TECHNICAL SPECIFICATIONS OF SIGNAL AND JUNCTION IMPROVEMENT (SIALKOT) (12 NOS CHOWK)

1 GENERAL

1.1.1 DESCRIPTION

Earthwork will consist of all necessary work for the excavation and placing in embankment or backfill or disposal by dumping of soil 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 laybyes, the widening of cuts and the flattening of rut 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.

1.1.2 SOIL INFORMATION

Any information concerning the properties of the soil or sub soil and other geotechnical information shown on the Drawings or other documents forming part of the Contract is for information only. The Contractor is obliged to make his own assessment of site conditions prevailing. No claim for extra cost or time extension will be entertained based on the information provided.
The Contractor shall be deemed to have visited the site prior to making his bid and shall ascertain the nature of the soil its quantity, locations and suitability to meet the specified requirements, 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.

1.1.3 REMOVAL OF EXISTING OBSTRUCTIONS

The pay items under Items 4/20, 4/19-c, 4/13 and 4/8-a shall include the cost of removal of all material regardless of its nature, encountered within the limits of the approved cross-section, including the removal and disposal, as required by the Engineer, of existing brick, stone, concrete or masonry, rock boulders or fragments, old pavements, culverts, bridges, walls, buildings and roads or parts thereof, retaining walls or any other material encountered during the excavation, unless a separate item appears in the Bill of Quantities for such features.

1.1.5 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 shall be included in the bid prices for earthwork. The Contractor shall provide necessary facilities for dewatering

and for draining or diverting watercourses when necessary for the protection of the Contract work or where required by the Engineer.

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

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

1.1.6 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 stated on the embankment, subgrade or pavement. He shall clean and trim all such drainage ditches from time to time, so that there may be a free flow of water throughout the whole period of the Contract. Ditches shall first be trimmed according to approved cross-sections and final trimming, including the repair of any damage that may have been done during the construction work, shall be carried out after the completion of the other construction work and shall be a condition for final approval and acceptance.

Unless otherwise specified no separate payment will be made for the excavation of side ditches, interception ditches, inlet and outlet ditches but such payment will be made under Item Ch.3 Item 2 which is applicable.

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

1.1.7 SURVEY AND LEVELING PRIOR TO COMMENCEMENT OF EARTHWORK

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

longitudinal profile shall be in the form and manner as instructed in writing by the Engineer.

1.1.8 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 100.9 above. However if the levels so taken differ appreciably from design levels the mater shall be referred to the Employer.

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 subbase materials 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 and earthwork to be paid for in Items Ch.3 Item 2 shall be the number of cubic meters of material measured by the average end-area method, except where the error may exceed plus or minus five ($\pm$5) % 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.

1.1.2 LEAD CHART

All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and as approved by Engineer-in-Charge along with reasons in writing. Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.25 km or more shall be taken as 0.50 km and distance of less than 0.25 km shall be ignored. Carriage by mechanical transport shall be reckoned in one km unit. Distances of 0.5 km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 30 metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km by mechanical.

1.1.5 MEASUREMENT AND PAYMENT

The rates are applicable to carriage of materials in plain areas on Pacca road only. For Kacha roads an allowance of 20% extra shall be allowed for 2nd and subsequent distance covered in Km. Rates. Rate upto 1st km. is however common to both Kacha and Pacca roads. For Hilly areas 25% above the rates in plain areas shall be allowed for total distance covered in Kms. Similarly, for desert road 15% above the rates in plain areas shall be allowed for total distance

covered in Kms and 25% above the rates in Hard Area. The rates for carriage by boat or streamer shall be the same as by any other mechanical means on land.

The Measurement and payment for the carriage of materials including loading unloading and stacking shall be made corresponding to CSR items as provided in Contract Agreement and shall constitute full compensation for performance and completion of work in all respects as specified and approved by the Engineer-in-Charge. No additional payment shall be made to Contractor for charges like demurrage, wharf age, toll tax, zila tax etc. the shortest route from Sargodha to Sahiwal ia about to 230 Km therefore the route chart will be below.

Nos	**Length (Km)**
1	1st Km
2	2nd Km
3	3rd Km
4	4th Km
5	5th Km
6	6th Km
7	7th Km
8	8th Km
9	9th Km
10	10th Km
11	11th Km to 200 Km
12	201 Km to 250 Km

1.3 MEASUREMENT AND PAYMENT

1.3.1 Measurement

The quantity of shall be measured in 100 Cft. This item is applicable for all gravel which are used in sub base, aggregate base course and gravel used in all type of concrete works. Only gravel from hilly area to crush plant/stock pile. From stock pile to site the distance will be covered in contractors bid rate.

1.3.2 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 concrete cover of manhole as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
	Carriage of 100 Cft. (2.83 cu.m) of all materials like stone 16.1aggregate, spawl, kankar lime (unslaked), surkhi, etc. or 150 Cft. (4.25 cu.m) of timber, by truck or by any other means owned by the contractor.	100 Cft

Chap-NSI **Recovery against dismantled material which may be good condition after dismantling the existing structures.**

19.1 **DESCRIPTION**

This work shall consist of existing all type brick masonry and RCC structure works, which are will be dismantled stated in the related items the above two types (brick masonry and RCC) there sufficient nos of bricks should be in good condition and steel also will be separated from concrete which will be sold out in market or through auction. Therefore the recovery we have proposed of the above stated items.

19.3 **MEASUREMENT AND PAYMENT**

19.3.1 **Measurement**

The quantity of shall be measured in cubic meter of brick work and in tonnes of steel.

19.3.2 **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 concrete cover of manhole as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
	Recovery against Existing Brick Work	No
	Recovery against Existing Steel	Tonne

Ch.3/2 EARTHWORK EXCAVATION IN ASHES, SAND AND SOFT SOIL OR SILT CLEARANCE, UNDRESSED LEAD UPTO 50 FT (15 METRE) WITH TRANSPORTATION.

2.1.1 DESCRIPTION

The work shall consist of excavating the roadway removal and satisfactory disposal of all materials taken from within the limits of the work (upto 50ftor 15 meter) only, also such excavation as is necessary for inlet and outlet ditches of structures and shall include all excavation after stripping of top soil (if required), shaping and sloping for the construction, preparation of all embankment, subgrade, shoulders, intersections and approaches as directed and in conformity to the alignment, grade, level and cross-sections shown on the plans or established by the Engineer. It shall include only material suitable for fill, backfill or in the embankment. All unsuitable or surplus material is provided for in Item Ch.3/2. Excavation for structures is covered under Item Ch. 3/10 (i). Excavation for diverting/widening watercourses is included.

Common Excavation

Common excavation shall consist of the removal and satisfactory disposal of all eolian, 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) cu m volume shall also be classified as "Common Excavation". Eolian and alluvial materials consist of gravel, shale, volcanic ash, loess, dunes and, loams, silts, sands and clays or any combination of these materials and termed as Common Excavation.

2.1.2 CONSTRUCTION REQUIREMENTS

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

The material shall be declared unsuitable if the soaked CBR (96 hours) is less than five (5) % or if falls under A-6 or A-7 of AASHTO soil classification.

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

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

2.1.3 MEASUREMENT AND PAYMENT

2.1.4 Measurement

The unit of measurement for common excavation shall be in Cft and be computed by average end area method based on cross-sections duly approved by the Engineer prior to commencement and completion of required excavation. The excavated material approved for fill under any item of the Bill of Quantities shall be used in the manner as described under the relevant item of work, irrespective of haulage distance.

2.1.5 Payment

Pay Item No.	Description	Unit of Measurement
Ch.3/2	Earthwork Excavation in Ashes, Sand and Soft Soil or Silt Clearance, Undressed Lead upto 50 ft (15 metre).	1000 Cft

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Ch.3/10 (i) EARTHWORK EXCAVATION IN IRRIGATION CHANNELS, DRAINS, ETC. TO DESIGNED SECTION, GRADES AND PROFILES, EXCAVATED MATERIAL DISPOSED OFF AND DRESSED WITHIN 50 FT. (15 M) LEAD: - I) ORDINARY SOIL WITH TRANSPORTATION

4.1.1 DESCRIPTION

Structural excavation shall include the removal of all material of whatever nature, necessary for the construction of foundations of all structures not otherwise provided for in these Specifications and in accordance with the plans or as directed by the Engineer. It shall include the furnishing of all Necessary equipment and construction of all cribs, cofferdams, caissons, dewatering, sheeting, shoring etc., which may be necessary for the execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposing of excavated material, which is not required for backfill, in a manner and in locations so as not to affect the carrying capacity of any channel and not to be unsightly. Only excavation below original ground and filling with granular fill shall be paid under this item. Common filling and backfilling shall be paid under Item Ch.3/10 (i) for all common filling and backfilling above the level of the original ground line.

4.1.2 MATERIAL REQUIREMENTS FOR BACKFILL

4.1.3 Backfill around structure

Backfill around structure shall be made with the following material:

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

4.1.4 Common backfill

Use of excavated material as backfill may be allowed under this item. Use of borrow material for common backfill shall be allowed on condition that the material requirements in Item Ch.3/2 are followed and subject to approval of borrow material by the Engineer.

4.1.5 CONSTRUCTION REQUIREMENTS

4.1.6 Structural excavation

a) General

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

In case the Contractor has excavated additional volumes than specified thereunder, the Contractor shall at his own expense backfill the volume with approved material as directed by the Engineer.

b) Preservation of channel

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

c) Depth of Footings

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

d) Preparation of Foundations of Footings

i) Foundation material on which structure is to be placed shall be compacted to 95% modified AASHTO T 180, unless otherwise directed by the Engineer. In case unsuitable material is encountered at foundation level, it shall be removed

to the depth and extent as directed and replaced with suitable material of the type as determined by the Engineer.

e) Cofferdams and Cribs

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

ii) Cofferdams and cribs for foundation construction shall be carried to adequate depths and heights, be safely designed and constructed and be made as water tight as is necessary for the proper performance of the work which must be done inside them. In general, the interior dimensions of cofferdams and cribs shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors and to permit pumping outside the forms. Cofferdams or cribs, which are tilted or moved laterally during the process of sinking, shall be righted, reset, or enlarged so as to provide the necessary clearance and this shall be solely at the expense of the Contractor.

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

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

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

f) Pumping

i) Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping of water will be permitted during the placing of concrete or for a period of at least twenty-four (24) hours

thereafter, unless it is done from a suitable sump pit separated from the concrete work by a watertight wall or other effective means.

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

g) Inspection

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

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

4.1.7 Backfill

Common backfill shall consist of earth free from large lumps, wood and other organic materials and of a quality acceptable to the Engineer. It shall be placed in the position and to the required depths shown on the Drawings and/or as required in writing by the Engineer and it shall be well compacted in layers not to exceed twenty (20) cm in depth to the density, ninety-five (95) % of maximum dry density, as per AASHTO T 180.

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

The fill behind abutments and wing walls of all bridge structures shall be deposited in well-compacted, horizontal layers not to exceed twenty (20) cm in thickness. The common backfill in front of such units shall be placed first to prevent the possibility of forward movement. Special precautions shall be taken to prevent any wedging action against the masonry and the slope bounding the excavation for abutments and wingwalls shall be destroyed by stepping or roughening to prevent wedge action. Jetting of the fill behind abutments and wingwalls will not be permitted.

No backfill shall be placed against any concrete or masonry structure until permission has been given by the Engineer and preferably not until the concrete or masonry structure has been in place fourteen (14) days, or until test cylinders show the strength to be eighty (80) % of the twenty-eight (28) days' cylinder strength of concrete as per Table 401-1. The backfilling shall be carried out on both sides of the structure simultaneously. All buried concrete surfaces shall be bitumen coated, cost of which shall be included in backfilling.

Any temporary backfill or platform constructed by the Contractor for speed up purposes or for any other work item shall be subsequently removed by the Contractor without any payment as directed by the Engineer.

4.1.8 MEASUREMENT AND PAYMENT

4.1.9 Measurement

a) Structural Excavation

The quantities of structural excavation to be paid for shall be the number of cubic meters of material measured in its original position below top soil computed by the average end-area method and excavated to the satisfaction of the Engineer.

Structural Excavation will be considered for measurement and payment after satisfaction of the Engineer as "earthwork excavation in irrigation channels, drains, etc. to designed section, grades and profiles, excavated material disposed off and dressed within 50 ft. (15 m) lead: - i) ordinary soil",

The volume of earth to be measured for structural excavation shall consist of a prismoid bounded by the following planes:

i) The vertical limits for computing pay quantities will be vertical planes thirty (30) cm outside of the neat lines of footings or foundations as shown on the Drawings or as directed by the Engineer. Neat lines of footings or foundations shall mean the outer faces of footings or foundations excluding lean concrete.

ii) The upper limit for payment of structural excavation shall be the ground surface, as it existed prior to the start of construction operations, except where structural excavation is performed within roadway excavation or ditch excavation areas; the upper limit shall be the planes of the bottom and side slopes of said excavated areas.

iii) The lower limits for computing pay quantities of structural excavation or structure backfill shall be a plane at the bottom of the completed footings, foundations, structures or lean concrete.

Measurement for structural excavation shall not include material removed below the footing grade and beyond specific limits to compensate for anticipated swell or as a result of effective swell during pile driving, or additional material resulting from slides, slips, cave-ins, silting or fillings, whether due to the action of the elements or to carelessness of the Contractor. The depths of the footings shown on the Drawings are approximate only and any variation found to be necessary during construction shall be paid for at the contract unit price.

No separate payment shall be made for compaction of excavated foundation under structures.

Measurement

The quantities of ch.3/10 (i) Earthwork excavation in irrigation channels, drains, etc. to designed section, grades and profiles, excavated material disposed off and dressed within 50 ft. (15 m) lead: - i) ordinary soil" is to be paid for shall be the number of Cft of material laid and compacted, placed within the lines of structure and limits defined above and accepted by the Engineer.

4.1.10 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 all the costs involved in the proper completion of the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch.3/10 (i)	Earthwork excavation in irrigation channels, drains, etc. to designed section, grades and profiles, excavated material disposed off and dressed within 50 ft. (15 m) lead: - i) ordinary soil	1000 Cft

SUBBASE AND BASE

ITEM 5.00 GENERAL

5.1.1 DESCRIPTION

The work shall consist of furnishing, spreading and compacting graded subbase, crushed aggregate base course, asphaltic base course, crushed limestone base course, cement stabilized subbase and base course, lime stabilized subbase and bitumen stabilized subbase and base, crack relief layers, constructed on a prepared bed and all incidentals in accordance with these specification in conformity with the lines, grade thickness and typical cross-section shown on the drawing and/or as directed by the Engineer.

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 various items of this section.

5.1.2.1 Sampling and Testing

Adequate representative samples shall be submitted to Engineer for testing and preliminary approval not less than twenty days, before the intended material is to be used in the work. The material, when deemed necessary by the Engineer, shall be sampled and tested in his presence by the Contractor for particular

subbase, base course as called for in the specifications of particular application and/or the Bill of Quantities and/or as shown on the drawing to assure conformance with the requirements of specifications. 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 Employer.

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

Sampling and testing, unless otherwise stated, shall be according to the standard methods prescribed in the latest edition of the American Association of State Highway and Transportation Officials (AASHTO) or standard specification and methods of sampling and testing, provided in latest version of American Society of Testing and Materials (ASTM) or, for particular materials or procedures, the British Standards Institution. 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".

5.1.2.2 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 that may have become dry, causing segregation shall be removed and representative samples of the damp sand selected.

5.1.2.3 Number and Size of Samples

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

5.1.2.4 Schedule for Sampling and Testing

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

5.1.2.5 Tolerances

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

5.1.3 PLANT & EQUIPMENT

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

5.1.4 TRIAL STRIPS

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

a) Maximum thickness of loose layer, which can be laid

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

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

ITEM Ch. 18 item 3 **Providing and laying sub-base course of stone product of approved quality and grade, including placing, mixing ,spreading and compaction of sub-base material to required depth, camber, grade to achieve 100% maxi mum modified AASHO dry density, including carriage of all material to site of work except gravel and. aggregate.**
i i) Crushed stone aggregate.

6.1.1 DESCRIPTION

This item shall consist of furnishing, spreading in one or more layers and compacting granular subbase according to the Specifications and the Drawings and/or as directed by the Engineer.

6.1.2 MATERIAL REQUIREMENTS

Granular subbase 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 & other deleterious substances and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable subbase.

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

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

Grading Requirements for Subbase Material

Sieve Designation		Percent Passing by Weight	
(mm)	(in)	A	B
60.6	2 ½	100	-
50.0	2	90~100	100
25.0	1	50~80	55~85
9.5	3/8	--	40~70
4.75	No. 4	35~70	30~60
2.0	No. 10	-	20~50
0.425	No. 40	-	10~30
0.075	No. 200	2~8	5~15

The Coefficient of Uniformity D_{60} / D_{10} shall be not less than 3, where D_{60} and D_{10} 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 ninety-eight (98) % of the maximum dry density determined according to AASHTO T 180 (Method D).

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

d) In order to avoid intrusion of silty and clayey material from the subgrade in the subbase, the ratio D_{15} (Subbase) / D_{85} (Subgrade) should be less than five (5).

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

f) 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 twenty-five (25) and a plasticity index of six (6) or less.

g) If oversize 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 five (5) % of the total mass.

h) Sand equivalent for all classes shall be twenty-five (25) minimum.

6.1.3 CONSTRUCTION REQUIREMENTS

6.1.3.1 Spreading

Granular subbase shall be spread on approved subgrade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

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

When the required thickness is fifteen (15) cm or less, the aggregates may be spread and compacted as one layer, but in no case shall a layer be less than seven and a half ($7^1/_2$) cm thick. Where the required thickness is more than fifteen (15) cm, the aggregates shall be spread and compacted in two (2) or more layers of approximately equal thickness, but in any case the maximum compacted thickness of one layer shall not exceed fifteen (15) cm. All subsequent layers shall be spread and compacted in a similar manner.

Granular subbase shall be spread with equipment that will provide a uniform layer conforming to the specified item both transversely and longitudinally within the tolerances as specified in “Table for Allowable Tolerances” in these

Specifications. No hauling or placement of material will be permitted when, in the judgment of the Engineer, the weather or road conditions are such that the hauling operation will cause cutting or rutting of subgrade or contamination of subbase material.

6.1.3.2 Compaction Trials

Prior to commencement of granular subbase operation, the Contractor shall construct a trial length, not to exceed, five hundred (500) m and not less than two hundred (200) m with the approved subbase material as will be used during construction to determine the adequacy of 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 1.20 (General) of these Specifications.

6.1.3.3 Compaction

The moisture content of subbase 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 subbase material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the 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 ten (10) cm.

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

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

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

6.1.3.4 Compaction requirements

The relative compaction of each layer of the compacted subbase shall not be less than ninety-eight (98) % 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.

6.1.3.5 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:

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

b) Moisture content for calculation of field density and Proctor shall be observed on material passing 19 mm sieve.

6.1.3.6 Tolerance

The subbase 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.

6.1.4 MEASUREMENT AND PAYMENT

6.1.4.1 Measurement

The quantity of subbase 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 subbase course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross-sections. The carriage from crush plant/stoke pile to site included in this item.

6.1.4.2 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, hauling, placing, watering, rolling, labor, equipment, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement

Providing and laying sub-base course of stone Product of approved quality and grade, including placing, mixing, spreading and compaction of sub-base materi al to requi red depth, camber, grade to achi eve 100% maxi mum modi f i ed AASHO dry densi ty, including carriage of all material to site of work except gravel and. aggregate.

i i) Crushed stone aggregate. 100 Cft

ITEM Ch. 18/4 Providing and laying base course of crushed stone aggregate of approved quality and grade, and supply and spreading of stone screening, including placing, mixing, spreading and compaction of base course material to required depth, camber and grade to achieve 100% maximum modified AASHO dry density, including carriage of all materials to site of work except gravel and. aggregate

7.1 DESCRIPTION

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

7.1.2 MATERIAL REQUIREMENTS

Material for crushed 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 crushed aggregate base course 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		Percent Passing by Weight	
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
2.0	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 D_{60} / D_{10} 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) % 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) % when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T 104.

e) The sand equivalent determined according to AASHTO T 176 shall not be less than forty-five (45) and the portion of filler, including any blended material, passing No. 40 mesh sieve shall have a liquid limit not more than 25 and a plasticity index not more than 4 when tested in accordance with AASHTO T 89 & T 90.

f) The material passing the 19 mm sieve shall have a CBR value of minimum eighty (80) %, tested according to the AASHTO T 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 fifteen (15) % of total volume of crushed aggregate base course.

7.1.2.1 Filler for Blending

If filler, in addition to that naturally present in the crushed aggregate base course 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 by Weight
3/8 in	100
4	85~100
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 Item 202.2 above.

7.1.3 CONSTRUCTION REQUIREMENTS

7.1.3.1 Preparation of Surface for Crushed Aggregate Base Course

In case crushed aggregate base course is to be laid over prepared subbase course, the subbase 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 in Item 201.3.1.

7.1.3.2 Compaction

Compaction process shall conform in all respect to the requirements specified under this heading in Item 201.3.1.

7.1.3.3 Compaction Requirement

The relative compaction of each layer of the compacted base shall not be less than 100 percent to the maximum dry density determined according to AASHTO T 180 (Method D). The field density shall be determined according to AASHTO T 191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T 224 shall be used.

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.

7.1.3.4 Moisture Content Determination

Moisture content determination shall conform in all respects to the requirements specified under Sub base

7.1.3.5 Trial Sections

Prior to commencement of crushed aggregate base course operations, a trial section of two hundred (200) m minimum, but not to exceed five hundred (500) m 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 1.20 (General) of these Specifications.

7.1.3.6 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, re-shaping, 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.

7.1.3.7 Acceptance, Sampling and Testing

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

7.1.4 MEASUREMENT AND PAYMENT

7.1.4.1 Measurement

The quantity of crushed aggregate base course 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 course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross-sections. The carriage from crush plant/stoke pile to site included in this item.

7.1.4.2 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, hauling, placing, watering, rolling, labor, equipment, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
18/4	Providing and laying base course of crushed stone aggregate of approved quality and grade, and supply and spreading of stone screening, including placing, mixing, spreading and compaction of base course material to required depth, camber and grade to achieve 100% maximum modified AASHO dry density, including carriage of all materials to site of work except gravel and. aggregate	100 Cft

ITEM Ch. 18

Item 10(iii) **Providing and laying plant premixed bituminous carpet, base course including compaction and finishing to required camber, grade and density. 4% Bitumen (Excluding carriage of crushed stone aggregate/bajri from Kirana Hill Quarry sargodha). 80mm thick**

8.1 **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, subbase or base course, subject to terms and conditions of the Contract and in strict accordance with this Section of the Specifications, the Drawings and the directions of the Engineer.

8.1.2 **MATERIAL REQUIREMENTS**

8.1.2.1 **Mineral Aggregate**

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

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

b) The crushing shall be so regulated that at least ninety-five (95) % 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.

c) Fine aggregate that is material passing No. 4 sieve, shall consist of one hundred (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 quartzitic nature, then hydrated lime or a better material shall be allowed. At the time of use, it shall be sufficiently dry to flow freely. Filler material shall conform to following gradation:

US Standard Sieve	Percent Passing by Weight

No. 30	100
No. 50	95~100
No. 200	70~100

The coarse and fine aggregates shall meet the following applicable requirements:

i) The percentage of wear by the Los Angeles Abrasion test (AASHTO T 96) shall not be more than forty (40).

ii) The loss when subject to five (5) cycles of the Sodium Sulphate Soundness test (AASHTO T 104) shall be less than twelve (12) %.

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

iv) 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.

v) The portion of aggregate retained on the 9.5 mm (3/8 in) sieve shall not contain more than twenty (20) % by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 3:1).

vi) 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.

vii) 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.

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

8.1.2.2 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.

8.1.2.3 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 203-1

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)	90~10	100
1" (25 mm)	–	75~90
3/4" (19 mm)	56~75	65~80
1/2" (12.5 mm)	–	55~70
3/8" (9.5 mm)	–	45~60
No. 4 (4.75 mm)	23~40	30~45
No. 8 (2.38 mm)	15~30	15~35
No. 50 (0.300 mm)	4~10	5~15
No. 200 (0.075 mm)	3~16	2~7
Asphalt Content weight percent of total mix	3 (minimum)	3 (minimum)

The asphalt concrete leveling / base 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 (0.01 in).....……..... 8~14

Percent voids filled with bitumen 55~65

Percent air voids in mix .....……..... 4~8

Percent voids in mineral aggregates …… According to Table 5.3, MS-2, Asphalt Institute, sixth edition 1993.

Loss in Stability .....…… 25 % (max)

Mixes composed of larger size aggregates with maximum size upto 38 mm ($1^1/_2$ in) will be prepared according to modified Marshal 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 that is used:

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

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

c) The batch weights are typically of four (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 two and a quarter ($2^1/_4$) times and the range of flow values shall be one and a half ($1^1/_2$) 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 (3.75 in) thickness, if the actual thickness varies:

Approximate Height (mm)	**(in)**	**Specific Volume (cu cm)**	**Correlation Ratio**
88.9	3 ½	1608 to 1626	1.12
90.5	$3\ ^9/_{16}$	1637 to 1665	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 ¾	1724 to 1752	1.00
96.8	$3\ ^{13}/_{16}$	1753 to 1781	0.97
98.4	$3\ ^7/_8$	1782 to 1810	0.95
100.0	$3\ ^{15}/_{16}$	1811 to 1839	0.92
101.6	4	1840 to 1968	0.90

8.1.2.4 <u>Job Mix Formula</u>

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. JMF shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established by Marshal Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), sixth edition 1993, or the latest Edition.

The JMF, with the allowable tolerances shall be within the range specified in Item 203.2.3. 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 combined gradation should produce a smooth curve approximately paralleling grading band limits for designated mix. The JMF with allowable tolerances for a single test then becomes the job control grading band. If application of job mix tolerances results in a job control grading band outside the master grading band, the full tolerances shall still apply.

Prior to final approval, the proposed job mix, with a bitumen content at the permissible upper percentage limit determined in JMF, shall be compacted to refusal (750 to 900 blows) and the resulting air voids in the mix shall not be less than three (3) %.

The ratio of weight of filler (passing sieve No. 200) to that of asphalt shall range from one (1) to one and a half ($1^1/_2$) for hot climate areas with temperature more than four hundred (400) °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 JMF shall be within the following limits:

Maximum Variation of Percentage of Materials

Retained No. 4 and larger	+ 7.0%
Passing No. 4 to No. 100 sieve	+ 4.0%
Passing No. 200	+ 1.0%

Asphalt Content

Weight 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 Marshal stability by immersion of specimen in water at sixty (60) °C for twenty-four (24) hours as compared with stability measured after immersion in water at sixty (60) °C for 20 minutes shall not exceed twenty-five (25) %. 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 JMF shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new JMF will be required.

8.1.3 CONSTRUCTION REQUIREMENTS

8.1.3.1 Bituminous mixing Plant

Plants used for the preparation of bituminous mixtures shall be "Batching Plants" conforming to AASHTO M 156 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.

8.1.3.2 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) % will pass sieve No. 4 and the other two bins shall contain aggregate of such sizes that eighty (80) % will be retained on sieve No. 4. Should fine material, be incorporated in the mix, separate bin shall be provided in addition to the three bins mentioned above. If filler is used as a separate component it will also be stored and measured separately and accurately before being fed into the mixer through filler screw mechanism.

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

Dried aggregate weighed and drawn to pugmill shall be combined with proportionate quantity of asphalt cement according to the JMF. Temperature of asphalt, except for temporary fluctuations, shall not be lower than fifteen (15) °C 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 that 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 sixty-three (163) °C. If aggregate contain sufficient moisture to cause foaming in the mixture or their temperature is in excess of hundred sixty-three (163) °C, they shall be removed from the bins and returned to their respective stock piles. In no case, shall the temperature of asphaltic mix exceed hundred sixty-three (163) °C 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 ($3^1/_2$) sieve decks to effectively control the gradation of hot bins.

8.1.3.3 Hauling Equipment

Dump truck used for hauling bituminous mixtures shall have tight, clean, smooth metal beds that 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 thirty (130) °C. Drivers of dump trucks will ensure that while reversing the vehicles, paver is not pushed back producing a hump.

8.1.3.4 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 that will give the best result for the type of power being used.

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

The paver shall be equipped with automatic screed controls with sensors for either or both sides of the paver, capable of sensing grade from an outside reference line, sensing the transverse slope of the screed and providing the automatic signals which 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 one-tenth ($\pm$0.1) % variation.

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

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

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

8.1.3.5 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.

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

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

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

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

8.1.3.7 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.

Care shall be taken to ensure that material is properly compacted up to joint positions. If this is not done or results in misshapen surface on a layer, the Engineer may instruct unacceptable material to be cut back before laying the adjacent material. Joints in superimposed layer of asphaltic material must be offset longitudinally by at least 2m and transversely by at least thirty (30) cm. Longitudinal joints in wearing course shall, after cutting back, be of good alignment and preferably coincident with the position of carriageway markings. Except where laying in echelon, joints in wearing course shall be cut back to a vertical face and Tack coated. Kerb faces, ironwork and the like in contact with wearing course shall be tack coated prior to laying wearing course.

The outer edges of wearing course shall be cut back to a good alignment, parallel with the road alignment. This will require a small additional width of wearing course to be laid.

The Contractor should allow, within his bid rates, for this additional width and for all cutting back of wearing course that will not be measured for payment. Tack coating of vertical faces will not be measured for payment.

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 thirty (130) °C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between hundred sixty-five (165) and hundred

ninety (190) °C. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

8.1.3.8 Compaction

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

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

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

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road center line, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the center line. 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 twenty (120) °C for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred ten (110) °C.

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

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

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

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

cleated compression strips may be used under the roller to transmit compression to the depressed area.

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

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 ^{O}C.

8.1.3.9 Frequency of Testing for Cores

One core shall be taken for each hundred (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 ninety-seven (97) % density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) m 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 ninety-seven (97) % compaction and the individual compaction of the core is not less than ninety-five (95) %, then the compaction is acceptable. If average of the cores further fails against compaction, then retake the cores at a distance of fifteen (15) m on either side and compaction shall be checked for all the five cores in the same fashion. If average of five cores is ninety-seven (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 then 96%, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner at the expense of the Contractor.

8.1.3.10 Surface Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) m straight edge by the 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) mm when placed either parallel or perpendicular to center line of roadway.

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.

The surface irregularities will also be tested by a rolling straight edge of the type designed by Transport Research Laboratory of UK, along any line or lines parallel to the edge of pavement on sections of 300m selected by the Engineer, whether or not it is constructed in shorter lengths. Sections shorter than 300m forming part of a longer pavement shall be assessed using the number of irregularities for a 300m length pro-rata to the nearest whole number. Where

the total length of pavement is less than 300m the measurements shall be taken on 75m length. No irregularity exceeding 10mm shall be permitted.

Maximum Permitted Number of Surface Irregularities using a Rolling Straight Edge

Surface under test	Irregularity			
	4 mm		7 mm	
Length	300m	75m	300m	75m
Asphaltic Base course	40	18	4	2

8.1.3.11 Base Thickness Tolerances

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

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

8.1.3.12 Acceptance Sampling and Testing

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

8.1.3.13 Weather Limitations

Hot asphaltic mixtures shall be placed only when the air temperature is four (4) °C or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

8.1.3.14 Trial Section

The Contractor shall prepare a trial section before the start of work in light of procedure given in Clause 1.20 (General).

8.1.4 MEASUREMENT AND PAYMENT

8.1.4.1 Measurement

The quantities for asphaltic leveling / base course will be measured by volume in Sft 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 for payment. Quantities of asphalt concrete mixed, wasted or disposed of in a manner not called for under the Specifications or remaining on hand after completion of the work will not be paid for. Carriage of material from crush plant/site pile to site is included in item rate.

8.1.4.2 <u>Payment</u>

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 of all materials including asphalt additive or anti-stripping agent if allowed by the Engineer to meet requirements of JMF; the drying and screening of aggregates; the mixing of bituminous material with the aggregates and the furnishing, placing and compaction of the mixed material and for all labor, equipment, tool and incidentals necessary to complete the work prescribed in this item:

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Pay Item No.	Description	Unit of Measurement
ITEM Ch. 18 Item 10(iii)	Providing and laying plant premixed bituminous carpet, base course including compaction and finishing to required camber, grade and density. 4% Bitumen (Excluding carriage of crushed stone aggregate/bajri from Kirana Hill Quarry sargodha). 80mm	100 Sft per inch Thick

<u>TABLE 307-1</u>

<u>DESIGN SHEETS FOR DENSE GRADED HOT MIX. FOR LEVELING AND POTHOLES, RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE</u>

AGGREGATE IN MIX	FILLER	FINE AGG.	COARSE AGGREGATES					BITUMEN USED	REMARKS
Sieve Size inch (mm)	200 (0.075)	No. 8 (2.36)	No. 4 (4.75)	3/8" (9.5)	1/2" (12.5)	3/4" (19)	1" (25)		

Specification Range	4-12	43-56	55-75	90-100	-	-	-	4% by Weight of Mix	Min Layer Thickness : 20 mm Aggregate max size : 9mm Rate of Aggregate Application : 50 kg/m^2
Allowed% Passing	9	48	65	100	-	-	-		
% by Weight	57%		43%		-	-	-		
Qty. by Proportion	4		3		-	-	-		
Specification Range	3-11	40-45	46-60	72-87	87-100	-	-	4% by Weight of Mix	Min Layer Thickness : 30 mm Aggregate size : 12mm Rate of Aggregate Application : 70 kg/m^2
Allowed % Passing	8	36	54	80	100	-	-		
% by Weight	46%		54%			-	-		
Qty. by Proportion	3		4			-	-		
Specification Range	4-11	32-46	46-60	65-80	75-88	90-100	-	3.5% by Weight of Mix	Min Layer Thickness :50 mm Aggregate size :20mm Down Rate of Aggregate Application : 115 kg/m^2
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 Weight of Mix	Min Layer Thickness :50 mm Aggregate size :20mm Down Rate of Aggregate Application : 150 kg/m^2
Allowed % Passing	8	30	40	54	62	76	100		
% by Weight	46%		54%				-		
Qty. by Proportion	3		4				-		

TABLE 307-2

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 AGG.	COARSE AGGREGATES					BITUMEN USED	REMARKS
Sieve Size inch (mm)	**200 (0.075)**	**No. 8 (2.36)**	**No. 4 (4.75)**	**3/8" (9.5)**	**1/2" (12.5)**	**3/4" (19)**	**1" (25)**		
Specification Range	2-10	24-37	40-50	88-100	-	-	-	4% by Weight of Mix	Min Layer Thickness : 20 mm Aggregate max size : 9mm Rate of Aggregate Application : 50 kg/m^2
Allowed % Passing	6	30	43	100	-	-	-		
% by Weight	36%		64%		-	-	-		
Qty. by Proportion	1		2		-	-	-		
Specification Range	1-9	14-28	32-45	57-70	75-100	-	-	3.5% by Weight of Mix	Min Layer Thickness : 30 mm Aggregate size : 12mm Rate of Aggregate Application : 70 kg/m^2
Allowed % Passing	6	25	37	63	100	-	-		
% by Weight	31%		69%			-	-		
Qty. by Proportion	1		2			-	-		
Specification Range	1-10	14-28	25-40	45-57	58-70	87-100	-	3.5% by Weight of Mix	Min Layer Thickness :50 mm Aggregate size :20mm Down Rate of Aggregate Application : 110 kg/m^2
Allowed % Passing	6	20	32	50	65	100	-		
% by Weight	26%		74%				-		
Qty. by Proportion	1		3				-		
Specification Range	2-10	12-25	20-35	36-51	45-60	65-81	82-100	3.5% by Weight of Mix	Min Layer Thickness :60 mm Aggregate size :25mm Down Rate of Aggregate Application : 135 kg/m^2
Allowed % Passing	6	17	26	41	52	72	100		
% by Weight	23%		77%				-		
Qty. by Proportion	1		3				-		

SURFACE COURSES AND PAVEMENT

ITEM 9.1 GENERAL

This section describes the requirements and procedures for execution of surface courses and pavements. The materials to be used shall conform to the Specifications and testing procedures as per American Association of State Highway and Transportation Official (AASHTO) or the American Society for Testing and Material (ASTM) or, for particular materials or procedures, the British Standards Institution as indicated in their latest editions. Samples of materials for laboratory tests and their subsequent approvals shall be utilized according to these references unless otherwise directed by the Engineer.

Materials, which do not conform to the requirements of these Specifications, will be rejected whether in place or not. They shall be removed immediately from the site of the work at the expense of the Contractor. While subgrade/subbase and paving operations are in progress, a detour shall be provided for vehicular flow in order to avoid any public inconvenience and thoroughly be maintained till completion of that particular section of the project or as a whole. In order to expedite the passage of public traffic through or around the work, the Contractor shall install road signs, warning lights, flares, barricades and other facilities for the safety, convenience and direction of public traffic. Also where directed by the Engineer, the Contractor shall furnish competent flagmen whose sole duties shall consist of directing the movement of public traffic through or around the work. The cost of furnishing and installation of such road-signs, lights, flares, barricades and other facilities shall be included in the respective work item. Should the Engineer point out the inadequacy of warning and protective measures and require additional measures, such action on the part of the Engineer shall not relieve the Contractor from responsibility for public safety or abrogate his obligation to furnish and pay for these services.

ITEM 9.1 ASPHALTIC MATERIALS

9.1.1 ASPHALT CEMENT

Asphalt Cement shall be an oil asphalt or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar or paraffin and shall be homogeneous and free from water. No emulsification shall occur when a thirty (30) gm sample is boiled for two (2) hours with two hundred fifty (250) cu cm of distilled water in a five hundred (500) cu cm Erlenmeyer flask equipped with a reflux condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to the requirements set forth in Table 301-2. The grade of asphalt to be used shall be in accordance with these Specifications or the Special Provisions or as directed by the Engineer.

9.1.2 ENVIRONMENTAL FACTORS

In areas where highly frost susceptible soils and severe low temperature conditions are encountered, it may be necessary to remove and replace soils susceptible to frost heave or take other precautions prior to pavement construction. In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table below gives recommended asphalt grades for various temperature conditions.

SELECTING ASPHALT GRADE

Temperature Condition	* Asphalt Grade
Cold, mean annual air temperature ≤ 7 °C (45 °F)	AC-10 AR-4000 80 / 100 pen
Warm, mean annual air temperature between 7 °C (45 °F) and 24 °C (75 °F)	AC-20 AR-8000 60 / 70 pen
Hot, mean annual air temperature > 24 °C (75 °F)	AC-40 AR-8000 40 / 50 pen

* Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types: cationic (ASTM D 2397 or AASHTO M 208) or anionic (ASTM D 977 or

AASHTO M 140). Selecting one of the two shall depend on the type of aggregate used for better affinity.

The grade of emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D 244, AASHTO T 59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used and the curing rate.

9.1.3 CUTBACK ASPHALT

Liquid asphalts (cutback) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Tables 301-3 and 301-4.

Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent.

Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of grade 80-100, fluxed or blended with a naphtha solvent.

9.1.4 EMULSIFIED ASPHALT

Asphaltic emulsions shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting or Slow Setting and shall conform to the requirements specified in Table 301-5.

The bituminous base used in manufacturing RS-1 type emulsion shall be asphalt cement, Grade 120-150 or Grade 200-300, as designated by the Engineer.

The bituminous base used in manufacturing SS1 type emulsion shall be paving asphalt, Grade 60-70 or Grade 120-150, as designated by the Engineer.

TABLE 301-1

APPLICATION TEMPERATURES

Asphalt Type/Grade	Mixing Temperature (°C)	Spraying Temperature Road Mixes (°C)
a) Asphalt Cement		
All grades	As required to achieve viscosity of 75~150 sec Saybolt-Furol or as required to achieve a Kinematic Viscosity of 150-300 centistokes	160 (max)
b) Emulsified Asphalts		
RS-1	–	–
RS-2	–	–
MS-1	10~70	20~70
MS-2	10~70	20~70
MS-2h	10~70	20~70
HFMS-1	10~70	20~70
HFMS-2	10~70	20~70
HFMS-24	10~70	20~70
SS-1	10~70	20~70
SS-1h	10~70	20~70
CRS-1	10~70	20~70
CRS-2	–	–
CMS-2	–	–
CMS-2h	10~70	10~70
CSS-1	10~70	10~70
CSS-1h	10~70	10~70
c) Cutback Asphalts (RC, MC, SC)		
30 (MC only)	–	–
70	–	20 min
250	55~80	40 min
800	75~100	55 min
3000	80~115	–

TABLE 301-2

REQUIREMENTS FOR ASPHALT CEMENT (AASHTO M 20)

	40-50		60-70		80-100		120-150	
	min	**max**	**min**	**max**	**min**	**max**	**min**	**max**
Penetration at 77 °F (25 °C) 100 g 5 sec	40	50	60	70	80	100	120	150
Flash point, Cleveland Open Cup, °F (°C)	450 (232)	- -	450 (232)	- -	450 (232)	- -	425 (218)	- -
Ductility at 77 °F (25 °C) 5 cm per min, cm	100	-	100	-	100	-	100	-
Solubility in trichloroethylene , %	99	-	99	-	99	-	99	-
Thin-film oven test, 1/8 in (3.2 mm), 325 °F (163 °C) 5hr Loss on heating, %	-	0.80	-	0.80	-	1.0	-	1.3
Penetration, of residue, % of original	58	-	54	-	50	-	46	-
Ductility of residue at 77°F (25 °C) 5 cm per min, cm	-	-	50	-	75	75	100	-

TABLE 301-3

REQUIREMENTS FOR MEDIUM-CURING TYPE ASPHALTS (AASHTO M 82)

	MC-70		MC-250		MC-800	
	min	**max**	**min**	**max**	**min**	**max**
Water, %	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup), °C	38	-	66	-	66	-
Kinematic Viscosity at 60 °C (140 °F) (See Note 1) Centistokes	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate at 360 °C (680 °F):						
at 225 °C (437 °F)	0	20	0	10	-	-
at 260 °C (500 °F)	20	60	15	55	0	35
at 315 °C (600 °F)	65	90	60	87	45	80
Residue from distillation at 360 °C (680 °F) Volume percentage of samples by difference	55	-	67	-	75	-
Tests on residue from distillation:						
Penetration, 100gm, 5 sec, at 25 °C (77 °F)	120	250	120	250	120	250
Ductility, 5 cm/ min, cm (see note 2)	100	-	100	-	100	-
Solubility in Trichloroethylene, %	99	-	99	-	99	-

Note: **1.** As an alternate, Saybolt Furol Viscosities may be specified as following:

Grade MC-70 Furol Viscosity at 50 °C (122 °F) – 60 to 120 sec
Grade MC-250 Furol Viscosity at 60 °C (140 °F) – 125 to 250 sec
Grade MC-800 Furol Viscosity at 82.2 °C (180 °F) – 100 to 200 sec

2. If penetration of residue is more than 200 and its ductility at 25 °C (77 °F) is less than hundred (100) cm, the material will be acceptable if its ductility at 15.5 °C (60 °F) is more than 100 cm.

TABLE 301-4

REQUIREMENTS FOR RAPID-CURING TYPE ASPHALTS (AASHTO M 81)

	RC-70		RC-250		RC-800	
	min	**max**	**min**	**max**	**min**	**max**
Water, %	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup), °C	-	-	66	-	66	-
Kinematic Viscosity at 60 °C (140 °F) (See Note) Centistokes	70	140	250	500	800	1600
Distillation test:						
Distillate, percentage by volume of total distillate at 360 °C (680 °F)						
at 190 °C (374 °F)	10	-	-	-	-	-
at 225 °C (437 °F)	50	-	35	-	15	-
at 260 °C (500 °F)	70	-	60	-	45	-
at 315 °C (600 °F)	85	-	80	-	75	-
Residue from distillation at 360 °C (680 °F) Volume percentage of samples by difference	55	-	65	-	75	-
Tests on residue from distillation:						
Penetration, 100g, 5 sec, at 25 °C (77 °F)	80	120	80	120	80	120
Ductility, 5 cm/ min, of 25 °C (77 °F) cm	100	-	100	-	100	-
Solubility in Trichloroethylene, %	99	-	99	-	99	-

Note: As an alternate, Saybolt Furol Viscosities may be specified as following:

Grade RC-70 Furol Viscosity at 50 °C (122 °F) – 60 to 120 sec
Grade RC-250 Furol Viscosity at 60 °C (140 °F) – 125 to 250 sec
Grade RC-800 Furol Viscosity at 82.2 °C (180 °F) – 100 to 200 sec

Table 301-5

REQUIREMENTS FOR EMULSIFIED ASPHALTS (AASHTO M 140)

Type	Rapid-Setting				Slow-Setting			
Grade	RS – 1		RS – 2		SS – 1		SS – 1h	
	min	max	min	max	min	max	min	max
Test on Emulsions:								
Viscosity, Saybolt Furol at 77 °F (25 °C)	20	100	-	-	20	100	20	100
Viscosity, Saybolt Furol at 122 °F (50 °C)	-	-	75	400	-	-	-	-
Settlement 5 days, % (a)	-	5	-	5	-	5	-	5
Storage stability test 1 day (b)	-	1	-	1	-	1	-	1
Demulsibility, 35 ml, 0.02 N $CaCl_2$, %	60	-	60	-	-	-	-	-
Cement mixing test, %	-	-	-	-	-	2.0	-	2
Sieve test, %	-	0.10	-	0.10	-	0.10	-	0.10
Residue by distillation, %	55	-	63	-	57	-	57	-
Test on Residue from Distillation Test:								
Penetration, 25 °C (77 °F) 100gm 5 sec	100	200	100	200	100	200	40	90
Ductility, 25 °C (77 °F), 5 cm/min cm	40	-	40	-	40	-	40	-
Solubility in trichloroethylene, %	97.5	-	97-5	-	97.5	-	97.5	-
Suggested uses	Surface treatment, penetration macadam and tack coat		Surface treatment & penetration macadam		Plant or road mixture with graded and fine aggregates, a substantial quantity of which passes a No. 8 (2.3 mm) sieve and a portion of which may pass a No. 200 (0.075 mm) sieve; slurry seal treatments.			

a) The test requirement for settlement may be waived when the emulsified asphalt is used in less than five (5) days' time; or the Engineer may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than five (5) days.

b) The 24-hours (1 day) storage stability test may be used instead of the five (5) days' settlement test.
c) The demulsibility test shall be made within thirty (30) days from date of shipment.

ITEM Ch. 18

Item No 6 Providing and laying bituminous priming coat, using 10 lbs. kerosene oil and 10 lbs. binder per 100 Sft. or 0.5 Kg kerosene and 0.5 Kg binder per square meter.

9.1.1 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 Specifications and in conformity with the lines shown on the Drawings.

9.1.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of the Item 301 "Asphaltic Materials", either cutback or Emulsified Asphalt, which ever is specified in the Bill of Quantities.

9.1.3 CONSTRUCTION REQUIREMENTS

Prior to the application of prime coat loose material shall be removed from the surface and the surface shall be cleaned by mechanical sweepers, blowers and hand brooms. The application is prohibited when the weather is foggy or rainy or when the atmospheric temperature is below fifteen (15) °C unless otherwise directed by the Engineer. On a soil surface or subbase or base course, the cleaned surface shall be given a light application of water and allowed to dry to a surface-dry condition before prime coat is applied. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. Prior to the application of prime coat on bridge decks and concrete pavements, the surfaces shall be cleaned of all loose material as described in Section 302.3. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer. Areas to be primed will be classified as under:

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

b) The top of the shoulders from the intersection of embankment slope and top of subgrade to the edge of the pavement line.

c) The bridge wearing surface from curb to curb and end to end of bridge wearing surface.

d) Other surfaces as shown on the plans or ordered by the Engineer.

Primed surface shall be kept undisturbed for at least twenty-four (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.

9.1.3.1 Equipment

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 1000 litre capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed hundred (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 one hundred eighty (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 therefrom. The Contractor will be responsible for any fire or accident resulting from heating of bituminous materials. The liquid shall be circulated or stirred during the heating. The tank shall be insulated in such a way that the drop in temperature when the tank is filled and not heated, will be less than two (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 ten (10) cm, to a total width of four (4) m. The spraying bar shall have nozzles from which the liquid is sprayed fan-shaped on the road surface equally distributed over the total spraying width.

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 litres 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 ten (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.

9.1.3.2 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 Item 301 by approved pressure distributors operated by skilled workmen. The spray nozzles and spray bars shall be adjusted and frequently checked so as to ensure uniform distribution. Spraying shall cease immediately upon any clogging or interference of any nozzle and remedial measures taken before spraying is resumed.

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

TYPE OF SURFACE	**LITRES PER SQUARE METER**	
	minimum	**maximum**
a) Subgrade, Subbase, Water bound base courses, and Crushed stone base course	0.65	1.75
b) Bridge, Wearing Surfaces, 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 the Engineer.

The prime coat shall be left undisturbed for a period of at least twenty-four (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 one-half (1/2) 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.

9.1.4 MEASUREMENT AND PAYMENT

9.1.4.1 Measurement

The unit of measurement shall be square Feet 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.

9.1.4.2 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 labor, material, tools, equipment and incidentals necessary to complete the work prescribed in this item:

Pay Item	**Description**	**Unit of**
No.		*Measurement*
ITEM Ch. 18 Item No 6	Providing and laying bituminous priming coat, using 10 lbs. kerosene oil and 10 lbs. binder per 100 Sft. or 0.5 Kg kerosene and 0.5 Kg binder per square meter.	100 Sft

ITEM Ch. 18 Item 7 Providing and laying bituminous tack coat, using 10 lbs. of bitumen per 100 Sft (0.49 Kg of bitumen per sq.m.)

10.1 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 a Bituminous tack coat, complete in accordance with these Specifications and to the width shown on the typical cross-sections of applicable drawings.

10.2 MATERIAL REQUIREMENTS

Asphaltic material shall conform to the requirements of Item 301 "Asphaltic Materials" for emulsified asphalt or cutback asphalt as called for in the Bill of Quantities.

10.3 CONSTRUCTION REQUIREMENTS

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.

10.3.1 Equipment

Equipment shall conform in all respect to the provision under Item 302.3.1 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. 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, shall be furnished.

10.3.2 Application of Asphaltic Material

Asphaltic material shall be applied by means of a pressure distributor, at the temperature stated in Item 301 for the particular material being used. Rates of application of cutback shall be within the range of two-tenths (0.2) to four-

tenths (0.4) litre per sq m and for emulsified asphalt the rate shall be within the rage of three-tenths (0.3) to six-tenths (0.6) litre per sq m; the exact rate shall be specified by the Engineer.

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 surf ices of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one-half (1/2) the roadway width 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 the Contractor at his own cost before the next course is applied.

10.4 MEASUREMENT AND PAYMENT

10.4.1 Measurement

The quantities of bituminous tack coat shall be measured in square feet for the actual area Tacked with asphaltic material on the prepared surface in accordance with these Specifications.

10.4.2 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 labor, material, tools, equipment and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
ITEM Ch. 18		
Item No 6	Providing and laying bituminous tack coat, using 10 lbs. of bitumen per 100 Sft (0.49 Kg of bitumen per sq.m.)	100 Sq.ft

ITEM Ch. 18 Item 10(iv) **Providing and laying plant premixed bituminous carpet, wearing course including compaction and finishing to required camber, grade and density.4.5% Bitumen (Excluding carriage of crushed stone aggregate/bajri from Kirana Hill Quarry sargodha). 50mm thick**

11.1 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, subbase, 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 or as directed by the Engineer.

11.2 MATERIAL REQUIREMENTS

11.2.1 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 hundred (100) % crushed rock or crushed gravel having two (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 hundred (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 thirty (30).

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

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) All aggregates shall have a liquid limit of not more than twenty five (25) and a Plasticity Index of not more than four (4) as determined by AASHTO T 89 and T 90.

e) The portion of aggregates retained on the 9.5 mm (3/8 inch) sieve shall not contain more than fifteen (15) % by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 3:1).

f) Stripping test shall be performed on crush 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.

11.2.2 Asphaltic Material

Asphaltic binder to be mixed with the aggregate to produce wearing course 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.

11.2.3 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 305-1
Asphalt Concrete Wearing Course Requirements

Mix Designation	Class A	Class B
Compacted Thickness	50~80 mm	35~60 mm
Asphalt Content weight, percent of total mix	3.5 (min)	3.5 (min)

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
0.300	No. 50	5~12	5~15
0.075	No. 200	2~8	3~8

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 (0.01 inch)	8~14
Percent voids filled with bitumen	65~75
Percent air voids in mix	3.5~5.5
Percent voids in mineral aggregates	According to Table 5.3 MS-2 (Asphalt Institute - USA), sixth addition, 1993.
Loss of Stability	20% (max)

11.2.4 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 Marshal 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 master range specified in Table 305-1. 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 one (1) and one and a half ($1^1/_2$) for hot climate areas with temperature more than forty (40) °C.

Prior to final approval, the proposed job mix, with a bitumen content at the permissible upper percentage limit determined in JMF, shall be compacted to refusal (400 to 600 blows) and the resulting air voids in the mix shall not be less than two (2)%.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with 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 Marshal Stability by immersion of specimen in water at sixty (60) °C for twenty-four (24) hours as compared with the stability measured after immersion in water at sixty (60) °C for twenty (20) minutes shall not exceed twenty (20) %. 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 JMF shall be established before the new material is used. When unsatisfactory results or other conditions make it necessary, a new JMF will be required.

11.3.1.1 CONSTRUCTION REQUIREMENTS

Construction requirements for this item shall conform to the same as specified for Asphaltic Concrete Base Course Plant Mix under Item 203.3, except as modified in the following items.

11.3.1 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.

11.3.2 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 plus or minus three (±3) mm from the desired thickness shown on the Drawings. For determination of thickness one (1) core per hundred (100) m of each lane will be taken. If the thickness so determined is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in Table 305-2, Item 305.4.2(2) of these Specifications.
The surface of the wearing course shall be tested by the Engineer using a three (3) m_straight edge at selected locations. The variation of the surface from the testing edge of the straight edge between any two contacts, longitudinal or transverse with the surface shall at no point exceed five (5) mm. The cross fall (camber) shall be with plus or minus two-tenths (±0.2) % of that specified and the level at any point shall be within plus or minus three (±3) mm of the level shown on the Drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material, by overlaying or by other means satisfactory to the Engineer.
The surface irregularities will also be tested by a rolling straight edge of the type designed by Transport Research Laboratory of UK, along any line or lines parallel to the edge of pavement on sections of three hundred (300) m selected by the Engineer, whether or not it is constructed in shorter lengths. Sections shorter than three hundred (300) m forming part of a longer pavement shall be assessed using the number of irregularities for a three hundred (300) m length prorata to the nearest whole number. Where the total length of pavement is less than three hundred (300) m, the measurements shall be taken on seventy-five (75) m length. No irregularity exceeding ten (10) mm shall be permitted.

Maximum Permitted Number of Surface Irregularities using a Rolling Straight Edge

Surface under Test	**Irregularity**			
	4 mm		7 mm	
Length	300m	75m	300m	75m
Wearing course	20	9	2	1

11.3.3 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 Frequency” in these Specifications.

11.4 MEASUREMENT AND PAYMENT

11.4.1 Measurement

The quantities of Asphaltic wearing course shall be measured by volume in Sft 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 plus or minus three (±3) mm shall be allowed in compacted

thickness of wearing course. However, any asphalt in excess of three (3) mm shall not be paid and any layer deficient by more than three (3) mm but not exceeding ten (10) mm shall be paid as per Item 305.4.2(b).
The quantities of bitumen material used and asphalt additive or anti-stripping agent, if allowed and used to meet with JMF requirement, shall 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.

11.4.2 Payment

a) 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 of all materials including asphalt additive or anti-stripping agent if allowed by the Engineer to meet requirements of JMF; the drying and screening of aggregates; the mixing of bituminous material with the aggregates and the furnishing, placing and compaction of the mixed material and for all labor, equipment, tool and incidentals necessary to complete the work prescribed in this item.

b) **Price adjustment**

i) If the thickness determined as per Item 305.3.2 of these Specifications is deficient by more than three (3) mm, but not more than ten (10) mm, payment will be made at an adjusted price as specified in Table 305-2 below:

Table 305-2

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 50.0 mm	90%
5.1 mm to 10.0 mm	80%

ii) When wearing course is more than ten (10) mm deficient in thickness, the Contractor shall remove such deficient areas and replace them with wearing course of an approved quality and thickness. Alternately, the Contractor may choose to overlay the area with wearing course in a thickness of minimum thirty (30) mm with smooth transition, as approved by the Engineer, on either side. The Contractor will receive no compensation for this additional work.

Pay Item No.	Description	Unit of Measurement
ITEM Ch. 18 Item 10(iv)	Providing and laying plant	

	premixed bituminous carpet, wearing course including compaction and finishing to required camber, grade and density.4.5% Bitumen (Excluding carriage of crushed stone aggregate/bajri from Kirana Hill Quarry sargodha). 50mm thick	100 Sft per inch Thick

ITEM Ch.6/52

(b) (i) Providing and fixing precast Edge Kerb Stone (4"to 6" thick), of 3500 PSI Compressive Strength, embeded in PCC 1:2:4 over lean concrete 1:4:8 etc complete in all respect b) With Painting (i) 14" high

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12.1 DESCRIPTION

This work shall consist of combination of kerb constructed of the following materials and in accordance with the specifications at the location and of the form, dimensions and designs shown on the Drawings or as directed by the Engineer. The kerb, gutter, channel or in combination may be constructed by one of the following methods:

a) Cast in place concrete kerbing

b) Precast concrete kerbing

c) Extruded concrete kerbing

12.2 MATERIAL REQUIREMENTS

The concrete for cast in place concrete kerbs, gutters and channels shall be 3500 PSI concrete or as indicated on the Drawings and shall conform to the requirements of that particular class prescribed under Item Chapter 6 “Classes of Concrete”. An air entraining agent, if required, shall be added during mixing in an amount to produce five (5) to eight (8) % air by volume in the mixed concrete.

Precast concrete kerbing units shall consist of Class C concrete conforming to the requirement of Item 401 and to lengths, shape and other details shown on the Drawings. Kerbing that shows surface irregularities of more than five (5) mm when checked with three (3) m straight edge or surface pits more than fifteen (15) mm in diameter will be rejected.

Forms to hold the concrete shall be built and set in place as described under Item 403 “Formwork”.

Forms for at least sixty (60) m of kerb or combination of kerb and gutter or channels shall be in place and checked for alignment and grade before concrete is placed. Curved sections shall have forms of either wood or metal and shall be

accurately shaped to radius of curvature shown on the Drawings. Steel Reinforcement if required shall conform to Item 404 “Steel Reinforcement”.

Expansion joint filler shall be either the performed type conforming to requirement of AASHTO M 153 or shall be precast fiber board packing.

Joint filler shall consist of one part cement and two parts of approved sand with sufficient quantity of water necessary to obtain the required consistency. The mortar shall be used within thirty (30) minutes after preparation.

The Bonding compound when used shall conform to AASHTO M 200.

12.3 CONSTRUCTION REQUIREMENTS

12.3.1 Cast in Place

a) Excavation and Bedding

Excavation shall be made to the required depth and the base upon which the kerb or combination of kerb and gutter is to be set shall be compacted to a minimum density of ninety (90) % of the maximum dry density as determined by AASHTO T 191 Method. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer.

Where directed by the Engineer, a layer of cinders or clean sand and gravel or other approved porous material having a minimum compacted thickness, of fifteen (15) cm shall be placed to form a bed for the kerb or combination of kerb and gutter.

b) Placing Concrete

Concrete may be placed in the gutter to the full depth required. The top of the kerb or combination of kerb and gutter shall be floated smooth and the edges rounded to the radii shown on the Drawings. Before finishing, the surface of the gutter shall be tested with a three (3) m straight edge and any irregularities of more than five (5) mm in three (3) m shall be eliminated. In finishing concrete only mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

c) Joints

The kerb and gutter shall be constructed in uniform sections of not more than twenty-five (25) m in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints of the concrete pavement or for closures but no section shall be less than two (2) m long. The sections shall be separated by sheet templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately five

(5) mm in thickness, of the same width as that of the kerb or kerb and gutter and not less than five (5) cm greater than the depth of the kerb or kerb and gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. When pre-cut fiber-board packing is used in the expansion joints it may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber board shall be pre-cut to the shape of the kerb so that its outer edge will be flush with the abutting kerb.

Expansion joints shall be formed in the kerb and gutter at intervals of six (6) to ten (10) m in order to coincide with the expansion joints of cement concrete pavement or as shown on the Drawing.

d) Dowels at Expansion Joints in Channels

At expansion joints in channels and in the channel portion of kerbs and channel built monolithically, painted dowel bars with slip sleeve shall be provided as a load transfer medium at locations shown on the Drawings.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the gutter and accurately at right angles to the expansion joint

e) Contraction Joints

Transverse contraction joints shall be provided opposite to all contraction joints in abutting concrete pavement and other locations shown on the Drawing spaced to a maximum of four (4) m.

The contraction joints shall be provided by forming grooves in the face and surface of structure at right angle to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section, five (5) cm deep by five (5) cm wide. The grooves shall be formed in the top of all kerbs and in the exposed roadway face of kerb and in the channel surface of monolithic type kerb and channels and in the surface of channels. The edges of the joints shall be tooled and the joints shall be left clean, neat and of specified width and depth.

f) Removal of Forms and Finishing

The forms shall be removed within twenty-four (24) hours after concrete has placed except that the form used against the face of the kerb in a combination of kerb and gutter shall be removed as soon as the concrete has set sufficiently to hold its shape. Minor defects shall be repaired with mortar containing one (1) part of Portland cement and two (2) parts of the fine aggregate. Plastering shall not be permitted on the face of a kerb or kerb and gutter and all rejected kerb or gutter shall be removed and replaced without additional compensation. All surfaces, which will be exposed in the finished construction of the kerb and

gutter, shall be finished, while the concrete is still "green" by wetting a wood block of float and rubbing the surface until they are smooth.

g) Curing

During seventy-two (72) hours following placing of concrete, the kerbs, channels and gutters shall be protected against premature drying by covering with suitable cotton or hessian mats and by frequent sprinkling with water, with liquid forming compounds or with waterproof paper or by any other method as mentioned in Item 401.3.8 "Curing Concrete" and approved by the Engineer.

h) Backfilling

After forms has been removed and concrete has been cured as specified, the excavation of kerbs, gutters or channels shall be backfired with suitable earth or granular material tamped into place in layers of not more than fifteen (15) cm each until firm and solid.

12.3.2 Precast

a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with a suitable material acceptable to the Engineer.

Bedding shall consist of Class B Concrete conforming to the requirements of Item 401 and shall be to the section and dimension shown on the Drawings.

b) Placing

The precast concrete kerbs shall be set in 1:3 of cement sand mortar to the line, level and grade as shown on the Drawings or as directed by the Engineer.

c) Joints

Joints between consecutive kerbs shall be three (3) to five (5) mm wide and filled with cement mortar to the full section of the kerb.

d) Back-filling

Backfilling shall meet the requirements of Item Backfill.

12.4 MEASUREMENT AND PAYMENT

12.4.1 Measurement

The unit of measurement for concrete kerb, gutter or combination of kerb and gutter, channel or extruded kerbs and channels shall be measured by the linear foot along the front face of the section at the finished grade elevation.

Deduction in length will be made for drainage structure installed in the kerbings such as catch basins, drop inlets etc. Measurement will not include any area in excess of those shown on the Drawings except for any area authorized by the Engineer in writing.

12.4.2 Payment

Payment for expansion joint filler material used in transverse expansion and contraction joints in kerbs and channel shall be understood to be included in the price tendered per linear meter for the kerbs and channels and shall not be paid for separately.

Concrete and mortar required for bedding, haunching and laying of cast-in-place or precast concrete kerbs, as shown on the Drawings, shall not be paid for as separate item but the cost shall be deemed to be included in the relevant Contract unit price for the cast-in-place or precast concrete kerb.

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 and placing all materials for concrete, for reinforcing steel if required on the Drawings for expansion joints, material, form for drainage opening, excavation, backfilling and dumping and disposal of surplus material and for all labor, equipment, tool and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
ITEM Ch.6/52 (b) (i)	**Providing and fixing precast Edge Kerb Stone (4"to 6" thick), of 3500 PSI Compressive Strength, embeded in PCC 1:2:4 over lean concrete 1:4:8 etc complete in all respect b) With Painting (i) 14" high**	**Rft**

Ch. # 1 Item # 25/(a/i) Providing, fabrication and fixing pole mounted Direction Board / road delineator of any shape and size, with pecified Sheet and thickness, supported with G.I Channel, (excluding the cost of vertical post and painting) etc complete in all respect. (a) RECTANGULAR SHAPE (i) 12-48 sft

&

Ch. 18/38 a (i) "Providing and fixing Full width Gantry comprising of 3 mm thick GI sheet (Z-275) fixed over double front and back truss made with Top & bottom chords of MSangle 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 350x150x15 mm thick MS sheet for each column fixed in prelaid RCC footing i/c the cost of polyurethene Paint to MS skeleton but excluding the cost of lettering/printing as approved and directed by the Engineer Incharge a (i) Two Supports"

13.1 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 NTRC sign standards or as shown on plans. Prior to manufacture and fabrication of the signs, the Contractor shall submit to the Engineer for approval detailed drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per Specifications, Drawings or as directed by the Engineer. Unless otherwise shown on the Drawings, all signs shall be lettered in both Urdu and English. In case of any discrepancy between NTRC requirements and these General Specifications, the requirements of NTRC shall govern.

13.2 MATERIAL REQUIREMENTS

Materials shall be of new stock unless otherwise shown on the Drawings or ordered by the Engineer and shall conform to the following requirements:

13.2.1 Sign Panels

Sign panels for regulatory, warning and informatory signs shall be manufactured from aluminum alloy conforming to ASTM B 209, alloy 6061-T6 or 5052-H38 plates of three (3) mm thickness as shown on the Drawings.

The blanks shall be free from laminations, blisters, open seams, pits, holes or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting and punching before preparing the blanks for application of reflective material.

The blanks shall be cleaned, degreased and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

13.2.2 Reflective Sheeting

Reflective sheeting used on road sign made of flexible white or colored, wide angle retroreflective sheeting (hereinafter called sheeting) and related processing materials designed to enhance nighttime visibility. The sheeting shall consist of optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface.

The sheeting shall have either a precoated pressure sensitive adhesive or a tack-free adhesive activated by heat applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting.

The sheeting manufacturer must provide documented evidence to the satisfaction of the Engineer that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

a) Color Requirements

Color shall be specified and conform to the requirements of Table 607-1.

Table 607-1

COLOR SPECIFICATION LIMITS* AND REFERENCE STANDARDS

									Reflectance Limit (Y)		**Munsell ****
Color	**X**	**Y**	**X**	**Y**	**X**	**Y**	**X**	**Y**	**min**	**max**	**Paper**
White	.303	.287	.368	.353	.340	.380	.274	.316	27.0	-	5PB 7/1
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15.0	40.0	1.25Y 6/12
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11.0	7.5R 3/12
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1.0	10.0	5.8PB 1.32/6.8
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14.0	30.0	2.5YR 5.5/14
Brown	.430	.340	.430	.390	.550	.450	.610	.390	3.0	9.0	5YR 3.6
Green	.300	.380	.166	.346	.286	.4288	.201	.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 colormetric system measured with standard illumination Source C

** Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218. Catalog No. MCP-90040

b) Coefficient of Retroreflection

The coefficients of retroreflection shall conform to the minimum requirements of Table 607-2.

Table 607-2

MINIMUM COEFFICIENT OF RETROREFLECTION

(CANDELAS PER SQUARE FOOT PER FOOT CANDLE)

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 seventy (70)% of the values for corresponding color in the above table.

The sheeting manufacturer shall provide a test report from British Standards Institution (BSI) or any internationally recognized laboratory stating that the sheeting meets the requirements according to BSI 873 Part 6 or FP 92 of FHWA.

The brightness of the reflective sheeting totally wet by rain, shall be at least ninety (90) % of the above values.

The reflective sheeting shall be sufficiently flexible as to permit application over and adhesion to a moderately embossed surface. It shall not show damage when bent ninety (90) degree over a fifty (50) mm diameter mandrill.

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty-five (25) mm diameter steel ball from a height of two (2) m onto its surface.

For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty-eight (48) hours after application, at temperatures of up to ninety (90) °C.

The reflective material shall be weather-resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and not less than seventy-five (75) % of the specified wet or dry minimum brightness values when exposed to weathering for five (5) years.

c) Performance Requirements and Obligation

The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retroreflective signs meets all requirements listed herein.

Sheetings processed and applied to sign board materials in accordance with sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table III of this specification. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retroreflection is less than the minimum specified for that sheeting during that period, listed in 607-3.

Table 607-3

MINIMUM COEFFICIENT OF RETROREFLECTION

(CANDELAS PER SQUARE FOOT PER FOOT CANDLE)

(.2° OBSERVATION AND –4° ENTRANCE)*

Sheeting Color	Minimum Coefficient of Retroreflection (7 years)	Minimum Coefficient of Retroreflection (10 years)
White	212	200
Yellow	144	136
Green	38	36
Red	38	36
Blue	17	16
Brown	10	9

For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 50% of the values for the corresponding color in the above table.

All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

Where it can be shown that retroreflective traffic signs supplied and used according to the sheeting manufacturer's recommendations have not met the performance requirements above the sheeting manufacturer shall cover restoration costs as follows for sheetings shown to be unsatisfactory during.

i) The entire seven years the sign manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

ii) 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 Contractor placing his order.

13.2.3 Metal Posts

Wide flange of 10 x 10 centimeters metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A 283 Grade D.

In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty-three (63) mm and seventy-five (75) mm respectively conforming to the specifications of ASTM A 501.

All posts shall be thoroughly cleaned, free from grease, scale & rust and shall be given one coat of rust inhibitive priming paint and two coats of gray 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 one hundred eighty (180) cm above shoulder level.

13.2.4 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 a half ($37^1/_2$) mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

b) The High Intensity Grade sheeting for the background should cover the whole area of the sign plate.

c) Prior to application of the High Intensity Grade reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by 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.

13.2.5 Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized quality ten (10) mm dia galvanized iron or aluminium alloy. The bolt heads to be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanized according to ASTM A 153.

13.2.6 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.

13.2.7 Caps over the pipes

These can be of heavy plastic or of aluminium well fitted so that they cannot be removed; any good adhesive can be used.

13.2.8 General

a) Very large signs need not be made of one piece; in that case extruded Aluminium panels shall be used or the various pieces of sheet shall be joined by angle-irons in non-corrosive materials and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded in the concrete as directed by the Engineer.

b) All the nuts and bolts and metal washers must be heavily galvanized or may be of stainless steel of high quality.

c) Relevant holes to receive ten (10) mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.

d) After the plates are fixed with nuts and bolts, the nuts shall be tack welded to the bolts as a safety measure against pilferage.

13.2.9 Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ Class A_1 in accordance with Item 401.1.1 and shall of the size 450 x 450 x 650 mm for category 1 & 2 and 600 x 600 x 750 mm or as shown on the Drawings or as directed by the Engineer for category 3.

13.2.10 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, chevroflex etc. and will be manufactured from highly durable tough plastic material withstanding vehicular impact. These shall be of High Intensity Grade reflective sheeting for maximum visibility by both day and night and consequently be resistant to impact, damage and vandalism.

13.3 CONSTRUCTION REQUIREMENTS

13.3.1 Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawings.

Backfilling around precast foundation blocks shall be carried out by using the surplus excavated material if approved by the Engineer and shall be compacted in layers not exceeding fifteen (15) cm in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer.

Concrete shall be placed against the undisturbed excavated faces, except that the top fifteen (15) cm of each footing shall be formed. Forming of the entire footing will not be permitted unless approved by the Engineer. Concrete shall be thoroughly rodded and spaded so as to eliminate all voids. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger.

Backfill shall be thoroughly compacted by mechanical tampers, and care taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished ground line. Pipe post bases and/or posts set in concrete shall be firmly supported, plumb, vertical and at the proper elevation.

In case precast concrete foundations are used, these shall be of the concrete Class A_1 and of the sizes as shown on the Drawings.

13.3.2 Erection of Posts

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting

process of the concrete. The posts shall be located at the positions shown on the Drawings.

13.3.3 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.

13.3.4 Categories of Signs

Traffic road signs shall be of three categories according to type of construction the Drawings.

a) Warning Sign

Constructed with single post and sign of equilateral triangle shape, as shown in, category 1.

b) Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the Drawings, category 2.

c) Informatory Signs

These signs shall be rectangular in shape and constructed with one, two or three numbers of posts or as shown on the Drawings. Dimensions may vary according to the requirements, however total area of sign shall be as under:

Category 3 a = One (1) sq m
Category 3 b = Two (2) sq m
Category 3 c = As shown on the Drawings

d) Additional Panel

If any panel is required to be installed, it shall be of the sizes 60x30 cm or 90x30 cm.

13.3.5 Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed portable safety barriers and hazard markers e.g. verge-master, flex-master

chevroflex, bigmax, edgemaster and passing place post and other etc., shall be installed in accordance with the techniques and methods laid down in the manufacturer's manual or guide and in conformity to the line and level and locations shown on the Drawings or as directed by the Engineer to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

13.3.6 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:

i) The Urdu writing shall be in "Persian" character.
ii) The Urdu and English writing shall be about the same in length, width and spacing.
iii) English letters are to be in "smalls" except the first letter of the word, which is to be in "capitals".
iv) The size and spacing for Urdu letters and words will generally conform to the dimensions shown herein for English letters.
v) The spellings of names of places, in Urdu and in English, shall be as written in the maps of Survey of Pakistan.

vi)	Height of "capital" letters	21 cm
vii)	Height of "small" letters	17 cm
viii)	Stroke Width and Width of border	3.5 cm
ix)	Space between words and border (at least)	5 cm
x)	Space between words	5 cm
xi)	Space one line will occupy	4 cm
xii)	Space between digits of numerals	4 cm
xiii)	Height of numerals same as capital letters	23 cm
xiv)	Space between lines (at least)	5 cm
xv)	Height of letters for "Km"	K-23 cm m-8 cm
xvi)	Width of letters for "Km" including spacing	K-8 cm m-9.6 cm
xvii)	Width of dividing line	2.0 cm

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 spellings shall be as written in the maps of Survey of Pakistan or as provided by the Engineer. Size and style of

lettering shall be as shown on the plans or as otherwise approved by the Engineer.

13.4 MEASUREMENT AND PAYMENT

13.4.1 Measurement

The unit of measurement for signs shall be measured by the linear foot along the front face of the section at the finished grade elevation. Measurement will not include any area in excess of those shown on the Drawings except for any area authorized by the Engineer in writing.

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 and placing all materials for concrete, for reinforcing steel if required on the Drawings for expansion joints, material, form for drainage opening, excavation, backfilling and dumping and disposal of surplus material and for all labor, equipment, tool and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement

Ch. # 18 Item # 25/(a/i) Providing, fabrication and fixing pole mounted Direction Board / road delineator of any shape and size, with pecified Sheet and thickness, supported with G.I Channel, (excluding the cost of vertical post and painting) etc complete in all respect. (a) RECTANGULAR SHAPE (i) 12-48 sft unit of measurement is Sq.foot

Ch. 18/38 a (i) "Providing and fixing Full width Gantry comprising of 3 mm thick GI sheet (Z-275) fixed over double front and back truss made with Top & bottom chords of MSangle 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 350x150x15 mm thick MS sheet for each column fixed in prelaid RCC footing i/c the cost of polyurethene Paint to MS skeleton but excluding the cost of lettering/printing as approved and directed by the Engineer Incharge a (i) Two Supports"unit of measurement is Sq.foot

Ch. # 13 Item # 36/(ii) Painting Traffic Lane Marking of specified width (1.5mm thick), with Thermoplastic (TP) Paint including Glass Beads, complete in all respect, as approved and directed by Engineer incharge (ii) 6"

14.1 DESCRIPTION

This work shall consist of furnishing non-reflective or reflective chlorinated rubber based or thermoplastic paint material or retroreflective preformed pavement marking (tape) whichever is called for in the Specifications and shown in the Bill of Quantities, for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications.

The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings.

14.2 CHLORINATED RUBBER PAINT

14.2.1 Material Requirements

A standard and acceptable quality of Chlorinated Rubber based paint shall be used. The paint shall be ready for application and shall be of a smooth quality. The paint shall be homogeneous, well dispersed to a smooth consistency and shall not cake, liver, thicken, curdle, gel, settle badly or show any objectionable properties after period of storage not to exceed six (6) months.

Composition

a) White Traffic Paint

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 % by Weight
	Vehicle, Solvent and Additives	45±5 % by Weight

b) Yellow Traffic Paint

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

c) Black Traffic Paint

i) Pigment:	Chrome Black and Extenders	100 % by Weight
ii) Vehicle:	Same as for white traffic paint	
iii) Paint Composition:	Pigments	55±4 % by Weight
	Vehicle	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.

14.2.1.1 Ballotini for Reflective Road Paint

The grading of ballotini dispersed in the paint shall be as follows:

Sieve Sizes	Percentage Retained
No. 12	0
No. 20	30
No. 30	50
No. 50	80
No. 80	100

Glass beads shall conform with AASHTO M 247. At least ninety (90) % glass beads shall be transparent, reasonably spherical and free from flaws.

The proportion of ballotini to paint shall be not less than five hundred (500) gm/ liter of paint.

14.2.2 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-tenths (0.2) degree and one-half (1/2) degree divergence expressed as candle power per meter per square meter of surface coating, as follows:

		Color			
		White		Yellow	
Divergence Angle	4 (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

14.2.3 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 film.

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 ten (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 a half ($2^1/_2$) sq m or less. The Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

14.3 HOT-APPLIED THERMOPLASTIC ROAD PAINTS

14.3.1 Material Requirements

14.3.1.1 Aggregate

The aggregate shall consist of light colored silica sand, calcite, quartz, calcined flint or other material approved by the Engineer.

14.3.1.2 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 these Specifications.

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 608-1.

TABLE 608-1

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	78	82
Extender and ballotini		

* For titanium dioxide only. No minimum is specified for yellow material.

Where specified, ten (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 608-2.

TABLE 608-2

GRADING OF COMBINED AGGREGATE, PIGMENT, EXTENDER AND BALLOTINI

Sieve	Percentage by mass passing Sprayed
2.80 mm	100
600 λm	75~95

14.3.2 Sampling and Testing

14.3.2.1 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.

a) At the manufacturer's plant.

b) After it has been re-melted by the road application contractor.

14.3.2.2 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 the following properties:

a) Softening Point

The softening point measured in accordance with appendix C shall be not less than 65 °C.

b) Color and Luminance

i) 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 seventy (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 sixty-five (65).

ii) Yellow Material

The Color of yellow material shall be approximately BS 381 C Color No. 355, Lemon. The luminance factor of yellow material as delivered by the manufacturer shall be not less than sixty (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 fifty-five (55).

c) Heat Stability

i) 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 sixty-five (65).

ii) 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 that fifty-five (55).

d) Flow Resistance

In testing the flow resistance, a cone made and tested in accordance with appendix F, shall not slump by more than twenty-five (25) %.

e) 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 forty-five (45).

14.3.3 Manufacturing, Packing and Storing of Paint

14.3.3.1 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.

14.3.3.2 Packing

a) The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination.

b) Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorisation (if applicable), color, chemical type of binder and maximum safe heating temperature.

c) Packing shall be not less than twenty-five (25) kg or more than one hundred (100) kg.

14.3.3.3 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.

14.3.4 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.

14.3.5 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 five (5) °C.

b) Preparation of Material on Site

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating will be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastic material, which has natural resin binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than four (4) hours.

i) 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.

ii) 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

i) Carriageway center 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.

ii) The road surface shall be dry and free from loose detritus, mud and other extraneous matter. Where old paint or thermoplastic material are present, the Contractor shall be responsible, if required, for removal of that paint to make the surface suitable.

iii) The drying time shall be not more than ten (10) minutes, in the laboratory test, (AASHTO M 249).

iv) The spray plastic shall be used at temperatures between two hundred eleven (211) and two hundred twenty-five (225) °C.

v) In addition, the glass beads included in the material a further quantity of glass beads shall be sprayed onto the hot spray plastic line at the time of application and shall be approximately four hundred (400) to five hundred (500) gm/sq m. The application should be pressurized.

vi) The finished lines shall be free from ruggedness on sides and ends and be in true plane with the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks and cracks.

d) Reflectorisation by Surface Application

When surface application of ballotini is required, additional ballotini (400 to 500 g/sq m 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 ballotini so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

Ballotini dispensed on the surface of the markings shall conform to the following grading:

Sieve	Percentage by mass passing
1.7 mm	100
600 λm	80~100
425 λm	45~100
300 λm	10~45
212 λm	0~25
75 λm	0~5

Not less than ninety (90) % by mass of the ballotini, shall be of transparent glass, spherical in shape and not more then ten (10) % shall be oval 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:

i) Sprayed lines other than yellow. Not less than 1.5 mm.

ii) Sprayed yellow edge lines not less than 0.8 mm.

The minimum thicknesses specified are exclusive of surface applied ballotini. The method of thickness measurement shall be in accordance with appendix H of BS 3262 (1976).

14.3.6 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.

14.5 MEASUREMENT AND PAYMENT

14.5.1 Measurement

The quantity of pavement marking of lines of specified widths in paint shall be measured by linear feet. The quantity of pavement marking of arrows of specified length in paint shall be measured by numbers. The quantity of pavement marking for various signs in paint shall be measured in square meters.
The quantity of retroreflective preformed pavement markings (tape) shall be measured in square meters.

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 at the Contractor's expense.

14.5.2 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 and placing all materials including sampling, packing and testing at approved laboratory, preparation of the surface and for all other costs necessary to complete the work as prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch.13 Item 36	**Painting Traffic Lane Marking of specified width (1.5mm thick), with Thermoplastic (TP) Paint including Glass Beads, complete in all respect, as approved and directed by Engineer incharge (ii) 6" payable unit is Rft**	

Ch. 18/12 (ii) Cold milling of asphalt layer/concrete surface of specified thickness,loading of debris onto haul trucks via conveyor system and disposal at appropriate place i/c the charges of self propelled milling machine of specified size, dumper, pump, water lorry, compressor and Tungsten Carbide Bits etc complete in all respect as approved by Engineer Incharge iv) 0 ~ 2" thick

And

Ch. 18/12 (iv) Cold milling of asphalt layer/concrete surface of specified thickness,loading of debris onto haul trucks via conveyor system and disposal at appropriate place i/c the charges of self propelled milling machine of specified size, dumper, pump, water lorry, compressor and Tungsten Carbide Bits etc complete in all respect as approved by Engineer Incharge iv) 0 ~ 4" thick

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15.1 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.

15.2 CONSTRUCTION REQUIREMENTS

Specialized equipment to be used for this item of work shall be capable of following operations:

a) 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.

b) Level and grade control shall be ensured through electronic sensors, capable of giving an accuracy of plus or minus two ($\pm$2) mm.

c) Scraper bars and belt conveyor system shall ensure picking and loading of milled material in a truck.

15.2.1 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.

15.3 MEASUREMENT AND PAYMENT

15.3.1 Measurement

The quantity of cold milling to be paid shall be measured by the number of square feet of area milled and cleaned as described above, as per Drawings or as directed by the Engineer. No allowance will be given for milling out side the approved limit. Any such area milled beyond approved limits, shall be reinstated by the Contractor at his own expense.

15.3.2 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, equipment and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. 18/12 (ii)	Cold milling of asphalt layer/concrete surface of specified thickness,loading of debris onto haul trucks via conveyor system and disposal at appropriate place i/c the charges of self-propelled milling machine of specified size, dumper, pump, water lorry, compressor and Tungsten Carbide Bits etc complete in all respect as approved by Engineer Incharge iv) 0 ~ 2" thick	payable unit is Sq.feet

And

Ch. 18/12 (iv) Cold milling of asphalt layer/concrete surface of specified thickness,loading of debris onto haul trucks via conveyor system and disposal at appropriate place i/c the charges of self-propelled milling machine of specified size, dumper, pump, water lorry, compressor and Tungsten Carbide Bits etc complete in all respect as approved by Engineer Incharge iv) 0 ~ 4" thick payable unit is Sq.feet

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Ch. 18/28 A (iii) **Providing & fixing Cat Eyes of size 4" x 4" x 3/4" duly casted with specified material having plastic strip containing mini retro-reflective glass beads of color white/red/yellow having specifid reflections , quality & shape i/c the cost of self built in 12 mm diax120 mm long steel zinc plated nail,fixing to road with epoxy/ hammering with separate nail complete. (A) Dual-Directional (iii) Micro Cube Corner Spark glow reflectors**

16.1 **DESCRIPTION**

This item shall consist of furnishing and installing reflectorised 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.

16.2 **MATERIAL REQUIREMENTS**

16.2.1 **Reflectorised Studs**

Reflectorised 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' studs shall be the short base type having a maximum base area of IS cm x 14 cm or as shown on the Drawings.

The base shall be formed in cast-iron with adequate webbing to ensure a firm key to the road when installed.

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated life of at least five (5) years. The pad shall be so designed as to produce a self whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass and shall be hermetically sealed into a copper socket.

i) Photometric Requirements

The reflectors shall have the following minimum Specific Intensity values, at 0.2° Divergence Angle, expressed as candlepower per foot candle of illumination at the reflector on a plane perpendicular to the incident light:

	COLOR

	Crystal	Yellow	Red
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 a half ($1^1/_2$) m from a uniformly bright light source having an effective diameter of one-half (1/2) cm.

The width of the photocell shall be one decimal two seven (1.27) cm and shall be shielded from stray light. The distance from the centers of the light source and photocell shall be decimal five three (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 studs shall support a vertical load of one thousand (1,000) kg when tested such that the studs is centered horizontally over the open end of a vertically positioned hollow metal cylinder seventy-five (75) mm internal diameter, twenty-five (25) mm high having six (6) mm thick wall. The load shall be applied to the top of the studs through a six (6) mm diameter by six (6) mm high metal plug centered on top of the studs.

Breakage or significant deformation of the marker at any load less than one thousand (1,000) kg shall constitute failure.

16.2.2 Adhesive

When 'Raised Profile' type of studs are used, a two-part adhesive having the following ingredients shall be applied to the stud for bonding to the pavement surface:

Package A	**kg/litre**
Epoxy Resin	0.94
Titanium Dioxide	0.07
Colloidal Silica	0.05
Talc	0.345

Package B	**kg/litre**
Modified Asphaltic Amine Hardener (Reinchold 2611)	0.24
Modified Asphaltic Amine Hardener (Reinchold 2613)	0.472
Carbon Black	0.0022
Colloidal Silica	0.04

Talc 0.650

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.

16.2.3 Cement Mortar

Cement mortar shall consist of one (1) part Portland cement to three (3) parts of fine aggregates.

16.3 CONSTRUCTION REQUIREMENTS

16.3.1 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:

a) Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one (1) cm around the stud base. The longitudinal center line axis of the cavity shall be the same as that required for the pavement stud when laid to correct line and direction.

b) 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.

c) 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.

d) The depth of the cavity shall be such that when the stud base and reflectors have been installed the elevation of the floor of the lens socket shall not be greater than two (2) mm or less than one (1) mm above the pavement surface.

e) The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in Item 609.2.3 above when the studs are installed into a cement concrete pavement.

16.4 MEASUREMENT AND PAYMENT

16.4.1 Measurement

The quantity of reflectorised pavement studs to be paid for shall be the number of 'Flushed Surface' type provided and installed as mentioned above.

16.4.2 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 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 prescribed in this item:

Pay Item No	Description	Unit of Measurement
Ch. 18/28 a (iii)	Providing & fixing Cat Eyes of size 4" x 4" x 3/4" duly casted with specified material having plastic strip containing mini retro-reflective glass beads of color white/red/yellow having specifid reflections , quality & shape i/c the cost of self built in 12 mm diax120 mm long steel zinc plated nail,fixing to road with epoxy/ hammering with separate nail complete. **(A) Dual-Directional (iii) Micro Cube Corner Spark glow reflectors**	Each

Ch. 4/20 Dismantling cement concrete reinforced, separating reinforcement from concrete,cleaning and straightening the same.
Ch. 4/19 c "Dismantling cement concrete plain c) Dismantling cement concrete 1:2:4 plain."
Ch. 4/13 Dismantling brick work in lime or cement mortar.

Ch. 4/8 (a) Dismantling in lime or cement mortar. (a) Cement Concrete Plain 1:4:8

16.1 DESCRIPTION

This work shall consist of dismantling, removal, wholly or in part and satisfactory disposal of broken material from buildings, fences, bridges, culverts, drainage facilities at different locations and any other obstructions which are not designated or permitted to remain on those sections of existing highways except for the obstructions to be removed and disposed of under other items in the Contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, pits and ditches.

16.2 CONSTRUCTION REQUIREMENTS

General

Engineer shall specify the extent of dismantling for each structure and the Contractor shall raze, remove and dispose of all remains of all those dismantled structures and other obstructions any portion of which are on the right of way, except utilities and those for which other provisions have been made for removal. All designated useable material shall be removed, without unnecessary damage, in sections or pieces, which may be readily transported, and shall be stored by the Contractor at specified places within the Project limits. Unusable perishable material shall be destroyed. Non-perishable material may be disposed of outside the limits of view from the project with written permissions of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by structural removal shall be filled to the level of the surrounding ground and, if within the prism of construction shall be compacted to the required degree of compaction designated on the plans of road design.

Salvaged pipe culverts or other structures shall be stored at designated and accessible points on the project as approved by the Engineer and shall be the property of the Employer. Dismantling shall be carried out either manually or with approved equipments. Structures to be dismantled may include plain or reinforced concrete, brick, stone masonry or any other such construction item.

16.2.1 Removal of Culverts and other Drainage Structures

Concrete culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. Unless otherwise directed, the sub-structures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed thirty (30) cm below ground surface. Where such portions of existing structures are wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure. Steel bridges and wood bridges as designated on the plans, shall be carefully dismantled without unnecessary damage. Steel members shall be match marked, unless such match marking is waived by the Engineer. All salvaged material shall be stored as previously specified.

Blasting or other operations necessary for the removal or dismantling of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work.
Removal of Pipes

Unless otherwise directed all pipes shall be carefully removed and every

precaution taken to avoid breaking or damaging the pipe. The Contractor shall be held responsible for the satisfactory removal of such structures in a usable condition. In case these provisions are violated, due to the Contractor's negligence, all material to be salvaged which is damaged in dismantling / removal to impair its future use will be charged to the Contractor at sixty (60) % of the current quoted price, delivered to the project, of an equal amount of new material. This amount of money shall be deducted from any money due or to become due to the Contractor.

Fences, Boulders, Stone Piles

Stones, fences, piles of stones or boulders of size greater than one-quarter (1/4) cu m in volume which lie within the limits of the work as shown on the plans or which fall within the approved cross sections shall be removed and disposed of as directed by the Engineer.

When fences enclosing pasture land or farm land are to be removed, the Contractor shall notify the property owner sufficiently in advance to permit the owner reasonable time to construct supplemental fences or make other arrangements.

MEASUREMENT AND PAYMENT

Measurement

The quantity of dismantling the structure to be paid for shall be measured in cubic feet of structure dismantled. All such measurements shall be agreed by the Engineer and the Contractor before the dismantling work starts. Necessary shop drawings will be prepared by the Contractor for such purpose.

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 dismantling, removal and disposal of material as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. 4/20	Dismantling cement concrete reinforced, separating reinforcement from concrete,cleaning and straightening the same	unit of measurement is 100 Cft
Ch. 4/19 c	"Dismantling cement concrete plain c) Dismantling cement concrete 1:2:4 plain."	unit of measurement is 100 Cft

Ch. 4/13 Dismantling brick work in lime or cement mortar. unit of measurement is 100 Cft
Ch. 4/8 (a) Dismantling in lime or cement mortar. (a) Cement Concrete Plain 1:4:8 unit of measurement is 100 Cft

Ch. # 04 Item # 46 & Ch # 03 Item # (a, b, c) **Dismantling and removing road pavement, etc., including screening and stacking of byproducts up to one chain lead (30 meter). (With Transportation)**

17.1 DESCRIPTION

This work shall consist of dismantling, removal, wholly or in part and satisfactory disposal of broken material from road pavement surface at different locations and any other obstructions which are not designated or permitted to remain on those sections of existing highways except for the obstructions to be removed and disposed of under other items in the Contract. It shall also include the salvaging of designated materials and backfilling the resulting trenches, holes, pits and ditches.

17.2 CONSTRUCTION REQUIREMENTS

General

Engineer shall specify the extent of dismantling for road structure pavement and the Contractor shall raze, remove and dispose of all remains of all those dismantled material and other obstructions any portion of which are on the right of way, except utilities and those for which other provisions have been made for removal. All designated useable material shall be removed, without unnecessary damage, in sections or pieces, which may be readily transported, and shall be stored by the Contractor at specified places within the Project limits. Unusable perishable material shall be destroyed. Non-perishable material may be disposed of outside the limits of view from the project with written permissions of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by structural removal shall be filled to the level of the surrounding ground and, if within the prism of construction shall be compacted to the required degree of compaction designated on the plans of road design.

17.2.3 Fences, Boulders, Stone Piles

Stones, fences, piles of stones or boulders of size greater than one-quarter (1/4) cu m in volume which lie within the limits of the work as shown on the plans or

which fall within the approved cross sections shall be removed and disposed of as directed by the Engineer.

When fences enclosing pastureland or farmland are to be removed, the Contractor shall notify the property owner sufficiently in advance to permit the owner reasonable time to construct supplemental fences or make other arrangements.

17.3 MEASUREMENT AND PAYMENT

17.3.1 Measurement

The quantity of dismantling the structure to be paid for shall be measured in cubic foot of structure dismantled. All such measurements shall be agreed by the Engineer and the Contractor before the dismantling work starts. Necessary shop drawings will be prepared by the Contractor for such purpose.

17.3.2 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 dismantling, removal and disposal of material as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. # 04 Item # 46 & Ch # 03 Item # (a, b, c)	Dismantling and removing road pavement, etc., including screening and stacking of byproducts upto one chain lead (30 metre). (With Transportation) unit of measurement is 100 Cft.	

ALL CONCRETE WORK OF THE PROJECT

18.1 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.

18.1.1 CLASSES OF CONCRETE

The classes of concrete recognized in these Specifications shall be designated: ratios concrete (1:2:4), (1:3:6), (1:1.5:3) and Lean Concrete (1:4:8). 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 ratios concrete (1:2:4) shall be used everywhere, for non-reinforced and reinforced concrete structures, except as noted below or directed by the Engineer. Concrete placed (1:1.5:3) drain for outlet the carriageway water from road to drain.
(1:3:6) concrete shall be used only where specified as per drawings.

Lean Concrete (1:4:8) shall be used under drain directed by the Engineer or specified in the Special Provisions or on the Drawings.

The concrete of the various classes shall satisfy the requirements shown in Table 401-1.

TABLE 401-1
Portland Cement Concrete Requirements

Ratio of Concrete	Min Cement kg/m^3	Max Size of Coarse Aggregate (mm)	28 days' Compressive Strength (min) (Cylinder) (kg/cm^2)	Consistency (Range in Slump) Vibrated (mm)	Maximum Permissible Water-Cement Ratio
(1:2:4)	300	50	210	25~75	0.58
(1:1.5:3)	400	38	280	100~150	0.58
(1:3:6)	250	38	170	25~75	0.65
Lean Concrete	175	51	100	-	-

18.1.2 TYPE OF CONCRETE WORKS

On Ground Concrete

Concrete poured by erecting formwork with necessary bracings on ground.

18.2 MATERIAL REQUIREMENTS

18.2.1 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.

18.2.2 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:

GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight
3 / 8 inch	100
No. 4	95~100
No. 16	45~85
No. 50	10~30
No. 100	2~10
No. 200	0~3

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 Item 401.3.9 of these Specifications.

18.2.3 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 401-2 and when tested in accordance with AASHTO T 11 & T 27 shall meet the following grading requirements.

TABLE 401-2
GRADING OF COARSE AGGREGATES

Designated Sizes	Percentage by Weight Passing Laboratory Sieves, 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 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 Item 401.3.9 of these Specifications.

The aggregate shall be non-alkali/silica reactive where the concrete is to be poured under water or exposed to humid conditions. 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 under take to carry out the job with out any extra cost and shall arrange to conduct the necessary tests as directed by the Engineer.

18.2.4 Combined Aggregate

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

18.2.5 Rubble or Cyclopean Concrete

Rubble or cyclopean concrete shall consist of tough, sound and durable rock. The stone shall be free from coatings, seams, or flaws of any character. In general, the percentage of wear shall not exceed fifty (50) when tested in accordance with the Standard Method of Testing for Abrasion of Coarse Aggregate by the use of the “Los Angeles Machine”, ASTM C 535.

18.2.6 Storage of Cement and Aggregates

a) All cement shall be stored, immediately upon arrival on the site of the work, in weather-proof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity of a sufficient quantity of cement for at least thirty (30) days' use. Bulk cement, if used, shall be transferred to elevated air tight and 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 recleaning and as approved by the Engineer.

18.2.7 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.

18.2.8 Admixtures

Admixtures shall only be allowed to be used with written permission from the Engineer. If air-entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer or permitted by the Engineer and shall conform to the requirements for each of the agents specified by the manufacturer or as directed by the Engineer.

18.3 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.

18.3.1 Proportioning of Concrete

All concrete shall be proportioned by weighing, except as specified herein. The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and consistency shall be approved by the Engineer. Such approval may be withdrawn at any time and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various 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 401.3.10 "Testing of Compressive Strength". Adjustment of the proportions shall be subject to the following provisions:

a) Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportions originally approved, the Engineer shall make such changes as are necessary.

b) Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes.

The Contractor's attention is drawn to the time required to prepare and test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is not delayed.

18.3.2 Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be determined to be as dry as it is practicable to satisfy the requirements for transportation and placing of the concrete as described hereinafter.
Consistency of concrete shall be determined as specified in AASHTO T 119. The Consistency of concrete at the time of delivery shall be as shown in Table 401.1 or as designated by the Engineer.

18.3.3 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.

a) 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.

b) 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.

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.

18.3.4 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 rehandling 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.

18.3.5 Handling and Placing Concrete

a) General

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork and struts, stays and braces serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their services unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used that does not reach its final position in the forms within the time stipulated above under Item "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, 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.

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 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 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.

18.3.6 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 in the succeeding layer. Work shall not be discontinued within fifty (50) cm of the top of any face, unless provision has been made for a coping less than fifty (50) cm 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) Side drain of Brick Maonary

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.

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.

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.

i) 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.

iv) 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.

18.3.7 Concrete Surface Finishing/Rendering

a) General

Concrete surface finishes shall be classified as follows:

Bridge Deck Surface Finish

Sidewalk Surface Finish
Ordinary Surface Form Finish
Class 1 Surface Form Finish

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) Sidewalk Surface Finish

After the concrete has been placed it shall be compacted and the concrete shall be struck off by means of a strike board, floated with a wooden or cork floating and finished with a broom. An approved edging tool shall be used on all edges and at all expansion joints. Brooming shall be transverse to the line of traffic and if water is necessary, it shall be applied to the surface immediately in advance of brooming. The surface shall not vary more than six (6) mm under a three (3)-meter straightedge and the finished surface shall be free of blemishes

ii) 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.

iii) 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:

i) All form finish surfaces of bridge super-structures, except the under surfaces between girders.

ii) All surfaces of bridge piers, columns and abutments, and retaining walls above finished ground and to at least three-tenths (0.3) m below finished ground.

iii) 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.

18.3.8 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 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 fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface.

All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.

The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within seventy-two (72) hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of sheets, which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used.

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 this Item "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 precasting 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.

18.3.9 Testing of Aggregates

Samples of fine and coarse aggregate to be used shall be selected by the Engineer. It shall be the responsibility of the Contractor to designate the source

or sources of aggregate and to obtain the necessary samples and submit them for testing at least thirty (30) days before actual concreting operations are to begin.

Samples of aggregates shall be obtained and tested in accordance with the following standard AASHTO methods:

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 (Morta-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.

18.3.10 Testing of Compressive Strength

Concrete compressive strength requirements consist of a minimum strength at the age of twenty-eight (28) days and the minimum strength that must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 401-1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with AASHTO T 23 and 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 bf 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 a 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. Further more 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.

18.4 MEASUREMENT AND PAYMENT

18.4.1 Measurement

The quantity of concrete to be paid for shall be the number of cubic feet of 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.

The measurement shall not include any concrete used in the construction of cofferdams or falsework.

The volume involved in fillets, scorings, or chamfers ten (10) sq cm 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.

18.4.2 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 item except works that are paid for under other pay items:

Pay Item No.	Description	Unit of Measurement

6/5 (h)	Cement concrete plain including placing, compacting, finishing and curing complete (including screening and washing of stone aggregate): (h) Ratio 1: 3: 6	100Cft
6/6	(a) (i) Rei nf orced cement concret e i n roof sl ab, beams, columns lintels, girders and other structural members laid in situ or precast laid in position, or prestressed members cast in situ, complete in all respects:- (3) Type C (nominal mix 1: 2: 4)	Per.Cft
Ch. 6/5(i)	Cement concrete plain including placing, compacting, finishing and curing complete (including screening and washing of stone aggregate): **(i) Ratio 1: 4: 8**	100Cft
Ch. 18/17	Providing and laying expansion joint of neoprine strip 4"x¼" (100 mmx 6 mm) and plastic bitumen	Rft
Ch. # 06 Item # 05/(F)	Cement concrete plain including placing, compacting, finishing and curing complete (including screening and washing of stone aggregate): (f) Ratio 1: 2: 4	100Cft

Chap-21/15 Providing and fixing 6"(150mm) thick R.C.C manhole cover 550mm (22") i/c C.I frame weighing 37.324 Kg as per standard drawing STD/PD No. 6 of 1977complete in all respects.

19.1 DESCRIPTION

This work shall consist of RCC manhole, cover which will be replaced by contractor and payment will be made to contractor as per stated in this item specification,

19.2 CONSTRUCTION REQUIREMENTS

Engineer shall satisfy as per STD/PD No 6 of 1977, 150mm thick RCC cover 550mm including C.I frame weighing 37.324 Kg to complete with all respect to carry out the work.

19.3 MEASUREMENT AND PAYMENT

19.3.1 Measurement

The quantity of shall be measured in per Set.

19.3.2 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 concrete cover of manhole as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Chap-21/15	Providing and fixing 6"(150mm) thick R.C.C manhole cover 550mm (22") i/c C.I frame weighing 37.324 Kg as per standard drawing STD/PD No. 6 of 1977complete in all respects.	Per Set

Ch. 10 Item 41c "Providing and laying Tuff pavers, having 7000 PSI ,crushing strength of approved manufacturer, over 2"" to 3"" sand cushion i /c grouting with sand in joints i/c finishing to require slope. Complete in all respect. (50% Grey / 50% Coloured) c) 80-mm thick "

20.1 DESCRIPTION

This work shall consist of pre cast Tuff paver which will be placed by contractor and payment will be made to contractor as per stated in this item specification,

20.2 CONSTRUCTION REQUIREMENTS

Engineer shall satisfy as per STD/PD No 6 of 1977, 75mm thick sand cushion including 80mm thick Tuff pavers and 700 PSI compressive strength to complete with all respect to carry out the work.

20.3 MEASUREMENT AND PAYMENT

20.3.1 Measurement

The quantity of shall be measured in Sq feet.

20.3.2 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 concrete cover of manhole as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. 10 Item 41c	Providing and laying Tuff pavers, having 7000 PSI ,crushing strength of approved manufacturer, over 2" to 3" sand cushion i /c grouting with sand in joints i/c finishing to require slope. Complete in all respect. (50% Grey / 50% Coloured) c) 80-mm thick	Per Sft

Ch. 23/23 Providing, laying, cutting, jointing, testing and disinfecting G.I. pipeline in trenches, with socket joints, using G.I. pipes of B.S.S. 1387-1967 complete in all respects, with specials and valves. iii) Heavy Quality (i) 4" i/d (100 mm) 5.4mm thick

20.1 DESCRIPTION

This work shall consist of G.I. pipe which will be placed by contractor and payment will be made to contractor as per stated in this item specification,

20.2 CONSTRUCTION REQUIREMENTS

Engineer shall satisfy as per Providing, laying, cutting, jointing, testing and disinfecting G.I. pipeline in trenches, with socket joints, using G.I. pipes of B.S.S. 1387-1967 complete in all respects, with specials and valves. iii) Heavy Quality (i) 4" i/d (100 mm) 5.4mm thick to complete with all respect to carry out the work.

20.3 MEASUREMENT AND PAYMENT

20.3.1 Measurement

The quantity of shall be measured in Rft.

20.3.2 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 concrete cover of manhole as directed by the Engineer, labor, equipments, tools and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. 23/23	Providing, laying, cutting, jointing, testing and disinfecting G.I. pipeline in trenches, with socket joints, using G.I.pipes of B.S.S. 1387-1967 complete in all respects, with specials and valves. iii) Heavy Quality (i) 4" i/d (100 mm) 5.4mm thick	Rft

ITEM 21 STEEL REINFORCEMENT

21.1 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.

21.2 MATERIAL REQUIREMENTS

All materials shall conform to the requirements hereinafter given. Test reports from approved sources shall be submitted to the Engineer for all steel reinforcement used. These reports shall show the results of chemical and physical tests made.

a) Deformed Billet Steel Bars (Grades 40 and 60) for Concrete Reinforcement-AASHTO M 31 (ASTM A 615)

b) Deformed Steel Wire for Concrete Reinforcement-AASHTO M 225 (ASTM A 496)

c) Welded Steel Wire Fabric for Concrete Reinforcement-AASHTO M 55 (ASTM A 185)

d) Steel Bar Mats for Concrete Reinforcement-AASHTO M 54 (ASTM A 184)

e) Cold-Drawn Steel Wire for Concrete Reinforcement-AASHTO M 32 (ASTM A 82)

f) Welded Deformed Steel Wire Fabric for Concrete Reinforcement-AASHTO M 221 (ASTM A 497)

g) Structural Shapes for Concrete Reinforcement ASTM A 36

21.3 CONSTRUCTION REQUIREMENTS

21.3.1 Fabrication of Bent Bars

a) Order Lists

Before materials are ordered all order lists and 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 $d \leq 1.6$ cm (5/8", No. 5 bar) — $D = 4 \times d$

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≥3.5 cm ($1^3/_8$", No. 11 bar)	D = 10 x d

For deformed bars grade 60, bending will be made only mechanically.

21.3.2 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 approved metal chairs or bolsters.

Any broken or damaged concrete spacer blocks shall be removed before concrete is placed. The use of pebbles, pieces of broken stone or brick, metal pipe or wooden blocks as spacers will not be permitted. Reinforcing steel when placed in the work shall be free from flake rust, dirt and foreign material and before any concrete is placed, any mortar that may be adhering to the reinforcing steel shall be removed. No concrete shall be deposited until the Engineer has inspected the placing of the reinforcing steel and given permission

to place the concrete. The Contractor shall allow the Engineer four hours time after the reinforcement and forms are in place to conduct the inspection. Any bar of incorrect size, length or shape shall be removed and replaced with correct bars. Any bar located or spaced incorrectly shall be relocated or spaced correctly before permission is given to place concrete and such replacements and corrections shall be at the Contractor's expense. All concrete placed in violation of these provisions shall be rejected and removed.

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. If approved by the Engineer, the cost of couplers shall be borne by the Contractor, but quantities of steel for payment in Pay Item 404 a will include splices by overlapping.

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 ($1^1/_3$) the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and one half ($1^1/_2$) turns or by butt welding unless otherwise shown on the Drawings.

d) Lapping of Bar-Mat

Sheet of mesh or bar-mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one mesh in width.

e) Covering

The minimum covering, Measured from the surface of the concrete to the face of any reinforcement bar shall, unless otherwise shown on the Drawings or directed by the Engineer, be not less than five (5) cm except as follows:

Top of slab	4.0 cm
Bottom of slab	3.0 cm
Stirrups and ties in T-beams	3.5 cm

In the footings of abutments and retaining walls the minimum covering shall be seven and a half ($7^1/_2$) cm. In work exposed to the action of sea water the minimum covering shall be ten (10) cm.

21.4 MEASUREMENT AND PAYMENT

21.4.1 Measurement

The quantity to be paid for shall be the calculated theoretical number of 100 Kgs of reinforcement steel bars, mesh or mats as determined from the approved bar bending diagrams and incorporated in the concrete and accepted, except when reinforcement is paid for under other pay items.

The weight of plain or deformed bars or bar mat will be computed from the theoretical weight of plain round bars of the same nominal size as shown in the following tabulation:

ASTM Designation	Weight kg/m	ASTM Designation	Weight kg/m
2	0.249	8	3.973
3	0.560	9	5.095
4	0.994	10	6.403
5	1.552	11	7.906
6	2.235	12	8.941
7	3.042	-	-

Clips, ties separators and other material used for positioning and fastening the reinforcement in place and structural steel shall not be included in the weight calculated for payment under this item. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the amount specified shall be measured for payment.

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 (l2) m.

For bent bars, the length along center line of bar will be paid.

21.4.2 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 materials, labor, equipment and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. # 06 Item # 11/(ii)	Fabrication of mild steel reinforcement for cement concrete, including cutting, bending, laying in position, making joints and fastenings, including cost of binding wire and labour charges for binding of steel reinforcement (also includes removal of rust from bars): **(ii) Deformed bars (Grade-60)**	100kg

CH. # 07ITEM # 04/(I)PACCA BRICK WORK IN FOUNDATION AND PLINTH IN:- (I) CEMENT, SAND MORTAR:- RATIO 1:3

22.1 DESCRIPTION

This work shall consist of furnishing all materials, equipment and labor required for constructing brickwork as shown on the Drawings and in accordance with these Specifications.

22.2 MATERIAL REQUIREMENTS

22.2.1 Portland Cement

Portland cement shall conform to the requirements set forth under Item 401.2.1.

22.2.2 Sand

Sand for mortar used in brickwork shall conform to the requirement for the fine aggregate specified in Item 401.2.2 except that the grading shall be according to AASHTO M 45.

22.2.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities. No water shall be used without the approval in writing of the Engineer.

22.2.4 Mortar

The mortar for all brickwork shall consist of one (1) part of Portland cement to three (3) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use.

22.2.5 Bricks

The size of the bricks shall be standard size (9"x4$^1/_2$"x3")22.86 cm x 11.43 cm x 7.62 cm. They shall be well-burnt without being vitrified, They shall be of uniform 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. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 140.62 kg/sq cm (2,000 psi).

22.3 CONSTRUCTION REQUIREMENTS

22.3.1 Mixing of Mortar

Methods and equipment used for mixing mortar shall be such that each ingredient entering into the mortar shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use. All mortar not used within thirty (30) minutes after addition of the water to the mix shall be wasted. Retempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

22.3.2 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.

22.3.3 Curing

All brickwork shall be cured for at least seven (7) days after laying. The curing method shall be to the satisfaction of the Engineer.

22.4 MEASUREMENT AND PAYMENT

22.4.1 Measurement

Measurement of brickwork shall be made to the lines of the structures as shown on the Drawings or as modified by the Engineer for the appropriate items in which such brickwork is incorporated.

The quantities to be measured shall be the number of cubic feet of brickwork laid and accepted.

22.4.2 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 and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch. # 07 Item # 04/(i)	Pacca brick work in foundation and plinth in:- **(i) Cement, sand mortar:- Ratio 1:3**	100Cft

Ch # 11Item #8/(b) **CEMENT PLASTER 1:3 UPTO 20' (6.00 M) HEIGHT :-**
B) ½" (13 MM) THICK

22.1 DESCRIPTION

This work shall consist of furnishing all materials, equipment and labor required for constructing plaster as shown on the Drawings and in accordance with these Specifications.

22.2 MATERIAL REQUIREMENTS

22.2.1 Portland Cement

Portland cement shall conform to the requirements.

22.2.2 Sand

Sand for mortar used in plaster shall conform to the requirement for the fine aggregate specified except that the grading shall be according to AASHTO M 45.

22.2.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities. No water shall be used without the approval in writing of the Engineer.

22.2.4 Mortar

The mortar for all plaster shall consist of one (1) part of Portland cement to three (3) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use.

22.3 CONSTRUCTION REQUIREMENTS

22.3.1 Mixing of Mortar

Methods and equipment used for mixing mortar shall be such that each ingredient entering into the mortar shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time after all the ingredients are in the mixer, except the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use. All mortar not used within thirty (30) minutes after addition of the water to the mix shall be wasted. Retempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

22.3.3 Curing

All plaster shall be cured for at least seven (7) days after laying. The curing method shall be to the satisfaction of the Engineer.

22.4 MEASUREMENT AND PAYMENT

22.4.1 Measurement

Measurement of plaster shall be made to the lines of the structures as shown on the Drawings or as modified by the Engineer for the appropriate items in which such plasterwork is incorporated.

The quantities to be measured shall be the number of Sft of plasterwork laid and accepted.

22.4.2 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 and incidentals necessary to complete the work prescribed in this item:

Pay Item No.	Description	Unit of Measurement
Ch # 11 #8/(b)	Item Cement plaster 1:3 upto 20' (6.00 m) height :- b) ½" (13 mm) thick	100Sft

VVD Intelligent Traffic Signal Controller:

VVD second-generation intelligent traffic light controller is suitable for many kinds of intersection, such as four ways, three ways and two ways intersection. The controller supports remote control and Internet communication. The max channel is 44 channel driving control (36 channels for vehicle lights, 8 channels for pedestrian lights).

It also supports; GPS time synchronization, traffic actuation, pedestrian push button, green wave.

VVD Intelligent Traffic Signal Software:

Two methods to program the controller,

- Handheld Device.
- Traffic management software.

Features:

1. Multiple working mode: Pre- time mode (1-1).
2. Green wave mode (1-2).
3. Pedestrian push button mode (2-1,2-2).
4. Traffic vehicle actual mode (3-3).
5. Signal plan: 240 solution, 30 stages and 240 menus with 30 phase, week plan, special day plan.
6. Hurry call.

7. Detect function:
   - Lamp failure detect.
   - Low voltage detects.
   - Green conflict detects.
   - Loop failure detect.

8. Traffic control function, may control the whole direction lamp, also can set each lamp status.

9. Support forced flash function, Turn on/off lamp one by one function.
10. Support total fault detection enable DIP setup functions input (main controller).

Video Camera Detector VVD:

Parameter:

Detection Functionalities: Vehicle presence + data + video.

1. Detection Zones: 8.
2. Detection Outputs: 8.
3. Communication with Controller: via 485 & Ethernet & wireless.
4. Resolution: 640x480 pixels.
5. Frame rate: 20 FPS.
6. Lens Types Focal Detection Distance:
    a. Wide Angle 2.8mm; 0-30m.
    b. Narrow Angle 6.0mm 15-75m.
7. Mounting Height: 3.5-12 m.
8. Compression: MJPEG, H.264.
9. Housing Material: Aluminum, Weatherproof (UV-resistant).
10. Operating voltage: 12-42VAC.
11. Communication with PC - Sensor: Interface & Via Ethernet.
12. PC Tool for Setup: Traffic Configuration Tool.
13. EMC: Electromagnetic Compatibility 2004/108/EG.
14. Protection grade:
    a. Housing = IP68.
    b. Connectors = IP67.

Features:

- Small size (with camera & controller)
- Dynamic, high sensitivity
- Non-intrusive ground installation.
- Adapted to day and night operations.
- Real-time traffic view and surveillance.
    - Continuous Video Transmission.

    - Queue Detection.
    - Traffic Monitoring
- Road vehicle detection

Video output board:

Specifications:

- Ports: COM interface of RS-45, including 485x1.
- Ethernet (TCP/IP) communication: LAN port x 2,
- Connect to pc & NVR/ POE port.
- 4 x POE ports for traffic camera connection.
- Protocol Compatibility: Customized protocols
- Address dialing: 7 pins.
- Detection result output: Each camera is equipped with 4 output channels for a total of 16
- Camera connection indicators: 4 No.
- Camera fault indicators: 4 No.
- Connector: double row 30-pin horn stand.
- Power supply: 12-48VDC; 2A.
- Protection level: IP54.
- Working voltage: -40 ℃ -85℃.
- Certification: CE.

Video wireless antenna:

Specifications:

- Chip: Qualcomm Enterprise Chip.
- Flash: 8MB.
- Transmission rate: 300 Mbps.
- Interface: 1*10/100 Mbps adaptive network interface.
- Antenna: Built-in dual-polarized high-gain 14 dBi alignment board antenna (horizontal wave half angle 60° vertical wave half angle 60°)
- Button: 1* digital switch / reset button, short press the digital tube to display the value plus one, long press for 15 seconds to return to the factory settings
- Indicator light: signal SIG indicator, ETH network interface status indicator, power indicator, digital tube indicator.
- Power consumption: <10w.
- Power supply: 24V 1A
- Non-standard POE power supply, DC12V 1A

4G router:

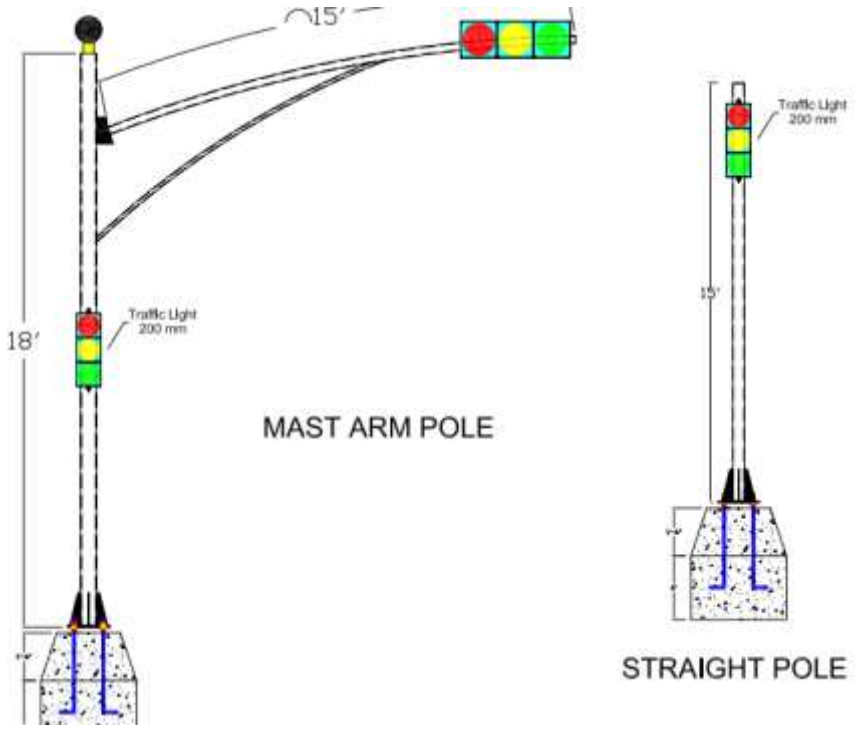
Features:

1. Support 1 wired LAN port and 1 wired WAN port (can be switched to LAN port);
2. The wired network port supports 10/100Mbps rate.
3. Support 1 WLAN wireless LAN
4. Support a variety of communication indicators, the operating status at a glance
5. Drawer SIM card holder, support APN/VPDN special network card
6. Support one key to restore factory settings
7. Support web configuration page
8. Support VPN (PPTP/L2TP/ IPSec /OPENVPN/GRE/SSTP) settings; u Support PPPOE, DHCP, static IP and other functions
9. Support static routing settings, firewall rule settings, etc.
10. Support traffic service, can be based on the interface speed limit
11. Support dynamic domain name (DDNS) and port forwarding
12. Support for mandatory portal (WIFIDOG), this function needs to be customized according to customer needs.

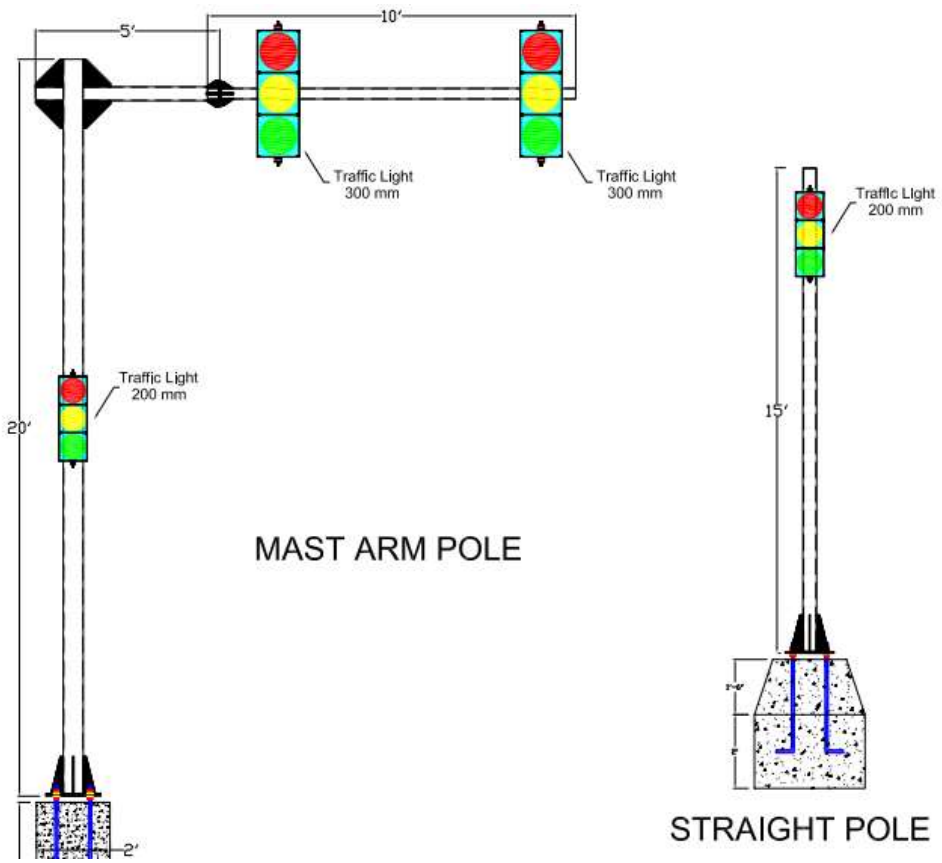
Poles for Traffic Signals

Poles should be supplied with a galvanized finish, paint over galvanized finish, or a factory finish paint coat in a decorative urban application.

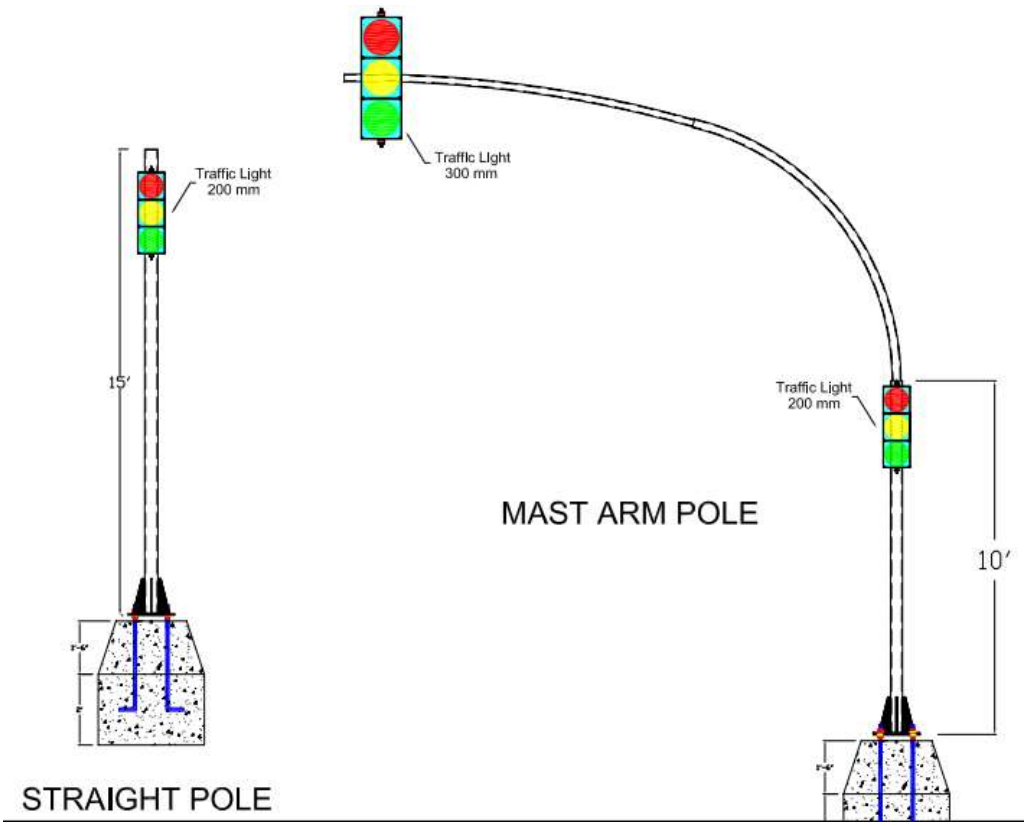
Option #01:



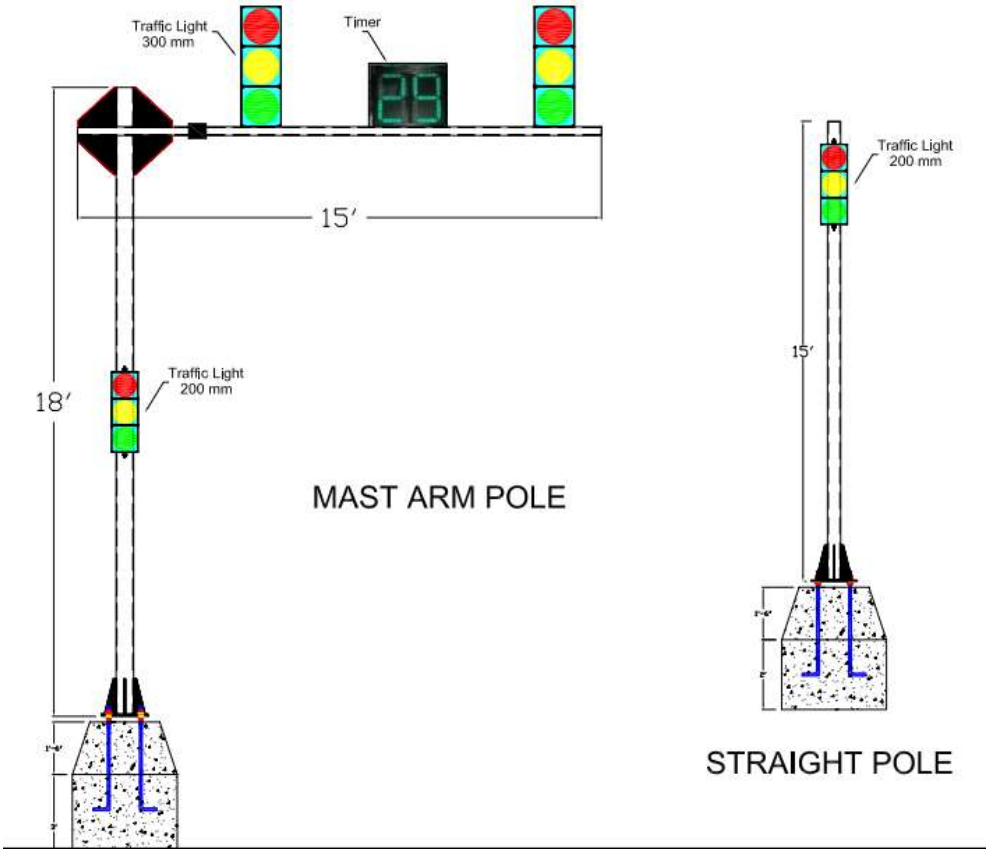
Option #02:


5′
10′
Traffic Light
300 mm
Traffic Light
300 mm
Traffic Light
200 mm
Traffic Light
200 mm
20′
15′
MAST ARM POLE
2′
STRAIGHT POLE

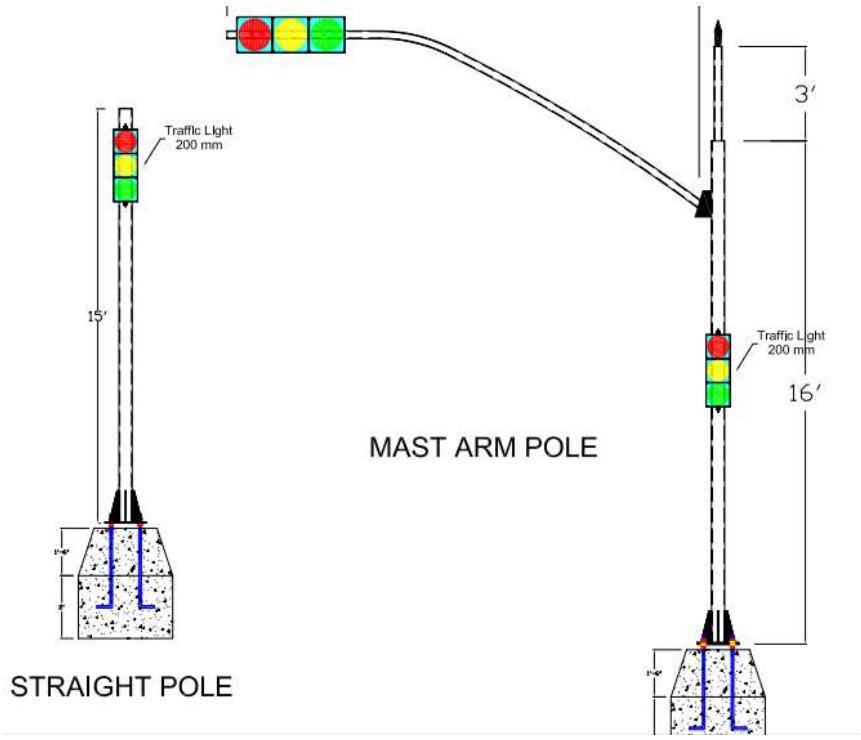
Option #03:


Traffic Light
300 mm
Traffic Light
200 mm
15′
Traffic Light
200 mm
MAST ARM POLE
10′
STRAIGHT POLE

Option #04:



Option #05:



I. 200mm HI-Intensity Traffic Light with Clear Lens:

1. **Application** – urban light signalling.
2. 1-way, 2-way, 3-way Traffic Signal Lights.
3. Input voltage – AC85V ~ 265V, DC12V/ DC24V.
4. Transparent polycarbonate optical lens – impact resistant.
5. Anti-phantom effect minimized, optimal viewing angle.
6. High intensity LED light source – low energy consumption.
7. 5mm LED (DIP) by EPISTAR.
8. Long life cycle – more than 80,000 working hours.
9. Highly durable polycarbonate housing; UV-light resistant.
10. Modular design – easy installation and maintenance.
11. Fixation system either with polycarbonate or aluminium mounting brackets.
12. Compliance with CE, RoHS, EN12368, ISO9001.

Technical Specifications:

This 200mm is Hi-Intensity traffic signal head is using latest hi-power LEDs as light sources. It has low power consumption and long-life time. This traffic head is 3 sections. They are red lamp, yellow lamp and green lamp. The housing uses polycarbonate material, it can be open and be maintained without other special tools. It is characterized with high impact strength, dimension stability, electricity insulation, corrosion resistance, abrasive resistance. The Fresnel lens design produces a uniform brightness and standard chromatography.

Specifications

Size	200mm
Color	Red /yellow/Green
LED Qty	R/Y/G:90Pcs
Light Intensity	R≥400cd Y/G≥600cd
View Distance	≥300m
Wave length	R:615nm~630nm Y:583nm~595nm G:500nm~505nm
IP Grade	IP54
Viewing Angle	L/R-30° U/D-30°
Working Temp	−40°C~ + 80°C
Working Voltage	AC 85V-265V , 50/60HZ , DC 12V,DC24V
Housing Material	Polycarbonate – UV Resistant
Life Span	≥80,000hrs
Power Consumption	R/Y/G: ≤9W
Warranty	3 years

Note:

- 120 vac, 12 vdc or 24 vdc are available.
- Lens are clear of High-quality Polycarbonate material.

II. 300mm HI-Intensity Traffic Light with Clear Lens:

1. **Application** – urban light signalling.
2. 1-way, 2-way, 3-way Traffic Signal Lights.
3. Input voltage – AC85V ~ 265V, DC12V/ DC24V.
4. Transparent polycarbonate optical lens – impact resistant.
5. Anti-phantom effect minimized, optimal viewing angle.
6. High intensity LED light source – low energy consumption.
7. 5mm LED (DIP) by EPISTAR.
8. Long life cycle – more than 80,000 working hours.
9. Highly durable polycarbonate housing; UV-light resistant.
10. Modular design – easy installation and maintenance.
11. Fixation system either with polycarbonate or aluminium mounting brackets.
12. Compliance with CE, RoHS, EN12368, ISO9001.

Technical Specifications:

This 300mm is Hi-Intensity traffic signal head is using latest hi-power LEDs as light sources. It has low power consumption and long-life time. This traffic head is 3 sections. They are red lamp, yellow lamp and green lamp. The housing uses polycarbonate material, it can be open and be maintained without other special tools. It is characterized with high impact strength, dimension stability, electricity insulation, corrosion resistance, abrasive resistance. The Fresnel lens design produces a uniform brightness and standard chromatography.

Specifications

Size	300mm
Color	Red yellow & Green
LED Qty	R /Y/G:168pcs
Light Intensity	R≥600cd Y≥800cd G≥800cd
View Distance	≥500m
Wave length	R:620~630nm Y:590~594nm G:503~508nm
IP Grade	IP54
Solar Power	≤6W
Viewing Angle	L/R-30° U/D-30°
Working Temp	−40℃~ + 80℃
Working Voltage	DC 12V,DC24V ; AC 85V-265V , 50-60HZ
Housing Material	Polycarbonate – UV Resistant
Life Span	≥80,000hrs
Power Consumption	R/Y ≤15W G≤17W
MOQ	20pcs
Warranty	3 years

Note:

- 120 vac, 12 vdc or 24 vdc are available.
- Lens are clear of High-quality Polycarbonate material.

III. 300mm Static Pedestrian LED Traffic Light:

1. **Application** – urban light signalling – pedestrian crossings.
2. Wide operating voltage.
3. Transparent polycarbonate optical lens – impact resistant
4. Anti-phantom effect minimized, optimal viewing angle
5. High intensity LED light source – low energy consumption
6. 5mm LED (DIP) by EPISTAR
7. Long life cycle – more than 80,000 working hours.
8. Highly durable polycarbonate housing, UV light resistant
9. Modular design – easy installation and maintenance
10. Fixation system either with polycarbonate or aluminium mounting brackets.
11. Compliance with CE, RoHS, EN12368, ISO900.

Technical Specifications:

This 300mm is Hi-Intensity Static Pedestrian signal head is using latest hi-power LEDs as light sources. It has low power consumption and long-life time. This traffic head is 2 sections. They are red lamp and green lamp. The housing uses polycarbonate material, it can be open and be maintained without other special tools. It is characterized with high impact strength, dimension stability, electricity insulation, corrosion resistance, abrasive resistance. The Fresnel lens design produces a uniform brightness and standard chromatography.

Specifications

Size	300mm
Color	Red & Green
LED Qty	R:80pcs G:78pcs
Light Intensity	R≥20000cd/m^2 G≥20000cd/m^2
View Distance	≥500m
Wave length	R:620nm~630nm G:503nm~508nm
IP Grade	IP54
Solar Power	≤6W
Viewing Angle	L/R-30° U/D-30°
Working Temp	−40°C~ + 80°C
Working Voltage	DC 12V,DC24V ; AC 85V-265V , 50-60HZ
Housing Material	Polycarbonate – UV Resistant
Life Span	≥80,000hrs
Power Consumption	R/G ≤6W
MOQ	20pcs
Warranty	3 years

Note:

- 120 vac, 12 vdc or 24 vdc are available.
- Lens are clear of High-quality Polycarbonate material.

PGE INTELLIGENT TRAFFIC SIGNAL
COUNTDOWN TIMERS

Detailed Technical Specifications

#	Feature	Description
1	Compatibility	Completely compatible (Tested with PSCA/ UTC/ adaptive controllers)
2	Operating System	Micro-chip AVR (8-bit)
3	Adaptive	Fully adaptive for three colors timing with continuous intelligent learning.
4	Input Voltage	120V-230V AC
5	Light Source	5mm Dip-star LED
6	Counter	0 to 199
7	Power Consumption	8W-18 W
8	Display Type	2 and half digits (188); 2 digits (88); Customized.
9	Display Color	Tri- Color functionality.
10	LED's in Each Segment	> 50 No LEDs total in each segment.
11	Input Sensing	3 Cycles in standard. (Customizable)
1	Input Signal	Sense traffic light input in parallel.

1	Source	
12	Sensing Sequence	Show (--) until verified cycle occurs and display starts from Green. 3 cycle for same time verification before counting display. Will not time display on any interruption in cycle.
13	Minimum body Size	Minimum 600mm X 400mm
14	Body Material	MS Body with Powder Coating.
15	Bracket Material	Aluminum /MS clamp Brackets.
16	Storage Temperature	-40oC to 85oc
17	Operating Temperature	-20oC to 60oC
18	Humidity	95% at 60oC (Non-Condensing)
19	Least Digit of Count	Time of each phase end on Digit-1
20	Life Span	Minimum 80,000 Hrs.
21	View Distance	> 500m
22	Wavelength	Red:625±5;Yellow:590±5;Green:505±55
23	IP Rating	Body: IP-54; Digits: IP-65
24	Segment Board (Material)	Digits/ Segments mounted on MS Housing with screws/ nut, bolts.
25	Controller Board	Smart design with single industrial power supply.
26	Warranty Period	One year

PGE PEDESTRIAN TOUCH BUTTON

Feature:

Pedestrian Touch Button is intended to use for providing the pedestrian safety in road traffic especially visually impaired people. The body of PGE Pedestrian Touch Button manufactured from ABS+PC material which make it resistance to any damage. More than one sound can be loaded into the device. Sounds installed in the device can be played with separate trigger .The operating range of the device is -20 / +60 degrees. The device can be operated with two different sources, AC 240V and DC 12V. Touch button take its power from the traffic light that is connected to. The maximum power consumption of pedestrian button about 2 watts and the blind clock push button power consumption about 3 watts. Body size of the device is 173.5 x 81.1 x62.7 mm. There are connection entries which makes it easy to mount on the pole.

- Outlook small, novel, compact, waterproof design, easy to install, ABS+PC material, high strength and anti-aging.

- With a non-contact touch button, more hygienic in public places with high sensitivity and long life.
- It can automatically adjust the volume according to the surrounding environment of the intersection, which is more intelligent.
- With 32-bit MCU control, the pedestrian button signal can be output through the receiver 8 group IO output or 485 output, the output signal can be freely mapped, or the output protocol can be customized, and the third-party traffic signal can be seamlessly connected.
- With led lights and language reminders, button prompt text and graphics can be customized;
- Simple installation: Standard hoop, fixing the product on the pedestrian traffic light pole, without additional power, directly on the pedestrian traffic light to take power.

SPECIFICATIONS:

Housing Color	Yellow
Material	ABS+PC
Working voltage	100-240VAC
Button type	Touch mode button
Power	< 2watt
Working temperature	-40℃~70℃
IP rate	IP65
Language	English(can OEM)
Product Size	81.1mm*62.7mm*173.5mm
Warranty	2 years

Specifications of Personnel Protective Equipments (PPEs)

Item	**General Specification as per OHS**
Safety Shoes	Full-grain IDROTECH® leather upper. Protex® waterproof, breathable membrane. Patented three-density VACUUM® sole unit with TPU disk buttons providing shock absorption and excellent slip resistance on uneven and wet surfaces. Anti-static. Stainless steel midsole and toecap. 200 joule EN ISO 20345.
Safety Gloves	Kavlar Cut Resistant Level-5
Dust Mask	Executive standard GB26266-2006 KN95 with ear-hook and KN95 filter
General Safety Mask	3 Ply with long flexible straps and 65 GSM
Safety Helmet	Class B for Construction Safety
Body Harness	Full Body Harness with double lanyard, double D Ring, Tested for minimum 1000kg
Insulated Gloves	Insulated Gloves Electric Tested at 1100 KVA
Safety Glasses	Safety Glasses of standard ANSI Z87. 1-2010 for construction safety
Nitrile Gloves	Nitrile Gloves for Chemical and Liquid Safety