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13 TRAFFIC SIGNS, MARKINGS AND STUDS

13.1 GENERAL

13.1.1 Scope

- 1 This Part covers the supply and installation of traffic signs (complete with posts and foundations), thermoplastic road marking, road marking paint for temporary roads and diversions, reflectorised studs and non-reflective studs.
- 2 Related Sections and Parts:

This Section

Part 16, Traffic Signals

Section 5, Concrete

13.1.2 References

- 1 The following manuals and standards are referred to in this Part:

Qatar Traffic Control Manual

BS 381CColours for identification purposes

BS 873.....Road traffic signs

BS 1470Wrought aluminium for general engineering purposes; plate sheet and strip

BS 1474Wrought aluminium for general engineering purposes; bar, extruded round tubes and sections

BS 1490Aluminium and aluminium alloy ingots for general casting purposes

BS 2000, Part 58.....Determination of softening point of bitumen (ring and ball)

BS 3262,(Part 1)Hot applied thermoplastic road marking materials

BS 6088Solid glass beads for Road Marking

ISO 591-1Titanium dioxide pigments

ISO 1461Hot dipped galvanising

ASTM A307Steel anchor bolts

ASTM C373.....Standard test methods for water absorption

ASTM C424.....Test methods for crazing resistance

CML 14-97Standard Method of test for determination of appearance, shape, dimensions

and compressive strength of ceramic non-reflecting road studs.

TRL Road Note 27Skid resistance portable tester.

13.1.3 Definitions for Reflective Traffic Studs

- 1 Entrance Angle: The angle in the horizontal plane between the direction of incident light and the normal (perpendicular) to the leading edge of the stud.
- 2 Observation Angle: The angle at the reflector between observer's line of sight and the direction of the light incident on the reflector.

- 3 Specific Intensity (S.I.): The candle-power of the returned light at the chosen observation and entrance angles for each foot candle of illumination at the reflector on a plan perpendicular to the incident light.

13.1.4 Submittals

- 1 Within three weeks of acceptance of the manufacturer's tender, the Contractor shall submit for approval working drawings for signs posts and base plates. Fabrication shall not begin until approval has been given.
- 2 The Contractor shall submit detailed drawings of the foundations proposed for traffic signs.
- 3 The Contractor shall submit samples of the proposed materials for approval on request by the Engineer before delivery to Site, at his own cost.
- 4 The Contractor shall submit to the Engineer for approval three copies of his working drawings for all traffic sign faces both in Arabic and English. Size and style of lettering shall be as designated. No order shall be placed without written agreement of the Engineer and the Concerned Authorities.
- 5 Before proceeding with drilling holes for sign foundations, the Contractor shall submit to the Engineer for approval; the type of plant proposed for drilling holes, details of any temporary metal casings, proposed method of concreting and the proposed method of conduit installation.

13.2 TRAFFIC SIGNS

13.2.1 Scope of Work

- 1 This work shall consist of furnishing and installing road signs and posts assemblies as designated. All sign faces and lettering shall be in accordance with the Qatar Traffic Control Manual. The required post sizes for different sign sizes shall be as tabulated in the Qatar Traffic Control Manual. Where in this section of the specification the term "designated" is used, this refers to the contract drawings and the Qatar Traffic Control Manual.
- 2 The minimum depths and sizes for sign foundations shall be as per the requirements of the Qatar Traffic Control Manual. For each of the signs the Contractor shall submit design calculations for the proposed foundations.
- 3 The following documents should be specifically referred to for this work;
 - (a) BS 873
 - (b) Qatar Traffic Control Manual
- 4 Permanent traffic signs shall be reflectorised or non reflectorised illuminated and shall, in respect of quality, comply with the requirements of the latest editions of;
 - (a) BS 873
 - (b) Qatar Traffic Control Manual
- 5 In the case of conflict with these specifications and the above documents, the matter shall be referred to the Engineer.
- 6 All foundations, framing and fixings for information signs shall be suitable for local conditions. The design calculations shall be submitted to the Engineer for approval. The wind loads shall be calculated based on the wind speed provided in Section 1 part 1 clause 1.5.2.

- 7 A positive system of identification of signs, posts and all fittings shall be adopted. The reference number of the sign together with the date of manufacture shall be indicated by self-adhesive numbers on the reverse side of the sign in the bottom left hand corner and in a consistent and readily visible position on all posts and fittings. The manufacturer's name or trademark will not be permitted on the face of the sign. It may be affixed on the back of the sign, provided approval to the size and colour of the mark has been obtained from the Engineer. Any previously marked reference number should be transferred to new signs on replacement.
- 8 All road signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of five years from the date of completion of the Works under the Contract. If any defect should arise due to poor material or workmanship, it shall be rectified by the Contractor.

13.2.2 Sign Foundations

- 1 Sign foundations shall either be reinforced concrete columns in drilled holes or shallow reinforced concrete spread footings. The dimensions and details of the foundations shall be as designated.
- 2 The number of anchor bolts and bolt locations and anchor bolt dimensions shall be as designated. All anchor bolts nuts and washers shall be hot dipped galvanised to ISO 1461. Any protruding parts to the bolt thread or nut shall be further protected by the application of a wax or grease impregnated tape. Any conduit cast into the foundation for cable access shall be mild steel, hot dipped galvanised after fabrication to ISO 1461. The minimum bend of conduit shall be 600 mm radius.
- 3 All concrete and reinforcing steel used in the sign foundations shall be of the designated grade and type and shall comply with the requirements of Section 5. Anchor bolts shall comply with the requirements of ASTM A307 with a minimum tensile strength of 414 N/mm².
- 4 Each bolt shall be supplied with two hexagonal nuts for levelling purposes complete with washers.
- 5 If an obstruction is encountered whilst drilling the foundation hole the Contractor shall inform the Engineer. The Contractor may elect to bore or drill through the obstruction depending on its nature or may propose to reallocate the signs slightly to avoid the obstruction subject to the approval of the Engineer. In either case the work is deemed to be included in the scope covered by this Part.
- 6 The sides of excavation shall be vertical and any additional excavations carried out beyond that designated, for the particular post and sign being erected, shall be filled with concrete or granular material as directed by the Engineer.
- 7 The reinforcement cage shall be securely fixed centrally about the axis of the foundation, any electrical conduit shall be securely fixed in position as designated before replacement of concrete.
- 8 The top of the concrete foundation shall be finished with a steel trowel to a smooth finish.
- 9 The top of the concrete foundation shall not extend more than 100 mm nor less than 50 mm above the finish grade level unless otherwise designated.
- 10 All backfilling and compaction shall be completed before the erection of any sign on the structure.
- 11 All excavations shall be approved by the Engineer before the sign is erected and before backfilling with fill or concrete as designated.

13.2.3 Traffic Sign Materials

- 1 Sign plates shall be manufactured either from sheet aluminium to BS 1470, SIC - 1/2H, NS3-3/4N, NS-1/2H or HS 30-WP with a minimum thickness of 3 mm (11 swg) or from extruded aluminium plank sections to BS 1470, HE 9-WP, HE 9P or HE 30-WP or extruded aluminium alloy plank sections to BS 1474, HE 9 TE and HE 30 TF. However information signs shall be constructed in extruded aluminium planks, which will either be self-locking or rear fixing, and the aluminium shall be BS 1470, BS 1474 or BS 1490 or other approved equivalent International standard.
- 2 All sign plates shall have clean, smooth edges cut to the required shape of the sign, and shall be etched and degreased to the sign sheeting manufacturer's specifications before application of the sheeting.
- 3 Illuminated signs shall be covered with "Super Engineering Grade" reflective sheeting.
- 4 Reflective signs shall be covered over the whole front face with "High Intensity" reflective sheeting. The sheeting shall be of the designated colour and shall have a manufacturer's guarantee of not less than five years. The rear faces shall be non-reflective grey and should give a similar life span to the sign face.
- 5 The reflective sheeting shall be fixed to the sign plate either with a heat activated adhesive using vacuum applicator or with a pressure sensitive adhesive using a pressure roller in accordance with the sheeting manufacturer's instructions.
- 6 Sign faces shall be formed from a single piece of reflective sheeting, but if for any reason the sign face must be fabricated from more than one piece of material all joints in the material shall be overlapped by not less than 6 mm and where sheeting is applied to extruded sections it shall extend over the top and bottom edges of the sections by not less than 3 mm. No butt joints shall be permitted and in horizontal joints the overlap shall be from the top.
- 7 The corners of all direction signs shall be rounded to a radius of 75 mm.
- 8 Signs constructed of aluminium sheet shall, when recommended by the Traffic Signs Manual, be framed on all edges using hot dipped galvanised steel angle or angle-channel of equivalent section.
- 9 Signs constructed from extruded aluminium plank sections are to present the same flanged appearance on all edges of the sign by fitting an aluminium end capping to the exposed ends of the plank section on both sides of the sign.
- 10 Where the designated sign width requires the use of more than one length of plank section, support beams shall be provided and positioned as approved by the Engineer.
- 11 For plank type signs supported on two posts the plank rails and support beams shall be manufactured from one length of extruded aluminium section. One tie bar shall be fitted between the bottom two plank rails (or the plank rail and support beam) at the centre of the span between the mounting posts.
- 12 Where plank type signs are supported on more than two posts, and the designated sign width is wider than the plank rail and support beams, the plank rail and support beam may comprise two or three lengths provided butt joints occur at an inner post. One tie bar shall be fitted between the bottom plank rail and support beam at the centre of the span between the mounting posts.
- 13 All stiffening and framing shall be continuous and shall prevent the sign from twisting.

- 14 All rivets or other devices fixing sign plates to their framework shall be of non-staining steel or other material approved by the Engineer and shall have a sufficient cross-sectional area to prevent failure from thermal stresses or wind pressure or such other stresses as may be designated.
- 15 All rivet and bolt holes shall be edge-sealed with clear lacquer after the application of the plastics sheeting.
- 16 Rivets shall be spaced at not more than 150 mm apart, around the outside edge of the sign plate and on cross braces the spacing shall be not more than 300 mm.
- 17 Any rivet brought through the sign face shall be coloured to match the sign face. Any rivet or other device fixing sign plates to their frame work shall have a protective washer of nylon or other approved insulating material inserted where they would be in contact.
- 18 All brackets, clips, screws, bolts, nuts and washers used for mounting sign plates to support posts shall be manufactured from stainless steel. For plank type signs, brackets and clips shall be extruded aluminium alloy section.
- 19 Saddles shall be aluminium alloy or other material approved by the Engineer and shall be provided with a nylon strip or other approved insulating material.
- 20 There shall be full adhesion of all sheeting material including letters, symbols and borders and there shall be no air bubbles, creases or other blemishes.
- 21 All panels, cut-out letters, numbers, borders, symbols and back grounds on reflective sheeting shall be carefully matched for colour at the time of sign fabrication to provide uniform appearance both by day and night. The sheeting manufacturer's recommendations on colour matching methods shall be observed. Non-uniform shading or undesirable contrast between reflective sheeting on any one sign will not be accepted.
- 22 The edges of all applied sheeting materials including edges of all plates which make up a sign, letters, symbols and borders shall be sealed as designated by the manufacturer.
- 23 Where required by the sheeting manufacturer the face of the sign plate shall have a coat of clear lacquer of a type designated by him.
- 24 The top of sign support posts shall be capped with a plastic cap.

13.2.4 Installation Requirements for Traffic Signs

- 1 All sign faces shall be of the designated type, colour and size.
- 2 Signs delivered for use in the project shall be in new and unused condition, except where otherwise designated; and shall be stored off the ground and under cover in a manner approved by the Engineer. Any sign damaged, discoloured or defaced during transportation, storage or erection shall be rejected.
- 3 The position and mounting height of each sign shall be as designated.
- 4 Designated post lengths are approximate only. When progress of the work is at the appropriate stage the Engineer will authorise the location of each sign, with the chainage and offset distance from the edge of the road pavement. The Contractor shall be responsible for determination of the exact post lengths to provide the designated vertical clearance. Field cutting of posts shall be performed by sawing. Welded posts will not be permitted.
- 5 All posts shall be erected vertically and where two or more posts are provided for any sign the faces of these posts shall be lined up and their deflection angle checked for compliance with this Part before concreting in.

- 6 For a period of 14 days after concreting in position, all posts shall be suitably braced to prevent movement. Sign faces should not be fixed to posts until after the bracing has been removed and the Engineer has inspected and approved the post stability and foundations.
- 7 All posts shall be of the designated type and shall be protected against corrosion by hot dip galvanising to ISO 1461.
- 8 Unless otherwise designated, all signs shall be erected so that the edge and face of the sign are truly vertical and the face is at an angle of 95 ° to the centreline; that is, facing slightly away from the centreline of the lane which the sign serves. Where lanes divide or are on sharp curves, the Contractor shall refer the orientation of the sign face to the Engineer for his instruction.
- 9 All sign supports shall be plumbed vertical.
- 10 The distance between the lower edge of the signs and the road surface shall be as designated.
- 11 Signs shall be fastened to sign supports in accordance with the designated requirements and the recommendations of the sign manufacturer to the satisfaction of the Engineer.
- 12 The Contractor shall at his own expense, immediately after erection and approval by the Engineer cover the sign in order to prevent misleading information being displayed. The covering shall be close weave hessian securely fixed over the face of the sign using a lacing of nylon cord so as not to damage the sign. The Contractor shall maintain such coverings in good order until receipt of the Engineer's instruction for their removal.
- 13 Signs shall be thoroughly cleaned immediately before being handed over. The type of detergent used shall be approved by the Engineer.

13.2.5 Advance and far Advance Directional Signs

- 1 The face of the sign shall be completely covered with 3M Diamond Grade or similar approved reflective material complying with the following Table 13.1A for retro-reflectivity.

Table 13.1A
Minimum Coefficients of Retro-Reflection

(a) 4° Entrance Angle ²

Observation Angle ¹

	0.2°	0.33°	0.5°	1.0°
White	430	300	250	80
Yellow	350	250	200	65
Red	110	75	60	20
Green	45	33	25	10
Blue	20	15	10	4.0

(b) 30° Entrance Angle ²

Observation Angle ¹

	0.2°	0.33°	0.5°	1.0°
White	235	150	170	50
Yellow	190	130	140	40
Red	60	30	40	13
Green	24	18	19	5
Blue	11	7	7	2.5

(c) 90° Orientation, 40° Entrance Angle ²

Observation Angle ¹

	0.2°	0.33°	0.5°	1.0°
White	150	85	35	20
Yellow	125	75	30	17
Red	40	25	10	6
Green	15	8	3.5	2.0
Blue	6	4	1.5	0.7

¹Observation (Divergence) Angle – the angle between the illumination axis and the observation axis

²Entrance (Incidence) Angle – The angle from the illumination axis to the retroreflector axis the retroreflector axis is perpendicular to the retroreflective surface.

³Values for screened red colour on white sheeting may be significantly lower.

2 The material also shall satisfy the requirements of the following Tables 13.1B & 13.1C with regard to colourimetric and photometric performance.

Table 13.1B
Chromacity factors

Colour	1		2		3		4		Limit Y (%)	
	X	Y	X	Y	X	Y	X	Y	Min	Max
White	.035	.305	.355	.355	.335	.375	.285	.325	40	-
Yellow	.487	.423	.545	.454	.465	.534	.427	.483	24	45
Red	.690	.310	.595	.315	.569	.341	.655	.345	3	15
Green	.030	.398	.166	.364	.286	.446	.201	.794	3	9
Blue	.078	.171	.150	.220	.210	.160	.137	.038	1	10

Table 13.1C
Minimum Luminance Factors

Colour	Factor
Red	0.03
Yellow	0.24
Blue	0.01
White	0.40
Green	0.01

- 3 All plastic sheeting shall be fixed in accordance with the sheeting manufacturer's instructions.
- 4 Unless otherwise agreed by the Engineer, sign faces shall be formed from a single piece of plastic sheeting.
- 5 Where, with the agreement of the Engineer, more than one sheet is used the number of sheets shall be kept to a minimum.
- 6 Only vertical and horizontal joints shall be permitted and all joints in plastics sheeting shall be overlapped by not less than 6 mm. The overlap on the horizontal joints shall be from the top; but joints in plastics sheeting shall not be permitted. The number of joints shall be kept to minimum.
- 7 Where sheeting is applied to extruded sections by pressure roller, it shall extend over the top and bottom edges of these sections by not less than 3mm.
- 8 All materials comprising the sign face, including the background, border and legends shall be carefully matched for colour at the time of sign fabrication to provide uniform appearance both by day and night. The sheeting manufacturer's recommendations on colour matching methods shall be observed.
- 9 Letter, numerals, symbols and borders shall be of material compatible with the sheeting to which they are applied. They shall be applied in accordance with the sheeting manufacturer's instructions.
- 10 Sheeting materials including letters, numerals, symbols and borders shall be fully adhered with a pre-coated heat activated adhesive using a vacuum applicator equipped with a temperature controller and there shall be no air bubbles, creases, cracks or other blemishes. Application of the material shall be made using equipment specifically designed and manufactured for the purpose by the sheeting manufacturer and maintained according to his instructions. Where the sheeting manufacturer requires the assembly materials to be provided with a coat of clear lacquer, it shall be uniform and continuous. All lacquer shall be applied at the time of fabrication of the sign face and shall be of a type specified or supplied by the sheeting manufacturer.
- 11 Details of the graphic designs, Arabic and English legends to be used on directional and certain informative signs are given on the Contract Drawings. The Contractor shall submit design drawings detailing the proposed layout of all such signs for the approval of the Engineer prior to their manufacture. Otherwise, the signs shall be in accordance with the specified regulatory, warning and informative signs detailed in the Qatar Traffic Manual, Volume 1.

13.3 PAVEMENT MARKINGS

13.3.1 Scope of Work

- 1 This Work shall consist of the supply and application of thermoplastic road marking paint for marking of the pavement as outlined herein. It shall include the marking of the centreline, the shoulder strip or edge, the barrier lines, the cross walks and any other markings required on the pavement for the control and direction of the traffic.
- 2 Where designated, thermoplastic road marking paint shall be used in the construction of rumble strips and jiggle bars. In such cases the requirements of this Part will apply except that the thickness and profile of the thermoplastic will be as per the designated details.
- 3 The pavement markings shall be painted on the road to the dimensions and in the locations designated on the drawings as per Qatar Traffic Control Manual.
- 4 The Contractor shall set out the markings and obtain the Engineer's approval before beginning the work.

13.3.2 Materials for Pavement Markings

- 1 The material used shall conform to the superimposed type British Standard Specification for Road Marking Materials BS 3262: Part 1. Where the materials do not conform to the BS the deviations shall be clearly given in reference to the relevant tables and paragraphs of BS 3262: Part 1.
- 2 Ballotini shall comply with the requirements of BS 6088.
- 3 The material shall consist of light coloured aggregate, pigment and extender, bound together with hard wearing resins, plasticised with oil as necessary in approximately the proportions by weight as Table 13.1.

Table 13.1
Composition of Thermoplastic

Material	Composition
Aggregate	40 %
Ballotini	10 - 20 %
Pigment and Extender	20%
Binder	20 %

- 4 The Contractor shall be responsible for blending the material to ensure that the performance requirements of this part of the specification are met. This approximate composition of the material as indicated above shall include the sprayed on ballotini.
- 5 The grading of various ingredients shall be such that the final product, when in a molten state, can be sprayed on the surface at a nominal 1.5 mm thickness.
- 6 The aggregate shall consist of white silica sand, crushed calcite, calcined flint or quartz, or other approved aggregate, and the colour shall comply, with the requirements laid down in paragraph 4b of BS 3262: Part 1.
- 7 Ballotini incorporated in the mixture shall be reasonably spherical, and free from flaws and not less than 80 % shall be transparent glass. The grading of the ballotini shall be as stated in BS 6088.

- 8 The pigment shall be titanium dioxide in accordance with paragraph 6a (I) of BS 3262: Part 1 and shall be not less than 10 % by weight of the mix.
- 9 The extender shall be whiting in accordance with paragraph 6b of Part 1 of BS 3262.
- 10 For yellow material sufficient suitable yellow pigment in accordance with BS 3262 shall be substituted for all or part of the titanium dioxide to comply with the performance requirements of this specification.
- 11 The binder shall not contain more than 5 % of resin or other acidic material. It shall consist mainly of hydrocarbon resins plasticised with mineral oil.
- 12 The resins used shall be of a colour at least as pale as Grade WG resin. It shall have an acid value not greater than 2, and must pass the heat stability test described below.
- 13 The oil used as plasticiser shall be a mineral oil with colour and viscosity as defined in paragraph 7a (ii) of BS 3262: Part 1; i.e., at least as pale as grade 4 on the P-R-S- Shellac and Varnish "A" Disc, and 1/2 to 3 1/2 poises at 25 °C viscosity. In addition, when heated for 16 hours at 150 °C it shall not darken excessively.
- 14 The softening point of the binder shall be used only as a guide to quality control, and the behaviour of the thermoplastic shall be judged from the performance tests described below.
- 15 The viscosity of the melted binder at the spraying temperature must be such as to produce a thermoplastic mix of the required spraying properties.
- 16 The temperature limits imposed by BS 3262: Part 1 for materials based on resin shall not apply. Temperatures up to 220 °C may be used; at these temperatures the material shall not discolour in the time required for its use.
- 17 Containers shall be made of a material which does not contaminate the contents and will protect the contents from contamination.
- 18 The capacity of each container shall be not less than 25 kg or more than 100 kg.
- 19 Each container shall be clearly marked with the manufacturer's name, batch number and date of manufacture.
- 20 Testing for the composition of the material and the grading of the aggregate shall be carried out in accordance with the methods in BS 3262 except as modified by this part of the specification. The composition of the laid material as found on analysis shall comply with Table 13.2 & Table 13.3;

Table 13.2
Proportion of Constituents

Constituent	Percent by Weight	
	Minimum	Maximum
Binder	18	22
Aggregate, pigment and extender and ballotini	78	82

Table 13.3
Grading of Combined Aggregate Pigment and Extender

BS	Sieve (mm)	Percent by Weight	
		Minimum	Maximum
0.850	100	-	
0.600	75	95	
0.300	35	65	
0.075	25	35	

13.3.3 Application of Thermoplastic

- 1 Application shall be by mobile sprayer, either hand-propelled or self-propelled.
- 2 The road surface shall be dry, and free of loose, detritus mud, or other extraneous matter.
- 3 All existing markings of more than 1 mm thick shall be removed completely before new markings are applied.
- 4 A tack coat should not be necessary when the thermoplastic is applied to carriageways. Where it is considered necessary to use a tack coat, this shall be rubberised type recommended by the manufacturers of the thermoplastic material.
- 5 In addition to the ballotini included in the mix, an additional quantity of glass beads shall be sprayed on to the hot thermoplastic line at the time of application. The rate of application shall be at the rate of about 0.5 kg/m².
- 6 The thermoplastic material shall be applied in intermittent or continuous lines of thickness 1.5 mm ± 0.3 mm.
- 7 For special lettering, arrows or symbols the material shall be applied by hand methods.
- 8 The finished lines shall be free from raggedness at all edges and be true in place with the road surface.
- 9 The upper surface shall be level, uniform and free from streaks, blisters, lumps and other defects.

13.3.4 Performance Requirements and Testing

- 1 The thermoplastic material shall meet the requirements of Table 13.4:

Table 13.4
Properties of Thermoplastic Material

Property	Minimum	Maximum
Density, g/cm ³	2.0 approx.	-
Open flashpoint °C	230	-
Softening point (ring and ball BS 2000 Part 58), °C	95	105
Luminance	65	-
Luminance (Yellow)	45	-
Flow resistance	No Slump	-
Flow resistance after 48 h at 40 °C	-	25
Abrasive wear 9/100 revs	-	0.3
Skid resistance	45	-

- 2 Testing of thermoplastic material shall be as described below. All specimens shall be prepared by carefully heating a representative sample to a temperature of (softening point + 50 °C) whilst stirring thoroughly to avoid segregation. The molten material shall be used without delay.
- 3 Heat Stability Luminance Test: The material shall be cast on to a suitable flat, glossy surface coated with a colourless release agent to give a slab 100 mm square by 3 mm thick. The luminance of the cast face, with reference to that of a block of magnesium oxide (luminance factor 100) shall be measured with the sample illuminated by a tungsten light source at an angle of 45 ° viewed at right angles by a selenium barrier layer photoelectric cell.
- 4 Flow Resistance Test: The material shall be cast into a conical mould having an apex angle of 60 ° and a vertical height of 100 mm. After cooling and setting for 24 h the cone shall be removed from the mould, placed on a flat level surface and maintained at a temperature of 23 °C ± 2 °C for 48 h.
- 5 Impact Test: A 3 mm thick coating of material shall be prepared as a screed on a Monel alloy panel 1.25 mm thick, previously coated with rubberised bitumen emulsion. The impact instrument, a 4.7 kg weight, shall be dropped vertically through 250 mm on to the surface of the panel, striking the surface with a hemispherical indentor of radius of 6 mm. The panel shall be retained by a metal block drilled to allow the indentor to strike the panel, with the depth of indentation limited to 2 mm. Five panels shall be tested and no fracture shall result from impact. A crack not longer than 2 mm will be accepted provided there is a smooth indentation in the material.
- 6 Abrasive Test: A 3 mm thick coating of material shall be screeded on to a Monel alloy panel and subject to wet (water lubricated) abrasion at 23 °C on a Taber Model 503 standard abrasion tester using H-22 Calibrade wheels, refaced between tests. The loss in weight after two successive tests of 100 revolutions shall be recorded and the average taken as the abrasive wear. The abrasive wear shall be less than the figure in Table 13.4.
- 7 Skid Resistance: A 100 mm wide line of material 1.5 mm thick shall be screeded on to a flat, level base for a minimum length of 800 mm. After cooling to ambient temperature the skid resistance shall be measured using the TRRL Portable Tester as described in Road Note 27. Measurements shall be made on different parts of the specimen, corrected for temperature effects, and the average recorded.

13.3.5 Protection of Pavement Markings

- 1 The Contractor shall control the traffic in such a manner as to protect the freshly marked surface from damage. The traffic control shall be so arranged as to give minimum interference to the travelling public. Signs, barricades, flagmen and control devices shall be supplied by the Contractor and a system of spaced warning flags or blocks shall be used to protect the fresh marking until it has dried as required. Any lines, stripes or markings which become blurred or smeared by the traffic shall be corrected by the Contractor.

13.4 TEMPORARY ROAD MARKING

13.4.1 ROAD MARKING PAINT

- 1 The use of road marking paint shall be restricted to traffic diversions or for other uses as directed by the Engineer.

- 2 Road marking paint shall be by an approved manufacturer. It shall be suitable for applying by brush or mechanical means to cement, concrete or bituminous pavement to give a chemically stable film of uniform thickness and shall be chlorinated rubber, one pack epoxy or alkyd based.
- 3 White paint shall contain not less than 6 % by mass of titanium dioxide as a pigment, conforming to type A (anatase) or type R (rutile) specified in ISO 591-1
- 4 Yellow paint shall be standard colour BS 381C No. 355, except where an alternative shade has been designated, and contain not less than 6 % by mass of a suitable yellow pigment.
- 5 The paint shall be supplied fresh and ready for use in sealed containers and stored in accordance with the manufacturer's instructions. The paint shall be applied without the use of thinners or other additives.
- 6 Paint shall be applied at a covering rate recommended by the manufacturer and approved by the Engineer.
- 7 Where markings are to be reflectorised with ballotini it shall be sprayed uniformly on to the wet paint film at the rate of 400-500 g/m². Ballotini shall be graded to comply with the requirements of BS 6088.
- 8 Road marking materials shall only be applied to surfaces which are clean and dry. Markings shall not be ragged at their edges and shall be uniform and free from streaks. Carriageway lane and edge lines shall be laid by approved mechanical means to a regular alignment.

13.4.2 ADHESIVE ROAD MARKING STRIP

- 1 For temporary diversions the use of self adhesive proprietary marking strips will be permitted.
- 2 Self adhesive proprietary road marking strips shall be of the details and dimensions shown on the drawings.
- 3 The strips shall have a metallic backing that peels off and shall have reflective properties by the incorporation of ballotini.

13.4.3 REMOVAL OF ROAD MARKINGS

- 1 Where it is necessary to remove existing thermoplastic road markings the material shall be completely removed by sand blasting or other abrasive methods.
- 2 Care shall be taken to avoid damaging the wearing course surface during this operation.
- 3 Any damage caused to the wearing course shall be made good to the satisfaction of the engineer.
- 4 The painting over of old road markings with black paint shall not be permitted.

13.5 REFLECTIVE STUDS

13.5.1 General

- 1 Reflective road markers shall be smooth, pressure moulded aluminium alloy, complying with BS 1490 with lenses to meet the performance requirements of this specification. They shall be capable of withstanding the climatic conditions of Qatar and be maintained free. A performance guarantee of five years is required.
- 2 The Road stud shall measure 130 mm x 115 mm x 25 mm when seated on the road surface. Exact size of the road stud shall be as designated.

- 3 The shaft shall be "Anti-Twist/Hot-Tite", 76 mm long.
- 4 The slope of the reflecting face shall be 20°.
- 5 The enveloping profile of the head of road studs shall be smooth and the studs shall not present any sharp edges to traffic.
- 6 The body of the stud shall be constructed in one integral part.
- 7 The anchorage part of the stud shall consist of a circumferential ribbed shank with parallel flats, the flats on the alternative ribs being at 90 ° to each other to prevent rotation of the stud when located in the road surface.
- 8 The studs shall be constructed in aluminium alloy to BS 1490 to provide a robust and durable location for the lenses. The alloy shall have the characteristics listed in Table 13.5.

Table 13.5
Composition of Alloy for Road Studs

Composition	Minimum (%)	Maximum (%)
Copper	-	0.1
Silicon	-	13.0
Iron	-	0.6
Manganese	-	0.5
Nickel	-	0.1
Zinc	-	0.1
Lead	-	0.1
Tin	-	0.1
Titanium	-	0.5
Aluminium	-	Remainder

- The Contractor shall submit mill certificates for the material showing the actual composition.
- 9 Reflective studs mechanical and physical properties shall comply with the Table 13.6 requirements:

Table 13.6
Mechanical and Physical Properties of Reflective Studs

Mechanical Properties	Minimum
0.2 proof stress test, N/m ²	120
Tensile Strength, N/mm ² .	280
Elongation, mm	2-5
Physical Properties	Minimum
Specific gravity	2.65
Method of Casting	Injection
Corrosion rating	Excellent
Brinell hardness number	55 - 60

13.5.2 Reflectors

- 1 The reflectors shall be rectangular in shape. The rectangular reflective unit shall be firmly located into a recess within the body of the stud such that the reflective face is established at the correct orientation. A sample of the proposed reflective studs shall be submitted for the Engineer's approval.
- 2 The Optical Performance (specific intensity) of each crystal reflecting surface shall not be less than the values listed in Table 13.7.

Table 13.7
Optical Performance of Reflectors

Observation Angle, °	0.3	0.5	1.0	2.0
Entrance Angle, °	5	10	10	15
Specific Intensity	160	100	27	3
Specific Intensity	120	72	20	2

- 3 For yellow reflectors the specific intensity shall be 50% of the value for crystal. For red and green reflectors the specific intensity shall be 20% of the value for crystal.
- 4 The colour limits of the reflector(s) when illuminated by CIE standard illumination A, with an entrance angle $V= 0^\circ$, $H= 5^\circ$ L or R, and an observation angle of 0.3° shall comply with the requirements given in the following paragraphs.
- 5 White (uncoloured) reflectors shall not produce a selective reflection; that is to say, the trichromatic co-ordinates X and Y of the standard illuminant A used to illuminate the reflector shall undergo a change of more than 0.91 after reflection by the reflector.
- 6 Red reflectors shall have chromaticity co-ordinates which lie within the area formed by the straight lines defined by the following pairs of points, 1 and 2, 2 and 3, the spectrum locus, and the line joint the ends of the spectrum locus:

Co-ordinate	Point 1	Point 2	Point 3
X	0.665	0.657	0.730
Y	0.335	0.335	0.262

- 7 Amber reflector shall have chromaticity co-ordinates which lie within the area formed by the straight lines defined by the following pairs of points, 1 and 2, 2 and 3, 3 and 4, and the spectrum locus:-

Co-ordinates	Point 1	Point 2	Point 3	Point 4
X	0.330	0.228	0.321	0.302
Y	0.385	0.351	0.493	0.692

- 8 Compliance with the colorimetric requirements shall normally be verified by means of a visual comparison test. If any doubt remains after this test, compliance shall be verified by the determination of the trichromatic co-ordinates as defined in the proceedings of the 1951 meeting of the International Commission (CIE).

13.5.3 Reflectivity

- 1 A sample of the road stud shall be submitted by the Contractor and relevant technical information, catalogues supplied by the manufacturers shall accompany the sample.
- 2 The reflectivity of the stud when new shall well exceed minimum standard as laid down in BS 873 and meet typical values as shown below:

Table 13.8
White Reflectors Tested to BS 873

Orientation	CIL Value (mod/1x)	CIL Value (mod/1x)
	Typical	Minimum
Observation angle 2 ° Entrance Angle 15 ° L and 15 ° R.	5-7.5	2
Observation Angle 2 ° Entrance Angle 10 ° L and 10 ° R	26.5-30	10
Observation Angle 0.5 ° Entrance Angle 10 ° L and 10 ° R	59-93	15
Observation Angle 0.3° Entrance Angle 5 ° L and 5 ° R	100-190	20

Table 13.9
Amber Reflectors Tested to BS 873

Orientation	CIL Value (mod/1x)	CIL Value (mod/1x)
	Typical	Minimum
Observation angle 2 ° Entrance Angle 15 ° L and 15 ° R.	3-4	1.0
Observation Angle 1 ° Entrance Angle 10 ° L and 10 ° R.	10-20	5.0
Observation Angle 0.5 ° Entrance Angle 10 ° L and 10 ° R.	20-50	7.0
Observation Angle 0.3 ° Entrance Angle 5 ° L and 5 ° R.	30-90	10.0

Table 13.10
Red Reflectors Tested to BS 873

Orientation	CIL Value (mod/1x)	CIL Value (mod/1x)
	Typical	Minimum
Observation angle 2 ° Entrance Angle 15 ° L and 15 ° R	1.5-2.0	2.0
Observation Angle 1 ° Entrance Angle 10 ° L and 10 ° R	4.5-7	10.0
Observation Angle 0.5 ° Entrance Angle 10 ° L and 10 ° R	10-20	15.0
Observation Angle 0.3 ° Entrance Angle 5 ° L and 5 ° R.	16-35	20.0

13.5.4 Installation of Reflective Studs

- 1 Reflective studs shall be installed and anchored to the pavement as follows:
 - (a) Drill a hole into the asphalt pavement to the dimensions recommended by the manufacturer. Ensure that the hole is free of dust and also the pavement surface within a radius of 200 mm of the hole is free from debris and dust.
 - (b) Fill the hole to overflow with the two part epoxy adhesive of the type specified in clause 10.6.2.

- (c) Immediately after pouring the grout, the road stud shall be inserted into the hole and the reflective face aligned to the oncoming traffic. The road stud shall be firmly embedded into the ground ensuring a good bed of grouting compound under the road stud and solid fixing. Protect the installed marker until the epoxy adhesive has completely set.
- (d) Clean off any surplus grouting and protect the road stud from traffic for approximately 60 minutes.

13.6 NON-REFLECTIVE STUDS

13.6.1 General

- 1 Non-reflective road studs shall be ceramic and of approximately 100 mm diameter at the base, the studs shall consist of a heat-fired, vitreous ceramic base and a heat fired opaque smooth matte surface.
- 2 The colour of the studs shall be white unless otherwise designated. The base of the stud shall have a rough surface to ensure a good bond to the road.
- 3 The adhesive used for the installation of non-reflective ceramic studs shall be a two part epoxy or other material recommended by the manufacturers and tested under the climatic and traffic conditions prevalent in Qatar.
- 4 The non-reflective ceramic studs shall conform to the dimensions and shapes shown on the drawings and shall be installed at the location indicated on the drawings or where designated by the Engineer.
- 5 The studs shall be ceramic manufactured and shall consist of a heat-fired, opaque, glazed surface. The glazed surface shall not be present on the bottom of the studs which will be cemented to the road surface. The outer surface of the studs shall be smooth except for purpose of identification, and all edges exposed to traffic must be convex and the radius nearest the edge may be less. Any change in curvature shall be gradual. The bottom surface of the marker shall be of a roughness comparable to at least that of a fine grade of sandpaper, and shall be substantially free form gloss or substance that may reduce its bond to the adhesive.
- 6 The body of the marker shall be white.
- 7 Brightness will be measured with equipment conforming ASTM E97 using a Brightness Standard of 75%. The minimum weight of the marker shall be 125 grams.
- 8 A random sample of 5 buttons shall be subjected to the compressive load test. The average compressive strength of the 5 buttons shall not be less than 680 kg and no individual button shall have a compressive strength less than 544 kg. The button shall be centered base down, over the open end of a vertically positioned hollow metal cylinder. The cylinder shall be 25.4 mm high, with an internal diameter of 76.2 mm and a wall thickness of 6.4mm. A load necessary to break the button shall be at speed of 2.5 mm per minute to the top of the button. In the event that the bottom of the marker is dimpled, a 2 mm layer of wood shall insert between the base of the marker and the hollow cylinder. Should any of the samples tested for strength fail to comply with this specification, 10 additional samples will be tested. The failure of any one of the additional samples shall be cause for rejection of the entire lot or shipment represented by the samples.'

13.6.2 Materials and Manufacture

- 1 The studs shall be produced from a combination of intimately mixed clays, shales, flints, feldspars or other inorganic material which will ensure the required properties are met. All studs shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.
- 2 The studs shall be of uniform composition and free from surface irregularities cracks, chipping, peeling, crazing and any other physical damage. The studs shall be precast in the form of a single based spheroidal segment terminating in a rounded or squared shoulder.
- 3 The height of the studs above road level shall be between 18 mm and 20 mm.
- 4 Compliance of the studs with respect to appearance, shape, dimensions and compressive strength shall be determined in accordance with CML Method 14-97. In particular, they shall exhibit an average compressive load at failure for each sample of 5 studs of not less than 680 kg and no individual value shall be less than 544 kg. Furthermore, the water absorption shall not exceed 1.0% when tested in accordance with ASTM C373. And the glazed surface of the stud shall not craze, spell, or peel when subjected to one cycle of the Autoclave test at 250 psi when tested in accordance with ASTM C424.
- 5 The adhesive for reflective studs and non-reflective studs shall be a two component epoxy. Each component shall be supplied in separate clearly marked containers and the time of use the contents of the two parts shall be thoroughly redispersed by mixing. Only complete containers of each part shall be used and these shall be mixed thoroughly until a uniform colour is achieved with no streaks of individual colours. The blend of the two components of epoxy thoroughly mixed together shall meet Table 13.11.

Table 13.11
Specification for Epoxy Adhesive

Property	Value
Gel time	5 to 30 minutes
Minimum Tensile strength of 1.6 mm film between steel blocks cured 24 h at 21 °C tested at 21 °C	7 N/mm ²
Shore hardness on 24 h sample at 21°C	70 to 80
Shore hardness on 24 h sample at 49 °C	30 minimum
Deformation temperature, °C	49 minimum

- 6 The Contractor shall submit recent test results that confirm the above properties of the supplied adhesive are met.
- 7 The epoxy shall be used strictly in accordance with the manufacturer's recommendation for storage preparation, mixing and application. Any differences from the manufacturer's recommendations and this specification shall be referred to the Engineer.
- 8 The final colour of the epoxy adhesive shall be uniform grey unless designated otherwise.

13.6.3 Installation

- 1 All sand, dirt and extraneous material shall be removed from the mark location and the surface cleaned and abraded. Cleaning shall be by compressed air. In the case of adhering material the application of heat or sand blasting will be required.
- 2 The surface shall be completely dry for the application of the adhesive.
- 3 The base of the supplied stud shall be free of any wax or grease from the manufacturing process. Any such wax or grease shall be sanded off the bottom of the marker.
- 4 The adhesive components shall be stored at the temperature recommended by the manufacturer both before use and during application. The two components of the adhesive shall be added to each other just before use, any unused mixed adhesive shall be discarded when catalytic actions cause stiffening and reduction of workability or balls of gelled resin formed in the container.
- 5 The mixed adhesive shall be applied to the prepared pavement area to be covered by the marker and the stud pressed onto the adhesive so as to squeeze out a small bead of adhesive around the periphery of the stud.
- 6 The Contractor shall carry out a trial outside of the permanent works to establish the approximate amount of adhesive required per marker and application on the works shall be carried out to this quantity.
- 7 The studs shall not be fixed to the pavement where asphalt has been laid within the last 14 days unless otherwise directed by the Engineer. The studs shall be spaced and aligned as designated or as per the Qatar Traffic Control Manual. The tolerance for placing shall be not more than ± 10 mm.
- 8 Where studs are to be applied to pavement where the road is to be opened to public traffic shortly after placing, the preheating of the roadway surface to permit a rapid set is permitted. In such cases, the procedure followed shall be as recommended by the supplier of the epoxy adhesive and as approved by the Engineer.
- 9 On roadway sections that are not opened to public traffic no preheating of the studs or road surface is required as long as the required bond strength of 12 kg/cm^2 can be achieved in less than 3 h.

END OF PART