samples is waived if successful application of the material has been achieved in the field.*

APPLICATION TEMPERATURES

TABLE 10-3.5

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 secs. 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	10-70	20-70
CMS-2	10-70	20-70
CMS-2h	10-70	20-70
CSS-1	10-70	20-70
CSS-1h	10-70	20-70
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	-

SECTION – 10-4
COARSE AGGREGATE FOR CEMENT CONCRETE

10-4 SECTION - COARSE AGGREGATE FOR CEMENT CONCRETE

10-4.1 DESCRIPTION

The work covered in this Section consists of supplying coarse aggregate which shall consist of gravel, crushed gravel, crushed stone, crushed air cooled blast furnace slag or crushed concrete or a combination thereof conforming to the requirements of this specification.

10-4.2 SOURCE

Coarse aggregate shall be obtained from an approved source.

10-4.3 GRADING

All coarse aggregate shall be properly graded from coarse to fine within the limits specified in the Table 10-4.1.

Table 10-4.1

GRADING OF COARSE AGGREGATES

Designated Sizes		Percentage by Weight Passing Laboratory Sieves Having Square Openings, in Inches							
(mm)	(inches)	2 ½ inch (63 mm)	2 inch (50mm)	1 ½ inch (37.5 mm)	1 inch (25.0 mm)	¾ inch (19.0 mm)	½ inch (12.5 mm)	⅜ inch (9.5 mm)	No.4 inch (4.75 mm)
12.5 to 4.75	½-in. to No. 4		-	-	-	100	90-100	40-70	0-15*
19.0 to 4.75	¾ -in. to No. 4	-	-	-	100	90-100	-	20-55	0-10*
25 to 4.75	1 -in. to No. 4	-	-	100	95-100	-	25-60	--	0-1O*
37.5 to 4.75	1½ -in. to No. 4	-	100	95-100	-	35-70	-	10-30	0-5
50 to 4.75	2 -in. toNo. 4	100	95-100	-	35-70	-	10-30	-	0-5
37.5 to 19	1 ½-in. ¾-in	-	100	90-100	20-55	0-15	-	0-5	-
50 to 25	2 -in. to 1-in.	100	90-100	35-70	0-15	-	0-5	-	-

**Not more than five (5) percent shall pass No: 8 sieve*

10-4.4 QUALITY

a. Specified Characteristics

Unless otherwise specified elsewhere the coarse aggregate shall conform to the following requirements.

i.	Percentage wear by Los Angeles Abrasion test At 500 Revolutions(AASHTO-T-96)	Not more than 40%
ii.	Soundness of Aggregate By use of Sodium sulphate(AASHTO-T-104) Max. Percentageloss on 5 cycles.	Not more than 12
	Flakiness Index (BS 812).	Not more than 35

b. Testing Procedures

i.	Sampling aggregates.	T-2
ii.	Sieve analysis.	T-27
iii.	Amount of material passing the No.200sieve.	T-11
iv.	Organic impurities.	T-21
v.	Mortar Strength.	T-71
vi.	Sodium sulphate soundness.	T-104
vii.	Friable particles.	T-112
viii.	Abrasion loss.	T-96
ix.	Specific Gravity.	T-84
x.	Absorption.	T-85
xi.	Production of Plastic Fines.	T-210
xii.	Fineness Modulus.	T-27
xiii.	Sand Equivalent.	T-17

xiv. Potential Reactivity of Carbonate Rock For Concrete Aggregate(Rock Cylinder Method)ASTM C 586

xv. Potential Alkali Reactivity of CementAggregate Combinations (Mortar-Bar Method)ASTM C 227

xvi. Potential Reactivity of Aggregates (Chemical Methods) ASTM C 289

xvii. Petrographic analysis. ASTM C 259

10-4.5 IMPURITIES

The deleterious matter in any coarse aggregate shall not exceed the following.

i.	Clay Lumps	0.25% Max
ii.	Material Passing No.200 Sieve	1.0%“
iii.	Soft fragments & shale	5.0%“

iv. Friable Particles 1.0%“

10-4.6 STOCKPILING AGGREGATE

The stockpile sites, as directed by the Engineer shall be prepared by clearing, burning of all trees, stumps, bush and debris. The floor for each stockpile shall be comparatively uniform in cross section. The completed stockpiles/stacks shall be neat and regular in form and shall be made to occupy the smallest feasible areas. The side slopes shall not be flatter than 1½ : 1 with maximum height of 6 feet (2 meters).

To avoid segregation of the various sizes in each stockpile, the aggregate shall be deposited in uniform layer or lifts. The aggregate shall be placed in each lift by trucks or other types of hauling units. Stockpiling from a conveyor belt will not be permitted. The piles shall be so located and so constructed that no intermingling of grading will occur.

10-4.7 MEASUREMENT AND PAYMENT

10-4.7.1 Measurement

Coarse aggregate shall be measured in bulk. The unit of measurement shall be one cubic meter (m^3) or 100 cubic feet (100 cft).

10-4.7.2 Payment

The unit rate shall be full compensation for furnishing coarse aggregate in well graded and clear state as per above specification at site of work, including loading, transportation, unloading, and stacking at site of work to be defined in the bid schedule.

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-4	Coarse Aggregate of Specified Gradation for Cement Concrete	Per cu m(m^3)

SECTION – 10-5

FINE AGGREGATE FOR CEMENT CONCRETE

10-5 SECTION - COARSE AGGREGATE FOR CEMENT CONCRETE

10-5.1 DESCRIPTION

The work covered under this Section consists of furnishing and placing Fine Aggregates for Portland Cement Concrete in stockpiles in accordance with these specifications at the location shown on the drawings or in the bid schedule.

10-5.2 FINE AGGREGATE

The fine aggregate shall consist of sand, stone screenings or other approved inert materials with similar characteristics, or a combination thereof, 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) % of material passing the No. 200 (75µm) sieve by washing nor more than one percent of clay lumps or one (1) % of shale. The use of beach sand is prohibited without the written consent of the Engineer.

For exposed work, the fine aggregate shall be free from any substance that will discolor the concrete surface.

At the option of the Engineer, when fine aggregate is to be used in the construction of concrete pavements for bases, the specified minimum amount passing No 50 sieve may be reduced to 5 percent and the specified minimum amount passing No 100 (200µm) sieve may be reduced to (Zero) 0 percent.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO T 11 and T 27 shall meet the following grading requirements as shown in Table 10-5.1:

TABLE 10-5.1

GRADING REQUIREMENTS OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight
Passing a 9.5 mm (3/8”) Sieve	100
Passing a 4.75 mm (No.4) Sieve	95~100
Passing a 2.38 mm (No.16) Sieve	45~85
Passing a 0.3 mm (No.50) Sieve	10~30
Passing a 0.15 mm (No.100) Sieve	2~10
Passing a 0.075 mm (No.200) Sieve	0~3

In case if fine aggregates fail under Fineness Modulus or Gradation however material passing No. 4 in combined aggregate, qualifies for these requirements, then the material can be accepted.

Fine aggregates shall be of such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO T 71, shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.3 to 3.1. Natural aggregates if required shall be thoroughly and uniformly washed before use. Sand equivalent (AASHTO T 176) shall be 75 % min.

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 Section 7-1 of these Specifications.

10-5.3 STOCKPILING OF AGGREGATES

The stockpile sites, as directed by the Engineer shall be prepared by clearing, burning of all trees, stumps, bush and debris as provided in Section 301. The floor for each stockpile shall be comparatively uniform in cross section. The complete stockpiles shall be neat and regular in form and shall be made to occupy the smallest feasible areas.

To avoid segregation of the various sizes in each stockpile, the aggregate shall be deposited in uniform layer or lifts. The aggregates shall be placed in each lift by trucks or other types of hauling units. Stockpiling from a conveyor belt will not be permitted. The piles shall be so located and so constructed that no intermingling of grading shall occur.

10-5.4 MEASUREMENT AND PAYMENT

10-5.4.1 Measurement

The quantity of aggregate of specified grades stockpiled shall be measured by volume. The unit of measurement shall be cubic meter or 100 cft.

10-5.4.2 Rate

The unit rate per unit of measurement shall be full compensation for furnishing and stockpiling all aggregates including all labour, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

10-5.4.3 Payment

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-5	Fine aggregate of specified gradation for Portland Cement Concrete	per Cu. m or Per 100 cft

SECTION – 10-6
MORTAR SAND

10-6 SECTION - MORTAR SAND

10-6.1 DESCRIPTION

The work covered under this Section consists of furnishing and placing in stockpiles mortar sand for use in cement mortar/Portland cement concrete in accordance with these specifications.

10-6.2 GENERAL REQUIREMENTS

Mortar sand shall consist of hard, strong, durable uncoated mineral or rock particles, free from injurious amounts of organic or other deleterious substances. It should not contain more than 4% silt.

10-6.3 ORGANIC IMPURITIES

Mortar sand when subjected to the calorimetric test for organic impurities and producing a color darker than the standard color shall be rejected unless the sand complies with the mortar strength test.

10-6.4 MORTAR STRENGTH

When subjected to the test for mortar making properties, the fine aggregate shall develop a compressive strength at the age of 3 days when using type III cement or at 7 days when using type I or II cement of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.40 ± 0.10. Type I, II and III cement are prescribed in the Standard Specifications for Portland Cement Section 10-1.

10-6.5 GRADING

Mortar sand shall be uniformly graded from fine to coarse as per limits given in Table 10-6.1.

TABLE NO.10-6.1

GRADING REQUIREMENTS OF MORTAR SAND

Sieve Size	Passing Percentage	
	General Purpose	Plaster
4.75 mm (No.4)	100	100
2.36 mm (No.8)	90-100	90-100
0.30 mm (No. 50)	5-70	5.40
0.15 mm (No.100)	0-15	0-10
0.075 mm (No.200)	0-5	0-10

10-6.6 METHODS OF SAMPLING AND TESTING

Sampling and testing of sand for mortar shall be in accordance with the following standard methods.

Sampling	AASHTO T 2
Organic Impurities	AASHTO T 21
Mortar Marking Properties	AASHTO T 71
Sieve Analysis	AASHTO T 27
Material Passing No.200 Sieve	AASHTO T 11
Sand Equivalent	AASHTO T 176
Reactive Aggregates	AASHTO M-6

10-6.7 STOCKPILING

The stockpile sites, as directed by the Engineer shall be prepared by cleaning, burning of all tress stumps, brush and debris as provided in Section 301. The floor for each stockpile shall be comparatively uniform in cross section. The completed stockpiles shall be neat and regular in form and shall be made to occupy the smallest feasible areas.

To avoid segregation of the various sizes in each stockpile, the aggregate shall be deposited in uniform layer or lifts. The aggregate shall be placed in each lift by trucks or other types of hauling units. Stockpiling from a conveyor belt will not be permitted. The piles shall be so located and so constructed that no intermingling of grading will occur.

10-6.8 MEASUREMENT AND PAYMENT

10-6.8.1 Measurement

Mortar sand shall be measured by volume. The unit of measurement shall be one cubic meter (m^3)/100 cubic feet.

10-6.8.2 Rate

The unit rate shall be full compensation for furnishing mortar sand in a clean state as per specification mentioned above including its loading, transportation to site of work, unloading for storage etc. complete.

10-6.8.3 Payment

Pay Item No.	Description	Unit of Measurement
10-6	Mortar Sand	per cubic meter (m^3) or 100 cft.

SECTION – 10-7
MINERAL FILLER

10-7 SECTION - MINERAL FILLER

10-7.1 COMPOSITION

Mineral filler shall consist of finely divided mineral matter such as hydrated lime, rock dust, slog dust hydraulic cement, or any other suitable mineral matter from approved sources. The mineral filler shall be thoroughly dry and free from lumps consisting of aggregations of fine particles. Ground phosphate will not be allowed as mineral filler and ful fill requirements of as per ASTM D242 AASHTO M17.

10-7.2 GRADATION

The mineral filler shall meet the gradation requirements given in Table given below

U.S. Sieve Size	Percent Passing
No.30 (600 mm)	100
No. 80 (180 mm)	95-100
No. 200 (75 mm)	70-100

10-7.3 PLASTICITY INDEX

The mineral filler shall have a Plasticity Index not greater than 4 as per ASTM D242 and.

10-7.4 MEASUREMENT

Mineral filler shall be measured by volume the unit of measurement shall be one cubic meter (m^3).

10-7.5 RATE

The unit rate shall be full compensation for furnishing mineral filler as per specifications mentioned above, including its loading transportation to site of work, unloading to storage etc, complete.

10-7.6 PAYMENT

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-7	Mineral Filler	per Cu. m (m^3)

SECTION – 10-8
CLAY BRICKS

10-8 SECTION - CLAY BRICKS

10-8.1 DESCRIPTION

The work under this section consists of supplying and stacking at construction site first class bricks according to the following specifications. The bricks to be used as brick soling either in sub-base course or street pavements shall be slightly over burnt but not defaced.

10-8.2 SOURCE

The bricks or tiles shall be supplied from the approved brick kiln.

10-8.3 CLAY/EARTH FOR BRICKS OR TILES

Clay/Earth shall be obtained from good earth containing 20-30% fine sand.

Clay/Earth shall not contain more than 0.5% soluble salts, more than 0.2% sulphate, and more than 4% organic contents. It shall not contain any gravel, coarse sand, kankar, roots of grass and plants.

10-8.4 PREPARATION

10-8.4.1 Mixing

Clay before use shall be dug up and left to weather for a weak. It shall be thoroughly natured, turned over for at least 48 hours and tempered until free from lumps and it is stiff. Any stone found shall be picked at the tempering shall be done in a pug mill or by treading. When ready for moulding, the clay shall be of such consistency (plasticity index of 7-10% for so as to hand moulding, which gives a homogeneous brick or tile.

10-8.4.2 Frogging

Each brick shall have a frog 6 mm (1/4”) deep on the upper face and, trademarks in it as approved by the Engineer. There shall be no frog in the clay tile.

10-8.4.3 Moulding

Hand or machine moulding shall be carried out in suitable iron moulds having a size, which shall give the required size of the brick or tile after burning. All bricks or tiles shall be sand moulded.

10-8.5 TEST REQUIREMENTS

The nominal size of the bricks shall be as specified. The standard nominal size is 228 mm x 114 mm x 76 mm (9” x 4½” x 3”). They shall be well burnt without being vitrified. They shall be of uniform color, 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 with each other. They shall be free from flaws and cracks. They shall not absorb more than 1/6 the of their weight of water after being soaked for 24 hours, in accordance with BS 1257 and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 140 kg/cm^2 (2000 lbs. Per square inch).

Tiles shall conform to above requirements in quality. The size of tiles shall be

i. 300 mm x 150 mm x 50 mm (12" x 6" x 2")

ii. 300 mm x 150 mm x 31 mm (12" x 6" x 1¼")

iii. 225 mm x 113 mm x 39 mm (9" x 4½" x 1½")

iv. 225 mm x 113 mm x 50 mm (9" x 4½" x 2") or as specially specified.

10-8.6 MANUFACTURERS DATA

Submit two copies of manufacturer's specification and other data for each type of brick and accessory required instruction shall be included for handling, storage, installation and protection of units and accessories.

10-8.7 SAMPLING

The bricks or tiles required for carrying out the tests laid down in these specifications shall be taken by one of the methods given below:

10-8.7.1 Sampling Bricks or Tiles in Motion

Samples in this way shall be taken when the bricks or tiles are being loaded or unloaded. Samples shall be taken at random from each of a number of convenient portions of the consignment or batch.

10-8.7.2 Sampling Bricks or Tiles from a Stack

Samples shall be taken at random from a stack. The number of bricks required for the tests shall be taken from across the top of the stack, the sides accessible and from the interior of the stack by opening the trench from the top. Whichever method is employed a sample of 50 bricks or tiles shall be taken at random from every consignment of 50,000 bricks/tiles or part thereof.

The samples thus taken shall be stored in a dry place not in contact with the ground until the tests are made.

The bricks for tests shall be taken at random from the sample.

10-8.8 MEASUREMENT AND PAYMENT

10-8.8.1 Measurement

Measurement of bricks or tiles shall be in numbers. The unit of measurement shall be one thousand. If more than 10% bricks in the stacks do not conform to the specification, the whole consignment will be rejected but if it is less than 10% the batch may be accepted but below specification bricks rejected.

10-8.8.2 Rate

The unit rate shall be full compensation for supply of bricks/tiles including loading, transportation to site of work, unloading and stacking including all incidentals etc. complete.

10-8.8.3 Payment

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-8	Filler Supply of Bricks of approved quality & Size	Per 1000 Nos.
10-8	Supply of Tiles of approved quality & Size	Per 1000 Nos

SECTION – 10-9
STONE FOR MASONRY

10-9 SECTION - STONE FOR MASONRY

10-9.1 DESCRIPTION

The work covered under this Section consists of supplying and stacking stone for stone masonry from an approved source. This shall be quarried according to an approved method.

10-9.2 SOURCE

Stone shall be obtained from nearest approved quarry. If the same quarry has stone of varying nature in different section sections, then stone from the approved section only shall be quarried and supplied.

10-9.3 QUALITY

Stone shall be hard, tough, compact, durable, having uniform colour and free from faults and cleavage. It shall be of a kind that previous use has been proven to be satisfactory for the specified purpose.

Stone for Ashlars masonry shall be free of seams, laminations, and minerals, which, by weathering would cause discoloration or deterioration.

10-9.4 SIZE AND SHAPE

Each stone shall be free from depressions and projections that might weaken it or prevent it from being properly bedded, and shall be of such shape as will meet both architecturally and structurally the requirements for the class of masonry specified.

In general stones shall have thickness of not less than 125 mm (5”) width of not less than 1½” times their respective thickness, with minimum width of 300 mm (12”), and lengths of not less than 1½” time their respective widths. Where headers are required their lengths shall be not less than the width of the widest adjacent stretches plus 300 mm (12 inches).

At least 50 percent of the total volume of the masonry shall be of stone having a volume of at least 0.03 Cu.m.

10-9.5 DRESSING AND CUTTING

The stone shall be dressed to remove any thin or weak portions. All visible edges shall be free from chipping. Face Stones shall be dressed to provide bed and joint lines with a maximum variation from true lines as follows:

1. Random Rubble Masonry 38 mm (1½”)
2. Course Rubble Masonry 6 mm (1/4”)
3. Ashlars Masonry 1.5 mm (1/16”)

10-9.6 BED SURFACES

Bed Surfaces of face stones shall be normal to the faces of the stone for about 75 mm (3”) and this point may depart from normal not be exceed 25 mm (1") in 300 mm (12 inches) for ashlar masonry and 50 mm (2") in 300 mm (12'), for all other classes.

10-9.7 JOINT SURFACES

In all classes except ashlar masonry, the joint surfaces for face stones shall form an angle with the bed surface of not less than 45 degrees.

In ashlar masonry, the joint surface shall be normal to the bed surfaces. They shall also be normal to the exposed faces of the stone for at least 50 mm (2"), from which point they may depart from normal not be exceed 25 mm (1") in 300 mm (12").

The corners at the meeting of the bed and joint lines shall not be rounded in excess of 38 mm (1½") in case of Random Rubble Masonry. Course Rubble Masonry & Ashlar Masonry shall have no rounding.

10-9.8 BEDDING

Rubble stone shall be evenly bedded and shall be quarried in as large blocks as will permit of being handled.

10-9.9 STACKING

Stacking shall be done on even ground and closely packed. The length and breadth shall be in multiples of 10.

10-9.10 MEASUREMENT AND PAYMENT

10-9.10.1 Measurement

Stone shall be measured by volume; the unit of measurement shall be one hundred cubic meter or one hundred cubic feet.

10-9.10.2 Rate

The unit rate shall be full compensation for furnished stone for a particular class of masonry conforming to the stone specifications and stacking at site of work including quarrying, dressing, loading, transportation and unloading etc. complete in all respects.

10-9.10.3 Payment

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-9	Stone for Random Rubble Masonry	Per cu. meter or per 100 Cu.ft.
10-9	Stone for Course Rubble Masonry	Per cu. meter or per 100 Cu.ft.
10-9	Stone for Ashlar Masonry	Per cu. meter or per 100 Cu.ft.

SECTION – 10-10
WATER

10-10 SECTION - WATER

10-10.1 DESCRIPTION

This work shall consist of furnishing and applying to any of the civil engineering work concerned with highway construction of Highway maintenance project in accordance with these specifications.

10-10.2 SOURCE

Water shall be obtained from an approved source.

10-10.3 QUALITY

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall contain no more than one thousand (1.000) parts per million of chlorides nor more than one thousand three hundreds (1,300) parts per million of sulfates (SO4). In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of neither more than twenty five (25) percent nor 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.

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 discoloration 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.

10-10.4 STORAGE

Water shall be stored in water tight tanks or containers so as to be adequately protected from the admixture of dust and other foreign matter.

10-10.5 MEASUREMENT AND PAYMENT

10-10.5.1 Measurement

Water shall be measured in bulk. The unit of measurement shall be 1000 liters.

10-10.5.2 Rate

The unit rate shall be full compensation for supplying and application of water and its transportation and storage etc. complete including all incidentals.

10-10.5.3 Payment

Payment shall be made under:-

Pay Item No.	Description	Unit of Measurement
10-10	Water	per 1000 liters

SECTION – 10-11

ADMIXTURES FOR CONCRETE

10-11 SECTION - ADMIXTURES FOR CONCRETE

10-11.1 DESCRIPTION

This Section covers specification for materials proposed to be used as air-entraining and chemical admixtures to be added to concrete mixtures in the field.

10-11.2 DEFINITION

10-11.2.1 Air Entraining Admixtures

For the purpose of these specifications an air-entraining admixture is defined as a material that is used as an ingredient of concrete, added to the batch immediately before or during its mixing, for the purpose of entraining air.

10-11.2.2 Chemical Admixture

Type. A Water reducing admixture

An admixture that reduces the quantity of mixing water required producing concrete of a given consistency.

Type. B Retarding admixture

An admixture that retards the setting time of concrete.

Type. C Accelerating admixture

An admixture that accelerates the setting time and early strength development of concrete.

Type. D Water reducing and retarding admixture

An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.

Type. E Water reducing and accelerating admixture

An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.

Type. F Water reducing admixture high range

An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater.

Type. G Water reducing high range and retarding admixture

An admixture that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater and retards the setting of concrete.

10-11.3 PHYSICAL REQUIREMENTS FOR AIR ENTRAINING ADMIXTURES& CHEMICAL ADMIXTURES

The air-entraining admixture shall conform the physical requirements as per AASHTO M154 (ASTM C260) as shown in Table 10-11.1.

The chemical admixtures shall conform the physical requirements as per AASHTO M194 (ASTM C494) as shown in Table 10-11.2.

10-11.4 PACKAGING AND MARKING

When the admixtures is delivered in packages or containers, the proprietary name of the admixture, the type under this specification and the net weight or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advices accompanying packaged or bulk shipments of admixtures.

10-11.5 STORAGE

The admixture shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment and in a suitable weather tight building that will protect the admixture from dampness and freezing.

10-11.6 SAMPLING AND INSPECTION

Every facility shall be provided the purchaser for careful sampling and inspection, either at the point of manufacture or at the site of the work, as may be specified by the purchaser.

10-11.7 REJECTION

i. The admixture shall be rejected if the purchaser desires when it fails to meet any of the applicable requirements of this specification.

ii. After completion of tests, an admixture stored at the point of manufacture for more than 6 months prior to shipment or an admixture in local storage in the hands of a seller for more than 6 months, shall be retested before use when requested by the purchaser. It shall be rejected, if the purchaser desires, when it fails to meet any of the applicable requiremnets of this specification.

iii. Packages or containers varying more than 5% from the specified weight or volume shall be rejected if the purchaser desires. If the average weight or volume of 50 packages or containers taken at random is less than that specified, the entire shipment shall be rejected if the purchaser desires.

10-11.8 METHOD OF TESTING

10-11.8.1 Air Entraining Admixtures

The properties enumerated in Table 10-11.1 shall be determined in accordance with the Standard Method of Testing Air Entraining Admixtures for Concrete (AASHTO Designation T 157 or ASTM C233). It is recommended that, whenever practicable, tests be made in accordance with Section 2(d) of Methods T 157 using the cement proposed for specific work.

10-11.8.2 Chemical Admixtures

The stated properties of chemical admixtures in Table 10-11.2 shall be determined in accordance with the standard test Methods outlined under AASHTO Designation M 194-82" Standard Specification for Chemical Admixture for concrete. (ASTM C494)

10-11.9 MEASUREMENT

10-11.9.1 Measurement

Measurement for Admixture for Concrete shall be by weight. The unit of measurement shall be kilogram.

10-11.9.2 Rate

The unit rate shall be full compensation for furnishing and supplying of concrete admixture according to the specifications at site of work or at store specified by the Engineer.

10-11.9.3 Payment

Payment shall be made as under:-

Pay Item No.	Description	Unit of Measurement
10-11	Air Entraining Admixture for Concrete	Per Kg
10-11	Chemical Admixture for Concrete	Per Kg

TABLE 10-11.1

PHYSICAL REQUIREMENTS OF AIR-ENTRAINING ADMIXTURES FOR CONCRETE AASHTO M154)

Time of setting, allowable deviation from control, h:min	
Initial: no more than	1:15 earlier Nor 1:15 later
Final: not more than	1:15 earlier Nor 1:15 later
Compressive strength, min, % of control:	
1 day	90
3 day	90
7 day	90
28 day	90
Flexural strength, min, % of control	

3 day	90
7 day	90
28 day	90
Length change, Max shrinkage (alternative requirements)	
Percent of control	120
Increase over control	0.006
Relative durability factor, min	80
Bleeding of the net amount of mixing water, max percent over control	2

TABLE 10-11

PHYSICAL REQUIREMENTS FOR CHEMICAL ADMIXTURES FOR CONCRETE (AASHTO M-194)

	Type A Water Reducing	Type B Retarding	Type C Accelerating	Type D Water Reducing & Retarding	Type E Water Reducing & Accelerating	Type F Water Reducing High Range	Type G Water Reducing High Range & Retarding
Water Contents Max % of Control Time of Setting.	95	-	-	95	95	88	88
Initial: at Least	-	1:00 LATER	1:00 EARLIER	1:00 LATER	1:00 EARLIER	-	1:00 LATER
Not More Than	1:00 EARLIER NOR 1:30 LATER	3:30 LATER	3:30 EARLIER	3:30 LATER	3:30 EARLIER	1:00 EARLIER NOR 1:30 LATER	3;30 LATER
Final; at Least	-	-	1:00 EARLIER	-	1:00 EARLIER	-	-
Not More Than	1:00 EARLIER NOR 1:30 LATER	3:30 LATER	-	3:30 LATER	-	1:00 EARLIER NOR 1; 30 LATER	3:30 LATER
Compressive Strength Min % Control A							
1 Day	-	-	-	-	-	140	125
3 Days	110	90	125	110	125	125	125
7 Days	110	90	100	110	110	115	115
28 Days	110	90	100	110	110	110	110
6 Months	100	90	90	100	100	100	100
1 Year	100	90	90	100	100	100	100
Flexural Strength Min % Control B							
3 Days	100	90	110	100	110	110	110
7 Days	100	90	100	100	100	100	100
28 Days	100	90	90	100	100	100	100
Length change Max. Shrinkage (Alternative Requirements) C							
Percent of Control	135	135	135	135	135	135	135
Increase Over Control	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative Durability Factor, Min D	80	80	80	80	80	80	80

The values in the table include allowance for normal variation in test results. The object of the 90% compressive strength requirement for a Type-B admixture is to require a level of performance comparable to that of the reference concrete.

ANNEX-I

RECOMMENDED MAJOR CONSTRUCTION EQUIPMENT

DESCRIPTION	CONSTRUCTION MACHINERY FOR		
	MAJOR PROJECTS	REHABLITATION/MEDIUM SIZE PROJECTS	MAINTENANCE PROJECTS
Bituminous Surface Treatment	1. Power Broom/Air Compressor. 2. Aggregate Spreader. 3. Engine Operated Bitumen pressure distributor (Auto type) 4. Dump Truck (10T) 5. Rubber Mounted Tandem Roller or P.T.R (9 Wheeled 18 T)	1. Aggregate Spreader (3-4 m wide). 2. Bitumen Distributor Auto or Tow Type 3. Dump Truck (10 T) 4. Static tandem roller (8-10T)	1. Tractor/trolley (50H.P) 2. Bitumen Sprayer (Manual) Static tandem roller (18 T)
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)	---	---
Concrete	1. Concrete Batching Plant (30 C.M/H) 2. Front End loader (2-3 Cm) 3. Concrete Transit mixer (6 CM) 4. Crane (20-45 T) 5. Vibrator (40 mm-50mm) 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 (1/2-1 Cm) 2. Tractor/trolley (50H.p) 3. Vibrator 4. Wheel Borrows.
Prestressed Concrete Structures	1. Pre-stressing Equipment Plus all equipment contained in item no.401. 2. Heavy duty Crane or Beam launching Truss.	---	---
Piling	Piling Equipment plus all those equipment mentioned in item No.401 for major projects.	---	---
Pavement Marking	Road Marking Machine	Manual	Manual
Recycling of Road Pavement Structure/	---	1. Cold Mix Recycler	---

Soil Stabilization		2. Grader (140 HP) 3. Water Tanker Tow Type 4. Vib. Combination roller	
Asphaltic base Course / Wearing Course Plant Mix	1. Power Broom / Air Compressor. 2. Front End Loader (2-3 cm) 3. Asphaltic Plant (80-120 T) 4. Paver (4 M wide) 5. Dumper (10-18 T) 6. P.T.R (9 Wheeler 21.T) 7. Tandem vibratory roller (10-12T)	1. Front End Loader (1.50-2.50 CM) 2. Asphaltic Plant (20-40 T) 3. Dumper (10T) 4. Paver(4M wide) 5. P.T.R (9 Wheeled) 18-T 6. Tandem Vibratory roller. (8-10T).	1. Bitumen Aggregate mixer (1 CM) 2. Wheel Barrow (0.5 CM) 3. Tandem Vibratory Roller (8-10T) 4. Tractor / Trolley (50 H.p)
Re-Cycling of Asphalt Concrete	---	1. Recycling Machine 2. Bitumen Bowser plus all equipment for Asphaltic Concrete under Item 305.	----
Shoulder Treatment	1. Grader (140 H.P) 2. Dumpers (10 T) 3. Water Tanker (tow type) 4. Combination Roller (10-12 T)	1. Heavy Duty Tractor /Trolley with Blade. 2. Water Tanker (Two Type). 3. Static Roller (10-12 T)	1. Tractor / trolley With blade (50H.P) 2. Water Tanker (Tow Type) 3. Static Roller (8-10 T).
Cold Milling	---	1. Cold Milling Machine (1M wide) 2. Dumpers (10T) 3. Water Tanker Tow Type	1. Cold Milling Machine (1M wide) 2. Dumpers (10T) Water Tanker Tow Type
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)	Manual Operated Bitumen Pressure Distributor (Tow-type)
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 (50-80 HP) 2. Water Tanker (Tow Type) 3. Static Roller (10-12T)
Granular Sub-Base	1. Power Broom / Air Compressor 2. Grader with Scarifier (140 H.P)	1. Heavy Duty Tractor with Blade. 2. Water Tanker (tow Type)	1. Tractor Trolley with Blade (50H.p).

	3. Water Bowser. 4. Combination Roller (10-12 T)	3. Static Roller (10-12 T)	2. Water Tanker (tow Type) 3. Static Roller (10-12T)
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 (140H.P) with Articulated Blade. 2. Water Tanker (Tow Type) 3. Combination Roller (10-12T)	1. Heavy Duty Tractor /Trolley with Blade (80HP). 2. Water Tanker (Tow Type) 3. Static Roller (10-12T)
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.	---
Bitumen Stabilized I. Sub-Base. Bitumen stabilized II. Base. a) Cold Mix b) Hot Mix	1. Grader with Scarifier (140HP) 2. Asphalt Distributor 3. Combination roller (10-12T). 1. Grader with Scarifier (140-165Hp) 2. Bitumen Distributer (Auto/Tow Type) 3. Tandem Static roller (10-12T) Equipment mentioned as per item 203	1. Heavy Duty tractor with blade 2. Combination Roller (10-12T) Same Equipment as for major projects. Equipment mentioned as per item 203.	---
Clearing and Grubbing	1. Bulldozer (160HP) or Grader (140HP) 2. Dumper (10T)	---	---
Removal of Trees	1. Excavator (0.3 Cm)	---	---

Stripping	1. Grader (140 HP)	---	---
Compaction of Natural Ground	1. Static Tandem Roller (8-12T) 2. Water Tanker (tow type)	---	---
Road Way Excavation	1. Bull Dozer (160-200 HP) 2. Front end Loader (2-3 CM) 3. Dump Truck(10-18T)	1. Bill Dozer (160HP) 2. Tractor/ Trolley (50 HP)	---
Structural Excavation and backfill	1. Excavator (0.3 cm) 2. Plate Compactor	Plate compactor	Plate compactor
Formation of embankment	1. Grader (140-165 Hp) 2. Combination /Sheep foot of 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 (80HP) 2. Static roller (8-12T) 3. Water Tanker (Tow Type)
Sub Grade Preparation	1. Grader (140-165 HP) with Scarifier. 2. Water Tanker (two type) 3. Combination Roller (10-12T)	---	---
Bitumen Stabilized sub Grade	1. Grader (140-165 HP) with Scarifier. 2. Asphalt Distributor 3. Tandem Roller (10-12T)	---	---