RAVI URBAN DEVELOPMENT AUTHORITY (RUDA)

GOVERNMENT OF PUNJAB

INFRASTRUCTURE DEVELOPMENT AT CHAHAR BAGH PHASE-2, LAHORE

PARTICULAR SPECIFICATIONS FOR ROADS & STRUCTURES

A. GENERAL

ITEM-101 DEFINITION OF TECHNICAL TERMS

Add at the end of Definitions

(Important Abbreviations)

AASHTO	-	American Association of State Highway and Transportation Officials
ASTM	-	American Society for Testing and Material
AWG	-	American Wire Gauge
AWPA	-	American Wood Preservers Association
BS	-	British Standard Code of Practice
ACI	-	American Concrete Institute
FHWA	-	U.S. Federal Highway Administration
PCA	-	Portland Cement Association
Wt.	-	Weight
Lb.	-	Pound
AWS	-	American Welding Society
Gallon	-	U.S. Gallon
In.	-	Inch
Ft.	-	Foot
Yd.	-	Yard
Ltr.	-	Litre
mm	-	Millimeter
cm	-	Centimeter
M	-	Meter
Km	-	Kilometer
SM	-	Square Meter
^{o}	-	degree
Sq. cm.	-	Square Centimeter
CM	-	Cubic Meter
ha	-	Hectare
Kg	-	Kilogram
Ton	-	Metric Ton (1000 Kg)
^{o}C	-	Degree Centigrade

ITEM-201 CONSTRUCTION EQUIPMENT & GENERAL REQUIREMENTS

Add at the end of 201-4

201-5 Trial Section

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

i) Equipment to be used.

ii) Layer thickness adopted

iii) Per day production.

iv) Results of tests.

201-6 As-Built Drawings/Shop Drawings

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

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

201-7 Safety Precautions

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

201-8 Scope

The Standard Specifications is a part of contract documents which shall be read in conjunction with the contract documents which are mutually explanatory to one another in order of precedence as given in the Condition of Contract.

ITEM-202 FIELD TEST LABORATORY

Add at the end of 202-3

202-4 Frequency of Tests & Tests Designation

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

Testing

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

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

Whenever a reference is made in the specifications to a specification manual, or a test designation either of the American Society For Testing and Materials, the American Association of State Highway and Transportation Officials, Federal Highway Specification, or any other recognized national organization, and the number or other identification representing the year of adoption or latest revision is omitted, it shall mean the specification, manual or test designation in effect on the day 30 days prior to the date for submission of bids. Whenever said specification manual or test designation provides for test reports (such as certified mill test reports) from the manufacturer, copies of such reports, identified as to the lot of material, shall be furnished to the Engineer. When material that cannot be identified with specific test reports is proposed for use, the Engineer may, at his discretion, select random samples from the lot for testing. Test specimens from the random samples, including those required for retest, shall be prepared in accordance with the referenced specification and furnished by the Contractor at his expense. The number of such samples and test specimens shall be entirely at the discretion of the Engineer. Unidentified metal products such as sheet plate, hardware, etc. shall be subject to the test requirements prescribed by the Engineer.

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

C. EARTH WORK

SECTION-411 (EXCAVATION AND EMBANKMENT)

411.2.2.2 BORROW

Delete second & third para of 411.2.2.2 (a) and add at the end of para No-1

Borrow area shall be furnished by the contractor and all the charges for borrow of earth at site, and also cost of earth will be included in his job & Bid rate. Borrow area will be outside the notified area of scheme. When the subgrade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimeters below subgrade level shall meet compaction requirement of 411-5.3 Soils having a minimum value of C.B.R of eight (8) percent and swell value of not more than 0.3 percent shall be used.

411-5.3 COMPACTION REQUIREMENT FOR NEW EMBANKMENTS

The text is deleted & substituted with following:

The subgrade embankment of 3' or less in height shall be compacted to at least 95% modified

AASHTO, Max. dry density for their full depth and full width. Embankments over 3' in height shall, have the top 3 feet compacted to not less than 95% modified AASHTO maximum-dry density to their full depth and width and those portions below 3 feet of the finished subgrade level shall be compacted to at least 90% of the modified AASHTO maximum dry density, to their full depth and width.

The compaction of each and every layer shall be tested and approved before next layer of fill is placed. The result shall be examined on a statistical basis, only one result in ten consecutive tests may fall below 95% relative compaction and no result: shall be below 93% in case of upper 3 feet of the subgrade. Likewise, for the lower portion, the degree of relative compaction shall. be 90 percent for at least 9 tests out of 10 consecutive tests and for the trench, it shall not be below 88 percent

421-4 RATE

Is Deleted & substituted with following

Rate is included all hauling cost, cost of earth and formation of embankment complete in all respect as directed by the Engineer. Unit of Rate will be 1 Cubic meter.

SECTION-501 (SUB-BASE COURSE)

501-1 DESCRIPTION

This work shall consist of the construction of a layer or layers of mechanically stabilized soil comprising either naturally occurring materials or mixtures of gravel, crushed aggregate, whichever is specified in the bid schedule, to suitable grading including fines, placed and compacted on a prepared formation to give a California Bearing Ratio value of at least 50 percent in accordance with these specifications and in conformity with the lines, grades, thickness and typical cross section

501-2 SOIL AGGREGATE MATERIAL

501-2.1 to 501-2.3 are deleted & substituted with following

501-2.1 General:

The aggregate material shall comprise of coarse and fine aggregate conforming to the grading requirements of Table 501-1 of General Specification of Punjab Highway and shall be free from vegetable matter and sand.

501-2.2 Aggregate:

Coarse aggregate shall consist of hard durable fragments of stone, gravel suitably crushed to give the required grading. The coarse aggregate shall have a percentage wear by the Los Angeles abrasion machine test of not more than 50 at 500 revolutions as determined by AASHTO T-96

- The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis, curve
- The Material shall have a CBR value of at least 50%, determined according to AASHTO T-193. The CBR value shall be obtained at a density corresponding to Ninety-eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.
- The coarse aggregate material retained on sieve No. 4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent
- In order to avoid intrusion of silty and clayey material from the subgrade in the subbase, the ratio D15 (Subbase)/D85 (Subgrade) should be less than 5. Where D85 and D15 are the particle diameters corresponding to eighty-five (85) % and fifteen (15) %, respectively, passing (by weight) in a grain size analysis, curve
- The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two third of the fraction passing the 0.425 mm (No 40) sieve. The fraction passing the 0.425 mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.
- Invariably be done, no hand picking shall be allowed, however hand picking may be allowed by the Engineer, if over-size quantity is less than 5% of the total mass
- Sand equivalent for all classes shall be 25 min

501-3.6 COMPACTION

501-3.6 (Para No-2 is Deleted & Substituted with the following)

The amount of rolling and tamping as required above is estimated as the minimum necessary for adequate compaction. During the progress of the work, the Engineer or his representative shall make density tests in accordance with AASHTO T-191, modified to include only material passing a 3/4-inch sieve, and if he finds the density is less than 100 per cent of the maximum density as determined by AASHTO T-180 (Modified Proctor), 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 the Contractor shall perform additional rolling or tamping as may be necessary to obtain that density.

SECTION-551 (WATER BOUND MACADAM)

551-3.8 DENSITY REQUIREMENT

501-3.8 Deleted & Substituted with following

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 (Modified). The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19 mm sieve) as directed by the Engineer. Also for adjustment of any material retained on 4.75 mm sieve, 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.

SECTION-641 (BITUMEN PLANT MIX BASE COURSE)

641-2 MATERIALS

641-2 is Deleted & Substituted with following

AGGREGATE

Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, vegetable matter and other deleterious substances, and be of uniform quality, geology and petrology. Water borne material such as river bed gravel, if used, shall also conform to the above criteria.

Coarse aggregate, which is material retained on the No. 4 sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. The aggregate shall contain not more than 8% by weight of flats/or elongated particles (ratio maximum to minimum 5:1) and shall contain 100% angular material, such that all faces of each piece are fractured faces in cuboid shape.

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

When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added.

The filler material shall consist of finely divided rock crust, hydrated lime, hydraulic cement or other suitable mineral matter and shall conform to the following gradation:

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

The Coarse and fine aggregates shall meet the following requirements

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

ii. The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO T 140) shall be less than 12%.

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

iv. All aggregates shall have a liquid limit of not more than 25% and a Plasticity Index of not more than 4 as determined by AASHTO T-89 and T-90.

v. The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimensions = 2.5:1).

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

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

b. 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

ASPHALTIC MATERIAL

Asphaltic binder to be mixed with the aggregate to produce asphaltic base shall be as asphalt cement penetration grade 60-70 as specified by the Engineer. Generally, it will meet the requirement of AASHTO M-20.

ASPHALT CONCRETE BINDER MIXTURE

The composition of the asphaltic concrete paving mixture for binder course shall conform to class shown in the following table:

Sieve Designation mm (Inch)	Percent Passing by Weight
25 (1")	100
19 (¾')	90-100
9.5 (3/8")	56-80
4.75 No. 4	35-65
2.38 No. 8	23-49
0.30 No. 50	5-19
0.075 No. 200	2-8
Asphalt Content Weight Percent of total mix.	3.5 (minimum)
The asphalt concrete binder course mixture shall meet the following Marshal Test Criteria:	
Compaction, number of blows each end of Specimen of Specimen	75
Stability (Minimum)	1000 Kg.
Flow, 0.25 mm (0.01")	8-14
Percent air voids in mix.	4-8
Percent voids in mineral aggregate	according to article 5.3, MS-2, (Asphalt Institute USA) edition 1993
Loss of stability	25% (Max.)
Filler/Bitumen ratio	1-1.5 (applicable to hot climate (> 40 ºC.)

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COMBINED AGGREGATES GRADATION

Retained on No. 4	±	7%
Passing No. 4 to No. 100 sieves	±	4%
Passing No. 200	±	1%

ASPHALT CONTENT

Weight percent of total mix.	±	0.3%

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

641-3 MIX DESIGN

Add at the end of 641-3.1 add the following text:

At least one week prior to production, a Job-Mix Formula (JMF) for the asphaltic concrete course mixture or mixtures to be used for the project, shall be established jointly by the Engineer and the Contractor.

The JMF shall be established by Marshal Method of Mix Design according to the procedure prescribed in the Asphalt Institute Manual Series No. 2 (MS-2), May 1992 Edition.

The JMF, with the allowable tolerances, shall be within the master range specified in Table No. 1. Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregates.

After the JMF is established, all mixtures furnished for the project represented by samples taken from the asphalt plant during operation, shall conform thereto with the tolerances as per clause 641-2 of these specifications.

Compaction

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

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

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

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centerline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centerline Intermediate rolling with a pneumatic tyred roller shall be done behind the initial rolling.

Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree C. for initial break down rolling while all other compaction operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

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

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 uncompacted premix, between paver and compacted asphalt below 120° C

Frequency for testing of cores

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

SECTION-642 (BITUMEN PLANT MIX CARPET OR ASPHALTIC WEARING COURSE)

Quality tests of aggregate & bitumen are same as used for asphaltic base course, for compaction & density follow the 641 grading according to General Specification.

SECTION 701 (PORTLAND CEMENT CONCRETE)

701-7 TESTING CONCRETE

701-7.2 CUBE STRENGTH TEST

The Sub-Clause is replaced with the following text:

701-7.2 CYLINDER STRENGTH TEST

The Contractor shall allow in his tender for making test cylinders of 6" diameter and 12" inch height of the concrete being used at various times when so requested by the Engineer-in-Charge's Representative and for testing same as specified in _____

701-15 CONCRETE STRUCTURE

The following specification 701-15.4 is added at the end:

701-15.4 SULPHATE RESISTANT CEMENT

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.

701-15.4.1 DESCRIPTION

This work shall consist of providing sulphate resistant cement in place of Portland cement to all classes of concrete mentioned in Item 701 of these Specification subject to the contact with soil having sulphate content more than one-tenth (0.1) % and with Ground Water having sulphate content more than one thousand five hundred (1,500) ppm or as mentioned in the Drawings or directed by the Engineer.

701-15.4.2 MATERIAL REQUIREMENTS

a) Cement

Sulphate resistant cement where required shall be sulphate resistant cement type 'A' fully conforming to Pakistan standard specification PS No. 612 1989/AASTHO M-74 and satisfying to requirements for fineness, chemical composition, strength, setting time and soundness etc. The average compressive strength of three mortar cubes prepared with 1:3 cement and standard silica sand mortar shall not be less than 220 lbs/sq in (23.5N/sq mm) at seven (7) days. The initial setting time shall not be less than forty-five (45) minutes and final setting time not more than ten (10) hours.

b) Aggregate

Fine and coarse aggregate shall be as mentioned in Item 701-2.2 of these Specifications.

c) Water

Water shall be as specified in Item 701-2.4 of these Specifications.

701-15.4.3 CONSTRUCTION REQUIREMENTS

The construction requirements of concrete with sulphate resistant cement shall be fully as specified General Specifications.

701-15.4.4 MEASUREMENT AND PAYMENT

The quantity of concrete with sulphate resistant cement shall be measured exactly in same way as mentioned in Item 701-16 of these Specifications.

The accepted quantity measured as provided above shall be paid only for the difference of cost for providing sulphate resistant cement in place of Portland cement at the Contract unit price for particular pay item listed below and shown in the Bill of Quantities, which price and payment shall be 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
701-15	Difference of cost for providing S.R. cement in concrete works of specified class:	
	i) For concrete class A_1	CM
	ii) For concrete class B	CM
	iii) For lean concrete	CM

SECTION-821 (REINFORCED DEFORMED STEEL)

At the end, add the following text:

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

SECTION-871 (PAINTING & VARNISHING)

At the end, add the following text:

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 Special Provisions 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.

CHLORINATED RUBBER PAINT

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,	1- 3%
iii) Paint Composition:	Pigments	55+4% by Weight
	Vehicle, Solvent and Additives	45+5% by Weight
b) Yellow Traffic Paint Pigment	Chrome Yellow and Extenders	100% weight
ii) Vehicle	Same as for white traffic paint	
ii) Paint Composition:	Pigments	55+4% by Weight

Vehicle, Solvent and Additives	45+5% by Weigh

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.

Ballotini for Reflective Road Paint

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

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

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

The proportion of ballotini to paint shall be not less than five hundred (500) grams per litre of paint.

Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per meter per square meter of surface coating, as follows:

		Colour			
		White		Yellow	
Divergence Angle	**(Degree)**	**0.2**	**0.5**	**0.2**	**0.5**
Incidence Angles	**4(Degree)**	**237**	**118**	**129**	**75**
Incidence Angles	**40(Degree)**	**75**	**43**	**43**	**32**

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, labour 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 unfavourable 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 10 cm. in width will be permitted. The paint, when applied, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted

Traffic paint shall be applied to the pavement at a rate of one (1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

B- HOT-APPLIED THERMOPLASTIC ROAD PAINTS

Material Requirements

Aggregate

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

Pigment and extender

a) White material.

The pigment shall be titanium dioxide complying with the requirements of Type A (anatase) or Type R (rutile) of BS 1851

b) Yellow materials.

Sufficient suitable yellow pigment shall be substituted for all or part of the titanium dioxide to comply with the other requirements of this specification

c) All materials.

The extender- shall normally be whiting (i.e. calcium carbonate prepared from natural chalk) complying with the requirements of BS 1795. The manufacturer may substitute lithopone complying with the requirement of BS 296 for any or all of the whiting.

d) Binder

The binder shall consist of synthetic hydrocarbon resin, or, with the approval of the Engineer, gun or wood resin, plasticized with mineral oil.

e) Composition of mixture

The proportions of the constituents of the mixed material as found on analysis shall comply with the requirements of table 1.

TABLE 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 ballotin		

(* For Titanium Di-oxide only, no minimum is specified for yellow material.

+ Glass Bead 10% Pre-mixed and 10% to be applied on the surface as Drop-on)

Where specified, 10% in the case of material to which surface ballotini is to be applied by pressure application.

The grading of the combined aggregate, pigment, extender and ballotini (where specified) as found on analysis shall comply with the requirements of table 2.

TABLE 2, GRADING OF COMBINED AGGREGATE, PIGMENT EXTENDER AND BALLOTIN

Sieve	**Percentage by mass passing**	
	Screeded	**Sprayed**
2.80 mm	100	100
1.18 mm	75-95	**-**
6001..t m (micron)	**-**	75-95

Sample and Testing

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.

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.

- **Softening point**

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

- **Colour and luminance**.

a) White material.

The luminance factor of white material as delivered by the manufacturer shall be measured in accordance with appendix D and shall not be less than 70 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 65.

b) Yellow material.

The Colour of yellow material shall be approximately BS 381C Colour No. 355, Lemon. The luminance factor of yellow material as delivered by the manufacturer shall be not less than 60 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with appendix D shall not be less than 55

- **Heat Stability.**

a) White Material.

When tested in accordance with appendix E, the luminance factor of white material as measured in accordance with appendix D shall be not less than 65

b) Yellow material.

When tested in accordance with appendix E, the luminance factor of yellow material as measured in accordance with appendix D shall be not less that 55

c) Flow resistance.

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

d) Skid resistance.

When tested in accordance with appendix G, the skid resistance of a newly laid marking prepared under the stated conditions shall be not less than 45.

Manufacturing, Packing and Storing of Paint

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

Packing

- The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination
- Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, reflectorisation (if applicable), colour, chemical type of binder and maximum safe heating temperature.

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.

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

Application of Material to the Road

a) Preparation of site

The thermoplastic paint shall only be applied to surfaces, which are clean and dry. Immediately before the application of paint, the surface shall be cleaned with mechanical broom, compressed air or Other approved means to remove surplus asphalt, oils, mud, dust and other loose or adhered material. The material shall not be applied if the road surface is at a temperature of less than 5° C.

b) Preparation of material on site.

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

- After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.
- On concrete carriageway, a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

c) Laying

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self propelled

machine. Other markings may be laid by hand, hand propelled machine or self propelled machine as approved by the Engineer. The surface produced shall be uniform in texture and thickness and appreciably free from blisters and streaks.

d) Reflectorization by surface application.

When surface application of ballotini is required, additional ballotini (400 g/m2 to 500 g/m2 from the machine) shall be applied by pressure concurrently with the laying of the line with sufficient velocity to ensure retention in the surface of the line. The 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.

Not less than 90%, by mass of the ballotini, shall be of transparent glass, spherical in shape and not more than ten (10) percent shall be ovate in shape or have other flaws. The ballotini shall be made of soda glass.

e) Thickness

Unless otherwise approved by the Engineer, the material shall be laid to the following thicknesses.

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

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

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

f) 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.

MISC. REFLECTORIZED PAVEMENT STUDS

DESCRIPTION

This item shall consist of furnishing and installing reflectorized pavement studs set into the traveled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer

MATERIAL REQUIREMENTS

Reflectorized Studs

Reflectorized Studs shall be "cat-eyes" either the 'Flush Surface' type or 'Raised Profile' type having the following characteristics

(a) 'Flush Surface' Type

The °Flush Surface' reflector shall be the short base type having a maximum base area of 18 cm x 14 cm or as shown on the Drawings.

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

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated

life of at least five (5) years. The pad shall be so designed as to produce a self whipping action of the reflector when depressed.

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

(b) 'Raised Profile' Type

The 'Raised Profile' reflectors shall consist of an acrylic plastic shell filled with an adherent epoxy compound molded from methyl methacylate into the shape of a shallow frustum of a pyramid having base dimension of approximately 10 cm x 10 cm and thickness not more than two (2) cm or as shown on the drawings.

The shell shall contain one or two prismatic reflector each inclined at an angle of thirty (30) degree to the horizontal and having an area not less than twenty (20) square cm or as indicated on the plans.

The reflectors shall attain the following standards for their photometric and physical qualities:

i. **Photometric Requirements**

The reflectors shall have the following minimum Specific Intensity values (S.I) expressed as candle power per foot candle of illumination at the reflector on a plane perpendicular to the incident light.

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	COLOUR		
	Crystal	**Yellow**	**Red**
Divergence Angle	0.20	0.20	0.20
(in Degree)	SI	SI	SI
Incidence Angle			
0	3.0	1.8	0.75
20	1.20	0.72	0.30

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The reflector for testing shall be located with the center of the reflecting face at a distance of one and half (1.5) m from a uniformly bright light source having an effective diameter of half (0.5) centimeter.

The width of the photocell shall be 1.27 cms and shall be shielded from stray light. The distance from the centers of the light source and photocell shall be 0.53 cms.

Failure of more than four (4) % of the reflecting faces shall be cause for rejection of the lot.

ii. **Strength Requirement**

The reflectors shall support a vertical load of 1000 kg when tested in the following manner.

A reflector shall be centered horizontally over the open end of a vertically positioned hollow

metal cylinder seventy-five (75) mm internal diameter, twenty-five (25) mm high and wall thickness of six (6) mm. The load shall be applied to the top of the reflector through a six (6) mm diameter by six (6) mm high metal plug centered on top of the reflector.

Failure shall constitute either breakage or significant deformation of the marker at any load less than one thousand (1000) kg.

iii. Adhesive

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

Package A	Kg/Litre
Epoxy Resin	0.94