

MANUAL OF SPECIFICATIONS AND STANDARDS FOR SIX LANING OF HIGHWAYS

(Second Revision)



INDIAN ROADS CONGRESS
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AND STANDARDS COMMITTEE (GSS)**

(As on 24th October, 2018)

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3.	Secretary General	(Nirmal, S.K.), Indian Roads Congress, New Delhi

INTRODUCTION

The “Manual of Specifications and Standards for Six Laning of Highways through Public Private Partnership” was first published in 2010 and subsequently revised in 2013. The Project Preparation, Contract Management, Quality Assurance & Public Private Partnership Committee (G-1) felt the necessity to revise this document and accordingly constituted a sub-group under the convenorship of Shri M.P. Sharma with Shri Ashok Kumar, Col. A.K. Bhasin, Shri Nirmaljit Singh, Shri A.V. Sinha & Shri P.L. Bongirwar as members to review the Manual. The draft revision was discussed in a number of meetings by G-1 Committee before approving the same in its meeting held on 6th October, 2018 for placing before the General Specifications & Standards Committee (GSS) for consideration. The GSS Committee in its meeting held on 24th October, 2018 approved this document for placing before the Council for consideration and approval. The Council in its 216th meeting held at Nagpur (Maharashtra) on 22nd November, 2018 approved the draft revision of “Manual of Specifications & Standards for Six Laning of Highways” for printing. The Sub-Group received inputs from Shri Jacob George in drafting Sections on Road Safety and Cross-section drawings which is duly acknowledged.

The Composition of Project Preparation, Contract Management, Quality Assurance & Public Private Partnership Committee (G-1) is as given below:

Singh, B.N.	Convenor
Padhy, L.P.	Co-Convenor
Nirmal, S.K.	Member Secretary

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Secretary General, IRC (Nirmal, S.K.)	

SECTION 1

GENERAL

1.1 This Manual describes the planning, standards, design, construction, maintenance, operation, safety and environmental requirements to be fulfilled in execution of the works of [] under a concession or Contract agreement and shall be read harmoniously and in conjunction with the latter.

This Manual is applicable for widening of highways from 4-lane to 6-lane through Public Private Partnership (PPP) mode. The general planning aspects laid out in this manual shall be applicable for widening from 2/4-lane to 6-lane or new construction of 6-lane highways. The scope of the work shall be as defined in the Concession Agreement. This Manual shall be read harmoniously with the intent of the Concession Agreement. The Manual may also be used for non-PPP projects.

1.2 The Project Highway and the project facilities shall conform to the requirements of design and specifications set out in this Manual, which are the minimum prescribed. The project report and other information provided by the Authority shall be used by the Concessionaire only for its own reference and for carrying out further investigations. The Concessionaire shall be solely responsible for undertaking all the necessary surveys, investigations and detailed designs in accordance with Good Industry Practice with due diligence, and shall have no claim against the Authority for any loss, damage, risk, costs, liabilities or obligations arising out of or in relation to the project report and other information provided by the Authority.

1.3 At least 2 weeks prior to commencement of the work, the Concessionaire shall draw up a Quality Assurance Manual (QAM) covering the Quality System (QS), Quality Assurance Plan (QAP) and documentation for all aspects of the bridge and road works, which shall include the Standard Operating Procedures which the Concessionaire, his personnel, his Contractors and their sub-contractors shall follow during execution and send three copies of each to the Independent Engineer (IE) for review. The class of quality assurance shall be as per IRC:SP:112-2017 "Manual for Quality Control in Road and Bridge Works."

1.4 The Codes, Standards, Technical Specifications and Guidelines applicable for the design and construction of project components are:

- i) Indian Roads Congress (IRC) Codes, Standards and Guidelines.
- ii) Specifications for Road and Bridge Works issued by the Ministry of Road Transport & Highways (MoRTH) hereinafter referred to as MoRTH or Ministry's Specifications.
- iii) Any other standards referred to in the Manual and any supplement issued with the bid document.

1.5 The version of the Codes, Standards, Specifications, etc. notified/published at least 60 days before the last date of bid submission shall be considered applicable.

1.6 The terms 'Ministry of Surface Transport', 'Ministry of Shipping, Road Transport & Highways' and 'Ministry of Road Transport and Highways' or any successor or substitute thereof shall be considered as synonymous.

- 1.7**
- a) The terms ‘Inspector’ and ‘Engineer’ used in MoRTH Specifications shall be deemed to be substituted by the term “Independent Engineer” for PPP projects to the extent, it is consistent with the provisions of the Concession Agreement and this Manual. The role of the Independent Engineer shall be as defined in the Concession Agreement.
 - b) In case of EPC contracts the term ‘Independent Engineer’ shall be replaced by ‘Authority Engineer’ and the terms ‘Concessionaire’ and ‘Concession Agreement’ shall be replaced by ‘Contractor’ and ‘Contract Agreement’ respectively.

1.8 In the event of any conflict or inconsistency in the provisions of the applicable IRC Codes, Standards or MoRTH Specifications, the provisions contained in this Manual shall prevail.

1.9 This Manual generally provides for design and construction as per Codes, Standards, Specifications, Guidelines, etc. as published by IRC, MoRTH and BIS for road and bridge works. Where the Concessionaire intends to use an alternative to these Standards and Guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

- i) He shall demonstrate that the proposed alternative conforms to any of the following International Standards, Codes of Practice, Specifications, Guidelines, etc.
 - a) American Association of State Highway and Transportation Officials (AASHTO)
 - b) American Society for Testing of Materials (ASTM)
 - c) Euro Codes and British Codes
- ii) In case the Concessionaire intends to use any alternative material, technology/ method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar projects (similar in category of road, traffic and climatic conditions) as the Project Highway, he would be permitted its use on certification by the owners of such similar projects regarding the continued successful performance of such materials, technologies, methods, procedures or processes for design life of the project. Such a certification shall be supported with details of critical performance parameters.

1.10 All items of building works shall conform to Central Public Works Department (CPWD) Specifications for Class 1 building works and standards given in the National Building Code (NBC). To the extent specific provisions for building works are made in IRC/MoRTH Specifications, the same shall prevail over the CPWD/ NBC provisions. For this purpose, building works shall be deemed to include toll plaza complex, road furniture, road side facilities, landscape elements and/or any other works incidental to the building works.

1.11 Alternative Standards and Specifications

- a) Where alternative Standards and Specifications are intended to be used in accordance with **Para 1.9**, all such proposals shall be submitted by the Concessionaire to the Independent Engineer together with certification and details mentioned in **Para 1.9**. In case, the Independent Engineer is of the opinion

- that the proposal submitted by the Concessionaire is not in conformity with any of the International Standards or Codes or evidence by successful performance, then he will record his reasons and convey the same to the Concessionaire for compliance. A record shall be kept by the Independent Engineer, of non-compliance, if any, by the Concessionaire. Adverse consequences, if any arising from adoption of any such alternative proposals shall be treated as “Concessionaire Default” and shall be dealt in accordance with the provisions of the Concession Agreement.
- b) Provisions under **Para 1.9 and 1.11 (a)** above shall also be applicable for EPC projects unless specified otherwise in the “Agreement”.

1.12 Guidelines for Preparing Schedules of the Concession Agreement

Certain paras (fully or part) in **Sections 1 to 14** of this Manual refer to the Schedules of the Concession Agreement. While finalizing the feasibility/project report for the Project Highway, and the scope of the project, each of these Paras should be carefully examined and addressed by the Authority with a view to make appropriate provisions in the Schedules of the Concession Agreement. A list of such para is enclosed at **Appendix 2**.

1.13 General considerations for Planning, Design and Construction

The objective of planning a 6-lane highway shall be to ensure that the long distance through traffic is able to operate at a speed dictated only by the flow on the main highway and not by any other factors, such as interference from local traffic, access traffic or cross traffic. The traffic having short distance or local O&D, access traffic and cross traffic shall be separated from the long distance through traffic. Service road shall be provided in continuous length on both sides. Unless otherwise specified in **Schedule ‘B’**, the continuity will be broken (i) at locations of major bridges, (ii) at locations of toll plaza in a length of 1 km, (iii) in areas where no cross traffic or access traffic is expected (e.g. forest/ghat areas, uninhabited areas, etc.) provided that the length of such section is not less than one km. The service roads shall be connected to the main highway through properly designed entry/exit ramps at locations given in **Schedule ‘B’**. Traffic needing access to the main highway shall first come on to the service road and then join the main highway through an acceleration lane/entry ramp. Similarly, all traffic exiting the main highway shall first come on to the service road through a deceleration lane/exit ramp from where it would distribute to the local road network for various destinations. However, when there is no settlement or road side development abutting the Project Highway or the connecting roads are spaced more than 2 km, service roads may not be necessary and access can be given directly through acceleration/deceleration lanes. The existing direct access to the highway shall also be modified accordingly. The locations of service roads and entry/exit ramps shall be specified in **Schedule ‘B’**.

The existing alignment and grade shall be followed, as far as possible and widening of the carriageway shall be done depending upon the site situation by adding a lane, either on the inside or outside of the existing carriageway. The new 6-lane highway, as far as possible, shall fit into the existing 4-lane section without rendering in fructuous the existing 4-lane facilities unless essential or required to fulfill the requirements laid down in this Manual. The improvements required shall be carried out within the available and proposed Right of Way (ROW).

The objective therefore is to construct a 6-lane highway for all road users as an active infrastructure

facility for people for their safety and services and as a catalyst in development of economy based on an inclusive approach.

General considerations shall, without being limited to, be as follows:-

a) The Constraints

The physical constraints in the existing highway are in the form of limitation of right of way, un-regulated access, inadequate service roads and underpasses, numerous at-grade junctions, lack of physical separation between local and through traffic etc. The operation constraints arise out of the necessity or possibility of closing a portion of the road for construction and/or diverting the traffic to temporary diversions, thereby reducing the capacity and safety of the existing highway. The solutions evolved by the Concessionaire shall be such that these operational constraints are overcome through appropriate planning, design and construction method, techniques and technologies and by adopting suitable traffic management measures.

b) Safety of Design

All designs shall be safe to ensure that the Project Highway or any part thereof (for example embankment, pavement, retaining structures, bridges, culverts, etc.) does not collapse (global stability) nor its serviceability/performance (for example settlement, roughness, undulations, deflections, etc.) deteriorates below acceptable level as prescribed in **Schedule 'K'** of the Concession Agreement.

c) Durability

The Project Highway shall not only be safe but also durable. This would mean that the deteriorating effects of climate and environment (for example wetting and drying, freezing and thawing, if applicable, temperature differences, aggressive environment leading to corrosion, etc.) in addition to the traffic shall be duly considered in design and construction to make the Project Highway durable.

d) Mitigating Disruptive Effects of Construction

The planning, design and construction of the highway shall be such that the construction of Project Highway does not have adverse impact on the environment and does not disrupt the lives and business activities of the people living close to the Project Highway.

1.14 Safety during Construction and Operation & Maintenance

1.14.1 The Concessionaire shall develop, implement and administer a surveillance and safety programme for providing a safe environment on or about the Project Highway, and shall comply with the safety requirements set forth in the Concession Agreement.

1.14.2 Before taking up any construction or maintenance operation/work, the Concessionaire shall prepare a Traffic Management Plan for each work zone and furnish it to the Independent Engineer for comments duly incorporating the following:

- i) Designate a Site Safety Team headed by a qualified Safety Officer.
- ii) Traffic safety devices as per IRC:SP:55 with the following specifications:

- a) Signages of retro-reflective sheet of high intensity grade.
- b) Delineators in the form of cones/drums as per IRC:SP:55 made of plastic/rubber having retro-reflective red and white band, at a spacing of maximum 5 m along with a reflective tape (red and white band) to be tied in between the gaps of cones/drums. A bulb/flasher using solar energy is to be placed on the top of the cone/drum for night delineation.
- c) Barricades as prescribed in IRC:SP:55 shall be used.
- iii) The arrangement of traffic during construction and maintenance shall conform to the requirements of IRC:SP:55, **Clause 112** of MoRTH Specifications and provisions of the Concession Agreement. During the construction period, the Concessionaire shall maintain, at its cost, the existing lane(s) of the Project Highway or divert the traffic on to an alternative route-diversion road so that the operating width and safety standards shall be equal to those of existing lanes (excluding paved shoulders, if any) for each direction. The crust of such alternative route/diversion road shall be provided for minimum 10 msa. The drainage of existing road and construction zone during construction shall be given special attention by the Concessionaire. Prior to commencement of construction works, the Concessionaire shall submit to the Independent Engineer, the detailed construction methodology to meet the aforesaid requirement including temporary drainage plan of existing road and construction zone.
- iv) Sprinkling of water for dust control at work zones, haul roads and plant camp sites
- v) Noise/Pollution suppression measures at work zones, haul roads and plant/camp sites
- vi) Mechanical, electrical and fire safety practices
- vii) Safety measures like PPE (Personal Protection Equipment) for workers engaged
- viii) First Aid and Emergency Response Arrangements i.e. First Aid Box, Ambulance, Paramedical Staff, Alarms, etc.
- ix) Safety training/awareness programmes
- x) Formats to maintain the accident records/emergency response provided during accidents

1.14.3 The Concessionaire shall also be responsible for ensuring compliance of all labor laws and regulations including those relating to the welfare of workers engaged both directly and indirectly on the Project Highway, besides their occupational safety and health.

1.15 The Concessionaire shall set up field laboratory for testing of materials and finished products as stipulated in **Clause 120** of MoRTH Specifications. It shall make necessary arrangements or additional/confirmatory testing of any materials/products at the government accredited laboratory, for which facilities at site laboratory are not available.

1.16 Environment Mitigation Measures

The Concessionaire shall carry out tests/monitor various parameters impacting the environment of the Project Highway keeping in view the guidelines of the Ministry of Environment and Forests and submit proposals for mitigation of adverse environment impact including provision of noise barriers, etc. for review and comments of the IE, if any and undertake implementation of the

proposals in consultation with the IE. Provision of IRC:SP:108 shall be complied with. The type and locations of the Noise Barriers shall be specified in **Schedule ‘B’**.

1.17 Utilities

The details of the new utilities which are to be constructed or provided for along or across the Project Highway shall be as specified in **Schedule ‘B’** of the Concession Agreement. The Concessionaire shall be responsible for protection of the existing utilities on the Project Highway that are not required to be shifted.

1.18 Review and Comments by the Independent Engineer

- a) For PPP Projects, in cases where the Concessionaire is required to send any drawings or documents to the Independent Engineer for review and comments, and in the event such comments are received by the Concessionaire, it shall duly consider such comments in accordance with the Concession Agreement and Good Industry Practice for taking appropriate action thereon. The correspondence between the Concessionaire and the Independent Engineer shall be deemed valid only if a copy thereof is endorsed to and received by the Authority.
- b) For EPC Projects, the design and drawings shall be got reviewed and approved from the Authority Engineer as per the Contract Agreement.

1.19 Definitions and Interpretation

1.19.1 Unless specified otherwise in this Manual, the definitions contained in the Concession Agreement shall apply.

1.19.2 Built-up-area shall mean sections of the Project Highway that are situated within the municipal limits. Sections of 200 m or more in non-municipal areas where permanent structures are built on one or both sides of the Project Highway on at least 50 percent of the total length comprising such section shall also be treated as built up area. The Built up areas shall be as specified in **Schedule ‘B’** of the Concession Agreement.

Rural areas are synonymous to non-built-up areas and urban areas are synonymous to built-up areas for the purpose of deciding various provisions given in this Manual.

1.19.3 The definition of PCU used in this Manual shall be as per IRC Codes and Guidelines.

1.20 Grade Separated Structures

- i) The structures through which the traffic flows at different levels are called grade separated structures
- ii) A grade separated structure which is provided for crossing of vehicles under the Project Highway is called as Vehicular Underpass (VUP).
- iii) A grade separated structure which is provided for crossing of vehicles over the Project Highway is called as Vehicular Overpass (VOP).
- iv) A grade separated structure which is provided for crossing of light vehicles under the Project Highway is called as Light Vehicular Underpass (LVUP).
- v) A grade separated structure which is provided for crossing of small vehicles under the Project Highway is called as Small Vehicular Underpass (SVUP).

- vi) Flyover is synonymous to VUP/VOP/LVUP/SVUP.
- vii) A structure provided above the Project Highway to cross pedestrians is called Foot Over bridge.
- viii) A structure provided over the railway lines to carry the Project Highway is called Road Over Bridge (ROB).
- ix) A structure provided below the railway lines to carry the Project Highway is called Road Under Bridge (RUB).
- x) A Trumpet interchange is a grade separator structure provided at major T-junction facilitating uninterrupted flow of traffic in each direction.
- xi) A Cloverleaf is a grade separator structure provided at a major cross road junction facilitating uninterrupted flow of traffic in each direction.

SECTION 2

GEOMETRIC DESIGN AND GENERAL FEATURES

2.1 General

- i) This section lays down the standards for geometric design and general features for six-lane divided carriageway.
- ii) Where there is constraint of ROW width, the Authority may specify construction of a bypass. The alignment of the bypasses shall be as specified in **Schedule 'B'** and in conformity with the site earmarked in **Schedule 'A'** of the Concession Agreement. Alternatively, the highway shall be elevated to a standard Cross-section of six-lane and such elevated section shall be specified in **Schedule 'B'**.
- iii) The geometric design of the Project Highway shall conform to the standards set out in this section as a minimum.
- iv) As far as possible, uniformity of design standards shall be maintained throughout the length of the Project Highway. In case of any change, it shall be effected in a gradual manner.
- v) Where the existing road geometries are deficient with respect to minimum requirements and its improvements to the prescribed standards are not feasible due to any constraint in acquisition of additional land, such stretches shall be specified as a deviation in **Schedule 'B'** of the Concession Agreement.

2.2 Design Speed

2.2.1 The design speeds given in **Table 2.1** shall be adopted for various terrain classifications (Terrain is classified by the general slope of the ground across the highway alignment).

Table 2.1 Design Speed

Nature of Terrain	Cross Slope of the Ground	Design Speed (km/h)	
		Ruling	Minimum
Plain and Rolling	Up to 25 percent	100	80
Mountainous and Steep	More than 25 percent	60	40

Short stretches (say less than 1 km) of varying terrain met with on the road stretch shall not be taken into consideration while deciding the terrain classification for a given section of Project Highway.

2.2.2 In general, the ruling design speed shall be adopted for the various geometric design features of the road. Minimum design speed shall be adopted only where site conditions are restrictive and adequate land width is not available. Such stretches where design speed other than ruling speed is to be adopted shall be as specified as deviation in **Schedule 'D'** of the Concession Agreement.

2.3 Right-of-Way

A minimum Right of Way (ROW) of 60 m should be available for development of a 6-lane highway. The Authority would acquire the additional land required, if any. The land to be acquired shall be

indicated in **Schedule ‘B’** of the Concession Agreement. The consideration for planning, design and construction described in **Para 1.13** shall apply. Where the alignment of 6-lane Highway is to be retrofitted on to existing highway, the details of ROW width on LHS and RHS from center line of existing carriageway(s) at 50 m intervals shall be provided to the Concessionaire in **Schedule ‘A’** of the Concession Agreement.

2.4 Lane Width of Carriageway

The standard lane width of project highway shall be 3.5 m.

2.5 Median

2.5.1 The median shall be either raised or depressed. The width of median is the distance between inside edges of carriageway. The type of median shall depend upon the availability of Right of Way. The minimum width of median, subject to availability of Right of Way, for various locations shall be as in **Table 2.2**.

Table 2.2 Width of Median

Type of Section	Minimum Width of Median (m)		
	Plain and Rolling terrain		Mountainous and Steep terrain
	Raised*	Depressed median	Raised*
Open country with isolated built-up area	5.0	7.0	2.5
Built up area	2.5	Not Applicable	2.5
Approach to grade separated structures	5.0	Not Applicable	2.5

* Including kerb shyness of 0.50 m on either side. But in case of existing 4-lane with raised median to 6-laning project also, the minimum kerb shyness of 0.5 m shall be maintained (i.e. 500 mm from the vertical face of existing kerb), by suitably augmenting the carriageways towards the shoulder side.'

The type and widths of median in various stretches of Project Highway shall be indicated in **Schedule ‘B’**.

2.5.2 The median shall have suitably designed drainage system so that water does not stagnate in the median. All median drains shall be of Cement Concrete.

2.5.3 In case of depressed median, a minimum 0.6 m width adjacent to carriageway in either direction shall be paved.

2.5.4 As far as possible, the median shall be of uniform width in a particular section of the highway. However, where changes are unavoidable, a transition of 1 in 50 shall be provided.

2.5.5 In the case of depressed median, metal beam type (thrie beam - one side) crash barriers or Wire rope barrier shall be provided on either side of the median subjected to the requirements laid out in **Clause 9.7**. Suitable shrubs as per **Section 11** of this Manual shall also be provided. However, in case the width of median is more than 9 m, no crash barrier is required to be provided in the median side.

2.5.6 The median in built up area shall be paved. In such locations, crash barriers and suitable ant glare measures such as plastic screens shall be provided at the center of median

to reduce headlight glare from opposite traffic. The total height of screen including the height of the barrier shall be 1.5 m and spacing shall be such as to effectively cut the glare. In case of unpaved median suitable shrubs shall be planted as per **Section 11** of this Manual.

2.6 Shoulders

2.6.1 Width of shoulders

The shoulder width on the outer side (left side of carriageway) shall be as given in **Tables 2.3** and **2.4**.

Table 2.3 Width of Shoulders in Plain and Rolling Terrain

Type of Section	Width of Shoulder (m)		
	Paved	Earthen	Total
Open country with isolated built up area	2.5	1.5	4.0
Built up area	2.5	-	2.5
Approaches to grade separated structures	2.5	-	2.5
Approaches to bridges	2.5	1.5	4.0

Table 2.4 Width of Shoulders in Mountainous and Steep Terrain (Hilly Area)

Type of Section	Width of Shoulder (m)		
	Paved	Earthen	Total
Open country with isolated built up area	Hill Side	1.5	-
	Valley Side	1.5	1.0
Built up area and approaches to grade separated structures/bridges	Hill Side	0.25 + 1.5 (Raised)	-
	Valley Side	0.25 + 1.5 (Raised)	-

Notes:

- i) In case retaining wall with parapet is provided on valley side, the earthen shoulder may not be provided.
- ii) Width of Paved Shoulder in approaches to grade separated structures as indicated in **Tables 2.3** and **2.4** above shall extend on either side of the structure in the entire length of retaining/RE walls. The retaining/RE walls on either side shall be abutting the paved shoulders and shall have crash barriers on top.

2.6.2 Where embankment is more than 6 m high, kerb with channel shall be provided at the end of paved shoulder to channelize the drainage as an erosion control device in accordance with **Section 6** of this Manual and earthen shoulder shall be raised upto the level of kerb.

2.7 Roadway Width

2.7.1 The width of roadway shall be the sum of the width of carriageway, shoulders and the median.

2.7.2 On horizontal curves with radius up to 300 m, width of pavement and roadway in each carriageway shall be increased as per **Table 2.5**.

Table 2.5 Extra Width of Pavement and Roadway in Each Carriageway

Radius of Curve	Extra Width
75-100 m	0.9 m
101-300 m	0.6 m

2.8 Crossfall

2.8.1 The crossfall on straight sections of road carriageway, paved shoulders and paved portion of median shall be 2.5 percent for bituminous surface and 2.0 percent for cement concrete surface.

2.8.2 The crossfall shall be unidirectional for either side carriageway sloping towards the shoulder in straight reaches and towards the lower edge on horizontal curves. The camber on the existing road shall be modified to unidirectional crossfall.

2.8.3 The crossfall for earthen shoulders on straight portions shall be at least 0.5 percent steeper than the slope of the pavement and paved shoulder subject to a minimum of 3.0 percent. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse crossfall of 0.5 percent so that the earth does not drain on the carriageway and the storm water drains out with minimum travel path.

2.9 Geometric Design

2.9.1 Geometric design shall conform to IRC:73, except as otherwise indicated in this Manual.

2.9.2 All horizontal curves shall consist of circular portion flanked by spiral transitions at both ends.

2.9.3 Super elevation

Super Elevation shall be limited to 7 percent, if radius of curve is less than desirable minimum radius. It shall be limited to 5 percent, if radius is more than desirable minimum and also at section where Project Highway passes through an urban section or falls on a major junction.

2.9.4 Radii of horizontal curves

The desirable minimum and absolute minimum radii of horizontal curves for various classes of terrain are given in **Table 2. 6**.

Table 2.6 Radii of Horizontal Curves

Nature of Terrain	Desirable Minimum Radius	Absolute Minimum Radius
Plain and Rolling	400 m	250 m
Mountainous and Steep	150 m	75 m

The radius of horizontal curves for various terrain conditions shall not be less than the desirable minimum values given in **Table 2.6** except for Sections as indicated in **Schedule ‘B’**. For such Sections, the radius shall not be less than the absolute minimum.

2.9.5 Sight distance

The safe stopping sight distance and desirable minimum sight distance for divided carriageway for various design speeds are given in **Table 2.7**. The Vertical design, specially at grade change

location, such as VUP/LVUP, ROB, Bridge locations shall be done using Intermediate Sight Distance (Desirable Minimum Sight Distance). As a minimum safe stopping sight distance shall be available throughout.

Table 2.7 Safe Sight Distance

Design Speed (km/h)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m)
100	180	360
80	130	260
60	90	180
40	45	90

Note: Absolute minimum sight distance shall be permitted only on existing road where further improvement is not possible due to sight condition etc. All new road shall be designed with desirable minimum sight distance.

2.9.6 *Vertical alignment*

2.9.6.1 The vertical alignment should provide for a smooth longitudinal profile. Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile and grade change shall not be allowed within 150 m. In this regard, directions given in IRC:73 should be kept in view.

2.9.6.2 *Gradients*

The ruling and limiting gradients are given in **Table 2.8**. Ruling Gradients shall be adopted as far as possible. Limiting Gradient shall be adopted in difficult situations and for short lengths.

Table 2.8 Gradients

Nature of Terrain	Ruling gradient	Limiting gradient
Plain and Rolling	2.5%	3.3%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

2.9.6.3 Long sweeping vertical curves shall be provided at all grade changes. These shall be designed as square parabolas.

2.9.6.4 Design of vertical curves and its coordination with horizontal curves, shall be in accordance with IRC:SP:23.

2.10 *Lateral and Vertical Clearance at Underpasses*

2.10.1 *General*

- i) In case of VUP/LVUP/SVUP, the proposed structure base shall be kept 15 cm above the ground level to ensure that these VUPs don't become water accumulation points.
- ii) Guard rails/crash barriers shall be provided for protection of vehicles from colliding with the abutments and piers and the deck of the structures.

2.10.2 *Vertical and Horizontal clearance*

Vertical and Horizontal clearances at underpasses shall not be less than the values given below:

Type of Underpass	Vertical Clearance	Horizontal Clearance
i) Vehicular Underpass (VUP)	5.5 m	20.0 m
ii) Light Vehicular Underpass (LVUP)	4.0 m	12.0 m
iii) Smaller Vehicular Underpass (SVUP)	4.0 m	7.0 m

Wherever existing slab/box culverts and bridges allow a vertical clearance of more than 2 m, these can be used in dry season for pedestrian and cattle crossing by providing necessary flooring. However, these will not be a substitute for normal requirements of LVUP/SVUP as per **Para 2.13**.

2.11 Lateral and Vertical Clearance at Overpasses

Wherever any structure is provided over the Project Highway; the minimum clearances at overpasses shall be as follows:

2.11.1 *Lateral clearance*

Full roadway width including service roads shall be carried through the overpass structure or as indicated in **Schedule ‘B’**. The abutments and piers shall be provided with suitable protection against collision of vehicles. Crash barriers shall be provided on abutment side and on sides of piers for this purpose. The ends of crash barriers shall be turned away from the line of approaching traffic. The span arrangement for the overpass structure shall be as specified in **Schedule ‘B’**.

2.11.2 *Vertical clearance*

A minimum 5.5 m vertical clearance shall be provided at all points of the carriageway and the service roads of the Project Highway.

2.12 Access to Project Highway

2.12.1 *Access*

Access to the project highway shall be on the principle of left-in/left out arrangement and interconnected through underpasses, overpasses or grade separators. The considerations for planning, design and construction described in **Para 1.13** shall apply.

2.12.2 *Service road*

2.12.2.1 The carriageway width of service road shall be minimum 10 m. In built-up areas where separator (as per **Para 2.15** of this Manual), between main carriageway and service road; and RCC/Cement Concrete lined drain-cum-footpath on ROW side are provided, no earthen shoulder shall be provided for service road. The minimum width of paved portion of the service road shall be 10 m. Any deviations to the above provisions shall be specified in **Schedule ‘D’** of the Concession Agreement. Wherever required provision for Parking Bays of length 20 m and width 3.0 m may be made along the service road and the same shall be specified in **Schedule ‘B’** of the Concession Agreement.

2.12.2.2 For the stretches where total length of a bridge is less than 60 m and the service road is required to be provided on both sides of the stream, then the service road shall continue across the stream and suitably designed 2-lane bridge structure shall be provided. In cases involving bridges of 60 m length or more, separate bridge structures may not be provided and service road shall be merged with the Project Highway at 50 m distance before the bridge structure. Any deviation to this shall be specified in **Schedule ‘D’**.

2.12.2.3 Wherever service roads are provided, provision shall be made for proper entry and exit ramps between the main highway and the service roads through properly designed acceleration and deceleration lane. The layout for entry/exit at service road shall be as per **Figs. 2.1A** and **2.1B**. Any deviations to these layouts due to site constraints shall be specified in **Schedule ‘D’** of the Concession Agreement.

2.12.2.4 Design speed

A minimum design speed of 40 km/h shall be adopted for service roads.

2.12.3 Acceleration and deceleration lanes: The following requirements shall apply:

- i) **Length:** Designed for a speed differential of 60 km/h
- ii) **Width:** 5.5 m (minimum)
- iii) **Taper at merge:** 1 in 15 beyond design length

2.12.4 The acceleration and deceleration lanes and transition length will be considered as incidental to the project and shall not be counted towards service road length.

2.13 Grade Separated Structures

2.13.1 The type and location of various grade separated structures (VUP, LVUP, SVUP, VOP) shall be as specified in **Schedule ‘B’** of the Concession Agreement. In case the lateral/vertical clearance and total length of viaduct to be provided is different from the minimum specified in this Section, the same shall also be specified in **Schedule ‘B’**. The connection to slip/ramp shall be as shown in **Fig. 2.1C** to **Fig. 2.1F**. Depending on the traffic volume and speed and other factors, the layout to be adopted for each case as per **Figs. 2.1C** to **2.1F** shall be specified in **Schedule ‘B’**.

2.13.2 Vehicular underpass/overpass

The vehicular under/overpass structures shall be provided at the intersection of the Project Highway with all the National Highways and State Highways. Such under/over passes shall also be provided across other categories of roads as per site requirements for crossing of traffic. The structure may be either an underpass or an overpass depending upon the nature of terrain, vertical profile of road and availability of adequate right of way etc. Decision whether the cross road or the Project Highway will be carried at the existing level will be taken at the time of preparing the feasibility report and would be based on considerations of drainage, land acquisition, provision of ramps for the grade separated facility, height of embankment and project economy etc.

2.13.3 Light Vehicle Underpass (LVUP)

The location of LVUPs shall be specified in **Schedule ‘B’**.

2.13.4 SVUP and foot over bridge

These shall be provided as specified in **Schedule ‘B’** of the Concession Agreement.

- i) A SVUP/Foot Over Bridge may not be necessary within a distance of 2 km from Vehicular underpasses/overpasses and Light Vehicular Underpasses.
- ii) The pedestrian crossings (SVUP/FOB) shall have provision for movement of physically challenged persons.
- iii) Underpasses shall be preferred to Foot Over Bridges.
- iv) SVUP/Foot over Bridge shall also be provided within a distance of 200 m from a school or hospital or factory/industrial area.

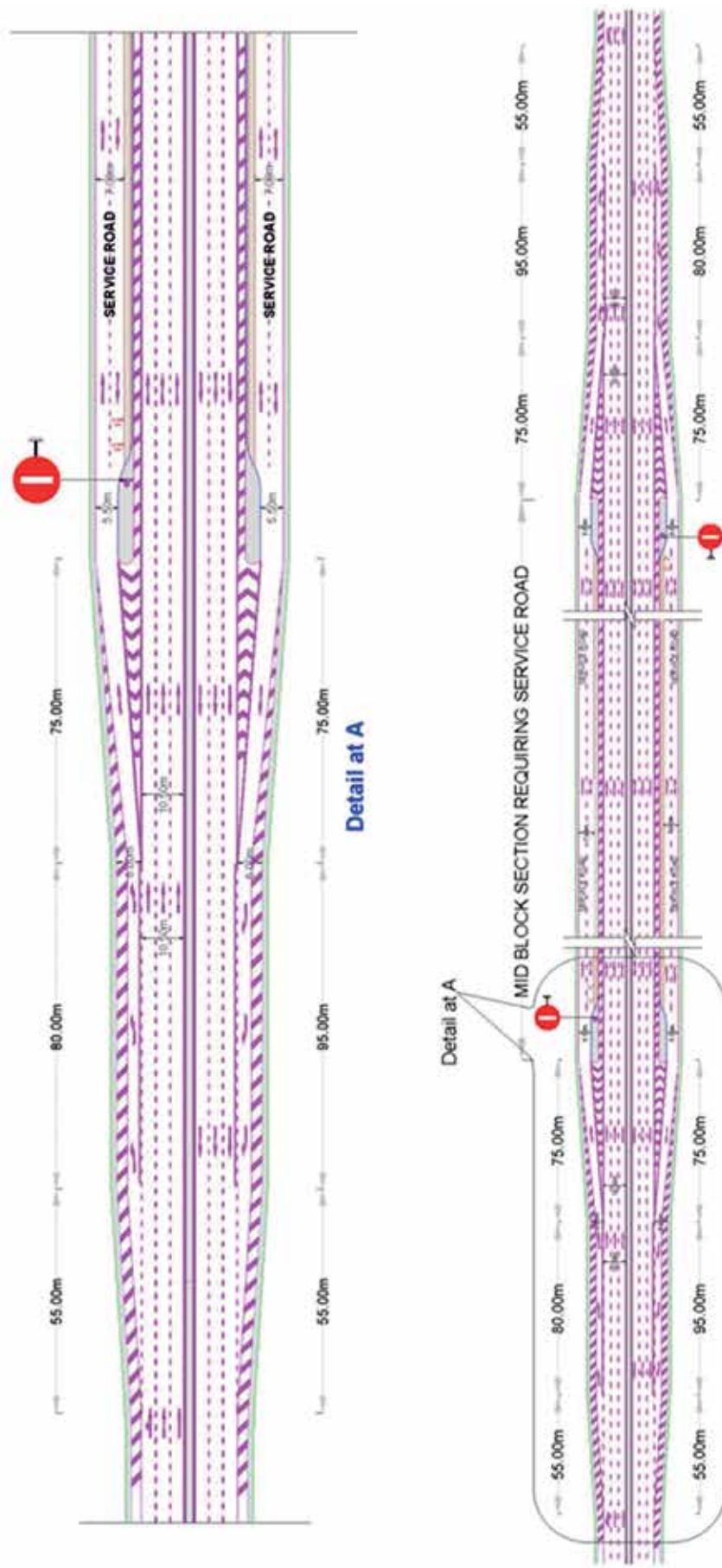


Fig 2.1A : Entry/Exit Arrangement with Service Road

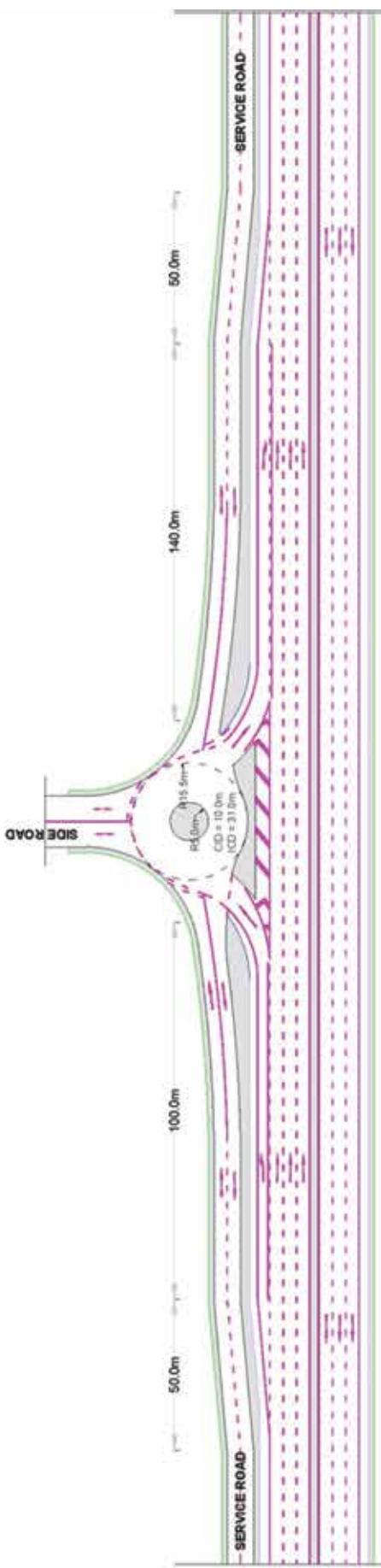


Fig. 2.1B Entry/Exit Arrangement with a Side Road where Service Road Continuing

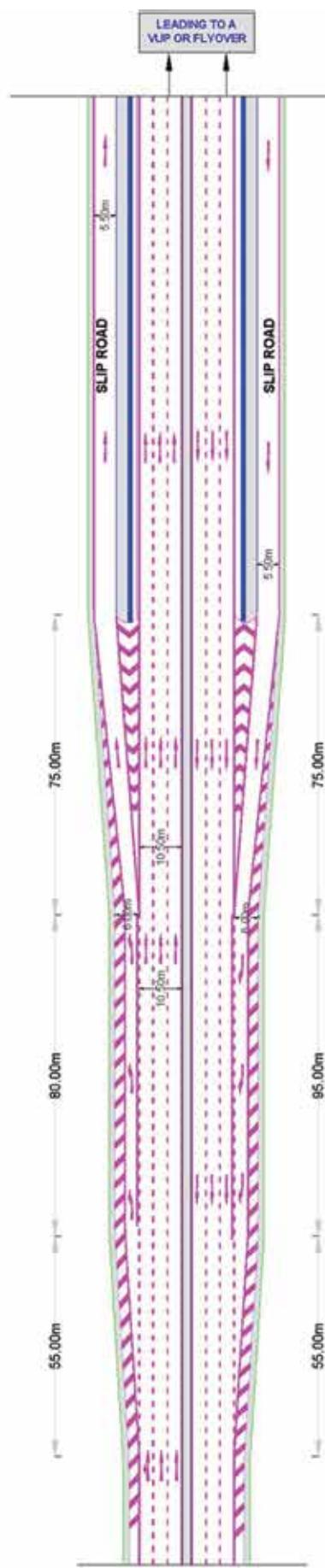


Fig. 2.1C Entry/Exit Arrangement with a Slip Road (No Service Road)

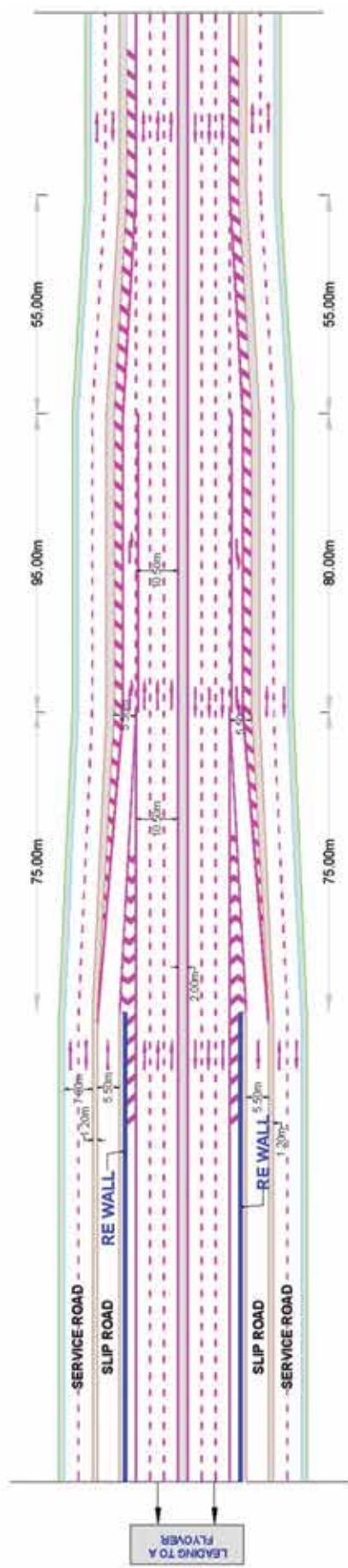


Fig. 2.1D Entry/exit Arrangement with a Slip Road (Service Road & Slip Road Segregated)

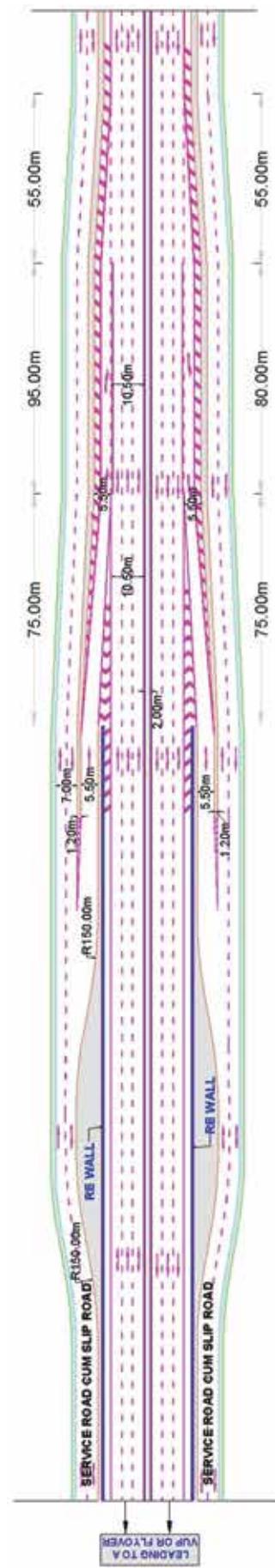


Fig. 2.1E Entry/Exit Arrangement with a Service Road cum Slip Road (Speed Reduction by Deflection)

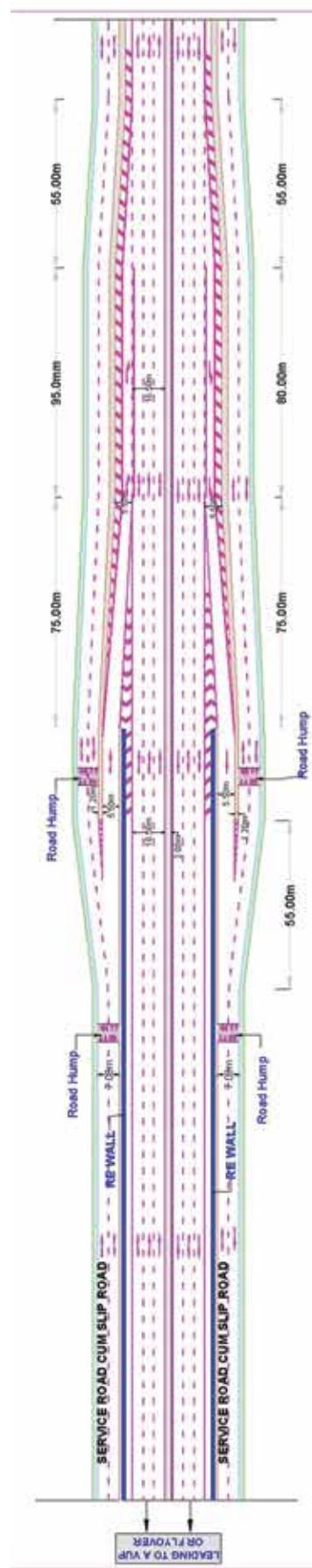


Fig. 2.1F Entry/Exit Arrangement with a Service Road cum Slip Road (Speed Reduction by Road Hump)

- v) The Bus Bays along with the Bus Shelters shall be provided at the pedestrian underpass/foot over bridge locations where buses normally stop to drop and pick up commuters as specified in **Para 12.7** of this Manual. Such locations shall be specified in **Schedule 'B'**.

A typical cross-section for SVUP is given in **Fig. 7.8**. The central portion open to sky shall be so covered as to allow air and light, but not rain water.

2.13.5 Road Over Bridges (ROBs)/Road Under Bridges (RUBs) for crossing the Railway tracks shall be provided as per **Section 7** of this Manual.

2.13.6 Tunnels

Standards for Tunnels shall be as given in **Section 14** of this Manual.

2.14 Median Openings

2.14.1 In open country, median openings shall not be spaced closer than 2 km. Additional controlled openings shall also be provided for inspection and diversion of traffic during repair and rehabilitation. In built up area, median opening shall be provided as per site requirement and the spacing between two medians opening in built up area shall not be less than 500 m. All such locations shall be mentioned in **Schedule 'B'** of Concession Agreement.

2.14.2 Median opening shall not be provided in front of the service road entry. The distance between the service road entry and the median opening shall be at least equal to the sum of length of acceleration lane, weaving length, and deceleration length. This distance shall however be not less than 150 m. Location of opening shall be so decided as to minimize contraflow.

2.14.3 All median openings shall be provided with additional 3.0 m wide shelter lane by the side of median in both directions for waiting of vehicles to take U-turn. Wherever required, horizontal geometries of the road shall be suitably adjusted.

2.14.4 Length of median opening shall be 18 to 20 m only. Length of median openings can be more than 20 m in case of median opening without storage lane, to serve as neutral place for small vehicles to wait. All plantations and objects in the median for at least 120 m from median tip shall be removed to ensure the visibility between approaching vehicle and that waiting/turning at median openings.

2.14.5 If location without service road is causing contra flow, additional median opening can be provided to avoid contra flow.

2.15 Separator, Footpath and Drain in Built-up Areas

2.15.1 A separator between main carriageway and service road of the following type shall be provided to prevent the pedestrians, local vehicles and animals entering the highway. Raised Footpath of minimum 1.5 m width with kerb on either side (200 mm above road surface), drain pipes across at minimum 10 m intervals and finished with CC paving blocks along with Metal Beam Barrier (Thrie Beam - one side) or pedestrian guard rail as given in **Para 9.8** of this Manual at the edge of footpath (towards carriageway side) shall be provided between service road and carriageway as shown in **Fig. 2.6**.

2.15.2 RCC/Cement Concrete lined drain-cum-footpath shall be provided at the edge of the service road (ROW side).

2.15.3 The raised footpath shall be depressed at suitable intervals to provide for convenient use of physically challenged persons.

2.16 Utility Corridor

Two metre wide strip of land at the extreme edge of ROW shall be kept for accommodating utilities, both over as well as underground. Provisions contained in IRC:98 shall be followed to accommodate utility services in built-up areas of Project Highway. Utility ducts in the form of 600 mm diameter NP-4 Pipe across the Project Highway at a spacing of 0.50 km shall be provided for crossing of underground utilities.

2.17 Typical Cross-sections

Typical cross-sections of Project Highway are given in **Figs. 2.2 to 2.13** for various locations as below:

Fig. 2.2 shows typical cross-section (Type-A1) for 6-lane divided highway in open country in plain/rolling terrain, without service roads and with depressed median

Fig. 2.3 gives typical cross-section (Type-A2) for 6-lane divided highway in open country in plain/rolling terrain with service roads on both sides and with depressed median

Fig. 2.4 shows typical cross-section (Type-A3) for 6-lane divided highway in open country in plain/rolling terrain, without service roads and with raised median for a new 6-lane construction

Fig. 2.5 gives typical cross-section (Type-A4) for 6-lane divided highway in open country in plain/rolling terrain with service roads on both sides and with raised median for a new 6-lane construction

Fig. 2.6 shows typical cross-section (Type-A5) for 6-lane divided highway in open country in plain/rolling terrain, without service roads and with raised median from an existing 4-lane to 6-laning Project

Fig. 2.7 gives typical cross-section (Type-A6) for 6-lane divided highway in open country in plain/rolling terrain with service roads on both sides and with raised median from an existing 4-lane to 6-laning Project

Fig. 2.8 shows typical cross-section (Type-B1) for 6-lane divided highway in built-up section in plain and rolling terrain with service roads on both sides and with raised median

Fig. 2.9 shows typical cross-section (Type-B2) for 6-lane divided highway in built-up section in plain and rolling terrain with service roads on both sides and with raised median from an existing 4-lane to 6-laning Project

Fig. 2.10 shows typical cross-section (Type-C1) for 6-lane divided highway on different contours in open country in mountainous terrain.

Fig. 2.11 shows typical cross-section (Type-C2) for 6-lane divided highway on different contours in built up section in mountainous terrain.

Fig. 2.12 shows typical cross-section (Type-C3) for 6-lane divided highway at same level in open country in mountainous terrain with shoulder

Fig. 2.13 shows typical cross-section (Type-C4) for 6-lane divided highway at same level in built up section in mountainous terrain with footpath

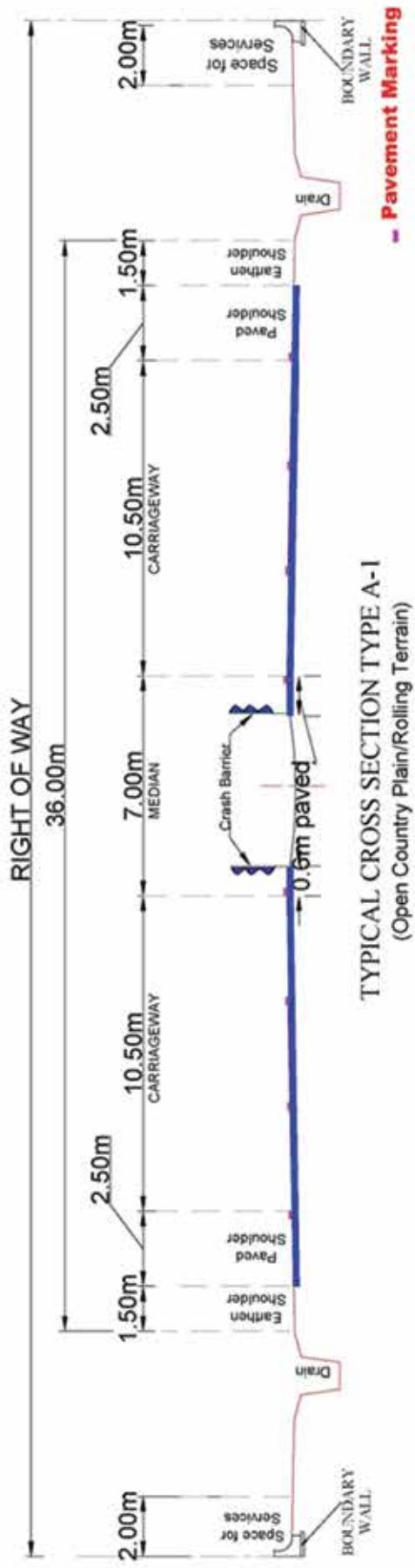


Fig. 2.2 6-Lane Divided Highway without Service Roads and with Depressed Median

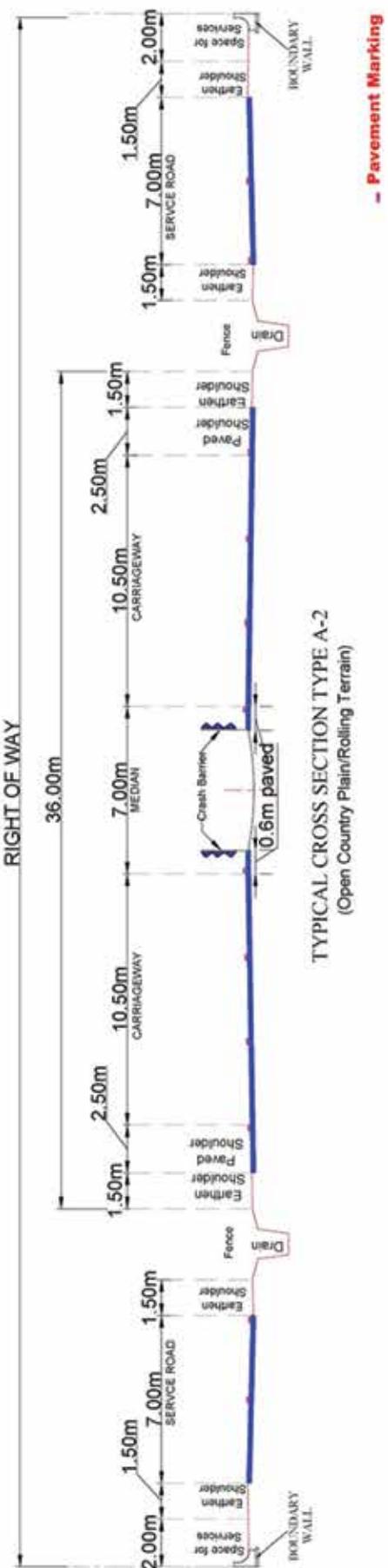


Fig. 2.3 6-Lane Divided Highway with Service Roads and with Depressed Median

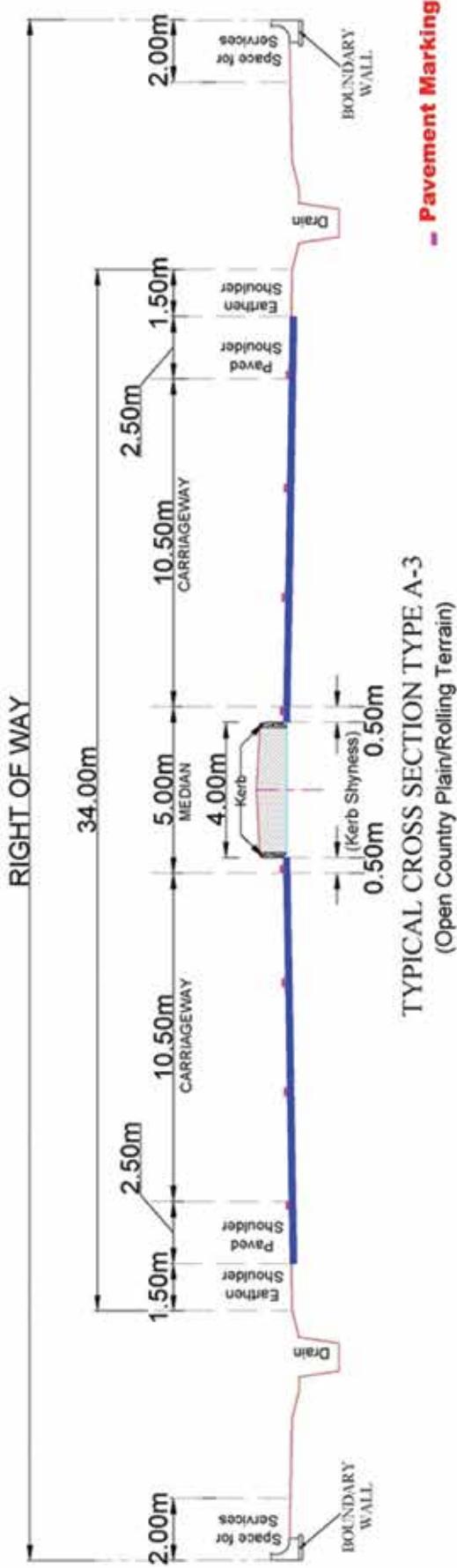


Fig. 2.4 6-Lane Divided Highway without Service Roads and with Raised Median for a new 6-Lane Construction

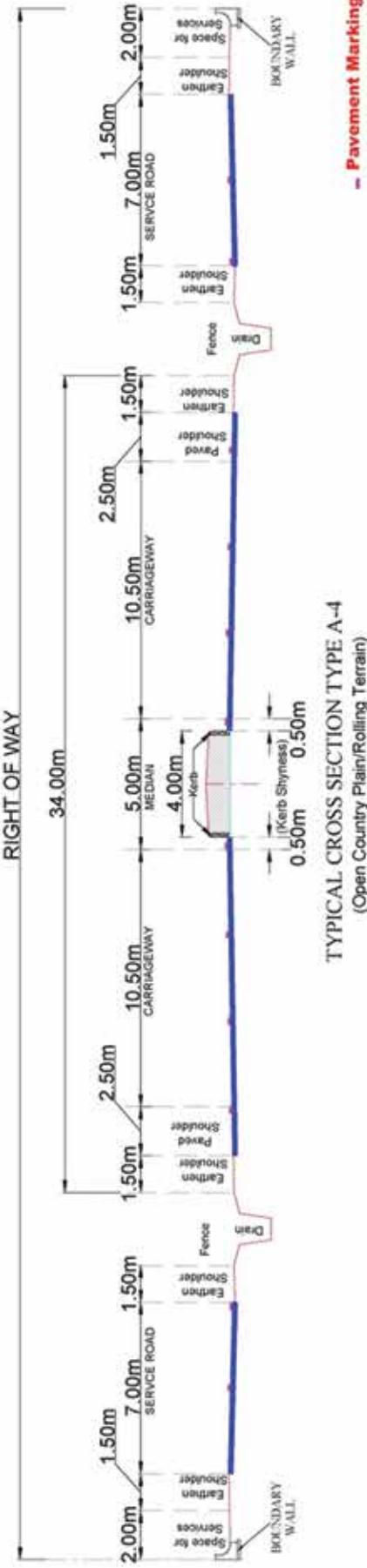


Fig. 2.5 6-Lane Divided Highway with Service Roads and with Raised Median for a new 6-Lane Construction

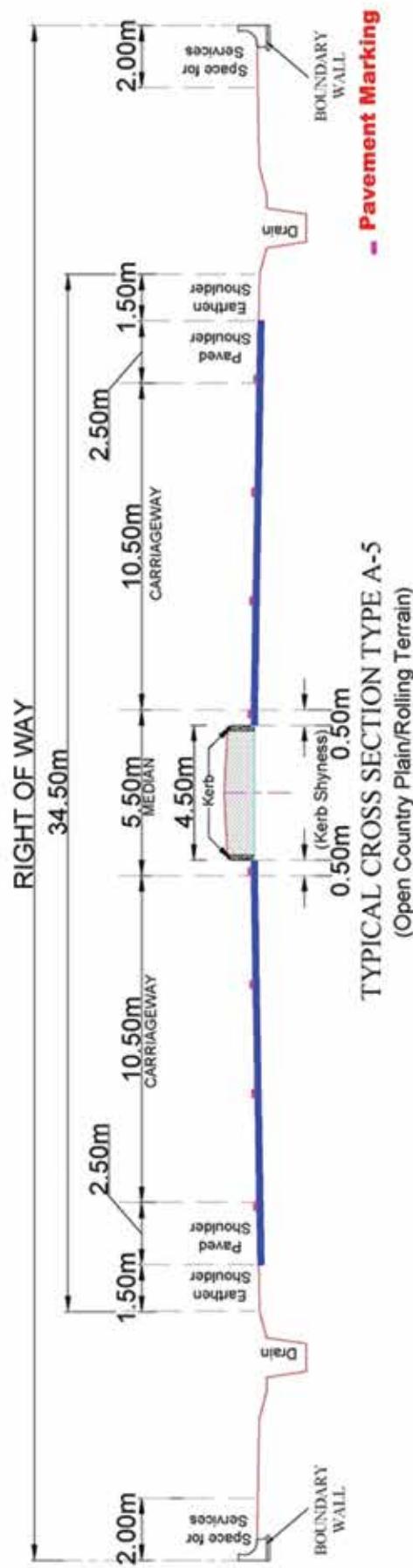


Fig. 2.6 6-Lane Divided Highway without Service Roads and with Raised Median in 4-Lane to 6-Laning Project

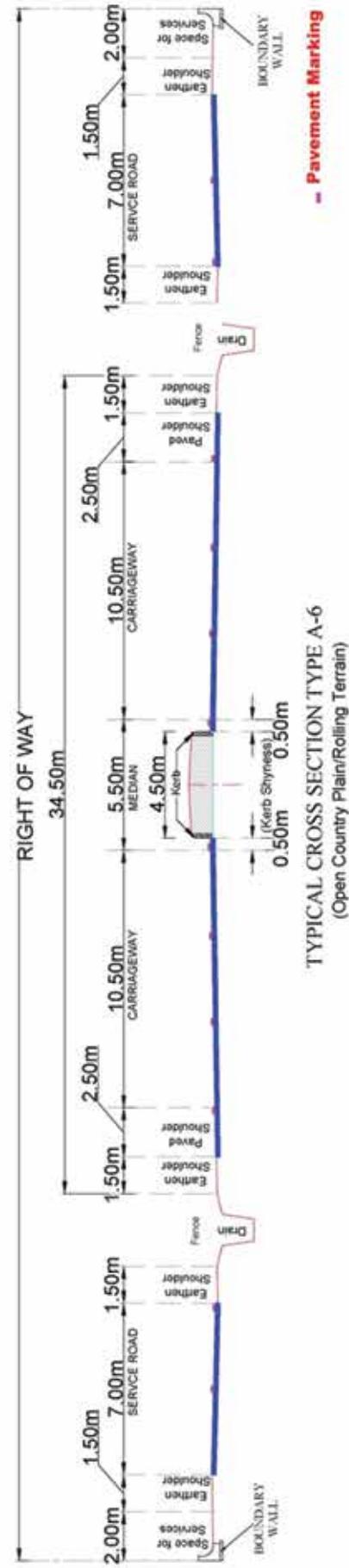


Fig. 2.7 6-Lane Divided Highway with Service Roads and with Raised Median in 4-Lane to 6-Laning Project

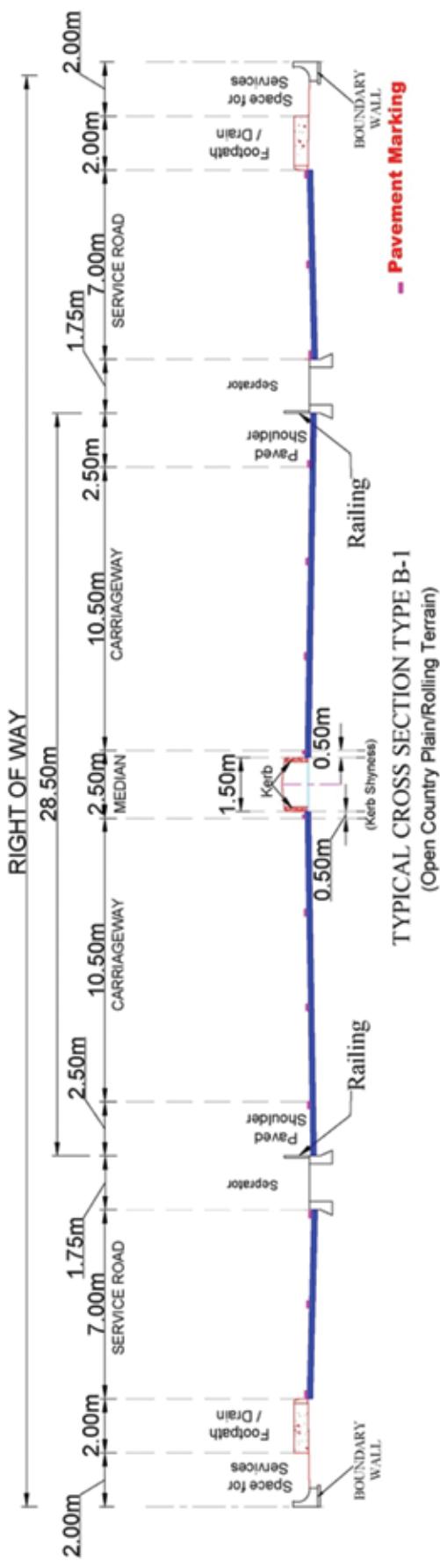


Fig. 2.8 6-Lane Divided Highway with Service Roads and with Raised Median for a new 6-Lane Construction

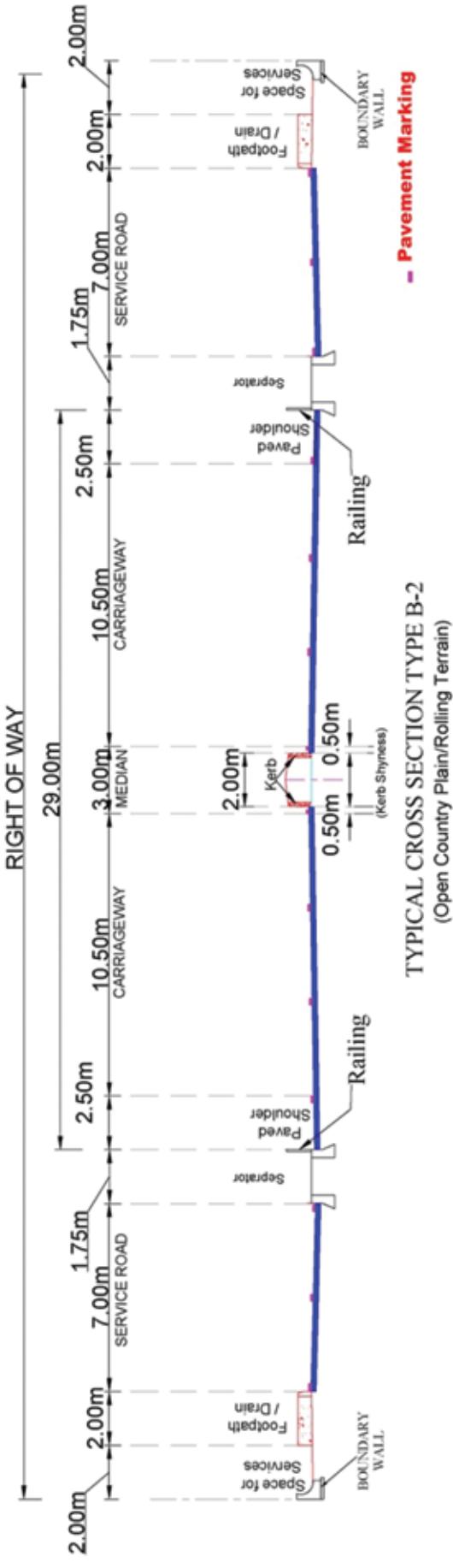


Fig. 2.9 6-Lane Divided Highway with Service Roads and with Raised Median for 4-Lane to 6-Laning Project

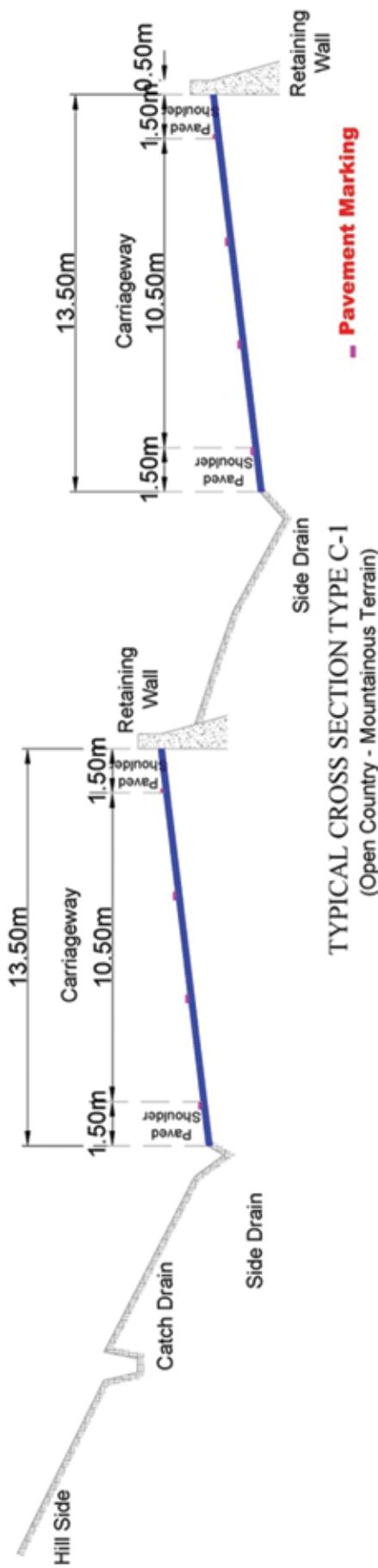


Fig. 2.10 6-Lane Divided Highway on Different Contours

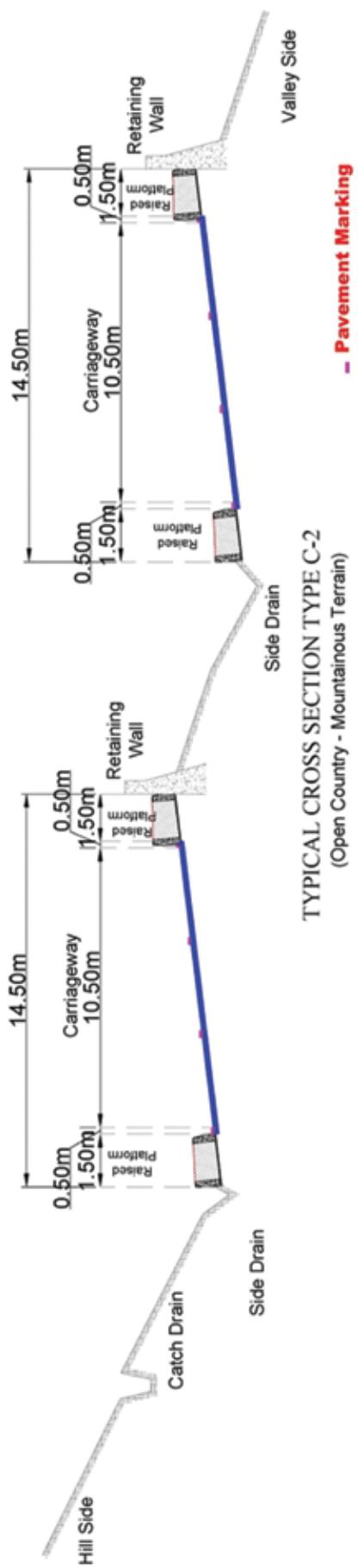


Fig. 2.11 6-Lane Divided Highway on Different Contours

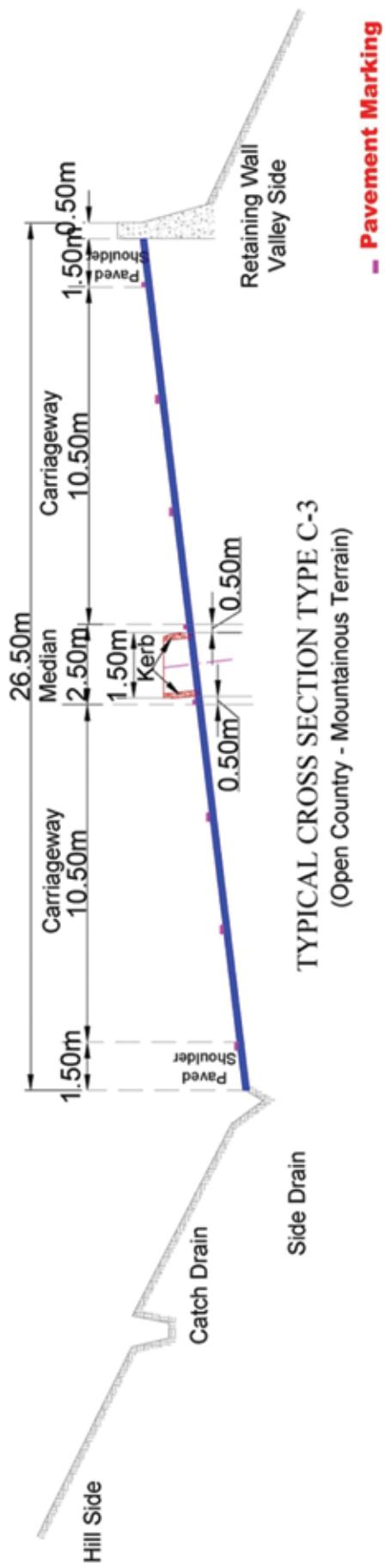


Fig. 2.12 6-Lane Divided Highway at same Level with Raised Median

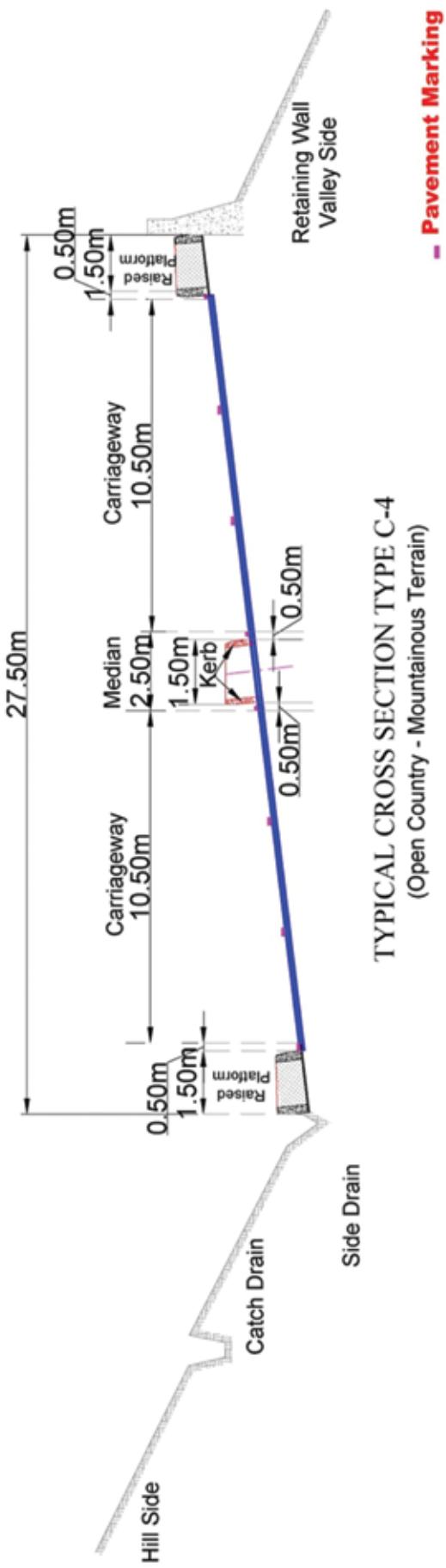


Fig. 2.13 6-Lane Divided Highway at same Level with Raised Median

SECTION 3

INTERSECTIONS AND GRADE SEPARATORS

3.1 Introduction

3.1.1 As mentioned in **Paras 1.13 and 2.12**, there shall be no direct access to the main highway and all access shall be from service roads which shall be provided on both sides of the main highway and interconnected through underpasses, overpasses or grade separators. The existing direct access to the highway shall be closed and alternative access through service roads only shall be provided.

3.1.2 The exit and entry arrangement before and after a grade separator shall also be treated as part of the development of grade separator intersection

3.2 At-Grade Intersections

3.2.1 There shall be no at-grade intersection of any road with the carriageway, but only with the service road. The intersection of the Project Highway with another National Highway (NH) or State Highway (SH) shall be grade separated. The existing direct intersections shall be closed and remodeled accordingly. The intersecting roads other than those mentioned above, shall be designed to facilitate all movements in following manner:

- a) Through underpass/overpass for crossing the Project Highway and then right turn through a ramp to merge with the Project Highway or service road if provided as per this Manual, or
- b) By merging with service road and crossing through the next available vehicular underpass.

There shall be interconnection between the service roads of both sides through underpasses which will facilitate cross movement of local traffic from one side to the other side and to facilitate change of direction of through traffic. Accordingly, the intersections on the service road including those at underpasses shall be designed for safe movements for all turnings.

3.2.2 The design of different elements of intersection shall be done as per IRC:SP:41 “Guidelines on Design of At-grade Intersections in Rural and Urban Areas” including other criteria given in this Manual.

- i) The design shall aim at simplicity and uniformity in design standards. Complex designs which may involve complicated decision making by drivers shall be avoided.
- ii) The intersection control shall be of ‘Stop Control’ unless specified otherwise. This will mean that traffic on the cross road must stop prior to entering the service road.
- iii) The traffic control by “STOP” or by “GIVEWAY” signs and pavement markings shall be decided based on the guidance given in IRC:67 and IRC:35. The visibility funnel given in IRC:35 shall be encumbrance free to ensure the mutual visibility between traffic plying in the service road/through road and that approach from side road.

- iv) At the intersection, the alignment of project highway shall be as straight and the gradient as flat as practicable. Gradients in excess of 2 per cent will not be allowed at intersections.
- v) The alignment and grade of intersecting roads shall be corrected to improve traffic conditions and safety. The intersecting roads shall be regraded, if required so that at least 30 m length of the intersecting road beyond junction is at the same level as that of main carriageway at the junction. The side road gradient even for the insignificant minor road that joins the service road at least for the length that falls within the visibility funnel shall be near to flat gradient.
- vi) The sight distance to be adopted shall be at least twice the safe stopping sight distance as specified in **Section 2**.
- vii) At multi leg intersections, the points of conflict should be studied carefully and possibilities of realigning one or more of the intersecting legs and combining some movements to reduce the conflicting movements shall be examined.

The objective shall be to simplify the design and appropriate control devices added to ensure more efficient and safe operation. The channelizing islands shall start from the edge of the paved shoulder.

3.2.3 Design standards

Design standards shall be as per IRC:SP:41. Salient features are given below:

- i) **Design Speed:** The approach speed shall be taken as the design speed adopted for the section of Project Highway on which the intersection is located. The design speed for various elements of the intersection shall be taken as 60% of the approach speed.
- ii) **Design Traffic Volume:** The traffic volume for the design of intersection and its distribution at peak hours shall be assessed, up to the operation period, taking into consideration the past trend, likely new development of land, socio-economic changes, etc.
- iii) **Design Vehicle:** Semi-trailer combination (refer IRC:3) shall be used in the design of intersections.
- iv) The number of lanes to be provided at the intersection shall be governed by peak hour traffic volume in each direction of travel and shall be determined based on the projected traffic for the year in which further capacity augmentation is considered. The minimum width of carriageway and slip road in junction area shall be as indicated in the junction layouts. Widening of carriageway shall be achieved depending upon the approach speed of traffic and based on taper rate stipulated below. Generally desirable minimum taper shall be followed. In unavoidable situations, absolute minimum values given in the **Table 3.1** can be adopted.

Table 3.1 Taper Rate

Speed (kmph)	Desirable Minimum Taper	Absolute Minimum Taper
< 50 kmph	1:35	1:20
50 to 65 kmph	1:40	1:25
66 to 80 kmph	1:45	1:30
>80 kmph	1:50	1:40

- v) **Type and radius of curve of intersection:** The type and radii of curves would depend upon the types of vehicles turning at the intersection and shall be decided based on the traffic data.
- vi) **Visibility at intersection:** A minimum twice safe stopping sight distance, appropriate for the approach speeds, shall be available for the traffic on the Project Highway.

3.2.4 Typical at -Grade junction layouts

Encompassing safety requirement and also to have better traffic control following layouts are suggested for at-grade intersections below structures on the project highway.

Fig. 3.1 Junction Layout below a Vehicular Underpass (VUP)

Fig. 3.2 Junction Layout below a Light Vehicular Underpass (LVUP)

Fig. 3.3 Junction Layout below a Smaller Vehicular Underpass (SVUP)

Fig. 3.4 Junction Layout for Medium Traffic Volume (Flyover with Viaduct Spans & Traffic Regulation by Roundabout)

Fig. 3.5 Junction Layout for High Traffic Volume (Flyover with Viaduct Spans & Traffic Control by Signalization)

Fig. 3.6 Junction below a Half Flyover connecting Service Road/Slip roads

For exceptional situation, if side road access has been permitted, the layout provided in **Fig. 3.7** shall be adopted

3.3 Grade Separated Intersections without Ramp

3.3.1 General

- i) If specifically provided in **Schedule ‘B’**, Grade Separated intersection without ramp may be provided.
- ii) All features pertaining to structures for this type of grade separator will be same as provided in **Section 2** of this Manual.

3.3.2 Geometric standards for design of various elements

The geometric design standards for various elements of this type of grade separators shall be as given in **Paras 3.2.1 and 3.2.2**.

3.3.3 Design of structures

For design of structures of grade-separated structures, the details given in **Sections 7 and 8** of this Manual shall be followed. Minimum length of viaduct required to be provided at various grade separated structures shall be specified by the Authority in **Schedule ‘B’** of the Concession Agreement.

3.3.4 Traffic control devices

The traffic signs shall be provided as per IRC:67 and pavement markings as per IRC:35 along with other essential provisions for traffic control devices made in **Section 9** of this Manual.

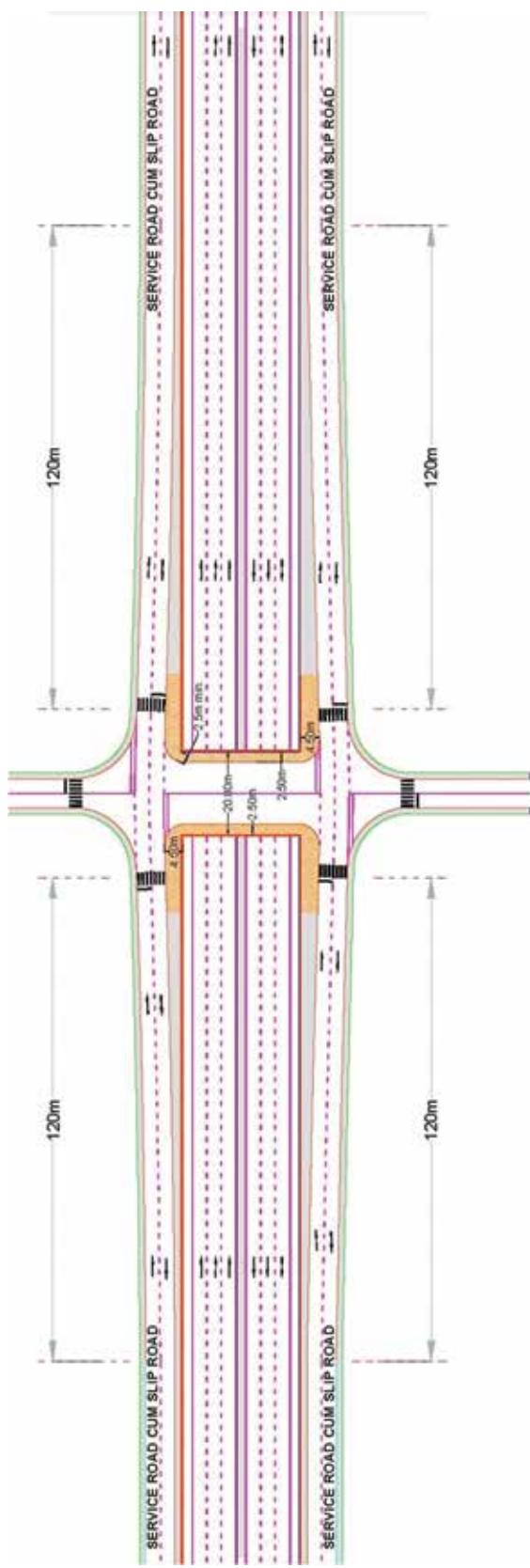


Fig. 3.1 Junction Layout Below a Vehicular Underpass(VUP)

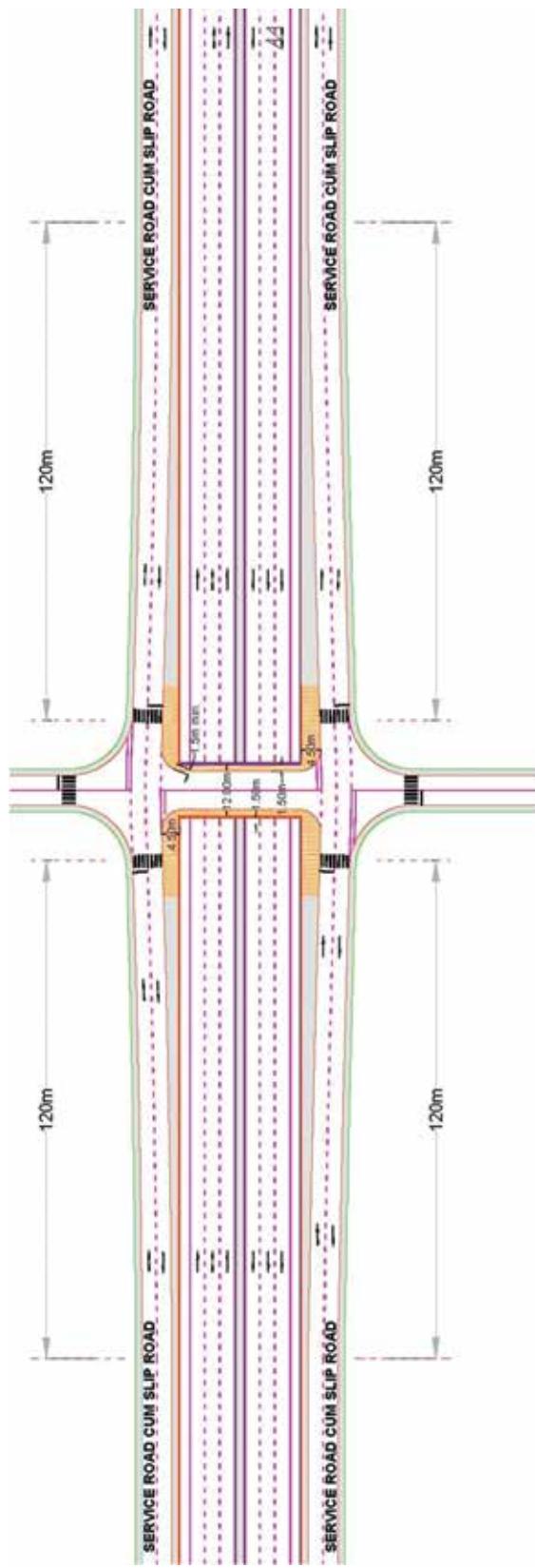


Fig. 3.2 Junction layout Below a Light Vehicular Underpass(LVUP)

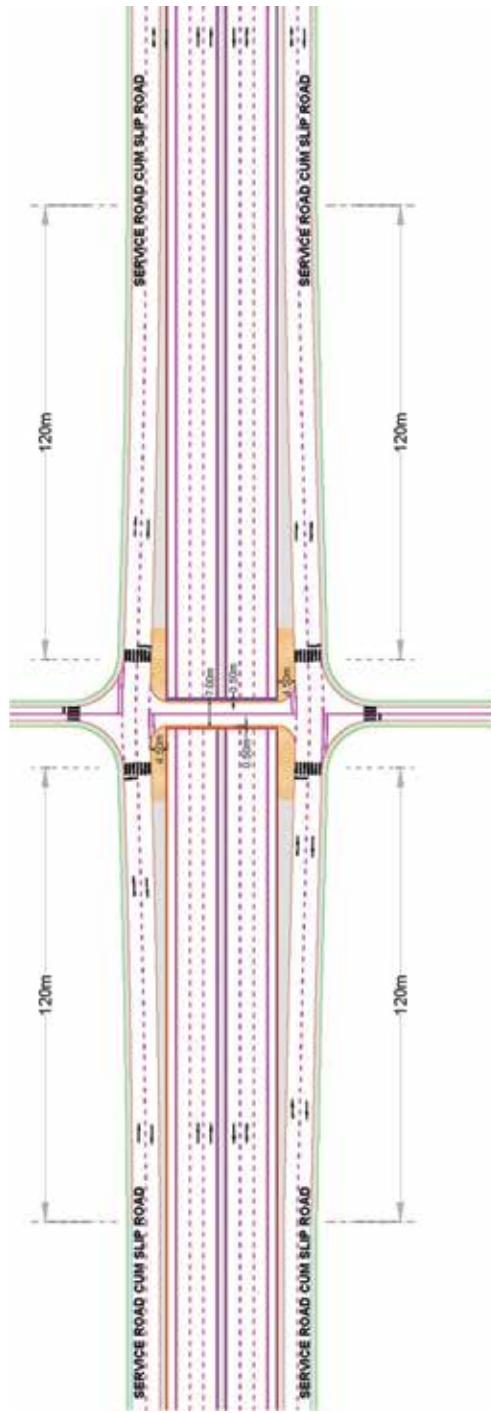


Fig. 3.3 Junction Layout a Smaller Vehicular Underpass(SVUP)

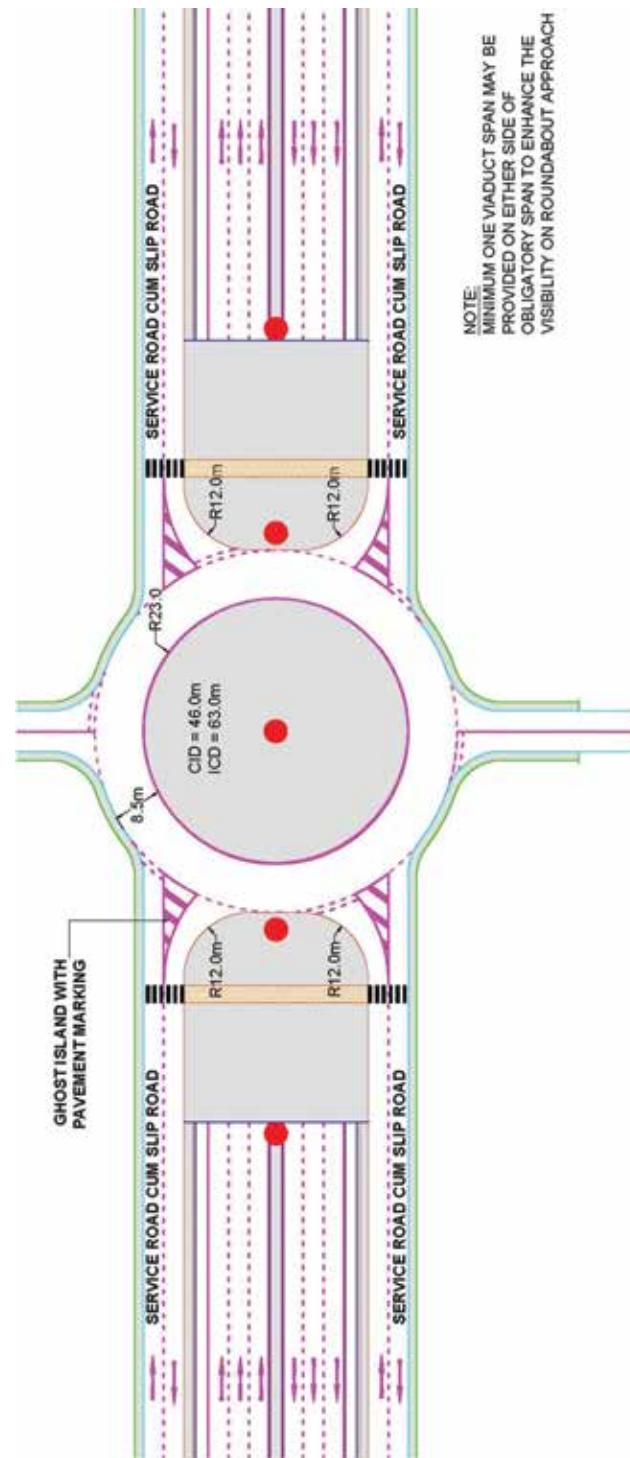


Fig. 3.4 Junction Layout for Medium Traffic Volume (Flyover with Viaduct Spans & Traffic Regulation by Roundabout)

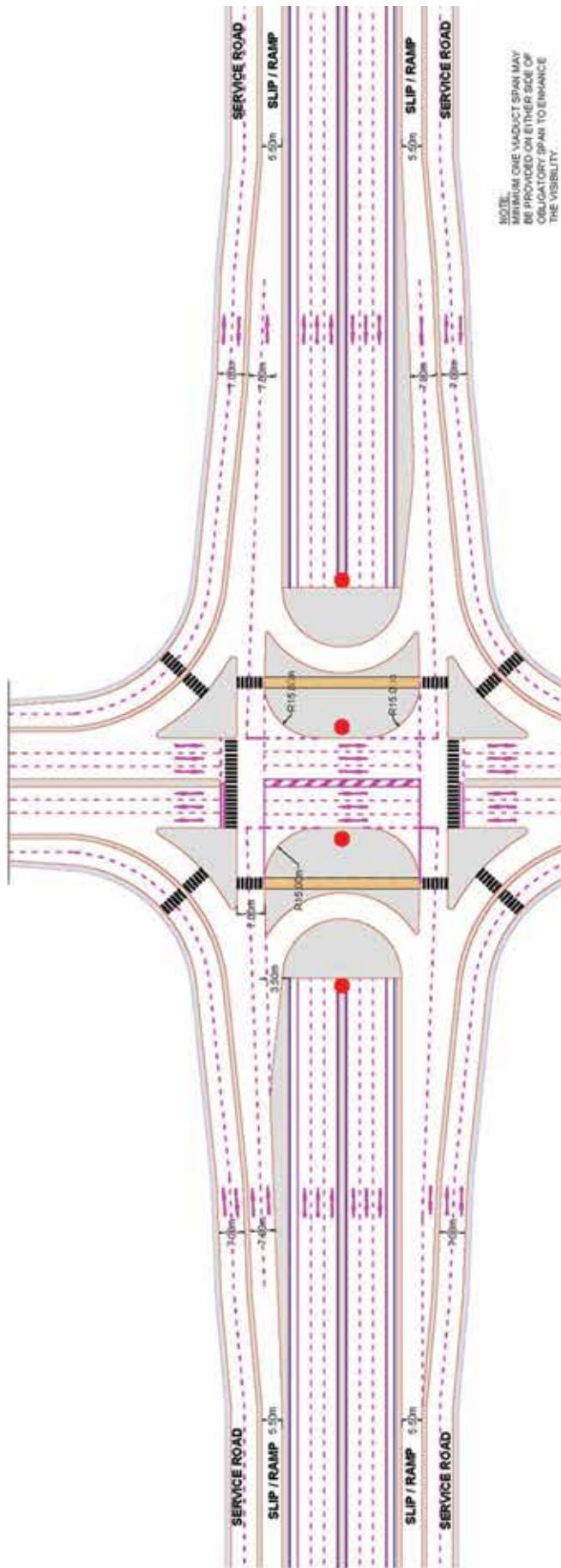


Fig. 3.5 Junction Layout for High Traffic Volume (Flyover with Viaduct Spans & Traffic Control by Signalization)

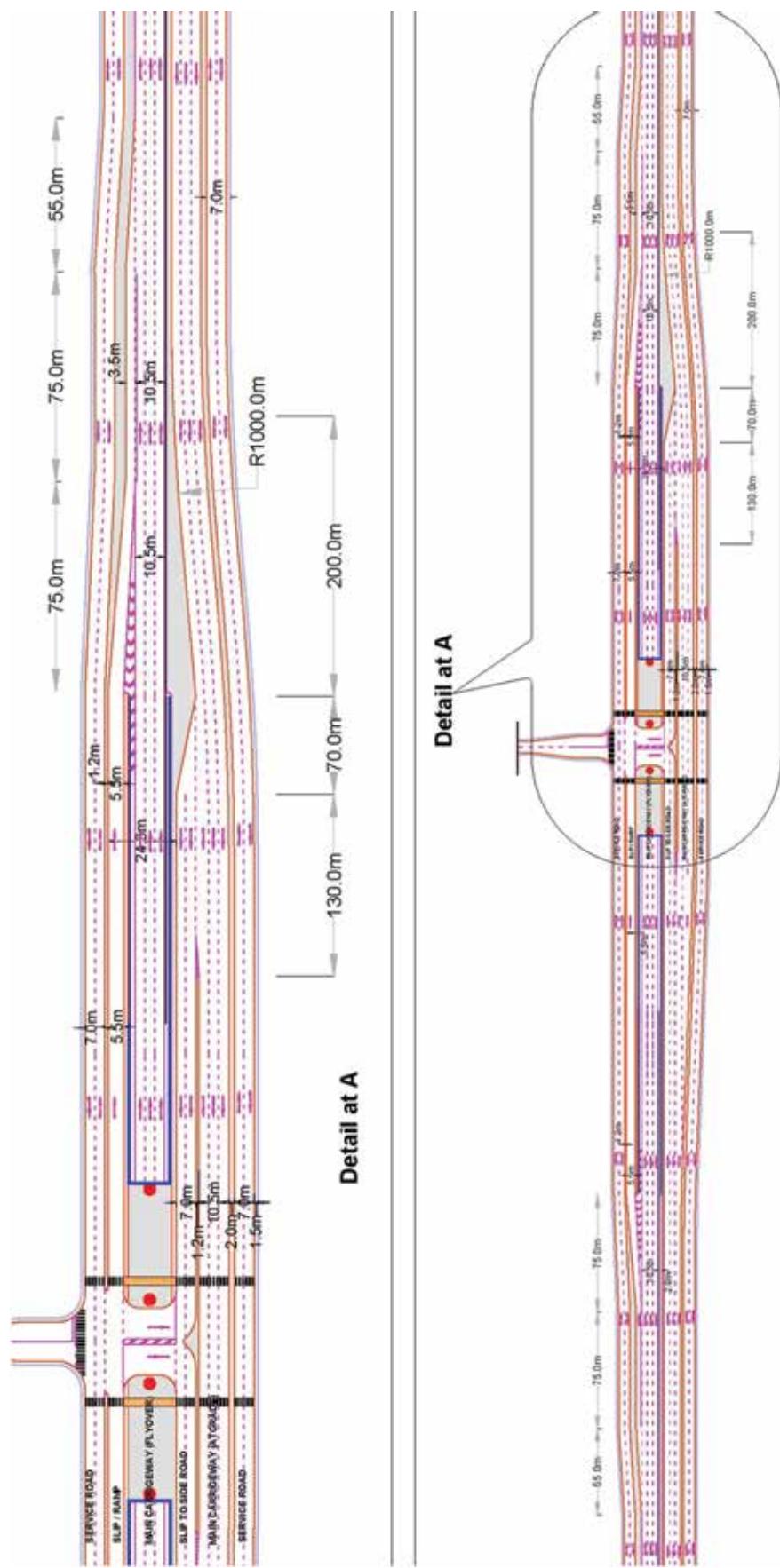


Fig. 3.6 Junction Below a Half Flyover connecting Service Road/Slip Roads

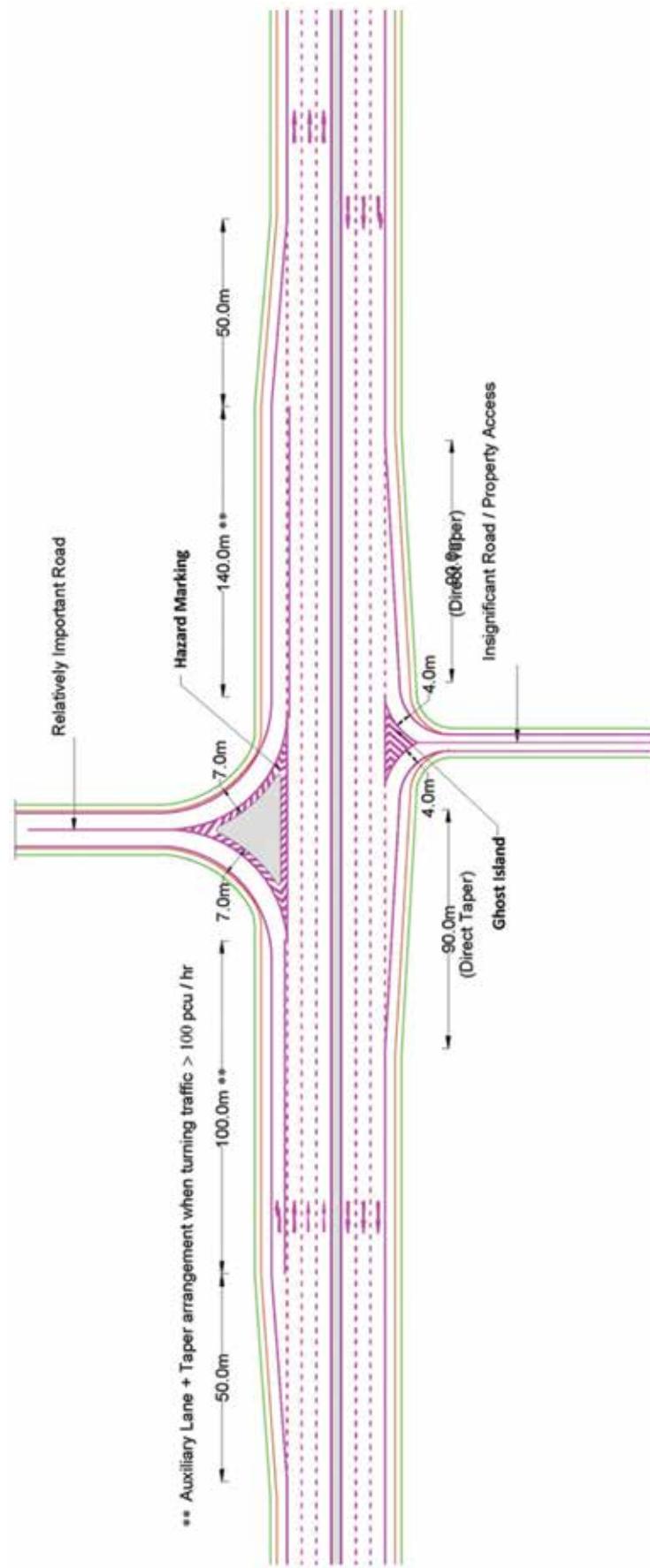


Fig. 3.7 Left-in/Left-out Arrangement (Side Road of Varying Importance)

3.3.5 *Detailed design and data for review by IE*

The Concessionaire shall submit the details of the ground surveys, traffic data, traffic forecast, design and drawings of the grade separated intersections and the structures, showing all safety features, to the Independent Engineer for approval

3.4 Grade Separated Intersections and Interchanges

3.4.1 General

- i) An Interchange is a grade-separated intersection with connecting roadways (ramps) for turning traffic between highway approaches. Such an Interchange will be necessary at all crossings of a highway, which is to be developed to completely access controlled standards. An Interchange may also be justified at locations where traffic on cross roads is heavy and when an At-grade intersection fails to handle the heavy volume of turning, merging and diverging traffic leading to excessive delays and fatal and major accidents. Cost effectiveness will decide whether to provide full Interchange or grade separated intersection without ramps.
- ii) An Interchange may be justified at the crossing of the Project Highway with another highway, and where the total traffic on all the arms of the intersection is in excess of 10,000 PCUs in peak hour.
- iii) The decision to provide Interchange at such locations shall be taken by the Authority and the requirement shall be clearly spelt out in **Schedule ‘B’** of the Concession Agreement, which shall also indicate specifications and traffic streams to be grade separated.
- v) The detailed design and layout of the Interchange shall conform to broad parameters and requirements specified by the Authority in **Schedule ‘B’** of the Concession Agreement. Based on detailed survey and investigations, the Concessionaire shall develop appropriate detailed drawings and designs and submit to the Independent Engineer for review and comments, if any.

3.4.2 Types of interchanges

- i) Interchanges are generally described by the pattern of the various turning roadways or ramps, which determine their geometric configuration. The common geometric configurations of Interchanges are the trumpet, diamond, cloverleaf, rotary and directional. Within each type of Interchange, there can be several variations such as split diamond, partial cloverleaf, etc. depending on the ramp arrangements.
- ii) The type of Interchanges, the shape and pattern of the Interchange ramps and loops and their designs shall be governed by factors such as the importance of the intersecting highway, the number of intersecting legs, the design volumes of through and turning traffic movements including their composition, the design speeds, available right of way and topography. The Interchange site shall be studied in detail and alternative designs made, to determine the most suitable arrangement of structures and ramps satisfying the specified requirements.

3.4.3 Geometric design standards for interchange elements

The geometric design standards shall be as per IRC:92 appropriate for the design speed adopted for the Project Highway. The design speed for ramps shall not be less than 40 km per hour. The desirable values of various parameters given in IRC:92 shall be adopted, unless there are severe site constraints.

3.4.4 Design traffic

The traffic volume for the design of various elements of Interchange including ramps shall be assessed up to the end of the Concession Period or twenty years, whichever is more, taking into consideration the past trends, likely new development of land, socio-economic changes, etc.

3.4.5 Design of structures

Design of structures shall conform to **Section 7** of this Manual. Minimum length of viaduct and RCC Retaining Wall/RE wall required to be provided shall be specified in **Schedule ‘B’**. In case length of Retaining/RE wall is not specified in **Schedule ‘B’** the same shall be deemed to be included in the scope of work and shall be provided as per site requirements.

3.4.6 Lighting

Lighting requirement shall be as per **Section 12** of this Manual. The top and underside of the grade separated structures and interchange area at the ground level upto 50 m beyond the point from centre on all legs of interchange/crossing both at top and bottom shall be provided with lighting.

3.5 Traffic Control Devices

The traffic signs shall be provided as per IRC:67 and pavement markings as per IRC:35 along with other essential provisions for traffic control devices made in **Section 9** of this Manual.

3.6 The Concessionaire shall submit details of the ground surveys, traffic data, traffic forecast, traffic management and safely plan during construction, design and drawings of the grade-separated intersections and interchanges showing all safety features to the Independent Engineer for review and comments.

SECTION 4

EMBANKMENT & CUT SECTIONS

4.1 General

4.1.1 The design and construction of the road in embankment and in cuttings shall be carried out in accordance with **Section 300** of MoRTH Specifications and the requirements, and standards and specifications given in this Section. This Section also covers Specifications for sub-grade and earthen shoulders.

4.1.2 Efforts should be made to remove the inherent deficiencies in plan and profile of the existing road. The final centre line of the road and the road levels shall be fixed duly considering all the relevant factors covering structural soundness, safety and functional requirements as per relevant IRC Codes and provisions of this Manual.

4.1.3 The existing road embankment shall be widened/modified to the specified cross-sectional details.

4.2 Embankment

4.2.1 The height of the embankment shall be measured with respect to the finished road levels. The following principles shall be kept in view while fixing the road level :

- i) No section of the road is overtopped. Top of sub-grade shall be at least 0.60 m above the general ground level in case of existing road, if the road has no history of overtopping.
- ii) The bottom of sub-grade shall be 1.0 m above the High Flood Level (HFL)/ level of water table if the road has been overtapped in the past. The HFL should be decided by intelligent inspections, local observations, enquiries and studying the past records. This shall be relevant to situations where road alignment is sited within the flood plain or in the vicinity of water bodies or where ponding of water is encountered and cannot be efficiently drained. If raising of any section(s) of the existing road is required, the same shall be specified in **Schedule ‘B’** of the Concession Agreement along with its FRL. In case of no mention in **Schedule ‘B’** of FRL, the road shall be designed by the following the principal as stipulated in IRC:37.

4.2.2 Materials and physical requirements

4.2.2.1 Sourcing of materials for embankment and sub-grade construction, as well as compliance with environmental requirements in respect of excavation and barrow areas under the applicable laws shall be the sole responsibility of the Concessionaire.

4.2.2.2 The material to be used in sub-grade shall satisfy the design California Bearing Ratio (CBR) at the specified density and moisture content.

4.2.2.3 The embankment and sub-grade shall be compacted to satisfy the minimum compaction requirements given in **Clause 305** of MoRTH Specifications.

4.2.3 Structural features and design of embankment

4.2.3.1 Embankment with height 6.0 m more above shall be designed in accordance with IRC:75 taking into account slope stability, bearing capacity, consolidation, settlement and safety

considerations based on geotechnical and investigation data. Where the embankment is to be supported on a weak stratum, appropriate remedial/ground improvement measures shall be taken.

4.2.3.2 Side slopes shall not be steeper than 2H:1V unless soil is retained by suitable soil retaining structures.

4.2.3.3 The side slopes and the earthen shoulders shall be protected against erosion by providing a suitable vegetative cover, kerb channel, chute, stone/cement concrete block pitching or any other suitable protection measures depending on the height of the embankment and susceptibility of soil to erosion. Drainage arrangement shall be provided as per **Section 6** of this Manual. In high rainfall areas and where soil is susceptible to erosion, before providing turning on slopes and shoulders, a coir or jute blanket shall be placed on such slopes and shoulders immediately after completion of work and in any event before onset of first monsoon after completion of work in that reach.

4.2.4 Use of pond ash for embankment construction

Where pond ash is used for embankment construction in pursuance of the instructions of the Ministry of Environment and Forests or otherwise, the embankment shall be designed and constructed in accordance with IRC:SP:58.

4.3 Roadway in Cutting

The road level shall be fixed, keeping in view the provisions of relevant IRC Codes.

4.4 Soil Investigations and Design Report

4.4.1 General

The Concessionaire shall carry out necessary soil surveys, and field and laboratory investigations for selecting appropriate borrow pits, identifying and treating problematic ground locations, if any, and for finalizing structural features and design of the embankment and cut sections and establishing improved ground properties. A report on the soil investigation shall be furnished along with the design.

4.4.2 Soil investigations for embankment

Soil investigations shall cover the following:

- a) Soil investigations and tests in accordance with the requirements specified in IRC:SP:19 and shall be reported in the Proforma given in **Table 1** of IRC:SP:19. In addition to this, all tests as per the requirements of MoRTH Specifications shall be reported.
- b) In respect of embankments with height more than 6 m, additional investigations and soil tests as per IRC:75 and **Appendix 10** of IRC:SP:19.
- c) Information regarding the topography, high flood level, natural drainage conditions, highest sub-soil water level, and the nature and extent of inundation, if any.
- d) The characteristics of embankment foundation including the presence of any unsuitable/weak strata, marshy areas, waterlogged areas, etc.
- e) Along the alignment of the road, where unstable strata, soft material or poor sub-soil conditions have been met with at the foundation level. The soil profile

shall be drawn after determining through borings, the type of soil at different levels. The borings shall be at maximum interval of 100 m to a depth of 2 m or more below the existing ground as necessary. In the case of high embankments, the borings shall be taken down to a depth equal to twice the height of the embankment.

- f) Any particular construction problems of the area or other important features.
- g) Geotechnical properties of pond ash, covering parameters specified in **Table 1** of IRC:SP:58 and Optimum Moisture Content (OMC) - dry density relationship for heavy compaction. This information shall be furnished, in case pond ash is used in embankment construction.

4.4.3 *Soil investigations for cut sections*

Soil investigations and tests shall be carried out in accordance with the requirements specified in IRC:SP:19 and information regarding depth of water table, seepage flow, presence of any weak, unstable or problematic strata.

4.4.4 *Design report*

The Concessionaire shall prepare the design report with all relevant details including the following:

i) Road Embankment

- a) The detailed design of the embankment, remedial/ground improvement treatment where required. For embankments with height more than 6 m, construction methodology should also be included.
- b) Design of retaining walls/reinforced earth structures.
- c) Design of protection measures for embankment slope and drainage arrangement.
- d) Design of pond ash embankment in case use of pond ash is proposed.
- e) Any additional information relevant to the design of embankment.

ii) Cut Section

- a) Type of cutting involved and proposed cut slopes shall be provided in accordance with the nature of the soil encountered. Where required, benching including use of slope stability measures like pitching, breast walls, etc. shall be adopted to make the slopes stable and safe.
- b) Design and details of erosion control, slope protection measures, etc.
- c) In cut sections in hilly terrain, the problem of seepage flow is common. Where such conditions exist, necessary measures shall be taken including provision of deep side drains to intercept the seepage flow and discharge the drained water into suitable outlets to avoid any damage to road and cut slopes. Design and details of drainage arrangement for sub-soil and surface water shall be furnished. It should be ensured that rain water and seepage water is quickly drained out. The gradient of drain shall not be flatter than 1 in 200.
- d) Any other additional information relevant to the design of cut slopes.

SECTION 5

PAVEMENT DESIGN

5.1 General

5.1.1 The design and construction of new pavement sections, and of strengthening measures (overlay) for the existing pavement shall be carried out in accordance with the criteria, standards and specifications given in this section. Where alternative specifications or materials are proposed to bring in innovation in design etc., provisions of **Paras 1.9** and **1.11** of this Manual shall apply.

5.1.2 The design of new pavement sections or strengthening of existing pavements shall take into account all relevant factors for assuring reliable performance and shall also satisfy the specified minimum performance requirements.

5.1.3 The Concessionaire shall undertake the necessary soil, material and pavement investigations, traffic volume and axle load studies in accordance with the good industry practice for preparing detailed designs.

5.1.4 The materials, mixes and construction practice shall meet the requirements prescribed in the MoRTH/IRC Specifications.

5.1.5 Where problematic conditions such as expansive soils, swamps or marshes, flooding, poor drainage, frost susceptible areas etc. are found to exist, adequate measures shall be adopted to deal with such site conditions.

5.2 Type of Pavement

5.2.1 The type of pavement to be provided shall be specified in **Schedule ‘B’** of the Concession agreement. If nothing is specified, the Concessionaire may adopt any type (flexible/rigid) of pavement structure for new construction and/or widening of existing carriageway.

5.2.2 Strengthening of the existing flexible pavement will be carried out by providing appropriate bituminous overlay, unless specified otherwise in **Schedule ‘B’** of the Concession Agreement.

5.3 Method of Design - New Pavements

5.3.1 *Method of design of flexible pavement*

The new pavement shall be designed in accordance with the IRC:37 “Guidelines for the Design of Flexible Pavements”.

5.3.2 *Method of design of rigid pavement*

There are three methods of design of Rigid Pavement prescribed by IRC Codes viz.(i) IRC:58 “Guidelines for the Design of Plain Jointed Rigid Pavements for Highways” (ii) IRC:101 “Guidelines for Design of Continuously Reinforced Pavement” and (iii) IRC: SP-76 “Guidelines for Conventional and Thin White Topping”. Rigid pavement shall be designed in accordance with the method prescribed in IRC:58. “Guidelines for the Design of Plain Jointed Rigid Pavements for Highways” unless otherwise specified in **Schedule ‘B’**.

5.4 Design Requirements for New Pavement Sections

5.4.1 *Flexible pavement - design period and strategy*

- i) Flexible pavement shall be designed for a minimum design period of 15 years, subject to the condition that design traffic shall not be less than 20 msa.
- ii) Stage construction shall not be permitted.

5.4.2 *Rigid pavement - design period and strategy*

Rigid pavement shall be designed for a minimum design period of 30 years. The stage construction shall not be permitted.

5.4.3 Pavement performance requirements for main carriageway, service roads, entry/exit ramps and acceleration/deceleration lanes shall be follows :

- i) The pavement structure shall be capable of giving the specified performance over the entire operation period.
- ii) The new pavement surface shall satisfy the following standards;
 - a) **Surface Finish:** As per requirements of **Clauses 902 and 903** of MoRTH Specifications
 - b) **Roughness in each lane:**
 - i) Rigid Pavement : $\geq 2000 \text{ mm/km}$ for each lane in a km length
 - ii) Flexible Pavement : $\geq 1800 \text{ mm/km}$ for each lane in a km length
 - c) **Rutting in wheel path measured by 3 m Straight Edge:** Nil
 - d) **Cracking or any other distress:** Nil
- iii) During the operation period, the pavement surface roughness or any structural or functional distress shall not exceed the values specified in **Schedule 'K'** of the Concession Agreement. Generally the pavement condition in terms of roughness, cracking and rutting should not deteriorate to the maximum values specified in **Schedule 'K'** for rectification, earlier than 5 years from the original level from the year of rectification. Any treatment in the form of renewal/overlay carried out or required to restore/correct/improve the riding quality or any distress shall be of such thickness and specification that will restore the riding quality to roughness not exceeding 2000 mm/km.
- iv) During the operation and maintenance period, the pavement strength shall be evaluated periodically through deflection measurements (Refer to **Para 5.8 (ii)** of this Section) and the stretches exhibiting any structural deficiency shall be suitably strengthened with overlays.

5.4.4 The performance of the rigid pavement shall meet the requirements as specified in IRC:SP:16 and IRC:SP:83.

5.5 Design Traffic

5.5.1 The design traffic shall be estimated in terms of cumulative number of standard axles (8160 kg) to be carried by the pavement during the design period.

5.5.2 Initial daily average traffic flow shall be assessed based on IRC:9.

5.5.3 Any likely change in traffic due to proposed six laning of the facility and/or future development plans, land use, shall be duly considered in estimating the design traffic.

5.5.4 The design traffic in case of service/slip road shall be minimum ten million standard axles. The crust composition shall be provided accordingly.

5.6 Sub-grade

The Sub-grade, whether in cut or fill, shall meet the requirements stipulated in **Clause 305** of MoRTH Specifications

5.7 Pavement Components and Materials

- i) Where several materials will adequately serve as component within the pavement structure, such as a sub-base or a base course, the Concessionaire shall have the option of using any of the materials specifications, subject to specified norms and product quality requirements.
- ii) The pavement construction materials for sub-base, base and bituminous surfacing shall conform to the requirements prescribed in MoRTH Specifications and IRC Standards.

5.8 Performance Evaluation

- i) Roughness in each lane for full length shall be measured twice a year using appropriate approved method and equipment.
- ii) The structural evaluation of the pavement shall be made by taking deflection measurements every 5 years in accordance with the procedure given in relevant IRC codes, unless needed earlier, for stretches exhibiting severe distress during the operation and maintenance period.

5.9 Strengthening of Existing Pavements

5.9.1 Before strengthening treatment is prescribed, a detailed pavement condition survey and evaluation shall be carried out in accordance with relevant IRC:82 to determine.

- i) The extent of distress and nature of deficiency in the existing pavement structure, and
- ii) Whether any special treatments e.g. provision for remedying reflection cracking, pavement internal drainage, sub-grade improvement reconstruction, or rectification of any other deficiencies are warranted.

5.9.3 Necessary corrective measures to treat the identified deficiency shall be taken along with strengthening of the pavement.

5.9.4 In stretches where the pavement is damaged/deteriorated to such an extent that the use of Falling Weight Deflectometer (FWD) may not result in a realistic assessment of the strengthening treatment, pavement shall be designed as new pavement.

5.9.5 Where an existing pavement is built over an untreated expansive/black cotton soil sub-grade, its Improvement strengthening shall be treated separately. Such stretches shall require reconstruction with provision of necessary measures such as replacement treatment of expansive sub-grade, drainage, etc. as per the prescribed specifications and IRC:37; and shall be designed as new pavement. Stretches to be reconstructed, whether due to expensive sub-grade or having grossly deteriorated, etc. shall be specified in **Schedule 'B'** of the Concession Agreement.

5.9.6 No granular layer shall be provided over an existing bituminous surfacing. Situations may arise where it is envisaged to strengthen grossly deficient existing road with a granular layer in addition to the bituminous overlay, or where for camber and/or grade correction substantial thickness of profile corrective course is needed. In such cases, the existing bituminous surfacing shall be completely removed by scarifying/milling and then the pavement built up with the granular layer(s) and bituminous overlay. The thickness and composition of bituminous surfacing (Binder course and Wearing course) over the granular layer shall conform to IRC:37. Removal of existing bituminous pavement shall not be necessary, if the finished road level is more than 1 m high from the existing bituminous surface.

5.9.7 *Design of overlay*

- i) The thickness of the bituminous overlay shall be determined on the basis of FWD method (IRC:115-2014) and the design traffic as per the relevant code of IRC.
- ii) The design period will be the same as specified for the new pavement sections vide **Para 5.4.1** of this Section.
- iii) Design of recycled mix where provided shall conform to the requirements of **Clause 519** of MoRTH Specifications and IRC:120 “Recommended Practice for Recycling of Bituminous Pavements”.
- iv) The design traffic will be estimated as per the procedure described for new pavement.
- v) The thickness of bituminous overlay for pavement strengthening shall not be less than 50 mm bituminous concrete, after attending to the requirements of profile corrective course.

5.9.8 *Bituminous mix for overlay*

- i) The specifications for the bituminous mixes for the overlay shall be as specified for bituminous surfacing for new pavement sections.
- ii) Design of recycled mix where provided shall conform to the requirements of **Clause 519** of MoRTH Specifications and IRC:120-“Recommended Practice for Recycling of Bituminous Pavements”.

5.9.9 *Pavement performance requirements and evaluation*

- i) The strengthened pavement shall satisfy the minimum standard and maintenance requirements specified for new pavement sections in this Manual and **Schedule ‘K’** of the Concession Agreement.
- ii) The performance measurement and evaluation will be done as given in this Manual.

5.10 *Paved Shoulders and Paved Median Strips*

- i) Paved shoulders and strip on median side shall be of same specification and composition as of new pavement of carriageway.
- ii) Where existing pavement/paved shoulder is proposed to be used as carriageway, it shall be capable of taking design traffic load as applicable for carriageway.

- iii) If the thickness of the existing paved shoulders, if any, is less than the thickness of the adjacent pavement, the paved shoulders shall be re-constructed to the new pavement thickness.
- iv) The overlay on the main carriageway pavement and on the paved shoulders shall be uniform in thickness and composition.

5.11 Earthen Shoulders

Top 150 mm of earthen shoulder shall be well graded naturals and, moorum, gravel, crushed stone or combination thereof, conforming to **Clause 401** of MoRTH Specifications and having soaked CBR value of not less than 30%. The granular layer shall be compacted to atleast 98% of the maximum dry density for the material determined as per IS:2720 (Part 8). Remaining portion shall conform to **Section 300** of MoRTH Specifications.

5.12 Construction, Workmanship and Quality of Works

All materials, construction operations, workmanship, surface finish and quality of completed construction for all pavement works including sub-grade, sub-base, base course, bituminous surface courses for both new pavement and strengthening of existing pavements, shoulders, service roads, etc. shall conform to the specified requirements and comply with the provisions of **Section 900** of the MoRTH Specifications.

5.13 Premature Distress

Notwithstanding the minimum design, specifications and standards specified in the preceding Paras for new pavements and strengthening of existing pavements, if the pavement shows premature distress in the form of cracking, rutting, patching, loss of camber or any other structural or functional distress, necessary remedial measures by strengthening/resurfacing/recycling shall be undertaken for conforming to the minimum requirements prescribed in **Schedule 'K'** of the Concession Agreement. In case of repetition of the distress, reconstruction shall be resorted to after proper investigations.

SECTION 6

HIGHWAY DRAINAGE

6.1 General

6.1.1 The design and construction of surface and sub-surface drains for highway drainage and drainage for structures shall be carried out in accordance with the requirement of this Section.

6.1.2 For efficient drainage system for the entire Project Highway including structures, directions contained in **Clause 309** of MoRTH Specifications, IRC:SP:42, IRC:SP:50 and IRC:SP:90 as relevant shall be followed.

6.1.3 In road sections in cuttings and at underpasses where it may not be possible to drain out the water using gravity flow, vertical drains may be planned and if necessary, arrangement for pumping shall also be made.

6.2 Surface Drainage

6.2.1 a) The minimum length of drain (lined/unlined) shall be provided in **Schedule ‘B’**.
b) The selection of type of roadside drains shall be based on the magnitude and duration of flow. The roadside drains shall be designed on the principles of flow in open channel.

6.2.2 The road side drains shall not pose any danger to traffic, slopes of cuttings, embankment, pavement or structures.

6.2.3 As far as possible, longitudinal slope shall not be less than 0.2 percent for lined drains and 0.3 percent for unlined drains. Permissible non-erodible flow velocity for corresponding earth surface as mentioned in **Clause 9.4** of IRC:SP:42 shall be kept in view.

6.2.4 The side slopes of the unlined drains shall be as flat as possible and shall not be steeper than 2H:1V.

6.2.5 RCC/ Cement Concrete drains shall be provided in the following situations:

- i) When due to space constraint, the drains are located near the toe of the embankment or near structures.
- ii) Drains located in built-up areas.
- iii) Flow velocity is more than 1 m/s in silt and sand; and more than 1.5 m/s in stiff clay.

6.2.6 In built-up areas, covered RCC/Cement Concrete or piped drains, with manholes at suitable intervals to de-silt the drains shall be provided.

6.2.7 The drainage of cross roads shall be maintained. RCC Box of sufficient size shall be provided across the cross road to maintain the longitudinal drainage along the Project Highway.

6.3 Median Drainage

6.3.1 In case of depressed median, longitudinal drain (lined or unlined) shall be provided to drain off rain water. The drain should have adequate longitudinal slope to the nearest culvert to drain off transversely. In super elevated sections the longitudinal drains should be designed to take the discharge from one side carriageway also.

6.3.2 Median shall be turfed or paved and could be crowned for drainage across the pavement. In super elevated sections combination of covered longitudinal and cross drains shall be provided.

6.4 Drainage where Embankment Height is more than 3 m

6.4.1 In case of embankment height between 3 m to 6 m, proper protection of slope by turfing/vegetation or by providing side channel or any other suitable measure shall be adopted.

6.4.2 In embankments with height more than 6 m and approaches to bridges, special arrangement for protection of embankment slopes shall be essential in order to ensure that embankment slopes maintain their shape during the monsoon season. In this respect, directions contained in **Clause 7** of IRC:SP:42 may be followed as appropriate for the climatic conditions of the area of the Project Highway.

6.4.3 Drainage arrangement shall include provision of kerb with channel at the edges of the roadway to channelise the water and Cement Concrete (CC) lined chutes along the slopes at designed intervals with energy dissipation basin, side channels at the bottom protection of the slope by turfing, vegetation and/or any other suitable type. The drainage system and slope protection shall be kept well maintained at all times.

6.4.4 The chute drains and drains at toe of the embankment shall be of Plain Cement Concrete (M15 grade), over bedding in Cement Concrete M10.

6.5 Catch Water Drains

6.5.1 Suitable catch water drains shall be provided on the hill slope above cutting to collect and remove surface water run-off from upper reaches. These drains shall be of trapezoidal shape with stone lining pointed with cement and sand mortar.

6.5.2 The catch water drains shall be designed to carry the intercepted water to the nearest culvert or natural drainage channel.

6.5.3 It shall be ensured that the catch water drains are provided in stable hill slopes outside the periphery of slide/unstable areas.

6.5.4 Where required lined chutes shall be provided to lead the discharge to the catch pit of culvert or to a natural drainage channel.

6.6 Sub-surface Drains

6.6.1 The sub-surface drainage shall be provided

- i) for lowering the water table required for drainage of sub-grade;
- ii) to intercept or drain out free water in cut slopes; and
- iii) For drainage of pervious sub-base in situations where it may not be practicable to extend the sub-base across the shoulder.

6.6.2 Sub-surface drains shall not be used for surface drainage.

6.6.3 The sub-surface drains shall be:

- i) Close jointed perforated pipes or open jointed unperforated pipes in trenches with backfill material around pipes.
- ii) Aggregate drains consisting of free draining material in the trench without any pipe.

6.6.4 Perforated pipes and unperforated pipes shall meet the requirements of **Clause 309.3** of the MoRTH Specifications.

6.6.5 The internal diameter of the pipe shall not be less than 150 mm.

6.6.6 The sub-surface drains shall be located not less than 0.5 m below the sub-grade.

6.6.7 *Backfill material*

- i) Backfill material shall be free draining sand gravel or crushed stone designed on inverted filter criteria for filtration and permeability, or of an appropriate grading conforming to the requirements of **Table 300.3** of the MoRTH Specifications.
- ii) Thickness of backfill material around the pipe shall not be less than 150 mm. The minimum thickness of material above the top of the pipe shall be 300 mm.

6.6.8 Sub-surface drains outside the road pavement shall be sealed at the top to avoid percolation of surface water into these drains.

6.6.9 *Use of Geo-textile*

- i) The sub-surface drains may be designed using appropriate geo-textile to serve the functions of filtration and separation.
- ii) The sub-surface drains can be provided with geo-textile either along the trench or around the pipe or both.
- iii) The geo-textile shall satisfy the requirements of **Clause 702** of the MoRTH Specifications.

6.6.10 Trench excavation, laying of pipe, backfilling, and use of geo-synthetics shall confirm to the requirements of **Clause 309.3** of the MoRTH Specifications.

6.6.11 The drain outlet shall be a free outlet and shall be provided as per **Clause 309.3** of the MoRTH Specifications.

6.6.12 *Aggregate drains*

- i) The trench for aggregate drain shall be of minimum 300 mm width and cut to a depth to expose the granular pavement courses to be drained.
- ii) Aggregate for the drain shall be gravel, stone aggregate or slag of grading as per **Table 8** of IRC:SP:42.
- iii) The aggregate drain shall be provided with a geo-textile wrap to act as filtration and separation layer.

6.6.13 Design of sub-surface drainage shall be based on a rational basis. Reference may be made to IRC:SP:42.

6.7 **Internal Drainage of Pavement Structure**

- i) Boxed type construction in which pavement is housed in earthen shoulders shall not be provided.
- ii) The sub-base shall be extended across the shoulders for efficient drainage of pavement.
- iii) The granular sub-base shall be of proper design and grading to perform satisfactorily as a drainage layer.

- iv) A suitable filter of granular material or geo-textile to act as filtration and separation layer shall be incorporated, where necessary, between the sub-grade and sub-base to prevent clogging.

6.8 Drainage for Structures

6.8.1 Culverts and bridges

6.8.1.1 For culverts and bridges provision of suitable cross slope/camber and down take pipes/spouts near the kerb, covered with gratings at the inlet points shall be provided at regular interval to facilitate rapid draining of water from the deck without any ponding. The length and location of these drainage spouts should be such that the water is not discharged on any bridge element.

6.8.1.2 The bridges particularly those in high rainfall area shall preferably be built in longitudinal gradient with suitably designed cross drains at abutment locations to facilitate proper drainage.

6.8.2 Grade separators/flyovers/road over bridges

6.8.2.1 Effective drainage shall be provided both longitudinally and transversely. The transverse drainage shall be secured by means of suitable camber in the roadway surface. Longitudinal drainage shall be secured by means of scuppers, inlets, or other suitable means of sufficient size and numbers to drain the run-off efficiently.

6.8.2.2 Efficient drainage of the deck structure shall be ensured by providing a suitably designed drainage arrangement consisting of drainage spouts connected to horizontal and vertical pipe system such that the water from the structure does not fall on the road, does not stagnate over the road or at entry and exit points of grade separated structure and is discharged into the draining system of the area. Care must be taken that the pipes are taken down in such a way that they are aesthetically pleasing.

6.8.2.3 Typically, water spouts are provided at the kerbs at the rate of 1 No. per 12 sqm. of the surface in level portions and 1 No. per 15 sqm. of the surface area on gradients. Water spouts are connected to runner pipe of suitable diameter (minimum 100 mm) on either side of roadway and taken down by downtake pipes at pier & abutment locations.

6.8.2.4 Drainage fixtures and downspouts shall be of rigid, corrosion resistant material not less than 100 mm as the least dimension and shall be provided with suitable cleanout fixtures.

6.8.2.5 The arrangement of floor drains shall be such as to prevent the splashing of drainage water against any portion of the structure. Overhanging portions of concrete floors shall be provided with drip moulds.

6.8.2.6 Catch water drains are necessary at the ends of viaduct portion so that water coming from grade separated structure does not over saturate and affect the earthen embankment. Similar catch water drains should be provided at the end of gradient so that water coming from the structure is properly let out to nearest drain.

6.8.2.7 An integrated drainage plan for the water coming from the deck of structures, local catchment area of the project and all other sources should be prepared so that no water falls on any surface of the structures, or remain standing or flowing over the level roads. All the water is collected through sumps and finally discharged into the local drainage system i.e. storm water drain/pipes etc. either by gravity through connecting drains or by pumping into the existing outgoing drains.

6.8.2.8 The rainwater from the deck of the structures usually does not flow transversely but flows on the high gradient slopes of the road or approaches and is collected in the valley curve portion. As such attention is to be paid to get this large quantity of water drained out fast without accumulating there causing problems for traffic flow resulting in traffic jams. The draining out systems should be designed with greater margins so as to avoid this problem, at least for grade separators, inside the cities or inhabited areas.

6.8.3 *Underpasses and subways*

6.8.3.1 Where rain water cannot flow into the drainage system by gravity due to the requirement of depressed road to get minimum head room, necessary provision for drainage by vertical drains and/or pumping shall be made so that there is no disruption of traffic through such location on account of water logging/flooding of underpass or subway.

6.9 Existing Drains, Canals and Minor Waterways

6.9.1 For the existing drains, canals and waterways, to be over passed by the highway, draining provisions shall be maintained and the effects of prolonged heavy rainfall must be catered for.

6.9.2 Special attention shall be paid to the drainage channels carrying industrial waste and effluent in particular to those draining chloride contaminated effluents which are detrimental to the RCC structures.

6.9.3 Adequate care shall be taken while crossing irrigation canals to prevent contamination of the flow in the canal by spillage from the highway.

6.9.4 When highway runs parallel to existing channels, adequate measures shall be taken in the form of bank protection and channel alignment to avoid water build up or stagnation against the highway slope endangering the pavement drainage. The drainage channels at the toe of the highway may have to be adequately protected or reshaped for discharge in to these channels. Where the discharge from road drainage is not permitted, separate cross drainage structures are to be provided on both sides of such channel.

SECTION 7

DESIGN OF STRUCTURES

7.1

General

- i) All structures shall be designed in accordance with the relevant Codes, Standards and Specifications, Special Publications and Guidelines of the IRC. Construction of all culverts, bridges and grade separated structures shall conform to MoRTH Specifications for Road and Bridge Works.
- ii) All bridges and grade separated structures shall have independent superstructure for each direction of travel unless specified otherwise in **Schedule ‘B’**. Culverts may have single or independent superstructure.
- iii) All bridges shall be high level bridges.
- iv) In built-up sections viaduct spans shall be provided in the approaches of the structure. However, embankment/RE wall/Retaining wall may be provided upto 7.5 m height. For this purpose the height shall be measured from existing road level.
- v) The width of median in the culvert and bridge portion shall, as far as possible, be kept same as that in the approaches. In case width of median is different from that of approach section due to site constraints, transition of 1 in 30 shall be provided near approaches for guiding vehicular traffic.
- vi) The median in the portion of structures shall be treated as below:
 - a) A suitably designed catch pit shall be provided to collect and carry discharge from median drain.
 - b) The median shall be open to sky. The safety barrier on the median side shall be provided at a clear distance of 0.5 m from the edge of carriageway.
- vii) Suitable provision shall be made for retaining the earth in the median portion either by extending the abutment wall or constructing a new retaining wall. The abutment wall shall have provision for taking the discharge from the median. Care shall also be taken to merge the wing wall/return wall and flooring of the old bridge with those of the new bridge.
- viii) Any utility service to be carried by the structures shall be specified in **Schedule ‘B’** of the Concession Agreement.
- ix) Provision for any utility service such as OFC & telephone cable to be carried by the structures shall be made in the design as per relevant circular of MoRTH. Provision of water pipeline and Gas line shall not be allowed.

7.2

Design Loads and Stresses

- i) The design loads and stresses shall be as per IRC:6 appropriate for the width of carriageway, velocity of stream, location, altitude, environment, etc.

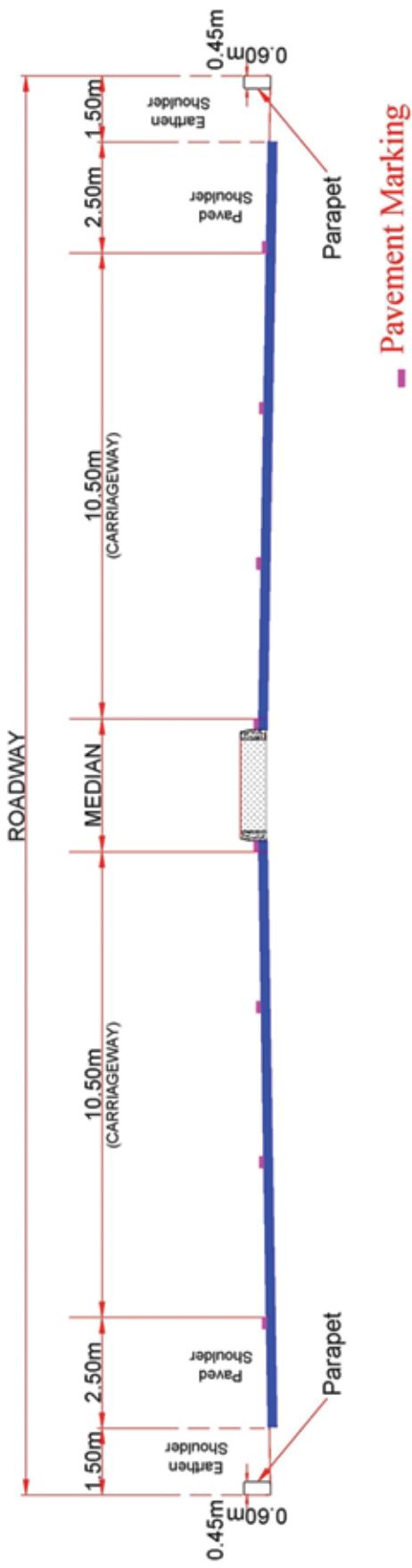
- ii) All new structures shall be designed for the condition when footpath is used as carriageway. The footpath portion may be provided at the same level as the bridge carriageway and separated by crash barrier in non built-up areas. In built-up areas, raised footpaths shall be provided.
- iii) All the components of structures shall be designed for a service life of 100 years except appurtenances like crash barriers, wearing surface and rubberized components in expansion joints and elastomeric bearings. All the requirements to achieve durability and serviceability shall be implemented

7.3 Width of Structures

Width of the culverts and bridges shall be adopted as below:

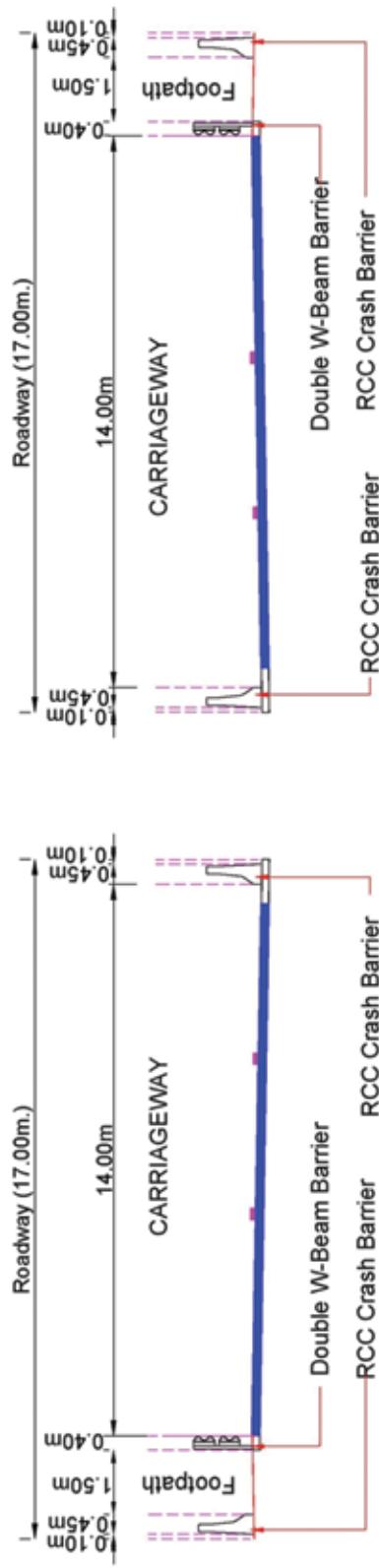
- i) **New culverts**

Overall width of all new culverts shall be equal to roadway width of the approaches. The outer most face of railing/parapet shall be in line with the outer most edge of shoulder. Typical cross-section of the new culverts for a 6-lane project highway is given in **Fig. 7.1**.
- ii) **New bridges**
 - a) All new bridges shall have a footpath on left side of the traffic direction. The carriageway width of the bridge shall be the distance between face to face of crash barrier/raised kerb. Full carriageway and paved shoulders of approaches should continue on the bridge. Additionally 0.5 m width for shyness should be provided on either side. RCC crash barrier should be provided shall be provided between footpath and carriageway and pedestrian guard rail at the outer edges of the bridge. However, in case a separate bridge is being provided for service road at the same location, then the footpath shall be provided for the bridge on the service road. Suitable connection between bridge and immediate approaches shall be made.
 - b) Typical cross-sections of new bridge with footpath (no service road bridge) and without footpath (with service road bridge) for a 6-lane Project Highway are given in **Figs. 7.2** and **7.3** respectively.
- iii) **Existing culverts**
 - a) All culverts which are structurally distressed or not having sufficient vent size or unsafe for design loads due to surcharge like in approaches to structures shall be reconstructed as new structures of width as per Sub-para 7.3 (i) of this Section.
 - b) All existing culverts which are not to be reconstructed shall be widened equal to the roadway width of the approaches.
- iv) **Existing bridges**
 - a) All bridges which are structurally distressed shall be reconstructed as new bridges of width as per Sub-para 7.3 (ii).
 - b) Components like bearings, expansion joints, railings, crash barriers, wearing surface, etc., which are not in sound condition, shall be replaced. Minor non-structural works shall be suitably repaired.



■ Pavement Marking

Fig. 7.1 Cross-Section of Culvert at Road Level
6-Lane Divided Highway



■ Pavement Marking

Fig. 7.2 Cross-Section of Bridge at Deck Level
6-Lane Divided Highway - Both Side new Bridges with Footpath (No Service Road)

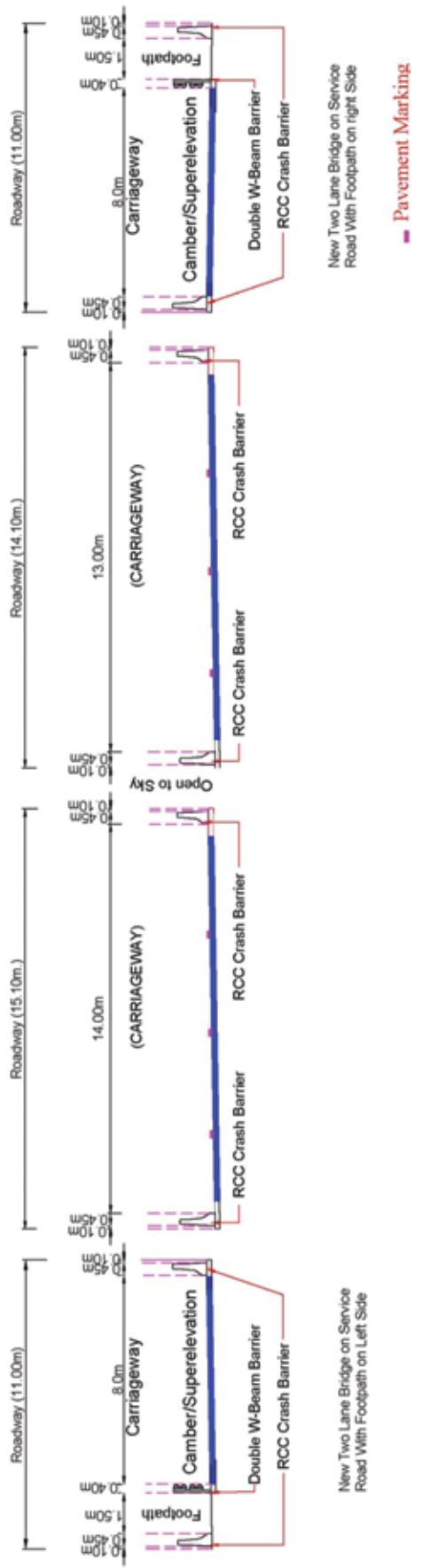


Fig. 7.3 Cross-Section of Bridge at Deck Level
6-Lane Divided Highway - Both Side new Bridges without Footpath and new Bridges on service Road with Footpath
(Service Road on Both side)

- c) If the width of additional widening is 1.0 m (0.5 m on either side) or less, the widening of the structure may be dispensed with and traffic shall be guided with the help of crash barriers in a transition of 1 in 20 on either side approaches.
- d) Widening as also dismantling of the bridges having T-beam or box type superstructure and deep foundations is generally difficult. Keeping in view the condition of superstructure, sub-structure and foundation, the Concessionaire may retain the existing two-lane bridge and construct another two-lane bridge by the side of the existing bridge effectively providing four-lane bridge for a three-lane one way approach highway. Alternatively, the Concessionaire may propose some innovative solution viz., to dismantle existing superstructure and construct new three-lane superstructure to be supported by existing substructure and foundation if their condition is good and if, on review by IE, the proposal is found to be feasible and safe. The bridge for a width of minimum 3-lanes for each carriageway shall be ensured. The wearing course, bearings and rubberized component of expansion joints which are damaged or older than 15 years of the existing bridge shall be removed and replaced and all repair and rehabilitation required shall be carried out before commissioning of the Project Highway. Typical cross-sections of such types of existing and new bridges are given in **Fig. 7.4** through **Fig. 7.7**.
- e) The width of the new structures constructed on the other side of the existing bridge shall be as specified in Sub-para 7.3 (ii) of this Section.
- f) List of bridge structures to be reconstructed/widened/upgraded as per **Para 7.3(iv)d** above shall be specified in **Schedule ‘B’** of the Concession Agreement.
- g) Any deviations to the above provisions shall be specified in **Schedule ‘D’** of the Concession Agreement.

7.4 Structure Types

The Concessionaire may adopt any type of structure and structure system commensurate with safety, serviceability and durability requirement. General Guidelines as below shall be followed:

- i) The structure should aesthetically blend with the environment.
- ii) The type and span arrangement may be such as to provide maximum riding comfort and involve minimum inspection and maintenance during the service life of structure.
- iii) Continuous superstructure with fewer number of bearings and expansion joints if not unsuitable otherwise should be preferred over simply supported spans.
- iv) For small bridges and culverts integral concept (in which sub-structures and superstructure are made jointless i.e. monolithic) is preferred.
- v) Wherever box girders are proposed for superstructure, the minimum clear depth inside the box shall be 1.50 m with suitable openings in the diaphragms and box to facilitate inspection.

- vi) Haunches of minimum size of 300 mm (horizontal) and 150 mm (vertical) shall be provided at the extreme corners of the box section. Suitable arrangements for lighting shall be made to enable inspection of the box.
- vi) The following types of structures shall not be accepted.
 - a) Drop in spans with halved joints (articulations)
 - b) Trestle type frames for sub-structures
- vii) If constructions of structures like cable stayed/ suspension bridge or with special techniques is envisaged, it shall be specified in **Schedule 'B'** of the Concession Agreement. Similarly, in case minimum span length, spacing between joints, obligatory spans etc. are desired by the client, then the same shall be specified in **Schedule 'B'**.
- viii) Concepts that involve precast elements are preferable for improved quality, better finish and reduction of environmental impact.
- ix) When the alignment crosses urban environment, the construction methodology should be such as to avoid prolonged disturbance to existing traffic.

7.5 Hydrology

All the structures shall have adequate waterway, which shall in any case be not less than that of existing bridge (except when such waterways can be reduced in cases like clogging or silting of spans, etc.). The design discharge shall be evaluated for flood of 100 year return period. Navigational clearance (horizontal and vertical) wherever required shall be ensured in consultation with the river Authority/IWAI.

7.6 Sub-Soil Investigations

7.6.1 The Concessionaire shall carry out Independent sub-soil investigations to establish the soil parameters required for detailed design of foundations in accordance with relevant provisions of IRC:78 and MoRTH Specifications.

7.6.2 For single span structures (bridges, over passes, ROBs etc.), bores shall be taken at each of the abutment locations. For structures having more than one span, at least one bore shall be taken at each of the foundation locations. However, for structures having smaller spans, the spacing between two bore holes may be kept as 10-12 m.

7.7 Culverts and Bridges using Pipes

- i) Reinforced concrete pipes for culverts and bridge structures shall be of Non Pressure (NP) - 4 type conforming to the requirements of IS:458.
- ii) Minimum diameter of pipes for new pipe culverts shall be 1200 mm.
- iii) Existing culverts of diameter 900 mm and above, which are in sound condition and functioning satisfactorily, may be extended, using pipes of same diameter. All culverts having pipe diameter less than 900 mm shall be replaced with pipes of minimum 1200 mm diameter under both the carriageways. Minimum depth of earth cushion over pipe excluding road crust shall not be less than 600 mm for new/reconstructed/retained culverts. In case the cushion is insufficient, encasing of pipe in concrete shall be ensured. Floor protection shall be as specified in the relevant IRC Codes and Specifications.

7.8 **Temporary Works**

7.8.1 *Form work*

The Concessionaire shall be responsible for the safe, workable design and methodology for all temporary or permanent forms, staging and centering required for supporting and forming the concrete of shape, dimensions and surface finish as shown on the drawings (Refer **IRC:87**). Adequate foundation for the staging shall be ensured. Redundancy in support system shall also be ensured by providing diagonals and additional members. The following Guidelines shall be adopted:

- i) Formwork shall be of steel, marine ply or laminated plywood.
- ii) Only such shuttering oil (release agent) shall be used, which permits easy removal of shutters without leaving stains or other marks on the surface of the concrete. Requirements given under **Clause 3.5** of IRC:87 shall also be complied with.
- iii) In case of tubular staging of heights more than 10 m, special attention shall be paid to the structural adequacy of the system, efficacy of the connections (clamps etc), and foundations. Foundation blocks of adequate thickness in M15 cement concrete shall be provided under the base plates to prevent differential settlements. All bent tubular props shall be straightened before re-use and the member with deviation from straightness more than 1 in 600 of its length shall not be re-used. For re-used props, suitable reduction in the permissible loads shall be made depending upon their condition in accordance with recommendations of the manufacturer and as reviewed by the IE.
- iv) In case of pre-stressed concrete members, the side forms shall be removed as early as possible and the soffit forms shall permit movement of member without restraint; when pre-stress is applied. Form supports and forms for cast-in-situ members shall not be removed until sufficient pre-stress has been applied to carry all anticipated loads during construction stage.
- v) Adequate foundations for formwork shall be ensured.

7.8.2 *Special temporary and enabling works*

Designs, drawings and methodology proposed by the Concessionaire in the use of special temporary and enabling works like Launching Girders, Cantilever Construction Equipment, Tall Formwork, Shoring for Earth Retention, Lifting and Handling Equipments and the like shall be submitted to the Independent Engineer (IE) for his review and comments if any. The Concessionaire shall be fully responsible for the design and structural adequacy of all temporary and enabling works. Review by IE shall not relieve the Concessionaire of this responsibility.

7.8.3 The construction methodology adopted by the Concessionaire should ensure speedy and safe construction including safety of workers.

7.9 **Foundations and Sub-Structures**

7.9.1 The design of foundations and sub-structures shall conform to IRC:78.

7.9.2 *Open foundations*

The design of open foundations shall conform to IRC:78. Floor protection shall be provided as per **Section 2500** of MoRTH Specifications.

7.9.3 Pile foundations

The design of pile foundations shall be done as per IRC:78. Initial load test shall invariably be done on at least two piles for each structure before starting piling work. However for structures of length less than 60 m length, the initial load test may be done on at least one pile.

7.9.4 Well foundations

The design of well foundations shall be done as per, IRC:78.

7.9.5 Raft Foundation

For design of raft foundation “Guidelines for the Design and Construction of Raft Foundation for Road Bridges” given in **Appendix 8** of IRC: 78 be adopted.

7.10 Approach Slabs

Approach slabs shall be provided for all bridges and grade separated structures as per **Clause 217** of IRC:6 and **Section 2700** of MoRTH Specifications.

7.11 Superstructures

7.11.1 The design of reinforced and pre-stressed concrete superstructures shall be as per IRC:112. The design of steel and steel-concrete composite superstructures shall conform to IRC:24 and IRC:22 respectively.

7.11.2 The Concessionaire shall submit the Method Statement to Independent Engineer for review and comments (For EPC, for approval of Authority Engineer) if any, indicating inter-alia the following

- i) Sources of materials,
- ii) Design, erection and removal of formwork,
- iii) Layout of casting yard together with necessary details,
- iv) Production, transportation, laying, compacting and curing of concrete,
- v) Sequence of concreting in cast-in-situ construction, side shifting of girders, if applicable and placing of girders on the bearings.
- vi) Details of construction joints
- vii) Pre-stressing system, if required,
- viii) Methodology and equipment for side shifting and launching of pre-cast girders,
- ix) Key personnel for execution and supervision,
- x) Testing and sampling procedure,
- xi) Equipment details

7.12 Bearings

7.12.1 All bearings shall be easily accessible for inspection, maintenance and replacement. Suitable permanent arrangements shall be made for inspection of bearings from bridge deck. Design and Specifications of bearings shall be as per IRC:83 (Part I, II, III and IV). Spherical bearings shall conform to the requirements of BS:5400. The materials of bearings may however conform to the relevant BIS codes nearest to the specifications given in BS:5400. The drawing of bearings shall include the layout plan showing exact location on top of pier and abutment cap

and the type of bearings i.e. fixed/free/rotational at each location along with notes for proper installation. The bearing should cater for movement in both longitudinal and lateral direction.

7.12.2 The Concessionaire shall procure bearings only from the manufacturers approved by MoRTH

7.12.3 The Concessionaire shall submit detailed specifications, designs and drawings including installation drawings and maintenance manual incorporating the replacement procedure.

7.12.4 The Concessionaire shall obtain and submit a complete Quality Assurance Programme (QAP) from the manufacturer. The QAP shall give the full details of the process of quality control, raw material testing, various stages of manufacture, testing of bearing components as well as testing of complete bearing in conformity with relevant part of IRC:83, prior to the commencement of manufacture of the bearings.

7.12.5 In addition to the routine testing of the materials and bearings at the manufacturer's premises, the Concessionaire shall arrange testing of random samples of one percent(minimum one number of each type) of bearings from independent agency approved by the IE.

7.12.6 The Concessionaire shall submit a certificate of confirmation regarding quality control measures taken during manufacture of the bearings and the material conforming to the prescribed standards and specifications. Full lot of bearings of the sample found to have inferior specifications to those certified by the manufacturer or to have major discrepancy in material specifications or which fail to meet the acceptance criteria, shall be rejected.

7.13 Expansion Joints

- i) Structures shall have minimum number of expansion joints. This may be achieved by adopting longer spans, making the superstructure continuous or by adopting integrated structures. Expansion joints shall conform to IRC:SP: 69. The Concessionaire shall furnish guarantee/proprietary indemnity bonds from the manufacturers/suppliers of expansion joints for a period of 10 years.
- ii) For existing bridges all expansion joints, which are older than 15 years shall be replaced even though it is not specified in **Schedule 'B'**.

7.14 Wearing Coat

- i) The wearing coat may be either bituminous or cement concrete type. The wearing coat shall have unidirectional camber and shall be in conformity with **Section 2700** of MoRTH Specifications.
- ii) Wearing coat older than 15 years or in damaged/distressed condition shall be replaced even though it is not specified in **Schedule 'B'**.

7.15 Reinforced Earth Retaining Structures

7.15.1 The design of Reinforced earth retaining structures shall be as per IRC:SP:102. Reinforced earth retaining structures should be given special attention in design, construction, ground improvement where necessary, maintenance and selection of System/System Design. Local and global stability of the structure shall be ensured. However, such structures shall not be provided near water bodies. The Specification of RE structures shall conform to **Section 3100** of MoRTH Specifications.

7.15.2 Design Accreditation and warranty for life of the structure from the approved supplier/ manufacturer shall be obtained and furnished. A qualified and experienced technical representative of the approved supplier/manufacturer shall be present on site throughout during the casting and erection phases to ensure that the quality of the works executed by the Concessionaire is in accordance with good industry practice.

7.15.3 The Concessionaire shall submit relevant information on the system covering inter-alia the following:

- i) General features of the system along with specifications and standards;
- ii) Authenticated copies of license/agreement, if any;
- iii) Details of plant and equipment to be used along with the names of manufacturers and name of process/system;
- iv) Details of projects where the process/system has been successfully used;
- v) Limitations, if any;
- vi) Acceptance tests and criteria;
- vii) Installation and maintenance procedure and schedule; and
- viii) Performance warranty.

7.15.4 The Concessionaire shall submit a method statement including the following :

- i) Design assumptions, calculations and drawings,
- ii) Construction Procedure,
- iii) Tests to be conducted including frequency and the formats for reporting the test results

7.15.5 The packaging of reinforcing elements shall clearly indicate the name of the manufacturer/supplier and brand name, date of production, expiry, if any and batch identification number along with the manufacturers test certificates.

7.16 River Training and Protective Works

River training and protective works shall be provided wherever required for ensuring the safety of bridges and their approaches on either side. The design of various types of river training and protective works shall be in accordance with IRC:89. The construction of river training works shall conform to MoRTH Specifications.

7.17 Safety Barriers

- i) For bridges without foot paths, concrete crash barriers shall be provided at the edge of the carriageway on all new bridges.
- ii) The type design for the crash barriers may be adopted as per IRC:5. The design loading for the crash barriers shall be as per **Clause 209.7** of IRC:6.
- iii) For bridges with foot paths, pedestrian railing shall be provided on the outer side of footpath and crash barrier shall be provided between carriageway and foot path in rural section.
- iv) The railings of existing bridges shall be replaced by crash barriers, where specified in **Schedule ‘B’** of the Concession Agreement.

- v) Parapets/Railings of the existing bridges/culverts to be repaired/replaced shall be specified in **Schedule ‘B’** of the Concession Agreement.

7.18 Rail-Road Bridges

7.18.1 ROB/RUB to be provided shall be as specified in this Manual, with particular reference to the provisions of **Para 7.3** of this Section. Any deviation to these provisions shall be specified in **Schedule ‘D’**.

7.18.2 *Road over bridge (road over rail)*

- i) The existing ROB shall be retained with repairs, widened or reconstructed as given in case of bridges in **Para 7.3(iv)**.
- ii) In case the bridge is to be provided over an existing level crossing, twin 3-lane bridges shall be constructed with overall width as given in Sub-para 7.3 (ii) of this Section. If the alignment of road at the existing railway crossing has skew angle more than 45 degrees, the alignment of road or of pier/abutment shall be suitably designed to reduce skew angle up to 45 degrees.
- iii) The horizontal and vertical clearances to be provided shall be as per requirement of the Railway authorities.
- iv) The Concessionaire shall be required to obtain approvals of all designs and drawings from the concerned Railway authorities.
- v) The construction of ROB within the railway boundary shall be under the supervision of Railway authorities.
- vi) The approach gradient shall not be steeper than 1 in 40.

7.18.3 *Road under bridges (road under railway line)*

- i) Full roadway width as in the approaches shall pass below the bridge structure.
- ii) The vertical and lateral clearances shall be as per Guidelines given in **Section 2** of this Manual.
- iii) These structures shall be designed to carry railway loads. The Concessionaire shall be required to obtain approvals of all designs and drawings from the concerned Railway Authorities. The design of structure shall be in accordance with relevant Railway codes.
- iv) The construction of RUB and its approaches shall be carried out in conformity with the terms specified in the approval granted by the Railway authorities and under their supervision.

7.18.4 In cases of ROB, the service road on both the sides shall be joined through one of the viaducts of ROB. This arrangement shall be on either side of the railway crossing

7.19 Grade Separated Road Structures

7.19.1 Grade Separated Structures (Ref. **Paras 2.13.1 & 3.3**) and Elevated Sections (Ref. **Para 2 (ii)**)

- i) The location, type and length of grade separated structures and elevated sections to be provided on the Project Highway shall be specified in **Schedule ‘B’** of the Concession Agreement.

- ii) The vertical and lateral clearances shall be as per requirements given in **Section 2** of this Manual. Design of structures shall conform to the requirements specified in this Manual.

A Typical cross-sections of a grade separated structures/elevated section is given in **Fig 7.8**.

7.20 Drainage of Structures

An effective drainage system for the deck shall be planned designed and installed so as to ensure that water from the deck is taken down to ground level/drainage courses by adequate size of drainage spouts and pipes.

7.21 Structures in Marine Environment

Necessary measures/treatments for protecting structures in marine environment shall be as specified in **Schedule ‘B’** of the Concession Agreement

7.22 Repairs and Strengthening

- i) Structures requiring repairs and strengthening shall be specified in **Schedule ‘B’** of the Concession Agreement. This shall be based on detailed condition survey of existing structures and shall bring out the nature and extent of repairs to be carried out covering the following in addition to other specific requirements:
 - a) Repair/replacement of damaged railings and parapets, provision of concrete barriers,
 - b) Replacement of wearing coat and approach slab (old concrete/bituminous wearing coat shall be replaced by bituminous wearing coat),
 - c) Replacement of expansion joints,
 - d) Replacement of bearings,
 - e) Structural repairs to substructure/superstructure, including replacement of substructure/superstructure, if required
 - f) Repair to flooring and protection works.
- ii) The Concessionaire shall submit repairs and strengthening plan for structures in **Para (i)** above to the Independent Engineer for review and comments, if any. For all other structures with minor deficiencies, not affecting structural inadequacies and integrity, appropriate repair measures may be proposed and submitted to the Independent Engineer for review and comments, if any.
- iii) Strengthening/rehabilitation work shall be carried out in accordance with relevant IRC Codes and Guidelines.
- iv) The Concessionaire shall take up repair and widening of existing bridge at a particular site only after the new bridge at that site is constructed and the same can be used by the traffic. Before taking up the works of repair and widening of the existing bridge, the Concessionaire shall make all arrangements to ensure that both way traffic can use the new-bridge and a smooth flow of traffic is maintained. The Concessionaire shall take all precautions to guard against any traffic accident due to such diversion and shall use all necessary road signs, traffic management measures etc. for the purpose. After completion of repair and

widening of the existing bridge, temporary works carried out for such diversions shall be made good by the Concessionaire.

7.23 Design Report

The Concessionaire shall furnish the design report including the following to the Independent Engineer for his review and comments (For EPC, for approval of Authority Engineer), if any.

- i) Sub-soil exploration report as per IRC:78 as specified in **Para 7.6** above.
- ii) Hydrological investigation report including design discharge calculation for the bridges, in case of any change in the proposed waterway of any bridge as specified in **Para 7.5** above.
- iii) Designs and drawings of temporary works, foundations, substructures and superstructure of structures.
- iv) Detailed report regarding the bridges whose width is less than the roadway width and the proposal for their improvement.
- v) Any other information relevant to the design report.

7.24 Responsibility for Design and Structural Adequacy

The Concessionaire shall be fully responsible for the design, structural adequacy and detailing of bridge and culvert structures. Review by IE (For EPC, approval by Authority Engineer), shall not relieve the Concessionaire of this responsibility.

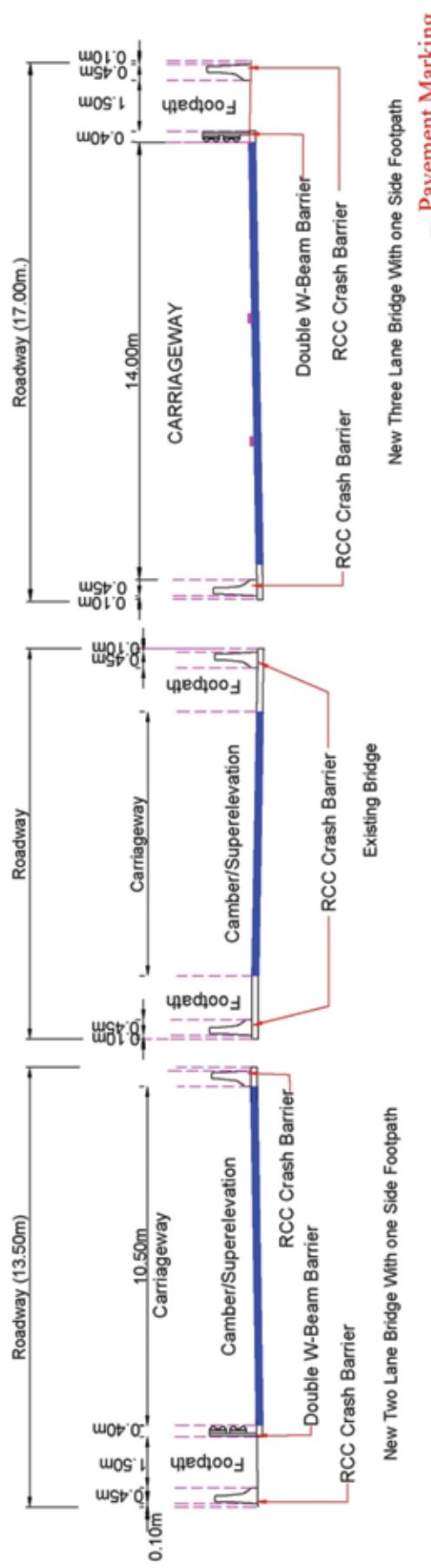
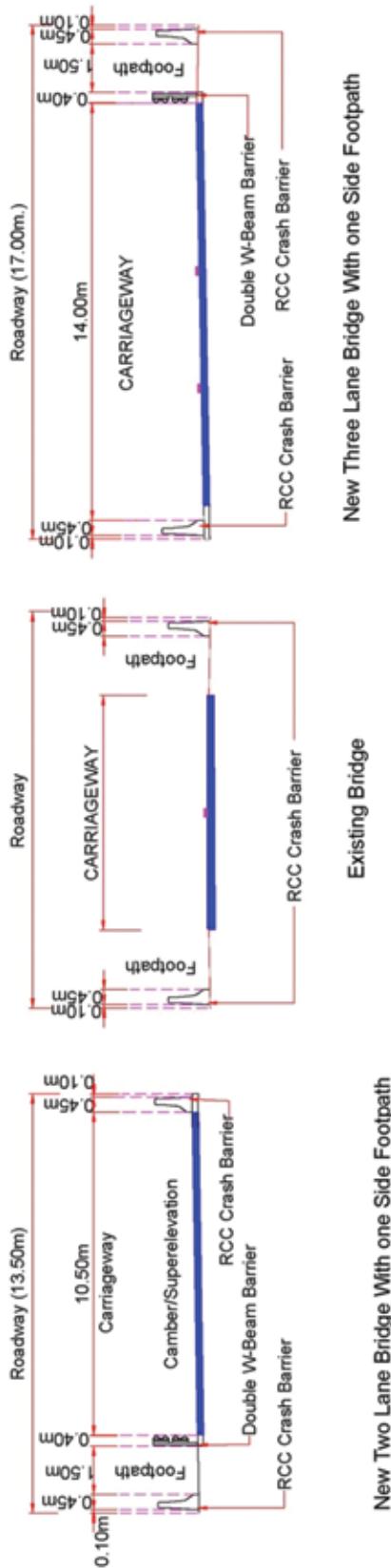
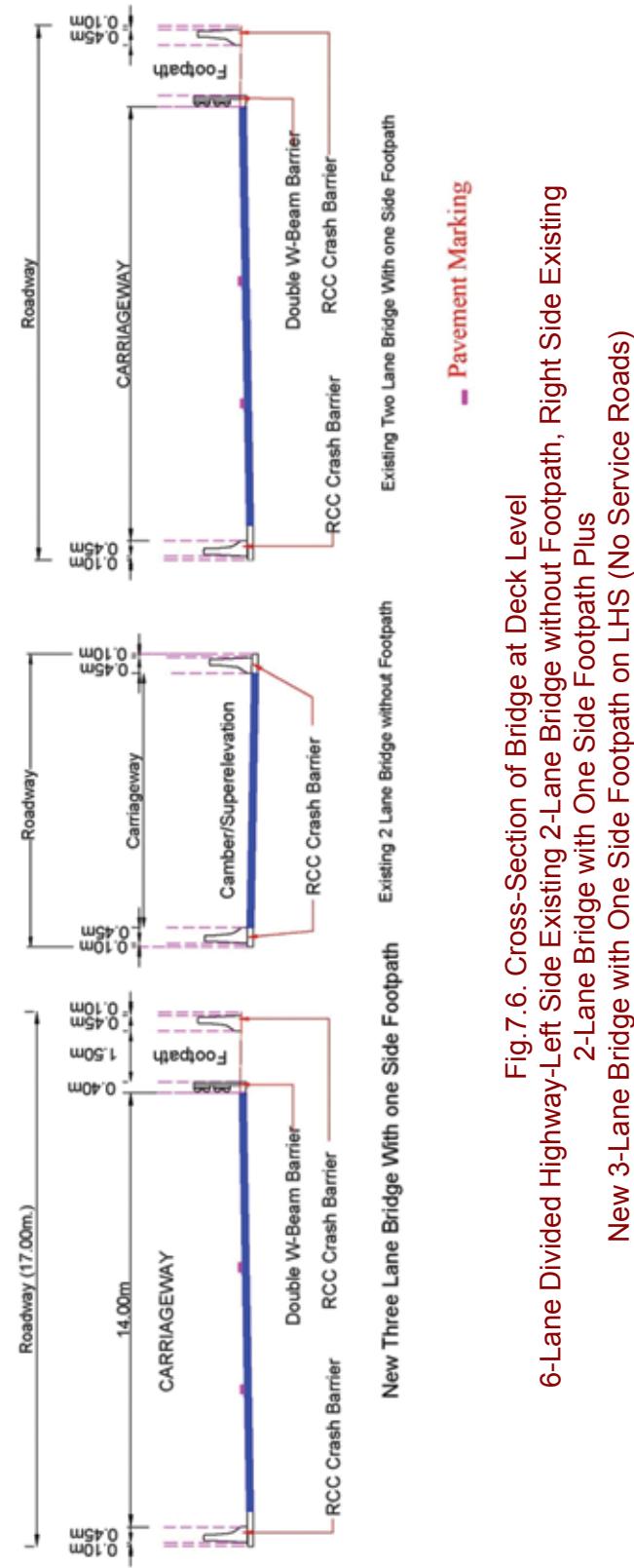


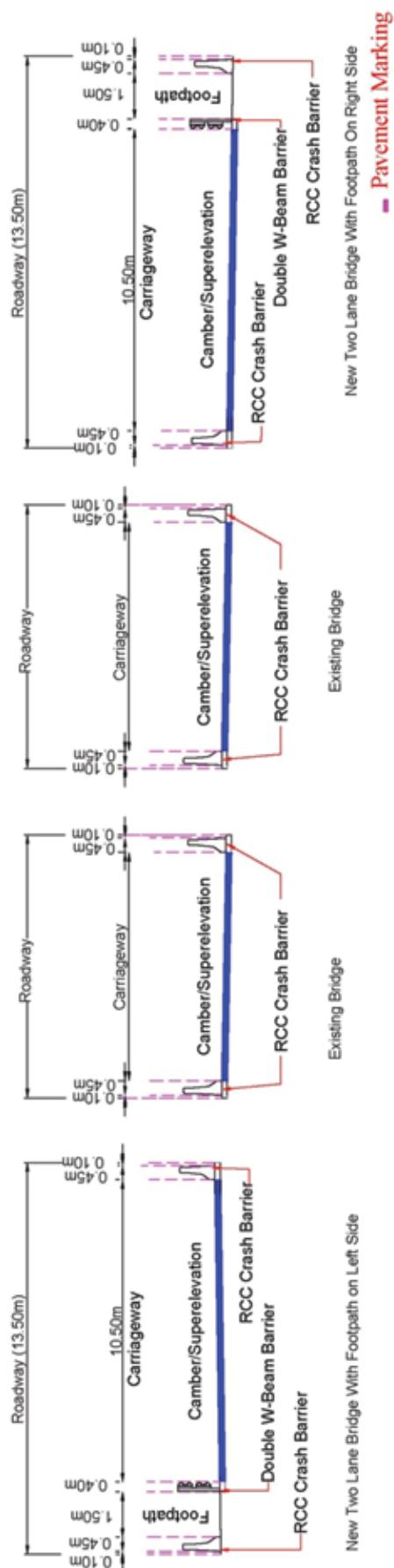
Fig. 7.4 Cross-Section of Bridge at Deck Level
**6-Lane Divided Highway - Right Side new Bridge and Left Side Existing Two-Lane Bridge with Footpath
 Plus new 2-Lane Bridge with Footpath on Left Side (No Service Roads)**



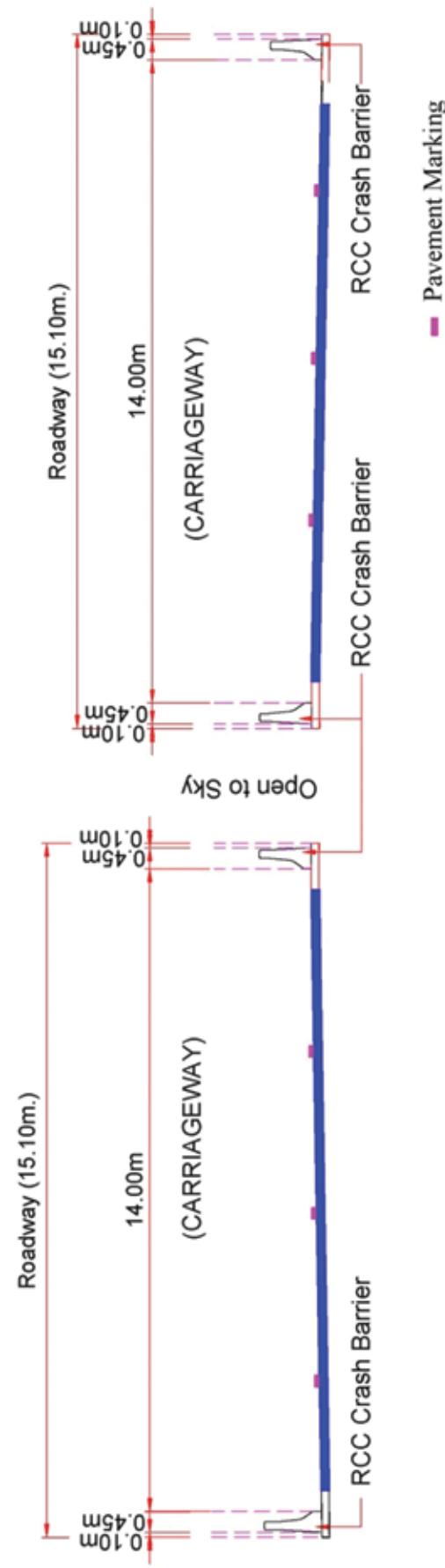
**Fig. 7.5 Cross-Section of Bridge at Deck Level
4-Lane Divided Highway(Bridges for 6-Lane Standard)
Right Side new 3-Lane Bridge and Left Side existing Two-Lane Bridge with Footpath
plus new 2-Lane Bridge with Footpath on Left Side (No Service Roads)**



**Fig. 7.6. Cross-Section of Bridge at Deck Level
6-Lane Divided Highway-Left Side Existing 2-Lane Bridge without Footpath, Right Side Existing
2-Lane Bridge with One Side Footpath Plus
New 3-Lane Bridge with One Side Footpath on LHS (No Service Roads)**



**Fig. 7.7 Cross-Section of Bridge Deck Level
6-Lane Divided Highway - Existing 2-Lane Bridge Without Footpath on Both Side
Plus new 2-Lane Bridge with One Side Footpath on outer Sides (No Service Roads)**



**Fig. 7.8 Cross-Section of Grade Separated Structure
Vehicular Under pass and Elevated Section 6-Lane Divided Highway**

SECTION 8

MATERIALS

8.1 General

All materials to be used in works shall be in conformity with the requirements laid down for relevant item in MoRTH Specifications. If the Concessionaire proposes to use any material, which is not covered in MoRTH Specifications, it shall conform to IRC or relevant Indian Standards, if there are any, or to the International Standards. Proprietary products proposed to be used shall be proven by use in comparable international road and bridge projects, and shall be supported with authenticated licensing arrangement with the manufacturer.

SECTION 9

TRAFFIC CONTROL DEVICES/ROAD SAFETY DEVICES/ROAD SIDE FURNITURE

9.1 General

The multi-lane highways being built under various road development programmes are adopting the geometric standards specifications, signage, road markings etc. as per the provisions contained in the codes of practice and the standards of the Indian Roads Congress supported by the Ministry's Specifications. However, accident data demonstrates that motorists leave the roadway for numerous reasons including errors of judgment. To ensure long term road safety on these highways, the following suitable engineering measure are considered essential for adoption so as to help in reducing risk of road crashes.

Traffic Control Devices, Road Safety Devices and Road Side Furniture shall comprise of road signs, road markings, object markers, hazard markers, studs, delineators, attenuators, safety barriers, pedestrian guard rails, boundary stones, km stones, etc. Guidelines given in IRC:8, IRC:25, IRC:26, IRC:35, IRC:67, IRC:79, IRC:103, IRC:119 and **Section 800** of MoRTH Specifications shall be used for providing these items unless otherwise specified in this Section.

9.2 Road Signs

The three types of road signs viz. mandatory/regulatory signs, cautionary/warning signs and informative signs shall be provided as given in IRC:67 and **Section 800** of MoRTH Specifications. Proper signs shall be provided for main carriageways, service and slip roads, toll plaza and other project highway facilities. Clustering and proliferation of road signs shall be avoided for enhancing their effectiveness.

9.2.1 There shall be corresponding road markings with stop signs, give way signs, merging or diverging traffic signs, lane closed signs, road narrowing signs, slip roads/diversion signs, compulsory keep left/right signs, or any other signs as per IRC:67.

9.2.2 The Specifications and Standards of road signs, which are not covered by IRC:67 would be as per International Standards.

9.2.3 All road signs shall be of Prismatic Grade Sheeting corresponding to Class C Sheeting described in IRC:67 and any of the sheeting Types VIII, IX or XI as per ASTM D 4956-09 fixed over Aluminum or Aluminum Composite Material. The sheeting for different type of signs can be chosen based on the selection guidance provided in IRC:67 depending upon the situation encountered by road users in viewing the signs. Sheeting with high coefficient of retro-reflection at small observation angle are for a road sign to be viewed by a driver from a long distance, whereas the sheeting with wide observation angle for better performance at short distance viewing. The Type XI sheeting will have better performance at short and medium distances. Micro prismatic sheeting of Type XI is preferred for gantry mounted overhead signs. Type IV micro prismatic sheeting can be used for delineator posts.

9.2.4 Shoulder kerb mounted signs shall be supported on GI pipes. Overhead signs shall be placed on a structurally sound gantry or cantilever structure made of GI pipes. Its height, lateral and vertical clearance for installation shall be as per the guidance provided in IRC:67 and also as per MoRTH specifications.

9.2.5 Locations of overhead traffic signs shall be specified in **Schedule ‘C’** of the Concession Agreement. The following conditions may be considered while deciding about the locations of overhead signs:

- i) Present and future traffic volume.
- ii) Restricted sight distance.
- iii) Built-up stretches.
- iv) Insufficient space for placing ground mounted signs and also where road features and roadside activities obscure the ground mounted signs.
- v) Distances of important places and routes at suitable intervals.
- vi) Before major intersections of considerable traffic bifurcation and on approaches to interchanges/flyovers/VUPs.

The overall size of gantry mounted signs shall be evolved based on design of sign boards given in IRC:67.

9.2.6 The road sign, traffic signal or any other device erected for traffic control, traffic guidance and or traffic information shall not obscure other traffic sign. Further, the signs and signals shall not carry any advertisement. Between two signs, there shall always more than $0.6 \times V$ meters distance (where V is the 85th percentile speed in kmph). Signs are normally erected on the shoulder side of the road; but due to terrain and abutting land use, for better visibility for drivers sign can be installed on median side also. For extra emphasis a second sign may be placed on the right side of the road as well for critical sections.

9.2.7 Wherever the Project Highway alignment is on a curve, there shall be advance cautionary signs for sharp curves (depending on whether it is on left or right) and chevron signs (rectangular in shape with yellow background and black arrow) at the outer edge of the curve. The sign for the curve ahead particularly in mountainous and steep terrain shall always be accompanied with chevron signs at the outer edge of the curve and appropriate delineation. Following guidance shall be adopted while installing curve signs:

- i) The curves with radii upto 450 m shall be provided with curves warning sign in advance of hazard and single Chevrons on outer edge of curve. Chevron signs shall be always placed on outer edge of the curve and spaced uniformly for the length covering transition length and the straight portion as given in IRC:67. Due to any reason, if there is any curve with radius less than 450 m, the safe negotiating speed for the particular curve shall be placed along with curve warning sign at both approaches. Generally, if the difference between the approach speed and permissible negotiating speed of any curve is more than 15 kmph, the curve warning for an acute curve with speed limit sign shall be placed on shoulder side and median side also.
- ii) The curves with radii 451 m to 750 m shall be installed with single Chevrons on outer edge of curve at 75 m spacing.
- iii) The curves with radii 751 m to 1200 m with deflection angle greater than 20 degree shall be provided with single Chevron signs.
- iv) For curves with radii 751 m to 1200 m with deflection angle less than 20 degree and also curves with radii from 1201 to 2000 m shall be provided with forgiving type delineator posts at 40 m spacing on outer edge of curves.

Fig 9.1 presents the road signs for relatively acute curves showing the positioning of chevron signs with respect to traffic movement. For a given curve, if chevron signs are provided, then delineator posts are not required.

9.2.8 Each exit ramp/slip road shall have ground mounted flag type direction sign indicating the name of the place and the important roads it would lead to.

9.2.9 *Direction information sign*

Gantry and shoulder mounted Advance Direction Sign shall be provided in advance of an interchange/ Flyover/ VUP or any urban reach. Flag type direction information sign shall be installed at the start of deceleration length or gorge indicating the destinations of the side roads.

Fig. 9.2 gives the typical placement of direction information signs. The font size of direction sign to be placed on Project Highway shall be based on design speed of Project Highway, whereas that on slip and service road shall be based on design speed of slip/service road.

9.2.10 *At-grade junctions*

Stack type advance direction sign and flag type direction signs shall be provided for at-grade junctions. The junction control shall be established either with STOP sign or GIVEWAY sign based on visibility funnel given in IRC:67. STOP and GIVEWAY sign shall not be installed on Project Highway, but shall be always on side road only. The tip of all splitter and triangular islands shall be installed with the direction regulatory sign of appropriate size along with Object Hazard Markers. Though both signs can be installed in one post, but while installing them the minimum clearance between vertical faces of signs and kerb specified in IRC:67 shall be ensured.

9.2.11 The approach arm to roundabout shall be provided with GIVEWAY sign and central island with turn left sign and double chevron signs as given in IRC:67. Relatively insignificant minor road approaches shall be provided with STOP sign and also a speed breaker at 5m to 6m away from STOP line, whereas a side road warning sign shall be placed on Project Highway. The visibility funnel on side road shall always be cleared of plantations and all things that obscure the mutual visibility of vehicle approaching to junction from side road and main highway and shall always be encumbrance free from all obstructions. The essential safety features for a side road with details of speed breaker are given in **Fig. 9.3**.

9.2.12 In case of a junction where the physical median is kept opened for U-turn or right turn movement, the plantations and other unwarranted objects obscuring visibility shall be removed for a length equal to stopping distance from the median tip to enhance the visibility in the junction influence area. Central median for stopping distances on both approaches can be covered by cement concrete or any treatment that would prevent growth of vegetation on central median.

9.2.13 *Facility information*

Roadside facility information sign shall be provided wherever necessary like for Eating place, Filling station, Police station and Hospitals.

9.2.14 *Prohibitory signs*

Required prohibitory sign shall be placed prohibiting the entry of certain movements like Bullocks carts into Project Highway and also parking prohibitory sign in junction influence area of Project Highway.

9.2.15 *Pedestrian signs*

Pedestrians guide rails shall be provided to streamline movements and guide pedestrians towards safe zebra crossing locations. Pedestrian guard rail shall be forgiving type and as per

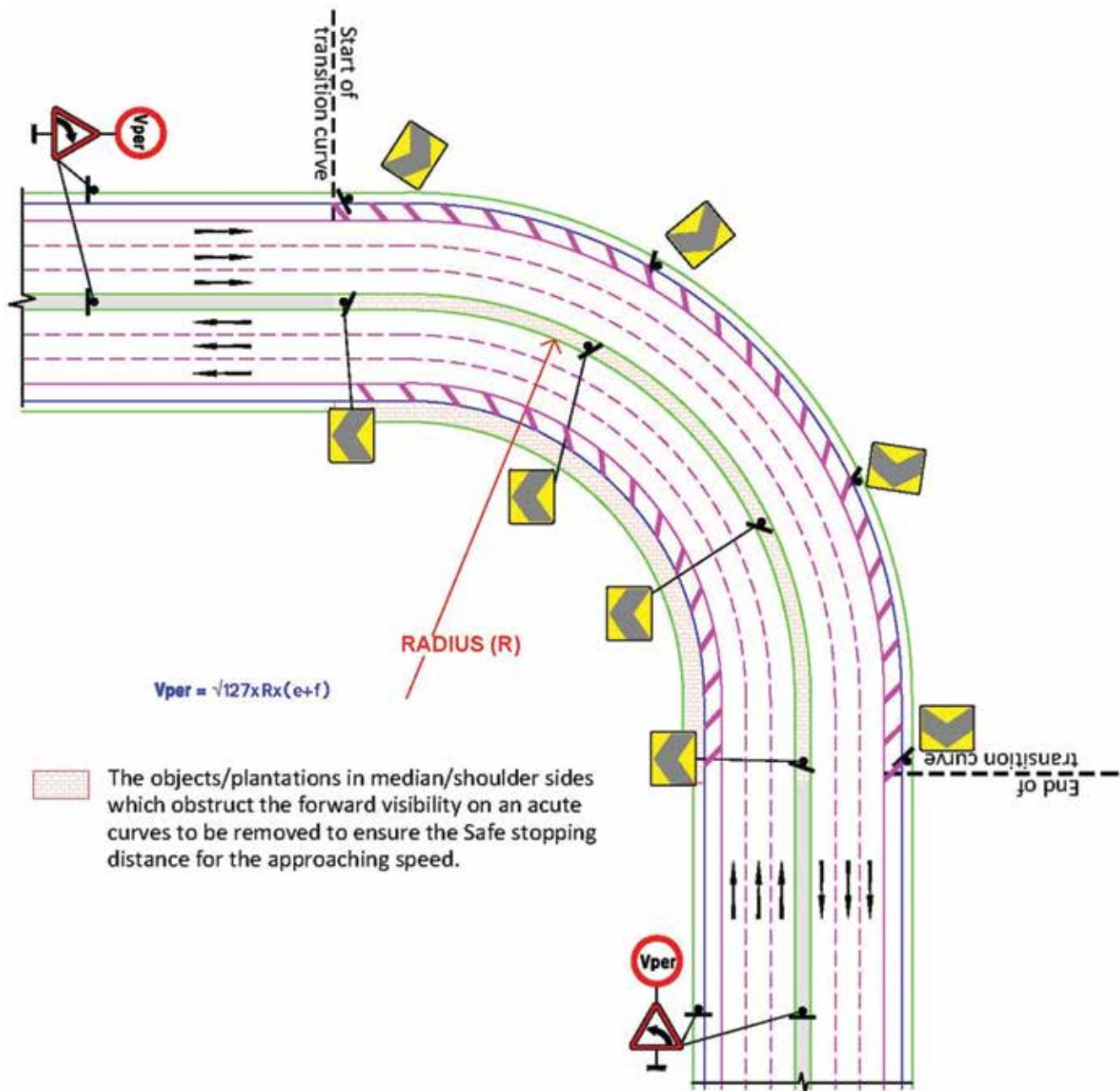


Fig. 9.1 Road Signs for an Acute Curve

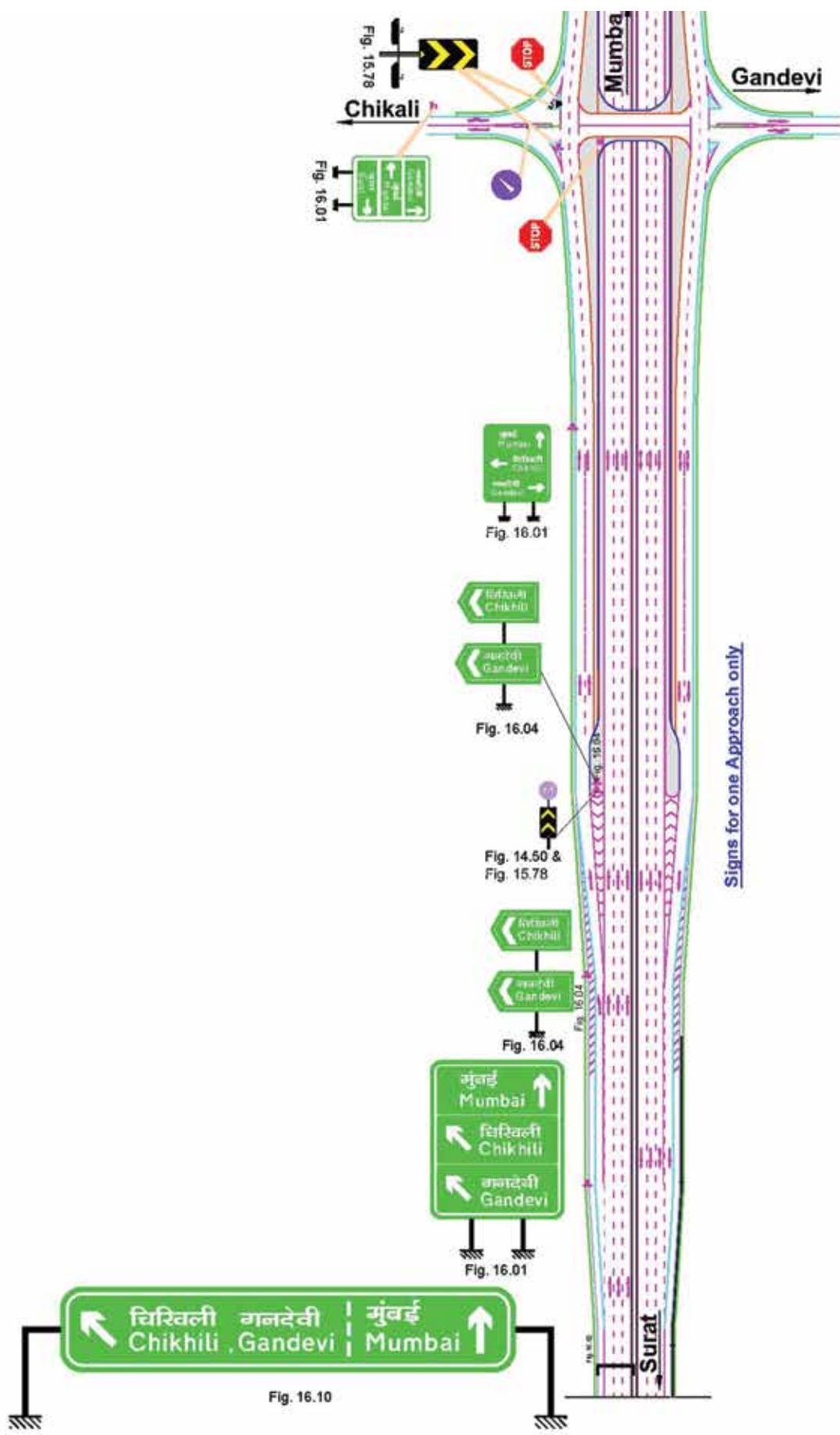


Fig. 9.2 Direction Information Signs for a Grade Separated Junction

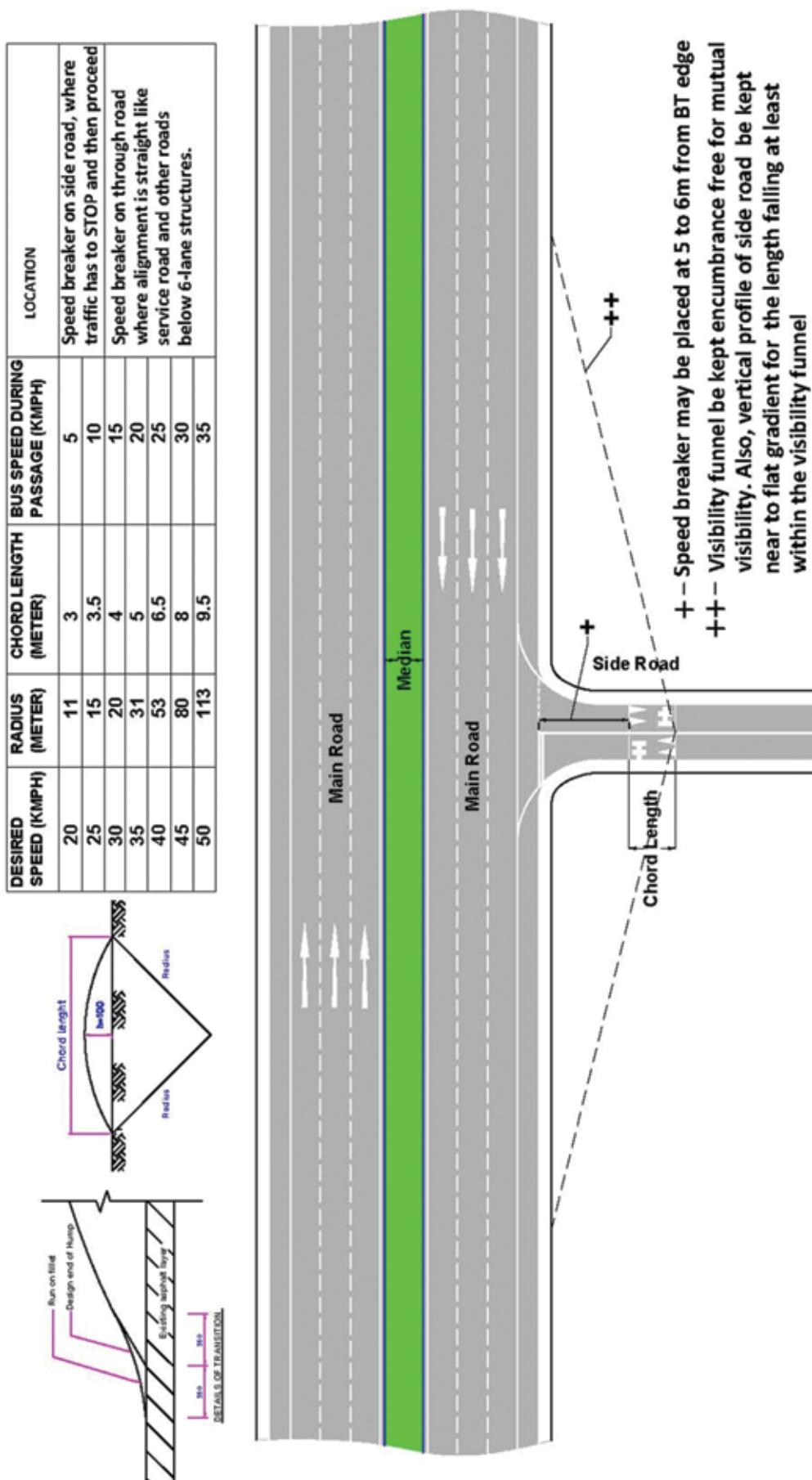


Fig. 9.3 Essential Safety Features for a Side Road with Details of Speed Breaker

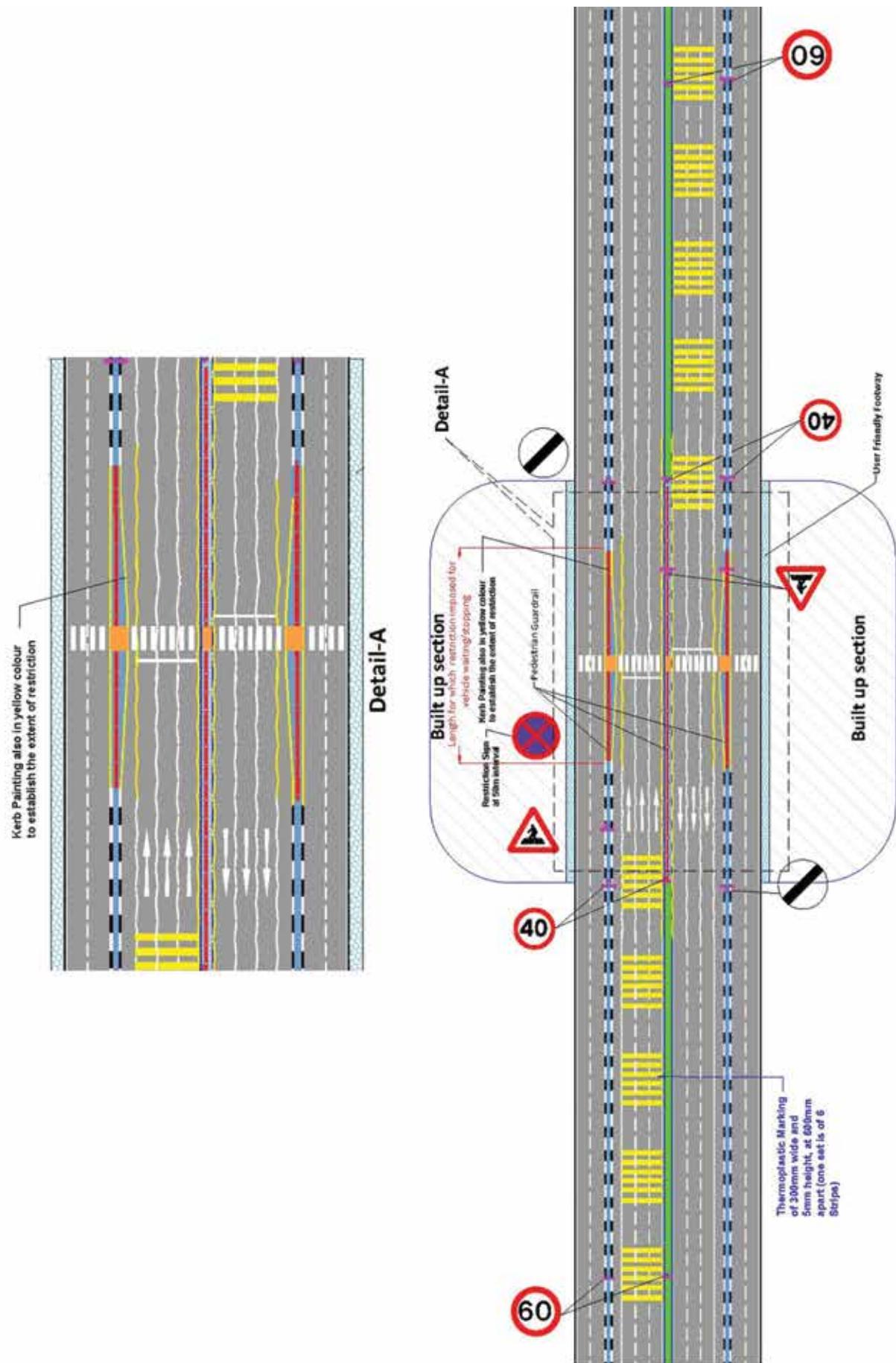


Fig. 9.4 Safety Measures when Highway passes through Settlements

IRC:103 and provided to protect and guide pedestrians to designated crossing points. The zebra crossing shall be provided with warning sign and also informative sign. On approach to school, warning sign shall be provided and zone shall be provided with footways and speed limit sign.

Across the 6-lane highway, generally grade separated pedestrians crossing facility shall be provided. On exceptional situations, at-grade crossing can be provided with adequate warning signs. The typical application is shown in **Fig. 9.4** and which also gives the safety measure to create gateway effect when the project highway passes through a settlement.

9.3 Road Markings

Road markings shall be of hot applied thermoplastic materials with glass reflectorizing beads as per relevant specifications. The quality of thermoplastic application shall be ensured by testing actual samples by random selection during application time to avoid any possible deception in the quality of materials used. Since the readability of Project Highway hinges on road markings, the minimum performance level indicated in relevant code and specification for road marking shall be ensured and any shortage shall invite reapplication of road marking.

9.3.1 *Longitudinal markings*

All curves upto 750 m radii shall be provided with traffic lane line marking meant for curves sections i.e. with shorter interval as per IRC:35. Flyover and VUPs/PUPs and their approaches of 300 m be provided with traffic lane line marking meant for intersections. The traffic lane line shall be continued for curves having radii less than 450 m, where general operating speed is 100 kmph.

9.3.2 In order to ensure the conspicuity of road markings, median side edge line shall be placed at least 350 mm from the vertical face of kerb as shown in **Fig 9.5**.

9.3.3 *Diagonal and chevron markings*

Chevron marking shall be provided for all entry/exit and shall be in continuation of shoulder edge line. Diagonal marking shall be provided in case of opposite stream of traffic.

9.3.4 *Bus and truck lane marking*

Bus and truck lane marking shall be provided with adequate chevron marking at diverging/merging locations with main carriageway. The continuity of shoulder edge line shall be maintained while making chevron markings.

9.3.5 *Stop line and give way marking*

Stop line marking shall be provided for side road as shown in **Fig 9.3**, where shoulder side edge line will be continued as broken lines.

9.3.6 *Pedestrian crossing marking*

Pedestrian crossing in mid-block section shall be provided with a platform with kerb as given in **Fig. 9.4** so that pedestrians can wait comfortably without being directly exposed to motorized vehicular movement.

9.3.7 *Hatch marking and ghost islands*

To avoid the accidents by hitting raised islands, hatch marking shall be provided to confine the drivers within the required space. In a junction, where Physical Island can not be installed, wide open area effect can be avoided by providing Ghost Island so as to streamline the traffic movement. Typical hatch marking around physical island and ghost island marking are given in **Fig. 9.6**.

9.3.8 Longitudinal marking to toll booths

The traffic lane marking running through the four-lane shall be continued till the toll booth, in such a way that traffic from each lane of project highway is guided to discharge uniformly to different toll booths as shown in **Fig. 10.4**. Toll booth shall be provided with chevron marking and hazard markers. There shall be transverse bar marking to alert the traffic about the approaching toll booth.

9.3.9 Parking restriction markings

In order to establish extent of restriction imposed, the colour of zig-zag edge line and kerb can be painted yellow colour as shown in **Fig. 9.4**.

9.3.10 Object markings

To streamline the traffic through the defined pathway and also to discourage zigzag vehicular movements, the paved surfaced between edge line and the adjacent raised islands/separators/ barriers shall be provided with diagonal markings. Typical application on approaches to bridge where bituminous surface is narrowing is shown in **Fig. 9.7**. Similar diagonal markings along with carriageway edge line can be applied in junctions and in truck/bus lay-byes.

9.3.11 Speed reduction measures

At locations where vulnerable road users are exposed to high speed traffic movement, the speed can be reduced by transvers bar marking as given in **Fig. 9.4**. For roads below 6-lane structures and service road, physical traffic calming measures like speed breaker can be provided for higher passing speed over speed breaker as shown in **Fig. 9.3**.

9.4 Road Delineators

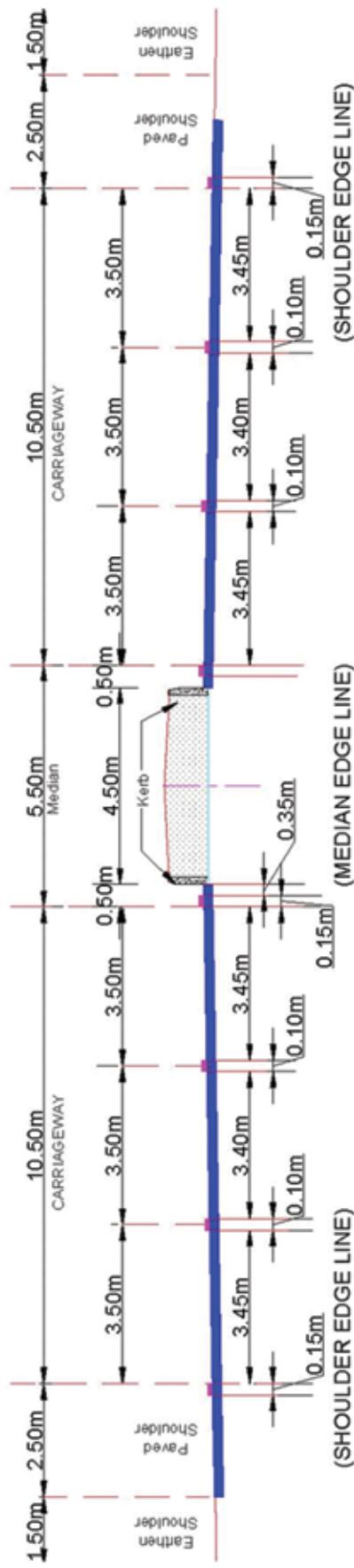
These are roadway Indicators, hazard markers and object markers as given in IRC:79.

9.4.1 Roadway indicators

Circular Iron Posts of 1.0 m height or concrete or any manufactures product with retro- reflective reflector of at least Type IV sheeting as per criteria, placement and spacing given in IRC:79 shall be provided. This will include low embankments and flat curves where crash barriers and chevron signs are not provided. Kerb edges running along the carriageway can be delineated with fixed median markers or with flexible median markers.

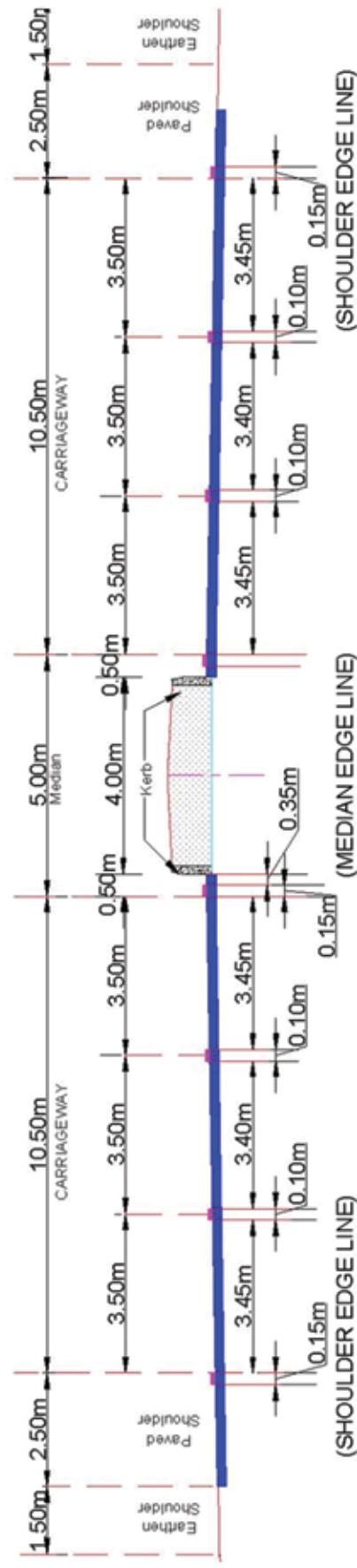
9.4.2 Hazard Markers shall be provided as given in IRC:67. In addition, the objects close to the traffic movement shall be provided with diagonal or chevron marking or hatch marking as appropriate as given in IRC:35.

9.4.3 Object Markers shall be provided as given in IRC:79 and IRC:67. All physical objects projecting above the Finished Road Level (FRL) that are falling within 3 m from the carriageway edge line shall be illuminated with Object Hazard Markers (OHM). The objects shall include foot path or utility poles or parapet or concrete barrier of Major Bridge, Minor Bridge, Culverts, RE wall at start of Underpass or flyovers. The Object Hazard Marker shall be either left OHM or right OHM or Two way Hazard Marker with respect to position of object to the traffic. **Fig. 9.7** shows the position of Object Hazard marker signs and also pattern of hazard marking where paved width gets reduced and similar hazard marking can be applied to shield an object adjacent to traffic way.



Pavement Marking

Existing 4-Lane to 6-Lane Project



Pavement Marking

New 6-Lane Construction

Fig. 9.5 Placement of Markings for Better Visibility

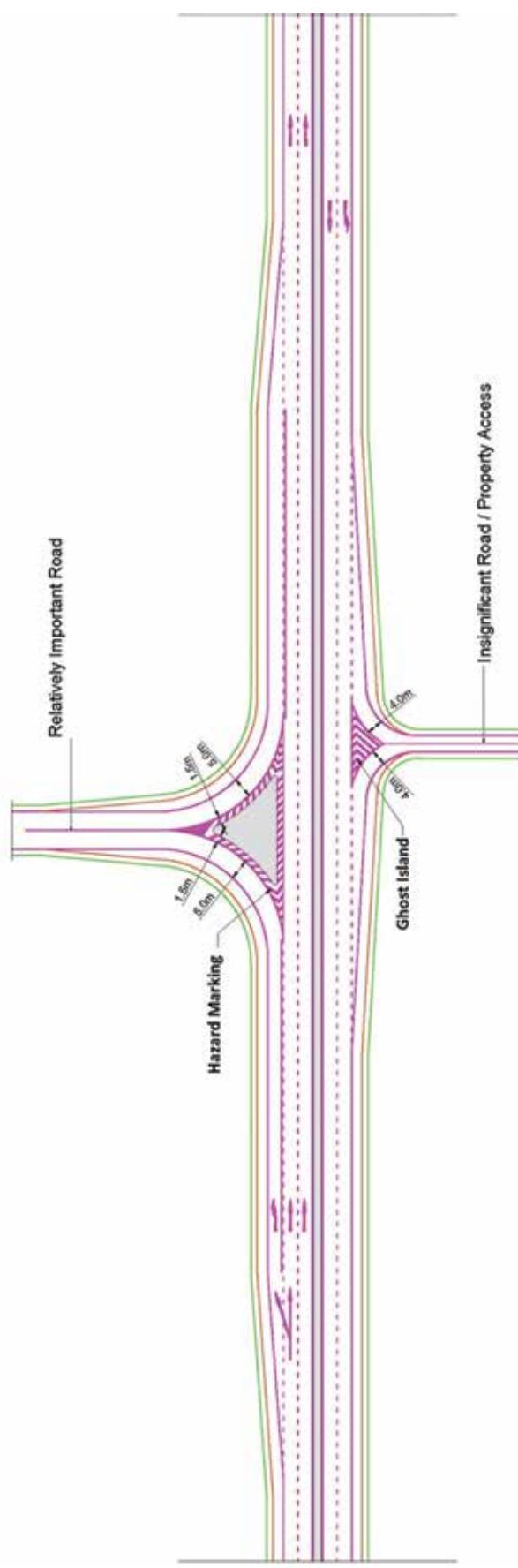


Fig. 9.6 Typical Hatch Marking around Physical Island and Ghost Island Marking

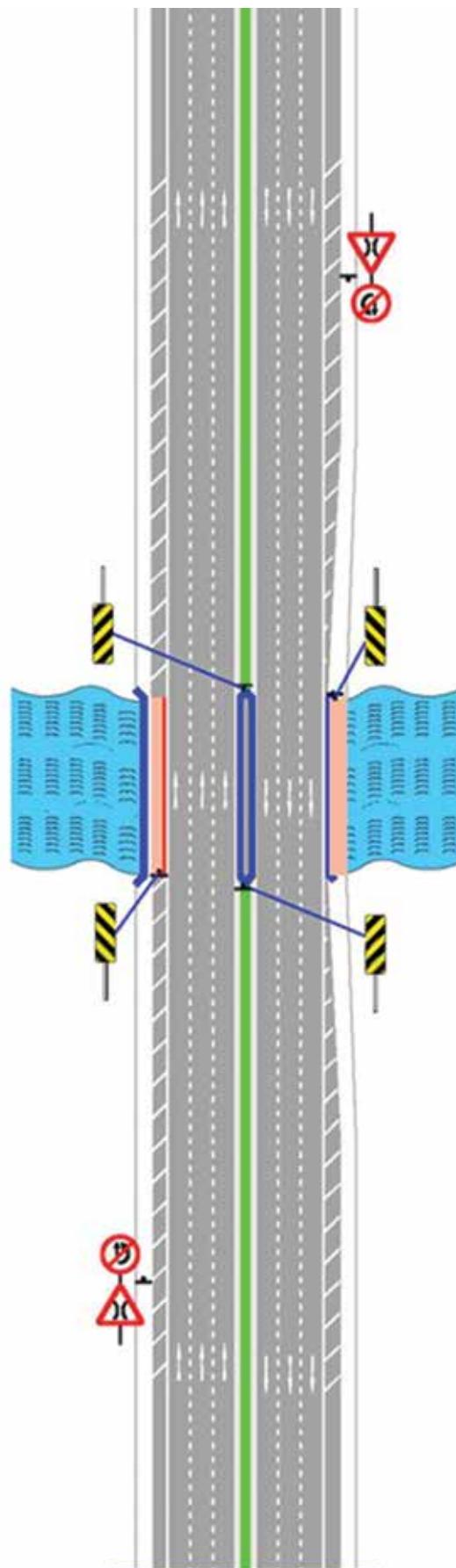


Fig. 9.7 Hazard Marking where Paved Width gets reduced along with Object Hazard Marker

In addition the kerbs in the medians/traffic islands and also concrete barrier shall be painted with black and white vertical stripes using the paint conforming to IS:164. Kerbs can painted with continuous yellow for the length for which a restriction has been imposed.

9.4.4 In case of an acute curve where the forward visibility for the approach speed is fall short of safe stopping sight distance due to median plantations, then median plantations to be removed as shown in **Fig 9.1**. Similarly the objects/plantations on inner shoulder side also shall be removed to ensure the forward visibility.

9.5 Reflective Pavement Markers (Road Studs)

The Reflective Pavement Markers(RRPM) i.e. road studs shall be provided to improve the visibility in night time and wet weather conditions. These shall be prismatic retro-reflective type conforming to ASTM D-4280. RRPM shall be provided on curves, approaches to bridges/grade separated structures and junction influence area. The RRPM on shoulder edge line shall be Red in colour and that on median edge line shall be Amber colour. RRPM shall be provided for traffic lane for all curves less than 450 m radii and shall be white in colour. The RRPM on traffic lane line shall be placed at the centre of gap of lane line marking. The RRPM shall be provided for pedestrian crossing to make them visible and shall be red colour. The details of road studs are provided in **Table 9.1**.

Table 9.1 Warrants for Road Studs

Sl. No.	Description of section	Length	Spacing	Location & Color
1)	All sections of Project Highway having horizontal curves	Curve radii upto 450	Curve length including transition with 20 m on either side	9 m
2)		Curve radii 451 to 750		18 m
3)		Curve radii 751 to 2000 m and critical section		27 m
4)	All sections of Project Highway on vertical grade	Length of Highway where vertical gradient is 2.5% and above and its vertical curves	Length including vertical grade and curves and adjoining 180 m portion on either side	18 m
5)	All sections of Project Highway where overtaking prohibited	Sections where overtaking prohibited	Length of no overtaking zone	18 m

Sl. No.	Description of section		Length	Spacing	Location & Color
6)	All Major/ Minor Bridge, ROB and all structures	Structure	Structure portion and adjoining 180 m on either side	9 m	For shoulder and median side edge lines. (Red colour on shoulder side and Amber colour for median side)
7)	(Interchange / Flyover/ VUP)	Approaches	Approach length including the length of acceleration/ deceleration length if any and 180 m adjoining on either side	18 m	
8)	Built-up areas	Built up area/ settlement / villages	Length of built up from the start to end	18 m	
9)	All entry/exit slip roads/ramps and its acceleration/ deceleration lanes	Entry/exit slip roads and ramps	Length of both side edge lines of slip roads/ ramp+ edge line of acceleration/ deceleration lane	9 m	Red colour on edge lines
10)		Continuity line for acceleration/ deceleration lane for entry/exit of slip	Chevron/diagonal markings on gorge	6 m	Red color for Chevrons/ diagonal markings
11)				8 m	Green color for crossable continuity line
12)	All junctions and median openings	Storage lane and acceleration/ deceleration lanes including 180 m on either side	Length of shoulder and median edge lines	18 m	Red colour on shoulder side and Amber color for median side
13)		Chevron/ diagonal markings	6 m	Red colour for Chevrons	
14)		Across the carriageway	At the start of the acceleration lane	3 rows at 1m apart	Green colour
15)	Pedestrian Crossing	For Zebra crossing marking	At four corners of all block of Zebra crossing markings	2 rows & at 0.5 m spacing	Amber colour

Alternatively, Solar Powered Road Markers are more effective and draw attention of drivers and shall be provided at locations like at Sl. 6 & 8 and also other locations where performance of normal road studs are not that effective due to street lightings and other roadside activities.

9.6 Traffic Impact Attenuators

The Traffic Impact Attenuators shall be provided at hazardous locations and gorge areas so as to act as energy absorber. The Traffic Impact attenuators or crash cushions shall be composed of W-beam fender panels supported by diaphragm with trigger mechanism or composed of sand barrels as per **Clause 814** of the MoRTH Specifications and the Contractor/Supplier shall furnish the certificate that the system to be installed has been tested in accordance with the NCHRP 350 and performs effectively at design speeds up to 100 kmph. The space requirement to shield a fixed object should be considered while designing and constructing the attenuators. **Fig. 9.8** shows the area that should be made available for crash attenuators installations. The design and

size of attenuators shall be as per International Standards. Following are the general criteria for providing crash attenuators:

- a) The location where there is a history of more than average number of accidents involving vehicles impacting obstruction.
- b) The 85th percentile speed of traffic plying through the traffic lane adjacent to obstruction in diverge area is greater than 70 kmph.
- c) At location where the lane changing manoeuvering of vehicles are substantial.
- d) Traffic is required to travel in close proximity to the potential obstruction where it is not feasible to install safety barrier in front of it.
- e) The obstruction with high value and if damaged by vehicle impact will have serious consequences.
- f) The gorge areas of all diverging which are one level above ground.

The specific location shall be identified following the criteria given above and the type of crash attenuators will be based on severity of the situation and shall be indicated in **Schedule 'B'**.

9.7 Safety Barriers

There are two types of safety barriers viz., roadside safety barriers and median safety barriers.

9.7.1 Roadside safety barriers

9.7.1.1 There are three types of longitudinal roadside safety barriers viz:

- i) Metal beam safety barrier which is semi-rigid type like i) "W" beam type steel barrier and ii) Thrie beam type steel barrier
- ii) Concrete Safety barrier- Rigid type
- iii) Wire Rope safety barrier, Flexible type

9.7.1.2 The steel barriers with strong post type usually remain functional after moderate collisions, thereby eliminating the need for immediate repair. If damaged by a vehicle collision, both posts and rails of W-beam are to be repaired. Lack in maintenance can cause the W-beam rails to protrude into traffic way creating highly unsafe situation. The wire rope though technically complicated, can be repaired with minimum costs. Though initial installation cost is relatively high for concrete rigid barrier compare to W-beam and wire rope safety barriers, the repair and maintenance issues can be minimized greatly in concrete rigid barrier. The psychological shyness of drivers to keep away from the safety barrier will be the least in rigid concrete barrier compared to other types. Since rigid barriers will not yield under any vehicle impact, it shall be provided for bridges and ROBs and also to shield roadside objects/hazards where the required set back distance cannot be retained with wire rope and W-Beam (due to any site condition), as they are deflective in nature.

9.7.1.3 W-beam and Thrie beam perform well on the outside of curves and even those of relatively small radius. W beam is used when the design vehicle is not the truck. Thrie beam is used in location where barrier is likely to hit regularly, as Thrie beam rail make it less prone to damage. Thrie beam should be installed at locations there is a higher probability of heavy vehicles impacts, as higher rail increases the ability to contain heavy vehicles.

9.7.1.4 The warrants for roadside barriers are given below

- i) Embankment height 3 m or more shall have safety barrier at the edge of formation. The height of embankment for installation for safety barrier shall be measured from the top of finished road level to bottom level of Original Ground Level (OGL) or invert level of ditch.
- ii) Safety barrier shall be provided for all curves upto 450 m radii.
- iii) Roadside obstacles such as bridge piers, abutments and railing ends, roadside rock mass, culverts, pipes and headwalls, cut slopes, retaining walls, lighting supports, traffic signs and signal supports, trees and utility poles shall be protected with safety barrier.
- iv) Concrete barrier shall be provided at following situation
 - a) Where embankment is retained by a retaining structure (concrete).
 - b) On valley side of highway in mountainous and steep terrain (concrete).
 - c) Between main carriageway and footpath in bridges (concrete).
- v) The metal beam and wire rope safety barrier shall not be installed upon a structure. For a safety barrier upon a structure, it shall be concrete rigid barrier. Wire Rope Safety Barrier shall not be used over major or minor bridges.
- vi) Steel barriers shall be provided in non-built-up sections whereas concrete barriers shall be provided in built-up sections
- vii) At hazardous locations identified in **Schedule 'C'** or through safety audit (concrete/steel as specified in **Schedule 'B'** or Safety Audit Report).
- viii) The requirements of Safety Barriers for structures are given in **Para 7.17** of this Manual.

9.7.2

Road side steel barriers

- a) **Design aspects :** The W-beam type safety barrier consists of steel posts and a 3 mm thick W-beam rail. There shall be a steel spacer block between the post and the beam to prevent the vehicle from snagging on the post, as the snagging can cause the vehicle to spin round. The steel posts and the blocking out spacer shall both be channel section of 75 mm x 150 mm size and 5 mm thick. The posts shall be spaced 2 m center to center. **Fig. 9.9** gives the typical details of W-beam rail and splices and shall be procured and installed from a reputed manufacturer.

The Thrie beam safety barrier shall have posts and spacers similar to the ones mentioned above for W-beam type. The rail and splices design details for typical Thrie beam are shown in **Fig. 9.10** and shall be from a reputed manufacturer. This barrier has higher initial cost than the W-beam type but is less prone to damages to vehicle collisions especially for shallow angle impacts.

The W-beam, the Thrie beam and the posts spacers and fasteners for steel barriers shall be galvanized by hot dip process and design elements and installations shall be as per the details shown for crash barrier in this manual so as to achieve the performance characteristics intended for W-beam. For any structural elements and details missing in this Manual for W-beam and its various end treatments, the details from international Guidelines/Manuals on W-beam which would conform to EN 1317 Part-2 can be adopted.

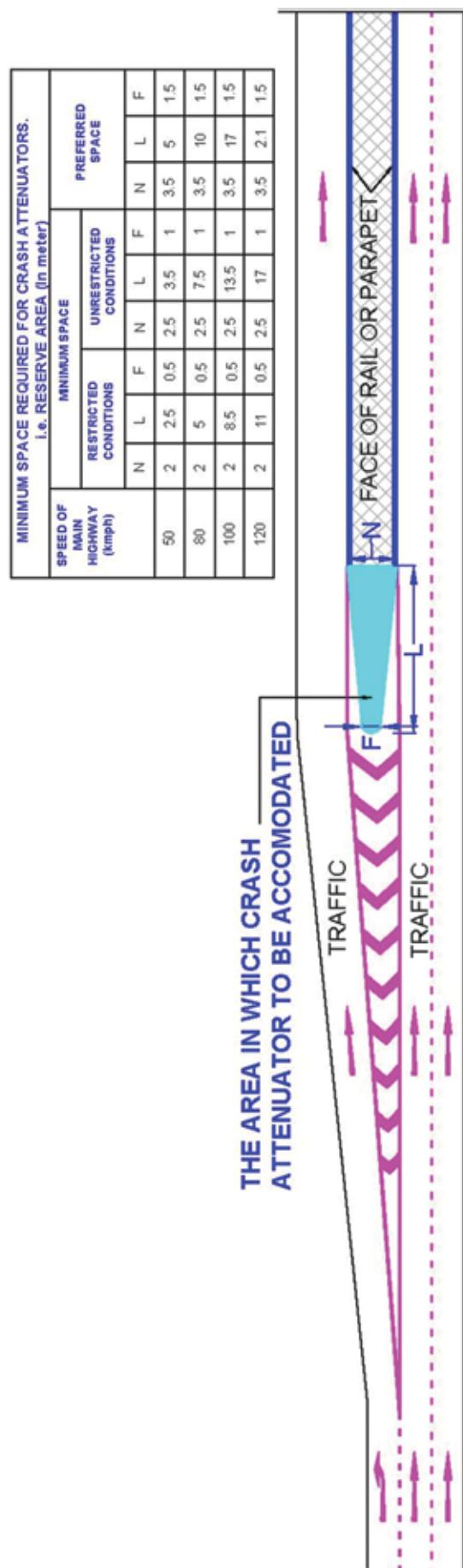


Fig. 9.8 Space required to place Crash Attenuators

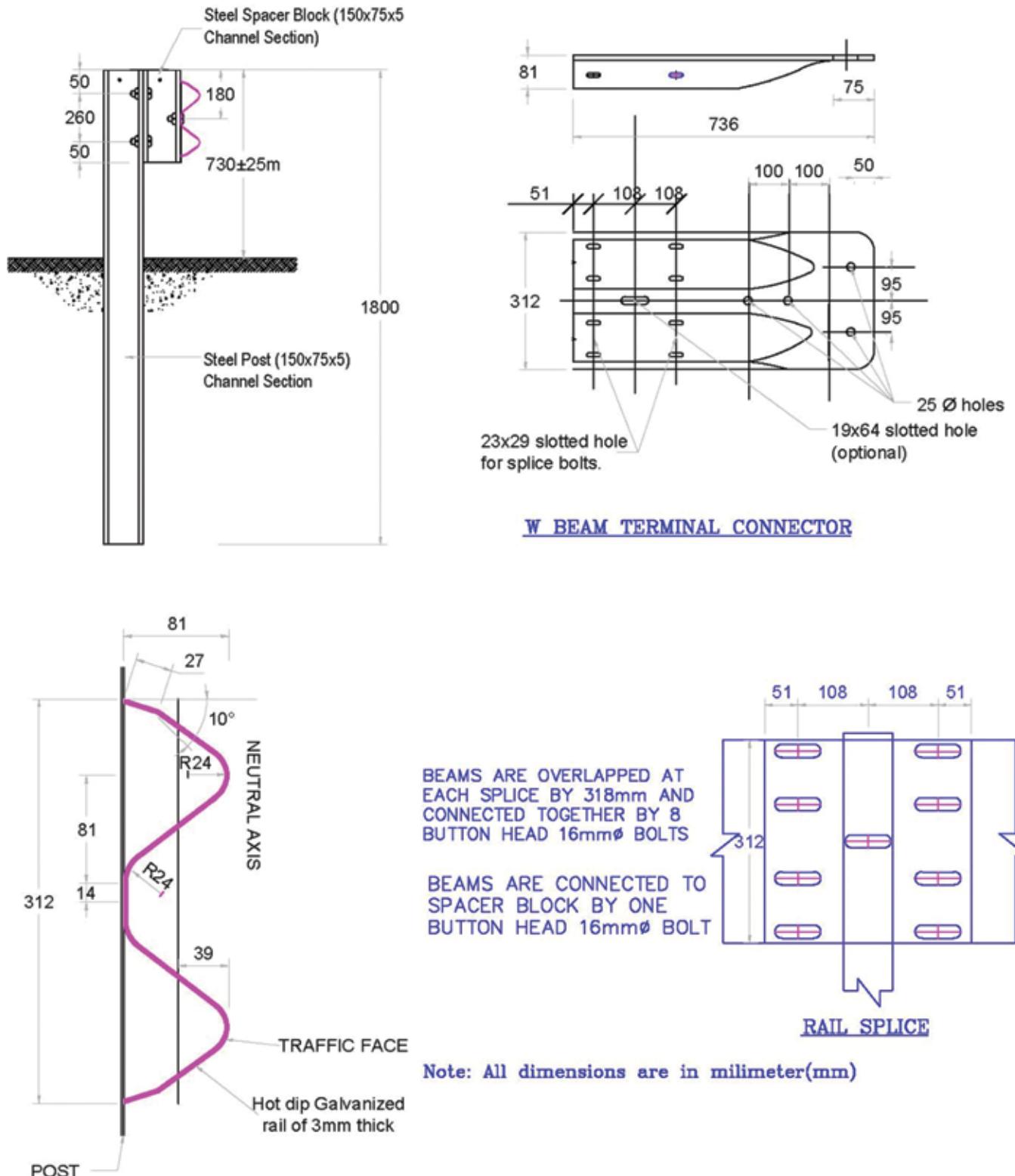
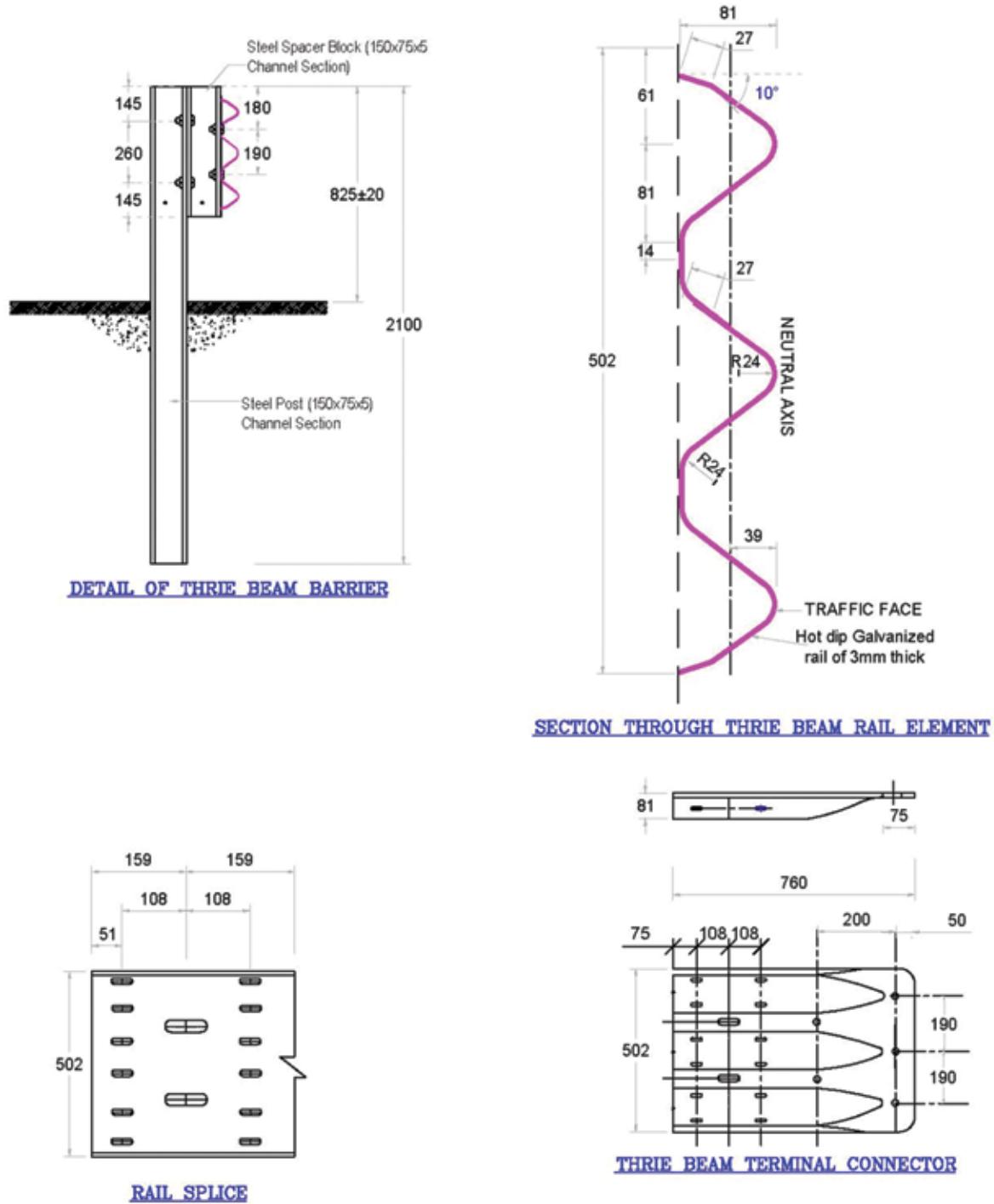


Fig. 9.9 Typical Details of W Beam Structural Elements



Note: All dimensions are in millimeter(mm)

Fig. 9.10 Typical Details of Thrie Beam Structural Elements

- b) **End treatment for steel barrier:** If hit, an untreated end of the roadside barrier can be hazardous, because the barrier beam can penetrate the passenger compartment and cause the impact vehicle to stop abruptly. End treatments should, therefore, form an integral part of safety barriers and the end treatment should not spear vault or roll a vehicle for head on or angled impacts. The end treatment on approach shall be Modified Eccentric Loader Terminal (MELT) arrangement as shown in **Fig. 9.11** and on departure side it shall be Trailing Terminal (TT) arrangement as shown in **Fig. 9.12**. Following the same end treatments, **Fig. 9.13** present the typical layout of W-beam whether on raised median sides or on depressed/flushed median sides. The international practices shall be adopted for those details which are not available in this Manual for MELT and TT arrangements for the end treatment of W-beam.
The W-beam to concrete transition shall be carried out by decreasing the post spacing, nesting one rail behind another and using steel section behind the W-beam. The transition between W-beam and concrete barrier is detailed in **Fig. 9.14**.
- c) **Placement:** The exact layout of the barrier shall be made by the design engineer keeping in view the lateral offset of the barrier and flare rate. The final layout shall be as site-specific combination of these factors.
 - i) The slope in front of W-beam shall be near to flat gradient so that safety barrier perform best when impacted by a vehicle and the slope of ground in front of barrier shall not be steeper than 10:1. Metal beam safety barrier installed on shoulder side, there shall be a lateral distance of at least 0.75 to 1.0 m width from edge of paved portion (i.e. carriageway + paved shoulder) should be available without any obstacles.
 - ii) On embankments, a minimum distance of 600 mm shall be maintained between the barrier and the start of embankment slope of a hazard to prevent the wheels from dropping over the edge.
 - iii) Raised kerbs or drains shall not be provided between the traveled way and the barriers. These destabilize the vehicle balance and disturb its equilibrium before it strikes the barrier thus defeating the essential purpose of safety and redirection of the impacting vehicle. When a kerb exists on the edge of road and on close proximity of traffic lane whether on shoulder side or median side, face of W beam shall always be less than 100 mm from the vertical face of kerb. **Fig. 9.15** gives the lateral clearance to be maintained in different situations.
 - iv) When metal beam is installed for shielding an object, minimum distance as specified by the manufacturer for deflection shall be maintained from the object/hazard. The distance between the barrier and the hazard shall not be less than the deflection of the barrier by an impact of a full sized vehicle.

9.7.3 Concrete roadside safety barriers

- a) **Design aspects:** Roadside concrete safety barriers are rigid barriers having a sloped front face and a vertical back face. For uniformity New Jersey type concrete barriers should be used where necessary. The concrete barrier may be pre-cast in lengths of up to 6 m depending upon the feasibility of transport

and lifting arrangements. Concrete grade for the barriers shall not be leaner than M30. The minimum thickness of foundations shall be 25 mm thick cement concrete or hot mix asphalt placed at the base of barrier to provide lateral restraint. Where more than 75 mm thick over lay on the road pavement is anticipated, the foundation step may be increased to 125 mm. However, longitudinal roadside concrete barrier should have elaborate footing design which is structurally safe unless sufficient earth support is available. Precast concrete barriers shall be properly anchored in cast in situ footing and entire assembly shall be checked against sliding and overturning. Suggested flare rates depending upon the design speed are given in **Table 9.2**.

Table 9.2 Flare Rates of Rigid barriers

Design speed in km per hour	Flare Rates
100	17:1
80	14:1
60	11:1
40	8:1

- b) **End treatment:** Safety barrier shall be provided with an end treatment, which shall be obtained by tapering the height of terminating end of the barrier within a length of 8 m to 9 m. In structures with footpath, the rigid barrier is placed between traffic way and footpath to protect pedestrian from vehicle impact. The approach and departure end of rigid barrier shall be continued with Metal beam barrier for a suitable length to ensure the continuity of safety barrier. In order to ensure the continuity of pedestrian pathway, metal beam barrier installed as continuation of concrete barrier can be terminated with terminal end arrangement described for metal beam barrier and then it can be resumed leaving 2 m in between enabling pedestrian to change their position from one side of barrier to other side of barrier as pictorially depicted in **Fig 9.14**.
- c) **Placement:** The exact layout of the barrier shall be made by the design engineer keeping in view the lateral offset of the barrier and site-specific requirements. Generally,
 - i) The slope in front of Rigid barrier shall be near to flat gradient so that safety barrier perform best when impacted by a vehicle and the slope of ground in front of barrier shall not be steeper than 10:1.
 - ii) Raised kerbs or drains shall not be provided between the traveled way and the barriers. These destabilize the vehicle balance and disturb its equilibrium before it strikes the barrier thus defeating the essential purpose of safety and redirection of the impacting vehicle.
 - iii) When a kerb exists on the edge of road and on close proximity of traffic lane whether on shoulder side or median side, face of Concrete barrier shall always be such that vehicle bumper would directly collide with barrier before wheel touches the kerb face.

9.7.4 Wire rope roadside safety barrier

- a) **Design aspects:** The wire rope barriers/systems are suitable for either shoulder and/or median side application, provided there is adequate clearance to account

for their deflection, as per manufactures system design specification and standards.

Wire rope barrier can be repaired quickly and only damaged posts are to be replaced. High tension 3 rope or 4 rope wire system confirming the requirements of EN 1317-2 for higher containment Level of H2 shall be used. Typical details of wire rope barrier are given in **Fig. 9.16** and wire rope barrier with ropes interwoven are also presented in **Fig. 9.17**. The wire rope barrier shall be the proprietary product of an approved manufacture and test result shall conform to EN 1317 Part 2.

- b) **End treatment:** The end treatment shall be as per the manufactures details conforming to EN 1317 Part 2. The Wire rope to W-beam transition shall be done through Modified Eccentric Loader Terminal (MELT) arrangement as shown in **Fig. 9.18**. The termination of Wire rope to a rigid or concrete barrier or a parapet shall be avoided and there shall be a transition from wire rope to W-beam in-turn to concrete barrier as shown in **Fig. 9.19**.
- c) **Placement:** The placement of the Wire Rope Safety Barrier shall be determined by the design engineer and shall be a combination of the deflection ratios of the barrier and the site-specific conditions.
 - i) The slope of surface between traffic way and wire rope safety barrier shall always be flatter than 10:1 and there shall not any object or raised kerb in between so to enable the cables to readily dis-engage from posts during impact and thereby minimizing snagging and ensuring that the vehicle is smoothly redirected.
 - ii) There shall be at least 1 m setback distance between wire rope safety barrier and the start of drop or embankment slope. While installing wire rope on a highway carrying two/three-wheelers and other small vehicles, the deflection as specified by the manufacturer shall be maintained as set back distance from the start of drop of embankment. The deflection can be reduced by closer post spacing, however the minimum setback distance shall be ensured.
 - iii) Raised kerbs or drains shall not be provided between the traveled way and the barriers. These destabilize the vehicle balance and disturb its equilibrium before it strikes the barrier thus defeating the essential purpose of safety and redirection of the impacting vehicle.
 - iv) When Wire Rope Safety Barrier is provided in front of a hazard, it shall be so located caters to the deflection specified by the manufacture. The barrier shall be extended at full height not less than 30 m in advance of the hazard on the approach side, and shall continue at full height for 7.5 m beyond the hazard on the departure side. The minimum length of fence shall be no less than 50 m. If there is a hazard present in the deflection area of the barrier, then the distance between fence and the hazard shall not be less than that deflection values described by the manufacture and will depend upon the post spacing
 - v) The Wire Rope Safety Barrier shall not be permitted in following situations:
 - Where a hazard is present within the deflection area of the fence.

- Where total fence length is less than 50 m.
- On a horizontal curves of radius 450 m or less.
- On vertical sag curves of radius less than 3 km.
- Where rate of change in setback is steeper than 1 in 10.

9.7.5 Median barriers

9.7.5.1 There are four types of median safety barrier viz., W-beam type steel barrier, (Strong post type), Thrie beam type steel barrier, (Strong post type), Concrete barriers, Wire Rope safety barrier with closer post spacing.

9.7.5.2 The warrants for median side barriers are given below

- i) On highways with narrow medians causing out-of-control vehicles jumping across the medians to other carriageway
- ii) Fixed objects on medians require shielding from the traffic flow, which may be a light post, foundation of overhead signs, bridge pier etc.
- iii) For all multilane highways where adequate land is available, it is preferable to provide wide depressed medians having width of 7 m or more but with W-beam metal crash barrier or wire rope safety barrier at the edges of the median
- iv) Wire ropes are ideally suited flushed median situations in a mutli lane highway owing to their double side nature and also not allowing crossover as wire rope never snaps. Wire rope on a narrow flushed median shall be placed at the center of flushed median, ensuring the sufficient deflection distance from both traffic way.
- v) At hazardous locations identified in **Schedule ‘C’** or through safety audit (concrete/steel as specified in **Schedule ‘B’** or Safety Audit Report).
- vi) The requirements of Safety Barriers for structures are given in **Para 7.17** of this Manual

9.7.5.3 Median side steel barriers

- a) **Design aspects:** The W-beam barrier shall be similar to the roadside barrier described in **Para 9.7.2 (a)**. The Thrie beam barrier shall be similar to the roadside barrier described in **Para 9.7.2 (a)**.
- b) **Placement:** Steel beam crash barrier shall be placed at both the edges of median along the carriageway as per the placement requirements given in **9.7.2 (c)**. The lateral placement and end treatment of W-Beam at median location as given in **Fig. 9.13** shall be followed. The Modified Eccentric Loader Terminal (MELT) arrangement on approach side and Trailing Terminal (TT) arrangement on departure side shall be adopted for W-beam end treatment in median location also.

9.7.5.4 Concrete median barriers

- a) **Design aspects:** Concrete median barrier shall be New Jersey type. These should be used in case of narrow medians of two meter or less along with an anti-glare screen for avoidance of headlight glare. The concrete barrier cannot be altered easily, hence rigid barrier shall be provided in narrow median in urban

location to prevent pedestrian intrusion and other side friction. The terminating end of the median barrier shall be tapered in a length of 8 to 9 m.

- b) **Placement:** The requirements given in **Para 9.7.3 (c)** shall be complied for placement of concrete median barrier. At locations where median is narrow, the exposed end on concrete barrier on median side can be provided with Traffic Impact Attenuators.

9.7.5.5 Wire rope median barrier

- a) **Design aspects:** The design aspects given in **Para 9.7.4 (a)** will be applicable for wire rope at median location.
- b) **Placement:** The requirements covered in **Para 9.7.4 (c)** for wire rope will be applicable for median barrier also. Also, when Wire Rope Safety Barrier is placed between two adjacent carriageways which are at the same level, it shall be placed at the center of the median with deflection area not be less than that deflection values described by the manufacture from either side of the fence. In case of two carriageways which are at different levels, it shall be at both sides of the median edge. In the case of a split median, it shall be on the carriageway of higher side. Wire rope barrier for median location can be adopted as long as the median is not raised and allowable deflection can be kept from both traffic way sides as given in **Fig. 9.15**. The end treatment presented in **Para 9.7.4 (b)** will be applicable for wire rope at median location also.

9.8 Pedestrian Facilities

9.8.1 General

Pedestrians are vulnerable to being involved in accidents. Therefore, adequate consideration shall be given to their safety through provision of facilities. The facilities for pedestrians given in this Section shall be provided on the Project Highway, especially roads and junctions being built below 6-lane structures.

9.8.2 Footpath (Sidewalk)

- i) The foot paths shall be provided in the built-up sections, on both sides. Pedestrian facilities for their safe and convenient movement along the highway and for crossing the highway shall be integral part of facility and therefore carefully planned and provided.
- ii) The width of sidewalks depends up on the expected pedestrian flow, but shall not be less than 1.5 m. Land to be acquired, if need be.

9.8.3 Pedestrian guardrails

- i) Pedestrian guardrails are an important design element to prevent indiscriminate crossing and spilling over of pedestrians on to the carriageway. Their judicious use can help to ensure that pedestrians cross the highway at predetermined and safe locations. As the guardrails would confine the movement of pedestrians to the footpath, it is obligatory that sufficient width of footpath be made available for the use of pedestrians.
- ii) **Design:** The design shall be such that the guardrails are neat and simple in appearance. The height of guardrail shall be 1.2 m from foot path level. The

visibility of the approaching vehicles by the pedestrians as well as the visibility of the pedestrians by the drivers of the approaching vehicles shall be adequate. The railings shall not have any thick horizontal member, other than the baluster to achieve the desired objective. It shall comprise of reinforced cement concrete, iron tubes, steel channeled sections and pipes, or steel sections appropriate for the environment. Refer to IRC:103.

- iii) **Application:** Pedestrian guardrails shall be provided at the following locations/ situations:
 - a) **Hazardous Locations on Straight Stretches:** In particularly busy reaches, where the road is congested and vehicles move at a fast pace, guardrails shall be provided on both sides of the carriage way so as to channelize the pedestrians on to the planned crossing locations.
 - b) **At Junctions/Intersections:** Railing barriers shall be provided to prevent people from crossing the junctions diagonally at signalized inter sections. The barrier shall open only at planned crossing facility (at the Zebra Crossing). At signalized junctions they shall be provided for sufficient length to guide the pedestrians to the nearest planned pedestrian crossing.
 - c) **Schools:** Provision of guardrails near schools, where children would otherwise run straight in to the road, is essential. If there is a pedestrian crossing or a school crossing patrol nearby, the guardrails shall be extended up to it.
 - d) **Bus Stops, Railway Stations, etc.:** Guardrails shall be provided alongside walks with suitable access at bus stops, railway stations and other areas of heavy pedestrian activity such as cinema houses, stadia, etc. for guiding pedestrians safely in such areas.
 - e) **Overpass, Subway, etc.:** Guardrails shall be provided at these locations in order to compel the pedestrians to use the facilities provided for them.
 - f) **Central Reserves:** Where there is a central reserve or a median, guardrails shall be erected within it to deter the pedestrians from attempting a crossing.
- iv) **Gaps/Set back Distance:** The guardrails shall be setback from edge of the carriageway by at least 150 mm

9.8.4 *Pedestrian crossing*

Provisions of pedestrian crossing described in this section are primarily applicable to road and junction build under 6-lane structure.

9.8.4.1 Where complete segregation of pedestrians from vehicular traffic is not provided, some form of planned road sharing principle shall be applied. Pedestrian crossings shall be provided where they will be well used. Pedestrian crossings shall be suitably integrated with the overall design of the inter section.

9.8.4.2 *At-grade pedestrian crossing (pedestrian cross walk)*

Pedestrian cross walks shall be provided at all important inter sections and such other locations where substantial conflict exists between vehicular and pedestrian movements. Wherever possible, the cross walks shall be at right angles to the carriageway and properly marked so that the pedestrians are subjected to minimum inconvenience. Cross walks shall not substantially

increase the walk distance of pedestrians. Adequate visibility, freedom from obstructions and sufficient space for waiting are the other important requirements for location of cross walks. At-grade pedestrian crossings can be uncontrolled or controlled. Uncontrolled pedestrian crossings shall be provided only where the intersection itself is left uncontrolled because of low volumes of both vehicular and pedestrian traffic even during peak hours and where accident records do not indicate any need to segregate vehicular traffic from cross pedestrian traffic. Uncontrolled pedestrian cross walk shall be marked by studs or paint line. Controlled form of crossing shall be achieved through provision of Zebra Crossings, whether at a non-signalized or signalized intersection.

9.8.4.3 Zebra crossing

A zebra crossing shall not be sited within 150 m of another such crossing. The zebra crossing shall be somewhat set back from the carriageway line. However, the setback distance shall not be so much as to cause an appreciable increase in walking distance for the pedestrians. Pedestrian guard rails may be necessary where the setback distance is appreciable or at the skew crossings. The width of the zebra crossing shall be adequate and shall generally lie within a range of 2.0 m to 4.0 m. The crossing shall, as far as possible, proceed uninterrupted through the median strip. In the event of the median strip being used as pedestrian refuge, adequate width of median shall be provided. In case of raised medians, such portion could be suitably depressed with kerb height not exceeding 150 mm. In the vicinity of zebra crossing, guard rails of sufficient length shall be provided to deter pedestrians from crossing the road at any arbitrary point along the road. **Fig 9.4** gives a typical layout for zebra crossing in a mid-block section.

9.8.5 Grade separated pedestrian crossing

9.8.5.1 Divided carriageway passing through built up area with narrow median makes their crossing more risky, as there is no pedestrian refuge space in the median side. This demands for a grade separated movement like Foot Over Bridge (FOB). The efforts required for a pedestrian to climb a FOB to cross a 6-lane highway is equivalent of approximately 500-700 m walking distance, which itself makes FOB not user-friendly. Provision of a lift or escalator at the FOB to encourage pedestrian to use FOB. At locations where maintenance of lift and escalator can not be ensured, other grade separated pedestrian crossing should be explored. Pedestrian subway is more user friendly as the first action of pedestrian is to go down on the steps and would be encouraging also, as total efforts required to use subway compared to FOB is very less

9.8.5.2 Half-subway (or depressed PUP) is an alternative solution, wherein main highway is raised by 1.5 m, which can be achieved with a gentle grade and pedestrian has to go down in steps from Ground level by 1.5 m only. Thus the sunlight and outward exposure would still be inside the half-subway, which will have headroom of 3 m. Since the main highway is raised by 1.5 m, it will not affect the visibility across the highway for the business establishments along the highway. Thus, the half-subway or depressed PUP should be considered as an alternative solution for grade-separated pedestrian crossing.

9.9 Work Zone Traffic Management Plans (WTMPs)

The traffic diversion plan during construction shall be prepared as per IRC:SP:55 for the entire project highway. Separate traffic diversion plan shall be prepared for structures and CD works.

Fig. 9.20 gives a typical Work Zone Traffic Management Plan (WTMP) for an existing 4-lane to 6-laning project. Once the service roads are completed, traffic will be diverted in to them so that main 6-lane can be developed as given in **Fig. 9.21**. Typical Work Zone Traffic Management Plan

given in IRC:SP:55 for various scenarios shall be adopted, tailor-made to the site condition. The traffic management is applicable during operational period also. **Fig. 9.22** give traffic diversion when one-lane of a carriageway is affected for some maintenance work, whereas **Fig. 9.23** gives the traffic diversion and safety arrangement when both carriageways are affected for major maintenance work.

9.9.1 *Temporary diversion for CD structures*

The layout **Fig 9.24** shown is applicable when a Cross Drainage structure has to be constructed and where a temporary diversion will need to be constructed for maintaining the traffic flow. The diversion in most cases would be on embankment; therefore, delineation is essential for both day and night time. Temporary diversion shall be developed and maintained to accommodate all types of vehicles likely to ply through the road.

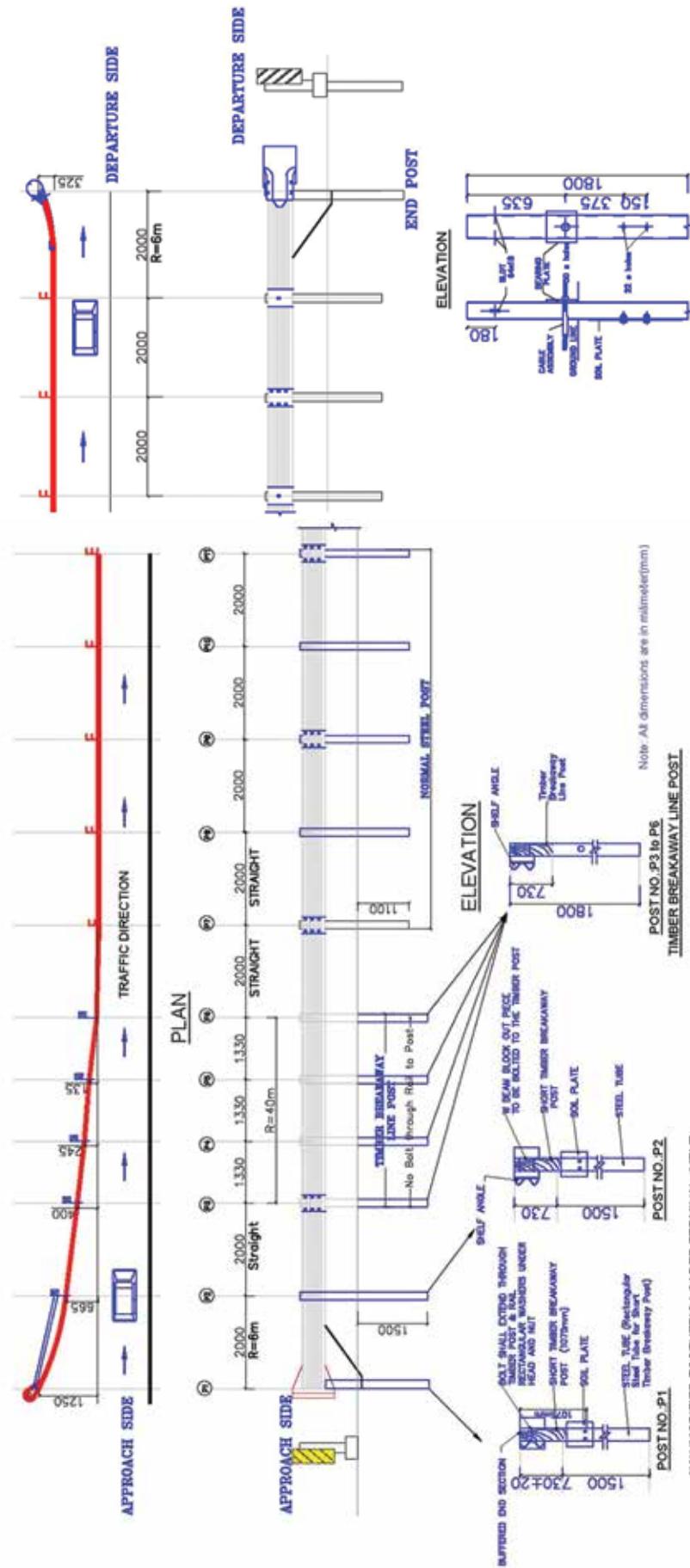
9.9.2 *Work at the center of carriageway*

The layout **Fig 9.25** shown is applicable for short term maintenance activities at the center of a carriageway. Generally, traffic cones are used so that it can be placed and removed easily.

9.9.3 *Flyover/VUP construction*

9.9.3.1 The layout **Fig 9.26** shows the Stage-1 in flyover/VUP construction. In the first stage, the traffic will be diverted to a service road or temporary road. The turning movements would continue at the existing intersection and construction of piers/embankment/RE wall would be taken up in the cordoned portion. Carefully planned pedestrian markings on the roads and protected safe passage for crossing of pedestrians shall be provided through work area.

9.9.3.2 The layout of **Fig 9.27** shows Stage-2 of flyover/VUP construction. In the second stage, the central portion will be taken up and junction will be blocked for direct cross road movement. During this short period of time, cross road movement will be accommodated like a circulatory movement using U-turn, whereas the through traffic will continue to ply through service road/temporary road. Direction signs would be carefully planned and installed. Carefully planned pedestrian markings on the roads and protected safe passage for crossing of pedestrians shall be provided through work area.



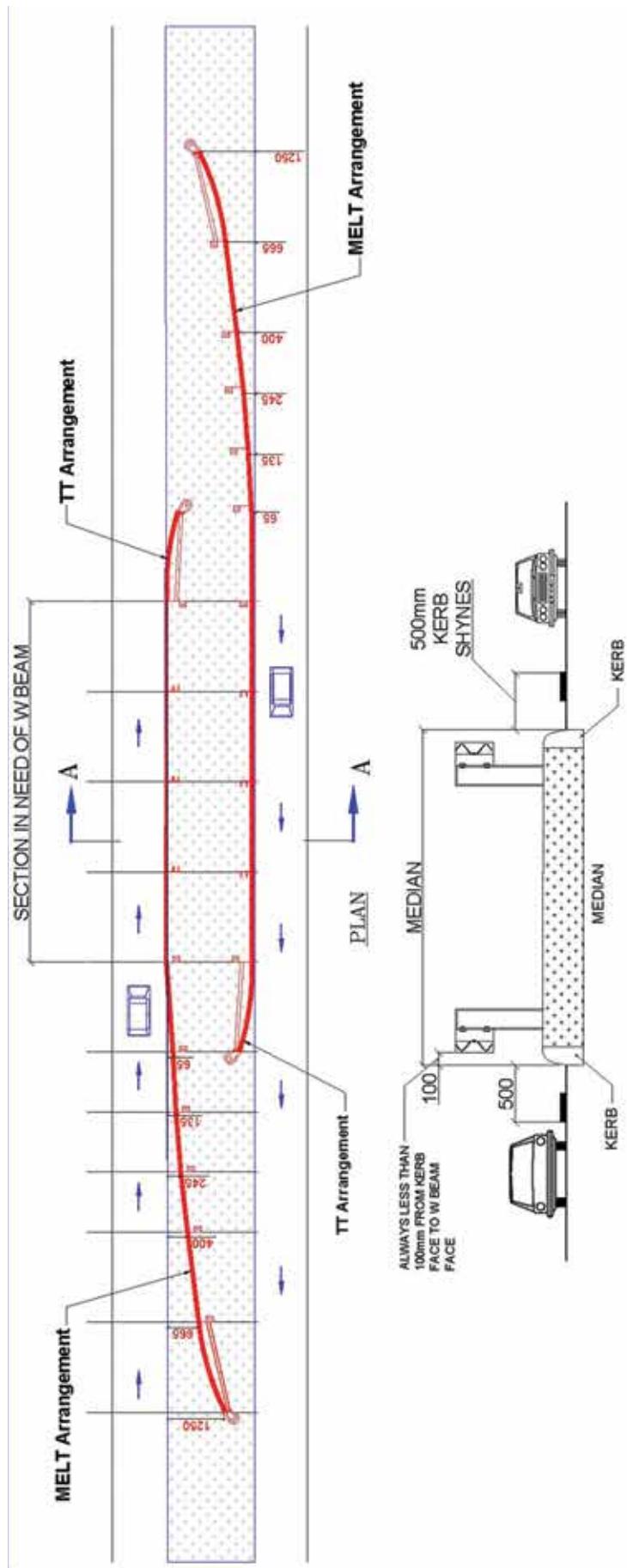


Fig. 9.13 Typical Layout of W Beam on Median Side

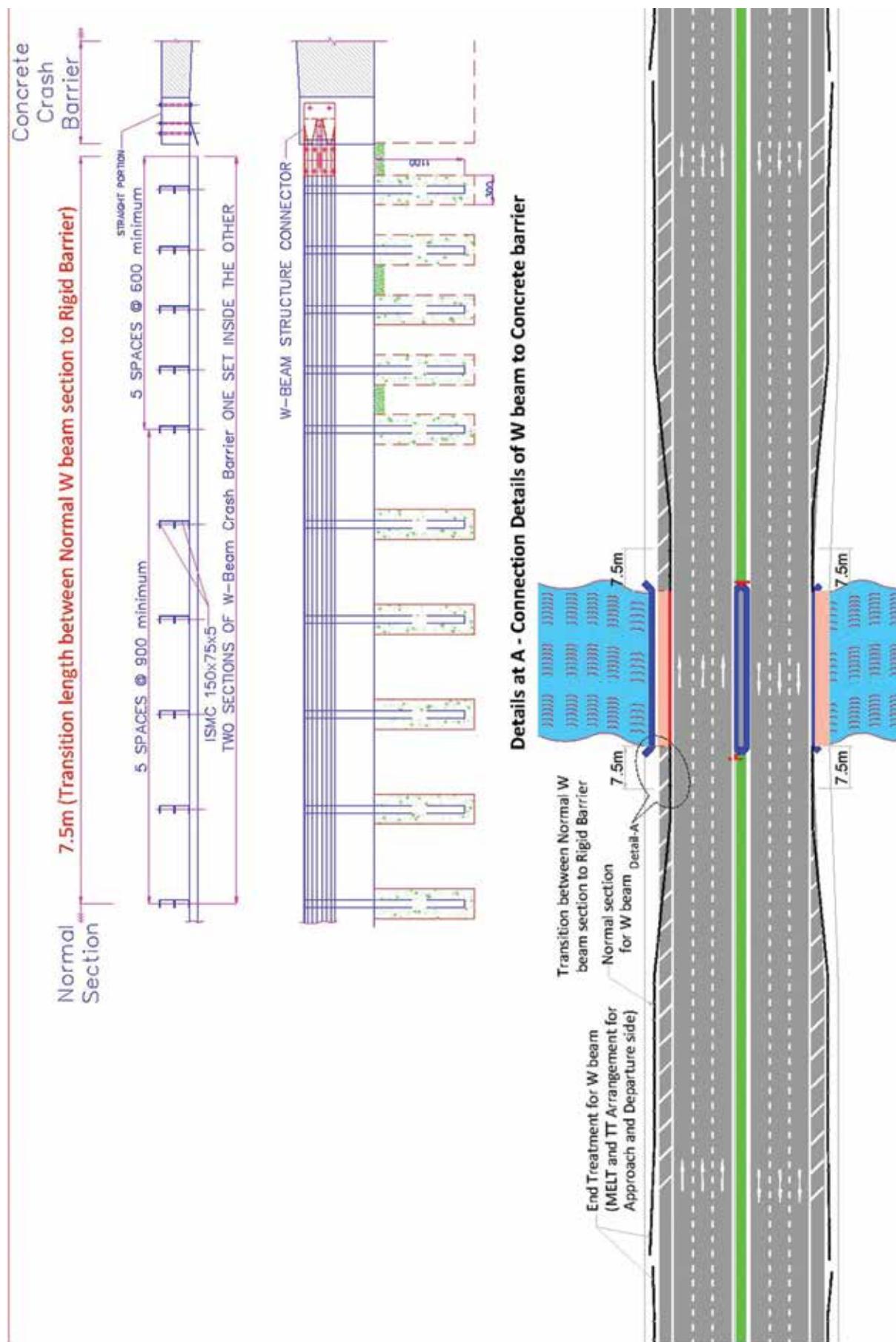


Fig. 9.14 Layout showing the continuity of Safety Barrier and Pedestrian Pathway

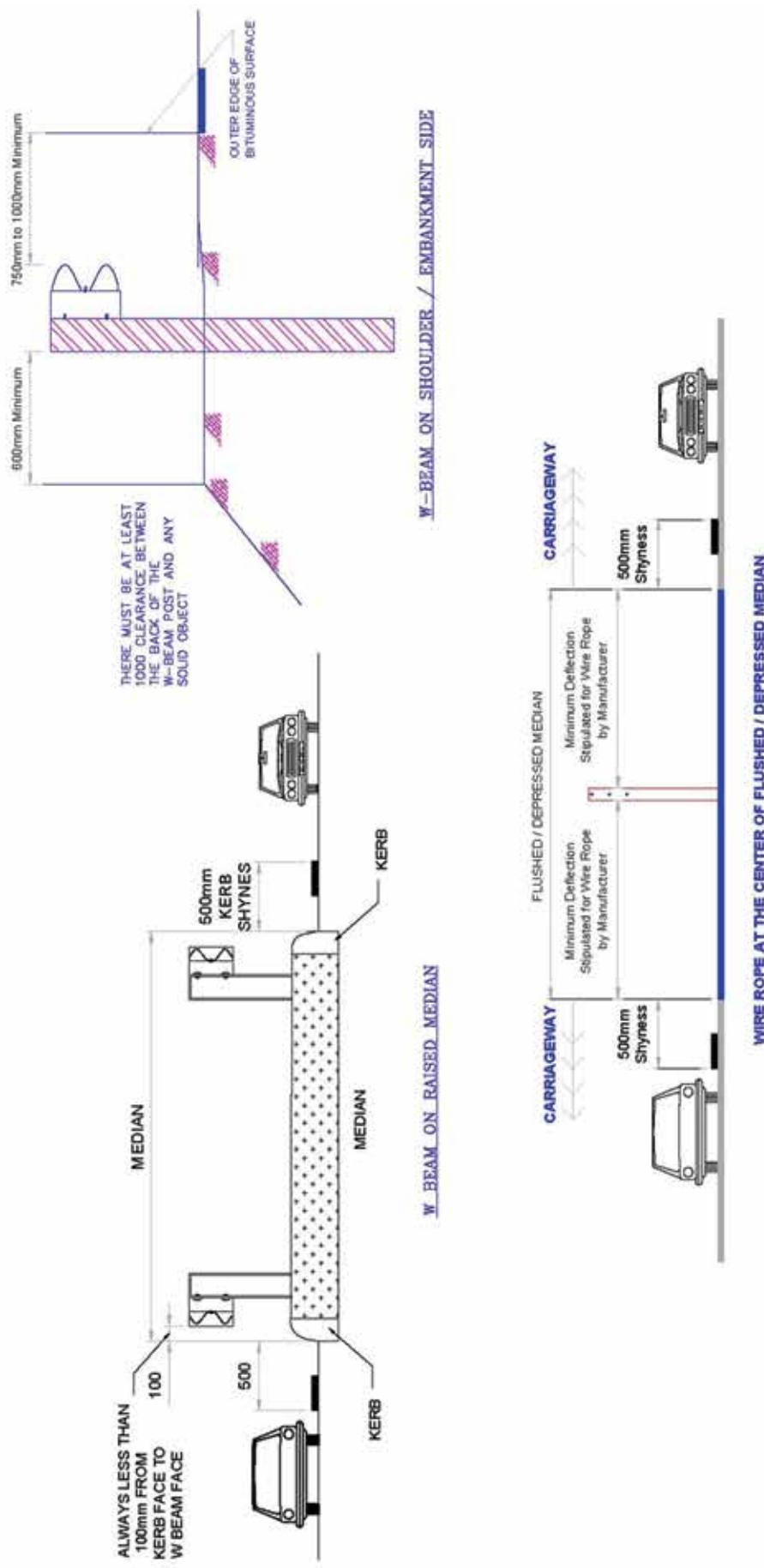


Fig. 9.15 Lateral Clearance for Different Barriers

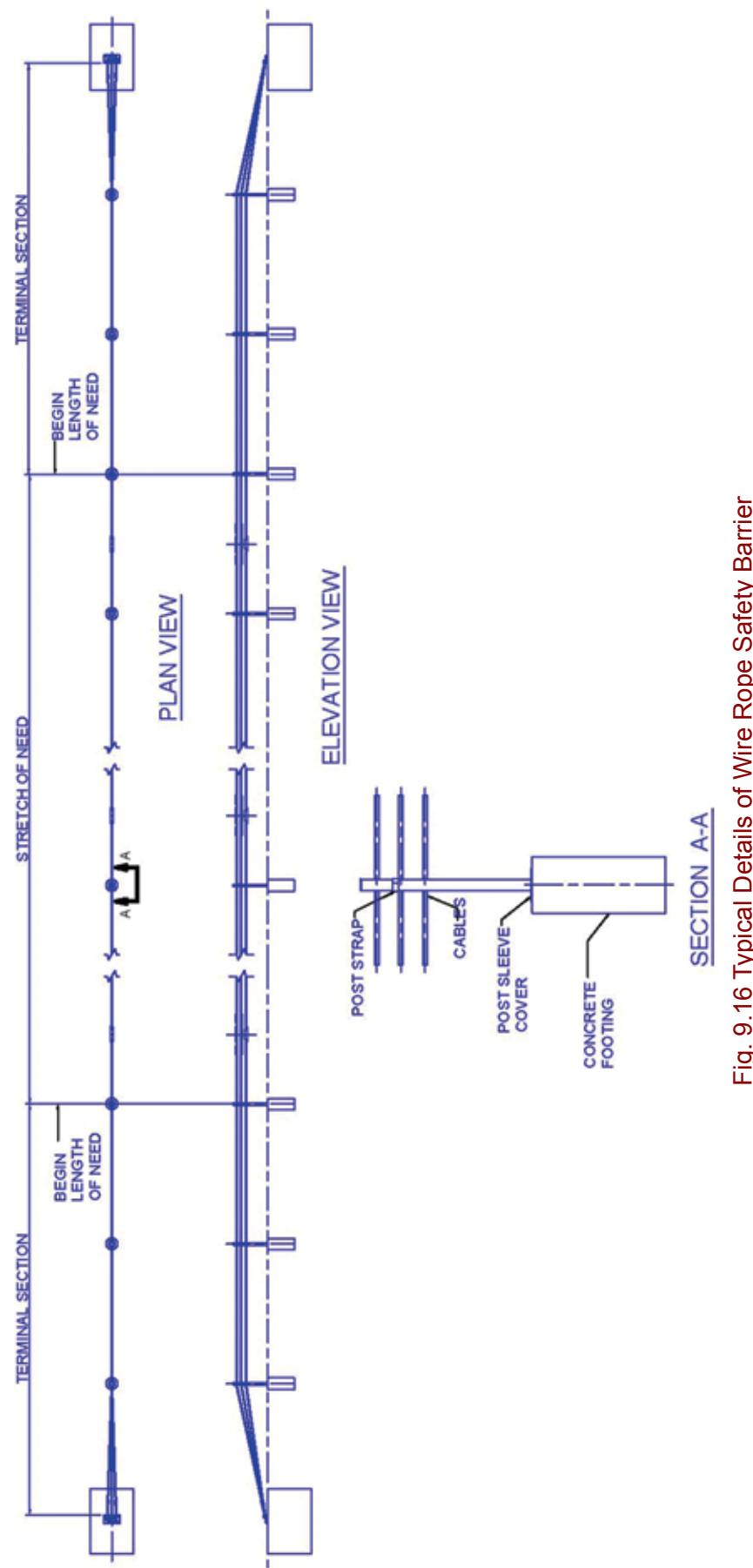


Fig. 9.16 Typical Details of Wire Rope Safety Barrier

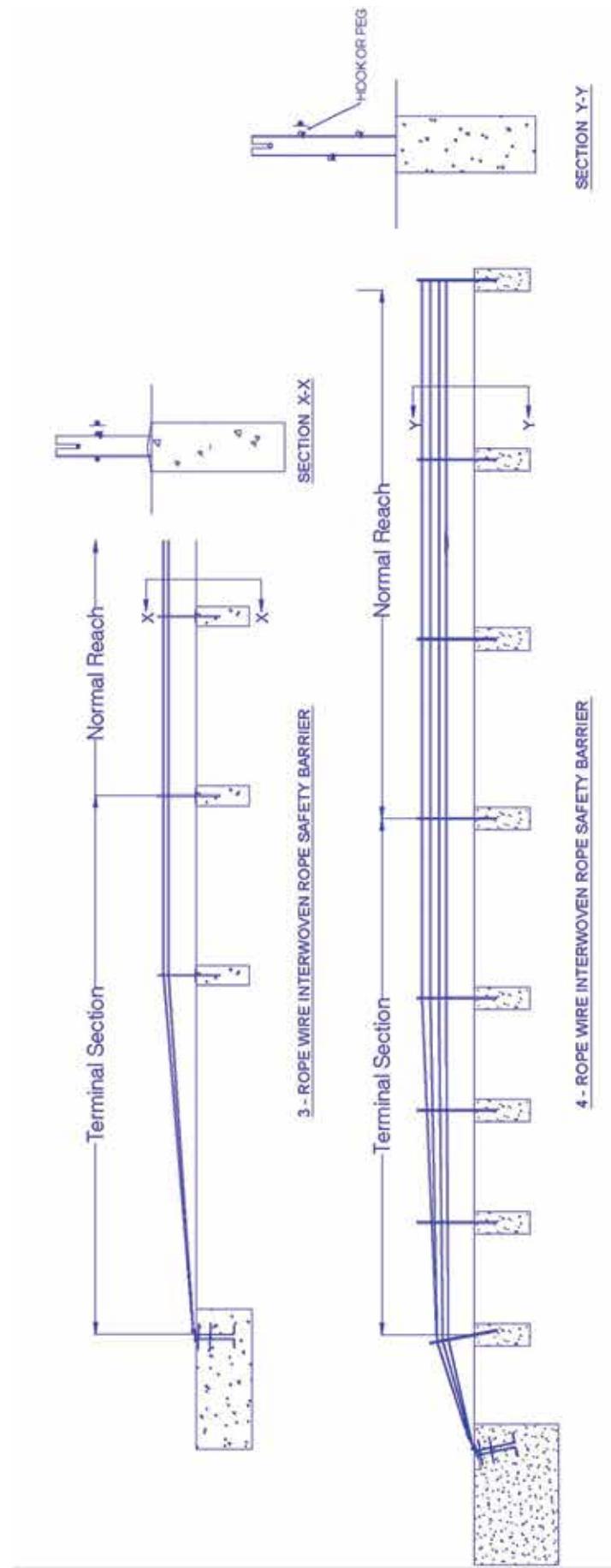


Fig. 9.17 Typical Details of Interwoven Wire Rope Safety Barrier

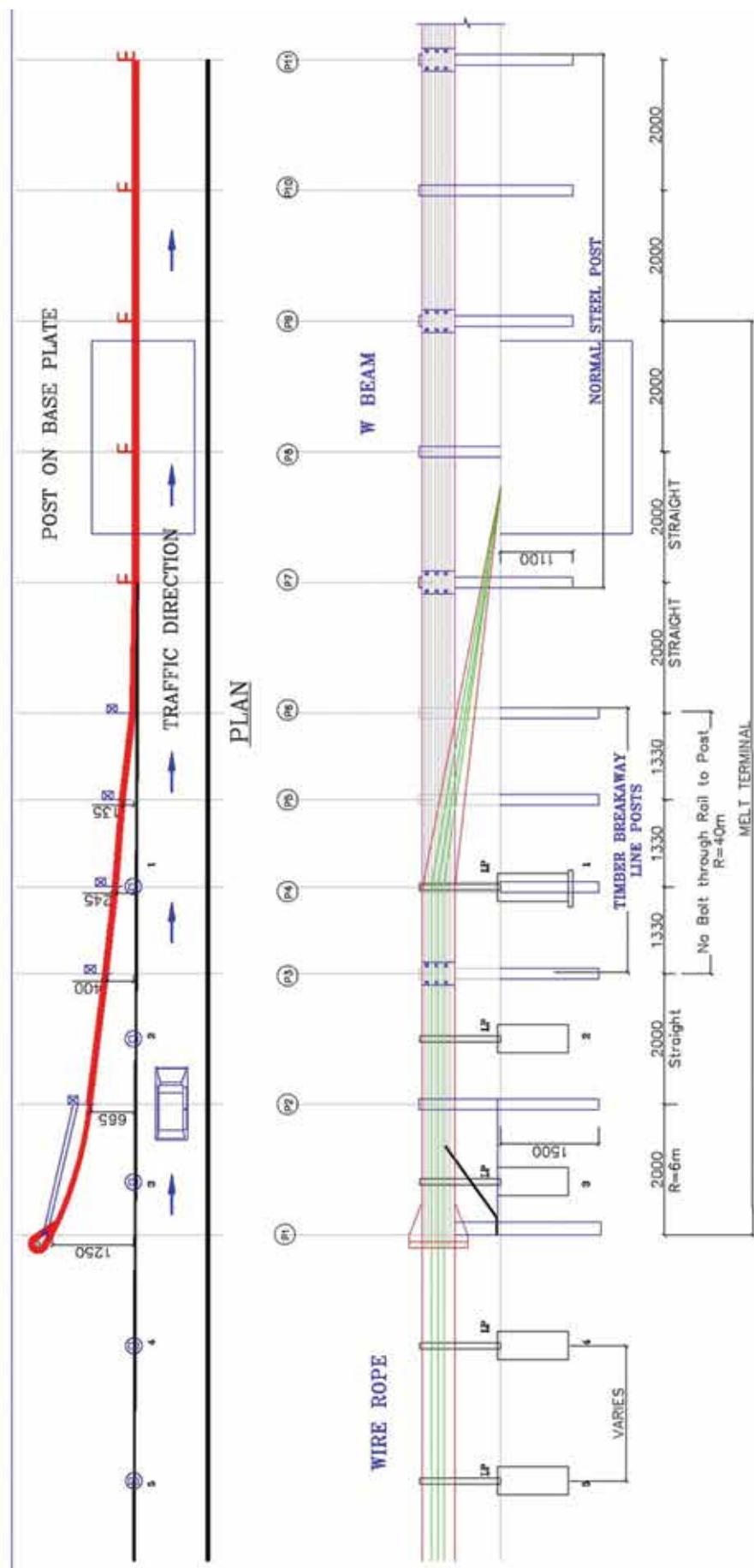
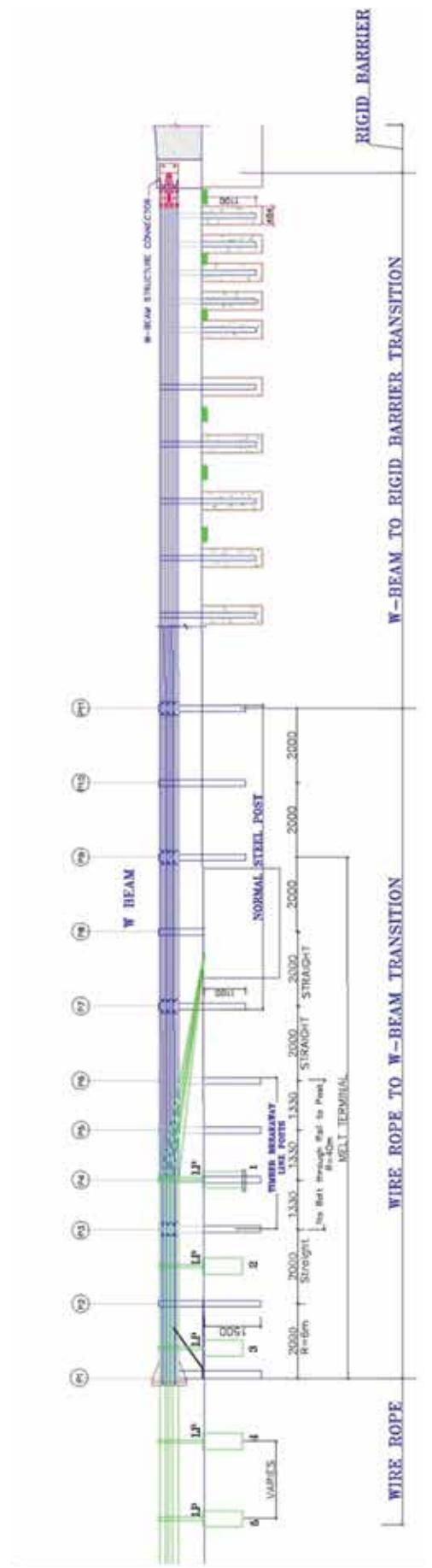


Fig. 9.18 Typical Details on Wire Rope to W Beam Barrier



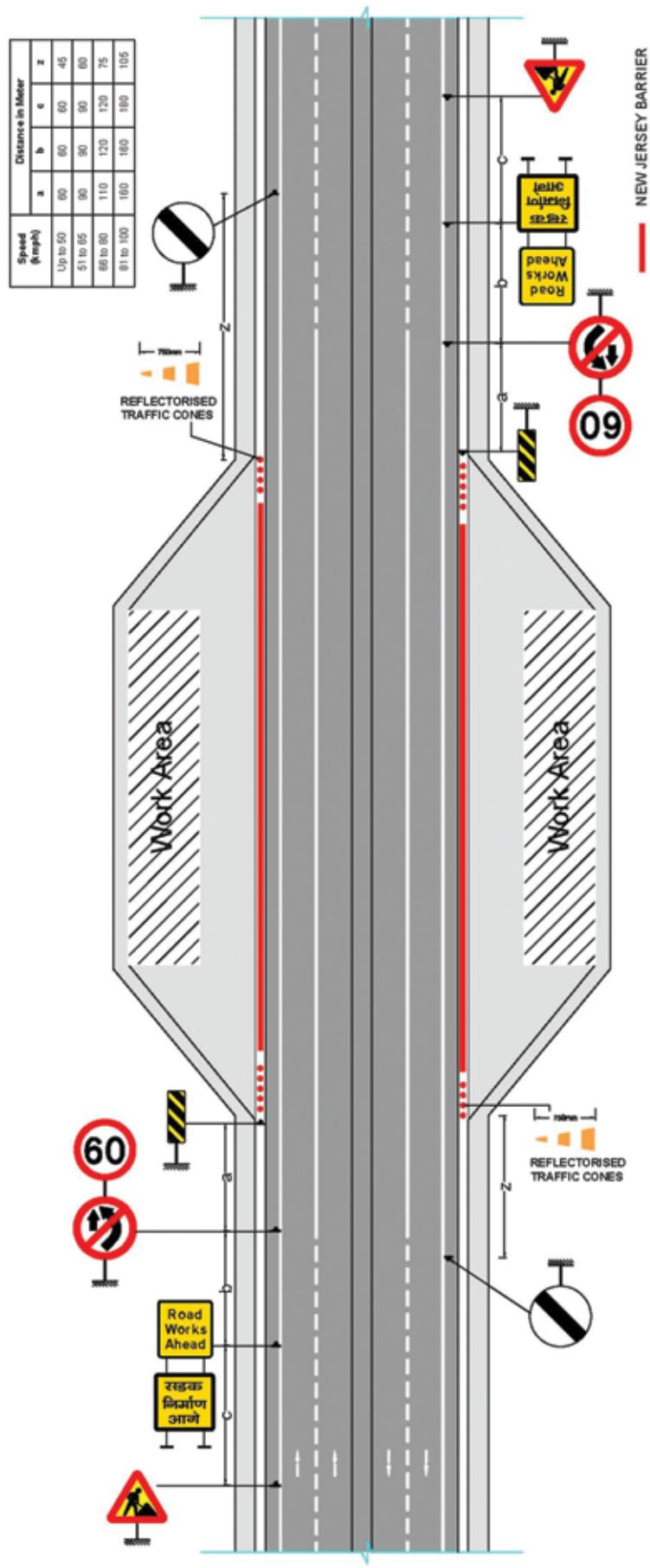


Fig. 9.20 Traffic Management during Lateral Widening

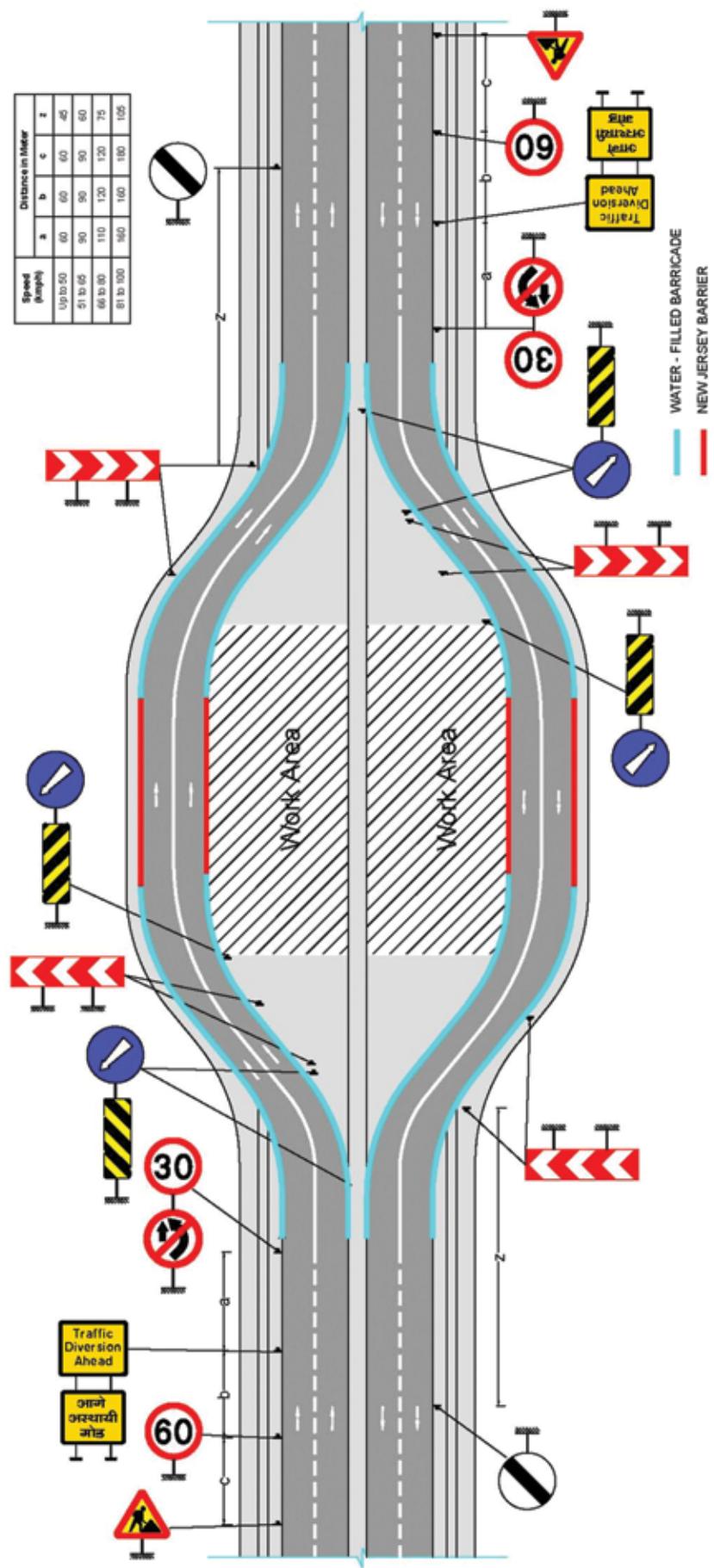


Fig. 9.21 Traffic Management for Shifting of Traffic from Carriageway to Service Road

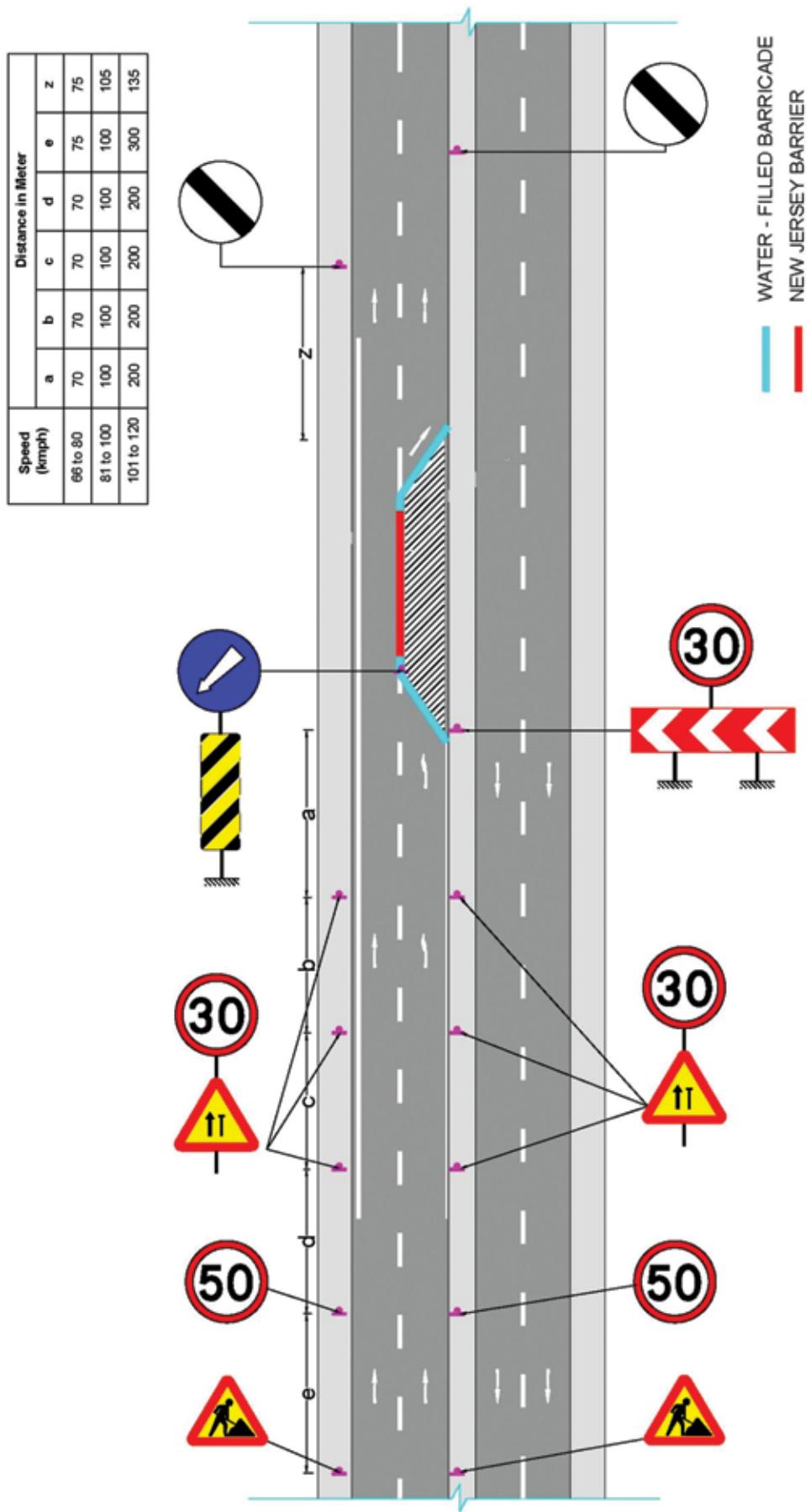


Fig. 9.22 One-Lane taken up for Maintenance Work during Operational Stage

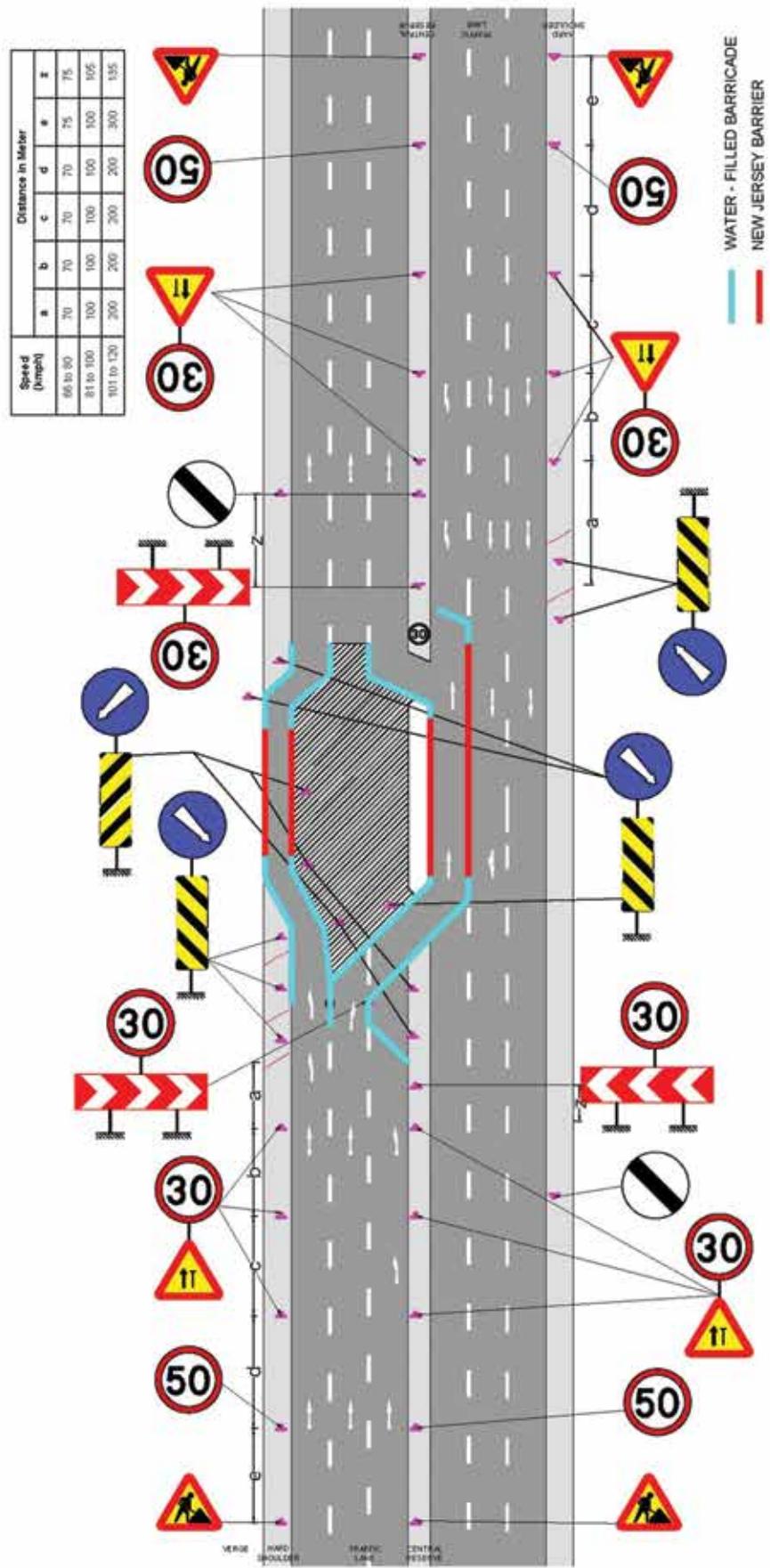


Fig. 9.23 Major Maintenance Work Affecting both Carriageway

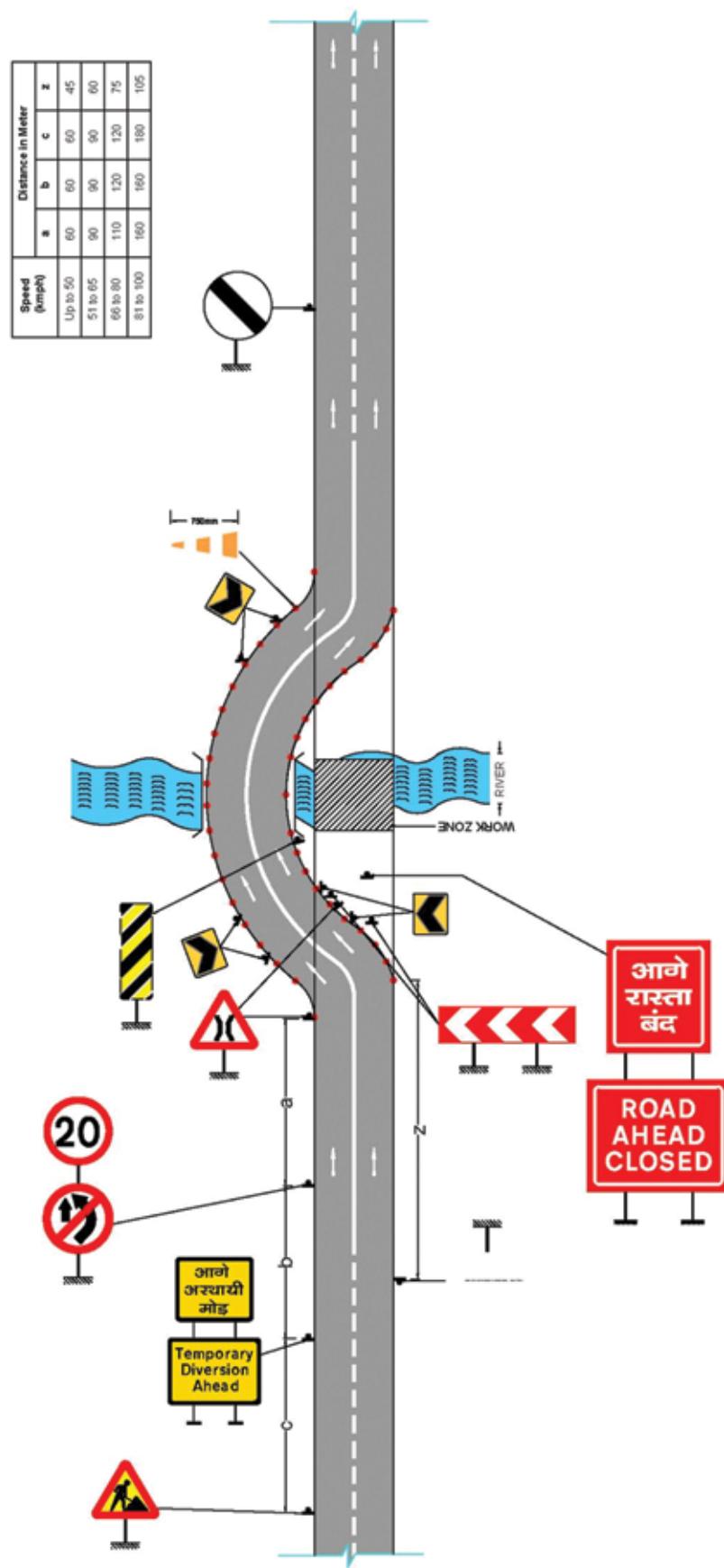


Fig. 9.24 Temporary Diversion for Reconstruction of CD Structures

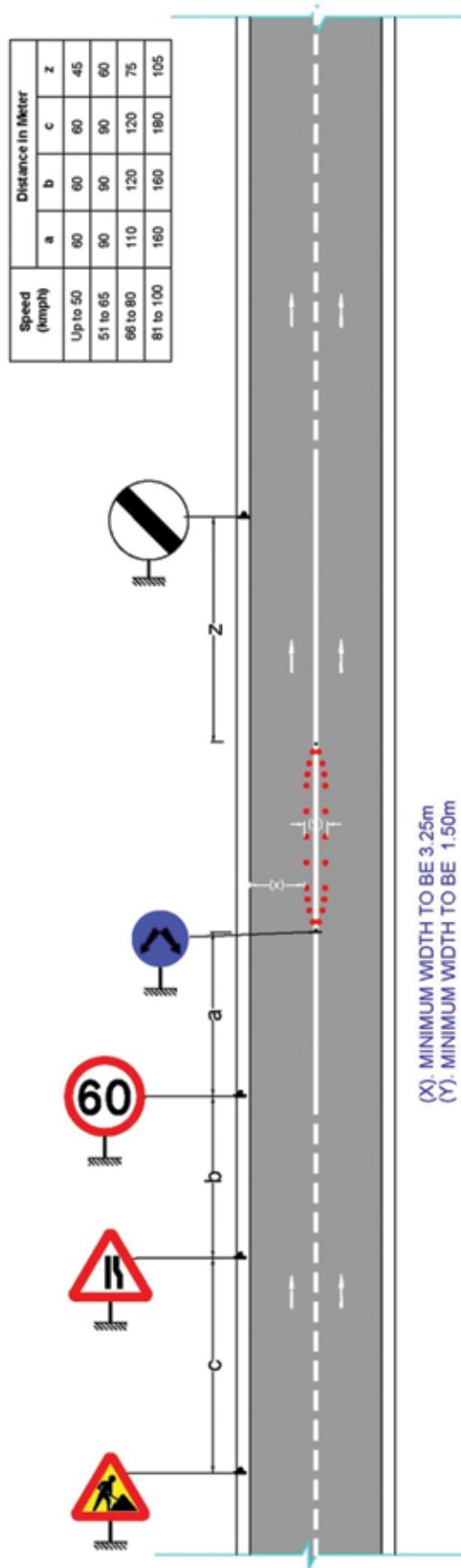


Fig. 9.25 Work at Centre of Carriageway

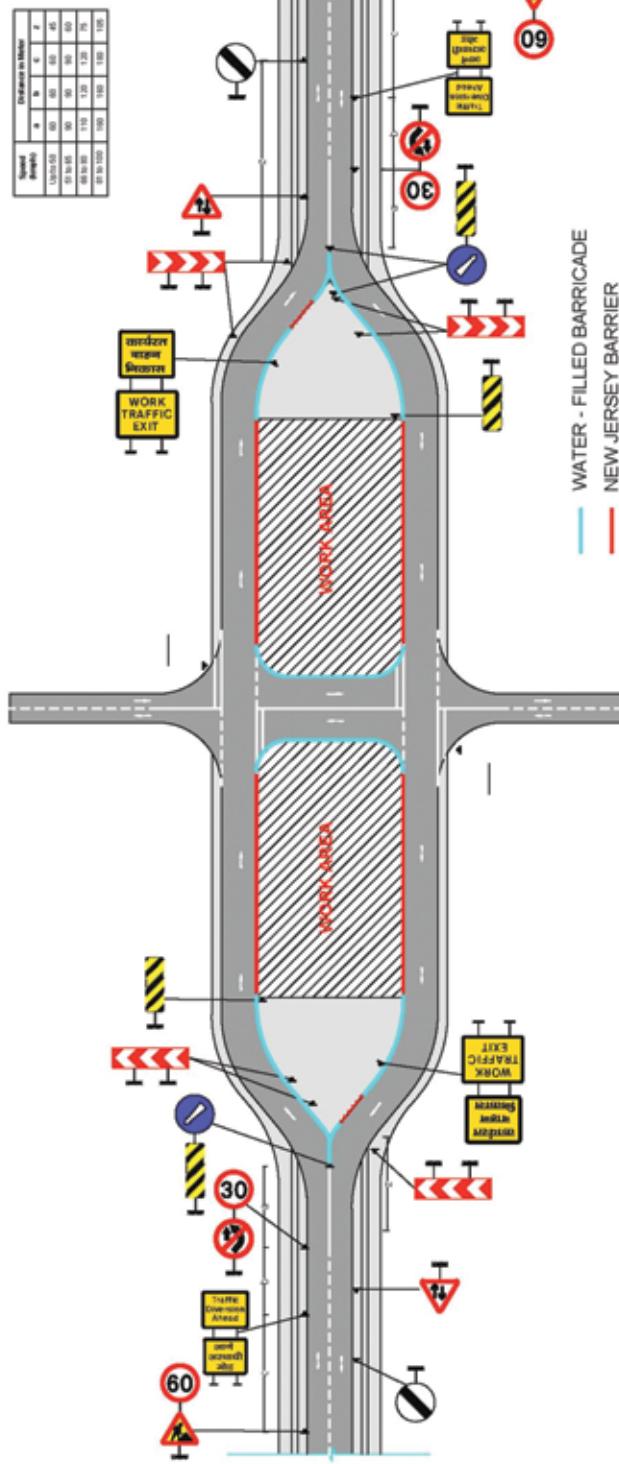


Fig. 9.26 Stage-1 of Flyover/VUP Construction

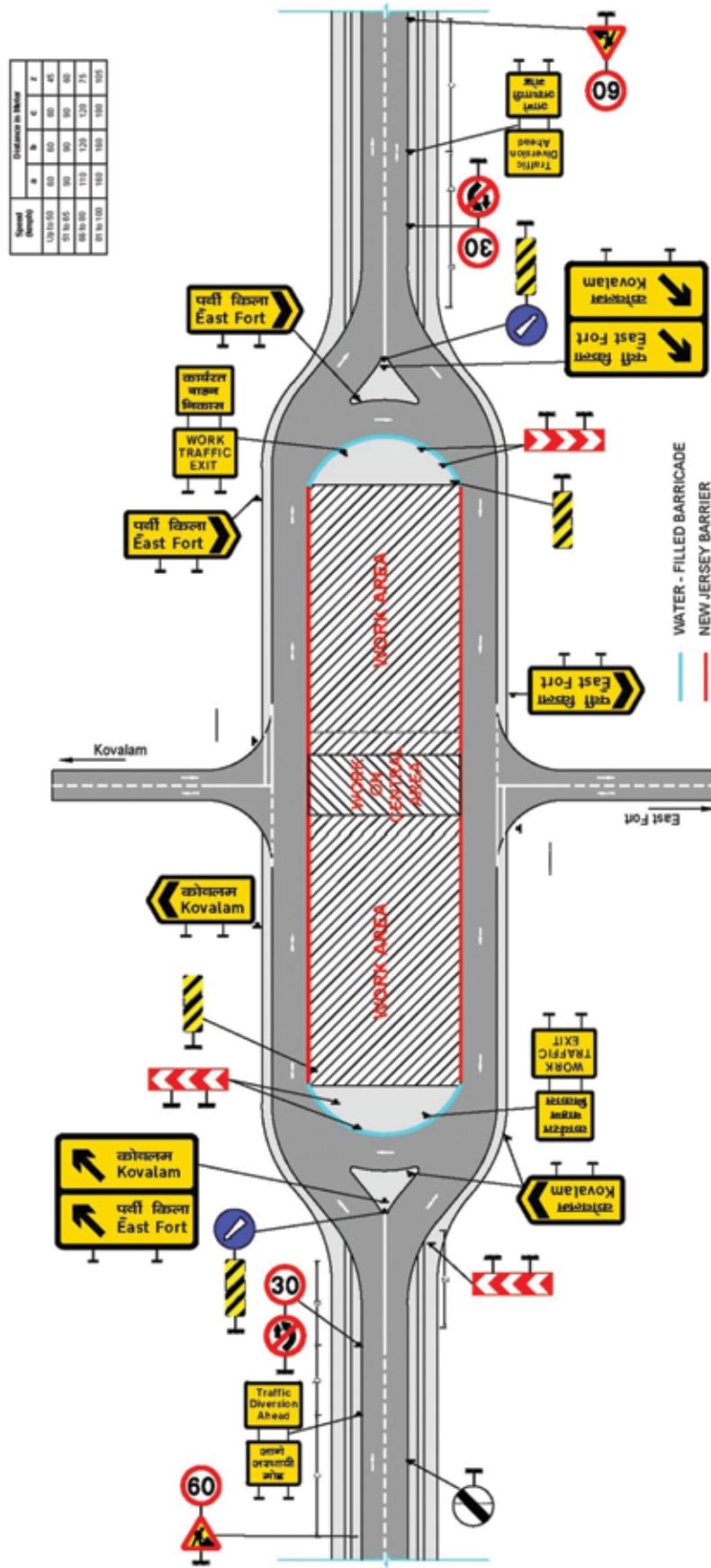


Fig. 9.27 Stage-2 of Flyover/VIP Construction

SECTION 10

TOLL PLAZAS

10.1 General

The Concessionaire shall provide the Toll Plazas at the locations specified in **Schedule ‘C’** for collection of toll fee as per the Concession Agreement. The fee collection system shall be speedy, efficient and user friendly. The design of the Toll Plazas should be such that they are aesthetically pleasing and efficient and the fee collection staff should be quick, courteous and adequately trained before deployment.

10.2 Location of Toll Plaza

The location of toll plaza shall be indicated in **Schedule ‘C’** of the Concession Agreement. Their locations shall be decided keeping in view the following factors:

- i) Land availability
- ii) Stream of traffic on Toll Plaza
- iii) Visibility for the approaching traffic
- iv) Reasonably away from road intersections and/or rail crossings
- v) Free from risk of flooding and submergence, etc.
- vi) Preferably on flat land and away from congested urban locations
- vii) Minimum diversion of traffic is possible.

10.3 Land for Toll Plaza

Adequate land for Toll Plaza shall be acquired to permit the provision of toll lanes for a projected peak hour traffic of 20 years subject to a minimum number of 16 toll lanes including all other buildings and structures to be accommodated at the Toll Plaza location. Land shall be acquired as per provisions of the Concession Agreement.

10.4 Layout and Design of Toll Plaza

10.4.1 Typical layout of a toll plaza along with building and associated facilities is given in **Fig. 10.1**. The layout shall provide for future expansion of toll lanes. Stage construction of Toll Plaza in respect of number of toll lanes shall be allowed. However, other structures as envisaged in the Concession Agreement shall be provided at the initial stage itself.

10.4.2 Width of toll lane

The width of each toll lane shall be 3.2 m, except for the lane for over dimensioned vehicles, where it shall be 4.5 m.

10.4.3 Traffic islands at the toll plaza

Between each toll lane of the toll plaza, traffic islands are required to accommodate toll booth. These islands shall be of minimum 25 m length and 1.9 m width. Protective barriers of reinforced concrete and traffic impact attenuators shall be placed at the front of each island to prevent out of control approaching vehicles crashing into the toll booth. They would be painted with reflective

chevron markings. For toll lane to be installed with weigh in motion system, the minimum length of islands shall be 35 m whereas 22.5 m on approach side.

10.4.4 Toll booths

Toll booths may be provided of prefabricated materials or of masonry. The toll booths shall have adequate space for seating of toll collector, computer, printer, cash box, etc. It should have provision for light, fan and air conditioning. The typical details of traffic island with toll booth are given in **Fig. 10.3**. Toll booth shall be placed at the centre of each traffic island. The toll booth shall have large glass window to provide the toll collector with good visibility of approaching vehicles. The bottom of the toll window should be placed at such a height (0.9 m) above ground level so as to provide convenience of operation. The toll booths shall be ergonomically designed and vandal proof. There shall be CCTV camera installed at each booth.

10.4.5 Tunnels

For the movement between toll office and toll booth of each toll lane, an underground tunnel across all toll lanes shall be provided. Its dimension would be sufficient to accommodate the required wiring/cable system and for convenient movement of personnel. It should also be provided with lighting and ventilation system so that the movement is convenient. The tunnel shall be of minimum 3 m width and 2.5 m height or alternately suitable safe overhead system of cash transfer may be planned, if required, and same shall be specified in **Schedule 'B'**.

10.4.6 Transition

A transition of 1 in 20 to 1 in 10 may be provided from six-lane section to the widened width at Toll Plaza on either side.

10.4.7 Canopy

All the toll lanes and toll booths shall be covered with a canopy. The canopy shall be wide enough to provide weather protection to toll operators, drivers and facilities. The canopy shall be of aesthetically pleasing design with cylindrical support columns located at traffic island so that there is no restriction on visibility and traffic movement. The vertical clearance shall be as prescribed in this Manual.

10.4.8 Drainage

The toll plaza shall be provided with surface and sub-surface drainage system so that all the storm water is drained off efficiently and no ponding or stagnation of water takes place at any area of the toll plaza.

10.5 Electronic Toll Collection

10.5.1 Hybrid ETC system of tolling shall be adopted. Design Layout of hybrid ETC is given in **Fig 10.2**.

The Concessionaire shall carry out, as per defined technical specifications, installation, testing, commissioning, operations and maintenance of Hybrid ETC System in all the lanes of Toll Plazas including but not limited to:

- i) Installation, integration, testing, commissioning, operations and maintenance of ETC RFID transceiver in all the lanes of Toll Plazas.
- ii) Installation, integration, testing, commissioning, operations and maintenance of Medium Speed Weigh in Motion in all the lanes of Toll Plazas and one Static Weigh Bridge in each direction of traffic at the Toll Plazas

- iii) Integration, testing, operations and maintenance of ETC RFID transceiver, Medium Speed Weigh in Motion, Static Weigh Bridge and other associated peripheral hardware into a single Hybrid Toll Management System/Software.

10.5.2 The Concessionaire shall ensure requisite civil work at Toll Plazas is completed prior to installation, integration, testing and commissioning of Hybrid ETC System. The Concessionaire shall ensure smooth flow of traffic during installation, integration, testing, commissioning of Hybrid ETC System and acknowledges that it will have no claims for against the Authority on account of any lane closure, if any and on account of any third party claims.

10.5.3 Scope of work

- a) The Concessionaire shall install, integrate, test, commission, operate and maintain Hybrid ETC System in all the lanes of the Toll Plazas. The list of equipment to be installed and commissioned for Hybrid ETC System and their minimum technical specifications have been provided in the **Annexure A**. A design layout of the Hybrid ETC system is provided in **Annexure B**. In case of EPC projects this will be provided by the Authority.
- b) The Hybrid ETC infrastructure shall be installed, commissioned, operated and maintained for a period of 5 years beyond which it shall be replaced or renewed as the case maybe, by the Concessionaire at cost of the Authority. The same cycle shall be maintained till the end of Concession Period as per the Concession Agreement.
- c) The Concessionaire shall set up a system within the Hybrid ETC System to provide real time data for user fee collection to the Authority as per mutually agreed templates. However, in case of any dispute, the template provided by the Authority shall prevail without recourse to the Dispute Resolution Procedure.
- d) The Concessionaire shall set up a system within the Hybrid ETC System to provide uptime availability data of all Hybrid ETC lanes in the Toll Plazas to the Authority. The Concessionaire shall design, procure/manufacture, install, test, commission operate and maintain a monitoring system that meets the concept and functions stated herein and detailed in **Annexure B**. However, in case the Concessionaire shows inability to set up a monitoring system, then Authority shall facilitate the set-up of such monitoring system that meets the concept and functions stated herein and detailed in **Annexure B**. The Authority, if it chooses, can setup a real time monitoring system or software on its own or through its representative. The Concessionaire will have to abide with data sharing of Hybrid ETC System uptime through this system as well. The Slow Speed Weigh in Motions (SSWIMs), if already installed and functional on a lane of the Toll Plazas shall not be removed. The installation of Medium Speed Weigh in Motions (MSWIMs) shall be carried out only on those lanes where there is no existing Weigh in Motion (WIM) equipment/hardware.

10.5.4 Service level

- i) The uptime availability of all critical components of Hybrid ETC lanes shall be 99 percent per lane per month for 90 percent of total lanes in a toll plaza (rounded off to nearest integer). For the balance 10 percent lanes, uptime availability of all critical components shall be 98 percent per lane per month.

- ii) The downtime for a toll lane shall be calculated at a cumulative level when any of the below mentioned critical component is non-operational for that specific lane:
 - a) ETC RFID transceiver
 - b) Automatic Lane Barrier
 - c) Lane Incident Camera
 - d) Automatic Vehicle Classifier
 - e) Hybrid Lane Controller
 - f) Any other plaza level or lane level equipment leading to disruption in ETC transactions
- iii) For all other components of Hybrid ETC System, the uptime availability shall be 98 percent per lane per month.
- iv) Scheduled downtime is defined as a period of time when system will remain unavailable for conducting necessary preventive maintenance, urgent repairs etc. The maximum scheduled downtime for any site shall be 4 hours per lane per month.
- v) The formula for calculation of Hybrid ETC System availability shall be as follows:

$$\text{System Uptime} = [1 - \{A/(B-C)\}] * 100$$

Where A = Time for which system is down per month basis scenarios identified in Clause 4B
 B = Total time in a month
 C = Scheduled downtime basis Clause 4D
- vi) The Concessionaire shall maintain adequate inventory to ensure the service levels prescribed in Clause 4A are adhered. Spares of critical components of Hybrid ETC System as identified in Clause 4B for at most 2-lanes shall be included in the cost of change in Scope of Work Order. There shall be no other provision or payment for additional Hybrid ETC equipment/hardware from the Authority.
- vii) The Concessionaire shall ensure that the Hybrid ETC Systems are operational as per the service levels defined in Clause A to facilitate payment of user fee through ETC. In case, a vehicle user with a valid, functional ETC RFID tag with sufficient balance in the linked account is not able to pay user fee through ETC through any lane owing to malfunctioning of Hybrid ETC equipment/hardware, the vehicle user shall be permitted to pass without payment of any user fee.
- viii) In case of non-adherence to service levels as defined in Clause 4A, suitable damages shall be levied on each lane by the Authority over and above the free passage of user as described in Clause 4G.
- ix) The Concessionaire shall ensure that all transaction files are uploaded as per defined service levels provided by the Authority or CCH. The service levels are prescribed in the table below:

S. No.	Description	Service Level	Damages
1	Sending clean transaction files in a specified format to CCH	<ul style="list-style-type: none"> Within 10 minutes of [ETC transaction] Up to 3 days of [ETC transaction.] 	<ul style="list-style-type: none"> Transaction post 10 minutes shall be processed only if the tag account has sufficient balance. In case of negative balance, the transaction shall be rejected. Liability of such transactions (after 10 minutes and before 3 days) shall lie with the Concessionaire. Transaction shall be rejected by CCH after 3 days.
2	<p>Sending violation transactions post audit at plaza level along with clear supporting images to CCH.</p> <p>The images should be clear enough to identify the vehicle class.</p>	<ul style="list-style-type: none"> Within 10 minutes of ETC transaction Up to 3 days of ETC transaction 	<ul style="list-style-type: none"> Transaction post 10 minutes shall be processed only if the tag account has sufficient balance. In case of negative balance, the transaction shall be rejected. Liability of such transactions (after 10 minutes and before 3 days) shall lie with the Concessionaire. Transaction shall be rejected by CCH after 3 days.
3	Populating blacklist file in the Hybrid ETC system of all the lanes.	<ul style="list-style-type: none"> Within 10 minutes of receipt from CCH 	<ul style="list-style-type: none"> Post 10 minutes, any clean/violation transaction file received by CCH for the same tag account with inadequate balance shall be rejected

- 10.5.5** A) The Concessionaire shall be provided a list of Acquiring parties by the Authority or a representative of the Authority amongst which the Concessionaire shall select one for the processing of ETC transactions. The list of Acquiring parties may be updated or modified from time to time by the Authority or a representative of Authority and the Concessionaire shall abide by all the terms and conditions of such directives.
- B) The Concessionaire shall effect and maintain at its own cost adequate insurance cover for any case of accidental damage to Hybrid ETC Systems. The Concessionaire shall indemnify the Authority against any claims whatsoever on this account.

10.6 Prevention of overloading

10.6.1 Toll plaza location shall also be provided with system for checking and preventing overloading of vehicles at Toll Plaza. For this purpose, weigh in motion systems at approaches to each toll lane are to be installed. Separate space for static weigh bridge and area to hold off-loaded goods from overloaded vehicles shall be provided after the toll barriers for each direction of travel.

10.6.2 The total number of toll booths and lanes shall be such as to ensure the service time of not more than 10 second per vehicle at peak flow regardless of methodology adopted for fee collection. For purpose of guidance following parameters are suggested as a capacity of individual toll lane for design purpose:

i)	Electronic toll collection (ETC lanes) (Toll collection through RFID Tags and no stoppage of vehicles)	1200 veh/hour
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Not less than 2 middle toll lanes shall be capable of being used as reversible lane to meet the demand of tidal flow.

Toll plazas shall be designed for projected peak hour traffic of 20 years. As mentioned in **Para 10.4.1**, the stage construction of toll plaza in respect of number of toll lanes shall be allowed. If at any time, the queue of vehicles becomes so large that the waiting time of the user exceeds three minutes, the number of toll lanes shall be increased so that the maximum waiting time is brought down to less than three minutes.

10.7 Pavement

Concrete pavement shall be provided in the Toll Plaza area including tapering zone, from durability and long time serviceability consideration and to permit the provision of toll lanes initially for a projected peak hour traffic of 10 years. The concrete pavement may be widened to provide for future toll lanes required as per stage construction. The rigid pavement shall be designed as per IRC:58. For this work, use of paver shall not be insisted.

10.8 Road Markings

The road markings shall be used in accordance with **Section 9** of this Manual. The road markings for the toll plaza area shall consist of lane markings, diagonals, chevron markings. Single centre line is provided at the centre of carriageway at toll gate to demarcate each service lane. Diagonal markings for central traffic island and chevron markings at side traffic island shall be provided to guide the approaching and separating traffic. **Fig. 10.4** gives typical toll plaza markings

10.9 Traffic Signs

A well thought out strategy should be evolved for providing traffic signs and road markings in and around the toll plaza in accordance with IRC:67 and IRC:35. The concessionaire would design the configuration/placement of signs for toll plaza which are not given in IRC:67 and furnish to IE for review so as to ensure uniformity of signs in use on all the highways across the country.

Signs should be placed along the project highway, roadway of toll plaza to guide and render assistance to the drivers approaching the toll plaza. It is necessary to alert the driver about the existence of toll plaza one km ahead with a repeater sign 500 m ahead as shown in **Fig. 10.4**, **Figs. 10.7A and 10.7B**. Stop sign shall always be used in combination with certain road markings such as stop line and the word 'STOP' marked on the pavement.

The toll plaza sign should be supplemented by the sign advising the users of the notified toll rates (fees) for various types of vehicles and exempted categories of vehicles as shown **Figs. 10.4, 10.5A and 10.5B**.

Overhead Lane Signs (O HLS) shall be mounted on the leading edge of the canopy covering the toll lanes above the centre of the lane to indicate to the user as shown in **Fig. 10.3, Figs. 10.6A, 10.6B, 10.6C and 10.6D**. Lane applicable to specific category of vehicle, lane with ETC System, reversible lane, etc. It shall also indicate whether the toll lane is open or closed for the processing of vehicles. A red cross signal would indicate that the lane is closed, whilst a green arrow would indicate that the lane is open to traffic.

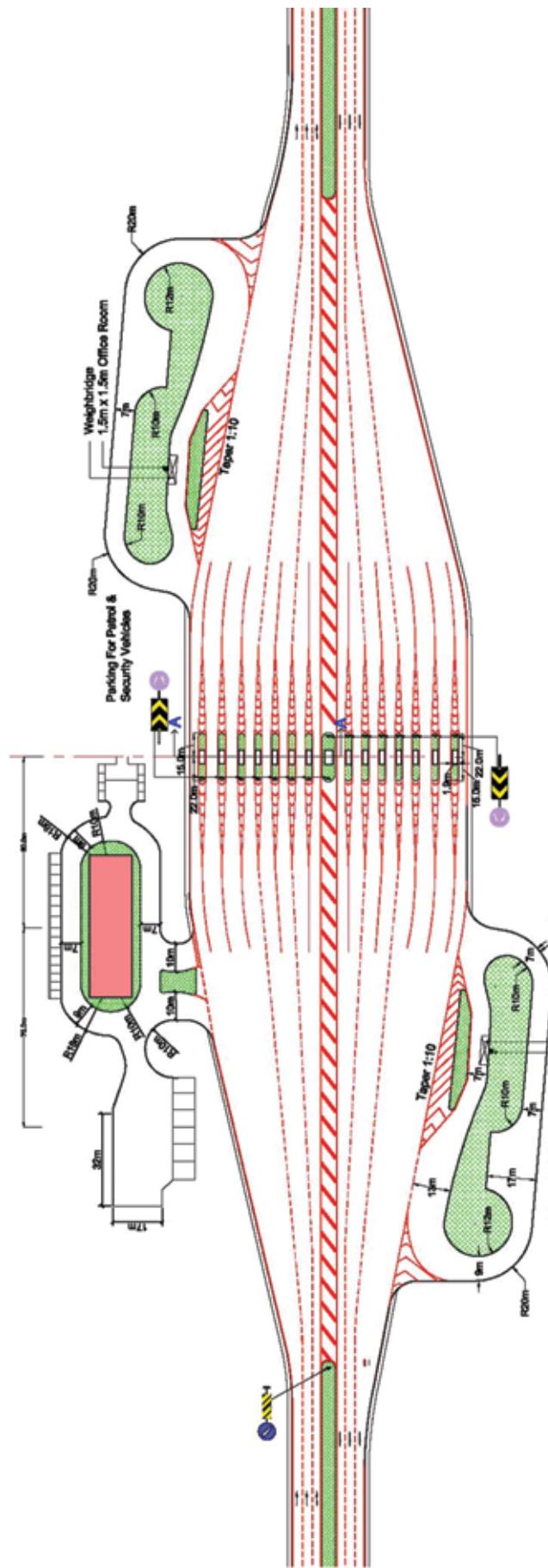


Fig. 10.1 Typical Layout of a Toll Plaza along with Building and Associated Facilities

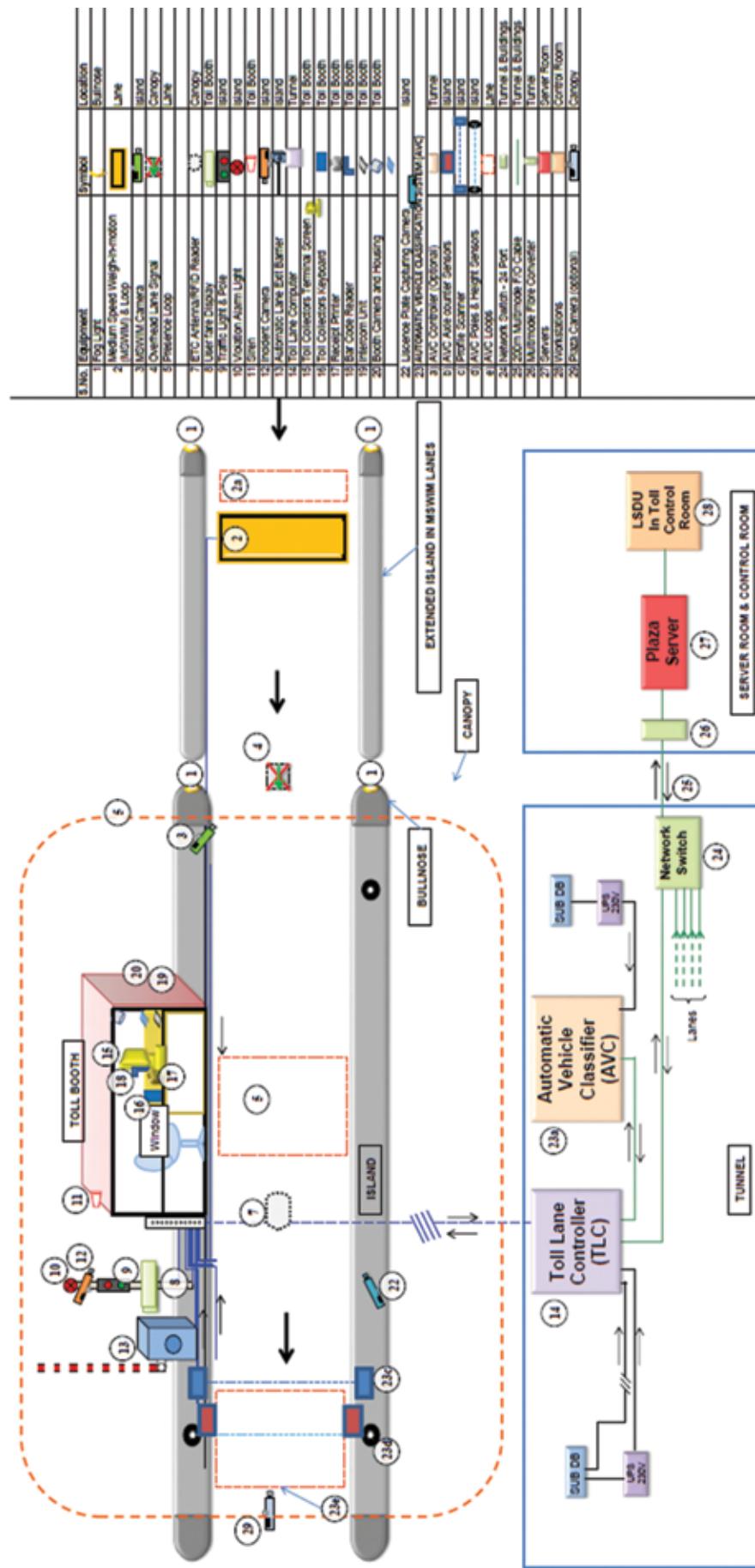


Fig.10.2 Design Layout of Hybrid ETC

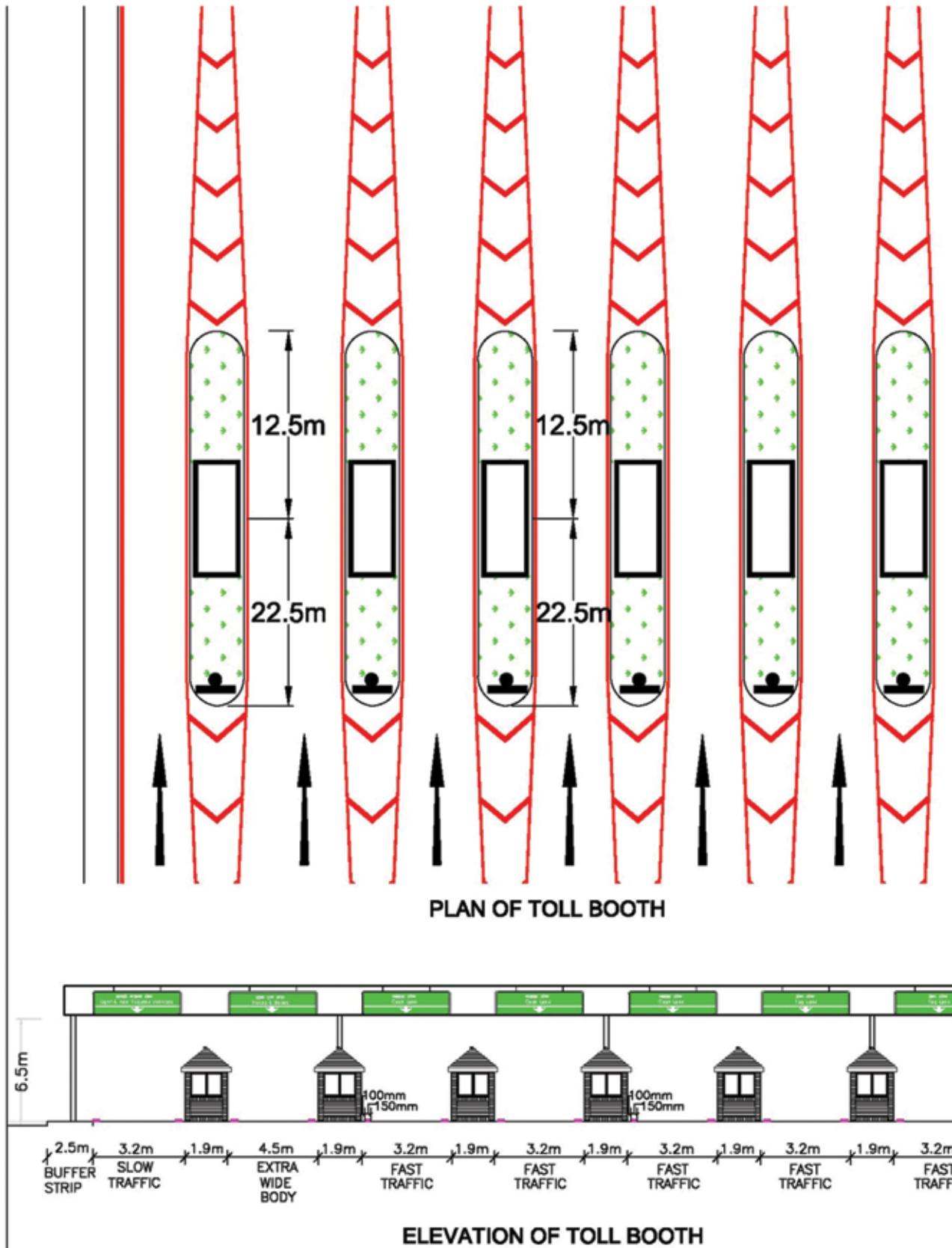


Fig. 10.3 Typical Details of Traffic Island with Toll Booth

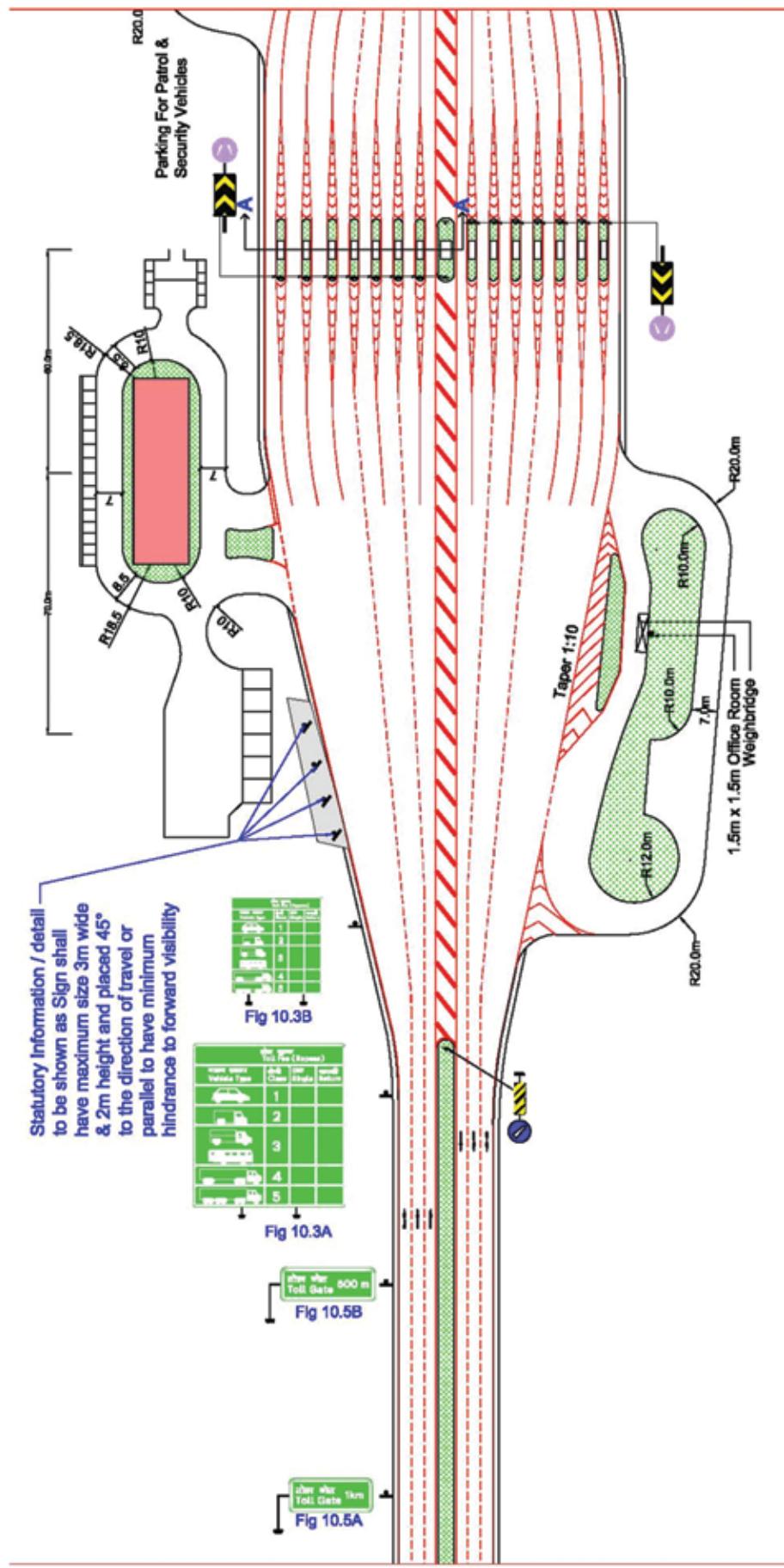


Fig. 10.4 Typical Toll Plaza Markings

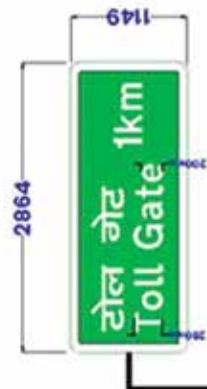


Fig 10.7A: Toll Gate Information Sign
(Font Size: Lowercase -200 mm & Uppercase-280 mm)

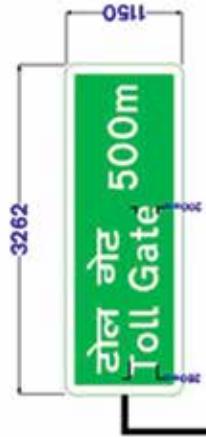


Fig 10.7B: Toll Gate Information Sign
(Font Size: Lowercase -200 mm & Uppercase-280 mm)

Vehicle Type	Toll Fee (Rupees)	
	Single	Return
Car	1	
2	2	
3	3	
4	4	
5	5	

Fig 10.5B: Toll Rate Sign
(Font Size: Lowercase -60 mm & Uppercase-84 mm)

Vehicle Type	Toll Fee (Rupees)	
	Single	Return
Car	1	
2	2	
3	3	
4	4	
5	5	

Fig 10.5A: Toll Rate Sign
(Font Size: Lowercase -100 mm & Uppercase-140 mm)



Fig 10.6D: Lane Dedicated Sign
(Font Size: Lowercase -120 mm & Uppercase-168 mm)



Fig 10.6C: Lane Dedicated Sign
(Font Size: Lowercase -120 mm & Uppercase-168 mm)



Fig 10.6B: Lane Dedicated Sign
(Font Size: Lowercase -120 mm & Uppercase-168 mm)

10.10 Water Supply

Adequate water supply shall be provided. For working out water requirement and internal drainage system, reference may be made to IS:1172, IS:5339 and IS:1742.

10.11 Fire Fighting System

Toll Plaza shall have fire fighting equipment, including smoke detectors and auto visual alarm system as per **Section 4.17.1** of National Building Code, so that the personnel working in the complex & the office and the road users are protected against fire hazards.

10.12 Toll Plaza Complex

Toll plaza shall have a separate office building so as to provide comfortable office space for manager, cashier and other staff. There shall be separate rooms for TV monitors, meetings, toilets, and for the sale of passes, smart cards, on board units and public interaction. The building shall have a strong room for keeping the cash and a garage to accommodate the security van (during operation of loading the collected revenue). There shall be parking space in the same campus for vehicles for the staff and workers and other vehicles engaged in the operation of the Project Highway. The size of the office complex depends on the minimum requirement of above facilities.

Provision for future expansion: The office building shall be located taking into consideration requirements of future expansion.

10.13 Toll Audit

The toll plaza shall have toll audit system and fraud protection measures. The operations for toll collection, supervision, auditing and cash handling shall be done through the qualified personnel with adequate number so that each operation is efficiently handled.

ANNEXURE-A
(Para 10.5.3)

Sr. No.	Item/Description	Unit	Quantity
I - Lane Level Equipment - Hybrid ETC Lanes			
1	ETC RFID transceiver near Pay-axis - mounted on canopy	No	1 per lane
2	Electronics Enclosure	No	1 per lane
3	Lane Controller with Industrial PC	No	1 per lane
4	AVC including sensors, loop and detector	Set	1 per lane
5	User Fare Display with mounting pole	Set	1 per lane
6	Automatic Barrier Gate	No	1 per lane
7	Overhead Lane Status light (OHLS)	No	1 per lane
8	Traffic light with mounting pole	Set	1 per lane
9	Loops with detector	Set	2 per lane
10	Incident Capture Camera with mounting pole	Set	1 per lane
11	License Plate Image Capture Camera with mounting poles	Set	1 per lane
12	TFT Monitor	No	1 per lane
13	Customized industrial grade keyboard	No	1 per lane
14	Thermal Receipt Printer	No	1 per lane
15	Barcode Reader with stand	No	1 per lane
16	Violation light & Alarm (on existing pole) and Foot switch in booth	No	1 per lane
17	Booth CCTV camera with voice recording	No	1 per lane
18	Cabling/Networking/Installation/Commissioning (Lump sum)	LS	1 per lane
19	Software – Lane Level	No	1 per lane
20	Intercom Slave unit in booth	No	1 per lane
21	Medium Speed Weigh In Motion	No	1 per lane

Sr. No.	Item/Description	Unit	Quantity
II - Plaza Level Equipment			
1	Plaza Servers in hot-standby configuration	No	1 per plaza
2	Static Weigh Bridge	No	2 per plaza
3	Workstations for MIS, Cashup, Audit & LSDU (Lane status display unit in control room)	No	4 per plaza
4	Network Printer	No	1 per plaza
5	8 Port Network switch (Layer 3)	Job	2 per plaza
6	24 Port Network switch (Layer 3)	Job	2 per plaza
7	Internet router for connection to the CCH	No	1 per plaza
8	Software – Plaza level	No	1 per plaza
9	Broadband Internet connection with minimum 2 Mbps link	Facility	1 per plaza
10	UPS system as required for complete Hybrid ETC Toll Plaza system	No	2 per plaza
11	55" LED Display for CCTV Monitoring	No	1 per plaza
12	Network Video Recorder (NVR) for CCTV recording	No	1 per plaza
13	CCTV cameras for Plaza building surveillance (server room, control room, cash up room, admin)	No	4 per plaza
14	Intercom Master Unit in Control Room - 10 Channel (For <=8 lanes)	No	1 per plaza
15	Intercom Master Unit in Control Room - 20 Channel (For >8 lanes)	No	per plaza

The minimum functional and technical specifications for hardware to be used in Hybrid ETC system at the plaza are specified in this section. The Concessionaire shall ensure that the equipment provided meets the basic functional criteria as prescribed in this section.

1.1 Queuing Area

1.1.1 Magnetic Loops

A) Functions

The magnetic loops shall be used for two purposes:

- i) **Presence Loop** – This is a single loop installed in the transaction area. This shall be triggered on the basis of vehicle detection leading to a certain set of activities as required.
- ii) **Exit Loop** – This is a single loop installed at the end of transaction used to trigger the exit barrier once the transaction has been completed.

B) Specifications

The loop detector units/cards shall conform to the following minimum requirements.

- i) The unit shall be easily removable and shall be fitted with at least two (2) loops per card.
- ii) The unit shall have a minimum of 4 separate adjustable sensitivity and frequency levels.
- iii) The unit shall have indicators for vehicle presence, loop on/off and failure.

1.1.2 Overhead Lane Status Sign (OHLS)

A) Function

The Over Head Lane Sign (OHLS) is located above the centre of the lane at the lane entrance. The purpose of the OHLS is to indicate to the User whether the toll lane is open for the processing of vehicle or closed. A red cross is used to signal that the lane is closed, whilst a green arrow is used to indicate that the lane is open to traffic.

Signs must be sufficiently bright and directed to indicate to a motorist, approaching the toll plaza, at a distance of 300 m on a bright cloud free day that the lane is available for use. The OHLS status shall also be visible up to a peripheral view of 45 degrees from the travel axis.

At any situation, both RED and GREEN part shall not glow simultaneously. Under failure conditions, only Red Cross shall be displayed until rectification.

B) Specifications

The following minimum specifications shall be met:

Description	Specifications
Size	300 mm X 300 mm
Display (Cross)	Red LED
Display (Arrow)	Green LED

Description	Specifications
LED	5 mm in diameter, 8000 mcd
Visibility Range	300 m
Enclosure	IP 65

1.2 Transaction Area

1.2.1 ETC RFID Transceiver

Concessionaire is free to choose any brand of ETC RFID transceiver as long as it satisfies the functional requirements prescribed by the Authority as below:

A) Functions

Each Hybrid ETC lane shall have one ETC RFID Transceiver. The ETC RFID Transceiver shall be mounted at least 5.5 meters above the finished road level. The Concessionaire shall provide cantilever pole (if required), brackets, fixtures and other accessories necessary for the installation of the RFID Transceivers.

The operator shall design the installation method of ETC RFID Transceiver and decide the height of the RFID Transceiver within the applicable laws and regulations. But in no case, the clearance from the ground level shall be less than 5.5 meter.

B) Specifications

Description	Specifications
RF/Radio:	
Frequency	UHF 865 to 867 MHz
Communications	Ethernet/Serial communication (EIA standard RS 232 C/RS 485)
RF Power maximum	1 W – transmitted & 4 W – EIRP (Equivalent Isotropically Radiated Power)
Reading distance	With the Transceiver mounted typically at a height of 6 m above the road surface, the coverage of the antenna shall not exceed a diameter of 3.6 m
Antenna	Circularly/Linear Polarized
Protocol	EPC Gen 2, ISO 18000-6C and shall comply with the general conformance requirements of the standard
Visual diagnostics	The Transceiver shall have LED indicators for sense; transmit Fault and Power which shall be visible clearly to the operator on ground while the system is operational.
Environmental:	
Enclosure	Light weight enclosure for the RFID Transceiver and circularly/linearly polarized antenna
Environmental	IP 65 or better for outdoor units
Relative Humidity	95% Condensing

Description	Specifications
Operating Temperature	-20°C to 55°C
Storage Temperature	-40°C to 85°C
Operational Characteristics:	
Air Interface & Adaptive Noise Features	The Transceiver technology employed should have the capability to optimize read rates for the vehicle identification application and adapt to instantaneous noise and interference level.
Application capability	1. Should have read reliability exceeding 99.5% in the distance range specified. 2. Diagnostic and Reporting Tools.
Upgradeability	The firmware should be upgradable to support future protocols.
Transaction Capability	Reading of Tag & EPC memory for at least 2 Tags per second for a moving vehicle with a speed limit of 40 kilometres/ hour.
Driver Software	The transceiver driver software shall be provided along with the transceiver that will interface to the ETC client through socket interface and handle the communication with ETC client. The packet structure shall be as notified in the ETC client-transceiver interface. The driver software shall implement filtering using a range of EPC-codes /Tag-TID code provided by set of bit pattern masks.

1.2.2 *Traffic Light with mounting pole*

A) Functions

The Traffic Light (TL) shall be located in the toll lanes in a position where it is readily visible to users of the toll road, usually on the side of the lane beyond the toll booth. The traffic light shall consist of two traffic light heads mounted on a suitable pole. An amber signal with arrow is used to indicate that the user should take suggested path, whilst the green signal is used to indicate that the user should proceed.

At any situation, both AMBER and GREEN part shall not glow simultaneously. Under failure conditions, only Amber arrow shall be displayed until rectification.

B) Specifications

The following minimum specifications shall be met:

Description	Specifications
Size	200 mm
Display (Stop)	Amber LED
Display (Start)	Green LED
Visibility Range	20 m (under normal visibility conditions)
Enclosure	SS
Protection	IP 65 rated

1.2.3 *Electronic Enclosure*

- A) All electronic interface and related peripheral/controllers shall be enclosed in an IP 65 compliant cabinet.
- B) The enclosure shall have a locking mechanism with a unique key providing access to the equipment inside.
- C) **Door monitoring:** The cabinet door shall be monitored utilizing proximity switch. Door open/close events shall be recorded as incidents identified by time and lane. The incidents shall be displayed on the plaza software subsystem.
- D) **Cabling Layout:** All external cables shall be protected against the effects of lightning and shall comply with all requirements for the control of interference from EMI. All data cables shall be screened and shall be properly separated and shielded from all power cables.
- E) **Ventilation and Internal Temperature:** All equipment endorsed by the cabinet shall be kept at a temperature consistent with manufacturers recommendations.
- F) **Finishing:** The cabinet surfaces shall be protected from the environment in which it is to be used and adequate surface treatments shall be applied. Each cabinet shall be painted and numbered in a manner consistent with the toll lanes and consistent with all equipment related functions (e.g. reporting to the plaza software subsystem).
- G) **Cable dressing:** All cables (power & signal) shall be properly routed and dressed with suitable railings inside the enclosure and ties.
- H) **Cable numbering:** The signal & power cable terminations shall be identified by proper numbering. In addition to the termination at the controller end, this numbering shall also be maintained at locations where the cables are exposed (like manholes, junctions) and at the peripheral end. Further, all the individual component boards shall be properly identified by labeling.
- I) **Cable terminations:** The signal & power cable (from the peripherals) terminations shall be kept separated inside the cabinet. The cable routing inside the enclosures shall be done in a proper manner, so that, the cable faults can be traced and faulty cables can be replaced easily and quickly.

1.2.4 *Hybrid Lane Controller (HLC)*

A) Functions

The Hybrid Lane Controller is used to control and monitor all the sub-systems and peripheral equipment and communication of the lane for user fee collection process and vehicle passage. The HLC is located in the booth or the tunnel. It is an electronic enclosure that houses the lane computer, AVC computer, peripheral coordination circuitry, redundant power supply, lane network switch and power protection blocks. It acquires the lane data and transmits to the Toll Management System (TMS) in real time.

The HLC shall be connected to the plaza, via fibre optic cable, and shall be required to transmit all transactions, incidents as well as other control information to the TMS in real time. All lanes shall be connected to the TMS server for this test. The LSDU shall be able to monitor activities of each lane in real time. The HLC shall be capable of interfacing with at least the following peripheral equipment:

- i) Fee Collector Display
- ii) User Fare Display
- iii) Overhead Lane Status Sign
- iv) Automatic Exit Barrier
- v) AVC System including loop
- vi) ETC Equipment
- vii) Incident Capture Camera
- viii) License Plate Image Capture Camera

The HLC shall be able to track and store in an accurate and fully auditable manner all lane and AVC transactions in a manner as to ensure the system and data integrity is not compromised in any way. A comprehensive test methodology shall be provided for this activity.

The HLC shall be capable of communicating with the local ETC server. Communication shall consist of data necessary to build a complete database in the local ETC server, from which the required financial and operating reports and statistics can be generated. The local ETC server shall also receive and log any reportable incidents occurring in the lane, which shall be transmitted real-time to the Incidents Computer (IC) for action by the toll supervision staff. In terms of incidents, real-time shall mean the time from the occurrence of the incident to the storage of the incident and the subsequent display of the incident on the IC; shall not be greater than 2 seconds.

Each Hybrid Lane Controller electrical component should be built on a single rack with its own electrical protections and automatic fuses. Each lane cabinet/enclosure shall have individual independent power sources, one from the UPS and another directly from the plaza power source. All the cabinet power inputs in the plaza are connected to an electrical switch to shut down the power of all plaza lanes for emergency purposes. Separate power supply (SMPS) shall be provided for AVC system and lane computer. The AVC computer shall have additional power back up (UPS) inside the electronic enclosure to provide power backup in case of complete shutdown of the plaza power supply. The UPS shall provide the backup of at least 4 hours to the independent AVC computer and AVC lane components.

B) System Configuration

The system located at the toll booth shall consist of at least the following:

- i) Lane computer
- ii) Independent AVC computer
- iii) Separate power supplies for lane and AVC computer
- iv) Power distribution panel with surge and lightening protection circuit
- v) Terminal blocks
- vi) Relays
- vii) Thermostat
- viii) IP 55 Electronic enclosure with high security locking mechanism

C) Lane Computer

Lane Computer shall be mounted inside the electronic enclosure. It shall acquire all the data from the lane peripherals and transmit them to the TMS in real time. The specification of lane

computer shall be upgraded as per the latest specifications/technologies available. A basic specification is provided in the table below.

Description	Specifications
Type	Industrial Grade Cabinet Computer
Motherboard	Industrial Grade
HDD	Based on estimated storage requirement for 6 months data
RAM	2 GB or latest as per requirement
Processor	Intel i3 or equivalent/higher
Processor Speed	2 Ghz or latest as per market
NIC	1 Gbps X 2 Numbers On-board
PCI Slot	2 Nos. spare
USB Port (for authorized)	4
Frame grabber card (if used for capturing images)	1 with 2 channels capable of capturing frames at the same time on both channel

D) Independent AVC Computer

Same as Lane Computer.

E) 8-Port PoE Industrial grade rugged Switch with 2 Fibre Port

This device shall have the capability to provide adequate continuous power to each of the CCTV cameras and associated equipment (e.g. video analytics module, PTZ mechanism) to meet the required performance, quality and reliability requirements.

- a) Switch shall have minimum 8 nos. 10/100Base-T (with minimum 6 PoE ports with power budget of 60W) ports and additional 2 numbers of SFP uplink ports loaded with MMF Modules.
- b) Shall have be IP 30 rated and shall work on up to 60°C temp in a sealed enclosure and should be DIN Rail mountable.
- c) Switch shall be IEC 60068-2-6, IEC 60068-2-27, IEC 60068-2-47, IEC 60068-2-64, IEC 61000-4-5 and NEMA TS-2 compliant.

F) 24 Port Switch with 4 Fibre Port

- a) Switch shall have minimum 24 nos. 10/100/1000 Base-T ports and additional 4 nos. SFP uplink ports loaded with MMF modules with dedicated stacking ports
- b) Switch shall have wire rate performance and 48 Gbps of dedicated stacking bandwidth.

1.2.5 Automatic Vehicle Classification (AVC) System

A) Functions

The AVC system shall be able to distinguish between pre-defined classes of vehicle. This information shall be transmitted to the lane computer, and simultaneously to the LSDU (Lane Status Display Unit) database system, on completion of AVC classification. The lane computer will match this information with the classification entered by the Fee Collector (FC). If there is a discrepancy between the two classifications, the incident capture camera shall be triggered to capture a digital image of the vehicle.

The classification sensors is a combination of the following:

- i) Height sensors, axle counters and profilers
- ii) Inductive loops

The choice of classification sensor rests with the Concessionaire. The Concessionaire can propose a better proven combination of above mentioned classification sensors. The treadles shall not be installed in the road directly without the frame for the same.

B) Specifications

The AVC shall have the following accuracy for the standard vehicles:

- i) For vehicle counting : 99%
- ii) For vehicle classification: 98%

The minimum specifications for Height Sensors shall be as follows:

Description	Specifications
Sensor type	Through beam
Sensor Range	Between 5 m
Light source wavelength	Infrared LED
Full clad housing	Outdoor mild steel
Power supply requirement	Vendor Specific
Access for maintenance, modularity of construction	All cables termination are well identified and have signal received indicator. Modular design with low cost maintenance.
Environmental Conditions	Operating Temperature of 10°C - 55°C
Sensor Type of Protection	IP 65
Reliability and maintainability	MTBF 30,000 hrs MTTR 1 Hour.

The minimum functional specifications for AVC shall be as follows:

In case of network failure, the AVC system shall function independently and store all data locally on a storage device. The data shall be sent to the independent database system via a separate data communication link which is different from the Hybrid Lane Controller.

The system shall be able to detect a vehicle moving in wrong direction.

The AVC computer

- i) Shall be a real-time processing unit
- ii) Shall be the trigger source for Incident Capture Lane Camera system
- iii) Shall have a local storage device capable of storing data for a period of at least 30 days.
- iv) Shall have a standby power supply capable of operations for a period of at least 24 hours

1.2.6 Medium Speed Weigh-in-Motion

A) Functions

- i) The MSWIM system shall be able to capture number of axles, axle spacing, number of wheels, gross weight of vehicle and height of each passing vehicle and provide data of each vehicle to the lane controller for further auditing and analysis.
- ii) The Gross Vehicle Weight of vehicles approaching the toll booth shall be automatically detected for speed range prescribed in the specifications.
- iii) This detected weight shall not be displayed on the computer terminal of toll collector until the toll collector classifies the vehicle.
- iv) If the vehicle is found to be overloaded based on Toll Collector Classification, the Weight information shall be displayed as “Overweight Warning” and appropriate toll receipts with 10 times the fare/fee, shall be generated automatically.
- v) The excess fee charged against such overloaded vehicles shall also be separately printed on user fee receipts of such vehicles.
- vi) MIS reports shall be available for the Authority, on numbers of overloaded vehicles crossing any toll plaza as per mutually decided format.

B) Specifications

Description	Specifications
Capacity of the Platform	30 Ton/Axle
Stationary Accuracy	±0.1% FSR
In Motion Accuracy	±7% FSR up to speed 50 Km/h; and
Overload capacity of the platform	150% of rated capacity
Vehicle separator	IR Based curtain housed in Weather Proof, IP 65 Rated pillars with proper sealing
Controller Housing	Water/ weather proof with anti-rust coating; IP 65 rated
Approval/ Certification	Weights & Measures Approved Model, Duly stamped & sealed by W&M Department on Installation
Re-calibration/ Stamping & Verification	Every 12 (Twelve) months
Downtime allowed for Periodic Maintenance	Maximum 24 (Twenty Four) hour/ Quarter

1.2.7 Fee Collector Terminal

The Fee Collector Terminal (FCT) shall consist of following equipment:

- A) Fee Collector touchscreen Display (FCD)
- B) Fee Collector Keyboard (FCK)
- C) Barcode Reader (BCR)
- D) Receipt Printer (RPR)

The FCT shall be the interface between the system and the Fee Collector. With the FCT, the collector shall be able to input the data in the system and the fee collector display and receipt printer shall provide the output data from the lane controller to the collector.

A) Fee Collector Display

The Fee Collector Display (FCD) shall be located on the Fee Collector's desktop and shall be screwed or bolted through the counter top. Suitable mounting brackets manufactured from stainless steel shall be provided to fix the screen to the desktop. All nuts and bolts are used to secure the FCT to the booth counter top shall be stainless steel. It shall be the system's interface to the fee collector, to display the status of transactions and status of the lane peripherals.

The minimum technical specifications are as follows:

Description	Remarks
Display Type	Touchscreen TFT with Diagonal Size of 18.5" Minimum
Cables	Power Cable 1 x VGA Cable (15- pin HD D – Sub)
Cable routes	Power cable is terminated to the Hybrid Lane Controller power distribution block via booth ducting VGA Cable is terminated to the SVGA Port at the LC via booth ducting
Colour	Manufacturer's Original Colour
Voltage	AC 230 V (50/60 Hz)
Power Consumption	80 W
Operating Temperature	0°C to 50°C
Relative Humidity	20% to 80%
Design Criteria	<ul style="list-style-type: none"> - Min. Resolution: 1024 X 768/60 Hz - Aspect Ratio : 4:3 - Number of Colours : 16.2 M, (6bit+FRC) - Video bandwidth: 70 MHz - Viewable size: 18.5" Minimum - MTBF: 30,000 hrs - MTTR: 0.25 hrs

B) Fee Collector Keyboard

The keyboard on the Fee Collector Terminal for registration of toll operations shall be a programmable Industrial Grade keyboard. The keyboard shall be used to enter data such as:

- i) Staff ID number
- ii) Classification of vehicle
- iii) Type of transaction
- iv) Accept/Cancel transaction
- v) Selecting method of payment
- vi) Operating OHLS
- vii) Bleed-off button
- viii) Violation Cancel/Accept Button

- ix) Simulation Button (Only to be used during Maintenance Mode)
- x) Alpha Numeric Keys in QWERTY format

The minimum specifications shall be as follows:

- i) Shall have good programming capability.
- ii) Programming under DOS and Windows, multiple page, multiple level, whole range key content, time delay, position sense answer back code, etc.
- iii) True spill-resistant design.
- iv) Optional blank key, double key for alternative key group layout.
- v) Optional Magnetic Stripe Reader
- vi) 70 programming keys + 6 position control key
- vii) Key top size: 18 mm x 22 mm for single key
- viii) Interface : PS/2 or USB
- ix) Dimension : 340 mm (W) x 150 mm (D) x 58 mm (H); Weight: upto 1.2 kg
- x) Color : OEM Specific

C) Barcode reader

Desktop mounted fixed barcode reader shall be installed in the toll booth on the fee collector desktop. The road user upon reaching the pay-axis of the lane will produce the return/ daily pass ticket. The fee collector will place the ticket on the barcode reader which will read the 2D barcode printed on the ticket. The lane controller shall get the transit details from the barcode which validates the ticket and authenticates the vehicle class (as entered by the fee collector) for processing of the transaction.

The minimum BCR features and specification shall be as follows:

- i) BCR shall be a high performance 2D omnidirectional laser scanner.
- ii) Shall have programmable sleep mode which can be reactivated by simple push of a button.
- iii) BCR shall perform Full automatic scanning operation.
- iv) Depth of Field: 300 mm (EAN 0.33 mm/13 mil, PCS = 90%).
- v) Scan Patten: 7 directions of scan field, 24 scan lines.
- vi) Scan Rate: 2400 scans/sec for omnidirectional scanning.
- vii) Dimension: 152 mm (H) x 152 mm (W) x 91 mm (D); Weight: not more than 500 g.
- viii) Interface: USB or Serial.

D) Receipt Printer

The thermal RPR shall be used to print receipts in the lanes. The printer shall be provided with the automatic advance function of the paper after printing so that the space for the first line of printing is aligned under the print head thus reducing the time taken to produce a receipt.

For design purpose, it shall be assumed that receipts will be approximately 70mm in length. The Authority and Project/plaza information will occupy space on the top. The area under this shall be used for particular printed data. The Concessionaire shall take the approval from the Authority for the format of the receipt.

The minimum technical specifications for the RPR shall be as follows:

Description	Specifications
Dimension	Maximum up to 145 mm (W) x 195 mm (D) x 148 (H)
Weight	Shall be less than 2 kg
Installation and Fixing Details	Installed and fixed on the Fee Collector desk
Cables	- Power cable - Serial RS232C/ Parallel /USB
Cable routes	Power cable is terminated to the HLC Termination Block via booth ducting. Data cable is connected to the HLC
Colour	Cool White/Dark Grey
Power Supply Requirement	24 VDC + 7%
Access for maintenance, modularity of construction	The cover can be opened for maintenance. It also has paper sensors. Off-the-shelf product.
Operating Temperature	5°C to 50°C
Relative Humidity	5 % to 90 %
Design Criteria	Print Speed: 47 LPS Print font: 9x17/12x24 Print column capacity: 56/42 columns
	Character size (mm): 0.99(W) x 2.4 (H)/1.41 (W) x 3.4 (H) Paper dimension (mm): 79.5 + 0.5 (W) x 83 (diameter) Paper thickness: 0.06-0.07 mm Auto cutter life: 1.5 million cuts Real-time printer status: Auto status back (ASB) messages MCFB: 52 million lines MTBF: 360,000 hours, Overall MTTR: 0.25 hrs

1.2.8 User Fare Display

A) Functions

The User Fare Display (UFD) shall be a LED display panel controlled automatically by the lane computer. It shall indicate to the road user the category of the vehicle and the amount payable/balance in prepaid account. The STOP/GO light shall be integrated in the UFD at the top corner.

B) Specifications

Description	Specifications
Size	750 mm x 400 mm
Display	Red LED
Visibility Range	10 m
Enclosure	MS
MTBF	50,000 hours

Description	Specifications
MTTR	Less than 30 minutes
Protection	IP 65

1.2.9 *Incident Capture Camera*

A) Functions

The Incident Capture Camera is installed at a convenient location on the island to capture images and video clips of the vehicles for the following incidents:

- i) Class discrepancy between the classes detected by the AVC and that entered by the fee collector
- ii) Exempt users
- iii) All transaction of vehicle with special events
- iv) Offending vehicles
- v) When the panic alarm footswitch is activated by the fee collector

The camera shall be installed inside the housing at the suitable height above the surface of the lane to be decided by the Concessionaire on a pole to record the vehicle images and video clip for every transaction in the lane. The vehicle images captured shall be of the front and right side portion of the vehicle.

General Requirements:

- i) The housing will be equipped with a hood to protect the camera under direct sunlight.
- ii) Protection: IP 65.
- iii) The stand of the lane camera shall be made of steel that shall not swing or twist under gutter speed of strong wind. The stand will be protected from corrosive environmental conditions.

B) Specifications

Description	Specifications
Image Sensor	1/3" Progressive Scan CMOS
Min. Illumination	0.01 Lux @(F1.2,AGC ON), 0 Lux with IR
Shutter time	1/25s ~ 1/100,000s
Lens	2.8 - 12 mm @ F1.4, Angle of view: 80°-28.7°
Lens Mount	φ14
Day& Night	IR cut filter with auto switch
Wide Dynamic Range	Digital WDR
Digital noise reduction	3D DNR
Video Compression	H.264/M-JPEG
Bit Rate	32 Kbps ~ 16 Mbps

Description	Specifications
Audio Compression	-S: G.711/G.726/MP2L2
Dual Stream	Yes
Max. Image Resolution	1280x960
Frame Rate	50 Hz: 25 fps (1280 × 960), 25 fps (1280 × 720), 25 fps (704 × 576), 25 fps (640 × 480), 60 Hz: 30 fps (1280 × 960), 30 fps (1280 × 720), 30 fps (704 × 576), 30 fps (640 × 480)
Image Setting	Saturation, brightness, contrast adjustable through client software or web browser
BLC	Yes, zone configurable
ROI	Yes, up to 4 configurable areas
Network Storage	Shall store data on NVR
Alarm Trigger	Motion detection, Dynamic Analysis, Tampering alarm, Network disconnect, IP address conflict, Storage exception
Protocols	TCP/IP, ICMP, HTTP, HTTPS, FTP, DHCP, DNS, DDNS, RTP, RTCP, PPPoE, NTP, UPnP, SMTP, SNMP, IGMP, 802.1X, QoS
Security	User Authentication, Watermark, IP address filtering, anonymous access
System Compatibility	ONVIF, PSIA, CGI, ISAPI
Communication Interface	1 RJ45 10M/100M ethernet interface
On-board storage	Built-in Micro SD/SDHC/SDXC card slot, up to 64 GB
Reset Button	Yes
Operating Conditions	-30°C ~ 60°C (-22°F ~ 140°F)
Power Supply	12 VDC ± 10%, PoE (802.3af)
Weather Proof	IP 66
Power Consumption	Max. 5.5 W (Max. 7.5 W with IR cut filter on)
IR Range	Up to 30 m

1.2.10 License Plate Image Capture Camera

The camera shall be installed inside the housing at the suitable height above the surface of the lane to be decided by the Concessionaire on a pole to allow the automatic number plate capturing of the vehicle in the lane.

A) General Requirement:

The system should automatically detect a vehicle in the camera view using video detection and activate license plate recognition. The system shall automatically detect the license plate in the captured video feed in real-time.

The system shall perform OCR (Optical Character Recognition) of the license plate characters (English alpha-numeric characters in standard fonts). It is expected that the software should provide at least 80% detection accuracy in day time and 70% during night time with proper IR illuminator and with standard license plates. The system shall be self-learning and shall improve the reading accuracy with time.

The system shall store JPEG image of vehicle and license plate and enter the license plate number into DBMS database along with date time stamp and site location details.

System should be able to detect and recognize the English alphanumeric license plate in standard fonts and format for all four wheelers including cars, HCV, and LCV.

The system shall be robust to variation in license plates in terms of font, size, contrast and colour and should work with good accuracy.

B) Vehicle Status Alerts

The system should have option to input certain license plates according to the hot listed categories like "Wanted", "Suspicious", "Stolen", etc. by authorized personnel such as administrator or supervisor. The system should be able to generate automatic alarms to alert the control room personnel for further action, in the event of detection of any vehicle falling in the hot listed categories.

C) Vehicle Status Alarm Module

On successful recognition of the vehicle number plate, system should be able generate automatic alarm to alert the control room for vehicles which have been marked as "Wanted", "Suspicious", "Stolen", "Expired". (System should have provision/expansion option to add more categories for future need).

D) Vehicle Log Module

The system shall enable easy and quick retrieval of snapshots, video and other data for post incident analysis and investigations. The system should be able to generate suitable MIS reports that will provide meaningful data to concerned authorities and facilitate optimum utilization of resources. These reports shall include:

- i) Report of vehicle flow at each of the installed locations for Last Day, Last Week and Last Month.
- ii) Report of vehicles in the detected categories at each of the installed locations for Last Day, Last Week and Last Month.
- iii) Report of vehicle status change in different vehicle categories

The system shall have search option to tune the reports based on license plate number, date and time, site location as per the need of the authorities. The system shall have option to save custom reports for subsequent use. The system shall have option to export report being viewed to common format for use outside of the system.

The system should provide advanced and smart searching facility of license plates from the database. There should be an option of searching number plates almost matching with the specific number entered (up to 1 and 2-character distance).

E) Central Management Module

The Central Management Module shall run on the video server in every TMS. It should be possible to view records and edit hotlists from the CCTV Workstation. The extracted data shall

be provided to other sub system through seamless integration. The system shall be integrated with Weight in Motion system which will detect overweight vehicles and will pass on the trigger to the licence plate image capture system to capture vehicle image with license plate.

The License Plate Image Capture system shall also achieve:

- i) Continuous monitoring of the operational status and event-triggered alarms from servers, cameras and other devices. This shall provide a real-time overview of alarm status or technical problems while allowing for immediate visual verification and troubleshooting.
- ii) Recording schedules can be continuous, event based, schedule based, trigger based etc.
- iii) Virtual Matrix – To allow viewing of live video in different layouts on operator screen.
- iv) Seamless working of fully integrated software platform.
- v) Archive search using dates, time, event etc.

F) Specifications

Description	Specifications
Image Sensor	1/2.8" Progressive Scan CMOS
Signal System	PAL/NTSC
Min. Illumination	0.05Lux @(F1.2,AGC ON) ,0 Lux with IR
Shutter time	1/25(1/30) s to 1/100,000s
Lens	E13: 6 mm@ F2.0 Angle of view:45.3°(4mm optional) E15: 12 mm@ F2.0 Angle of view:22°
Lens Mount	M12
Day & Night Function	Day Night visibility with color images/videos
Video Compression	H.264/MPEG4/MJPEG
Bit Rate	32 Kbps ~ 16 Mbps
Dual Stream	Yes
Maximum Image Resolution	1920 x 1080
Frame Rate	50Hz:25fps (1920×1080), 60Hz:30fps (1920 × 1080)
Image Settings	Saturation, brightness, contrast adjustable through client software or web browser
Alarm Trigger	Motion detection, Dynamic Analysis, Tampering alarm
Security	User Authentication, Watermark, IP address filtering, anonymous access
System Compatibility	ONVIF, PSIA, CGI
Operating Conditions	-10°C ~ 60°C (14°F ~ 140°F), Humidity 90% or less (non-condensing)
Power Supply	DC, PoE (802.3af)
Weather Proof	IP 66

Description	Specifications
IP Range	E13: Approx. 20-30 metres; E15: Approx. 50 metres
OCR	Yes
Note	This Camera needs external high power IR panel to illuminate license plate with a stronger IR light.

1.2.11 Emergency Footswitch Alarm System

A) Functions

The emergency footswitch is located in each booth under the fee collector's desk. The footswitch is provided for use in case of emergency or an accident. Pressing the footswitch shall raise an alarm to the auditor via the LSDU & activate a siren. The siren is fitted on the top of the booth. The siren also is triggered by the incidents like violation and the HP & MC convoy as mentioned in the design specification documents earlier.

B) Specifications

The minimum specifications for the emergency footswitch are as follows:

Description	Specifications
Installation and Fixing Details	Mounted on the floor inside the tollbooth under the desktop.
Cables	- Power cable - Signal cable
Cable routes	- The power cable is laid inside the booth manhole before terminating to the HLC Termination Block. - Data cable is connected to the HLC DI board from the termination block
Material and finishes	Steel
Colour	Manufacturer's Original Colour
Power Supply Requirement	220~240 V AC 50-60Hz with 10 A
Access for maintenance, modularity of construction	Modular Design, only plug and replace when fails
Environmental Considerations	Operating Temperature 0°C - 50°C
Reliability and maintainability	MCBF: 100,000 operations MTTR: 0.5 hrs

The minimum specifications for the siren are as follows:

Description	Specifications
Technology	Motor Driven or better
Audible rating	112 dB at 1 meter
Environmental	Designed to meet IP 54

1.2.12 Booth CCTV Cameras

A) Functions

The booth CCTV camera shall be a fixed dome type IP (Internet Protocol) colour camera installed inside the booth to capture the activities of the fee collector while performing his operations. The camera shall also capture the view of the paying vehicle.

These cameras shall have inbuilt voice recording and SD memory card of minimum 32GB for local storage of videos and voice recordings. These cameras shall be connected to the plaza video server installed at the TMS server room at each plaza building.

The camera shall be capable of triggering alarms in case of camera tampering detection and audio detection. The triggering alerts can be controlled by the control room operator.

B) Specifications

The technical specifications of the booth cameras shall be as follows:

Description	Specifications
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Fixed Focal
Focal Length	f = 2.8
Aperture	F1.8
Field of View	110° (Horizontal) 64° (Vertical) 135° (Diagonal)
Shutter Time	1/5 sec. to 1/30,000 sec.
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.08 Lux @ F1.8 (Color) 0.001 Lux @ F1.8 (B/W)
IR Illuminators	Built-in IR illuminators, effective up to 25 meters or better IR LED*8
On-board Storage	SD/SDHC/SDXC card slot
Compression	H.264 & MJPEG
Maximum Frame Rate	30 fps @ 1920x1080 In both compression modes
Maximum Streams	4 simultaneous streams
S/N Ratio	Above 55dB
Dynamic Range	97dB or better
Video Streaming	Adjustable resolution, quality and bitrate

Description	Specifications
Image Settings	Adjustable image size, quality and bit rate, time stamp, text overlay, flip & mirror, configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, scheduled profile settings, seamless recording, smart stream, 3D Noise Reduction, Video Rotation
Audio Capability	Audio input /output (full duplex)
Compression	G.711, G.726
Interface	External microphone input Audio output
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
ONVIF	Supported
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server, SD Card File upload via HTTP, SMTP, FTP, NAS server and SD card
Connectors	RJ-45 cable connector for Network/PoE connection Audio output DC 12V power input Digital input*1 Digital output*1
LED Indicator	System power and status indicator
Power Input	Max. 9 W (PoE)
Safety Certifications	CE, LVD, FCC Class B, VCCI, C-Tick
Operating Temperature	Starting Temperature: -10°C to 50°C (14°F~ 122°F)

1.2.13 *Intercom Slave Communication Unit (ISCU)*

A) Function

Intercom Slave Communication Unit (ISCU) shall be used for communication between the fee collector at the lane and the auditor/supervisor at the plaza building. It shall have the following functions:

- i) It shall provide hands free two-way verbal communication between the supervision staff in the control room and the Fee Collector. The Fee Collector shall be able to attract the attention of the auditor in the control room by pressing a single button on the intercom slave unit.

- ii) The equipment shall also have the facility to allow the supervision staff to monitor communication in the booth between the Fee Collector and the user or between any two booths without alerting the Fee Collector.
- iii) The voice communication system shall operate independent of the HLC system.
- iv) Voice communication shall also be implemented in various rooms of the plaza building and at building access points.
- v) Two-way communications shall be possible as soon as the auditor responds by selecting the appropriate lane button on the master communication unit.
- vi) One-way communication shall be possible from the Control Room intercom to all lanes simultaneously (broadcast).

B) Specifications

ISCU shall meet the following minimum specifications:

Description	Remarks
Installation and Fixing Details	Fixed in the booth (wall/desktop mount).
Speech Method	Hands-free
Wiring distance	120 meters with 0.202 mm diameter (33 AWG) cable, 300 meters with 1.024 mm diameter (18AWG) cable
Speaker	20 ohms
Power Consumption	6 W (max.)
Power Supply Requirement	Power supply from Master System
Wiring	2 wires, non-twisted
Environmental Considerations	Operating Temperature of 10°C to 50°C
Reliability	30,000 hrs

The operator may also propose/provide an IP based intercom system.

1.2.14 Automatic Lane Exit Barrier (ALB)

A) Functions

The function of the ALB is to control the passage of vehicles through the lane. Each lane shall be fitted with an ALB, the exact location of the ALB shall be provided by the Concessionaire in the lane layout drawing at the time of tender.

The operation of barrier is linked to the lane controller. It allows the vehicle to pass through after a successful transaction has happened at the lane.

The system consists of a fixed housing and a movable arm with a high impact breakaway device or provision. The housing shall contain the motor and control units along with the integrated metal detectors for vehicle detection purpose. The housing shall be installed on the right side of the traffic direction, after the booth on a concrete base.

The boom arms shall be fitted with a swing-away flange to prevent damages to the barrier/

vehicle in case of an unpermitted or forced drive-through. Boom contact shall be available which gives continuous alert to the TMS when the boom is missing or swung away.

B) Specifications

The ALB shall meet the following technical specifications:

- i) The lane exit barrier shall be suitable for high-speed ETC transactions. One full open-close cycle shall not take more than 1.2 seconds. The barriers used shall be capable of full lane open from a close state in less than 0.6 seconds.
- ii) The housing and any mounting frame shall be fabricated from corrosion-resistant materials. They shall be IP 55 rated. The barrier shall be driven electrically. The motor shall not be damaged when the barrier is blocked in any position. Exit barriers shall have presence detectors independent to the AVC system to prevent barrier arms coming down on vehicles while passing. This shall be in the form of infrared units and dedicated embedded loops. Apart from the barrier arm, the mechanism may not have any moving protrusions that pose a risk to persons standing in close proximity to the barrier.
- iii) The barrier arm shall be fabricated from a light, corrosion resistant material readily and inexpensively available in India. The barrier arm shall further have a protective mechanism whereby controlled fracture of the barrier arm occurs without damage to the housing or motor in the event of frontal collision. Preference will be given to non-destructive break-away mechanisms. Further, there shall be a protection mechanism to detect the presence of vehicles to avoid accidental hitting on the vehicles, whenever the boom is triggered for closing.
- iv) Suitable power supply scheme shall be implemented by the Contractor to feed the Exit barrier to protect the source from being damaged due to electrical surges/spikes injected by the dynamic (inductive) load. Further, the drive shall be so designed as to the damping factor is just sufficient for the drive to operate the booms without any jerks during open/close to avoid freak hitting by the exiting vehicles.
- v) Barrier arms shall have retro-reflective red stripes in accordance with the local traffic sign standards.
- vi) The Automatic Barrier Gate shall be IP 55 rated.
- vii) The Automatic Barrier Gate shall receive power directly from dedicated online UPS. Suitable protection shall be provided by the Contractor at the load end to protect the Boom Barrier. The Contractor shall fulfill any specific earthing requirement.
- viii) The following minimum specifications shall be met:
 - Boom Length: 3.5 m
 - Boom Material: Aluminium

1.2.15 Network Video Recorder (NVR)

H.265 Linux-based embedded standalone NVR shall be provided. Shall support 16-Channel /24-Channel/32-Channel network cameras. The NVR shall be ONVIF compliant and scalable configuration with features to help users to set up and manage advanced IP surveillance systems with ease. The NVR shall also support remote and mobile access, via web based application,

and app for both iOS and Android devices.

The NVR shall have minimum following technical features:

- a) H.265 Compression Technology
- b) Plug & Play One Button Auto Setup
- c) Intuitive, Intelligent and Interactive UI
- d) Live viewing, recording and Playback features
- e) Embedded Linux OS or OEM Specific
- f) Support RAID 0/1/5 Storage
- g) Up to 12MP Camera Liveview & Playback
- h) Dual Lan Network Ports with Failover Function
- i) ONVIF Open Platform

1.3 Administrative Area

1.3.1 Master Communication Unit

A) Functions

The master communication unit MCU is a master communication system to control communication between the fee collector at the lane and the auditor at the plaza building. The unit will be located in the control room and controlled by auditor/supervisor.

B) Specifications

Description	Specifications
Power Source	24V DC
Current Consumption	Max. 1A, 80mA in standby
Communication	Push-to-talk at master station hands free at sub station
Calling	LED and intermittent ringing tone at master until answered
Frequency Response	770 – 6800Hz
Total Harmonic Distortion	3% @ 1000Hz at 20 ohms
Mounting	Wall or desk mount
Wiring	2 conductor per sub station
MTBF	30,000 hrs

1.3.2 Static Weigh Bridge

The handling of overloaded vehicles shall be governed by terms of directives issued by the Authority.

A) Functional Requirements

- i) A Static Weigh Bridge (SWB) shall be installed in each direction of traffic, after the toll plaza, in a separate area having facility of parking of overloaded vehicles.

- This is to ensure that an overloaded vehicle does not ply on National Highways.
- ii) The SWB system shall be able to capture Toll Transaction Number with Date and Time, Vehicle Registration Number, Category of Vehicle, Permissible Weight, and Gross Vehicle Weight along with date/time of weighing, and the receipt printed by the SWB system shall contain these information. This system shall also be integrated with the toll system and generate a closure report.
 - iii) The SWB station shall have a CCTV camera for capturing image of vehicle while weighing.
 - iv) Monthly MIS reports shall be available for the Authority, such as Actual Over loaded vehicles, Total Overweight Vehicles (WIM) vs Actual Overweight vehicles (SWB) etc.

B) Technical Specifications

Type	Site specific (Pit/Pit less/Mobile)
Body/Platform	Steel
Size	18 meter x 3 meter
Capacity	120 Tonnes
Structure	I-Beam complying BIS 2062. Top Plate - 10 mm or more – Steel as per BIS 2062
Structure	Duly certified for Structural Analysis And Design(STAAD)-III
Number of Load cells	8
Type of Load Cells	Compression Type/Double Ended Shear Beam – Stainless Steel 17-4 Ph
Protection Class for the Load Cells	IP 68 or better, Operational Temp: -10 to 65 Degrees
Protection Class for the Weighing Indicator	IP 65 or better, Operational Temp: -10 to 65 Degrees
Overload capacity	150% of rated capacity
Accuracy Class	OIML - C-IV
Accuracy Tolerance	Up to 0.02%
Painting	Anti-rust & anti-corrosion painting
BIS Specification	IS-9281(Part-III)
Compliant	Legal Metrology Act 2009 (1 of 2010) & Rules framed there under from time to time - Duly sealed by the Weights & Measures Dept.
Approval/ Certification	Weights & Measures Approved Model

1.3.3 UPS System

A) Specifications

Online UPS with 4 hours of backup and sizing based on power requirement calculation, shall be provided. The UPS design shall take the following into account:

- i) The system shall be capable of maintaining an uninterrupted power supply to the UPS loads for a sustained period of at least 4 hours under full load conditions from a fully charged battery.
- ii) It shall also be capable of continuously supplying power to the system under an intermittent interruption cycle.
- iii) The UPS shall be capable of operating at input voltages of 210/380Volts ±10% and 50 Hz ±2.5 Hz.

1.3.4 Network Laser Printer (Black and White)

A) Specifications

At least 2 Network Printer shall be required in the Plaza office/Control Room with following minimum specifications:

- 25 PPM
- Duplex;
- Fast Ethernet; and should support Paper size(s): Letter/Legal/Executive/ Statement/8.50" x 13"/Envelope No. 10/Monarch Envelope/Custom Size.

1.3.5 Cabling

A) Specifications

All cables and wires shall be of good quality, conforming to normally accepted industry standards, and shall be of the proper type and have sufficient ratings for the particular application.

All exposed ends of unconnected cables and wires shall be coated with water tight sealing compound or sealing tape to avoid damage to conductors. All communication cables used shall have a clearly marked label securely fixed near each end in accordance with the cable network diagram.

All cables and wires shall be adequately protected from the edges of equipment housing or other surrounding objects. All the cables and wires shall be neatly arranged and securely placed in such a way that all terminals are relieved of the weight of the cables. Terminals shall be coded and identified as per the wiring diagrams. Live metal shall be recessed or protected to avoid accidental contact.

1.3.6 Workstation

A) Functions

The workstation will be used by the System Administrator and/or Toll Supervisor to access the system for Admin/Audit purpose. At least 4 work stations/laptops should be provided in the Plaza office/Control Room with following minimum specification.

B) Specifications

The TMS workstation shall comply with the minimum specifications prescribed in the below table.

Description	Specifications
Processor	Intel Core i5, Processor 2.4 GHz; 8 MB Cache, 1600 MHz, 4 Cores, Hyper threading, Intel HD Graphics

Description	Specifications
Memory(RAM)	4 GB or better
Storage	300 GB or better
Network	Integrated NIC
Ports	RJ-45, 1 USB 3.0, 3 USB 2.0
Monitor	18.5" LED
Input interface	Keyboard and Mouse
Antivirus	Yes

1.3.7 Server

A) Functions

The Plaza Server should have 1+1 redundancy and should be provided with Server Rack 24U, with fan and adequate power points and cable management adjustable for caster/wall mount.

B) Specifications

Description	Specifications
Form factor/height	2U Rack
Processor	4 - core Intel Xeon E5-2600 v2 series processors – 2 Nos. or better
Cache	15 MB per processor or Better
Memory	32 GB RAM, DDR 4, Shall be expendable to 64 GB
Internal Storage	Minimum 8 TB SAS/SATA or Better
Media bays	ODD and tape drive bay
RAID support	Integrated 6 Gbps or new optional 12 Gbps* hardware RAID-0, -1, -10 with optional RAID-5, -50, -6, -60
Power supply (std/max)	2 - Redundant Hot swappable
Hot-swap components	Power supplies, fan modules and hard disk drives
Network Interface Controller (NIC) Trusted Platform Module (TPM)	4 × 1 GbE (std.), 2 × 10 GbE Embedded Adapter (slot less opt.)/TPM
PCIe 3.0 Expansion slots (x16/x8)	4 - 6 PCIe ports or 4 PCI-X (CTO) or 2 double-width PCIe (for GPU)
USB ports	2 front/4 back/2 internal
Internal storage	Minimum 8 TB SAS/SATA or Better

Description	Specifications
Energy-efficiency compliance	80 PLUS® Platinum and ENERGY STAR® Compliance
Monitor	18.5" LED
Input interface	Keyboard and Mouse
Operating System	Windows Server 2012 Std. or Open source OS such as Linux, Unix flavours, as per requirement of Toll Management System.

1.3.8 *Display for CCTV Monitoring*

The Display shall be a 55" inch professional grade display with wide viewing angle, full HD resolution and shall be suitable for 24x7 indoor application. The monitor shall have high contrast ratio, lightweight design, full high definition 1920x1080 resolution, and anti-glare panel. It shall have inbuilt VGA, DVI, S-Video and HDMI ports for multiple video inputs.

Description	Specifications
Panel Size	55 inch
Light source	LED Backlight
Resolution	1920 X 1080 pixels
Dynamic Contrast Ratio	1400:1
Viewing angle	Horizontal: 178 Degree, Vertical: 178 Degree
Display feature	Full HD; Panel
Response time	Minimum 8 ms
Lifetime	Minimum 50,000 Hrs.
Colours	Minimum 16 Million
Brightness	350cd/m ²
Panel thickness	Not more than 65 mm

1.3.9 *Network Switches*

A) **Functional Requirement for Switches**

- i) Switch should support port security, DHCP snooping, Dynamic ARP inspection, IP Source guard, BPDU Guard, spanning tree root guard.
- ii) Switch should be IPv6 Certified/IPv6 logo ready and Switch/Switch's Operating System should be tested and certified or in process of certification for EAL 2/ NDPP or above under Common Criteria Certification.
- iii) Switch should have 1:1 redundant internal power supply. Power supply modules, fan modules and transceivers modules should be hot swappable.
- iv) Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w,

802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z, 802.3az.

B) 24 Port Layer 3 Switch with 4 Fiber Port

- i) Switch shall have minimum 24 nos. 10/100/1000 Base-T ports and additional 4 nos. SFP uplink ports loaded with MMF modules with dedicated stacking ports.
- ii) Switch shall have wire rate performance and 48 Gbps of dedicated stacking bandwidth.

1.3.10 Building Surveillance System

The system shall be connected to the NVR. The Video Management Software installed on NVR shall provide the facility to control the cameras at the Supervision Control room at the plaza buildings.

The cameras shall be for monitoring of security areas such as plaza compound, security garage, control room, change of shift room and cash counting room, lobby, hallway, tunnel, fee collector walkway, parking, staircase, DG room, electrical room, server room, UPS room, loading bay, etc.

These cameras shall be – Fixed lens Bullet CCTV night vision colour cameras. The bullet cameras installed outdoor shall be installed in the weather proof enclosure.

A) Fixed lens Bullet CCTV night vision color cameras

Description	Specifications
Image Sensor	1/2.8" Progressive CMOS
Maximum Resolution	1920x1080 (2MP)
Lens Type	Fixed-focal
Focal Length	f = 3.6 mm
Aperture	F2.1
Field of View	83° (Horizontal), 53° (Vertical), 91° (Diagonal)
Shutter Time	1/5 sec. to 1/30,000 sec. or better
Day/Night	Removable IR-cut filter for day & night function
Minimum Illumination	0.06 Lux @ F2.1 (Color)
	0.001 Lux @ F2.1 (B/W)
IR Illuminators	Built-in IR illuminators, effective up to 30 meters
On-board Storage	Slot type: SD/SDHC/SDXC card slot
	Seamless Recording
Compression	H.265 & MJPEG
Maximum Frame Rate	30 fps @ 1920x1080
	In both compression modes

Description	Specifications
Maximum Streams	4 simultaneous streams
S/N Ratio	50 dB or better
Dynamic Range	95 dB or better
Video Streaming	Adjustable resolution, quality and bitrate, Stream
Image Settings	Adjustable image size, quality and bit rate, Time stamp, text overlay, flip & mirror, Configurable brightness, contrast, saturation, sharpness, white balance, exposure control, gain, backlight compensation, privacy masks, Scheduled profile settings, 3D Noise Reduction, Video Rotation, Defog
Audio Capability	Two-way audio (full duplex)
Compression	G.711, G.726
Interface	External microphone input
	Audio output
Users	Live viewing for up to 10 clients
Protocols	IPv4, IPv6, TCP/IP, HTTP, HTTPS, UPnP, RTSP/RTP/RTCP, IGMP, SMTP, FTP, DHCP, NTP, DNS, DDNS, PPPoE, CoS, QoS, SNMP, 802.1X, UDP, ICMP, ARP, SSL, TLS
Interface	10 Base-T/100 BaseTX Ethernet (RJ-45)
ONVIF	Supported
Alarm Triggers	Video motion detection, manual trigger, digital input, periodical trigger, system boot, recording notification, camera tampering detection, audio detection
Alarm Events	Event notification using digital output, HTTP, SMTP, FTP and NAS server, SD Card
	File upload via HTTP, SMTP, FTP, NAS server and SD card
Smart Focus System	Fixed Focus
Connectors	RJ-45 cable connector for Network/PoE connection
	Audio input
	Audio output
	DC 12V power input
	Digital input: 1, Digital output:1
LED Indicator	System power and status indicator

Description	Specifications
Casing	Weather-proof IP 66-rated housing
	Vandal-proof IK10-rated metal housing (Casing Only)
Safety Certifications	CE, LVD, FCC Class A, VCCI, C-Tick
Operating Temperature	10°C to 50°C

1.3.11 *Hybrid Toll Management System/Software – Lane and Plaza level*

- i) The Toll Management System (TMS) shall be responsible for capturing & processing toll transactions into information, that will be used to verify toll collections, provide toll collector control, cash-up and shall include a host of management tools and reports for the effective administration of the toll operation.
- ii) The TMS shall also assist in auditing the toll collection operation. It shall be a modular system with the capability for various modules and functions to perform independently at different levels of the toll collection operations.
- iii) The TMS shall have various customizable reports.
- iv) The TMS shall have financial management and traffic analysis tools to assist the Concessionaire in planning operations.
- v) The Service Provider shall ensure that security updates and latest service packs, “patches” are loaded on the Lane/AVC Controllers as well as Toll Plaza Servers. Industry standard operating systems shall be utilized and all user licenses shall be provided.
- vi) The database shall be an industry standard relational database management system and shall be supplied with all the latest service packs and patches, including required user licenses.
- vii) Toll Management System should be able to support all kind of Fare structures & Payment methods including, but not limited to, Daily Pass, Return Pass, Monthly Pass, Discounted tariffs, Exemptions, Open/Closed fare schemes etc. and shall meet the Tolling System requirements of the respective Concession Agreement.
- viii) Fully integrated with all other peripherals and systems such as WIM, SWB etc.
- ix) Shall be able to send data to Central data center designated by the Authority, in real time.

1.3.12 *Monitoring system*

System of the Hybrid ETC hardware in real time through a system logger shall be available. The monitoring system shall keep record of its operation and status of the various Hybrid ETC Systems and devices in a unified manner in the database. All incident and events shall be recorded. Data retrieval software shall be provided to retrieve and display the operating history of the specified systems and devices.

The system shall be used for monitoring the up-time of entire system (including each peripheral and network connectivity) including generation of system alerts/reports on system downtime for SLA monitoring/compliance. This shall also include monitoring of downtime of any lane/plaza level equipment, poor/low video quality, no video signal, communication network or bandwidth

related issues etc. Entire process of capturing downtime, reporting, escalating till resolution should be enabled within the system itself like standard CRM practices.

“ETC” shall mean electronic payment of user fee using RFID tags or any such device.

“Hybrid ETC System” shall mean new Electronic Toll Collection (ETC) system which will also facilitate other modes of payment of user fee apart from ETC mode of collection of user fee and includes all the hardware items as listed in **Annexure A**.

“ETC RFID transceiver, Medium Speed Weigh in Motion (MSWIMs), Static Weigh Bridge, Hybrid Toll Management System/Software” shall be defined as per the **Annexure B**.

“CCH” shall mean a company or body engaged by the Authority to undertake and act as the Central Clearing House for clearing and settlement of ETC transactions and other related services.

“Acquiring Party” shall mean an institution certified by the Authority or a representative of Authority to process ETC transactions at toll plazas.

SECTION 11

LANDSCAPING AND TREE PLANTATION

11.1 General

The Concessionaire shall plant trees and shrubs of required number and type at the appropriate locations within the Right of Way and in the land earmarked by the Authority for afforestation keeping in view of the IRC Guidelines on Landscaping and Tree Plantation. The Authority shall specify the number of trees which are required to be planted by the Concessionaire as compensatory afforestation or otherwise in **Schedule ‘C’** of Concession Agreement. In case the number of trees to be provided is not specified in **Schedule ‘C’**, the concessionaire shall not be required to plant trees. The Concessionaire shall also maintain the trees and shrubs in good condition during the Concession Period as per the maintenance schedule.

11.2 Design Considerations in Various Locations

11.2.1 Set-back distance of trees and other plantation

Trees on the roadside shall be sufficiently away from the roadway so that they are not a hazard to road traffic or restrict the visibility. Most vulnerable locations in this regard are the inside of curves, medians, junction corners and cut slopes. Trees shall be placed at a minimum distance of 14 m from the centre line of the extreme traffic lane to provide recovery area for the vehicle that runs off the road. A second row of trees 6 m further away will also be planted wherever possible. Preferably the first row of trees shall consist of species with thick shade and other rows of vertical type providing thin shade. The distances for alternative rows of trees shall be reckoned from the nearest edge of the unidirectional carriageway. No plantation shall be allowed on the embankment slopes.

11.2.2 Set-back of trees on curves

In plain terrain a stopping sight distance of 180 m corresponding to the design speed of 100 km per hour may be ensured on all curved sections of the Project Highway along the innermost lane. However, where there are site restrictions, their requirement may be reduced to 130 m corresponding to the design speed of 80 km per hour as a special case. The existing trees and vegetation on the sides have to be suitably thinned/trimmed, or even removed if necessary and a regular programme of pruning of the offending trees shall be undertaken as part of the maintenance operations. In all cases, location of trees shall be checked to ensure that clear vision of all highway signs/signals is available at all times to the motorists. Also, the foliage or trees shall not come in the way of roadway lighting. In urban/built-up sections of the Project Highway, trees can be planted on the raised footpaths, provided the distance between the edge of the kerbs and the nearest edge of tree is not less than 2 m.

11.2.3 Vertical clearance of trees and other plantations

For safe traffic operation, the vertical clearance available across the roadway shall be minimum 5 m. From this angle, the probable size of all plants shall be anticipated in advance, at the time of initial planting. To allow for the effects of growth, wind and rain, trees shall be trimmed to 6 m and 6.5 m above the pavement in rural and urban areas respectively.

11.2.4 Plantation in medians

In the sections of the Project Highway where median width is more than 2.5 m, shrubs shall be planted and maintained to cut-off headlight glare from traffic in the opposite direction.

Flowering plants and shrubs are eminently suited for the purpose. These shall be planted either in continuous rows or in the form of baffles. The height of shrubs shall be maintained at 1.5 m to cut off the effect of traffic lights coming from the opposite direction.

In the sections, where the width of median is less than 2.5 m, shrubs or flowery plants may be planted in between crash barriers or other means like plastic strips shall be provided to cut off glare.

The shape of shrubs and plants shall be suitably regulated so that there is no overgrowth either vertically or horizontally beyond the edge of the median.

In the vicinity of road intersections and median openings, median plantation shall be avoided or restricted to low-growing varieties to ensure adequate visibility.

11.2.5 Spacing of avenue trees

The spacing of avenue trees will depend on the type and growth characteristics of trees, requirement of maintenance, penetration of distant views, etc. A range of 10-15 m would meet the requirement for most varieties.

11.2.6 Choice of trees

The following guidelines shall be kept in view while selecting the species of trees to be planted:

- i) Trees shall be selected with due regard to soil, rainfall, temperature and water level.
- ii) Trees which become very wide shall be avoided as their maintenance would cause interference with traffic flow.
- iii) The species must be capable of developing a straight and clean bole up to a height of 2.5 to 3.5 m from the ground level.
- iv) The selected trees shall, preferably, be fast growing and wind-firm. These shall not be thorny or drop too many leaves.
- v) The trees shall be deep rooted, as shallow roots injure pavements.
- vi) In urban areas, the species selected shall be of less spreading type, so that these do not interfere with overhead services, clear views of signs/signals, and efficiency of roadway lighting.

11.3 Landscape Treatment

A suitable landscape treatment with provision of foundations and coloured lighting so as to enhance the overall aesthetics duly designed by a qualified and experienced landscaping architect, shall be provided at grade separators, elevated sections, viaducts, traffic islands, toll plazas, bus bays, truck lay byes, rest areas, O&M centre, etc. The locations where landscape treatment is to be given shall be specified in **Schedule 'C'**. The landscape treatment shall also be provided for special areas as given in IRC:SP:21 (Para 8).

11.4 Report to be submitted

The Concessionaire shall submit scheme for plantation of trees and landscaping treatments including their maintenance duly designed by a landscaping architect, and submit to the Independent Engineer for review and comments, if any.

SECTION 12

PROJECT FACILITIES

12.1 General

The requirement of the project facilities to be provided shall be indicated in **Schedule ‘C’** of the Concession Agreement. This shall include information regarding location and size of the facilities. Land required for provision of facilities shall be acquired by the Authority and the date of handing over of the land to the Concessionaire shall be indicated in the Concession Agreement.

12.2 Road Boundary Walls (RBW)

Road Boundary stones walls shall be provided at the boundary on both sides of the right of way available under the control of the Authority, except at ingress and egress points. These shall be spaced at 200 m. The boundary stones walls shall be of reinforced cement concrete as per Type Design given in **Fig. 12.1**.

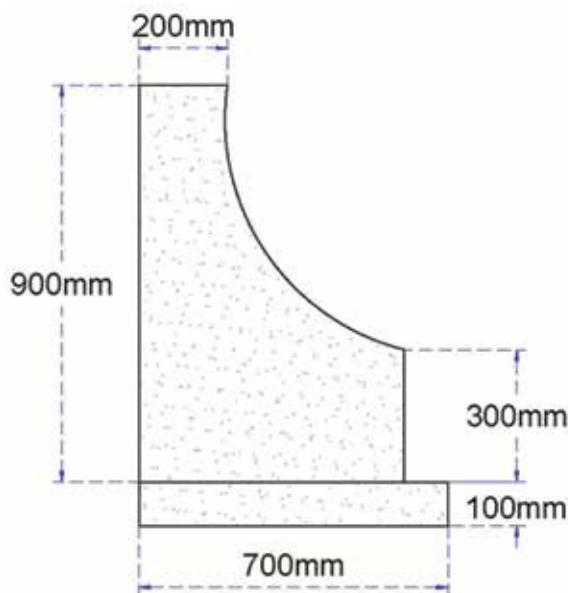


Fig. 12.1 Boundary Wall

12.3 Kilometre and 200 m Stones

- a) The km and 200 m stones shall be provided on both side of the project highway. The side of the road on which such stones will be provided, shall be decided by the Authority.
- b) The design and specifications of kilometer stones shall conform to IRC:8. The matter to be written on various kilometer stones and the pattern thereof, shall be as specified in IRC:8. 200 m stones shall be provided at every 200 m distance. The design and specification of 200 m stone shall conform to IRC:26. The matter to be written on various 200 m stones shall be as specified in IRC:26.

12.4 Pedestrian Facilities

Pedestrian facilities shall be provided as specified in **Section 9.8** of this Manual.

12.5 Street Lighting

12.5.1 General

- i) The concessionaire shall provide lighting at specified locations of the project highway, using appropriate system and source of electric power as per the requirements of this Section. Such locations shall be specified in **Schedule ‘C’**.
- ii) The Concessionaire shall make suitable arrangements for procuring power supply to ensure uninterrupted lighting during night and when visibility is low, including provision of DG sets as standby arrangements.
- iii) The Concessionaire shall bear all costs of procurement, installation, running and operation cost of all lighting, including cost of energy consumption specified in this Section.

12.5.2 Specifications

- i) Unless stated otherwise in this Manual, the minimum level of illumination on the locations of the Project Highway where lighting is to be provided as per this section shall be 40 Lux.
- ii) The layout of the lighting system together with type of luminaries for different locations shall be prepared by the Concessionaire in such a manner that the minimum illumination level prescribed in Para 12.5.2(i) can be achieved and shall be submitted to the Independent Engineer for review and comments, if any, for compliance by the Concessionaire.
- iii) Overhead electrical power and telecommunication lines erected within the ROW by the Concessionaire shall be provided with adequate clearance so that safe use of the highway is not affected.
- iv) Vertical and horizontal clearances for electrical installations shall conform to IRC:32.
- v) All the fixtures, wires/cables, lights shall conform to relevant BIS specifications as a minimum. The Concessionaire with the prior review and comments of the Independent Engineer can use fixtures with better specifications.

12.5.3 Locations where lighting is to be provided

Unless specified otherwise in **Schedule ‘C’** of the Concession Agreement and elsewhere in this Manual, the Concessionaire shall provide lighting at the following locations of the Project Highway:

- i) **Toll Plaza Area:** The lighting in and around Toll Plaza, toll booths, office building, on the approach road, etc. shall be as per **Section 10** of this Manual.
- ii) Rest Areas as given in Para 12.9
- iii) **Truck Lay-Bye:** Lighting at the truck lay-bye shall be as per **Para 12.6**
- iv) **Bus Bay & Bus Shelter Locations:** Lighting shall be provided as per **Para 12.7**
- v) **Grade Separated Structures, Interchanges, Flyovers, Underpasses (vehicular/pedestrian) and Overpasses:** Lighting shall be provided as per **Para 3.4.6** of this Manual.
- vi) Built-up sections on the Project Highway both in the median of main carriageway and on the service roads on either side.

12.6 Truck Lay-byes

12.6.1 General

The Concessionaire shall construct and maintain adequate number and size of truck lay-by for parking of trucks by the side of the Project Highway as indicated in **Schedule ‘C’** of the Concession Agreement. The Guidelines, as given here, shall be followed in regard to location, size and facilities to be provided at the truck lay-byes and a typical layout is given in **Fig. 12.2**.

12.6.2 Location and size

Truck lay-byes shall, in general, be located near check barriers, interstate borders, places of conventional stops of the truck operators, etc. The places be identified on the basis of field survey and shall have adequate space for facilities as specified in this section and future growth.

12.6.3 Facilities

The truck lay-byes shall have the following facilities:

- i) Paved parking,
- ii) Rest areas with toilets, drinking water,
- iii) Telephone

12.6.4 Lighting

The truck lay-byes and 50 m length of the Project Highway on its either side shall be illuminated at night to provide a average illumination of 40 Lux. Suitably designed electric poles having aesthetic appeal and energy saving bulbs may be used to provide required illumination. Alternatively, photo voltaic lamps may be used.

12.7 Bus Bays and Passenger Shelters

12.7.1 General

The buses shall be allowed to stop for dropping and picking up passengers only at the bus bays. The Authority will indicate in **Schedule ‘C’** of the Concession Agreement, the number and broad location of bus bays to be provided by the concessionaire. The bus bays shall conform to the Specifications and Standards given in this Section. In case where bus stands are provided by the concerned State Government Transport Authority, the Concessionaire shall provide only access road within the Right of Way.

12.7.2 Location

The location of the bus bays shall be fixed on the basis of following principles:

- i) The bus stops shall be sited away from bridges and other important structures and embankment sections more than 3 m high.
- ii) As far as possible, bus bays shall not be located on horizontal curves or at the summit of vertical curves.
- iii) The location shall have good visibility, not less than the safe stopping sight distance.
- iv) The bus bays shall not be located too close to the road intersections. A gap of 30 m from the tangent point of intersections to start/end of the bus bay shall be desirable. At minor intersections (e.g. junctions with village roads), distance of 60 m may be adopted. However, if a substantial volume of buses is to turn right

at the intersection, it is necessary that the bus bay shall be located sufficiently ahead of the intersection so that the buses can be maneuvered easily from the pick-up stop on the left hand side to the extreme right lane for turning. The location of the bus bays may be fixed after due consultation with the local communities expected to use such facilities.

- v) At major four-way intersections involving transfer of a substantial number of passengers from one pick-up stop to the other, it might be desirable to construct a single, composite bus stop of suitable design to cater to all the bus routes collectively.
- vi) In hilly areas, the bus bays shall be located, preferably, where the road is straight on both sides, gradients are flat and the visibility is reasonably good (usually not less than 50 m). Subject to these requirements, it will be advisable to choose locations where it is possible to widen the roadway economically for accommodating bus bays.

12.7.3 Layout and design

- i) For plain area, typical/layouts of bus bays given in **Fig. 12.2** shall be adopted. The length "L" shown in **Fig. 12.3** shall be 15 m. which shall be increased in multiples of 15 m if more than one bus is likely to halt at the bus bay at one time.
- ii) For hilly areas, where there is a general constraint on space, the layout indicated in **Fig. 12.4** may be adopted.
- iii) The chanellizing island between the paved shoulder and bus-bay shall not be raised but it shall be paved with CC blocks.
- iv) Bus bays shall be provided on both sides of the project highway for each direction of travel independently, so that the buses do not have to cut across the road. Bus bays on opposite sides shall be staggered to a certain extent to avoid undue congestion on the highway. At intersections, the bus bays for up and down direction shall be located on farther sides of the intersection.
- v) Covered steps with rise not exceeding 150 mm (minimum 5 m wide) along with a ramp for use of disabled persons (1 m wide minimum) with railing on either side shall be provided for climbing up/down from Bus Shelter to underpass/overpass to carriageway and vice versa. The cover of the steps shall be aesthetically pleasing and protect the users from sun, wind and rain. The entire area used by the pedestrians shall be provided with granite stone cladding and flooring.
- vi) The bus bay shall be provided with a shelter for passengers. The shelter shall be structurally safe and aesthetic in appearance, while also being functional so as to protect the waiting passengers adequately from sun, wind and rain. If the shelter is constructed on the hill side, slopes shall be properly dressed and suitably protected to avoid slips.
- vii) The bus bay and passenger shelter shall be designed to provide for safe and convenient use by physically challenged persons as well.

12.7.4 Pavement

The pavement in the bus bays shall have adequate crust with respect to the wheel loads expected. Also, the surfacing shall be strong enough to withstand forces due to frequent braking and acceleration by the buses.

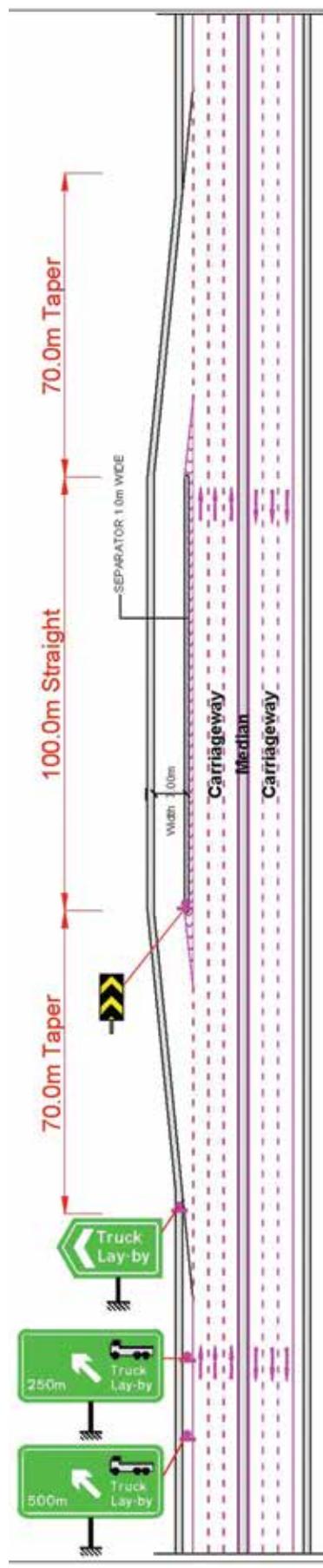


Fig. 12.2 Typical Layout of Truck Lay Bye

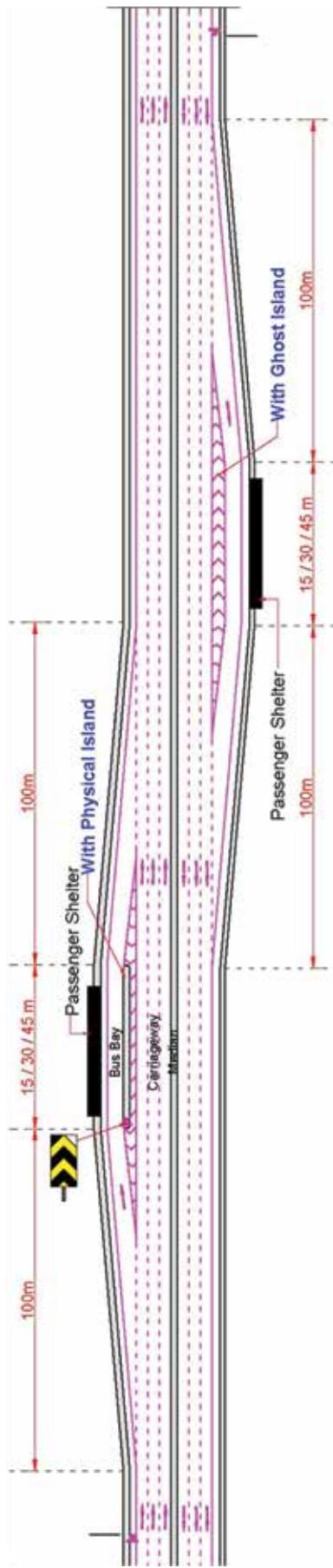


Fig. 12.3 Typical Layout of Bus Bay

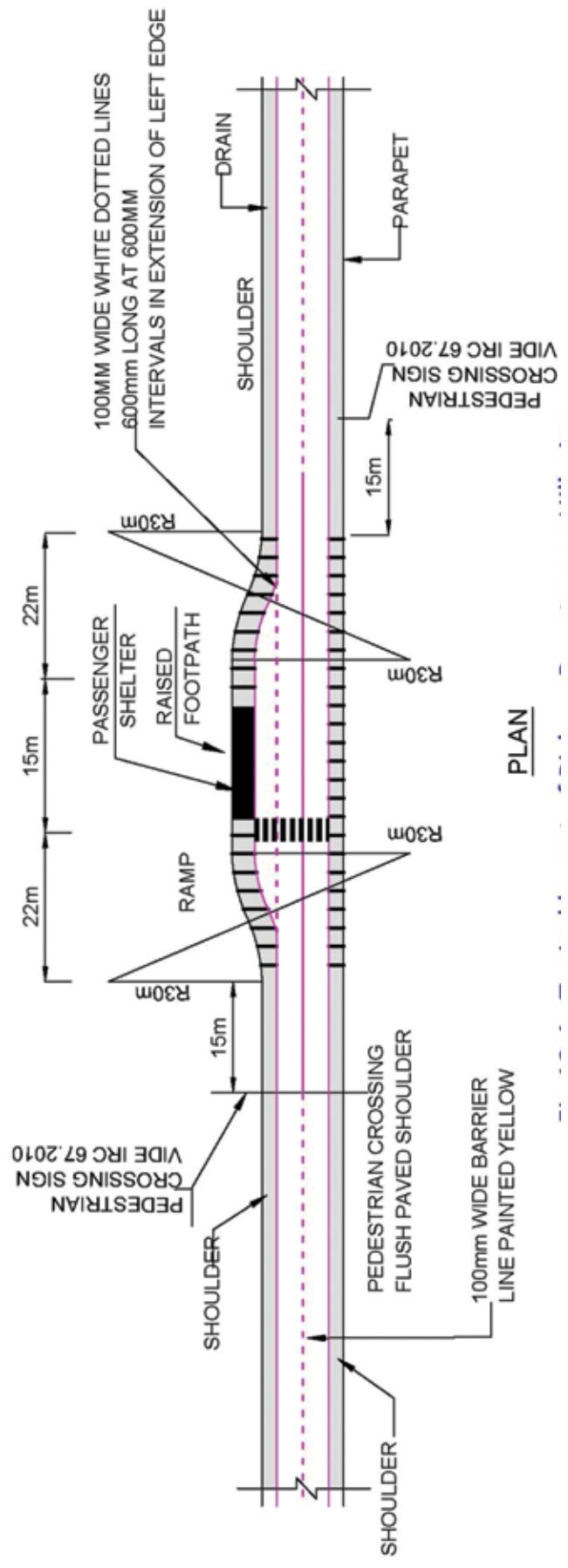


Fig. 12.4 Typical Layout of Pick up Bus Stop on Hilly Area

12.7.5 Drainage

- i) The bus bays shall have proper cross slope to drain off the excess water. No water, which is likely to splash on the waiting passengers, shall be allowed to collect near the bus shelters.
- ii) Suitable kerb gutter section with requisite longitudinal slope and outlets at intervals to ensure quick disposal of water shall be provided.
- iii) Adequate drainage for the steps and pedestrian movement area shall be provided.

12.7.6 Road markings

Pavement markings as specified in **Section 9** of this Manual shall be provided at the bus stops as shown in **Figs. 12.3 and 12.4** with the word 'BUS' written prominently on the pavement. Pedestrian crossings shall be marked slightly behind the standing position of the buses in order to reduce pedestrian conflicts. The kerbs shall be marked with continuous yellow line to indicate "No Parking".

12.7.7 Landscaping and plantation

The total area of ROW near the bus bay location shall be landscaped and planted with shady trees for giving pleasing appearance of the area.

12.7.8 Lighting

The entire bus bay area shall be provided with lighting (average illumination of 40 Lux).

12.8 Rest Areas

12.8.1 The rest areas shall be provided at the locations given in **Schedule 'C'**. Rest areas shall be provided by the Concessionaire on the lands included in the site and procured by the Authority. Within the areas so provided, the Concessionaire shall construct and operate, or cause to be constructed and operated, facilities such as toilets, telephones, cafeteria, restaurant, parking for cars, buses and trucks, dormitory, rest rooms, shops for travel needs, fuel stations and garage, first aid, etc. In approximately 2 Hectares of land, the following minimum facilities shall be provided.

Cafeteria/Restaurant for seating 50 persons; Toilets (separate for ladies and gents) (WC - 5 nos.; Urinals - 10 nos.); Dormitory with 20 beds; drinking water facility; parking for 100 trucks and 50 cars in addition to STD/ISD Telephone Facility, Shops and First Aid facilities.

The facilities shall be provided keeping in view the expected peak hour traffic.

The whole area shall be elaborately landscaped to provide a pleasing environment.

12.8.2 Lighting shall be provided as given in **Para 12.7**.

12.9 SVUP

Facility for SVUP shall be provided as specified in **Para 2.13.4**

12.10 Highway Patrol Unit(s)

The Concessionaire shall establish and operate Highway Patrol Unit(s) at the Toll Plaza Locations, which shall continuously patrol the highway in a stretch not exceeding 50 km and shall remain in

contact with the Control Room on a real time basis. The patrol shall render assistance to users in distress and disabled vehicles through own intervention or by calling for assistance from Control Room, Crane operators or ambulance as required. The patrol shall promptly clear the road of any obstruction. Where the obstructions take time to be cleared, the section shall be cordoned off by placing traffic cones, which shall be illuminated during night. The Specifications of Patrol Vehicle including equipments and man power are given at **Annexure C**.

12.11 Emergency Medical Services

These services shall include setting up medical aid posts by the Concessionaire. The Concessionaire shall provide “Two Patient Capacity” rescue ambulance(s) at the Toll Plaza location(s). Specifications of “Two Patient Capacity” rescue ambulance along with medical devices, on-board equipments, medicines and man power are given in **Annexure D**.

12.12 Crane Services

The Concessionaire shall provide a crane of adequate capacity (minimum 20 MT) at each Toll Plaza location (s) with all necessary equipment so that it can reach the site of the incident within 30 minutes of call and clear the disabled/accidented vehicles. It shall also be fitted with a GPS based Vehicle Tracking system to monitor its movement on 24 hours x 7 days of a week basis.

12.13 Communication System

The Concessionaire shall provide a suitable Communication System with all necessary equipment for meeting his O&M obligations.

12.14 Advanced Traffic Management Systems (ATMS)

For ATMS, **Clauses 816.1 to 816.17** of Specifications for Road and Bridge Works of MoRTH shall be applicable.

12.15 Operation and Maintenance Centre

12.15.1 There shall be operation and maintenance centre(s) either at the toll plaza (s) or at any other location along the Project Highway as identified by the Concessionaire. The land for the same shall be acquired by the Concessionaire at his cost and risk. The operation and maintenance centre would have following minimum facilities:

- i) Main control centre and Administrative block
- ii) Equipment for operation and maintenance and storage space for them
- iii) Storage space for equipment and material for traffic signs and markings
- iv) Workshop
- v) General garage and repair shop
- vi) Testing laboratory
- vii) Parking space for minimum 4 number of large vehicles and for other expected vehicle during peak hours including those for working staff and visitors

12.15.2 All building works shall be designed to meet the functional requirements and shall be compatible with regional architecture and micro climate. Locally available materials shall be given preference but not at the cost of construction quality.

12.15.3 The circulation roads and parking spaces in the O&M centre shall be paved to withstand vehicle loads and forces due to frequent acceleration and braking of vehicles. Parking bays/lots shall have proper cross slope and drainage. The marking of the parking bays shall be as per IRC:35 to demarcate parking and circulation space. Parking lots shall have illumination as provided in IS:1944 (Parts I and II)

12.15.4 The whole campus of operation and maintenance centre shall have system for security with safe entry and exit.

PATROL VEHICLE SPECIFICATIONS

Every Patrol Vehicle (PV) should adhere to the minimum specifications as described below:

General Vehicle

Type	Description
Vehicle Type	<ul style="list-style-type: none"> PV should be a large size Sport Utility Vehicle(SUV) or Multi Utility Vehicle(MUV) with a seating capacity of minimum 4 people. PV should have trunk with open ceiling at the rear end of the vehicle with minimum trunk dimensions of 1400 mm x 1400 mm x 900 mm where 1400 mm is the length of trunk measured from inside, 1400 mm is the breadth of trunk measured from inside and 900 mm is the height measured from the surface of trunk to the top ceiling of the seating area of the vehicle. The PV should be a new vehicle and should not have covered more than 2000 km at the time of procurement (from date of first registration). PV should be able to accelerate from 0km/ h to 80 km/h within 20s with a top speed of 80 km/h when tested in accordance with IS:11851-1986.
Two-External Equipments	<ul style="list-style-type: none"> PV should have high intensity red and blue blinkers along with light bar mounted on top of a vehicle. PV should have 1 Portable Variable Message Sign(VMS) for large display of warning. The portable VMS Should have a single line display with the minimum height of 200 mm for each character. The overall length of signboard should be atleast 1500 mm and display color should be red. VMS should be clearly readable from 50 m distance. PV should have provision for fog lights. PV should have beacon lighting - white color flashing light mounted at the top of the vehicle.

Type	Description
Branding and Recognition	<p>The PV conspicuity code is split into three Sections</p> <ul style="list-style-type: none"> • Color • Conspicuity Improving Items • Recognition of personnel <p>The Section “Color” describes the vehicle basic color. The Section “Conspicuity Improving Items” includes all Symbols, Marking and Striping defined as such by this standard. The Section “Recognition of personnel” describes the dress code and safety garments of Patrol Vehicle personnel.</p> <ul style="list-style-type: none"> • Color <p>The basic color of the complete exterior of PV should be brilliant blue, front, rear and side bumpers included. The color should be weather resistant and withstand daily cleaning and washing.</p> <ul style="list-style-type: none"> • Conspicuity Improving Items <ul style="list-style-type: none"> • This definition includes all marking and symbols as shown in the sketch below. The vehicle should be painted with brilliant blue on the entire body. • PV should have “NHAI Highway Surveillance Unit” written on all four sides of the vehicle in brilliant red color of retro reflective quality as shown in figure. • PV should have a text at the centre of all four sides of the vehicle with “Emergency Number” written on top and “1033” written right below “Emergency Number” in brilliant red color of retro reflective quality. The “Emergency Number” marking should be atleast 10 cm high and the ratio of height of “1033” and “Emergency Number” should be 2:1. • Recognition of personnel <ul style="list-style-type: none"> • All PV Personnel should wear brilliant blue color uniform including brilliant blue color jackets required in winters. • Safety garments for PV personnel should conform to at least ISO 14116:2008.

The branding and recognition pattern of PV described above should resemble with the one shown in the sketches below:

**Fig. PV – Side View**

Equipments

Following are the list of equipments and specification of each to be kept in working condition in every PV.

Type	Description
Tracking Equipments	<ul style="list-style-type: none"> Automatic vehicle tracking system with GPS technology for tracking vehicle's current location; Information to be viewable on GIS software.
Communication Equipments	<ul style="list-style-type: none"> 1 Two-way radio device with antennae or better technology for mobile communication, for communication with Regional Command Center and with on-road units. Should have a sufficient range to communicate in the entire region(or state) & sufficient battery life (12 hours+); 1 Public address system consisting of microphone, amplifier and loudspeaker to address the traffic in case of accident, should have minimum 100 W amplifier with loud sound; 1 Cellular phone for communication.
General Surveillance Equipments	<ul style="list-style-type: none"> Digital Camera with minimum 5 megapixel camera quality; White color high intensity torch lights with two set of spare batteries; Orange color reflective safety jacket along with gum boots and helmet (1 for every attendant); 3 Rain suit (1 for every attendant of Surveillance Unit); 2 units of liquid containers with minimum 5 L capacity for carrying petrol/diesel along with a funnel; 1 water container; 1 rope of minimum 20 m length; 10 orange/red color reflective flags of atleast 300 mm height; Whistle; Hand signals.

Type	Description
Vehicle Repairing Equipments	<ul style="list-style-type: none"> • 3 pairs of leather gloves; • 2 ton hydraulic jack capable of lifting car, bus and light trucks, should be able to attain a maximum height of atleast 300 mm; • 1 Heavy duty steel towing chain of minimum 1.5 m length; • 1 Animal hook; • 1 Tyre gauge with minimum 0-50 psi range and tyre sealant; • 1 Portable tyre inflator pump capable of filling tyres upto a pressure of 50 psi; should be able to inflate tyres of cars, buses and light trucks; • 1 pair of Starter leads with multimeter: For making connections with external power source; • 1 Tow bar for towing purposes; • 1 Mechanical toolkit with equipment like hammer, fencing pliers, mallet, ratchet wrench set, screwdriver set, battery brush, etc.
Extrication & First Aid Equipments	<ul style="list-style-type: none"> • 1 Portable electric windshield cutter operated by battery or external power source, should be able to cut all type of windshields causing minimum glass dust; • 1 Hydraulic/electric portable hand cutter and spreader combined tool, should be able to cut off vehicle parts, metal structure, steel plate. Should have maximum cutting force > 250 KN, spreading force ≥ 25KN with opening distance of Blades > 150 mm; • 4 wooden wedges, 4 rectangular wooden blocks of minimum dimensions $150 * 120 * 60$ mm for stabilizing light and heavy vehicles; • Two struts capable of stabilizing a vehicle of minimum 1500 kg weight; • 1 Long spinal board (with head immobilizer & securing straps and plastic material at high strength, should be waterproof & conforming to EN 1865 standard); • 1 Cervical collar for both kids & adults (should have pre-molded chin support, locking dips and rear ventilation panel and an enlarged trachea opening, should have high density polyethylene and foam padding, should be X-ray lucent and easy to clean and dis-infect); • 1 KED extrication device for both kids and adults should be made of polymer/wooden bars in a nylon jacket; • Pick-up stretcher conforming to EN 1865 standard (minimum usable length of 1650 mm and extendable to a minimum of 2010 mm, minimum width of 400 mm, mass not more than 11 kilograms & should have minimum loading capacity of 150 kilograms: <ul style="list-style-type: none"> • First aid kit; • Woolen blankets; • 1 Map locating nearest hospital, police station, fire station

Type	Description
Scene Management Equipments	<ul style="list-style-type: none"> • Minimum 10 Reflective cones of 750 mm each, should be orange in color with retro-reflectorised white band and a heavy rubber base with minimum possibility of being displaced by wind/vehicular traffic; • 4 kg dry Powder Fire Extinguisher; • 3 pairs of Rubber gloves; • 1 Hard bristle broom; • 1 Shovel; • Sign boards with messages: <ul style="list-style-type: none"> • 3 - “Accident ahead”; • 3 - “Lane merging”- 3 units; • 3 - “Direction arrows” – 3 units; • 2 - “Speed Limit” (80, 60, 40); • 2 - “Keep left/right”; • 2 – “Lane closure”; • 2 - “Men at work”. • All signs should be of retro reflective sheeting of High intensity grade or Prismatic grade; • 9 units of Sign stand (for triangular and circular sign) for height between 1.5 m to 2 m; • 2 Reflective type barricade, tape; • 3 pairs of safety glasses and masks for protection of safety officers from glass debris/ airborne dust; • 10 kg sealed bucket with lime or cement inside.

Manpower and Trainings

Type	Description
Highway surveillance in-charge	<ul style="list-style-type: none"> • 1 Highway surveillance in-charge should be appointed per shift per vehicle; • Employee appointed should have minimum 2 years of relevant experience in route patrolling and traffic management; • Employee appointed should be able to read/write and maintain log books; • Employee appointed should undergo trainings including fields such as: <ul style="list-style-type: none"> • Vehicle use and maintenance; • Safety policies; • Radio and communication procedures; • Public relations/ customer service; • Defensive driving; • Public relations/customer service; • Maintenance of traffic;

	<ul style="list-style-type: none"> • Vehicle recovery procedures; • Victim extrication procedures; • Extinguishing vehicles fires; • Basic first aid training; • Work side protection; • Minor vehicle repairs.
EMT	<ul style="list-style-type: none"> • 1 EMT should be appointed per shift per vehicle. • Basic qualification of EMT – Diploma in E.M.T. • B.Sc. (PCB) with certification in BLS/ALS/ACLS/ITLS (or) B.Sc Nursing/ GNM/ ANM (or) B.Pharma/ D. Pharma or any other equivalent paramedical course from recognized university/institution of IMC/INC. • Employee appointed should have minimum 2 years of relevant experience in first-aid and life saving emergency skills including spinal immobilization, bleeding control, oxygen therapy, defibrillation and medicine administration. • Employee appointed should undergo atleast one training (with duration of minimum one month) in tertiary care institution or at a recognized institute with experience in handling life-saving equipment. • Basic training of employee should include fields such as: <ul style="list-style-type: none"> • Vehicle and equipment use and maintenance; • Victim extrication from a crashed/damaged vehicle; • Safety policies; • Radio and communication procedures; • Public relations/customer service.
Driver/helper	<ul style="list-style-type: none"> • 1 driver/ helper should be appointed per shift per vehicle. • Employee appointed should have a valid license to drive a SUV vehicle. • Employee appointed should be able to read/ write & maintain log books. • Basic training of employee should include fields such as: <ul style="list-style-type: none"> • Vehicle driving along multiple shifts; • Minor repairing of vehicle; • Vehicle and equipment use and maintenance; • Radio and communication; • Work site protection

'2 PATIENT CAPACITY' RESCUE AMBULANCE SPECIFICATIONS

Every '2 Patient Capacity' rescue ambulance should adhere to the minimum specifications as described below:

Vehicle Characteristics

General Construction

- The road rescue ambulance shall comply with homologation requirements given in standards notified under CMVR 1989 and the AIS-125 Code. Wherever, there is difference in the homologation requirements given in other standards notified under CMVR 1989 and AIS-125 code, the requirements of AIS-125 code will be applicable.
- The rescue ambulance vehicle shall be a Swaraj Mazda/Tempo traveler or equivalent which should be a new vehicle and should not have covered more than 2000 km at the time of procurement (from date of first registration).

Performance Requirements

- The road rescue ambulance loaded to the permissible gross vehicle weight shall be able to accelerate from 0 km/h to 70 km/h within 40s, when tested in accordance with IS: 11851-1986.

Electrical Requirements

- **General**
 - Electrical installations shall comply with those Clauses of IEC 60364-7-708 which are applicable to rescue ambulances.
- **Battery and alternator**
 - Batteries shall be positioned to allow maintenance without removing the battery from its securing device. The construction of the battery and all connections to it shall be such as to prevent any possibility of an inadvertent short circuit. Additional batteries may be required to power the medical devices carried on board and the intended use of the rescue ambulance. In such cases, the manufacturer shall ensure optimal charging of the additional batteries without any impact on the primary vehicle battery. The additional circuit shall not draw current more than as specified by the manufacturer.
 - Indicative Capacity/Power (These values are given as a broad guideline only. The manufacturers may alter them based on vehicle characteristics and operational requirements) should be as per the below mentioned table:

Indicative Capacity/ Power Requirements		
Additional Battery(ies) (if deployed)	Nominal Voltage 12V	80Ah
	Nominal Voltage 24V	63Ah (2x12V)
Alternator Power		700W

- When the engine is idling, electrical stability should be maintained between electrical load and alternator output. In order to achieve, this it may be necessary to fit an electrical load prioritization device to the vehicle.
- Manufacturer shall give declaration regarding the certified capacity of the electric system of the vehicle model in the following format:

Sr. No	Rescue Ambulance Type	Additional Electric Load of Medical Equipment's permissible (Watts)
1	C/ Basic Life Support	XXX

- This shall be prominently displayed in the patient compartment at an appropriate location. Further each electrical socket provided in the patient compartment should be permanently labelled as regards its voltage and amperage.
- **Electrical installation**
 - Recessed externally mounted power connector to enable external power to be provided for operations such as the following:
 - a) Charging battery (ies).
 - b) Operating medical devices, when installed.
 - c) Operating a stand-alone patient compartment heater, when installed.
 - d) Operating an engine pre-heater, when installed.
 - The connector for 220/240 V, shall be a male connector and not interfere with the electrical and mechanical safety.
 - It shall be not possible to start the engine whilst it is connected to an external 220/240 V power supply unless an automatic mechanical disconnection is fitted. If no automatic mechanical disconnection is fitted, the connector shall be on the driver's side. The 220/240 V circuit shall be protected either by an "earth leakage device" with a maximum setting of 30 mA or by a separated transformer. If the protection is given only by an "earth leakage device" there shall be a label near the plug that reads as follows: "CAUTION! CONNECT ONLY TO AN AUTHORISED SOCKET."
 - The patient's compartment shall be fitted with a minimum 4 number of connections. For these connections a permanent power supply shall exist.
 - Any additional electrical systems fitted to the base vehicle shall be separated from the base vehicle electrical system and the body or chassis shall not be used as an earth return for additional circuits. All circuits in the additional system(s) shall have separate overload protection. Overload protection may consist of either fuses or so called Electronic Management Control systems. All circuits shall be well defined and cables clearly marked at the connection points and at a maximum of 1m intervals along its length.
 - The system shall have enough circuits and be so constructed that when/if a circuit fails all illumination and medical technical equipment can be switched to an alternative power source.
 - The wiring and, where applicable conduits, shall withstand vibrations. No wiring shall be located in or pass through conduit intended for medical gas installation. The wiring shall not be loaded higher than that stated by the wire

manufacture.

- Where there are different voltage systems, the connections shall be non-interchangeable.

Vehicle Body

- **Fire safety**
 - All interior materials shall comply with the flammability requirements specified in IS: 15061, as notified under CMV (A) R, 1989 though the standard does not cover rescue ambulance in the scope.
- **Fitment of fire extinguisher**
 - The rescue ambulance shall be equipped with Two fire extinguishers of 2 Kg each.
- **Minimum loading capacity**
 - The minimum loading capacity of at least 2 stretcher facilities in the patient compartment. Serious casualties/ patients must not be transported on patient compartment seat without use of stretcher & proper restraining support provided to the patient.
- **Partition wall**
 - Full partition wall or a partition wall with a door or a window shall separate the driver's compartment from the patient's compartment. Where a door is fitted, it shall be secured against opening if the road rescue ambulance is in motion.
 - One or two windows with a minimum separation of 100 mm shall be provided in the partition wall made of material complying with the requirements of CMVR. The windows shall allow direct visual contact with the driver. The opening area of the window shall have a maximum area of 0,12 m². It shall be secured against self-opening and shall have an adjustable blind or other means of preventing the driver being disturbed by the light of the patient's compartment.
- **Openings (Doors, Windows, Emergency Exits)**
 - General
 - a) The driver seat shall comply with the requirements of AIS:023-2005 or IS:15546-2005 as applicable and notified under CMVR. There shall be a minimum of two openings – one at the rear (door/tailgate) and one at the side (door/window) of the patient's compartment. All openings shall have seals to protect against the ingress of water and dust.
 - b) All openings shall comply with the minimum dimensions set out in the following table:

		Dimensions in mm
Side Opening (optional)	Height	1300
	Width	660
Rear Opening	Height	1300
	Width	1050

- Doors
 - a) Each external door of the patient's compartment shall be fitted with a security system which enables the following:
 - lock and unlock from inside without use of a key;
 - lock and unlock from outside with use of a key;
 - Unlock from the outside using a key when the door is locked from the inside.
 - b) Note: This security system may be integrated with an optional central locking system. The patient's compartment doors shall be capable of being positively restrained in the open position. An audible or visual signal shall warn the driver when any door is not completely closed when the vehicle is in motion. The key can be a mechanical or non-mechanical device.
- Windows
 - a) In the patient's compartment, there shall be a minimum of two external windows. There shall be one on each side or one on the side and other at the rear. The windows shall be positioned or screened to ensure patient's privacy when required. Windows shall be fitted with safety glasses complying with the requirements of IS:2553 specified under Rule 100 of CMV(A)R, 1989.
- Stretcher loading
 - a) Loading area requirements shall be in accordance with the following table.

Loading Angle (Stretcher)	Maximum	160 a
Loading Height Stretcher	When the patient is manually loaded or unloaded on the stretcher, the centre of the stretcher handles shall be no more than 975 mm above ground level. The maximum height of either the floor or the loading holding assembly above ground level shall not exceed 900 mm at net vehicle mass plus loose equipment.	

The loading angle (**Fig. 1**) should be kept as low as possible.

- b) Where a ramp or lift is installed between ground level and vehicle floor level, it shall be covered with a anti-slip surface and capable of taking a constant load of 350 kg. In the event of a power failure the loading device shall be capable of being operated manually.

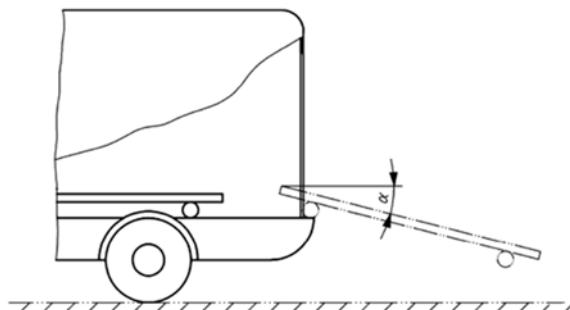


Fig.1 Loading Angle for the Stretcher

Patient's Compartment

- General
 - The patient compartment should have minimum internal dimensions of at least 2500 mm (length) x 1800 mm (width) x 1800 mm (height).
 - The patient's compartment shall be designed and constructed to accommodate the medical devices listed in the equipment table. The width of the patient compartment after installation of cabinets, etc. shall provide 40 ± 15 cm clear aisle walkway between the main stretcher/undercarriage and the base of squad bench/attendant seats, with the main stretcher located in the street side (non-centered) position.
 - The length of the Patient Compartment shall provide at least 64 cm and not more than 76 cm of unobstructed space at the head of the primary patient, when measured from the face of the backrest of the Doctor's/Paramedic's Seat to the forward edge of the stretcher.
 - The ceiling, the interior side walls and the doors of the patient's compartment shall be lined with a material that is non-permeable and resistant to disinfectant. The edges of surfaces shall be designed and/or sealed in such a way that no fluid can infiltrate. If the floor arrangement does not allow fluids to flow away, one or more drain with plugs shall be provided. Exposed edges that could come into contact with the occupant's hands, legs, head etc., during normal use shall have a radius of curvature of not less than 2.5 mm except in the case of projections of less than 3.2 mm, measured from the panel. In this case, the minimum radius of curvature shall not apply provided the height of the projection is not more than half its width and its edges are blunted. All installations in the patient compartment above 700 mm from floor level shall not have sharp exposed edges and shall terminate in rounded edges. Sharp edges shall meet the requirements of IS:15223 for M1 and AIS:047 for M2 as amended from time to time. Medical equipment and their holding devices (for example stretchers, platforms, suction units etc.) are excluded. Drawers should be secured against self-opening and where lockers are fitted with doors that open upwards they should be fitted with a positive hold open mechanism.
 - The rescue ambulance should be equipped with a lockable drugs compartment with security lock. Floor coverings shall be chosen that will provide adequate grip for the attendant including when wet and should be durable and easy to clean.
 - The rescue ambulance should also be fitted with a hand-holding device positioned above the stretcher. The hand-holding device shall be positioned along the longitudinal axis. If the patient's compartment is to be equipped with a non-foldable chair, space shall be provided with a width of at least 600 mm measured at elbow height and a ceiling height above the seat squab of at least 920 mm. Vehicle maintenance equipment (e.g. Spare wheel and Tools) shall be placed such that accessing them does not cause inconvenience to the patient

- **Patient and attendant seating**

- The minimum number of patient and attendant seats should be as per the following table:

Minimum Number		2
Position (s)	On one side of the stretcher	1
	On one side of the stretcher 2/3 end	1
Positions (s) at head of stretcher		-

- **Patient and attendant seat dimensions**

- Patient and attendant seat dimensions shall be minimum of 381 mm X 381 mm per seat. Seats fitted in the patient compartment shall be installed in either forward/sideward/rear-facing positions and shall be fitted with Two Point (Lap Belt) or Three Point Retractable Safety Belts (preferred for forward/rearward facing seats) in conformance with IS:15140-2003. Head restraints shall be fitted as applicable and in accordance with AIS-023:2005 or IS:15546-2005. Backrests shall be constructed to a minimum dimension of 300 mm x 100 mm.

- **Patient compartment environmental equipment**

- The patient compartment shall be heated, ventilated, and air conditioned as required in accordance with the criteria specified hereto.

- **Air conditioning criteria**

- The cooling system should be such that, given an outside and inside temperature of 32°C, the cooling down to at most 27°C in the patient's compartment should not take longer than 15 min. After 30 min. a temperature of at most 25°C should be reached.
- The inside temperature should be measured in the centre of the patient compartment and at the mid-point from the cooling outlets (if several outlets are available). The installation of the system shall not encourage exhaust gases entering the patient's compartment.

- **Heating**

- If the heating system is provided, the system shall be such that given an outside and inside temperature of -10°C, the heating up to at least +15°C shall not take longer than 45 min. The inside temperature shall be measured in the centre of the patient compartment and at the midpoint from the heater outlets (if several outlets are available). The installation of the system shall not encourage exhaust gases entering the patient's compartment.

- **Interior lighting**

- Natural colour balance lighting shall be provided as set out in the table below.
- Note: The colour temperature of the light will change the appearance of skin and organs. Therefore, it is important that the interior lighting is suitable for patient care during transport. Although it may not be necessary in rescue ambulance use to define "daylight" or "natural colour balance" in a more exact

way other than the colour temperature. The colour temperature of the interior lights should be minimum 4000 Degrees Kelvin.

Patient's compartment illumination –Maximum intensity Lux	
Patient Area (Stretcher)	150
Surrounding Area	50

- Light levels shall be measured along the central longitudinal axis of the stretcher at the head, mid-point and foot position with the stretcher in its normal position for transportation in the rescue ambulance.
- **Interior noise level**
 - The interior noise level in the patient compartment shall comply with requirements of AIS:020. During the test, the Siren of the rescue ambulance shall be kept in the Off position.
- **Ingress of dust and rain water**
 - All doors, windows and hatches shall not allow ingress of dust and rain water when in the fully closed position, when tested in accordance to IS:11739-1986 as amended from time to time, for recording dust ingress in automotive vehicles, and when tested in accordance to IS:11865-2006 as amended from time to time, for water proofing test for automobiles.
- **Mounting systems**
 - Permanent seats and their anchorages in the patients' compartment, designed for use by patients and attendants when the rescue ambulance is in motion, shall comply with the requirements of IS:15546-2005 (for M1 category vehicles) and AIS:023-2005 (for other than M1 category vehicles).
 - All items e.g. medical devices, equipment and objects normally carried on the road rescue ambulance shall be restrained, installed or stowed to prevent them becoming a projectile when subjected to accelerations/decelerations of 10 g in the forward and rearward directions.
 - When subjected to these accelerations/decelerations, the distance travelled by an equipment or an item shall not endanger the safety of persons on the road rescue ambulance.
 - After being subjected to these accelerations/decelerations:
 - a) no items shall have sharp edges or endanger the safety of persons in the road rescue ambulance;
 - b) the maximum distance the stretcher and any item attached to either the holding assembly or stretcher may travel shall be no more than 150 mm. The displacement of the patient during the test may exceed 150 mm;
 - c) it shall be possible to release all persons in the road rescue ambulance without the use of equipment not carried on the road rescue ambulance.
 - All tested lockers, rails and non-dedicated storage locations or storage devices shall be labelled to show the total maximum permissible weight allowed.

Testing of Maintain Systems and Fixations of the equipment in the Patient's Compartment:

- Verification of conformity to fixation and maintain systems shall be made when the stretcher(s)/medical device(s) and holding assembly is placed in the mean position of all possible positions available.
 - The sample submitted for test, shall be identical to or have the same characteristics and behaviour during test as would the production item or vehicle.
- Note: Care should be taken that no internal/external additional reinforcement through the rig will modify the behaviour during test.
- The stretchers and chairs shall be loaded with a dummy (as specified in IS:15140-2003) which is then secured with the restraint system.
 - The head end of the stretcher shall be fixed in a position of 15° measured from the horizontal. The lying area of the stretcher tray assembly (holding assembly) shall be in a horizontal position.
 - The stretcher shall be fixed on the stretcher's holding assembly. The sedan chair when provided shall also be fixed in its holder.
 - The dynamic tests can be carried out with the appropriate stretcher(s) or medical device(s) installed or stowed in the holding system(s) or with weights having the mass distribution and dimensions corresponding to the mass and dimensions of the stretcher(s) and device(s) intended to be installed on or stowed in the holding system.
 - In case of dynamic testing, the dynamic test shall be carried out using a patient's compartment assembly or a relevant part of the construction approved by the notified body and the following test method:
 - The test assembly shall be accelerated/decelerated in the longitudinal and transverse and vertical directions in accordance with the **Fig. 2**.
 - The impact speed shall be between 30 km/h and 32 km/h.
 - Test weights for use in lockers should be sand bags with masses in kg increments, with a tolerance of +10% - 0%.

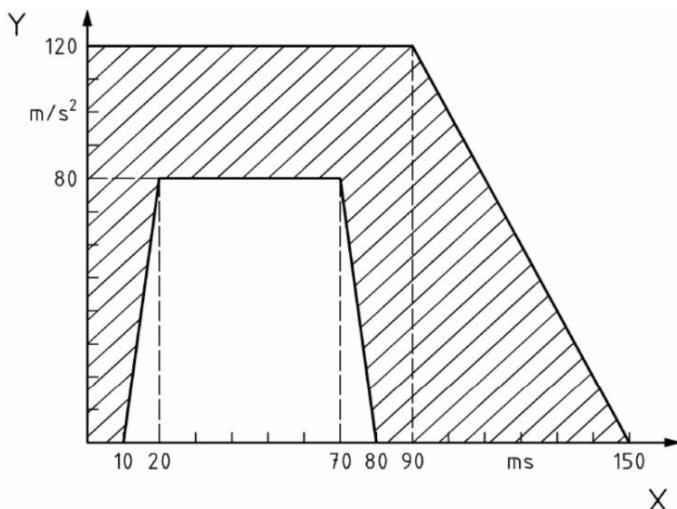


Fig.2 Acceleration Impulse

Medical Devices & On-board equipment

- **Medical Devices Storage**

- All equipment required for a set procedure shall be stored in a specified location. Essential equipment required for use outside the vehicle shall be easily accessible via normally used doors. All equipment shall be securely and safely stowed to prevent damage or injury whilst the vehicle is in motion.

- **Requirements for Medical Devices**

- General**

- ◆ The device shall be designed for use in mobile situations and in field applications. If a medical device is designated as “portable”, which is mandatory for use inside a rescue ambulance (except main stretcher, pickup stretcher, vacuum mattress & long spinal board). It shall be in accordance with IEC:60601-1 and shall
 - a) be possible to be carried by one person
 - b) have its own built in power supply (where relevant)
 - c) be capable of use outside the vehicle
 - d) be placed preferably along the street side wall of the patient compartment or along the ceiling ensuring the minimum possible distance to be connected to the patient without hindering the movement of personnel around the main stretcher.

- Temperature**

- ◆ Unless otherwise marked on the device, the device shall function as described in the following two points, when brought back to room temperature (20°C) after storage in temperatures ranging from -30°C to 70°C.
- ◆ Unless otherwise marked on the device, the device shall function throughout the temperature range from 0°C to 40°C.
- ◆ Unless otherwise marked on the device, the device shall function for at least 20 min. when placed in an environment at -5°C after storage at room temperature (20°C).

- Humidity and ingress of liquids**

- ◆ Devices shall comply with ISO:60601-1 and with particular device standards of the series ISO:60601-2 where applicable.

- Mechanical strength**

- ◆ **General:** Where there are not more stringent requirements for mechanical strength in particular devices standards exists, then the following mechanical strength requirements shall apply to medical devices for use in road rescue ambulances.
- ◆ **Vibration and bump:** After vibration tests and bump test in accordance Vibration & Bump test, the maintain system and device shall function within the tolerances specified by the manufacturer.
- ◆ **Free fall:** If the medical device is fixed, as defined in ISO:60601-1, it is exempted from the free fall test. Devices which are taken out of holders and/

or carried by hand shall be submitted to the Free Fall Test according to the Free Fall Test (mentioned subsequently) and shall then function within the tolerances specified by the manufacturer.

Note: A medical device may consist of fixed and loose components, the Free Fall Test applies to the loose components only.

Fixation of devices

- ◆ The device shall be restrained by means of a fixation system.
- ◆ The fixation system(s), maintain system(s) or storage system(s) shall hold the device to withstand accelerations or decelerations of 10 g longitudinal (forward, backward), 10 g transverse (left, right) and 10 g vertical.
- ◆ Terminal units and electrical socket outlets shall not be used as part of the fixation system.
- ◆ If rails systems are used, they shall comply with ISO:19054.

Note: Rail systems consist of e.g. rail supports, rails, rail clamps, equipment mount holders, equipment mounts, equipment pin holders and equipment pins.

Electrical safety

- ◆ All devices shall be selected and mounted so that no harmful influence to the electrical supplies results.

User interface

- ◆ Buttons, switches, indicators and controls shall be easily accessible and visible. SI units (except for blood pressure and airway pressure) and standardized graphical symbols where applicable shall be used.

Gas installation

- ◆ All the components should be certified as per ISO/TC 121/SC6 and ISO:15001-2003 as "Compatibility of Medical Equipment with Oxygen"

◆ **Source of supply**

- a) The source of supply shall consist of one or more of the following, as per the requirement of the source supplies in the different types of road rescue ambulances.
 - i) Gas in cylinders, e.g. Oxygen
 - ii) Any other compressed medical gas as required for treatment and therapy of patients.
 - iii) Vacuum system.
- b) Note: All the components of the source of supply should be certified as per ISO:7396.
- c) All compressed gas cylinders except for sizes up to 2.2 L Water Capacity, must be stored and used in an upright position with the valve end up. Only special compressed gas cylinders designed and certified for use in a horizontal position can be placed in that position.
- d) The valve of the compressed gas cylinder when is at a height of more than 1500 mm from the ground level, the cylinder compartment should be

provided with an retractable/foldable/flushed/enclosed foot step to permit the user to stand comfortably to access the cylinder valve at the time of changing the cylinders.

- e) The cylinder compartment should have facility to place the regulators safely at the time of replacing empty cylinders and fitting filled ones.
- f) Rescue ambulances should never be operated with lesser number of cylinders as specified in equipment table.

System design

- a) The rescue ambulance whenever fitted with a stationary oxygen system, shall have all the essential components and accessories required for two sets of piped oxygen system which shall include as a minimum:
 - i) One no. Pressure Regulator for each of the supply sources (stationary as well as portable).
 - ii) Low pressure, electrically conductive, hose approved for medical oxygen.
 - iii) Oxygen piping concealed and not exposed to the elements, securely supported to prevent damage, and be readily accessible for inspection and replacement.
 - iv) Oxygen piped to a self-sealing duplex oxygen outlet station for the primary patient with a minimum flow rate of 100 LPM at the outlet.

In addition to the above, the ambulance shall have hospital type piped medical oxygen system (manifold) capable of storing and supplying medical grade oxygen. The system should comprise of an oxygen cylinder manifold as specified, a cylinder changing wrench, chained and clipped with/within the oxygen cylinder compartment; a pressure regulator; oxygen piping approved for medical oxygen; a duplex oxygen outlet station with quick-disconnect interface for the primary patient and a second duplex oxygen outlet station with quick-disconnect interface for the secondary patient. A medical grade oxygen pressure regulator with inlet filter & static outlet pressure of 4.12 bars /60 psi shall be provided at the cylinder manifold. It shall include a pressure gauge, an inlet filter, a safety relief valve; a locking mechanism to prevent settings from being inadvertently changed; shall maintain accurate readings and calibrations during ambulance operation and not be affected by the temperature conditions. The manifold should have oxygen cylinders of B or D size only (minimum one D & one B type cylinder/equivalent). An adapter to refill the cylinders from a bulk cylinder should be provided.

- b) The patient cabin shall have a digital display panel for oxygen supply status. The display panel should be certified for use with Medical Oxygen and should have three individual values displayed to constantly indicate the pressure level of both the cylinders as well as the distribution pressure level. The digital displays should show the actual pressure measured by three individual digital pressure sensors as per the pressure level under monitoring (one each for both the cylinders and one for the line pressure).

- c) The changing from one cylinder to the other should not affect the distribution pressure in any way and this change over should occur as fully automatic operation.
 - d) The rescue ambulance shall be supplied with an emergency oxygen outlet for each of the stationary oxygen system available on any of the walls of the patient compartment easily accessible to the patient head end and connected directly at the output of the pressure regulator of the stationary oxygen system ensuring that any fault in the oxygen distribution system would ensure uninterrupted oxygen supply to the patient. The terminal outlets shall be of the same design and operational criteria as the self sealing duplex outlets of the distribution system.
 - e) Outlets shall be adequately marked and identified and not interfere with the suction outlet, whenever provided.
 - f) Stationary oxygen system shall be accessible from outside of the vehicle and shall be physically isolated from the patient as well as the driver compartment.
- Gas piping**
 - a) Gas piping shall not pass through cupboards and compartments, all ducts for gas installations or gas piping shall be vented.
 - b) The use of remote high pressure lines and gauges are not allowed.
 - Stationary oxygen supply**
 - a) The stationary oxygen supply shall comprise a source in accordance with equipment table (under normal temperature and pressure) pressure regulators and terminal units or pressure regulators with flow metering devices. Rescue ambulances should never be operated with lesser number of cylinders as that designated.
 - Portable oxygen supply**
 - a) The portable oxygen supply shall comprise a source in accordance with the equipment table (under normal temperature and pressure) and a pressure regulator with flow metering device.
 - Pressure regulators and flow metering devices**
 - a) The pressure regulators shall be directly connected to the source of supply and shall comply with the following as applicable:
 - b) ISO:10524-1-2006, Pressure regulators for use with medical gases - Part 1: Pressure regulators and pressure regulators with flow-metering devices.
 - c) ISO:10524-3-2005, Pressure regulators for use with medical gases - Part 3: Pressure regulators integrated with cylinder valves.
 - d) Flow metering devices for connection to terminal units and for connection to flow-rate control units shall be of dial type without any floats and shall conform to ISO:15002.
 - Terminal units**
 - a) Terminal units shall comply with the requirements of ISO:7396.
 - b) The components of terminal unit should be cleaned as defined in "Compatibility

of Medical Equipment with Oxygen" as per ISO/TC121/SC6 and ISO:15001-2003.

- c) The terminal outlet should have an hexagonal geometrical profile to permit only geometrically matching adapters.
- d) The process of inserting the probe into the terminal unit of the distribution system as well as pressure regulators shall be:
 - i) an axial force not exceeding 100N and/or
 - ii) a torque not exceeding 1 N-m
- e) The process of releasing the probe from the terminal outlet should be by
 - i) applying an axial force having torque not more than 1 N-m and not less than 0.1 N-m.
 - ii) applying a push or pull force of not more than 110 N and not less than 20 N.
- f) When all locking provisions have been released, disconnection of the probe from the terminal unit shall require a force of not more than 100 N.
- g) Danger to personnel can occur as a result of the rapid expulsion of probes from terminal units. The design should prevent this from occurring.
- h) The terminal outlets should be colour coded as per ISO:32-1977 colour coding.

Pneumatic power supply

- a) If the road rescue ambulance is equipped with terminal units, the range of operating pressure shall be
 - i) for compressed medical gases 3.5 ± 0.5 Bar
 - ii) for vacuum ≤ 0.4 Bar absolute pressure and the maximum allowable pressure change between the source of supply and the terminal units shall be
 - for compressed medical gases 10% at a flow of 40 l/min;
 - for vacuum 20% at a flow of 25 l/min.

Additional outlet connectors

- a) For road rescue ambulances complying with Pneumatic power supply, one additional outlet connector (i.e. a terminal unit or a gas specific connection point) complying with the primary outlet shall be fitted in addition to the outlet connectors necessary for the devices intended to be normally used.

Test Pressure

- a) The gas piping shall withstand a pressure of 8 Bar i.e. twice the maximum operating pressure of 4 Bar.
- b) Note: This pressure is also the maximum pressure supplied by pressure regulators in single fault condition.

Pin-Index Cylinder Valves

- a) Pin-index outlet connections of cylinder valves shall comply with IS:3224.

- **Flexible Hoses**
 - a) Flexible hoses for connecting medical devices to outlet connectors (i.e. terminal units or a gas-specific connection points) shall comply with ISO:5359-2008. If flexible hoses are used between the pressure regulators and the terminal units, the requirements of ISO:11197 apply.
- **Alarms**
 - a) The alarm level would be as per IEC:60601-1-8-2006.
- **Marking and Instructions**
 - a) Marking and instructions for use shall comply with Annexure 1 of AIS:125. Operating and maintenance instructions, service records and any other appropriate regulations shall accompany the product.
 - b) Standardized symbols should be used or it should be written in English or any other local language of the area where the equipment is to be used. Usage of any other local languages are not mandatory but is only advised.
- **Maintenance**
 - a) The manufacturer shall supply instructions for carrying out preventive maintenance.
 - Mechanical Strength - Test Methods for Medical Devices for use in Road Rescue Ambulances
- **Vibration and bump test** – The medical devices shall be submitted to the following tests:
 - ◆ Vibration (sinusoidal) according to IEC:60068-2-6, Test Fc
 - ◆ Frequency range: 10 Hz to 150 Hz
 - ◆ Amplitude/acceleration: $\pm 0,15 \text{ mm}/2 \text{ g}$
 - ◆ Sweep rate: 1 octave/minute
 - ◆ Number of sweep cycles: 4 in each axis
 - ◆ Random vibration broadband – reproducibility medium according to IEC:60068-2-64, Test Fh
 - ◆ Acceleration Spectral Density 10 Hz to 20 Hz: $0,05 \text{ g}^2/\text{Hz}$
 - ◆ Acceleration Spectral Density 20 Hz to 150 Hz: $0,05 \text{ g}^2/\text{Hz}$,
- **-3 dB/Octave**
 - ◆ Total RMS acceleration 1,6 grms
 - ◆ Duration/axis/mounting: 30 min
 - ◆ Bump according to IEC:60068-2-27, Test Ea
 - ◆ Peak acceleration: 15 g
 - ◆ Acceleration Spectral Density
 - ◆ Pulse duration: 6 ms
 - ◆ Number of bumps: 1000
 - ◆ Direction: vertical, with the medical device in its normal operating position(s)

- **Free Fall** – The medical device shall, while functioning, be submitted to the following test:
 - ◆ Free fall according to IEC:60068-2-31, Test Ec
 - ◆ Height of fall: 0,75 m
 - ◆ Number of falls: One on each of the six sides/surfaces of the device
- **List of Equipment**
 - Supplementary devices may be introduced depending on local requirements. Where applicable the equipment shall be available across the full age range of patients.
 - The minimum mass including a mass reserve required for the listed sanitary, medical and technical devices should be 225 kg.
 - The equipment shall comply with the standards mentioned against them if any. Tests conducted by notified international bodies as per the relevant standards shall be acceptable if verifiable certified copies of the test reports and certificates are available.
 - All rescue ambulances must be fitted/ carry the following list of equipment with them at all times.

S No.	Equipment	Quantity
1.	Main automatic loading stretcher (length 1900 mm - 1970 mm, width 530 mm to 570 mm with loading capacity of 150 kg) conforming to EN 1865 standard	2
2.	Scoop stretcher (lightweight aluminum stretcher, length 1600 mm - 2000 mm, width - minimum 42 cms, loading capacity - minimum 150 kgs) conforming to EN 1865 standard	2
3.	Vacuum mattress (length 1900 mm - 1970 mm, width 530 mm to 570 mm with loading capacity of minimum 150 kg) conforming to EN 1865 standard	2
4.	Long spinal board with head immobilizer & securing straps and plastic material at high strength, should be waterproof & conforming to EN 1865 standard	2
5.	Set of fractures/ splints made of mouldable metal or alloy (aluminum) - sizes for both children & adults and for hand & wrist, half arm, full arm, foot and ankle, half leg, full leg (all splints should be washable and reusable)	2 each
6.	Cervical collar for both kids & adults (should have pre-molded chin support, locking dips and rear ventilation panel and an enlarged trachea opening, should have high density polyethylene and foam padding, should be X-ray lucent and easy to clean and dis-infect)	4 each
7.	KED extrication device	1

S No.	Equipment	Quantity
8.	Stationary oxygen - Minimum 2 Nos. of 10 L water capacity cylinders at maximum 150 kgf/ cm ² filling pressure manufactured as per IS:7285 & certified by chief controller of explosives, Nagpur along with 3/8 bull nose valve as per IS:3224	2
9.	Portable oxygen - Minimum 1 Nos. of 10 L water capacity cylinders at maximum 150 kgf/ cm ² filling pressure manufactured as per IS:7285 & certified by chief controller of explosives, Nagpur along with 3/8 bull nose valve as per IS:3224	2
10.	Manual resuscitator with oxygen inlet and mask	2
11.	Airways (nasopharyngeal airways of size 6.5 mm, 7.5 mm, 7 mm, 8.5 mm & 8 mm & oropharyngeal of size 0, 1, 2, 3 & 4)	2 each
12.	Electric portable suction aspirator with air flow of at least 30 L/ min and vacuum level of at least 600 mm Hg (ISO:10079-1-1999)	2
13.	Manual portable suction aspirator conforming to IS:4533-1995	3
14.	Suction Catheter (12 & 16)	2 each
15.	Laryngeal mask airway (for both kids & adults)	2 each
16.	Infusion solutions, Litre	4
17.	Equipment for injections and infusions set (IV Sets)	2
18.	Infusion mounting	2
19.	Tourniquet (multiple sizes) conforming to IS:7971-1987	2
20.	Automatic External Defibrillator with ability to deliver shock up to 200 joules through biphasic technology; should also consist of an audio alarm	1
21.	Nebulizer conforming to IS:9462-1980	2
22.	Manual B.P. Monitor (cuff size: 10 cm - 66 cm)	2
23.	Portable Automatic B.P., heart rate & saturation monitor	2
24.	Oximeter of ISO:9919 standards	2
25.	Stethoscope conforming to IS:3391-1965	2
26.	Thermometer (min: 28 degrees to 42 degrees Celsius)	2
27.	Device for blood sugar determination	2
28.	Diagnostic Light	2
29.	Blanket	2

S No.	Equipment	Quantity
30.	Non woven stretcher sheet	2
31.	Kidney bowl	2
32.	Vomiting Bag	2
33.	Non-glass urine bottle	2
34.	Waste bag	2
35.	Bed Pan	2
36.	Sharps container	2
37.	Sterile surgical gloves, pairs	5
38.	Non-sterile gloves for single use	100
39.	Basic protective clothing including high visibility reflective jacket	3
40.	Safety/ debris gloves	3
41.	Safety shoes	3
42.	Safety helmet	3
43.	Personal protection equipment against infection including disinfectants	3
44.	Fire extinguishers (minimum 2 kgs) complying with IS:13849 or IS:2171)	2
45.	Hammer	1
46.	Shovel	1
47.	Hydraulic Cutter/ Spreader	1
48.	Warning Triangle Lights	4
49.	Spotlight	1
50.	Public addressal system	1
51.	Two way radio transceiver or better technology for mobile communication with highway surveillance team, tow away crane & control room	1
52.	Internal phone within patient compartment for communication with driver	1
53.	Automated vehicle tracking system with GPS technology for continuous tracking of vehicle location	1

- List of medicines & dressing material to be carried in rescue ambulance at all times:**

S No.	Medicines & Dressing Material	Quantity
1.	Band-Aids	20
2.	Betadine Solution 500 ml (bottle)	1
3.	Cotton roll 500 gm	1
4.	Crape bandage 15 cm x 4 mtr	2
5.	Crape bandage 7 cm x 4 mtr	2
6.	Dressing pad 10 cm x 10 cm (pre-sterilized)	10
7.	Dressing pad 10 cm x 20 cm (pre-sterilized)	10
8.	Elasto plast (dyna plaster) 10cm	2
9.	Gauge cloth 80 cm x 18 mtr	1
10.	Gauge rolls 4 "	1
11.	Gauge rolls 6 "	1
12.	Plain bandage of various sizes	3
13.	Hydrogen Peroxide 400 ml (bottle)	1
14.	Micropore tape 2",4"	2
15.	Surgical Spirit Bottle 500 ml (bottle)	1
16.	Glucose 100 gm	2
17.	IV Fluid Dextrose 25% (bottle)	5
18.	IV Fluid Normal Saline (bottle)	10
19.	IV Fluid Ringer (RL) (bottle)	10
20.	IV Fluid 5% GNS (bottle)	5
21.	Inj adrenaline 1 ml	5
22.	Asthalin-neubilizing solution	5
23.	Inj atropine 1 ml	20
24.	Inj avil 2 ml	5
25.	Budesonide-neubilizing solution	5
26.	Inj distilled water 5 ml	5
27.	Inj dizazepam 2 ml	5

S No.	Medicines & Dressing Material	Quantity
28.	Inj hydrocortisone 100 mg	5
29.	Inj lasix 2 ml	5
30.	Inj paracetamol 2 ml	5
31.	Inj rantidine 2 ml	5
32.	Inj tramadol 2 ml	5
33.	Inj tranexaminc acid	4
34.	Inj neostigmine	4
35.	Inj haemaccel	2
36.	Inj mannitol	5
37.	Inj sodabicarb 7.5%	5
38.	Inj metaclopromide	5
39.	Inj phenytoin	5
40.	Inj hyosymine bromide or dicyclomine hydrochloride	5
41.	Inj methargin	5
42.	ORS 4.20 gm	10
43.	Syp Antacid Anaesthetic Gel (bottle)	1
44.	Syp Paracetamol 60 ml (bottle)	1
45.	Tab Activated Charcoal (strip)	1
46.	Tab Clopidogrel (strip)	1
47.	Tab Disprin/Asprin (strip)	1
48.	Tab Paracetamol (strip)	1
49.	Tab Isosorbrite Dinitrate 5 mg sublingual (strip)	1
50.	Xylocaine (wocaine gel) 2% 30 gm jelly (tube)	1

Rescue Ambulance Manpower

- **1 trained EMT staff with the following qualifications/ experience**
 - Basic qualification of EMT – Diploma in E.M.T.
 - B.Sc. (PCB) with certification in BLS/ ALS/ ACLS/ ITLS (or) B.Sc Nursing/ GNM/ ANM (or) B.Pharma/ D. Pharma or any other equivalent paramedical course from recognized university/institution of IMC/INC.
 - Minimum 2 years of relevant experience in first-aid and life saving emergency skills including spinal immobilization, bleeding control, oxygen therapy, defibrillation and medicine administration.
 - At least one training (minimum one month) in tertiary care institution or at a recognized institute with experience in handling life-saving equipment.
 - Basic training in extrication.
- **1 Driver**
 - Valid license to drive an rescue ambulance.
 - Ability to read/ write & maintain log books.
 - Basic training in delivering first aid & victim extrication.

Rescue Ambulance Branding & Recognition

- **Recognition and visibility of rescue ambulances**

The Rescue Ambulance Conspicuity Code is split into six Sections.

- i) Colour
- ii) Conspicuity Improving Items (C2I)
- iii) Emblems
- iv) Warning Lights
- v) Sirens
- vi) Recognition of personnel

The Section “colour” describes the vehicles basic colour. The Section “Conspicuity Improving Items” or “C2I” includes all Symbols, Marking and Striping defined as such by this standard. The Section “Emblems” refers to every item that doesn’t fall under the definition of C2I which can be private company signs or corporate identities. The Section “Warning Lights” describes colour, position, alignment, luminosity, photometric brightness, flash patterns and electrical current consumption of all used warning lights. The Section “Sirens” determines the volumes, frequencies and electrical current consumption of all used sirens and speakers.

- **Colour**

- The basic colour of the complete exterior should be brilliant blue as per Annexure-I attached, front, rear and side bumpers included. The colour should be weather resistant and withstand daily cleaning and washing.

- **Conspicuity improving items**

- This definition includes all marking and symbols as shown in the **Figs. 3 and 4** below. All C2I-markings should be in brilliant red, RAL- Code 3024 and in retro

reflective quality. “AMBULANCE” markings, the Star of Life and the emergency number symbol. All “AMBULANCE” markings must follow a 7:1 ratio, length to height.

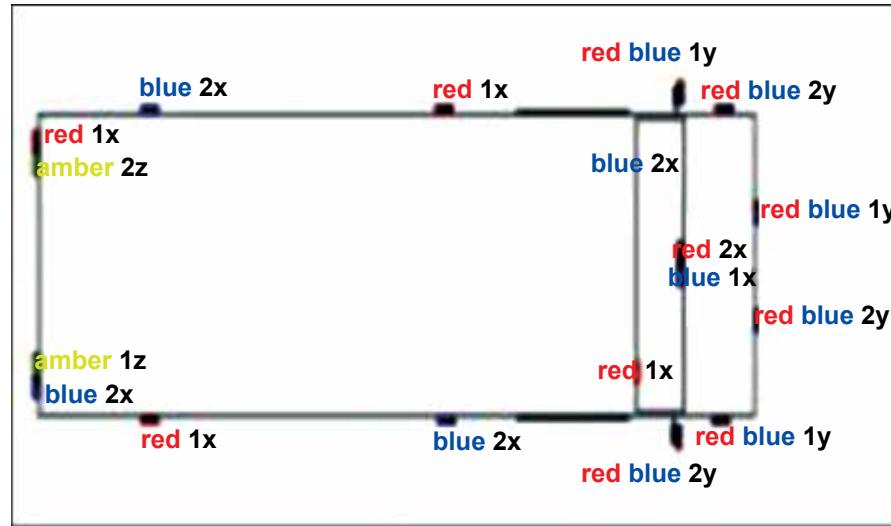
- **Front:** No less than 50% of the front side of the vehicle should be brilliant Blue in contrast to no less of 10% brilliant red. The word “AMBULANCE” on brilliant blue background, minimum of 65% of the hood width, shall be in mirror image (reverse reading) for mirror identification by drivers ahead.
- **Side:** The side of the vehicle should be equipped with a two lined red on the white ground colour as shown in **Fig. 4**. The vehicle side should be brilliant blue followed by an “AMBULANCE” marking on the same height. “Star of Life” symbol, with a size of 40cm x 40cm, and the emergency number logo, with a size of 40cm x 75cm. The vertical centre from both of them should match the vertical centre of the side windows of the driver cabin. The words “Basic Life Support” shall be marked respectively just above the word ambulance in size no less than 50% of the size of the word “AMBULANCE”

- **Emblems**

- NHAI emblem should be placed instead of “XXX” in a non-reflecting manner and the size can't be bigger than 60% of the “AMBULANCE” markings. Ambulance Calling Number 1033 must be displayed prominently on the side and back of the Road rescue ambulance.

- **Warning lights**

- All warning lights have to be mounted rectangular to the horizontal ground. They must provide 100% of their intensity in a vertical angle of ± 4 degrees and 50% in a vertical angle of ± 8 degrees. The minimum intensity is for blue and red lights at 100cd at daylight and 200cd in the night. The horizontal minimum angle should be at least 45 degrees. All lights must flash between 2Hz and 4Hz and should be mounted as on the graphic below:


Flash Pattern

1. Indicates light flashing the same time
2. Indicates light flashing

3. 180 degree out of phase with 1
 4. 'x' indicates 'ON' lights in primary and secondary mode
 5. 'y' indicates 'ON' light only in primary mode
 6. 5 'z' indicates 'ON' light only in secondary mode
- Lights marked with "red blue" must show red and blue in one piece one at a time. In daytime they must flash red in nighttime they must flash blue. Two lights have to be mounted in the lower middle windshield only flashing to the outside of the car. All lights should be flashing as shown in the graphic above. To switch from Primary into Secondary Mode there has to be one switch that allows only one mode.
- **Sirens**
 - All siren loudspeakers have to be mounted on the front of the vehicle. Hidden installation is allowed. The main sound direction must be in driving direction. Permitted are wail and yelp signals that cycle between 10-18 respectively 150-250 per minute at an sound pressure level of 110dB(A) to 120dB(A). The sirens should be tested in accordance with IS:1884 (though not covered in the standard). The frequency range must be at least one octave and should be between 500Hz and 2.000Hz. An additional electronic air horn can be used. Further there should be a public address system that can be worked at all times ergonomically from the driver's seat. The siren switch can only be used if the warning lights are on.
 - **Recognition of personnel**
 - Safety garments for rescue ambulance personnel should conform to at least ISO:14116-2008.



Fig. 3 Rescue Ambulance – Front View

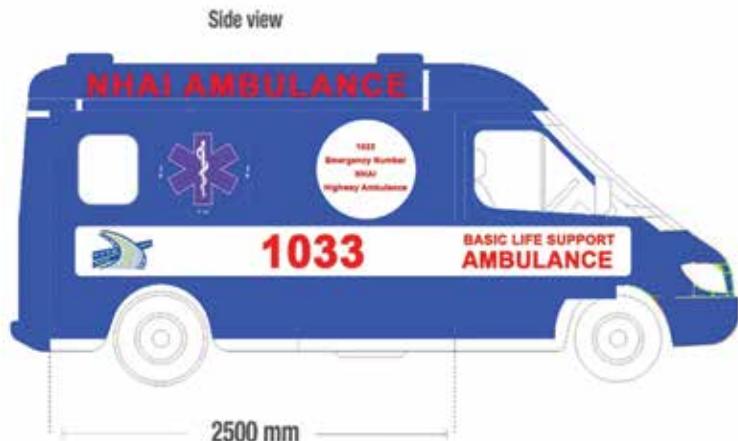


Fig. 4 Rescue Ambulance Side View

Brilliant Blue Colour Code : C: 87%, M: 74%, Y: 0%, K: 0%

SECTION 13

SPECIAL REQUIREMENTS FOR HILL ROADS

13.1 General

13.1.1 (a) Survey and Investigation

- i) Detailed Survey & investigation shall be done for the stretches passing through Mountainous /Hilly terrain (either whole or part of project length) for specifying the adequate details in Schedules by the Authority.
- ii) Concessionaire to develop contour lines mapping duly superimposed on plan lay out drawing.
- iii) Possibilities of sediment/weathered rocks related slides etc. should be surveyed in details before Slope cutting.
- iv) The Cutting should be done from the Top to Bottom with proper care for side slopes and side drains in cutting.
- v) An appropriate design for slope stability should be selected by the concessionaire in accordance to survey & investigation done for slope conditions using either one or combination of the following technique; Breast Wall, Concrete Cladding, Soil Nailing, Rock Bolting, Rock Fall Netting, Hydro-seeding, Using Geo-Textiles, Anchors Covering Slopes with Wire Mesh & any other suitable method.

(b) Six Lanning Carriageway

- i) If the additional carriageway at same level as that of the existing carriageway by using valley side formation as well as hill side cutting.
- ii) If the additional carriageway not feasible at same level then by forming a split highway preferably in down the level of exiting carriageway.
- iii) If either of these options not technically feasible, provision of a tunnel for additional three-lane may be explored.
- iv) For new six-lane carriageway cutting of hill slopes be minimised by forming a split highways of three-lane each.

13.1.2 The Concessionaire shall pay due attention to geo-technical, environmental and social aspects of hill roads and take appropriate measures to ensure the following (The guidelines given in IRC:SP:48 may be referred to for details):

- i) Stability against geological disturbances
- ii) Prevention of soil erosion
- iii) Provision of efficient drainage and preservation of natural drainage system

13.1.3 If there are any landslide prone areas along the road alignment, adequate investigation shall be undertaken and appropriate remedial measures shall be provided as per guidelines given in IRC:SP:48.

13.1.4 Where any new construction/realignment is involved, the alignment shall avoid large scale cutting and filling and follow the profile of land, as far as possible. Areas having potential landslide or settlement problems shall be avoided. Adverse impact on the environment shall be

reduced by adopting proper mitigation measures. Refer to Guidelines given in IRC:SP:48.

13.1.5 Unstable hill slopes shall be adequately addressed by providing appropriate bioengineering and stabilization measures.

13.1.6 Necessary safeguard shall be taken to protect ecologically sensitive areas like wildlife and bird sanctuaries, reserve forests, national parks, etc.

13.1.7 Protective structures for traffic such as parapets, railings, roadside safety barriers, boulder nets, etc. shall be provided, where necessary.

13.1.8 In mountainous and steep terrain, the scope of work defined by the Authority may be three-lane carriageways on different alignments (contours).

13.2 Set Back Distance at Horizontal Curves

Requisite sight distance should be available across the inside of horizontal curves. Lack of visibility in the lateral direction may arise due to obstructions like walls, cut-slopes, wooded areas, etc. Set back distance from the central line of the carriageway, within which the offending obstructions should be cleared to ensure the needed visibility, can be determined using the equation given in IRC:52.

13.3 Grade Compensation at Curves

At horizontal curves, the gradient shall be eased by applying the grade compensation correction for gradients steeper than 4 percent in accordance with IRC:52.

13.4 Hairpin Bends

Hairpin bends where unavoidable, may be designed either as a circular curve with transition curves at each end or as a compound circular curve. Design criteria given in IRC:52 shall be adopted for the design of hairpin bends. At hairpin bends, the full roadway width shall be surfaced.

13.5 Climbing Lane

Climbing lane shall be provided, where specified in **Schedule ‘B’** of the Concession Agreement, in order to address the necessity of making available separate lane for safe overtaking for vehicle traveling uphill. Proper signs and road markings shall be provided to ensure that the absolute right of way for climbing vehicles is available.

13.6 Rock Blasting

Heavy rock blasting should be avoided. Controlled blasting shall be resorted to. Blasting shall be supervised by experienced personnel. Blasting and related operations shall be carried out in accordance with Clause 302 of MoRTH Specifications.

13.7 Cut Slopes

Cut slopes shall be rendered stable in the construction stage itself, by cutting at the correct angle and benching etc. including slope stabilizing structures like drains, breast walls, pitching, etc.

13.8 Tunnels

Where it is necessary to cross hills or high ridges, the various alternatives including construction of tunnel to avoid deep cuts shall be considered and the most preferred alternative shall be chosen. The alternative to be followed shall be indicated in **Schedule ‘B’** of the Concession Agreement. Where road is to be taken through tunnel, its salient details shall be indicated in **Schedule ‘B’** of the Concession Agreement. Alternatively the specifications given in **Section 14** of this Manual shall be adopted.

13.9 Drainage

For drainage of water from roadside, an effective system of drainage shall be constructed to lead the run-off to natural water courses. In particular, catch water drains (Refer to **Para 6.5** of this Manual) shall be provided above the cut slopes. It shall be ensured that water is not drained into villages and cultivated land. Location of cross drains and culverts should be so chosen as to avoid erosion of the outlet. Erosion control works like drop walls, apron at out-fall points along with pitching/paving of the channel shall be provided where required.

13.10 Retaining Walls

13.10.1 Retaining walls shall be provided:

- i) To support the down hill side unstable strata or fills,
- ii) To achieve width of roadway, where cutting into hill is restricted,
- iii) To arrest damage caused to the valley side and the road, by undercutting by a stream or other water course,
- iv) At valley points, where water flows over the road,
- v) At places where the valley side gets saturated in the monsoons and is likely to result in slips and damage to the road
- vi) At any other locations warranting provision of retaining walls.

13.10.2 The retaining walls on the existing highway shall be inspected by the Concessionaire to check and assess the requirements of repairs and/or strengthening or reconstruction. If so, required, the repair and/or strengthening or reconstruction work shall be carried out as per the assessment.

13.10.3 For general features, arrangement and design, Guidelines given in IRC:SP:48 may be referred to.

13.11 Breast Wall

13.11.1 Breast walls shall be provided:

- i) To support uphill sides unstable strata or fills,
- ii) To achieve width of roadway where cutting of hill slopes is essential,
- iii) To arrest damages caused to the hill side toe due to pore water pressure/ undercutting by side drains water flow,
- iv) At hill side locations where the hill slopes get saturated in the monsoons and is likely to result in slips and damages to the road,
- v) To assets in drainage from hill-slope through weep- holes in breast wall on to the side drains in front of the wall,
- vi) At any other locations warranting provisions of Breast Walls.

13.11.2 The Breast walls on the existing roads shall be inspected by the Concessionaire to check and assess the requirements of repairs and/ or strengthening or reconstruction. If so required, the repair and/or strengthening or reconstruction work shall be carried out as per the assessment.

13.11.3 For general features, arrangement and design, Guidelines given in IRC:SP:48 may be referred to.

13.12 Aprons etc.

Construction of apron, pitching, flooring shall conform to **Clauses 2503 to 2507** of MoRTH Specifications.

13.13 Disposal of Debris

Disposal sites shall be identified by the Concessionaire for disposal of waste, debris, etc. Tipping of waste into valley sides, stream channels, water bodies, and forest areas shall not be resorted to.

13.14 Report to be Submitted

The Concessionaire shall submit report containing proposal for special requirements in hill areas to the IE for review and comments, if any.

SECTION 14

TUNNELS

14.1 General

14.1.1 Project highway shall be constructed in tunnel either to carry the alignment under or through a natural obstacle or to minimize the impact on the community under conditions such as

- i) Long, narrow mountainous terrain where a cut section is economically unviable or leads to adverse environmental consequences
- ii) Narrow right-of-way where all the surface area must be retained for road purpose
- iii) Railway yard, airport or similar facilities
- iv) Parks or other land uses, existing or planned
- v) Prohibitive costs of land acquisition exceeding the costs of tunnel construction and operation

14.1.2 Planning and design of tunnel shall be based on various conditions along the Project highway alignment including the topography, geology, meteorology, environment, locations and traffic volumes and shall generally conform to provisions of IRC:SP:91 and this Manual.

14.1.3 Wherever tunnel is required to be provided its location, length and number of lanes shall be indicated in **Schedule ‘B’** of the Concession Agreement.

14.2 Geometrics

14.2.1 A tunnel shall have the same geometric standards as on the main carriageway outside the tunnel except as specified in this Section.

14.2.2 Cross-section

Shape of tunnel cross-section shall be commensurate with the methodology of construction, e.g., mining or cut-and-cover method, geotechnical conditions and structural consideration.

14.2.3 Horizontal clearance

The tunnel shall cater for carriageway, paved shoulder, edge strip as on the adjoining carriageways outside the tunnel, and space to be provided for ventilation ducts, escape footway, emergency lay-by where necessary, lighting, drainage, fire and other services.

14.2.4 Vertical clearance

The tunnel shall have a minimum vertical clearance of 5.5 m over the full width of carriageway and paved shoulders. Vertical clearance over footway shall be 3.0 m minimum. Additional vertical clearance shall be provided for accommodating tunnel ventilation and lighting fixtures.

14.2.5 Number of traffic lanes

Design service volume for tunnel shall be same as for the portion of highway outside the tunnel. Number of lanes to be provided shall be based on the traffic projections for 25 years. Tunnels shall have minimum 3-lanes carriageway for each direction of traffic. Provision shall be made for providing additional tubes as and when traffic demands. In case there is existing 2-lane tunnel, another 2-lane tunnel shall be added for one side traffic (2x2 lanes) and a new 3-lane tunnel shall be added for other side of traffic. In case there are two existing tunnels of 2-lanes each,

another tunnel of 3-lane or two tunnels of 2-lanes each shall be added.

14.2.6 Carrigeway & paved shoulder

The carriageways of the tunnels shall be of cement concrete. Tunnels shall have paved shoulder of 3.0 m on left side and edge strip of 0.50 m on the right side. In case of tunnels having more than 500 m length provision shall be made for 100 m long and 3.0 m wide emergency lay-bye beyond the left most lane at 750 m intervals to facilitate refuge by break down/damaged vehicles and also for maintenance of vehicles. Proper transitions, line of sight and informative signs shall be ensured for such lay-bye. Typical tunnel cross-sections for unidirectional traffic conditions for three-lane configuration with cut and cover construction and mining type construction are shown in **Figs. 14.1** and **14.2**. A typical layout of lay-bye is shown in **Fig. 14.3**.

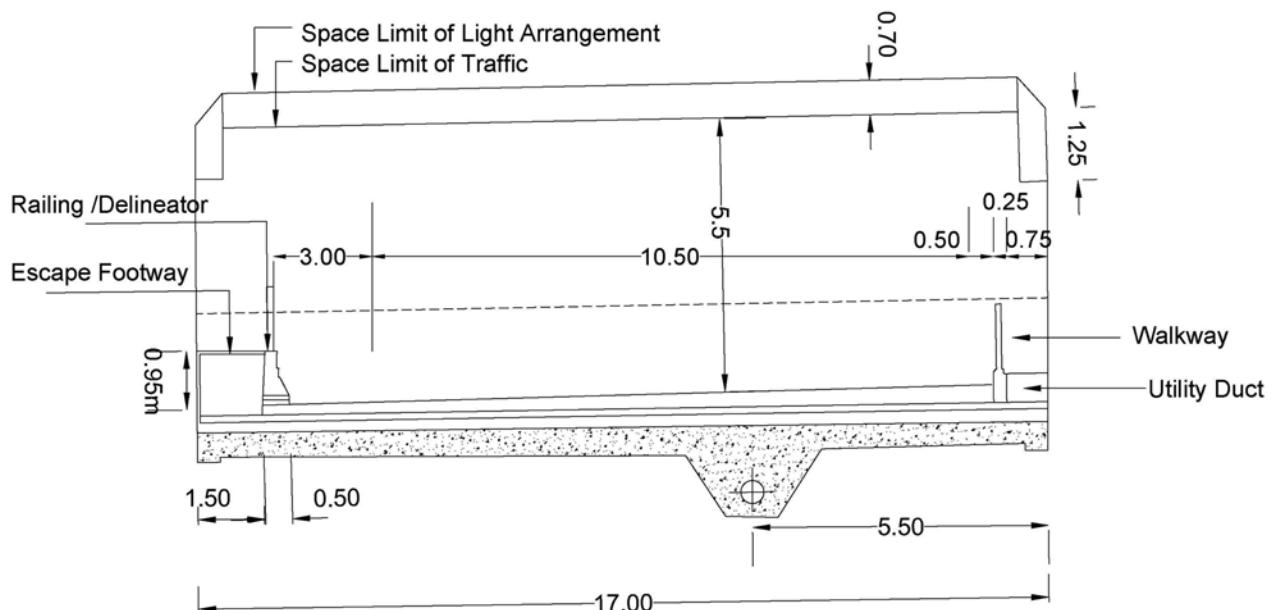


Fig. 14.1 Typical Cross-Section of Three-Lane Tunnel Cut and Cover Construction

All Dimensions are in meters

14.2.7 Tunnel spacing

The clear distance between the twin tubes shall be kept depending upon the type of strata and structural stability of the tunnel subject.

14.2.8 Tunnel passage

The twin tunnels of more than 500 m length shall be connected by a cross passage at an inclination to facilitate diversion of the traffic from one tube to other tube in the event of an incident/accident in one of the tubes at a spacing of 300 m. The cross passage shall be at an angle of 30 degrees with the direction of flow as shown in **Fig. 14.4**. The cross passage shall have provision for one traffic lane, edge strip of 0.60 m, crash barriers and walkways on either side. In normal conditions the cross passage shall be barricaded.

14.2.9 Vertical alignment

The vertical gradient shall not be more than 2.5 percent for tunnels of length more than 500 m. In short tunnels, the gradient may be limited to 6 percent however, in such cases the ventilation system should be designed to take effect of gradient and possible incidence of fire.

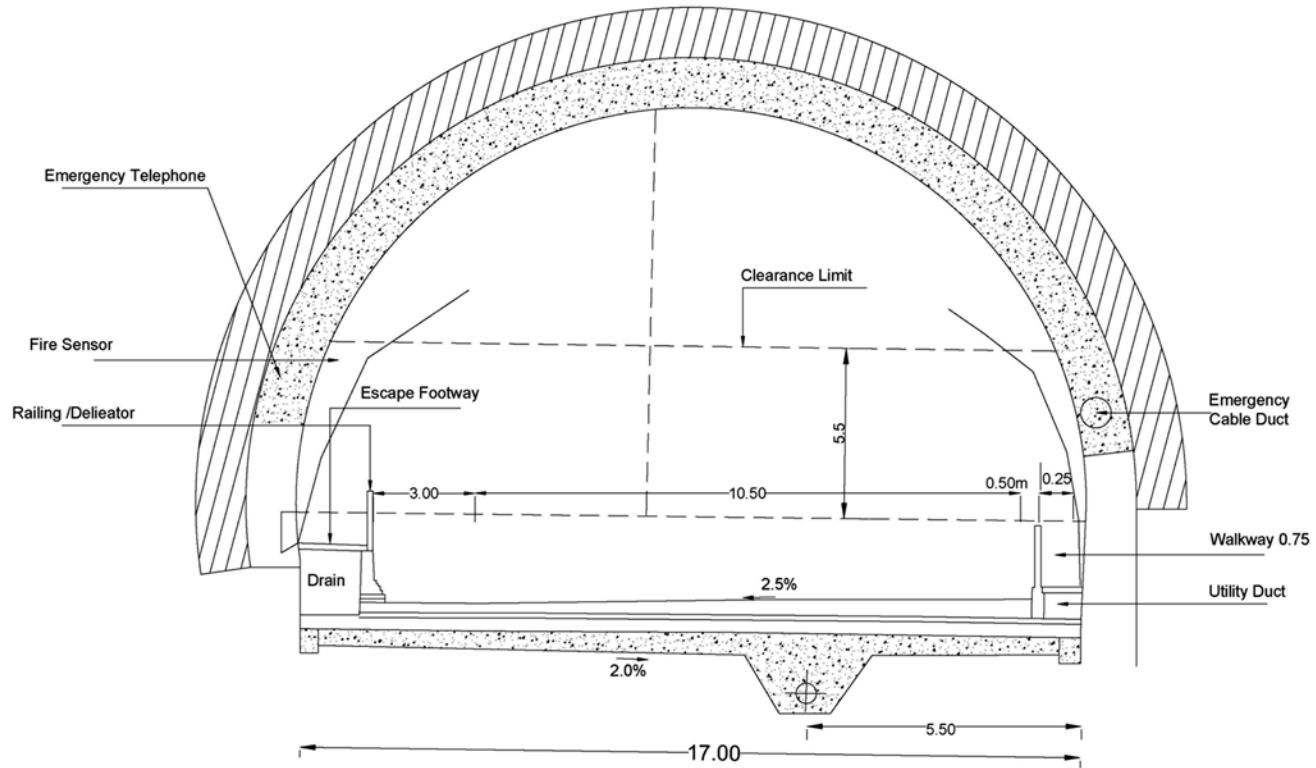


Fig. 14.2 Typical Cross-Section of Three-Lane Tunnel Mining Type Construction

All Dimensions are in meters

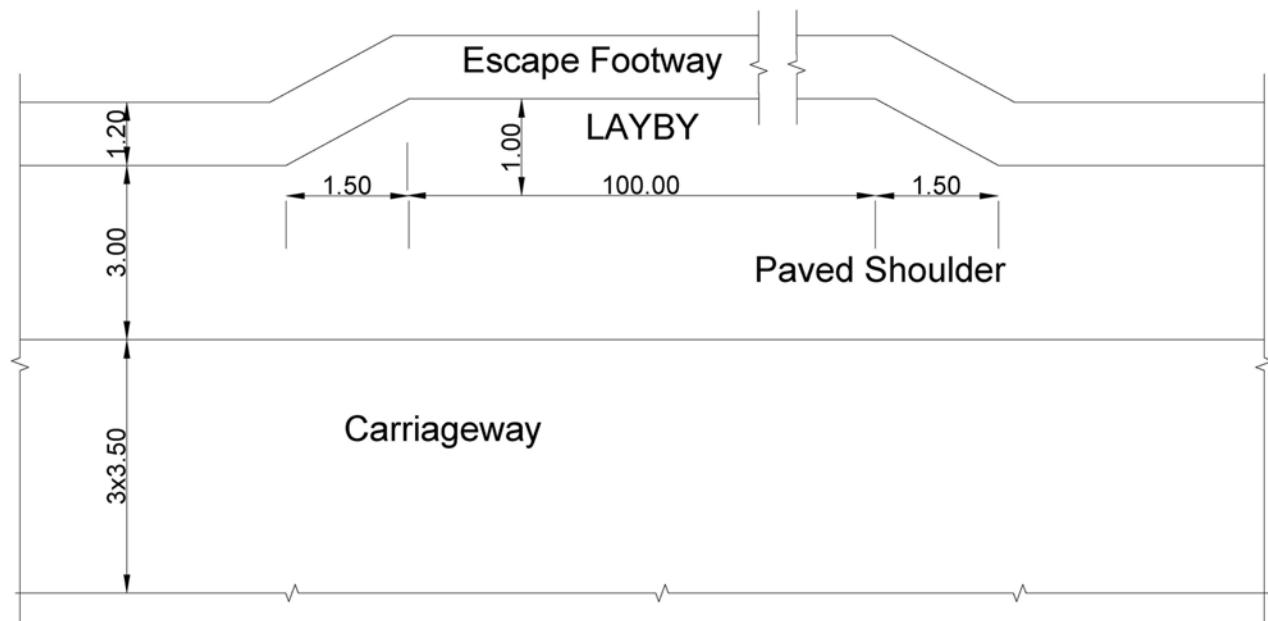


Fig. 14.3 Typical Layby inside Tunnel for Tunnel Length more than 500 M
(At 750 m Interval)

All Dimensions are in meters

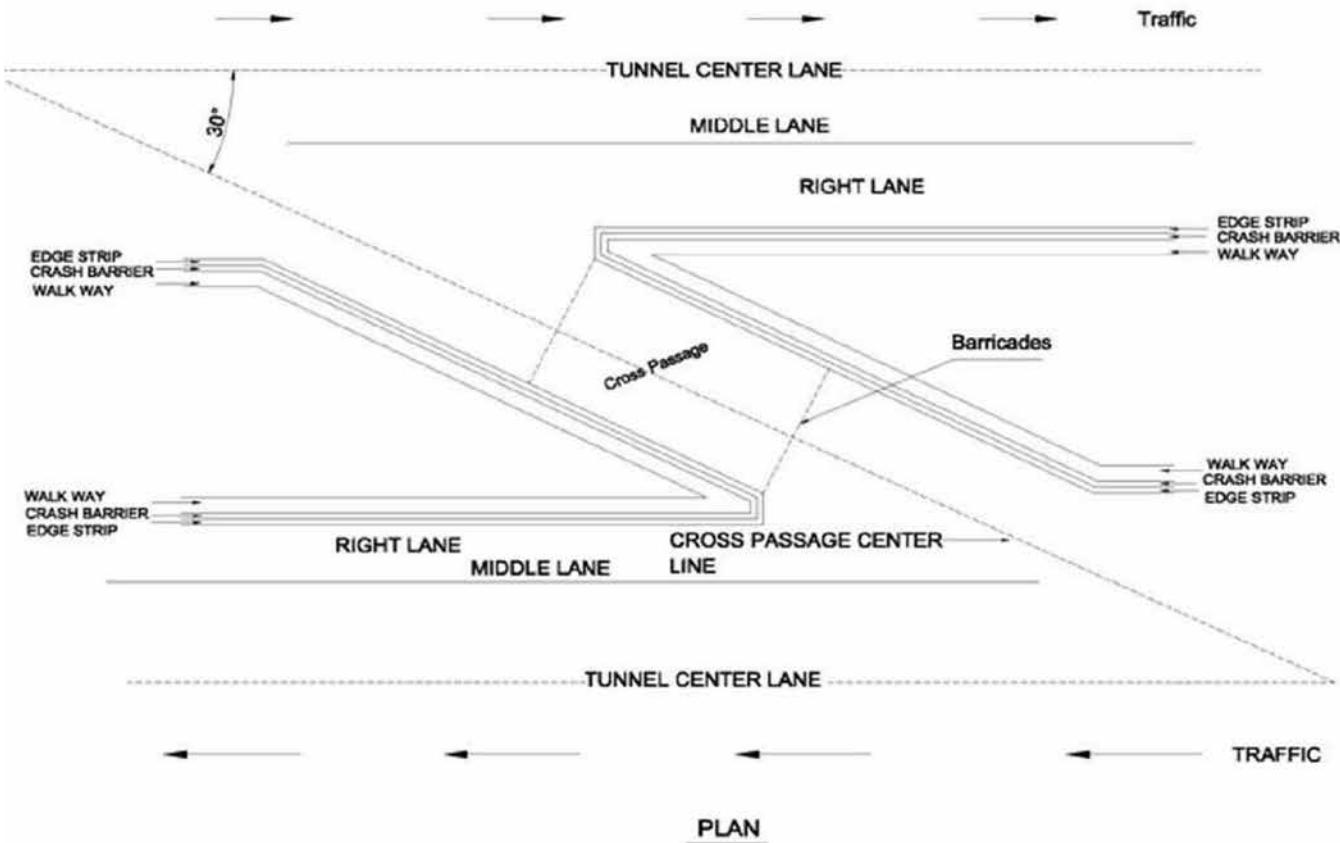


Fig. 14.4 Tunnel Passage

14.2.10 Horizontal alignment

The horizontal alignment shall be straight as far as practicable. However the straight stretch shall not be more than 1500 m to avoid the effect of monotony and induction of an unconscious increase in speed. Similarly, last few metres of the tunnel shall have gentle curve. The curves, if provided shall be gentle and meet the minimum radius requirements for design speed of the tunnel. Tunnel alignment at the ends and open/approach cuts shall merge smoothly with adjoining road in the open air. The crossing of central median shall be provided at suitable locations at approaches of both tunnel tubes so as to allow emergency services gain immediate access to either tube and also to send back diverted traffic to proper traffic lanes.

14.2.11 Tunnel approach

Tunnel approach shall have smoothly aligned tunnel walls without any sudden narrowing to avoid a shift from the tunnel wall and a good day/night visibility of the edge lines. Tunnel wall lining shall be of white colour with high luminous reflectance.

14.2.12 Tunnel Portals

Tunnel portals should, apart from providing protection at entry and exit, convey drivers about the presence of the tunnel, reduce the luminance of facing walls and be in harmony with the surrounding environment from aesthetics considerations.

14.3 Geotechnical Investigations

In order to make a realistic geotechnical and geophysical assessment of the ground through which the tunnel is to pass and detailed mapping of surface geology of the tunnel area necessary

for the planning and design of alignment and portal locations, shape of tunnel, tunnel supporting systems, minimum distance to be kept between two tunnels, independent geotechnical investigations should be carried in accordance with the provisions of IRC:SP:91.

14.4 Structural Design

14.4.1 Assessment of applicable loads shall be based on structural properties of the ground likely to be met during tunneling as arrived from detailed geo-technical investigations.

14.4.2 The design shall cater to the most adverse combination of load conditions including only those loads which have reasonable probability of simultaneous occurring with due consideration for the methodology of construction particularly in case of soft strata and soils. The design shall be checked for loading conditions during the stages of construction, operation and maintenance.

14.4.3 *Tunnels in rock*

Provisions of IRC:SP:91 shall be followed for the structural design of tunnels passing through rock.

14.4.4 *Tunnels through soft strata and soils*

Structural design of tunnel system passing through soft strata and soils may be carried out by suitable national or international standards, specialist literature and best engineering practices.

14.5 Design of Drainage System

Efficient and effective drainage system shall be provided in the tunnel for the removal of water from rainfall, seepage, tunnel washing operations, vehicle drippings/spillage on fire fighting operations.

14.5.1 In order to trap rainwater from hill slopes and prevent it from flowing into the approach cuts and the tunnel, suitable catch water drains shall be provided above the top of sides of the open/approach cuts and above excavated portals.

14.5.2 In the open/approach cuts discontinuous kerbs shall be provided to demarcate the edge of the carriageway. Beyond the kerbs, side drains with adequate waterway shall be provided in the open/approach cuts.

14.5.3 Inside the tunnel, suitable side drains shall be provided behind the kerbs/crash barriers. Suitable drain pipes going through the kerbs/crash barriers shall be provided to lead seepage and wash water to the drains. The drains shall be located below the walkways meant for the pedestrians and maintenance personnel, as shown in the sketches below. The carriageway shall have suitable camber to facilitate drainage into the side drains. In case of bi-directional tunnel, the camber shall be from the centre outwards and in case of uni-directional tunnel from high speed lane towards low speed lane. The vertical profile shall facilitate self draining of tunnel by providing high point somewhere in the tunnel. However, for long tunnels this may not be possible and detailed draining system shall be designed by providing sumps and combination of self draining and pumping arrangements.

14.5.4 The black topped road surface inside tunnel, generally constructed on rocky subgrade, gets damaged due to seepage water and creates severe problem for surface drainage. Hence the pavement inside the tunnel and in approach cuts shall be of high performance pavement concrete.

14.6 Waterproofing

Waterproofing in the form of tunnel lining such as cast in situ plains on reinforced concrete shall be provided for structural protection from surrounding weathering effects as well as operational considerations. To prevent water leaks inside the tunnel, water proof sheet at least 0.8 mm thick with synthetic textile buffer between shotcrete and lining shall be provided.

14.7 Ventilation

14.7.1 Natural ventilation may be sufficient for tunnels of length up to 500 m. However for tunnels of length more than 250 m natural ventilation system should be used only after thorough evaluation of reliance on natural ventilation especially with reference to effects of meteorological and operating conditions.

14.7.2 Mechanical system of ventilation shall be provided in case of tunnels of length more than 500 m.

14.7.3 Detailed design of ventilation shall be carried out as per IRC:SP:91 keeping in view the length, shape, size, tunnel environs and complexion of the likely traffic for which tunnel has been designed.

14.8 Tunnel Illumination

Tunnel illumination/lighting shall be designed and provided as per MoRTH Guidelines for Expressway, **Chapter 13.5** for Tunnel Lighting.

14.9 Tunnel Furnishing

Provisions shall be made for installation of tunnel furnishing such as sign boards, fire fighting arrangements, cable trays for telephone and power lines etc. in consultation with relevant local authorities.

14.10 Signages and Carriageway Markings

14.10.1 Variable messages signs inside the tunnel shall be provided for the information of traffic of lane blockage/closure due to incidents related to vehicles/non-vehicles, weather and human hazards etc. or maintenance operations as also to warn of possible hazard ahead due to any abnormal situation. Signage system shall be complemented by providing traffic lights above each lane at the entry portal end and inside. Signages indicating distance travelled, distance/direction to an exit on evacuation route shall be provided inside the tunnel.

14.10.2 Tunnel carriageway markings consisting of a discontinuous line separating the traffic lanes and continuous line separating the lateral traffic lane from the paved shoulder and emergency lay-by shall have good day/night visibility and conform to IRC:35. The markings shall be done by means of self propelled machine which has a satisfactory cut-off capable of applying broken line automatically.

14.10.2.1 Material

- i) Hot applied thermoplastic paint with glass beads shall be used as carriageway marking material.
- ii) Carriageway marking may also be in the form of pre-fabricated sheet material, e.g. plastic sheets, which may be set into the pavement with upper surface flush with the pavement surface.

14.11 Emergency Facilities

14.11.1 Tunnel emergency facilities to mitigate damage in the event of incidence of fire or any other accident in the tunnel shall be provided in conformity with the standards for installation of emergency facilities according to the classification based on traffic volume and length of tunnel as shown in **Fig. 14.5** and Guidelines of Emergency Facilities for each classification of tunnel vide **Table 14.1** as per details in following **Para 14.11.2**.

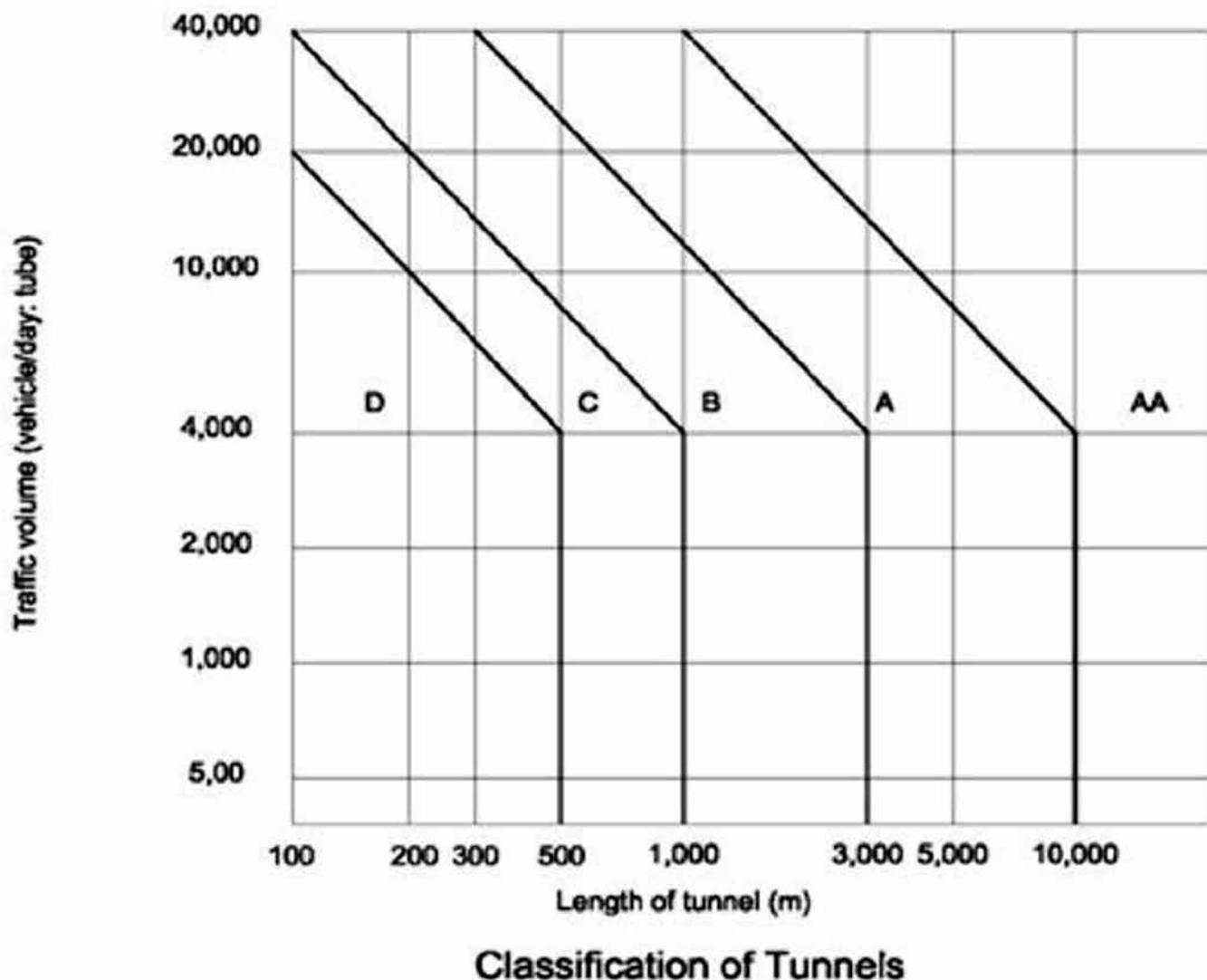


Fig 14.5 : Length of Tunnel vs Traffic Volume

14.11.2 Types of details of emergency facilities to be provided are categorized as Information and Alarm Equipment, Fire Extinguishing Equipment, Escape and Guidance Facilities and other equipment. Requirements are as under:

i) **Information and Alarm Equipment**

- a) Emergency Telephone to be used exclusively for dispatching information regarding the occurrence of an accident to the highway authorities by persons involved in or discovering the accident (installed at intervals of 200 m).

Table 14.1 Installation Standards of Emergency Facilities

Classification		AA	A	B	C	D	Remarks
Emergency Facilities							
Emergency telephone		○	○	○	○	○	Omitted in Class D tunnels less than 200 m in length
Publication type information equipment		○	○	○	○	○	
Fire detector		○	○	○	○	○	Omitted in tunnel without ventilation system
Emergency alarm equipment		○	○	○	○	○	Can be omitted in tunnels less than 200 m in length
Emergency alarm equipment	Tunnel entrance information board	○	○	○	○	○	To be installed in Class A tunnels 3,000 m or more in length
Emergency alarm equipment	In-tunnel information board	○	●				
Fire extinguisher		○	○	○	○	○	To be installed in Class B tunnels 1,000 m or more in length
Fire plug		○	○	●			To be installed in Class B tunnels 1,000 m or more in length
Emergency exit lamps		To be installed in tunnels with evacuation aids					
Guide board		To be installed in tunnels with evacuation aids					
Guide board	Emergency exit direction board	To be installed in tunnels with evacuation aids					
Guide board	Guide board	○	○	○	○	○	To be installed in tunnels without evacuation aids
Smoke discharge equipment and escape passage		<ul style="list-style-type: none"> ● Evacuation aids to be provided in tunnels of around 750 m or more in length. ● Smoke discharge equipment to be provided in tunnels of around 1,500 m or more in length. 					
Backup and duplicate equipment		<ul style="list-style-type: none"> ● Evacuation tunnels provide for those Class AA tunnels and Class A tunnels of a length of 3,000 m or more which employ a two-way traffic system and a longitudinal ventilation system. ● Either evacuation aids or smoke discharge to be provided for Class AA. 					
Hydrant		○	○	●			To be provided in Class B tunnels 1,000 m or more in length. Tunnels equipped with hydrants are to be provided with water supply points near the entrances.
Radio communication auxiliary equipment	Coaxial cables	○	●				To be provided in Class A tunnels 3,000 m or more in length.
Radio rebroadcasting equipment	Entrance/exit telephone interrupt function provided	○	○				To be provided in Class A tunnels 3,000 m or more in length.
Cell phone connectivity equipment		○	●				To be provided in Class B tunnels 3,000 m or more in length.
Loudspeaker equipment		○	○	○	○	○	To be provided
Water sprinkler system		To be provided in tunnels equipped with a radio rebroadcasting equipment (with interruption function)					
CCTV		○	●				To be provided in Class A tunnels 3,000 m or more in length, and serviced in two way traffic.
Lighting equipment for power failure		To be provided in tunnels 200 m or more in length.					
Emergency Power supply equipment	Independent power plant Non-failure power supply equipment	To be provided in tunnels 500 m or more in length.					
Emergency Power supply equipment		To be provided in tunnels 200 m or more in length.					
Other equipment		● - Use with consideration					
		○ - Mandatory					

LEGEND:

○ - Mandatory

- b) Push button type information equipment to be pressed by persons involved in or discovering an accident in order to inform the highway authorities etc. of the occurrence of the accident (installed at intervals of 50 m).
- c) **Fire Detectors:** Detect fires and automatically notify their location to the highway authorities etc. (installed at interval of 25 m).
- d) **Emergency Alarm Equipment:** when something goes out of order in the tunnel, drivers running in the access zone as well as in tunnel promptly notified through this alarm equipment. The system includes entrance information boards at tunnel entrances and the in-tunnel information boards in emergency parking areas in the tunnels.

ii) Fire Extinguishing Equipment

- a) **Fire Extinguishers:** Installed for initial control of small-scale fires. Portable powder-type fire extinguisher, two per set, are equipped (Installed at intervals of 50 m).
- b) **Fire Plug:** Hose-reel water plugs are installed for initial control of ordinary fires. Designed even for road users to be able to handle them (installed at intervals of 50 m).
- c) **Smoke Discharge Equipment:** when a fire arises, this device keeps the spread of smoke to a minimum level and also functions to force smoke to be discharged. Usually, ventilation equipment (working in reverse mode) is used as a smoke remover.

iii) Escape and Guidance Facilities

- a) **Guide board:** In an emergency, these direct road users in the tunnel the distance/direction to an exit or evacuation route, the current position, and other information.
- b) **Escape Passage:** These are evacuation tunnels and evacuation exits for the road users in the tunnel to a safe place. The former is built for escape, separately from the main tunnel, while the latter connects the main tunnel to an evacuation which runs in parallel with it, or two main tunnels. The evacuation tunnel may have a vertical clearance of 4.5 m. The exit for evacuation shall be shutter type of light weight and non-inflammable materials. Adequate signage for direction of movement and easy opening mechanism shall be provided. Evacuation tunnel shall be used only by the evacuating persons and emergency vehicles.

iv) Other Equipment

- a) **Hydrant supply water for fire fighting activities by fire service crew:** The storage capacity of tank is designed to supply water to the following fire Fighting measures for at least 40 minutes simultaneously. Design allowance shall be 20 percent extra.
 - three fire hydrants (with fire hose)
 - two sections of sprinkler
 - two hydrants.
- b) **Radio Communication Auxiliary Equipment:** Used for communication with the fire squads engaged in rescue or fire-Fighting activities in the tunnel.
- c) **Mobile Connectivity:** Arrangements for mobile connectivity shall be provided.

- d) **Radio Rebroadcasting Equipment:** This is installed in the tunnel so that radio broadcasting can be made by the authorities to transmit information in an emergency.
- e) **Loudspeaker Equipment:** Reliable information is supplied to those who have alighted from their vehicles.
- f) **Water Sprinkler System:** Sprinkle fire particles of water from water spray heads in order to prevent fire from spreading, support fire-Fighting activities.
- g) **Observation Equipment:** CCTV with zoom function are installed at intervals of 200 m.
- h) **Lighting Equipment for Power Failure:** Maintains minimum lighting required during power failure or a fire.
- i) **Emergency Power Supply Equipment:** Used to keep emergency facilities functioning during power failure. There are two kinds, storage cell type and an independent power plant.

14.12 Safety During Construction

14.12.1 It shall be ensured that all applicable rules and regulations relating to the construction of tunnels are duly complied with in strict conformity with the spirit and body of such regulations.

14.12.2 A Project Safety Plan (PSP) relevant to particular site shall be prepared by the Concessionaire and got approved from the competent authority. The PSP shall address all site-specific issues and take all the identified risk elements. During all operations connected with the construction of tunnels appropriate safety precautions shall be taken through the implementation of the PSP.

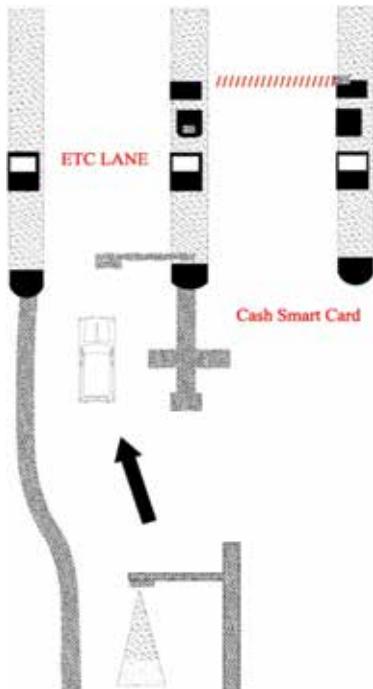
14.12.3 An emergency management plan shall be part of the approved Project Safety Plan which shall be well communicated to all working personnel and prominently displayed at site. Emergency Research Measures should be drawn up to take care of various possible contingencies.

14.12.4 Provisions of IRC:SP:91 shall generally be followed for safety during construction of tunnels.

ETC PRE-SCREENING ARRANGEMENT AND OPERATION

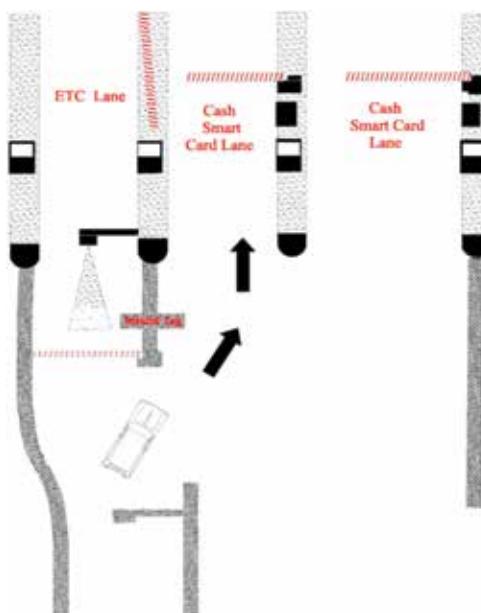
A) VEHICLE WITH VALID TAG

When the vehicle approaches the dedicated ETC lane, the first transceiver reads the Tag and allow the vehicle to proceed.



B) VEHICLE WITHOUT TAG OR INVALID TAG

When the vehicle approaches the dedicated ETC lane, the first transceiver detects vehicle as non-Tag I invalid Tag and bring down the barrier blocking the entry to ETC lane. This will force the vehicle to eject from the ETC lane and go to adjacent Cash Lanes.



APPENDIX-2
(Reference Para 1.12)

List of paras for preparing Schedule 'B' & 'C' of the Concession Agreement

Section	Para	Particulars to be specified
Schedule B		
Section 1	1.16	Type and locations of Noise Barriers
	1.17	Details of new utilities which are to be constructed or provided for along or across the Project Highway
Section 2	2.1 (ii)	Details of elevated sections
	2.1 (v)	Deficient road geometrics
	2.3	Right of way
	2.5.1	Type and width of Median in various stretches of Project Highway
	2.11.1	Span arrangement for overpass structure
	2.12.2.1	Provision for parking bays along the service road
	2.13.1	Type and location of various grade separated structures
	2.13.3	Location of Light Vehicle Underpass (LVUP)
	2.13.4	Location of SVUP and Foot Over Bridge
	2.13.4(v)	Location of Bus Bays along with Bus Shelters
Section 3	3.3.1 (i)	Locations of Grade Separated Intersections without Ramp
	3.3.3	Length of viaduct at Grade Separated Structures
	3.4.1 (v)	Detailed design and layout parameter and requirements of the interchange.
	3.4.5	Minimum length of viaduct and RCC Retaining Wall/ RE Wall.
Section 4	4.2.1 (ii)	Sections of existing road to be raised
Section 5	5.2.1	Type of pavement
	5.3.2	Method of design of rigid pavement
Section 6	6.2.1 (a)	Minimum length of drain
Section 7	7.1 (ii)	No Independent superstructure for all bridges and grade separated structures
	7.3 (iv) (d)& (f)	List of bridge structures to be reconstructed/ widened/ upgraded

Section	Para	Particulars to be specified
	7.4 (vii)	Details of Constructions of structures like cable stayed/suspension bridge or with special technique
	7.17 (iv)	Replacement of railing of existing bridges by crash barriers
	7.17 (v)	Replacement/repairs of Parapets/Railings of existing bridges
	7.19.1	Location, type and length of grade separated structures
	7.21	Measures for protecting bridges in marine environment
	7.22 (i)	Structures to be repaired/strengthened, nature and extent of repairs
Section 9	9.6	Types of crash attenuations
	9.7.5.2 (v)	Safety barrier at hazardous location
Section 10	10.4.5	Tunnel dimension for safe overhead system of cash transfer
Section 13	13.5	Requirement of Climbing lane
	13.8	Alignment/Construction of tunnel and its salient details
Section 14	14.1.3	Location length and number of lanes of Tunnel
Schedule C		
Section 9	9.2.5	Location of overhead traffic sign
Section 10	10.1 & 10.2	Location of Toll Plazas
Section 11	11.1	No. of trees to be planted
	11.3	Landscape Treatment
Section 12	12.1	Requirement of Project facilities
	12.5.1 & 12.5.3	Location of Project Highway for lighting
	12.6.1	Number & size of truck-lay-byes
	12.7.1	Number and Location of bus-bays
	12.8.1	Location of Rest Areas

**(The Official amendments to this document would be published by
the IRC in its periodical, 'Indian Highways' which shall be
considered as effective and as part of the Code/Guidelines/Manual,
etc. from the date specified therein)**