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KERAJAAN MALAYSIA
JABATAN KERJA RAYA MALAYSIA

STANDARD SPECIFICATION FOR ROAD WORKS

Section 6: Road Furniture



KETUA PENGARAH KERJA RAYA
JABATAN KERJA RAYA MALAYSIA
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FOREWORD

As practices in road construction change over time, it is imperative for Jabatan Kerja Raya (JKR) to continuously update and improve their Standard Specifications. These new specifications are not only aimed at keeping abreast with current technologies but also to help improve the quality of construction works and its final product. Consequently, these new specifications will ultimately have a significant positive impact on the construction industry especially with the incorporation of new products and technologies.

The JKR Standard Specification for Road Works is an essential component in the road infrastructure construction industry. This Specification provides an improved guidance in the material selection and quality control of workmanship and products, based on current best practices. The purpose of the JKR Standard Specification is to establish uniformity in road construction to be used by road designers, road authorities, manufacturers and suppliers of road related products.

This particular document, the **"Standard Specification for Road Works – Section 6: Road Furniture"**, is a part of a series of improved specifications in the JKR Standard Specification for Road Works. The compilation of this document was carried out through many discussions that had been held by the technical committee. The draft had also been presented and discussed at length in a specially held workshop to get feedback and comments from relevant parties involved, which were then carefully considered and incorporated into the Specification wherever appropriate or necessary.

The Specification has also gone through the different phases of vetting and approval before the production of its final draft and printed copy. It will be reviewed and updated from time to time to cater for any changes in policies and the inclusion of current requirements, if necessary. Any feedback or improvement to be considered for future revisions should be forwarded to Bahagian Pembangunan Inovasi & Standard, Cawangan Jalan, JKR Malaysia.

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SECTION 6 – ROAD FURNITURE

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6.1 CORRUGATED SHEET STEEL BEAM HIGHWAY GUARDRAIL

6.1.1 Description

This work shall comprise the supply and installation of corrugated sheet steel beam highway guardrails inclusive of bolts, nuts, posts and other ancillary works, all in accordance with this Specification, the Drawings, and as directed by the S.O.

6.1.2 Materials

6.1.2.1 Beam Element

Unless otherwise specified in the Drawings, corrugated sheet steel beam highway guardrails shall conform to the requirements of AASHTO Specification M180 for Class `A' Type II (galvanised) guardrail. Guardrails shall be fabricated and furnished complete with terminal or buffer sections, connecting and splicing bolts, nuts and washers, etc., all conforming to the requirements of AASHTO Specification M180 and as necessary for erecting the guardrails as shown in the Drawings or as required by the S.O.

The mechanical properties of the base metal for beams shall conform to the following tensile requirements:

- minimum yield point – 345 MPa
- minimum tensile strength – 483 MPa
- elongation on a 50mm test gauge of beam element shall not be less than 12%

The test specimens shall be prepared and tested as specified in ASTM A653/A653M. If galvanized test specimens are used, the correction for thickness shall be 0.08mm.

The base metal of beam or sheet shall comply to AASHTO M180 with nominal thickness of 2.67mm. The nominal thickness for the galvanized beam or sheet shall be 2.82mm with a tolerance for underspecified thickness of 0.25mm. There shall be no limit for over thickness. For fabricated beams, thickness measurements shall be made for tangent portions of the cross section.

Unless otherwise shown in the Drawings, the beam elements shall be shaped from sheets having a nominal width of 483mm for W beams and 749 mm for thrie beams. Tolerance from the nominal width of minus 3.2mm will be permissible. The effective length of the beam element shall in general be 4000mm long with provision for mounting of post at 2000mm centres.

The beam shall be of uniform section, straight or curved as required and so designed that when installed it will not hold water.

The edges shall be rolled or rounded to eliminate sharp edges. Warped, kinked or bent sections shall be rejected.

The beam shall be hot-dipped galvanized after fabrication and shall comply to ASTM A653/A653M. The zinc used for the coating shall be as prescribed in ASTM B6 or AASHTO M120 and shall be at least equal to the grade designated as 'Prime Western". No test specimen shall have a coating weight of less than 1100 g/m2 for any Single Spot Test.

The sheets or beams shall be of prime finish, that is, free from injurious defects such as blister, flux and uncoated spots.

The coating shall be smooth, free of beading or sharp projections along the edges and shall adhere tenaciously to the surface of the metal. The adherence of the zinc coating to the surface of the base metal shall be determined by cutting or prying with a stout knife applied with considerable pressure in a manner tending to remove a portion of the coating by parring or whiffling, and it shall not be possible to peel any portion of the coating so as to expose the base metal.

Bolts and nuts shall conform to the requirements of ASTM A307. All bolts, nuts and washers for use with guardrail shall be hot-dipped galvanized as specified in MS 740 or ASTM A153 or AASHTO M232.

The terminal sections shall be fabricated from sheet steel manufactured from the same type of metal and having the same gauge thickness and galvanized in the same manner as the beam elements and also to conform to the same mechanical properties.

6.1.2.2 Posts

The post and packers shall be structural steel conforming to the requirement of ASTM A36. The dimensions of the posts shall follow the drawings and shall have a dimension of 178mm x 76mm x 6.0mm thick x 1830mm long. The packer shall be channel sections of dimension 178mm x 76mm x 6.0mm thick x 360mm and shall be of the same material as that used for the posts. The post and packers shall be hot-dipped galvanized in accordance with ASTM A123 or AASHTO M111.

The base metal of post and packer shall be of nominal thickness 6.0mm. The nominal thickness for the galvanized post and packer shall be 6.20mm with a tolerance for under specified thickness of 0.28mm.

Should other types or materials is proposed for posts or packers, the Contractor shall supply technical specifications that address those properties. The Contractor shall also provide warranty from the manufacturer and test certificate indicating that the proposed guardrail have been subjected to full-scale crash tests, Test Level 3(TL-3) minimum, as defined by ASSHTO MASH (Manual for Assessing Safety Hardware).

6.1.2.3 Delineators

Delineators shall be fixed on the beam or mounted on the packers or posts and shall be of High Intensity Prismatic retroreflective sheeting or of a higher grade. The Contractor shall supply technical specifications that address the details of the shape and properties of the delineators for the S.O. approval.

6.1.3 Installation of Guardrails

6.1.3.1 Setting Posts

Before posts are erected, the alignment and finished levels of the guardrails shall be set accurately on site as per drawings, for approval by the S.O.

Post holes at the correct positions shall be dug either manually or mechanically to the required level. The posts shall then be set plumb in the holes with the front face forming a smooth line to the approval of the S.O. After the posts are in place, the holes shall be backfilled with grade 20 concrete compacted in such a manner as not to displace the posts from correct alignment as shown in the Drawings. All posts shall not be anchored to concrete block in the ground unless otherwise specified such as when approaching rigid object on lateral earth clearance of less than 600mm. Posts may be installed by means of driving with suitable equipment if the S.O. is satisfied that the Contractor is capable of installing the post to the designed depth, line and level, accurately.

The posts shall be spaced at 2000mm apart except those of the terminal sections. Unless otherwise specified in the Drawings, the length of post for all last three posts from the end or terminal section shall be 2180mm without concrete surround. Due to the nature of the terrain, there may be a need to use longer posts than those shown in the drawing. The Contractor shall verify with the S.O. before placing order for such posts.

6.1.3.2 Placing Beams

The guardrail beams shall be fixed and firmly bolted together with the packers on to the post to the lines and grades as shown in the Drawings, and as directed by the S.O.

The beam elements and terminal sections shall be formed to proper shape and dimensions complying with AASHTO M180. They shall be punched and drilled with holes for mounting and splicing, and ready for assembly before being delivered to the site. No punching, drilling, cutting or welding shall be permitted in the field unless approved by the SO for special reasons and for sampling.

Beam to be erected on a radius of less than 45m shall be shop-curved. The beam element shall be spliced by lapping in the direction of traffic. The splice shall be fastened with eight bolts

and shall not be less than 318mm in length. All connections or splices shall be formed with oval shoulder button-headed bolts to minimise projections on the road side of the guardrails. The strength in tension of the beams and of the joint to adjacent rails shall be not less than 330 kN. All bolt heads shall be embossed with the manufacturer's brand. All bolts and nuts shall be anti-theft type.

6.1.3.3 Terminal Anchorages

Terminal anchorages used for both ends of guardrail structure shall be constructed as shown in the Drawings and as directed by the S.O. The approach and departure ends of guardrail structure must be anchored to concrete block of minimum size 400mm x 400mm x 1100mm embedded deep in the ground to give the needed stability to the adjoining section and should be flared well away from the travelled way to prevent vehicles from striking the anchored ends with the resulting over-ride or roll over.

The type of anchorage used on the approach end shall be Terminal Anchorage Unit Type 2. The anchorage on the departure end of the guardrail structure shall be Terminal Unit Type 2 or 90 degree Twist Terminal Unit Type 3.

For 90 degree Twist Terminal Type 3, the beam element must be curved in factory to provide a smooth curve without any kink. The top of the beam element shall be flushed with the finished ground line.

In the embankment section adjacent to a cut section, where the guardrails need to be carried to cut section, the ends shall be flared and anchored into the side of the hill, mound etc. by 2 nos. 25mm dia. galvanized bolts 375mm long with galvanized nuts and washer embedded in 300mm x 1200mm x 900mm size reinforced concrete anchorage block embedded in the slope**.**

Guardrails adjacent to bridge should be anchored to the bridge parapet and the guardrails should form a smooth line with the face of the bridge parapet. Care shall be taken to drill in the concrete parapet of the bridge for fixing bolts.

6.1.4 Marking, Painting and Storage

6.1.4.1 Marking

In addition to the marking specified in AASHTO Specification M180, the JKR logo shall also be marked on each beam element.

Each beam element shall be identified by the following:-

- Name or Brand of Manufacturer
- Identification Symbols or Code for Heat Number and Coating Lot
- AASHTO Specification Number

- Class and Type

Markings shall not be placed at such a location on the beam section that they will be obscured after erection or in a manner that the brand will be conspicuous to any traffic. Marking material shall be able to resist obliteration during storage, transportation and erection.

Markings placed on the beam shall be placed in the centre of corrugation and shall be die-embossed with letters and numbers not exceeding 12mm in height.

Marking for end sections and back-up plates may be on durable tags securely attached to each section or bundle.

6.1.4.2 Painting

The beam shall normally not be painted. However, when specified, they shall be powder coated and baked using Polyester based powder. The powder coated surface shall be tough, durable, colour stable, corrosion resistant and UV resistant.

6.1.4.3 Storage

All galvanised beam elements, terminal sections, bolts, nuts and washers and posts shall be stored under a cover that will protect them from rain until they are erected or used. While in storage, the materials shall not be in direct contact with the soil and there shall be a minimum space of 300 mm between the lowest most elements and the ground surface.

6.1.5 Basis of Acceptance

The manufacturer shall be accredited with ISO 9001 2000 and shall have implemented standard procedures for checking the quality of the beam elements and terminal section which include incoming inspection of material, dimensional verification, galvanizing thickness, final test and the inspection of finished goods. This is to ensure that the final product is of high quality, good uniformity and free from all defects in manufacturing.

At the fabricating plant, warehouse or after delivery to the site of construction. Mill Test certificates for the raw materials used in the manufacture and for the galvanized coating weight showing the results of tests carried out for the purpose of establishing compliance with the standard shall be submitted for every 200 pieces or less of posts, beam sections, back up plates, terminal sections, bolts and nuts delivered to the site. The Contractor shall obtain approval for the material to be used from the S.O. before starting work on the installation.

However, the S.O. may still select one piece of guardrail, backup plate and terminal section from each lot of 200 pieces or less for testing before installation to determine the specification requirements have been complied with. This can be carried out at the manufacturer's fabricating plant using calibrated testing equipment and witnessed by the S.O. or

carried out by independent testing laboratory, SIRIM. If one piece fails to meet the requirements, then two additional pieces shall be tested. If either one of these pieces fail to conform, the lot represented by these samples shall be rejected and removed from the site. The cost of all sampling and testing shall be borne by the Contractor.

The Contractor shall also provide warranty from the manufacturer in the form of certified documentary evidence indicating that the guardrail system have been subjected to full-scale crash tests, Test Level 3(TL-3) minimum, as defined by National Cooperative Highway Research Report 350, Test Level 3 (NCHRP-350) or AASHTO MASH (Manual for Assessing Safety Hardware).

6.2 TRAFFIC SIGNS

6.2.1 Description

This work shall consist of the supply, assembly, erection and installation of sign faces, sign plates, posts and backing frames, all in accordance with the details shown in the Drawings and as specified herein. It shall include all excavation and backfilling, all necessary foundations, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations where required, application of paints and finishes, etc., to complete the works all to the satisfaction of the S.O.

6.2.2 Sign Definitions

For the purpose of this Specification, traffic signs are defined as follows:

i) Non-illuminated signs are those signs which are not lit either internally or externally and shall be retro-reflective;

ii) Externally illuminated signs are those which comprise either retroreflective or non-retroreflective facing with external lighting luminaire.

6.2.3 Sign Classification

For the purpose of this Specification, the following classifications shall apply:

(a) Permanent Traffic Signs

Any of the traffic signs defined in Sub-Section 6.2.2 above or any part thereof as shown in the Drawings or as directed by the S.O. to remain in position upon completion of the Works.

(b) Temporary Traffic Signs

Any of the traffic signs defined in Sub-Section 6.2.2 above or any part thereof designed by the Contractor with the approval of the

S.O. which will not remain in position at the completion of the Works.

6.2.4 Standards

All traffic signs shall, except where specified otherwise, comply with the requirements of the latest ARAHAN TEKNIK (JALAN) Series 2, published by Ibu Pejabat JKR, Kuala Lumpur.

6.2.5 Permanent Traffic Signs

6.2.5.1 General Requirements

Permanent traffic signs shall be constructed, assembled, located and erected as shown in the Drawings or as directed by the S.O.

Each complete traffic sign or part thereof shall be capable of passing the tests specified in BS 8442:2006.

All externally illuminated traffic signs shall comply with BS EN 12899-1 unless shown otherwise in the Drawings.

Before the commencement of fabrication of any traffic sign, unless shown otherwise in the Drawings, the Contractor shall submit for the S.O.'s approval the details of fabrication drawings for all signs.

All traffic sign housings shall be provided with vandal and weather resistant locks. Keys, in the quantities determined by the S.O., shall be provided to the S.O. Types of lock shall be kept to a minimum.

Traffic signs shall be carefully handled to prevent damage (methods shall include the use of proper slings), and shall be transported and stored in accordance with the manufacturer's instructions.

6.2.5.2 Foundations

The type and size of foundations for permanent traffic signs shall be as shown in the Drawings and, unless stated otherwise therein, shall comply with this Specification and the latest ARAHAN TEKNIK (JALAN) Series 2, published by Ibu Pejabat JKR, Kuala Lumpur.

All excavations, erection of formworks, placing of reinforcement, etc., for foundations shall be carried out in compliance with this Specification and shall be approved by the S.O. before placing of concrete and backfilling.

Unless shown otherwise in the Drawings, signs supported by a single post placed in the ground shall have the post installed centrally in 300 mm diameter holes filled with grade 20 concrete

complying with Section 9 of this Specification, to minimum depth of 900mm from the ground surface. The hole shall be excavated either mechanically or manually.

Posts shall be supported for a minimum of three (3) days after placing the concrete. Backfilling shall not take place until at least 48 hours after placing the concrete or other period as agreed by the S.O.

Where signs are illuminated, provision shall be made for cable entry through the foundation by means of ducting as shown in the Drawings.

All backfilling of foundation pits and reinstatement of existing surfaces above the foundations shall comply with Section 2: Earthworks of this Specification. Where pockets are formed in concrete foundations their plan dimensions shall be 100 mm larger than those of the post.

Any pockets formed in concrete foundations to receive posts shall be temporarily sealed or capped pending installation of the posts and shall be cleaned out immediately prior to the erection of the posts. The posts shall be placed centrally in the pockets and be bedded on mortar designation complying with Section 9: Concrete of this Specification and the pockets shall be filled up to existing ground level with concrete in accordance with Section 9: Concrete of this Specification.

6.2.5.3 Posts

Posts for permanent traffic signs shall be as shown in the Drawings and shall comply with BS EN ISO 1461:2009: Hot Dip Galvanised Mild Steel (HDGMS). The average galvanizing coating for steel above 3 mm thick shall be 70 microns while for steel above 6 mm thick shall be 85 microns. The supplier of HDGMS shall produce galvanizing warranty certificate. No painting is required for galvanized steel.

- Steel ≥ 6mm thick - 85µm
- Steel ≥ 3mm to < 6mm - 70µm
- Steel ≥ 1.5mm to < 3mm - 55µm

Unless shown otherwise in the Drawings, posts shall be of tubular hollow section steel of not less than 60 mm outside diameter complying with BS EN 10255:2004.

Unless shown otherwise in the Drawings, posts shall not protrude above the top of the sign unless supporting an external luminaire where the protrusion shall be kept to a minimum.

Signs erected on a single post shall be positioned so that the post is in the centre of the sign, unless shown otherwise in the Drawings.

Compartments for electrical equipment shall be as shown in the Drawings. In the case of signs supported by more than one post, such compartments shall be on the post furthest from the carriageway unless directed otherwise by the S.O.

Flange plates shall have holes or slots as shown in the Drawings to accommodate any holding down bolts.

6.2.5.4 Sign Plates

All permanent sign plates shall be as shown in Drawings and shall comply with BS EN 12899-1.

a) Sign plates shall be made of 10 S.W.G. sheets of aluminium alloy HS 30WP conforming to BS EN 485-2:2013 with a minimum thickness of 3 mm or ;

b) Aluminium composite material. The aluminium composite material shall have the following properties complying to MS 832 : 1984 and ASTM E 330-97:

(i) Minimum total thickness : 4 mm
(ii) Minimum aluminium skin thickness (each side): 0.5 mm
(iii) Peel strength (kgf/mm) : 0.85
(iv) Coefficient of Linear Expansion (x 10^{-5}/^{o}C) :
- Edgewise: 3.5
- Lengthwise: 2.5

(v) Flexural Stiffness (GPa) :380
(vi) Wind Load Test (@ 1500 Pa) :8.2mm

The retroreflective sheeting shall be applied on non-coated aluminium surface only. Back surface of aluminium plate shall be painted in executive grey or equivalent grey.

A sign plate not exceeding 1.2 m in height and 2.4m in width shall be made from a single sheet. Where more than one sheet is used to make up a sign plate, the sheets shall be rectangular, of approximately the same size and shape, and the position of the joints shall be to the approval of the S.O.

Sign plates shall be drilled at all locations where rivets or bolts are required for attaching the plate to the backing frame or mountings before application of the sign face. However, riveting shall be carried out only after the application of the sign face.

Subject to the S.O.'s approval, double sided "Very High Bond" (V.H.B.) tapes may be used as an alternative to rivets. Nevertheless, the tape shall comply with the following requirements:

(a) Peel Adhesion - 440 N per 100 mm;
(b) Tensile Adhesion - 910 kPA;
(c) Dynamic Adhesion - 550 kPA

Where top and bottom light spill screens are required as shown in the Drawings, these shall extend for the whole width of the sign, be fabricated out of the same material as the sign plate and shall have corners cut to the same radius as the other corners of the sign plate.

Top and bottom light spill screens shall be considered part of the sign plate and any stiffeners and mounting fittings shall be designed to accommodate the combined size.

6.2.5.5 Sign Faces

Sign faces for permanent traffic sign shall be retroreflective prismatic sheeting as shown in the Drawings and shall comply with the Malaysian Standard Specification for Reflective Sign Faces Materials (MS 1216 or ASTM D4956, whichever is relevant and current) except for High Intensity Prismatic and Wide Angle Prismatic sheeting.

Retroreflective sheeting is a material consisting of one or more retro-reflective elements embedded within a transparent film having a smooth, flat outer surface. Two types of retroreflective sheeting that have been established and identified for use on traffic signs are High Intensity Prismatic and Wide Angle Prismatic sheetings. Both these sheetings are available in sheets and rolls using pressure sensitive adhesive. Application of pressure sensitive adhesive sheeting to sign substrates is by using hand squeezed roller applicator.

All retroreflective sheeting shall be fixed in accordance with the manufacturer's instruction.

Unless agreed otherwise by the S.O., sign faces shall be formed from a single piece of retroreflective sheeting.

Where, with the agreement of the S.O., more than one retroreflective sheeting is used, the number of sheets shall be kept to a minimum. All faces up to 1 m in size shall be produced with a single sheet and no joint will be accepted.

Only vertical and horizontal joint shall be permitted and all joints in retroreflective sheeting shall be overlapped by not less than 6 mm. The overlap in the horizontal joint shall be from the top and the vertical joint shall be from the left; butt joints will only be accepted for prismatic retroreflective sheeting.
Retroreflective sheeting shall be applied evenly over the whole surface of the sign plate and shall adhere fully. It shall be free from twists, cracks, folds or cuts, air bubbles and other blemishes.

All retroreflective sheetings used on the same sign shall be carefully matched for colour to produce a uniform appearance both by day and by night. Non-uniform shades of colour on any one sign will not be accepted.

The edges of all the retroreflective sheeting shall be properly fitted to ensure no delimitation of the sheeting from the base substrate.

Where sheeting is applied to the extruded section by pressure roller, it shall extend over the top and bottom edges of this section by not less than 3 mm.

Any cut-out letters, 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 instruction.

The Contractor shall furnish to the S.O. a letter of warranty for the specified period for all sign faces from the manufacturer of the sheeting or the sign fabricator.

The retroreflective sheeting manufacturer shall furnish the S.O. a written warranty that the fluorescent colours shall be durable for a minimum 7 years for permanent signs and a minimum 3 years for temporary signs.

The letter of warranty shall have minimum details as follows:

- Project title
- Name of end user
- Name of contractor
- Date of installation
- Defects warranted against; delamination, colour fading, reflectivity, blemishes,
- Reference to relevant standards
- Total quantity of material used (grade to be stated)
- Endorsement by authorised personnel
- Compliance to JKR specifications, MS 1216 and ASTM D 4956-09.

6.2.5.5.1 Requirements

(a) Photometric – Coefficient of Retroreflection RA

(i) High Intensity Prismatic sheeting is a retroreflective sheeting referred to as 'high-intensity' which is typically an unmetalised microprismatic retro-reflective element material complying with ASTM D 4956-09 Table 1

TABLE 1 : MINIMUM COEFFICIENT OF RETROREFLECTION (R_A) CD/FC/FT^2 (CDLX^{-1}M^{-2}) FOR HIGH INTENSITY PRISMATIC SHEETING

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow Green	Fluorescent Yellow	Fluorescent Orange
*0.1^{oB}	-4^o	500	380	200	70	90	42	25	400	300	150
*0.1^{oB}	+30^o	240	175	94	32	42	20	12	185	140	70
0.2^o	-4^o	360	270	145	50	65	30	18	290	220	105
0.2^o	+30^o	170	135	68	25	30	14	8.5	135	100	50
0.5^o	-4^o	150	110	60	21	27	13	7.5	120	90	45
0.5^o	+30^o	72	54	28	10	13	6	3.5	55	40	22

(ii) Wide Angle Prismatic sheeting is a retroreflective sheeting which is typically an unmetalised cube corner microprismatic retroreflective element material complying with ASTM D4956 as shown in Table 2.

TABLE 2 : MINIMUM COEFFICIENT OF RETROREFLECTION(R_A) CD/FC/FT^2 (CDLX^{-1}M^{-2}) FOR WIDE ANGLE PRISMATIC SHEETING

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow Green	Fluorescent Yellow	Fluorescent Orange
*0.1^o	-4^o	830	620	290	83	125	37	25	660	500	250
*0.1^o	+30^o	325	245	115	33	50	15	10	260	200	100
0.2^o	-4^o	580	435	200	58	87	26	17	460	350	175
0.2^o	+30^o	220	165	77	22	33	10	7	180	130	66
0.5^o	-4^o	420	315	150	42	63	19	13	340	250	125
0.5^o	+30^o	150	110	53	15	23	7	5	120	90	45
1.0^o	-4^o	120	90	42	12	18	5	4	96	72	36
1.0^o	+30^o	45	34	16	5	7	2	1	36	27	14

Notes:

* Values for 0.1^o observation angle are supplementary requirements that shall only apply when specified by the purchaser in the contract or order

(b) Daytime Color

Colour shall conform to the requirements of Table 3. Daytime colour and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminium test panels shall be determined instrumentally in accordance with ASTM E 991. Computations shall be done in accordance with ASTM E 308 for the 2^o observer.

TABLE 3 : COLOR SPECIFICATION LIMITS (DAYTIME) [A]

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404
Green[B]	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346
Blue[B]	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355

[A] The four pairs of chromaticity coordinates determine the acceptable colour in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant D65.

[B] The saturation limit of green and blue may extend to the border of the CIE chromaticity locus for spectral colours.

(c) Night Time Colour

Night time colour of the sheeting applied to alumunium test panels shall be determined in accordance with ASTM E 811 and evaluated in accordance with ASTM E 308. Sheeting shall be measured at 0.33^0 observation and -40 entrance at 90^0 rotation. Colour shall conform to the requirements of Table 4.

TABLE 4 : COLOR SPECIFICATION LIMITS (NIGHTTIME) [A]

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White (no requirement)	-	-	-	-	-	-	-	-
Red	0.513	0.487	0.500	0.470	0.545	0.425	0.572	0.425
Orange	0.595	0.405	0.565	0.405	0.613	0.355	0.643	0.355
Brown	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Yellow	0.650	0.348	0.620	0.348	0.712	0.255	0.735	0.265
Green	0.033	0.370	0.180	0.370	0.230	0.240	0.091	0.133
Blue	0.595	0.405	0.540	0.405	0.570	0.365	0.643	0.355
Fluorescent Orange	0.480	0.520	0.473	0.490	0.523	0.440	0.550	0.449
Fluorescent Yellow	0.554	0.445	0.526	0.437	0.569	0.394	0.610	0.390
Fluorescent Yellow - Green	0.625	0.375	0.589	0.376	0.636	0.330	0.669	0.331

[A] The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant D65.

(d) Accelerated Outdoor Weathering Requirements

The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 1500 hours' exposure in a xenon arc weatherometer in accordance with ASTM G 26, Type B, Method A. Following exposure, panels shall be washed in a 5% HCL solution for 45 second, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retroreflective shall be not less than 100 and the colour is expected to conform to the requirements of Table 3 and 4 for weathered sheeting. The sample shall:

(i) Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 0.8mm shrinkage or expansion.

(ii) Be measured at 0.2^{o} observation angle and -4^{o} and +30^{o} entrance angle, the coefficient of retroreflection shall not be less than 80% of initial values in Table 1 or 2.

(e) Field Performance

Retroreflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer's recommendations, is expected to perform effectively for a minimum of 3 years.

The finish of all sign faces shall be capable of passing the tests described in MS 1216, and the standard of fabrication and workmanship shall be such that under normal conditions of service and proper maintenance, the sign faces shall last not less than 8 years for High Intensity and Wide Angle Prismatic retroreflective sheeting (7 years for fluorescent yellow & fluorescent yellow green) from the date of issue of warranty letter without any serious blemishes or defects.

(f) Shrinkage

The retroreflective sheeting shall not shrink in any dimension more than 0.8mm in 10 min or more than 3.2mm in 24 hours when tested in condition all adhesively bonded and unbonded test samples and specimens at a temperature of 73 ± 3°F (23 ± 2°C) and 50 ± 5% relative humidity for 24 hours prior to testing.

(g) Flexibility

The sheeting shall be sufficiently flexible to show no cracking when bending the sheeting, in 1 second, around a 3.2mm mandrel with adhesive contacting the mandrel. For ease of testing, spread talcum powder on the adhesive to prevent sticking to mandrel. The test specimen shall be 70 by 229mm. The test temperature shall be 73 ± 3°F (23 ± 2°C).

(h) Liner Removal

The liner, when provided, shall be easily removed without soaking in water or other solutions, and shall not break, tear, or remove adhesive from the sheeting. The protective liner, if any, shall be easily removed following accelerated storage for 4 hours at 160°F (71°C) under a weight of 2.5 psi (17.2 kPa).

(i) Adhesion

The adhesive backing of the retroreflective sheeting shall produce a bond that will support a 1¾-lb (0.79 kg) weight for adhesive classes 1, 2, and 3 or a 1 lb (0.45 kg) weight for adhesive class 4 for 5 mins, without the bond peeling for a distance of more than 51 mm.

(j) Impact Resistance

The retroreflective sheeting applied according to the sheeting manufacturer's recommendations to the test panel of alloy 6061-T6, 0.10cm by 7.6 cm by 12.7 cm and conditioned for 24 hours, shall show no cracking or delamination outside the impact area when the face of the pane is subjected to an impact of a 100 inch-pounds (11.3Nm) using a weight with a 15.8 mm diameter rounded tip dropped from a height necessary to generate an impact 100 inch-pounds, at test temperatures of both 32^0F (0^0C) and 72^0F (22^0C) 2 lb (0.91 kg) weight, with am15.8 mm diameter rounded tip, dropped from the height necessary to generate an impact of 10 inch lb. (1.13 Nm).

(k) Specular Gloss

The retroreflective sheeting shall have a specular gloss of not less than 40 when tested with test method as specified in MS 1216 at an angle of 85°.

6.2.5.6 Backing Frames

Backing frames for permanent traffic signs shall be as shown in the Drawings and shall comply with this Specification.

Signs exceeding 600 mm in height or width shall be stiffened by means of angles while signs exceeding 1 m in height or width shall have a backing frame fabricated from 40 mm x 40 mm x 3 mm angles.The backing frame shall be made of Hot Dip Galvanised Mild Steel angles in accordance with BS EN ISO 1461:2009 with average galvanizing coating thickness of 70 microns. The suppliers of HDGMS shall produce galvanizing warranty certificate.

The angles shall be welded, bolted or riveted together to form the backing frames as shown in the Drawings.

Backing frames shall not project beyond the face of the sign.

Where large signs are built in sections, the backing frames of these sections shall be bolted together with 8 mm diameter bolts at not more than 200 mm centres.

The details of joints between angles of the backing frame and of joints between sections of large signs shall be to the approval of the S.O.

The sign plate shall be riveted to the backing frame after the application of the sign face.

6.2.5.7 Construction and Assembly

Traffic signs shall be constructed and assembled as shown in the Drawings and shall comply with. BS EN ISO 1461: 2009.

All sign plates, backing frames, purlins, posts and other components shall be de-burred prior to assembly.

Where framing and stiffening are not an integral part of the sign plate, their joints shall be welded or joined with suitable brackets utilising nuts, bolts and washers.

Purlins shall be required for those traffic signs exceeding 1.50 m in any dimension.

Where purlins are adopted, they shall be attached to each vertical member of the backing frame and the sign stiffening and framing shall be continuous in the vertical direction. Unless otherwise permitted by the S.O., purlins shall be spaced equally apart. Connections shall be made at every point where a purlin crosses a post.

Where purlins are not adopted, the sign stiffening and framing shall be continuous in the horizontal direction.

All rivets and other devices used in the fixing of sign plates to their stiffeners or backing frames, or those used in the construction of housings, shall be of a material compatible with the materials being joined.

Spacing of rivets or other devices used in the fixing of sign plates to their stiffeners or backing frames shall be uniform and shall not exceed 150 mm around the outside edge of any sheet or section of a sheet, and shall not exceed 300 mm on cross braces. Hollow rivets shall be filled with a plastic plug flush with the head of the rivet.

An additional washer of neoprene, nylon or other material approved by the S.O. shall be used against the sign face to protect it from the effects of any metal nuts, bolts, washers and/or screws.

Where traffic signs, including external lighting luminaires or their supports, are required to have holding down bolt fixings, the bolts shall be lightly greased before final installation and they and their anchorages shall be installed so as to achieve the loadings, torque settings and requirements shown in the Drawings.

Sign plates shall be connected to posts by a method approved by the S.O. Banding systems shall be of stainless steel. Where ferrous components are permitted, any drilling of such components shall be completed before the application of any finish.

Any hole drilled to accommodate rivets or bolts in plates with plastic sheeting shall, immediately prior to the insertion of the rivet or bolt, have a clear lacquer, as recommended by the manufacturer of the plastic sheeting, applied to its edge to prevent the ingress of moisture. The surfaces of rivets or bolts exposed on the sign face shall be coloured by a material approved by the S.O. to match that part of the face.

Traffic signs to be erected on road lighting columns shall have fixings compatible with the column cross-section and finish. Unless otherwise permitted by the S.O., columns shall not be drilled and wiring shall be contained in approved external conduits.

In addition to the requirements of this Specification, variable message traffic signs shall be of a type approved by the relevant authorities.

6.2.5.8 Location and Erection

The approximate location of each permanent traffic sign shall be as shown in the Drawings. All traffic signs shall have their exact location determined by the S.O. and recorded on the As-built Drawings.

All posts shall be erected plumb and where two or more posts are provided for any one sign, the face of the posts shall be lined up.

Signs erected on two posts shall have each post positioned so that the distance from the centre of the post to the edge of the sign plate is 300 mm, unless directed otherwise by the S.O.

Any pockets formed in concrete foundations to receive the posts shall immediately, prior to erection, be cleaned out. The posts shall be placed centrally in the pockets and be bedded in and filled up to finished foundation level with grade 20 concrete.

Traffic signs mounted on posts, except those on gantries, shall be erected to have their faces plumb and orientated in relation to the carriageway in accordance with the latest ARAHAN TEKNIK (JALAN) Series 2, published by Ibu Pejabat JKR, Kuala Lumpur.

Traffic signs mounted on gantries shall be erected as shown in the Drawings.

No traffic sign shall be dismantled, *resited* or removed without prior approval from the S.O.

6.2.5.9 Covering of Permanent Traffic Signs

Where it is required in the Contract that permanent traffic signs are to be blanked-out or are to have an alternative message, the covering to be adopted shall comply with the following requirements.

The covering shall be 1.5 mm (16 S.W.G.) thick made from a material compatible with that of the sign plate, or a material approved by the S.O.

Cover plates shall be fixed by means of 5 mm diameter stainless steel bolts, washers and nuts or non-ferrous rivets not more than 600 mm apart, the bolts passing through 12 mm diameter, 5 mm thick plastic distance pieces between the sign face and cover plate. Any holes remaining in the finished sign face shall be filled with blocked rivets coloured on the face by methods approved by the S.O.

Where self-adhesive plastic film is used, it shall be compatible with the sign face materials and be applied and removed in compliance with the manufacturer's instructions.

Any loose covering used must be sufficiently opaque to prevent reflection from the covered sign and be securely fastened to the back of the sign. Under no circumstances shall tape or other adhesive material be applied to the face of the sign. A minimum space of 50 mm shall be left between the covering and the face to permit airflow over the sign.

Traffic signs which are to be covered shall not be erected on trafficked highways without the covering in place.

Removal of any covering shall be carried out with minimum disturbance to traffic and only after the S.O. has given his approval.

Irrespective of any requirement in the Contract to cover signs, any traffic sign erected at such a time that its legend does not relate either wholly or in part to the traffic movement and route in operation, shall have its sign face securely covered with one of the materials described above until such time as the S.O. authorizes its removal.

6.2.6 Temporary Traffic Signs

Temporary traffic signs shall be constructed either as non-illuminated or externally illuminated signs as directed by the S.O.

Sign faces for temporary traffic sign shall be Wide Angle (Fluorescent Orange) Prismatic retroreflective sheeting as shown in the Drawing and shall comply with the Sub-Section 6.2.5.5.1.

Retroreflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer’s recommendations, is expected to perform effectively for a minimum of 3 years. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that :

(i) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night time driving conditions; or

(ii) the coefficient of retroreflection is less than 100 when measured at 0.2° observation and -4° entrance at 90° rotation. All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.

Location and erection of temporary traffic signs shall be in accordance with the requirements of the latest ARAHAN TEKNIK (JALAN) ATJ 2C/85, published by Ibu Pejabat JKR, Kuala Lumpur. Erection of temporary traffic signs mounted on posts shall comply with Sub-Section 6.2.5.8.

Any temporary covering of temporary traffic signs shall comply with Sub-Section 6.2.5.9.

Removal of temporary traffic signs shall be carried out as soon as they become superfluous or pose a hazard to traffic. Methods of removal and making good shall be submitted to the S.O. for approval beforehand. Making good shall be carried out immediately after removal of the traffic sign to the satisfaction of the S.O.

6.2.7 Traffic Signs on Gantries

Where traffic signs are erected on gantries, the signs shall comply with the relevant requirements of this Specification.

Fabrication and construction of gantries shall be as shown in the Drawings and as directed by the S.O.

6.2.8 Preparation and Finish of Metal and Other Surfaces

Traffic signs shall be prepared, protected against corrosion and finished in compliance with B.S. 873 or its latest replacement.

Faces of sign plates shall be prepared to receive sign face materials in compliance with B.S. 873 or its latest replacement and in accordance with the manufacturer's recommendations.

Steel backing frames, fittings and purlins shall be prepared and protected in compliance with B.S. 873 or its latest replacement. Steel posts and post housings shall be prepared and protected in compliance with B.S. 873 or its latest replacement.

Backs of aluminium or aluminium alloy sheets forming plate signs and external parts of luminaire housings and other permanently exposed components shall, to prevent retro reflection, be dulled with paint using a method approved by the S.O.

Ferrous steel shall be finished both inside and out by galvanising, electro-plating or application of zinc or aluminium spray or other equivalent finish approved by the S.O. Aluminium and other metals shall be left untreated unless shown otherwise in the Drawings.

Unless shown otherwise in the Drawings, stainless steel shall be left untreated except where the component is visible against the sign face when it shall be coloured on the face by methods approved by the S.O.

External surfaces shall be prepared and protected as described in the Contract. Cabinets and feeder pillars shall have final coats of paint applied on Site after final installation, including the fitting of any internal apparatus required as part of the permanent Works. Internal surfaces shall, unless shown otherwise in the Drawings, receive the same treatment as for external surfaces except that final paint coats shall be applied before internal components are installed.

6.3 ROAD MARKINGS

6.3.1 Description

This work shall consist of the supply of road marking material and its application to form continuous or intermittent lines, letters, arrows, symbols or figures. The markings shall be white or yellow laid to the dimensions and at the locations shown in the Drawings and as specified herein or as directed by the S.O. The work includes the supply of all labour, tools, equipment, materials, and warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work.

The requirements specified hereafter emphasise on the performance of road markings during their functional life. The requirements are expressed by several parameters representing different aspects of the performance of road markings.

6.3.2 Road Marking Materials

The road marking materials shall be of thermoplastic type and shall comply with the requirements of BS EN 1871, and shall demonstrate compliance with the relevant performance of BS EN 1436.

Road marking paints shall be used for temporary road markings only and it shall comply with the requirements of MS 164.

6.3.3 Preparation of Site

Thermoplastic materials and road marking paints shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or extraneous matter, or over old material or paint marking incompatible with the paint being applied.
A tack coat compatible with the marking material shall be applied on the clean and dry surface in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

If a tack coat, primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration, the tack coat, primer or undercoat shall be fully compatible with the marking paint and the road surface. The rate of application of tack

coat, primer or undercoat shall be in accordance with the manufacturer's instructions and to the satisfaction of the S.O.

Where the application of a tack coat, primer or undercoat is inappropriate, the Contractor shall seek the approval of the S.O. to omit such application.

6.3.4 Preparation of Material on Site

6.3.4.1 Thermoplastic Material

Thermoplastic material shall be supplied in block or powder form. If the material is supplied in block form, it shall be broken into pieces, each weighing not more than 4 kg, which shall be melted in a heater fitted with a mechanical stirrer to prevent local overheating and to ensure uniform distribution of the premix glass beads or reflective elements.

A thermometer of sufficient accuracy shall be used during laying to ensure that overheating of the material does not occur.

Once molten, hydrocarbon resins shall be used within 6 hours whereas wood and gum resins shall be used within 4 hours. The material shall not be heated beyond the manufacturer's specified temperature during application. Excess material shall be discarded on completion of application.

6.3.4.2 Road Marking Paint

All paint shall be thoroughly stirred before application to keep the pigments in uniform suspension. The use of thinners or other additives shall not be permitted unless approved otherwise by the S.O.

6.3.5 Laying

Centre lines, lane lines and edge lines shall be marked by approved mechanical means or as directed by the S.O. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of marking material approved for use. The rate of application of the marking material for each coat shall be that recommended by the manufacturer unless specified otherwise. When more than one coat is used, the succeeding coat shall not be applied until the previous coat has fully set.

The drop-on glass beads or reflective elements shall be applied by pressure or gravity feed concurrently with the laying of the road marking. The rate of application of these elements is recommended to be not less than 400 g/m^2 in order to achieve the specified minimum initial coefficient of retroreflected luminance as specified in sub-section 6.3.9.

Road markings of a repetitive nature other than centre lines, lane lines, etc., shall, unless decided otherwise by the S.O., be set out with stencils which comply with the size and spacing requirements as shown in the Drawings.

6.3.6 Protection of Markings

All markings shall be protected from traffic until they have dried sufficiently so that no pick-up by vehicle tyre will occur.

6.3.7 Thickness

6.3.7.1 Thermoplastic Material

Thermoplastic material shall be laid to the following thicknesses and shall be measured from the surface of the pavement:-

(a) For synthetic hydrocarbon resin binder

(i) screed lines: not less than 2 mm, nor more than 5 mm;
(ii) extruded lines: not less than 2mm, nor more than 5 mm;
(iii) sprayed lines other than yellow lines: not less than 1.5 mm;
(iv) sprayed yellow edge lines (for `no parking', `no waiting', etc.): not less than 0.8 mm.

(b) For gum or wood resin binders

(i) screed lines: not less than 3 mm nor more than 5 mm;
(ii) extruded lines: not less than 2 mm, nor more than 5 mm;
(iii) sprayed lines other than yellow lines: not less than 2 mm;
(iv) sprayed yellow edge lines (for `no parking', `no waiting', etc.): not less than 2mm nor more than 3 mm.

The thickness shall be measured by using a suitable device such as micrometer gauge or callipers, on samples of markings laid on steel plates beneath the application machine during the laying operations. In addition, thickness measurements shall also be carried out on laid road markings at an interval of 250 meters on each line, and on each other markings.

6.3.7.2 Road Marking Paint

Road marking paint shall be laid to give a wet film thickness of not less than 315 microns and not more than 400 microns.

6.3.8 Tolerance on Width

The tolerance on the specified width of the marking shall be within the range of + 10% and minus 0%.

6.3.9 Retroreflectivity Requirements

Retroreflectivity is the ability of a road marking to reflect light from a vehicle's headlight back to the driving position of a vehicle. Initially it will be determined by the amount of glass beads or reflective elements spread on the marking. The continuing performance of the marking is determined by the amount and quality of glass beads included in the body of the marking.

Glass beads or reflective elements used in premix thermoplastic shall comply with the requirements of BS EN 1424, while drop on glass beads or reflective elements used on the road markings shall comply with the requirements of BS EN 1423, and shall demonstrate compliance with the relevant performance of BS EN 1436.

For retroreflection under car headlamp illumination in dry condition, the minimum initial coefficient of retroreflected luminance R_L shall be 300 mcd/m^2/lx.

For retroreflection under car headlamp illumination in wet condition, the minimum initial coefficient of retroreflected luminance R_L shall be 75 mcd/m^2/lx.

The Contractor shall demonstrate that the markings comply with the retroreflectivity requirements by testing them with a retroreflectometer or equivalent, in accordance to BS EN 1436 Annex B. The test shall be carried out not more than seven (7) days after laying, at an interval of 250 meters on each line, and on each other markings.

6.3.10 Skid Resistance Requirement

If so stipulated in the BQ or in the drawings for skid resistance requirement, the Contractor shall demonstrate that the markings comply with the skid resistance requirement by testing them using the standard British Pendulum apparatus, in accordance to BS EN 1436 Annex D.

Skid resistance of road markings will decrease in value due to the effects of traffic and weathering.

For both permanent and temporary road markings, the skid resistance shall be in the SRT units and shall be not less than 45SRT units.

A modified version of the UK formula shall be used to convert readings to an equivalent skid resistance value at 35ºCelsius, which is a more realistic reference temperature to be adopted for the tropics. The skid resistance value shall be determined using the formula:-

$$\mathbf{SRT(35^oC) = \frac{(100 + t)\ X\ SRT}{135}}$$

where, SRT (35ºC) = equivalent skid resistance value at 35ºCelsius
t = temperature of water lying on the road at the time of testing
SRT = mean of five readings as the skid resistance value

The test is only applicable for road markings with 300mm width or more and shall be carried out not more than seven (7) days after laying.

6.3.11 Defective Materials or Workmanship

Materials which are defective or which have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location, shall be removed by approved chemical or mechanical means. To the extent necessary, the road pavement shall be made good and the markings reapplied, all at the Contractor's expense and to the approval of the S.O.

Where directed by the S.O., existing markings shall be removed in the same manner as above.

6.3.12 Clearing Up

The Contractor shall clean up all spatters, splashes and smirches of the marking materials completely to the satisfaction of the S.O.

6.3.13 Opening to Traffic

The completed road markings shall not be opened to traffic until the material has fully set and this will usually be not less than 1 hour after the material has been laid.

6.3.14 Removal of Road Markings

The unwanted road markings shall be removed from the pavement in such a way so as to avoid any possible confusion of motorist especially in wet conditions.

The Contractor shall remove the road markings completely and to the satisfaction of the S.O by blasting, grinding, scraping, burning off or jabbing action using a suitable blade tool without damage to the underlying road pavement. The Contractor shall seek the approval of the S.O. for removal by burning off since this technique is not recommended where the public are close to works, as the fumes are toxic. Removal by painting over with paint of a colour to closely match the surrounding road surface shall not be allowed.

Any excessive damage to the pavement shall be repaired by the Contractor to the satisfaction of the S.O. Any road markings incorrectly removed shall be remarked by the Contractor to the satisfaction of the S.O. The Contractor shall clean up and remove from the roadway all materials and debris from his operations and leave the roadway clear for use by the public.

6.4 CONCRETE KERB

6.4.1 Description

This work shall consist of the supply and installation of cast in situ or precast concrete kerbs constructed at the locations and in accordance with the lines, levels, grades, dimensions and types as shown in the Drawing, all in accordance with the Specification.

6.4.2 Materials

Concrete for kerb section shall be grade 20/20 concrete unless indicated otherwise in the Drawings and shall conform to the requirements of Section 9: Concrete of this Specification.

Unless shown otherwise in the Drawings, bedding shall be grade 10/25 concrete.

6.4.3 Installation of Kerbs

6.4.3.1 Excavation

Excavation shall be made to the required depth and the base shall be trimmed and compacted to a firm and even surface. All soft and unsuitable material shall be removed and replaced with suitable material as defined in Section 2: Earthworks of this Specification. The bedding material shall then be placed and compacted to form a bed of required thickness as shown in the Drawings.

6.4.3.2 Cast In Situ Kerb

When cast in situ kerb is placed next to a concrete pavement, expansion joints in the kerb shall be located in line with expansion joints in the pavement.

Concreting shall generally be in accordance with the requirements of Section 9: Concrete of this Specification. Forms shall not be removed within 24 hours of the concrete being placed. Minor defects shall be repaired with mortar containing 1 part Portland Cement to 2 parts sand (1PC:2S). The kerb face shall be trowelled smooth with a tool custom made to the design profile. Other exposed surfaces of the sections shall be steel trowel finished.

6.4.3.3 Precast Concrete Kerb

Precast concrete kerbs shall be cast using steel moulds and shall be of the types as shown in the Drawings.

Each kerb shall be set so that its front top arris conforms to the line and grade required. All spaces under the kerb shall be filled

with bedding material which shall be thoroughly tamped to assure a solid and even surface.

6.4.3.4 Machine Extruded Concrete Kerb

In situ concrete kerbs shall be laid by approved extrusion machine or, if practicable, in the case of concrete pavements, by the concrete paver itself. The kerbs shall be dense with regular sides, edges, arrises and chamfers, finished to a fine surface free from blow holes and dragging, and shall be impervious.

To overcome irregularities in the foundation, the machine shall be capable of automatically adjusting the mould position, while in operation, to the required line and grade. The machine shall be operated to produce compacted concrete with un-rendered surfaces substantially free from pitting. The kerb faces and other exposed faces shall be finished as specified for cast in situ kerb.

Connection of extruded kerb to existing kerb shall be made by hand to give a smooth transition.

6.4.3.5 Expansion Joints

Construction joints shall be provided at maximum 3m intervals for cast in situ and machine extrusion construction. Joints shall be formed or cut through the full cross-section using a template and the edges finished with a suitable grooving tool.

Expansion joints shall be provided at both sides of all pits constructed prior to kerb. Construction joints for cast in situ and machine extruded kerbs shall be 10mm wide and filled with preformed filler extending over the full cross-section. Pits constructed into broken out kerb do not require expansion joints.

Precast concrete kerb shall be laid with joints as narrow as possible and filled with mortar containing 1 part Portland cement and 2 parts sand. The expansion joint in the kerb shall be 20 mm and shall be filled with an expansion joint filler of the same nominal thickness as the pavement joint. Any voids between filler and the concrete kerb shall be filled with mortar. Where a Portland cement concrete pavement is to be constructed contiguous to a kerb, expansion joints shall be constructed in the kerb directly in line with the pavement joints.

6.4.3.6 Backfilling

The spaces in the front and back of each kerb shall be refilled to the required elevation with suitable material approved by the S.O. which shall be tamped in layers of not more than 150 mm until properly compacted.

The finished work shall be true to line, grade and level to within $\pm$ 10 mm and shall present a smooth appearance free from kinks and distortion visible to the eye.

Any kerb sections dislodged during backfilling or otherwise misaligned shall be removed and re-laid by the Contactor at his own expense. Care shall be taken in backfilling to ensure that no damage, defacement or staining is caused to the kerbs and that the compaction requirements are achieved.

6.4.4 Kerb Opening & Special Features

Kerb opening shall be located and installed in accordance with the Drawings. Special features such as ramps, transitions and end treatments shall be formed into the kerbs as required according to the details shown in the Drawings.

6.4.5 Tolerances

All sections shall be constructed with a smooth, uniform appearance and the horizontal and vertical alignment shall not deviate from the design alignment by more than $\pm$ 25 and $\pm$ 10 mm respectively. Cross-section dimensions shall be within $\pm$ 5 mm of those shown in the Standard Drawings. Notwithstanding the above tolerances, the alignments of the kerb shall have smooth lines.

6.4.6 Curing and Protecting

Newly laid concrete surfaces shall be protected from any disturbance such as premature drying, damage by rain, vandalism etc. for a period of 24 hours after pouring.

The concrete shall also be covered with suitable material and kept moist for a period of 5 days.

Sufficient signs, barricades and lights shall be erected to protect the newly laid kerbs from traffic.

6.4.7 Kerb Painting

The kerbs shall normally not be painted, unless specified otherwise in the Drawings. If kerb painting is so directed by the S.O. painting works shall conform to the requirements of JKR Standard Specifications For Building Works, Section M: Painting Work.

6.4.8 Kerb Repairs

Broken or damaged kerbs shall be removed and disposed to the Contractor's spoil site at his own expense. The exposed concrete repair surface shall be roughened to remove all laitance and expose the aggregate to provide a thorough bond with concrete cast subsequently. The roughened surface shall be cleaned with water to remove loose chips and foreign material. Immediately before fresh concrete is cast against the surface, the existing surface shall be thoroughly wetted.

6.5 WIRE ROPE BARRIER SYSTEM

6.5.1 Description

This work shall comprise the supply and installation of wire rope barrier system inclusive of bolts, nuts, posts and other ancillary works, all in accordance with this Specification, and the Drawings, and as directed by the S.O.

Tensioned wire rope barrier systems shall be systems designed specifically for the purpose of providing a restraining traffic barrier to reduce the severity of run-off-road accidents.

6.5.2 Materials

6.5.2.1 Ropes

All ropes shall be steel ropes, fitted with terminals. The ropes shall be 19mm diameter; 3 x 7 (6/1) coreless construction, complying with BS 302 Part I or BS EN 12385-4.

The minimum breaking load of the rope shall be 17.7 tonnes.

The ropes shall exhibit a minimum Modulus of Elasticity of 11,600 kg/mm^2 after pre-stressing.

6.5.2.2 Posts

All posts shall be formed so that it would bend forward uniformly upon impact.

The posts should be manufactured from mild steel, 6mm thick to B.S. 4360 or its replacement, and galvanized to BS EN ISO 1461: 2009.

All concrete foundations shall be Grade 25/20.

6.5.2.3 Plastic Cap

Plastic cap is to be fitted onto the post. Choice of red/yellow/white 1" x 4" (25mm x 102mm) reflector is to be placed on every 4th post either on the cap or on the post as specified by S.O.

Reflector shall be of High Intensity Prismatic retroreflective sheeting or of a higher grade.

6.5.2.4 Anchor Block

Minimum concrete grade for anchor block shall be Grade 25/20. Dimension of the anchor block shall be as specified by manufacturers.

6.5.3 Installation of Wire Rope Barrier System

The components of the tensioned wire rope barrier systems shall be supplied and installed in accordance with the manufacturer's instructions, as outlined in the test documents.

All post shall be installed in concrete footings with suitable sockets including covers to the sockets. Driven post shall not be used.

Intermediate blocks or tension bays shall be installed at the dimensions recommended by the manufacturers.

Anchor blocks shall be installed in accordance with the manufacturer's published recommendations. The maximum spacing between anchor blocks shall be no longer than 1 km.

All ropes shall be tensioned appropriate to the ambient temperature and be free-standing according to the manufacturer's instructions. Plastic ties for intertwined ropes on both sides of posts are optional.

6.5.4 Basis of Acceptance

6.5.4.1 Material

Test certificates for material used in the wire rope barrier system showing the results of tests carried out for the purpose of establishing compliance with Clause 6.5.2 of this standard shall be submitted for every 500m or less of wire rope section.

6.5.4.2 Installation

The post must be installed to the depth, line and spacing shown in the Drawings. The installation must not cause any structural damage to the post and to the pavement 100mm from any part of any post. The Contractor shall also provide the relevant document on:-

(a) Current calibration certificates for the tensioning devices.
(b) Manufacturer's Instruction for installation and maintenance procedures (if any).
(c) Anchor block testing (pull over test).

6.5.4.3 System

Tensioned wire rope barrier systems shall have been subjected to full-scale crash tests, to Test Level 3 (TL-3) minimum as defined by NCHRP-350 or ASSHTO MASH (Manual for Assessing Safety Hardware) and CEN Acceptance Tests as defined in BS EN 1317-1:2010, to certify that the offered system can successfully reduce the speed of colliding vehicles and deceleration within acceptable limits.

Testing compliance shall be proven by certified documentary evidence for the specific design.

6.6 DELINEATOR POST

6.6.1 Description

This work shall consist of setting out, supply and installation of delineator posts at the locations as shown in the Drawing, or as directed by the S.O.

6.6.2 Materials

6.6.2.1 Timber Posts

Timber posts shall be seasoned or treated hardwood of rectangular cross section with the dimension of 100mm x 50mm and shall be 1700mm in length. Timber posts shall be straight, sound and free from compression failures and other fractures, termite galleries, end splits and bark.

The entire timber post above ground level surface area of the guide posts shall be smooth and shall be coated in paint with stripes of black and white either by brushing, spraying or immersion in accordance with the paint manufacturer's published requirements.

The surface of the guide post to be painted shall be dry and free from all foreign matters including saw-dust, sand, dust, dirt, or other material or substance that could prevent the paint adhering to it. The painting works shall conform to the requirements of JKR Standard Specifications for Building Works, Section M: Painting Work.

6.6.2.2 Metal or Steel Posts

Metal or steel posts shall be 50mm in diameter and 1700mm in length.

All faces of steel delineator posts shall conform to a smooth gloss white powder coat finish to a minimum coat thickness of 0.100mm or galvanised to BS EN ISO 1461:1999.

Steel delineator posts shall be free of rust or other defects for the duration of the warranty period. Steel delineator shall not have blunt edges exposed to passing motorists.

6.6.2.3 Flexible Delineator Posts

The flexible delineator posts shall be made to a design and from material, which provide the properties of strength, flexibility, impact and heat resistance and durability required. Flexible delineator posts shall be minimum 750mm in length.

The Contractor shall supply test certificate and technical specification that address those properties. The Contractor shall also provide warranty from the manufacturer on the capability of

the delineator post in retaining 85% of its colour, appearance and physical properties for a minimum of 5 years.

The material shall be resistant to mould growth and shall not be affected by hydrocarbon solvents (such as turpentine, kerosene, or diesel) which may be used for cleaning process.

The flexible delineator posts shall be capable of self erecting and remaining serviceable after being subjected to a series of direct impacts by a typical passenger vehicle. The delineator post shall be installed in accordance with the recommendations of the manufacturer.

The delineator posts shall be capable of withstanding a series of 10 bumper bar impacts at a speed of 60km/h and a 5 bumper bar impacts at a speed of 100km/h directed at 90 degrees to the front face of the delineator post. The impacting vehicle shall suffer little or no damage during the impact test. The delineator post shall return to within 5 deg. of vertical within ½ hour of impact. A trial installation shall be conducted with a minimum sample of three (3) delineator posts as directed by the S.O. which shows the delineator post is capable of withstanding the above vehicle impacts.

6.6.3 Delineators

The delineators shall be red and white in colour of the circular shape, corner-cubed prismatic lens and shall be not less than 75 mm diameter, or of the rectangular shape of 180mm x 50mm for height and width respectively and shall be of High Intensity Prismatic retroreflective sheeting or of a higher grade. Retroreflective sheeting intended for fixing to timber posts shall be backed by light gauge aluminium.

Delineators shall be capable of clearly reflecting light under normal atmospheric conditions from a distance of 300m when illuminated by the upper beam of passenger vehicle light.

The delineators shall be mounted / fixed so that the top of the reflector is 50mm below the top of the delineator post. In each direction of travel, the colour of the delineators shall be white on the left side of the road and red on the right side of the road.

6.6.4 Installation of Delineator Post

6.6.4.1 Location

The location of delineator posts shall be as indicated in the drawings or as directed by the S.O. Delineator posts shall be placed at the edge of the road formation level with the wide face presented to the oncoming traffic.

Unless shown in the drawings specified otherwise, the delineator posts shall be placed near the outer edge of the shoulder and at a

uniform distance, minimum 1.2m and not more than 4.0m, from the pavement edge line, in such a manner so as not to impede the flow of water in the drain.

6.6.4.2 Buried or Drilled of Delineator Posts

Delineator post holes shall be drilled or dug with vertical sides and having depth of 500mm for rigid post and as specified in the drawing or manufacturer's specification for flexible delineator post. Timber post shall not be driven The posts shall be firmly embedded in the ground to the satisfaction of the S.O and the length of post above the ground shall be 1.2m at all time.

Allowance shall be made in the height of guide delineator posts above the ground level for the effects of super elevation and other road geometry parameters in order to keep the delineator posts within the range of the beam of vehicle headlights.

6.6.4.3 Backfilling

The excavated material shall be used for backfilling around the delineator post and shall be compacted in layers of depth not more than 150mm for the full depth of the guide posts up to the ground level. Unless specified otherwise, the density of the compacted backfill shall not be less than that of the adjacent shoulder pavement.