IRC:SP:99-2013

MANUAL
OF
SPECIFICATIONS AND STANDARDS
FOR
EXPRESSWAYS

INDIAN ROADS CONGRESS
2013

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Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

November, 2013

Price : ₹ 1200

(Plus Packing & Postage)

First Published : November, 2013

Printed by India Offset Press, Delhi-110064

1000 Copies

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INTRODUCTION

Recognizing the need for expeditious development of Access Controlled Facilities simultaneously ensuring safe and high speed travel which interalia improves the productivity of road transport system, it was decided by the Ministry of Road Transport & Highways and the Planning Commission through a series of meetings during December 2012 and January 2013 that a standard Manual of Specifications and Standards for Expressways should be brought out by the Indian Roads Congress (IRC). Accordingly, the IRC formulated the proposal and the task for the same was entrusted to IRC by the Ministry of Road Transport & Highways on 11th February, 2013. An Expert Group comprising of following experts was constituted by IRC for the preparation of the Manual:-

1.	Shri S.C. Sharma	Team Leader
2.	Shri D.P. Gupta	Member
3.	Shri R.S. Sharma	Member
4.	Dr. L.R. Kadiyali	Member
5.	Shri Kiyoshi Dachiku	Member
6.	Ms Neha Vyas	Member

The Ministry of Road Transport & Highways constituted a Peer Review Group under the Chairmanship of Director General (Road Development) & Special Secretary having members representing all categories of stakeholders.

The Expert Group prepared a Technical Note on Critical Issues which was discussed during the Workshop organized by the MORTH on 22nd February, 2013 and also in Planning Commission on 6th March, 2013. The Critical Issues were deliberated, discussed and frozen during these two meetings, which enabled the Expert Group to move forward.

It was decided that the Manual should be structured on the lines of the existing Manual of Specifications and Standards for Four-laning of Highways published by IRC. The expressways need to be planned as fully access controlled highways where entry and exit points are provided at pre-determined locations.The Manual is intended mainly for new/green field expressways projects. This Manual is not applicable for design of expressways in urban areas andin hilly terrain. Due consideration has been given to conservation of material and environmental aspects as well. As a departure from the existing guidelines, the Manual professes near ground level expressways in the plain terrain and with moderate cutting and fillings in the rolling terrain.

The design considerations require that this type of expressways is constructed where flood, drainage or water table do not pose any problem and due care is taken from drainage point of view while keeping the expressway level close to the existing ground level.

The side approach roads should invariably cross over the expressway facility to maintain the sanctity of access controlled features.

The Draft Version 1 of the Manual prepared by the Expert Group was discussed by the Peer Review Group during its second meeting held on 26th May, 2013. The comments of the Peer Review Group were suitably incorporated by the Expert Group in Draft Version 2, which was placed before the H-7 Committee and the G-1 Committee of IRC. The H-7 Committee (list of the members appended) approved the draft in its 4th meeting and the comments of the same were also incorporated by the Expert Group and placed the modified version before G-1 Committee. The G-1 Committee constituted a Sub-Group under the Chairmanship of Shri Ashok Kumar with the following members:-

1. Shri A.K. Bhasin
2. Shri R.K. Pandey
3. Shri Kishore Kumar
4. Shri Jacob George
5. Shri Varun Aggarwal

The G-1 Committee (list of the members appended) finally approved the Draft Manual on 27th July, 2013. The GSS Committee during its meeting held on 6th August, 2013 approved the draft Manual. The final version of Manual was considered, deliberated and approved by IRC Council during its 200th Council Meeting held at New Delhi on 11th& 12thAugust, 2013 after taking on board the comments offered by the Members.

SECTION – 1
GENERAL

1.1 Application

This Manual is applicable for the construction of Expressways (four lanes, six lanes or eight lanes) through Public Private Partnership (PPP) mode. The scope of work shall be as defined in the Concession Agreement. This Manual shall be read harmoniously with the intent of the Concession Agreement.

This Manual is intended mainly for Expressways planned as green field projects. For this purpose, the Expressway is defined as an arterial highway for motorised traffic, with divided carriageways for high speed travel, with full control of access and provided with grade separators at location of intersections. Generally, only fast moving vehicles are allowed access on Expressways. They are inter-city Expressways located in open country outside the built-up area. The alignment may, however, pass through isolated small stretches of built-up area as long as the character of the Expressway as a whole does not change. The Manual is not directly applicable to the design of Expressways in urban areas and in hilly terrain.

1.2 Concessionaire's Responsibility

The Project Expressway 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[1] shall be used by the Concessionaire only for his 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 and due diligence, and shall have no claim against the Authority for any loss, damage, risks, costs, liabilities or obligations arising out of or in relation to the project report and other information provided by the Authority.

1.3 Quality Assurance Requirements

At least two 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 and send three copies each to the Independent Engineer (IE) for review. The class of quality assurance shall be Extra High QA (Q-4) for all aspects of the project covering project preparation, design and drawings, procurement, materials and workmanship (Refer IRC:SP:47 and IRC:SP:57).

[1] Authority/Government/Client

1.4 Acceptable Codes, Standards, Guidelines and Technical Specifications

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

i) "Guidelines for Expressways" issued by the MORTH and published by the Indian Roads Congress (IRC).

ii) Indian Roads Congress (IRC) Codes and Standards (Refer **Appendix-1).**

iii) Specifications for Road and Bridge Works issued by the Ministry of Road Transport & Highways (MORTH) hereinafter referred to as MORTH or Ministry's Specifications.

(iv) Any other standards referred to in the Manual and any supplement issued with the bid document.

1.5 Latest Version/Amendments

Latest version of the Codes, Standards, Specifications and Amendments thereto notified/ published at least 60 days before the last date of bid submission shall be considered applicable.

1.6 Terms Relating to Ministry of Road Transport and Highways

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

1.7 Terms Denoting Independent Engineer

The terms 'Inspector' and 'Engineer' used in MORTH Specifications shall be deemed to be substituted by the term "Independent Engineer", 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.

1.8 Conflict or Inconsistency in the Codes, Standards, Guidelines and Specifications

In case of any conflict or inconsistency in the provisions of the applicable IRC Codes, Standards or MORTH Specifications, the provisions contained in this Manual shall apply.

1.9 Building Works

All items of building works shall conform to Central Public Works Department (CPWD) Specifications for Class 1 building works[2] and standards given in the National Building Code (NBC). For the Project Expressway through the state entity, to the extent specific provisions

[2] The State Government may prescribe concerned State PWD Specifications, if so desired.

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, roadside facilities, landscape elements and/or any other works incidental to the building works.

1.10 Alternative Standards and Specifications

The requirements stated in the Manual are the minimum. The Concessionaire may, however, adopt international practices, alternative specifications, materials and standards to bring in innovation in the design and construction provided they are better or comparable with the standards prescribed in the Manual. The proposed alternative specifications and techniques, including those which are not included in the MORTH/IRC Specifications shall be supported with authentic standards and specifications mentioned below:

a) American Association of State Highway and Transportation Officials (AASHTO)

b) American Society for Testing of Materials (ASTM)

c) Euro Codes

d) National Standards of any of the following countries:

United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, the Netherlands, Spain, Australia, New Zealand, Japan and South Africa.

(e) IRC revised codes or new codes or amendments to existing codes, which become applicable after the deadline specified in para 1.5

Such a proposal shall be submitted by the Concessionaire to the Independent Engineer. 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, 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 the non-compliance by the Concessionaire of the minimum Specifications and Standards specified in the Manual. Adverse consequences, if any, arising from any such non-compliance, shall be treated as "Concessionaire Default" and shall be dealt in accordance with the provisions of the Concession Agreement.

1.11 Guidelines for Preparing Schedules of the Concession Agreement

Certain paras (full or part) in Sections 1 to 15 of this Manual refer to the Schedules of the Concession Agreement. While finalizing the feasibility/project report for the Project Expressway, and the scope of the project, each of these paras should be carefully examined and addressed by the Authority with a view to making appropriate provisions in the Schedules of the Concession Agreement. **(A list of the paras that refer to such Schedules has been provided at Appendix-2 for ready reference).**

1.12 General considerations for Planning, Design and Construction

The Project Expressway shall be planned as a "fully access controlled highway" where entry to and exit from the Expressway shall be provided only at pre-determined locations through properly designed entry/exit ramps and/or from interchanges. In doing so, the Concessionaire shall take measures to overcome the physical and operational constraints and plan, design and construct the Project Expressway using appropriate methods, management techniques and technologies. General considerations shall, without being limited to, be as follows:

i) **Carriageway provision and future widening**

The number of lanes to be provided for the Project Expressway shall be specified in **Schedule-B of** the Concession Agreement. It shall be developed in accordance with the typical cross-sections given in Para 2.16 of Section–2. Where only four lane (2x2) or six lane (2x3) carriageway is specified initially with depressed median, placement of the divided carriageway shall be as shown in the typical cross-sections **(Fig. 2.1(a)** and **Fig. 2.1(b))**. In this situation, the width of median shall be increased by multiple of 3.75 m for each additional lane to allow widening of the carriageway on the right side of the inside lane to achieve the ultimate eight lane carriageway (with 15 m wide depressed median) as and when required in future.

In the case of flush median, future widening shall be done on outer side.

ii) **Safety of design**

The Project Expressway shall be designed to provide for high level of safety and operational efficiency for the movement of large volumes of traffic at high speed. Alignment design, geometrics, cross-sectional features, structures, road signage, markings, advance information system, and other traffic safety and management features and tolling system shall be designed to conform to the best standards and international practices to achieve a consistent, safe and efficient design to cater for highest safety to the user and meet the intended functions of the Project Expressway. Interchanges, exits and entrances should be tested for ease of operation and for route continuity from a driver's point of view.

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

iii) **Durability**

The Project Expressway 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, rainfall, 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 Expressway durable.

iv) **Mitigating disruptive effects of construction**

The planning, design and construction of the Project Expressway shall be such that its construction does not have adverse impact on the environment, ecology and does not disrupt the lives and business activities of the people living close to the Project Expressway. Appropriate measures shall be taken as specified in Section-14 of this Manual.

1.13 Safety during Construction and Operation & Maintenance

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

1.13.2 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.

iii) Sprinkling of water for dust control at work zones, haul roads and plant/camp sites.

iv) Noise/Pollution suppression measures at work zones, haul roads and plant/camp sites.

v) Mechanical, electrical and fire safety practices.

vi) Safety measures like PPE (Personal Protection Equipment) for workers engaged.

vii) First Aid and Emergency Response Arrangements i.e. First Aid Box, Ambulance, paramedical staff, alarms, etc.

viii) Safety training/awareness programmes.

ix) Formats to maintain the accident records/emergency response provided during accidents.

1.14 Field Laboratory

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

1.15 Environment Mitigation Measures

The Concessionaire shall carry out tests/monitor various parameters impacting the environment of the Project Expressway 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, and undertake implementation of the proposals in consultation with the IE.

1.16 Utilities

The details of the new utilities which are to be constructed or provided for along or across the Project Expressway shall be as specified in **Schedule-B** of the Concession Agreement. No utility should be situated under any part of the roadway, except where the utility crosses the Expressway. Such utilities shall cross through a culvert.

1.17 Review and Comments by the Independent Engineer

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.

1.18 Definitions and Interpretation

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

1.18.2 *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 Expressway is called as Vehicular Underpass (VUP).

iii) A grade separated structure which is provided for crossing of vehicles over the Project Expressway is called as Vehicular Overpass (VOP).

iv) A structure provided below the Project Expressway for crossing of the pedestrians is called Pedestrian Underpass (PUP).

v) A structure provided below the Project Expressway for crossing of the cattle is called Cattle Underpass (CUP).

vi) A pedestrian/cattle underpass through which light vehicles of height up to 3 m can also pass is called Light Vehicular Underpass (LVUP).

vii) Flyover is synonymous to VUP/VOP.

viii) A structure provided above the Project Expressway for crossing of pedestrians is called Foot Over Bridge(FOB)

ix) A structure provided over the railway lines to carry the Project Expressway is called Road Over Bridge (ROB).

x) A structure provided below the railway lines to carry the Project Expressway is called Road Under Bridge (RUB).

SECTION – 2
GEOMETRIC DESIGN AND GENERAL FEATURES

2.1 General

i) This Section lays down the standards for geometric design and general features for expressways. The application of geometric standards should aim at achieving safety, mobility and efficiency in traffic operation.

ii) The geometric design of the Project Expressway shall conform to the standards set out in this Section as a minimum. The Concessionaire shall ensure that liberal geometric standards are followed to the extent feasible within the given Right of Way.

iii) As far as possible, uniformity of design standards shall be maintained throughout the length of the Project Expressway. In case of any change, it shall be effected in a gradual manner to conform to driver expectations.

iv) The geometric design should address environmental concerns and provide positive guidance to the driver to travel safely.

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 Expressway alignment).

Table 2.1 Design Speed

Nature of Terrain	Cross Slope of the Ground	Design Speed (km/hr)
Plain	Less than 10 percent	120
Rolling	Between 10 and 25 percent	100

2.2.2 Short stretches (say less than 1 km) of varying terrain met with on the alignment shall not be taken into consideration while deciding the terrain classification for a given section of the Project Expressway. Where an intervening stretch is classified as hilly/mountainous stretch and it may not be expedient from economic and environmental consideration to adopt even standards applicable to rolling terrain, a lower design speed of 80 km/h consistent with the topography and driver expectancy may be adopted and in such stretches speed limit signs shall be posted.

2.3 Right-of-Way

2.3.1 The Right-of-Way (the ROW) for the Project Expressway shall be as given in **Schedule-A** of the Concession Agreement. The Authority would acquire the additional land required, if any. The land to be acquired shall be indicated in **Schedule-A** of the Concession Agreement. The recommended minimum Right of Way in Plain/Rolling terrain for expressways is given in **Table 2.2**.

Table 2.2 Right of Way in Plain/Rolling Terrain

Section	Right of Way Width* (ROW)
Rural Section	90 m – 120 m
Rural Sections passing through semi- urban areas	120 m#

Note: * The ROW width includes 2 m wide strip on either side reserved for placement of utilities outside fencing.

\# In case an elevated expressway on viaduct is proposed, the width of ROW may be reduced as per site conditions and availability of land.

2.3.2 Additional land at bridge approaches, grade separated structures, interchange locations, toll plazas and for project facilities shall be acquired as per design.

2.3.3 No service roads shall be provided within the ROW of the Expressway.

2.4 Lane Width of Carriageway

The standard lane width of the Project Expressway shall be 3.75 m. Expressways shall have a minimum of two lanes for each direction of travel.

2.5 Median

2.5.1 The median shall be depressed or flush. As a rule depressed median shall be provided except in situations where the availability of ROW is a constraint. The width of median is the distance between inside edges of carriageways. The recommended width of median is given in **Table 2.3.**

Table 2.3 Width of Median

Type of Median	Recommended Median Width (m)	
	Minimum	Desirable
Depressed	12.0	15.0
Flush	4.5	4.5
Flush (to accommodate structure/pier on median)	8.0	8.0

2.5.2 The depressed median shall have suitably designed drainage system so that water does not stagnate in the median.

2.5.3 An edge strip of 0.75 m width of depressed median adjacent to carriageway in either direction shall be paved with same specifications as of the adjoining carriageway.

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

2.5.5 Median barriers shall be provided as specified in Section 10 of this Manual. In the case of flush type medians, suitable antiglare measures such as metal/plastic screens shall be provided to reduce headlight glare from opposite traffic. The total height of screen including the height of the barrier shall be 1.5 m.

2.6 Shoulders

2.6.1 The shoulder on the outer side (left side of carriageway) shall be 3 m wide paved plus 2 m wide earthen. The shoulder composition shall be as below:

i) The composition and specification of the paved shoulder shall be as that of the main carriageway.

ii) The earthen shoulder shall be provided with 200 mm thick layer of non-erodible/granular material for protection against erosion.

2.7 Roadway Width

2.7.1 The width of roadway shall depend upon the width of carriageway, shoulders and the median.

2.8 Crossfall

2.8.1 The crossfall on straight sections of expressway carriageway shall be as given in **Table 2.4.** Each carriageway shall have unidirectional crossfall.

Table 2.4 Crossfall on Different Surfaces

Cross-Sectional Element	Annual Rainfall	
	1000 mm or more	Less than 1000 mm
Carriageway, Paved shoulders, Edge Strip, Flush Median	2.5 percent	2.0 percent

2.8.2 The crossfall for earthen/granular shoulders on straight portions shall be at least 1.0 percent steeper than the values given in **Table 2.4**. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse crossfall so that the earth does not drain on the carriageway and the storm water drain out with minimum travel path.

2.9 Design of Horizontal and Vertical Alignment

2.9.1 The general principles and design criteria laid down in MORTH Guidelines for Expressways shall be followed except as otherwise indicated in this Manual.

2.9.2 *Horizontal alignment*

2.9.2.1 Alignment shall be fluent and blend with the topography. The horizontal curves shall be designed to have largest practical radius and shall consist of circular portion flanked by spiral transitions at both ends.

2.9.2.2 Super elevation

Super elevation shall be limited to 7 percent, if radius of curve is less than the desirable minimum radius. It shall be limited to 5 percent if radius is more than or equal to the desirable minimum. Super elevation shall not be less than the minimum specified crossfall.

2.9.2.3 Radii of horizontal curves

The desirable minimum and absolute minimum radii of horizontal curves are given in **Table 2.5**.

Table 2.5 Minimum Radii of Horizontal Curves

Design Speed (km/h)	120	100	80
Absolute Minimum Radius (m)	670	440	260
Desirable Minimum Radius (m)	1000	700	400

The radius of horizontal curves for various terrain conditions shall not be less than the desirable minimum values given in **Table 2.5** except for sections as indicated in **Schedule−B** of the Concession Agreement. For such sections, the radius of curve shall not be less than the absolute minimum.

2.9.2.4 Transition curves

Properly designed transition curves shall be provided at both ends of the circular curve. The recommended minimum length of transition curves is given in **Table 2.6**.

Table 2.6 Minimum Length of Transition Curves

Design Speed (km/h)	Minimum Length of Transition Curve (m)
120	100
100	85
80	70

2.9.3 Sight Distance

2.9.3.1 The safe stopping sight distance and desirable minimum sight distance for divided carriageway for various design speeds are given in **Table 2.7**. The desirable values of sight distance shall be adopted unless there are site constraints. A minimum of safe stopping sight distance shall be available throughout.

Table 2.7 Safe Sight Distance

Design Speed (km/hr)	Safe Stopping Sight Distance (m)	Desirable Minimum Sight Distance (m) (Intermediate Sight Distance)
120	250	500
100	180	360
80	120	240

2.9.3.2 At critical locations or decision points where changes in cross-sections occur such as toll plazas and interchanges, the sight distance shall not be less than the decision sight distance given in **Table 2.8**. The criteria for measuring the decision sight distance are same as for the stopping sight distance.

Table 2.8 Decision Sight Distance

Design Speed (km/h)	Decision Sight Distance (m)
120	360
100	315
80	230

2.9.4 Vertical Alignment

2.9.4.1 General

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. Desirably there should be no change in grade within a distance of 150 m. The directions given in IRC:73 and IRC:SP:23 should be complied.

Decks of small cross drainage structure (i.e. culverts or minor bridges) shall follow the same profile as the flanking road section, without any break in the grade line.

The aspect of efficient drainage shall be kept into consideration while designing vertical profile and cross-sections of the Project Expressway as stipulated in IRC:SP:42 and IRC:SP:50.

The vertical alignment shall be coordinated with the horizontal alignment as indicated in Section 2.9.5.

2.9.4.2 Gradients

The ruling and limiting gradients are given in **Table 2.9.**

Table 2.9 Gradients

Terrain	Ruling Gradient	Limiting Gradient
Plain	2.5 percent	3 percent
Rolling	3 percent	4 percent

Ruling gradient shall be adopted as far as possible. Limiting gradients shall be adopted only in very difficult situations and for short lengths.

In cut-sections, minimum gradient for drainage considerations is 0.5 percent (1 in 200) if the side drains are lined; and 1.0 percent (1 in 100) if these are unlined.

2.9.4.3 Vertical curves

Long sweeping vertical curves shall be provided at all grade changes. Summit curves and Valley curves shall be designed as square parabolas. The length of the vertical curve is controlled by sight distance requirements, but desirably curves with longer length shall be provided from aesthetic considerations. The minimum grade change requiring vertical curve and the minimum length of vertical curve shall be as given in **Table 2.10**.

Table 2.10 Minimum Length of Vertical Curve

Design Speed (km/h)	Minimum Grade Change Requiring Vertical Curve	Minimum Length of Vertical Curve (m)
120	0.5 percent	100
100	0. 5 percent	85
80	0.6 percent	70

2.9.5 *Coordination of horizontal and vertical alignment*

The overall appearance of an expressway can be enhanced considerably by judicious combination of the horizontal and vertical alignments. Plan and profile of the road shall not be designed independently but in unison, so as to produce an appropriate three-dimensional effect. Proper co-ordination in this respect will ensure safety, avoid visual discontinuities and contribute to overall aesthetics.

Vertical curvature superimposed upon horizontal curvature gives a pleasing effect. As such the vertical and horizontal curves shall coincide as far as possible and their length shall be more or less equal. If this is difficult for any reason, the horizontal curve shall be somewhat longer than the vertical curve. Short vertical curve superimposed on long horizontal curve and vice versa gives distorted appearance and shall be avoided. Sharp horizontal curves shall be avoided at or near the apex of pronounced summit/sag vertical curves from safety considerations.

The designer shall check profile design in long continuous plots to help avoid a roller-coaster profile.

2.10 Lateral and Vertical Clearance at Underpasses

Wherever a cross road is proposed to be taken below the Project Expressway, minimum clearances at underpasses shall be as follows:

2.10.1 *Lateral clearance*

i) Full roadway width of the cross road shall be carried through the underpass. For Vehicular Underpass, the lateral clearance shall not be less than 12 m (7 m carriageway + 2 × 2.5 m shoulder width on either side) or as indicated in **Schedule-B** of the Concession Agreement.

ii) For Light Vehicular Underpass, the lateral clearance shall not be less than 10.5 m including 1.5 m wide raised footpaths on either side.

iii) For Pedestrian and Cattle Underpasses, the lateral clearance shall not be less than 7 m.

iv) Crash barriers shall be provided for protection of vehicles from colliding with the abutments and piers and the deck of the structures as per Section–10 of this Manual.

2.10.2 *Vertical clearance*

Vertical clearance at underpasses shall not be less than the values given in **Table 2.11**.

Table 2.11 Vertical Clearance

i) Vehicular Underpass	5.5 m
ii) Light Vehicular Underpass	3.5 m
iii) Pedestrian, Cattle Underpass	3.0 m (to be increased to 4.5 m, in case certain categories of animals such as elephant/camel are expected to cross the Project Expressway frequently. This shall be as specified in **Schedule-B** of the Concession Agreement)

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 pedestrian and cattle crossings as per para 2.13.4.

2.11 Lateral and Vertical Clearance at Overpasses

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

2.11.1 *Lateral clearance*

Full roadway width for 8–lane carriageway or wider where specified in **Schedule-B** of the Concession Agreement shall be carried through the overpass structure. 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** of the Concession Agreement.

2.11.2 *Vertical clearance*

A minimum 5.5 m vertical clearance shall be provided from all points of the carriageway of the Project Expressway.

2.12 Access Control

2.12.1 *Access*

Project Expressway shall be designed for fast motorized traffic with full control of access. Access to the Expressway shall be provided with grade separators at location of intersections. Parking/standing, loading/unloading of goods and passengers and pedestrians/animals shall not be permitted on the Expressway.

2.12.2 *Location of interchange*

The locations of individual interchanges are determined primarily to reduce detour considering regional network and nearness to places of importance. Location of interchange is guided by the following situations:

i) At crossing or nearest points of other Expressways, National Highways, State Highways and important arterial roads.

ii) At crossing or nearest points of major roads to important ports, airports, material transport facilities, commercial and industrial areas, and places of tourist interest.

The interchanges shall be provided at the locations specified in **Schedule–B** of the Concession Agreement.

2.12.3 *Connecting roads*

Connecting roads where required to maintain proper circulation of local traffic, continuity of travel and to facilitate crossing over to the other side of the Project Expressway through an under/overpass shall be constructed on the land acquired within the ROW of the Project Expressway. These shall be provided outside the fencing. The location, length, other details and specifications of connecting roads, to be constructed by the Concessionaire shall be specified in **Schedule–B** of the Concession Agreement. The width of the connecting road shall be 7.0 m. The construction and maintenance of connecting roads shall be part of the Project Expressway.

2.13 Grade Separated Structures

2.13.1 The type, location, length, number and the openings required and approach gradients for various grade separated structures shall be as specified in **Schedule-B** of the Concession Agreement. The approach gradient to the grade separated structure shall not be steeper than 2.5 percent (1 in 40).

2.13.2 *Vehicular Underpass/Overpass*

The vehicular under/overpass structures shall be provided at the intersection of the Project Expressway with all the National Highways, State Highways and Major District Roads. Under/over passes shall also be provided across other categories of roads which cannot

be terminated and are required to be continued across the Project Expressway. For such intersections where parallel cross roads are located within 2 km distance crossings may be designed as a staggered crossing by connecting parallel cross roads and taking them across the Project Expressway through a vehicular underpass/overpass. The vehicular underpasses/overpasses shall be so located that no vehicle is required to travel more than 2 km on connecting road for crossing over.

The structure may be either an underpass or an overpass depending upon the nature of terrain, vertical profile of road, availability of adequate right of way, etc. Unless otherwise specified in **Schedule-B** of the Concession Agreement, the Project Expressway shall be carried at the existing level and the entire cost involved in raising or lowering the road would be included in the cost of the Project Expressway. Decision whether the cross road or the Project Expressway 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. In built up areas, the Project Expressway shall be elevated on via duct as specified in **Schedule-B** of the Concession Agreement.

2.13.3 *Light Vehicle Underpass (LVUP)*

The location of LVUP shall be specified in **Schedule-B** of the Concession Agreement.

2.13.4 *Cattle and Pedestrian Underpass/Overpass*

The crossing facilities shall be provided such that the pedestrians do not have to walk for more than 500m to reach the crossing point. These shall be provided as specified in **Schedule-B** of the Concession Agreement.

i) A PUP/CUP may not be necessary within a distance of 2 km from Vehicular Underpasses/Overpasses and Light Vehicle Undepasses.

ii) The pedestrian crossings shall have provision for movement of disabled persons.

iii) Pedestrian underpass/foot over bridge shall also be provided within a distance of 200m from a school or hospital or factory/industrial area.

2.13.5 *ROB/RUBs shall be provided as per Section−6 of this Manual.*

2.13.6 *Tunnels*

Standards for Tunnels shall be as given in Section–7 of this Manual.

2.14 Median Openings

2.14.1 Median openings with detachable barrier shall be provided for traffic management for maintenance works and vehicles involved in accidents. Such barriers shall be located at ends of interchanges and rest areas. It is desirable to provide median openings with detachable barriers at about 5 km spacing. Maintenance and emergency crossovers generally should

not be located on super elevated curves and closer than 450 m to the end of a speed change taper of a ramp or to any structure.

2.15 Fencing and Boundary Stones

Fencing shall be provided all along the Project Expressway at 2 m inside the ROW boundary or as specified in **Schedule–B** of the Concession Agreement. The fencing shall be of type and design given in Section–10 of this Manual. The ROW shall be demarcated by installing Road Boundary Stones at the edges.

2.16 Typical Cross Sections

Typical cross sections of Project Expressway are given in **Figs. 2.1(a), 2.1(b), 2.1(c) and 2.2(a), 2.2(b), 2.2(c)**.

Fig. 2.1(a) shows typical cross section for 4–lane (2x2) expressway in plain/rolling terrain, with depressed median (Future widening inside).

Fig. 2.1(b) shows typical cross section for 6–lane (2x3) expressway in plain/rolling terrain with depressed median (Future widening inside).

Fig. 2.1(c) shows typical cross section for 8–lane (2x4) expressway in plain/rolling terrain with depressed median.

Fig. 2.2(a) shows typical cross section for 4–lane (2x2) expressway in plain/rolling terrain, with flush median.

Fig. 2.2(b) shows typical cross section for 6–lane (2x3) expressway in plain/rolling terrain, with flush median.

Fig. 2.2(c) shows typical cross section for 8–lane (2x4) expressway in plain/rolling terrain, with flush median.

Typical cross sections for culverts, bridges, and grade separated structures are given in Section–6 of this Manual.

Typical cross sections for tunnels are given in Section–7 of this Manual.

2.17 Clear Zone

A clear zone is the unobstructed traversable area provided beyond the edge of the through carriageway for the recovery of errant vehicles. A clear-zone width of 9–11 m for design speed of 100–120 km/hour for the errant vehicles leaving the through carriageway to recover be provided. Embankment slopes of 1V:4H or flatter are recoverable slopes and if it is not feasible to provide the suggested clear-zone distance from the edge of the carriageway, a crash barrier should form part of the clear-zone distance. The concept is illustrated in Fig. 2.3 (adapted from AASHTO Roadside Design Guide).

2.18 Capacity of Expressway

Rural expressways shall be designed for Level of Service-B.

For the purpose of design and future augmentation of the Project Expressway, the design service volume for level of service− B for plain/rolling terrain shall be 1300 PCU/hr/lane. The design service volume can be determined as per MORTH Guidelines for Expressways. The design service volume per day will depend on the peak hour flow and will be as specified in **Table 2.12**.

Table 2.12 Design Service Volume for Expressways in Plain and Rolling Terrain (in PCUs/per day) for LOS B

Design Service Volume in PCUs per day for LOS B		
4-Lane	**6-Lane**	**8- lane**
86,000 for Peak hour flow (6%) 65,000 for Peak hour flow (8%)	1,30,000 for Peak hour flow (6%) 98,000 for Peak hour flow (8%)	1,73,000 for Peak hour flow (6%) 1,30,000 for Peak hour flow (8%)

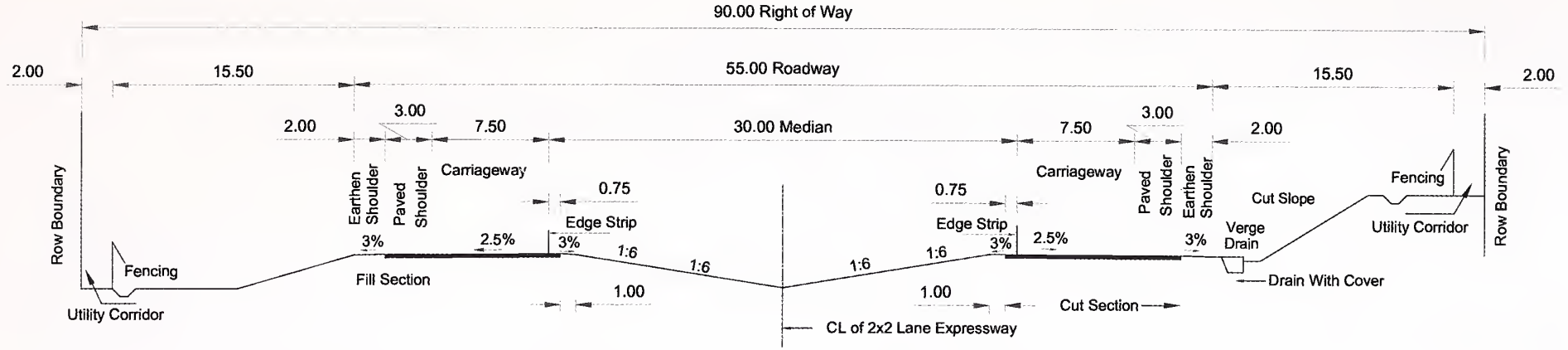


Fig. 2.1(a) Typical Cross-section For 4-Lane (2x2) Expressway in Plain or Rolling Terrain With Depressed Median (Future Widening Inside)

NOTE - All Dimesions are in metres

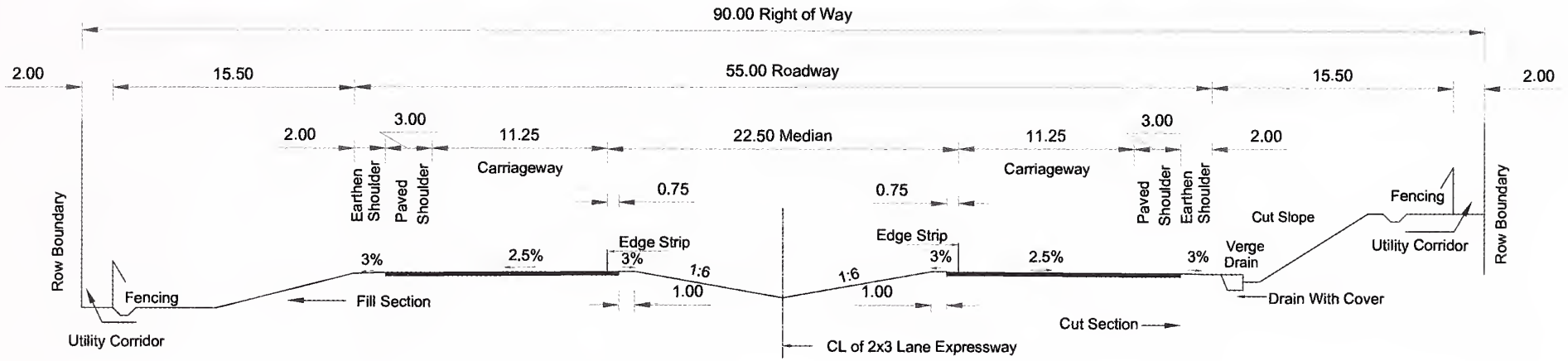


Fig. 2.1(b) Typical Cross-section For 6-Lane (2x3) Expressway in Plain or Rolling Terrain With Depressed Median (Future Widening Inside)

NOTE - All Dimesions are in metres

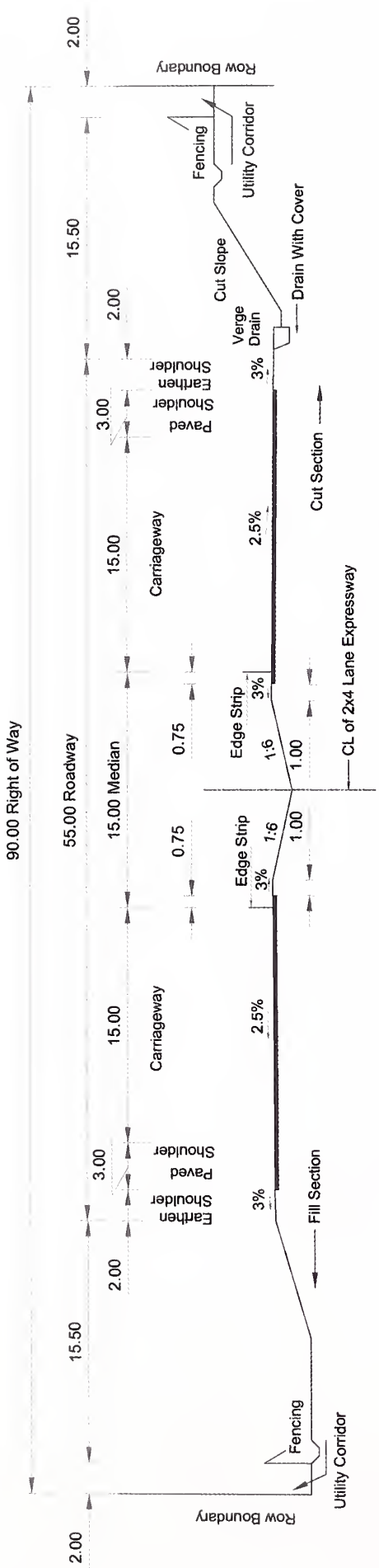


Fig. 2.1(c) Typical Cross-section For 8-Lane (2x4) Expressway in Plain or Rolling Terrain With Depressed Median (Future Widening Inside)

NOTE - All Dimesions are in metres

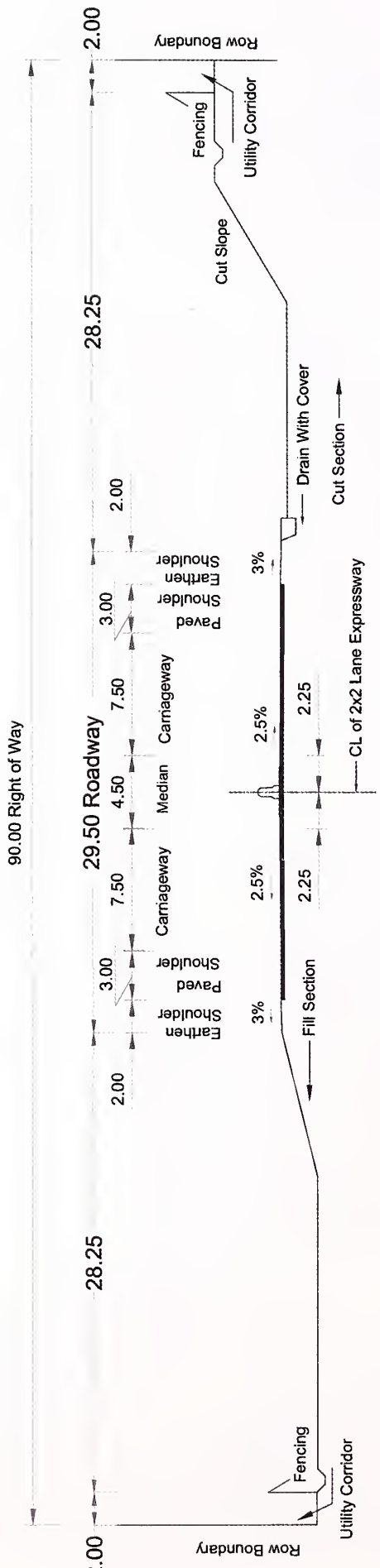


Fig. 2.2(a) Typical Cross-section For 4-Lane (2x2) Expressway in Plain or Rolling Terrain With Flush Medain

NOTE - All Dimesions are in metres

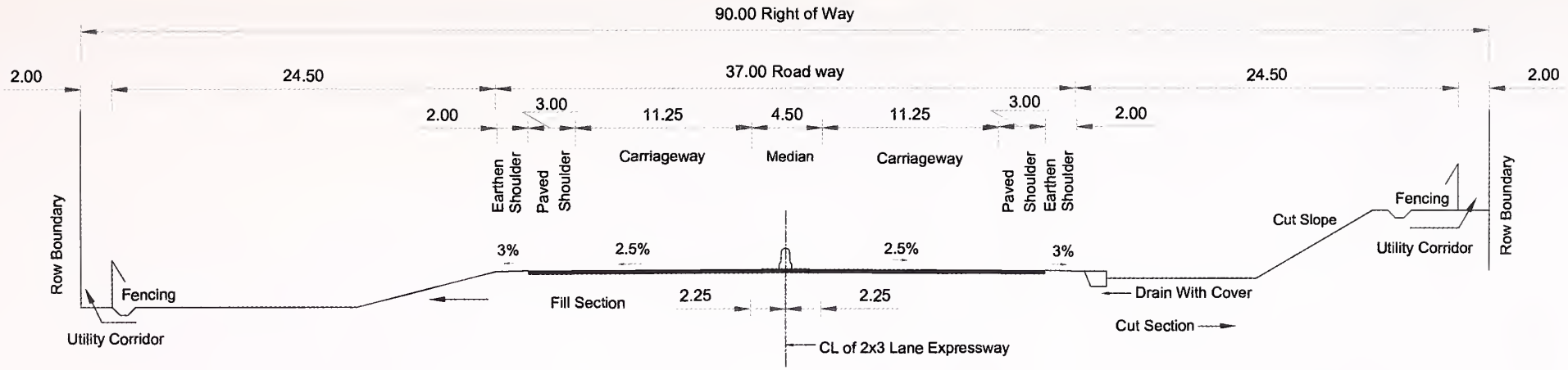


Fig. 2.2(b) Typical Cross-section For 6-Lane (2x3) Expressway in Plain or Rolling Terrain

With Flush Medain

NOTE - All Dimesions are in metres

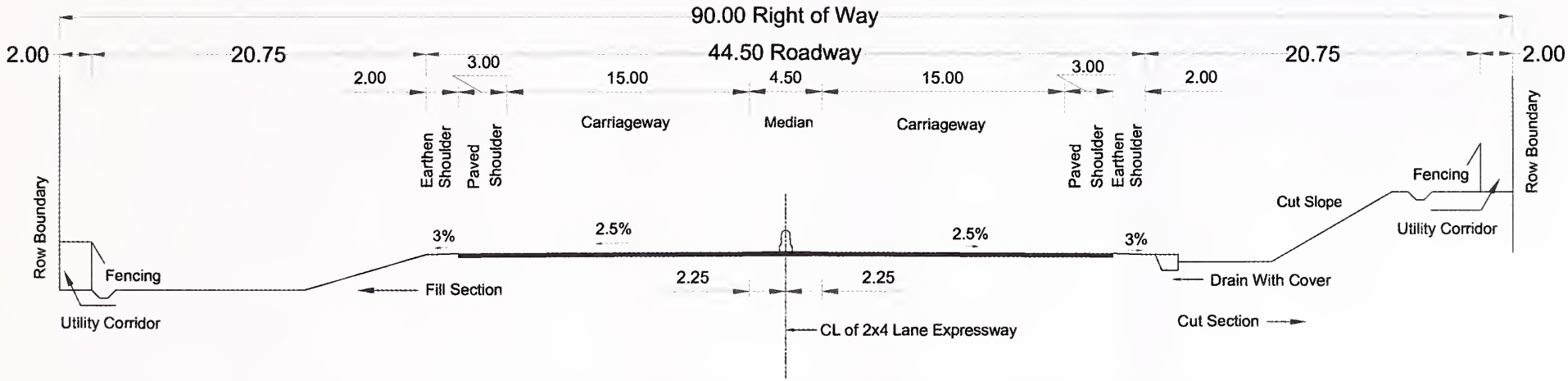
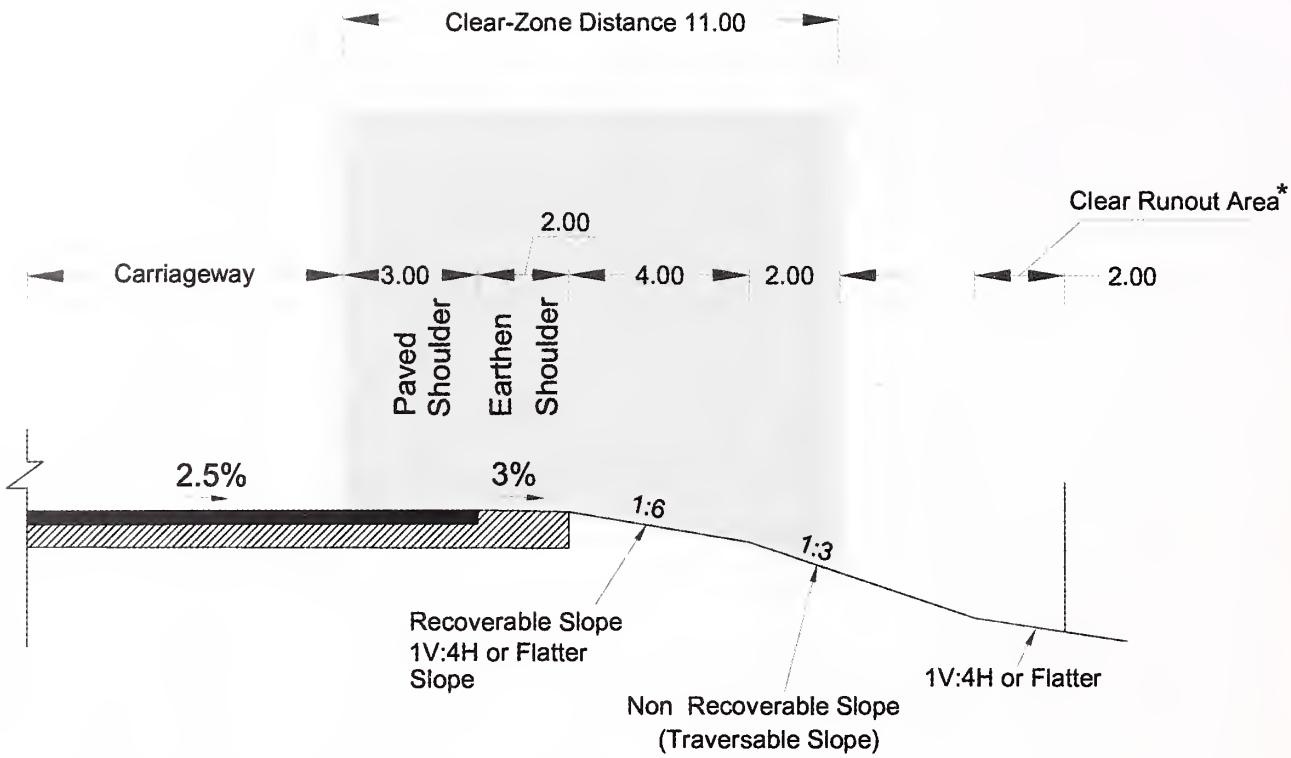


Fig. 2.2(c) Typical Cross-section For 8-Lane (2x4) Expressway in Plain or Rolling Terrain

With Flush Medain

NOTE - All Dimesions are in metres



* The Clear Runout Area is Additional Clear-Zone Space that is Needed Because a Portion of the Suggested Clear-Zone (Shaded Area) Falls on a Non-Recoverable Slope.

Fig 2.3 Clear Zone

NOTE - All Dimesions are in metres

SECTION – 3
GRADE SEPARATORS AND INTERCHANGES

3.1 Introduction

The intersections to be provided shall be one of the following types:

i) Grade Separators (Grade separated Intersections without ramps)

ii) Interchanges

The types and locations of Grade Separators (Grade-separated Intersections without ramps) and Interchanges shall be based on requirements stipulated in MORTH Guidelines for Expressways. These shall be specified in **Schedule–B** of the Concession Agreement.

3.2 Grade Separators

3.2.1 The access from the Project Expressway to the cross roads in case of Grade Separators shall be through the nearest interchange.

3.2.2 *Geometric standards for design*

The geometric design standards for various elements of Grade Separators shall be as given in MORTH Guidelines for Expressways except as otherwise indicated in this Manual. Gradient for approaches shall not be steeper than 2.5 percent (1 in 40).

3.2.3 *Design of structures*

Design of structures shall conform to Section–6 of this Manual. Minimum length of viaduct required to be provided shall be specified in **Schedule–B** of the Concessionaire Agreement.

3.3 Interchanges

3.3.1 *Types of Interchanges*

There are two broad categories of Interchanges, based on traffic exchange:

i) **Service Interchanges :** This refers to an interchange of the Expressway with a road less in importance than Expressway.

For this category, it is considered that Expressway shall be a toll road, and the other intersecting road shall be a “non-tolled” road or a road with open system of tolling with the toll plaza on the other road minimum 2 km away. This requires the consideration of tolling system which considers a barrier system as well as toll booths on the interchange ramps. This requires provision of appropriate deceleration and acceleration lanes and operating speed limitations in the interchange areas.

ii) **System Interchanges :** This refers to an interchange between two Expressways

For this category, since both the intersecting routes are toll roads under closed system, toll booths on ramps are not required. The system needs to cater for high speed operation. The toll collection arrangements need to be considered on integrated basis between the two involved expressway stretches. The modalities need to be suitably addressed.

3.3.2 *Service interchanges*

Generally, Trumpet−type and T−type Interchanges are the preferred configuration. The advantages are;

i) Suitable for three way junction with no weaving,
ii) Limited requirement of ROW area,
iii) Single point toll plaza,

Diamond and Cloverleaf Interchanges require a number of toll plazas on entry/exit ramps, whereas Trumpet-type or T−type Interchanges require single toll plaza.

3.3.3 *System interchanges*

System interchanges are to handle high volume of traffic. The connecting ramps can be directional, semi-directional and large radius loops as well. The aspect of toll sharing between adjacent concessionaires shall be integrated. The basic forms may comprise of three legs or four legs.

For Three Leg Interchanges, the T-type configuration would require larger loops and semi directional ramps of larger radius based on traffic volumes. This may also require catering for frontage road.

For Four Leg Interchanges, the forms may be Diamond, clover leafs directional and semi directional interchanges and composite interchanges requiring combinations of straight, curved or with loops and weaving. These configurations generally require multi-level structures. **Fig. 3.1** presents illustrative service and system interchanges.

3.3.4 *Ramp types*

Ramps are provided at interchanges for desired turning movements. Based on movement requirements, the connecting ramps may be classified as Direct, Semi-direct and Loop ramps (**Fig. 3.2**).

3.3.5 *Spacing between interchanges*

Interchange spacing is based upon demand for access from the important cross roads, adequate distance to provide for signing and weaving and permit sufficient lengths of speed change lanes for respective adjacent interchange to operate safely and efficiently

at a desired level of service. For expressways, a spacing of 3 km is absolute minimum from deceleration, weaving and acceleration consideration. For spacing less than 3 km, both the interchange shall be considered as a combined one. For expressways, a spacing of 20–30 km is desirable.

3.3.6 *Ramp design speed*

Recommended design speeds for interchange ramps are given in **Table 3.1**.

Table 3.1 Recommended Design Speeds for Ramps

Configuration	Type of Ramp	Range of Expressway Design Speeds (km/h)	
		100–120	80–100
		Range of Ramp Design Speeds	
System Interchange	Semi-Direct	50–70	40–60
	Loop	70–90	60–80
	Direct	80–100	70–90
Service Interchange	Semi-Direct	40–60	40–60
	Loop	60–80	60–70
	Direct	60–90	60–80

3.3.7 *Ramp width and cross-section*

The ramp shall have two lanes. The ramp cross-section showing carriageway width and shoulder (both paved and earthen) is given in **Fig. 3.3** for two way two lane ramps on tangent alignment. The width of paved and earthen shoulders considered here are for interchange ramp design only. Applicable extra wide carriageway shall be provided, as needed from ramp radius consideration.

3.3.8 *Acceleration/deceleration lanes*

Each entry and exit ramp shall have acceleration/deceleration lane for the Project Expressway. The length of the acceleration/deceleration lanes shall be decided on the basis of speed differentials of the Project Expressway traffic and the speed permitted on the ramps.

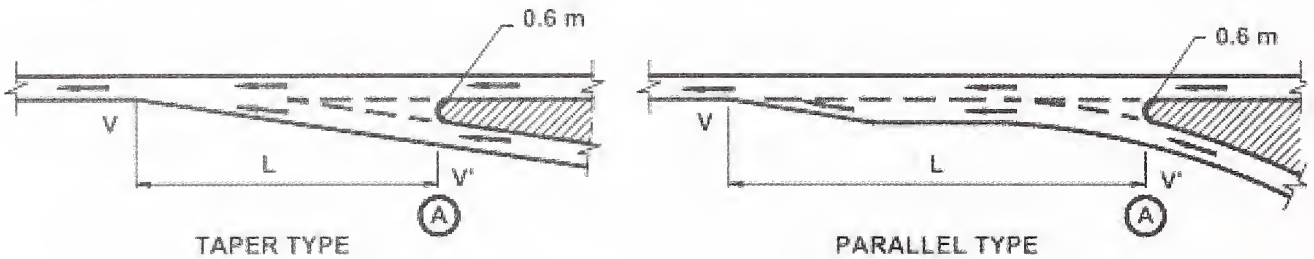
Drivers exiting an interchange are required to reduce speed to meet with toll payment where such a scheme exists. Drivers entering an expressway from a ramp accelerate until the adjacent through lane speed is reached.

For safety, expressway exits should be located on tangent sections, wherever possible to provide maximum sight distance and optimum traffic manoeuverability operation. The following recommendations should be considered from safety aspect.

Typical requirements of Acceleration length and Deceleration length and speed change length adjustment factors are presented in **Table 3.2** and **Table 3.3**. For flat grade exceeding 2 percent, adjustment factors given in MORTH Guidelines for Expressways shall apply.

Table 3.2 Minimum Acceleration Lengths for Entry (Grades of 2 percent or Less)

Expressway Design Speed V (km/h)	Acceleration Length L (m)				
	V' Speed on Entry Curve at A (km/h)				
	40	50	60	70	80 or more
80	145	115	65	–	–
100	285	255	205	110	40
120	490	460	410	325	245

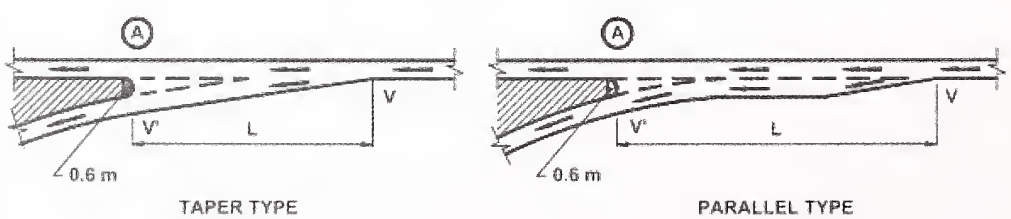


V = Design speed of expressway

V' = Design speed of entry curve

Table 3.3 Minimum Deceleration Lengths for Exit (Grades of 2 percent or Less)

Expressway Design Speed V (km/h)	Deceleration Length L (m)				
	V' Speed on Exit Curve at A (km/h)				
	40	50	60	70	80 or more
80	100	90	80	55	–
100	145	135	120	100	85
120	175	170	155	140	120



V = Design speed of expressway

V' = Design speed of exit ramp

Note: For parallel type, a taper rate may be 8:1 for design speed up to 50 km/h and 15:1 for design speed of 80 km/h. For intermediate values of design speed, suitable rate of taper be adopted.

3.4 Detailed Design and Data Reports

The Concessionaire shall submit the details of the ground surveys, traffic data, traffic forecast, design and drawings of the intersections and interchanges showing all safety features to the Independent Engineer for review and comments, if any.

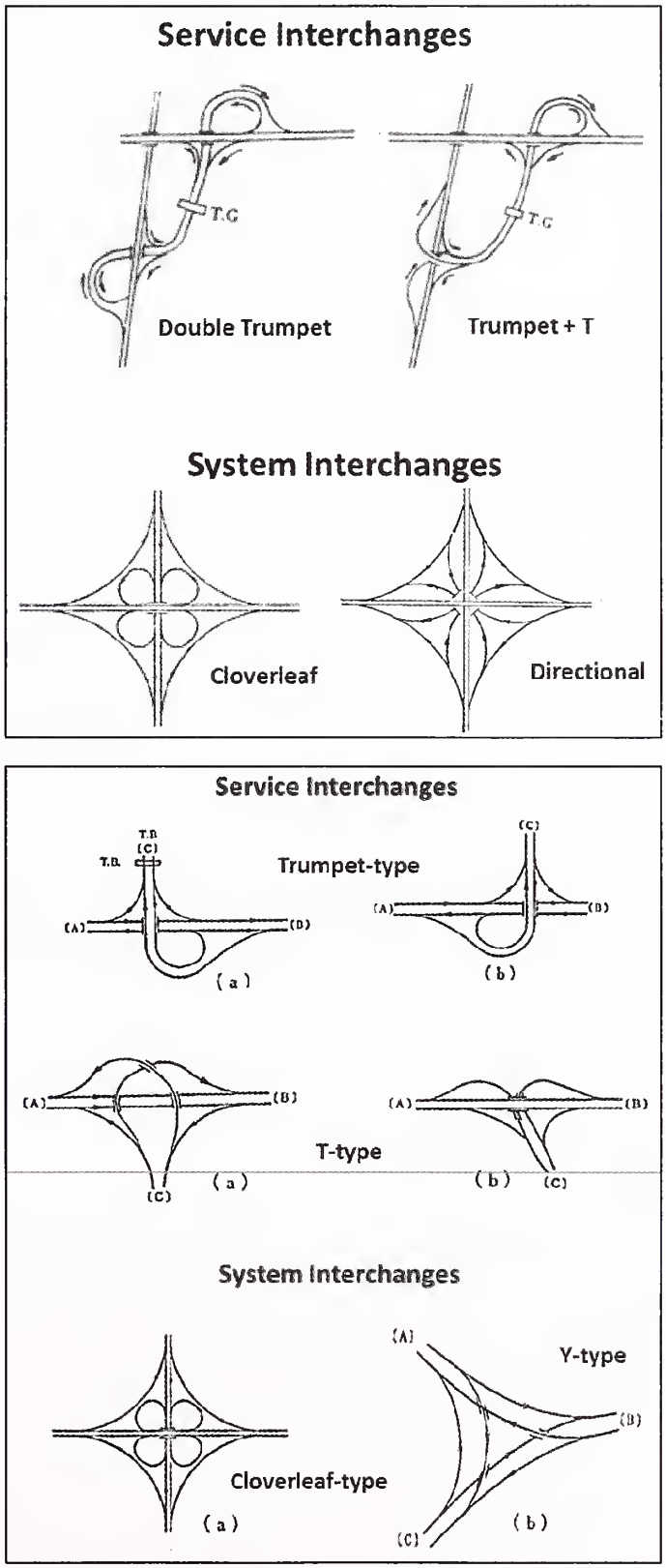


Fig. 3.1 Service and System Interchanges

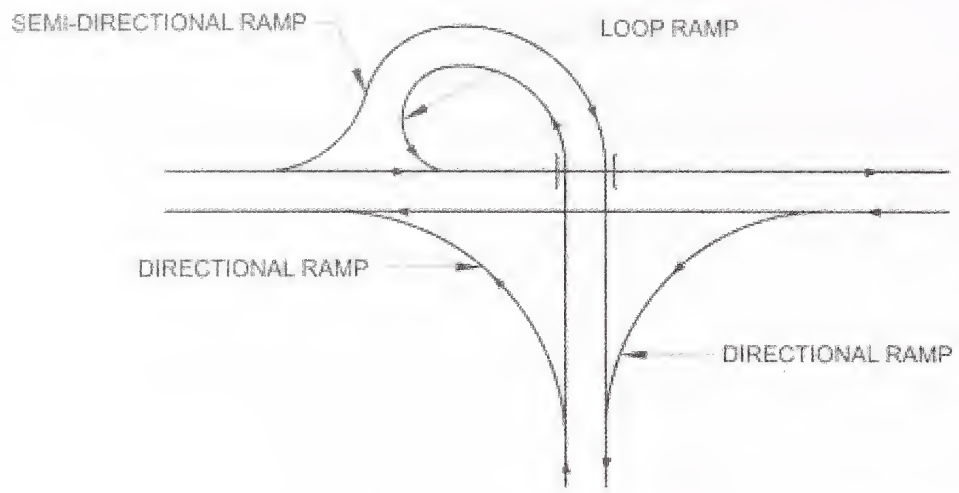
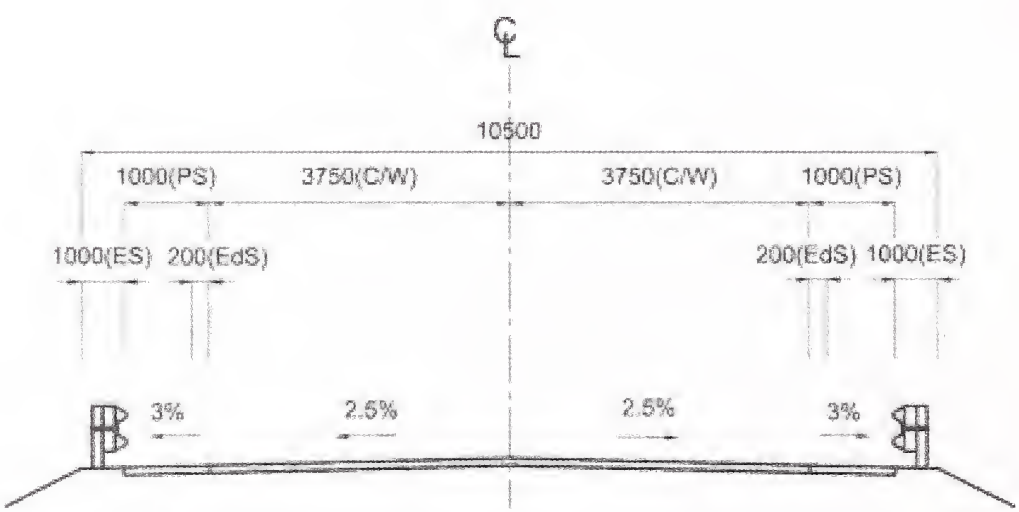


Fig. 3.2 Different Types of Ramps



LEGEND:

C/W - Carriageway
PS - Paved Shoulder
ES - Earthen Shoulder
EdS - Edge Strip

Note: All Dimensions shown are in millimeters unless otherwise indicated

Fig. 3.3 Ramp Cross-Section

SECTION – 4
EMBANKMENT AND CUT SECTIONS

4.1 General

4.1.1 The design and construction of the road in embankment and in cutting 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 subgrade and earthen shoulders.

4.1.2 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 In plain terrain, the level of the expressway will generally be controlled by drainage and earthwork considerations and can be constructed near ground level where no flooding is reported/observed and the Water Table is not high. In rolling terrain where fill material is available from cuttings, the embankment could be sufficiently raised to permit construction of underpasses without lowering the level of cross roads. The principles given in para 4.2 below shall be followed for fixing the height of the embankment.

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. The top of sub-grade shall be at least 0.5 m above the general ground level.

ii) The bottom of sub-grade shall be at least 1.0 m above the high flood level/high water table/pond level. 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 plains or in the vicinity of water bodies or where ponding of water is encountered and cannot be efficiently drained.

iii) To fulfil the minimum free board requirement and provide smooth vertical profile for portions forming approaches to structures.

4.2.2 Structural Features and Design of Embankment

4.2.2.1 To attain a natural appearance along the roadside, the side slopes should be as flat as possible and rounded. The slopes should be designed from stability considerations and to provide a reasonable opportunity for a driver to recover control of an errant vehicle. If the right of way or other constraints make it impractical to provide recoverable slopes, it would be necessary to provide a safety barrier. Embankment slopes 1V:4H or flatter are recoverable slopes. Fixed obstacles such as culvert headwalls shall not extend above the fill slope within the clear zone distance. Embankment slopes between 1V:3H and 1V:4H are traversable but non-recoverable and a clear run-out area at the base is desirable as shown in **Fig. 2.3**.

4.2.2.2 Embankment with height 6.0 m or 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.

4.2.2.3 The side slopes shall be protected against erosion by providing a suitable vegetative cover, kerb and 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.

4.2.3 *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, and the side slopes of the cut section shall be governed by the type of soil met with. Generally, the side slopes shall be as given in **Table 4.1**. The slopes should be evaluated with regard to soil stability and potential crash severity. Desirably, the toe of the rock-cut slope should be located beyond the minimum lateral distance from the edge of the carriageway needed by the driver of an errant vehicle to either regain control or to slow down the vehicle.

Table 4.1 Slopes and Cut Sections

Type of Soil	Slope (H:V)
1) Ordinary Soil	3:1 to 2:1
2) Rock	½:1 to ⅛:1 (depending upon quality of rock)

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 investigations shall be furnished along with the design to the Independent Engineer.

4.4.2 *Soil investigations for embankment*

Soil investigations shall cover the following:

i) 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.

ii) 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.

iii) Information regarding the topography, high flood level, natural drainage conditions, highest sub-soil water level, and the nature and extent of inundation, if any.

iv) The characteristics of embankment foundation including the presence of any unsuitable/weak strata, marshy areas, water logged areas, etc.

v) Along the alignment of the road, where unstable strata, soft material or poor subsoil 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.

vi) Any particular construction problems of the area or other important features.

vii) 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 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 para 1.10 of this Manual shall apply.

5.1.2 The design of pavement shall take into account all relevant factors for assuring reliable performance, surface characteristics and shall satisfy the specified minimum performance requirements.

5.1.3 The Concessionaire shall undertake the necessary soil, material and pavement investigations and 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 or recognised international specifications for performance specific mixes.

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 designed and adopted to deal with such site conditions.

5.2 Type of Pavement

5.2.1 The Authority may require provision of specific type (flexible/rigid) of pavement depending upon specific site conditions. Such requirements shall be as specified in **Schedule–B** of the Concession Agreement. Unless otherwise specified in **Schedule–B**, the Concessionaire may adopt any type (flexible/rigid) of pavement structure for new construction.

5.3 Method of Design–New Pavements

5.3.1 *Design of flexible pavement*

The pavement shall be designed to ensure the specified performance for the projected traffic needs, climate and type of soils in the given area. The Concessionaire is expected to use a design procedure that is appropriate to produce a cost-effective structure meeting the performance requirements and long term durability. The Concessionaire may use IRC:37 "Tentative Guidelines for the Design of Flexible Pavements" or it may use any internationally accepted design procedure that is based on past performance and research. It will be the Concessionaire's responsibility to provide a pavement structure that fully meets the prescribed performance requirements throughout the operation period.

5.3.2 *Design of rigid pavement*

Jointed 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".

Continuously Reinforced Concrete Pavements (CRCP) shall be designed as per any recognised international guidelines which shall be subject to approval by the Independent Engineer.

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 20 years or operation period, whichever is more.

ii) Alternative strategies or combination of initial design, strengthening and maintenance can be developed by the Concessionaire to provide the specified level of pavement performance over the operation period subject to satisfying the following minimum design and performance requirements.

a) The pavement shall be designed to resist specific distresses in each layer and the choice of materials and mixes shall be such that the pavement remains structurally serviceable throughout the operation period without requiring any major structural strengthening. The requirement and frequency of resurfacing should not be closer than 10 years. A longer period will be desirable. The resurfacing process will be milling the existing layer to the depth of distress and replacing the same by the material that meets the characteristics of the original surface.

b) The pavement strengthening when required shall incorporate the consideration of (i) strength of existing layers as evaluated using deflection testing by FWD, (ii) design period for strengthening to extend five years beyond the period of concession, and (iii) specified performance requirements.

5.4.2 *Rigid pavement-design period and strategy*

i) Rigid pavement shall be designed for a minimum design period of 30 years or operation period, whichever is more.

ii) The Pavement Quality Concrete (PQC) shall rest over Dry Lean Concrete (DLC) subbase of 150 mm thickness.

iii) The PQC shall be of a grade not lower than M-40.

iv) The DLC will meet the minimum cement and compressive strength requirement as prescribed in IRC:SP:49. DLC will extend beyond the PQC (including that in shoulder, if any) by 1.0 m on either side.

v) Below DLC layer, a properly designed drainage layer of 150 mm thickness shall be provided throughout the road width. It shall be designed to obtain a drainage coefficient of not less than 30 m per day.

5.4.3 Pavement Performance Requirements

i) The pavement structure shall be capable of giving the specified performance over the entire operation period.

ii) The flexible 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 measured by calibrated Bump Integrator : Not more than1800 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

e) Surface macro-texture depth for satisfactory skid resistance: Not less than 1.00 mm (measured by sand patch test).

iii) The new rigid pavement shall satisfy the following standards:

a) Surface Finish: As per requirements of Clauses 902 and 903 of MORTH Specifications.

b) Roughness: In each lane measured by calibrated Bump Integrator: Not more than1800 mm/km for each lane in a km length.

c) Cracking distress, texture as specified in IRC:15 and IRC:SP:83.

iv) 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. Periodic condition assessment surveys shall be conducted to monitor surface condition to track deterioration with time and to take appropriate timely corrective and preventive measures. Generally, the flexible pavement condition in terms of roughness, cracking and rutting should not deteriorate to the maximum values specified in **Schedule-K** of the Concession Agreement, earlier than 10 years from the year of initial construction.

v) During the operation and maintenance period, the pavement strength shall be evaluated periodically through deflection measurements (Refer to para 5.6 (ii) of this Section) and the stretches exhibiting any structural deficiency shall be rectified.

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 Estimate of the initial daily average traffic flow shall be based on determination of diverted traffic, induced and development traffic.

5.5.3 Any likely change in traffic due to future development plans, land use, shall be duly considered in estimating the design traffic.

5.5.4 Traffic growth rate shall be estimated for each category of commercial vehicles to be considered for design of pavement. For traffic projections, the procedure outlined in IRC:108 may be followed. The Concessionaire shall adopt a realistic value of the rate of traffic growth, provided that annual rate of growth of commercial vehicles shall not be adopted less than 5 percent.

5.6 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 by FWD every 3 years in accordance with the procedure laid down in IRC guidelines for structural evaluation and strengthening of flexible road pavements using FWD, unless needed earlier for stretches exhibiting severe distress during the operation and maintenance period.

iii) Other surface characteristics such as cracking, rutting. skid resistance shall be measured periodically at least once a year or earlier where required.

5.7 Strengthening of Existing Flexible Pavement

5.7.1 Where strengthening of pavement is needed, a detailed pavement condition survey and evaluation shall be carried out 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, subgrade improvement reconstruction, or rectification of any other deficiencies are warranted.

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

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

5.7.4 No granular layer shall be provided over an existing bituminous surfacing.

5.7.5 *Design of overlay*

i) The design of pavement strengthening shall be undertaken on the basis of the procedure outlined in "Guidelines for Structural Evaluation and Strengthening of Flexible Road Pavements using Falling Weight Deflectometer (FWD)"

ii) The design period will be as specified in para 5.4.1 of this Section.

iii) The design traffic will be estimated as per the procedure described in para 5.5.

iv) 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.

5.7.6 *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 or any recognised international specifications to meet the performance requirements for the projected traffic and life.

5.7.7 *Pavement performance requirements and evaluation*

i) The strengthened pavement shall satisfy the performance standards and maintenance requirements specified for new pavements in this Manual and **Schedule-K** of the Concession Agreement.

ii) The performance measurement and evaluation will be done as given in this Manual.

5.8 Paved Shoulders and Edge Strips

The thickness and composition of the paved shoulder and edge strip shall be same as that of the main carriageway.

5.9 Design Report

The Concessionaire shall prepare a design report and submit it to the Independent Engineer for review and comments. The pavement design proposals formulated based on the detailed investigations as required as per the relevant design Manual/Guidelines shall be submitted

with the following details,and other additional details specific to the type of pavement proposed.

i) Soil investigation data for new pavements as per Table 13.2 of IRC:SP:19. Report shall include OMC-dry density relationship with heavy compaction and soaked CBR values in addition to other data and information as per the prescribed Proforma.

ii) Test values of aggregate for pavement courses as per Tables 13.3 and 13.4 of IRC:SP:19. All tests as per requirements of MORTH Specifications shall be reported in addition to the tests and information included in the above mentioned Tables.

iii) Estimation of traffic growth, axle load and VDF and traffic projections for pavement design.

iv) Any other relevant information required by the Independent Engineer for review and comments, if any.

SECTION – 6
DESIGN OF STRUCTURES

6.1 General

i) All structures shall be designed in accordance with the relevant Codes, Standards and Specifications, Special Publications and Guidelines of the Indian Roads Congress. Construction of all culverts, bridges and grade separated structures shall conform to MORTH Specifications for Road and Bridge Works.

ii) Unless specified otherwise in **Schedule–B** of the Concession Agreement, the provision of bridges and grade separated structures shall be as follows:

a) For the initial 4-lane configuration of the Expressway, the structures shall be of 4-lane Standards.

b) When Expressway is widened from 4-lane to 6/8 lane at a future date, existing structures shall be configured to 8-lane Standards.

c) For the initial 6-lane and 8-lane Expressway, the structures shall be of 8-lane Standards

iii) All bridges and grade separated structures shall have independent structure for each direction of travel.

iv) All bridges shall be of high level type.

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 50 shall be provided near approaches for guiding vehicular traffic.

vi) 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.

vii) Duct for utility service shall be provided on all the structures and the details for the same shall be specified in **Schedule–B** of the Concession Agreement.

6.2 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 structures shall be designed for the condition when paved shoulder and edge strip on median side is also used as carriageway.

iii) All the components of structures shall be designed for a service life of 100 years except appurtenances like crash barriers, wearing surface, expansion joints and bearings. All the requirements to achieve durability

and serviceability shall be implemented in design, construction and maintenance.

6.3 Width of Structures

Width of the culverts, bridges and grade separated structures shall be adopted as below:

i) **Culverts**

a) The pipe culverts shall extend up to a distance of clear zone as defined in Section–2 of this Manual, on either side.of carriageway. The side slopes at the culvert shall be same as of the adjoining embankment and may be achieved by reducing the cushion over pipe.

b) For the slab and box type culverts, the outer face of the left crash barrier on the structure shall be in line with the outer edge of the earthen shoulder. On the inner side, the culvert shall extend upto full width of median. Joint between the structures of two sides may be provided at the middle of median.

c) The slope of the adjoining embankment shall be suitably graded to merge with the top level of culvert with longitudinal slope not steeper than 6H:1V.

Cross-sections of the pipe culverts for a 4/6/8 lane expressway are given in **Figs. 6.1a, 6.1b** and **6.1c** respectively for depressed median and in **Figs. 6.2a, 6.2b** and **6.2c** respectively for flush type median on approaches.

Cross section of the slab and box type culverts for a 4/6/8 lane expressway are given in **Fig. 6.3a, 6.3b, 6.3c** respectively for depressed median and in **Figs. 6.4a, 6.4b and 6.4c** respectively for flush type median.on approaches.

ii) **Bridges and Grade Separated Structures/ROBs**

The overall width of structures shall be such that the outer face of left crash barrier on the structure is in line with outer edge of earthen shoulder and inside crash barrier is located at a clear distance of 0.75 from the edge of outermost carriageway of adjoining road (the paved edge strip of 0.75 m on median side shall continue on the structure also).

Cross section of bridges and grade separated structures for a 4/6/8-lane expressway for one side are given in **Figs. 6.5a, 6.5b** and **6.5c** respectively. These are applicable both for depressed median and flush type median on

the approaches.

6.4 Structure Types

The Concessionaire may choose any type of structure and structure system commensurate with safety, serviceability and durability requirements. The general guidelines as below shall be followed:

i) The type and span arrangement may be such as to provide riding comfort.

ii) 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. 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.

iii) The following types of structures shall not be accepted.

a) Drop in spans with halved joints (articulations)

b) Trestle type frames for substructures

iv) If construction 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 span(s), etc are desired, the same shall be specified in **Schedule–B** of the Concession Agreement.

v) In case span length is specified in **Schedule–B** of the Concession Agreement, the Concessionaire shall have option to adopt larger span length but not reduce them. The change in span length as above shall not be treated as change in scope provided the total length of structure is not less than that specified in **Schedule–B** of the Concession Agreement.

6.5 Temporary Works

6.5.1 *Formwork*

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 M-15 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.

6.5.2 *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 the IE shall not relieve the Concessionaire of this responsibility

6.6 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.

6.7 Bearings

6.7.1 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 and III). Spherical bearings shall conform to the requirements of BS:5400 and materials of such bearings may 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 rotation and movement in both longitudinal and lateral direction.

6.7.2 The Concessionaire shall procure bearings only from the manufacturers approved by the MORTH.

6.7.3 The Concessionaire shall submit detailed specifications, designs and drawings including installation drawings and maintenance manual incorporating the replacement procedure for review of the Independent Engineer. The bearings shall be of such type which do not require replacement for at least 50 years for major bridges, vehicular underpasses and rail road structures and 25 years for other structures.

6.7.4 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.

6.7.5 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.

6.7.6 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.

6.8 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. In any case, the number of expansion joints shall not be more than 1 for each 100 m length of the bridge or part thereof. For avoidance of doubt, the structures upto 100 m length shall have only one joint at one side abutment, the structures over 100 m and upto 200 m length may have two joints and structures over 200 m and upto 300 m length may have maximum 3 expansion joints.

ii) The Concessionaire shall furnish guarantee/proprietary indemnity bonds from the manufacturers/suppliers of expansion joints requiring no replacement for a period of 10 years.

iii) The Concessionaire shall procure expansion joints only from manufacturers approved by the MORTH.

iv) The expansion joints should cater for movement in both longitudinal and lateral direction.

6.9 Reinforced Earth Retaining Structures

6.9.1 The design and construction of reinforced earth structures shall conform to section 3100 of MORTH Specifications. Reinforced earth retaining structures shall not be provided near water bodies. Such 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.

6.9.2 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.

6.9.3 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 manufacturer's test certificates.

6.10 Road-Rail Bridges

6.10.1 *Road over bridge (road over railway line)*

i) If the alignment of road at the existing railway crossing has skew angle more than 45°, the alignment of road or of pier/abutment shall be suitably designed to reduce skew angle up to 45°.

ii) Railways normally do not allow construction of solid embankment in their right of way. The horizontal and vertical clearances to be provided on the railway land shall be as per requirement of the Railway authorities.

iii) In case the Authority has obtained approval of General Arrangement Drawings, the same shall be appended with the Request for Proposal. The Concessionaire shall have option of adopting the same span arrangement or have his revised proposal for GAD approved from the Railways. In case the total length of stilt portion is not reduced, it will not be considered as change of scope. However, before submitting the revised proposal to the Railways, prior consent of the Authority shall be required.

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 the Railway authorities.

vi) The approach gradient shall not be steeper than 1 in 40.

vii) Outside the railway boundary, one span of 12 m conforming to the requirements of Vehicular Underpass shall be provided on either side of ROB to cater for the local traffic, inspection, and pedestrian movement.

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

i) Full roadway width as in the approaches shall pass below the railway lines allowing for widening of Expressway upto 8-lane at a later date and keeping space for utilities, drains, etc. The service roads wherever provided shall be continued in the bridge portion also.

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.

6.11 Grade Separated Road Structures

i) The location, type and length of grade separated structures to be provided on the Expressway shall be as 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 requirements specified in this Manual.

6.12 Drainage

An effective drainage system for the bridge 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. Guidelines for drainage given in Section–9 of this Manual shall be adopted.

6.13 Safety Barriers

i) Reinforced Cement Concrete crash barriers shall be provided on the edges of all slab/box type culverts bridges and grade separated structures..

ii) The design loading for the crash barriers shall be as per Clause 209.7 of IRC:6.

iii) The type design for the crash barriers may be adopted as per IRC:5. High Containment type crash barrier shall be provided on the Road Over Bridges

and Vehicle crash barrier type shall be provided on all other structures. The sketches of concrete crash barriers extracted from IRC:5 are given in **Figs. 6.6a** and **6.6b** for Vehicular Crash barrier and High Containment type Crash barriers respectively.

iv) Crash barriers on the structures shall be suitably continued and connected with safety barriers on approaches on either side of the structures to have smooth transition as per guidelines given in Section–10 of this Manual.

6.14 Future Widening of Structures

Future widening of structures shall be adopted by suitable method so that there is seamless travel path. Suitable markings and signages shall be placed for guidance of traffic. It will be better if the new structure is stitched with the existing structure by dismantling the crash barrier on the existing structure. Where stitching is not possible, new structure may be added abutting the old structure, crash barrier dismantled and longitudinal joint provided between the old and widened structure. The edge strips of the two structures may be suitably marked to prohibit vehicles travelling on this portion. Any other innovative method of widening the old structure may be adopted so that safety of structure and traffic is not compromised.

6.15 Design Report

The Concessionaire shall furnish the design report, including the following, to the Independent Engineer for his review and comments, if any.

i) Sub soil exploration report as per IRC:78.

ii) Hydrological Investigation report including hydraulic design in respect of design discharge for the bridges and culverts, waterway, afflux if any, scour depth, design HFL, etc.

iii) Detailed designs and drawings of temporary works, foundations, substructures and superstructure of structures and appurtenances.

iv) GAD and preliminary design proposal for future widening to 8-lane configuration.

v) Any other information relevant to the design of structures.

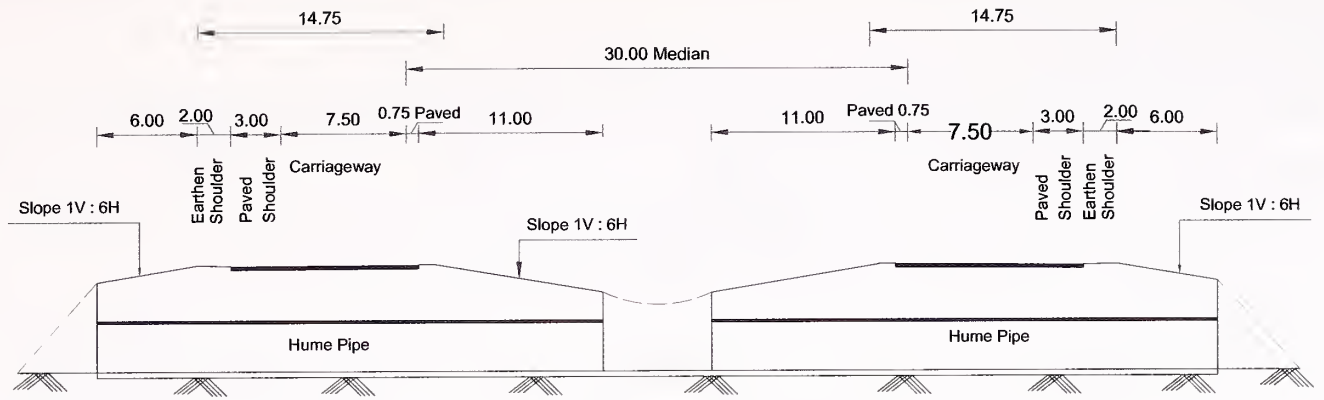


Fig. 6.1 (a) Typical Cross-section of Pipe Culvert for 4-Lane (2×2) Expressway with Depressed Median

NOTE - All Dimensions are in metres

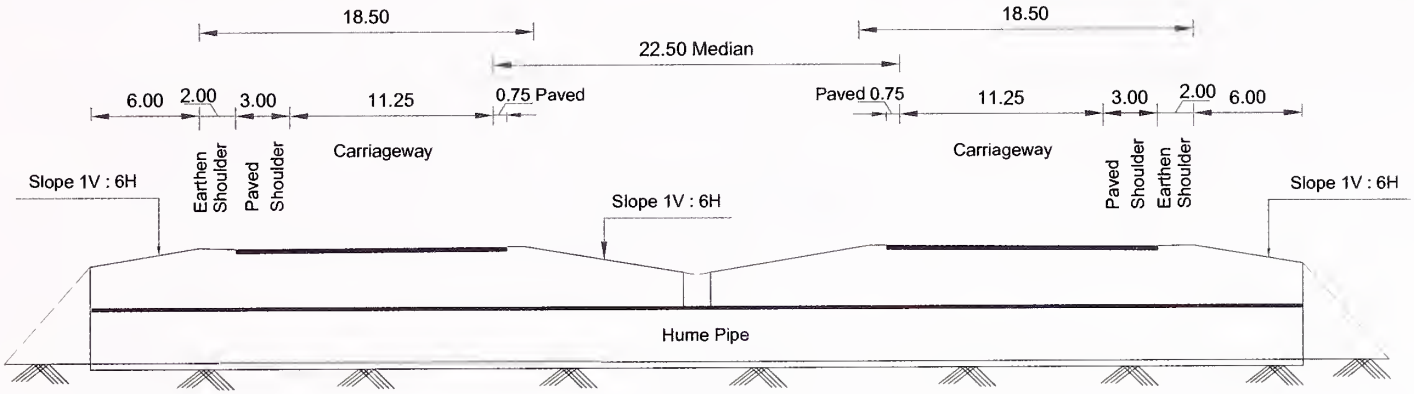


Fig. 6.1 (b) Typical Cross-section of Pipe Culvert for 6-Lane (2x3) Expressway with Depressed Median

Note - All Dimensions are in metres

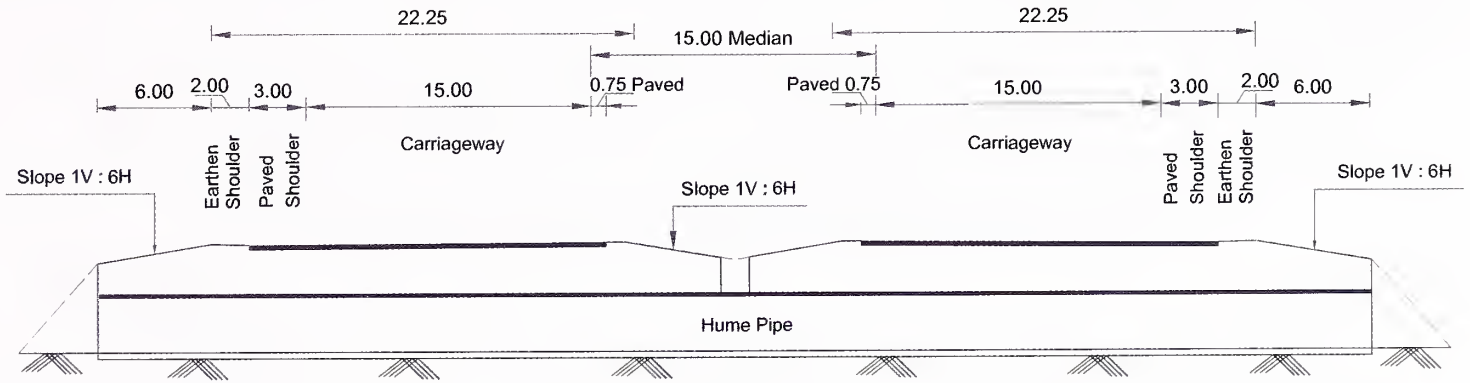


Fig. 6.1 (c) Typical Cross-section of Pipe Culvert for 8-Lane (2x4) Expressway with Depressed Median

Note - All Dimensions are in metres

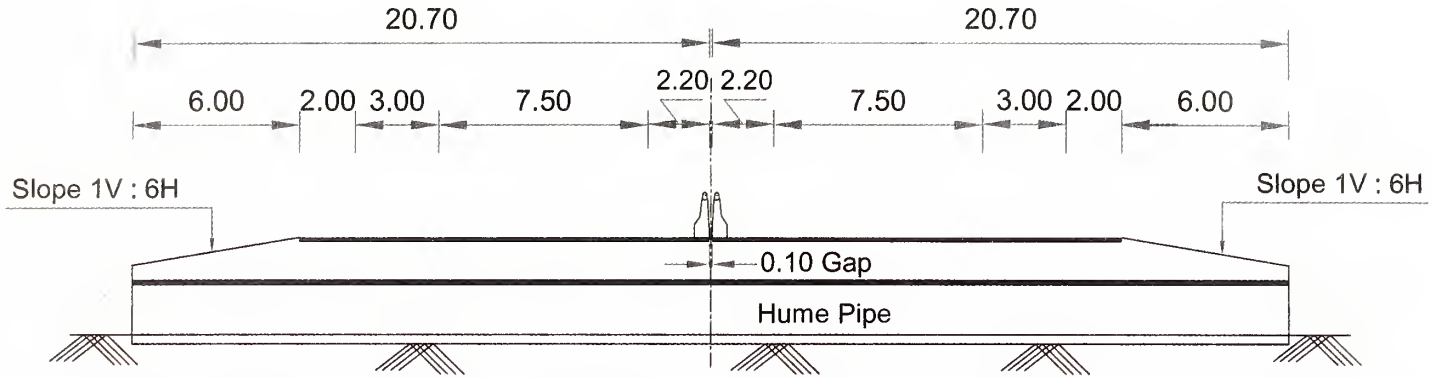


Fig. 6.2 (a) Typical Cross-section of Pipe Culvert for 4-Lane (2x2) Expressway with Flush Median

Note - All Dimensions are in metres

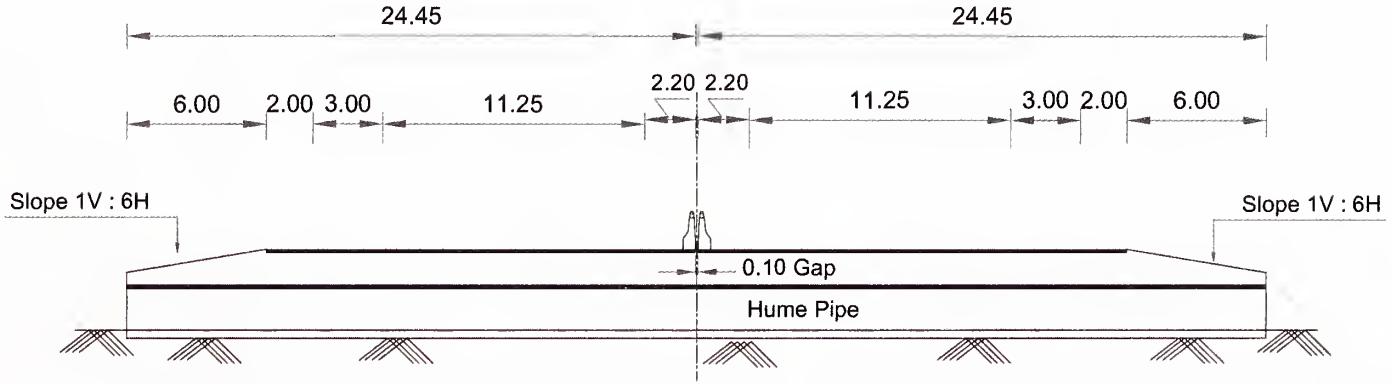


Fig. 6.2 (b) Typical Cross-section of Pipe Culvert for 6-Lane (2x3) Expressway with Flush Median

Note - All Dimensions are in metres

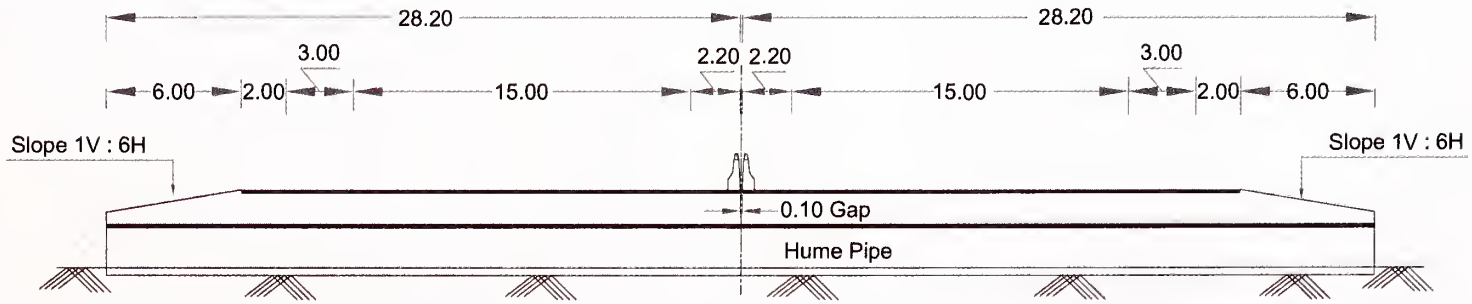


Fig. 6.2 (c) Typical Cross-section of Pipe Culvert for 8-Lane (2x4) Expressway with Flush Median

Note - All Dimensions are in metres

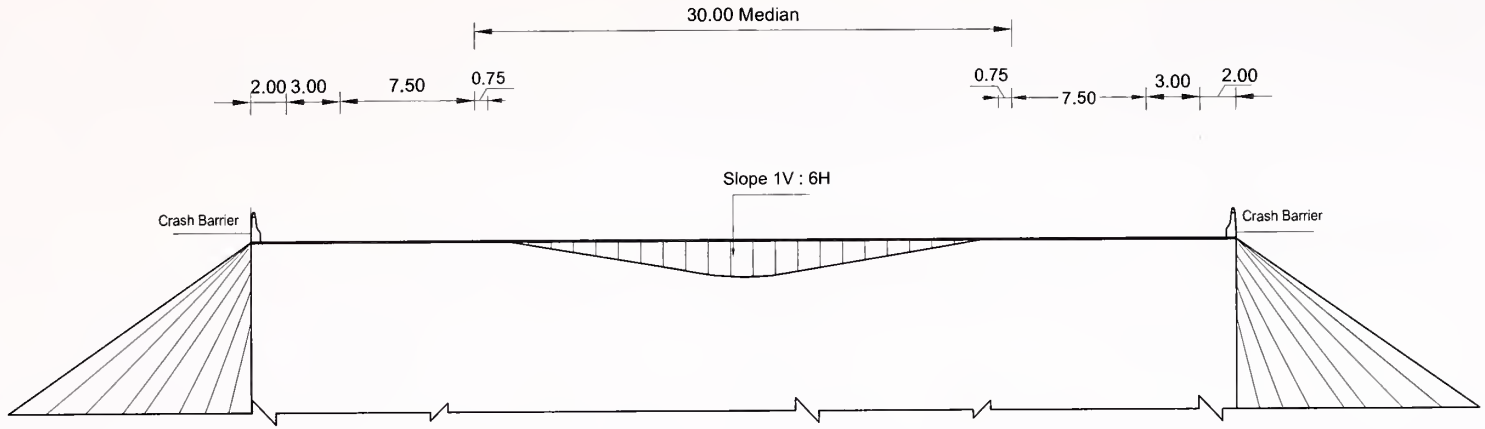


Fig. 6.3 (a) Typical Cross-section of Slab and Box Type Culvert for 4-Lane (2x2) Expressway with Depressed Median

Note - All Dimensions are in metres

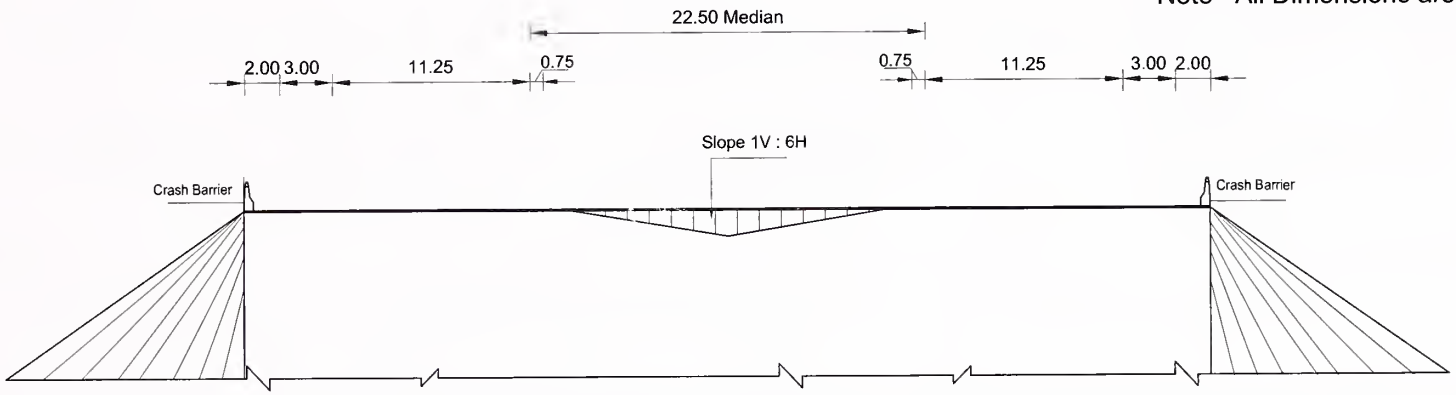


Fig. 6.3 (b) Typical Cross-section of Slab and Box Type Culvert for 6-Lane (2x3) Expressway with Depressed Median

Note - All Dimensions are in metres

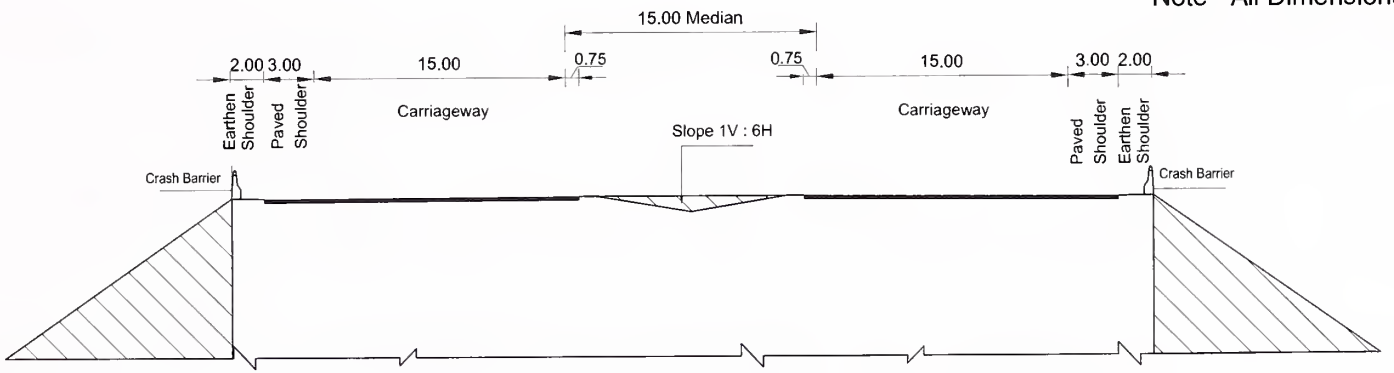


Fig. 6.3 (c) Typical Cross-section of Slab and Box Type Culvert for 8-Lane (2x4) Expressway with Depressed Median

Note - All Dimensions are in metres

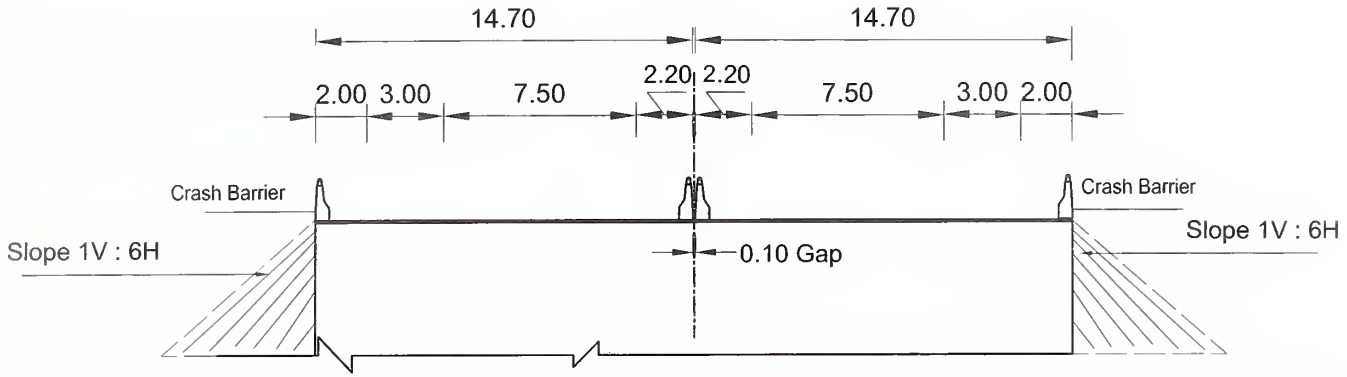


Fig. 6.4 (a) Typical Cross-section of Slab and Box Type Culvert for 4-Lane (2x2) Express Highway with Flush Median

Note - All Dimensions are in metres

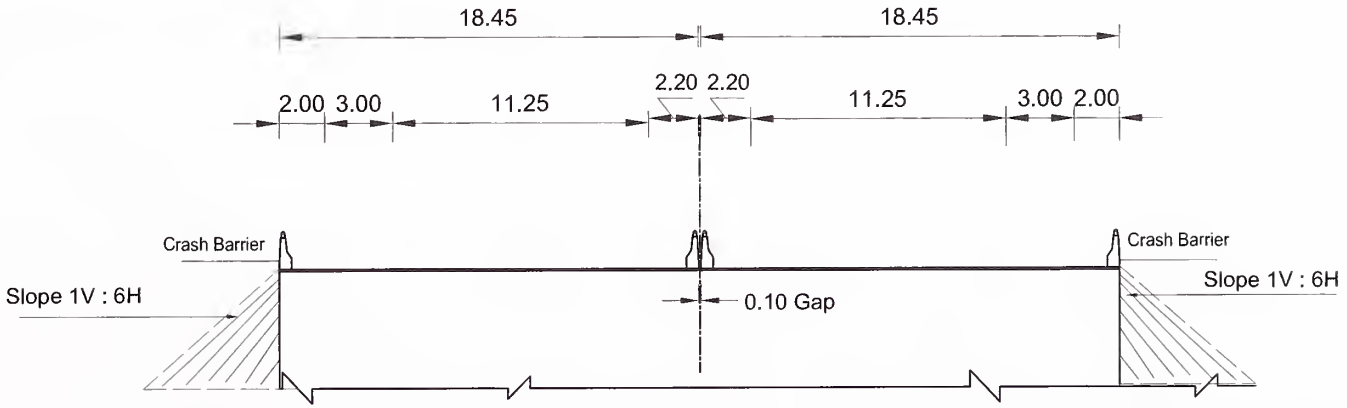


Fig. 6.4 (b) Typical Cross-section of Slab and Box Type Culvert for 6-Lane (2x3) Express Highway with Flush Median

Note - All Dimensions are in metres

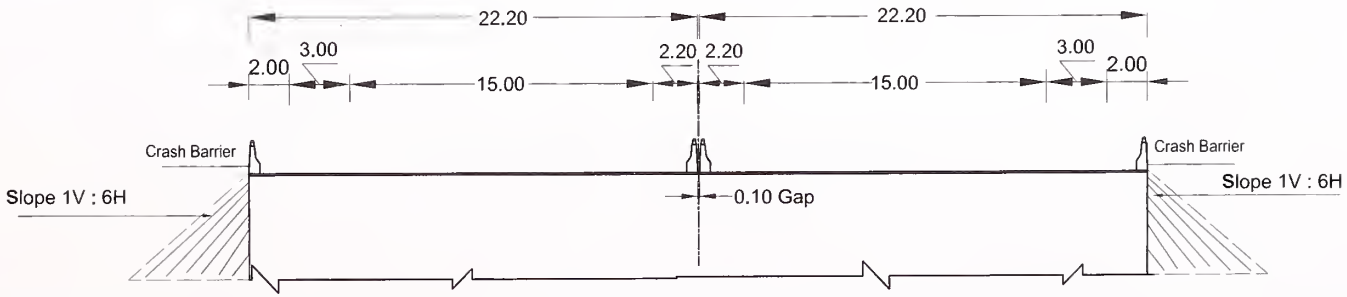


Fig. 6.4 (c) Typical Cross-section of Slab and Box Type Culvert for 8-Lane (2x4) Express Highway with Flush Median

Note - All Dimensions are in metres

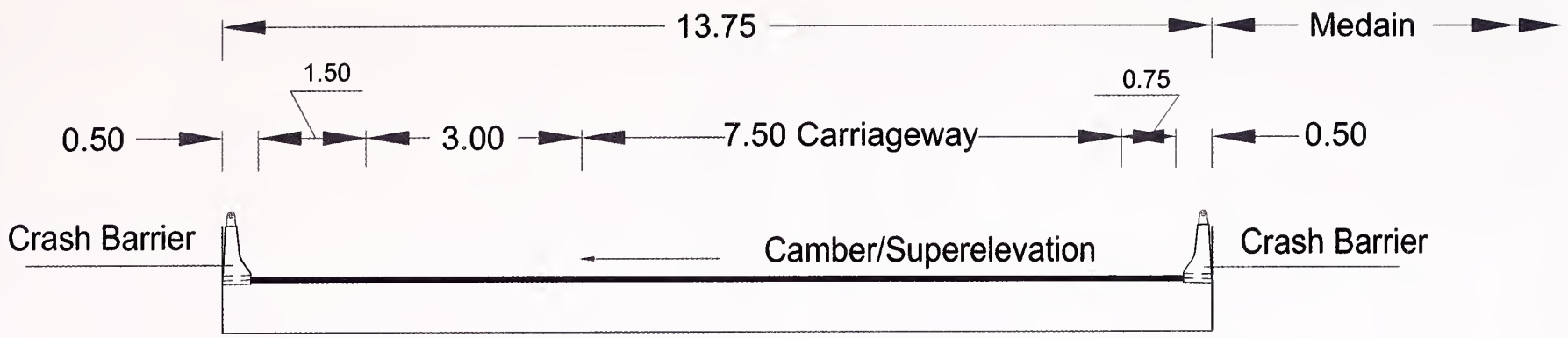


Fig. 6.5 (a) Typical Cross-section of 4-Lane (2x2 Lane) Bridge and Grade Separated Structures (One side)

Note - All Dimensions are in metres

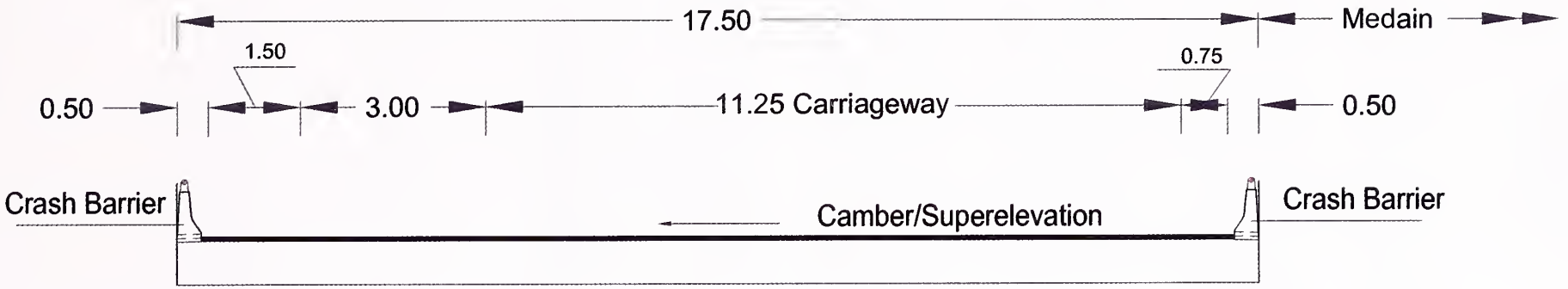


Fig. 6.5 (b) Typical Cross-section of 6-Lane (2x3 Lane) Bridge and Grade Separated Structures (One side)

Note - All Dimensions are in metres

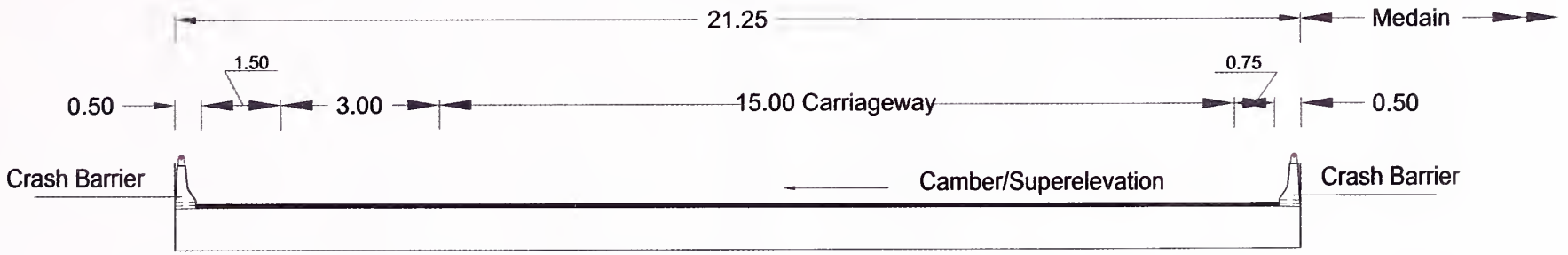
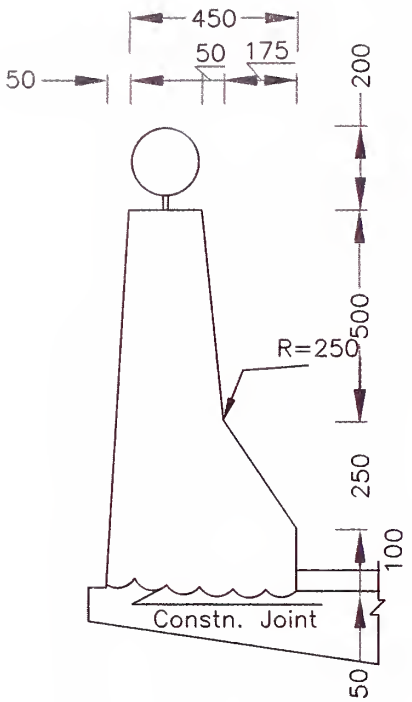
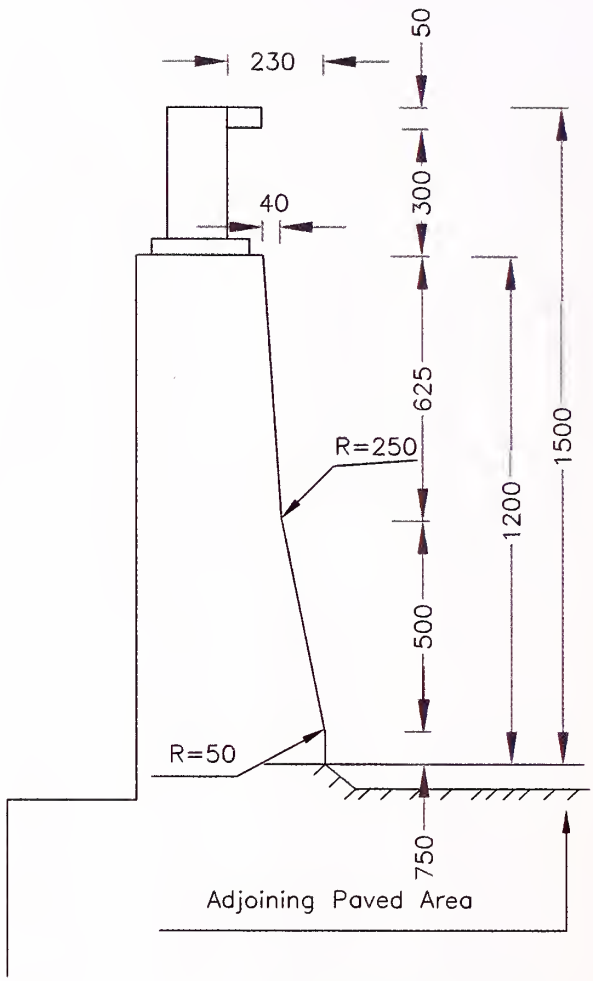


Fig. 6.5 (c) Typical Cross-section of 8-Lane (2x4 Lane) Bridge and Grade Separated Structures (One side)

Note - All Dimensions are in metres



(a) Vehicle Crash Barrier



(b) High Containment Crash Barrier

Fig. 6.6 Typical Details of Crash Barriers

(Extracts From IRC:5)

Note - All Dimensions are in Millimetres

SECTION – 7
TUNNELS

7.1 General

7.1.1 Expressway 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.

7.1.2 Planning and design of tunnel shall be based on various conditions along the expressway alignment including the topography, geology, meteorology, environment, locations and traffic volumes and shall generally conform to provisions of IRC:SP:91 and this Manual.

7.1.3 Wherever tunnel is required to be provided, its location, length and number of lanes shall be indicated in **Schedule–B** of the Concession Agreement.

7.2 Geometrics

7.2.1 A tunnel shall have the same geometric standards as on the expressway carriageway outside the tunnel except as specified in this Section.

7.2.2 *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.

7.2.3 *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-bye where necessary, lighting, drainage, fire and other services.

7.2.4 *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.

7.2.5 *Number of traffic lanes*

For Project Expressways up to 8-lanes, twin tubes of 3-lane configuration shall be provided.

7.2.6 *Paved shoulder*

Tunnels shall have paved shoulder of 3.0 m on left side and edge strip of 0.75 m on the right side. In case of tunnels having more than 500 m length, provision shall be made for 10 m long and 1.5 m wide emergency lay bye beyond the left most lane at 750 m intervals to facilitate refuge for break down/damaged vehicles and also for maintenance vehicles. Proper transitions, line of sight and informatory signs shall be ensured for such lay-bye.

Typical tunnel cross sections for unidirectional traffic conditions for three-lane carriageway configurations are given in **Fig. 7.1** for cut and cover type construction and in **Fig. 7.2** for mining type construction. A typical layout of lay-bye is shown in **Fig. 7.3** for tunnels of length more than 500 m.

7.2.7 *Tunnel spacing*

The clear distance between the twin tubes shall be kept depending upon the type of strata and structural stability of the tunnel. Guidance in this regard may be taken from IRC: SP: 91 or any specialist literature.

7.2.8 *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. 7.4**. The cross passage shall have provision for one traffic lane, edge strip of 0.75 m, crash barriers and walkways on either side. In normal conditions, the cross passage shall be barricaded.

7.2.9 *Vertical alignment*

The vertical gradient shall not be more than 3 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.

7.2.10 *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, the 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. In case of twin tunnel, 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.

7.2.11 *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.

7.2.12 *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.

7.3 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 Section–3 of IRC:SP:91.

7.4 Structural Design

7.4.1 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.

7.4.2 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.

7.4.3 *Tunnels in rock*

Provisions of Section–4 of IRC:SP:91 shall be followed for the structural design of tunnels passing through rock.

7.4.4 *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.

7.5 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.

7.5.1 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.

7.5.2 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.

7.5.3 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. 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. In case this is not feasible, detailed draining system shall be designed by providing sumps and combination of self draining and pumping arrangements.

7.5.4 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.

7.6 Waterproofing

Waterproofing in the form of tunnel lining such as cast in situ 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.

7.7 Ventilation

7.7.1 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.

7.7.2 Mechanical system of ventilation shall be provided in case of tunnels of length more than 500 m.

7.7.3 Detailed design of ventilation shall be carried out as per Section–7 of IRC:SP:91 keeping in view the length, shape, size, tunnel environs and complexion of the likely traffic for which tunnel has been designed.

7.8 Tunnel Illumination

For tunnel illumination/lighting refer Section 15 of this Manual.

7.9 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.

7.10 Signages and Carriageway Markings

7.10.1 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.

7.10.2 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-bye 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.

7.10.2.1 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.

7.11 Emergency Facilities

7.11.1 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. 7.5** and guidelines of emergency facilities for each classification of tunnel vide **Table 7.1** as per details in para 7.11.2.

7.11.2 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 7.1 Installation Standards of Emergency Facilities

Emergency Facilities \ Classification			AA	A	B	C	D	Remarks
Information alarm equipment	Emergency telephone		O	O	O	O	O	Omitted in Class D tunnels less than 200 m in Length
	Pushbutton type information equipment		O	O	O	O		
	Fire detector		O	O				Omitted in tunnel without ventilation system
	Emergency alarm equipment	Tunnel entrance information board	O	O	O	O	O	Can be omitted in tunnels less than 200 m in Length
		In- tunnel information board	O	•				To be installed in Class A tunnels 3,000 m or more in length
fire extinguishing	Fire extinguisher		O	O	O	O	O	
	Fire plug		O	O	•			To be installed in Class B tunnels 1,000 m or more in length
Escape and guidance equipment	Guide board	Emergency exit lamps	To be installed in tunnels with evacuation adits					
		Guide board	To be installed in tunnels with evacuation adits					
		Emergency exit direction board	To be installed in tunnels with evacuation adits					
		Guide board	O	O	O			To be installed in tunnels without evacuation adits
	Smoke discharge equipment and Escape passage		• Evacuation adits 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. • Evacuation tunnels provide for those Class AA tunnels and Class A tunnels of a length of 3,000 m or more which empoly a two-way traffic system and a longitudinal ventilation system. • Either evacuation adits or smoke discharge to be provided for Class AA					
Other equipment	Hydrant		O	O	•			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 ports near the entrance.
	Radio communication auxiliary equipment	Coaxial cables	O	•				To be provided in Class A tunnels 3,000 m or more in length.
		Entrance/exit telephone	O	O				
	Radio rebroadcasting equipment	interrupt function provided	O	•				To be provided in Class A tunnels 3,000 m or more in length.
	Cell phone connectivity		O	O	O	O	O	To be provided
	Loudspeaker equipment		To be provided in tunnels equipped with a radio rebroadcasting equipment (with interruption function)					
	Water sprinkler system		O	•				To be provided in Class A tunnels 3,000 m or more in length, and serviced in two way traffic.
	CCTV		O	•				To be provided in Class A tunnels 3,000 m or more in length.
	Lighting equipment for power failure		To be provided in tunnels 200 m or more in length.					
	Emergency Power supply equipment	Independent power plant	To be provided in tunnels 500 m or more in length.					
		Non-failure power supply equipment	To be provided in tunnels 200 m or more in length.					

LEGEND: O- Mandatory •- Use with consideration

b) Pushbutton 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.

7.12 Safety During Construction

7.12.1 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.

7.12.2 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.

7.12.3 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.

7.12.4 Provisions of Section–6 of IRC:SP:91 shall generally be followed for safety during construction of tunnels.

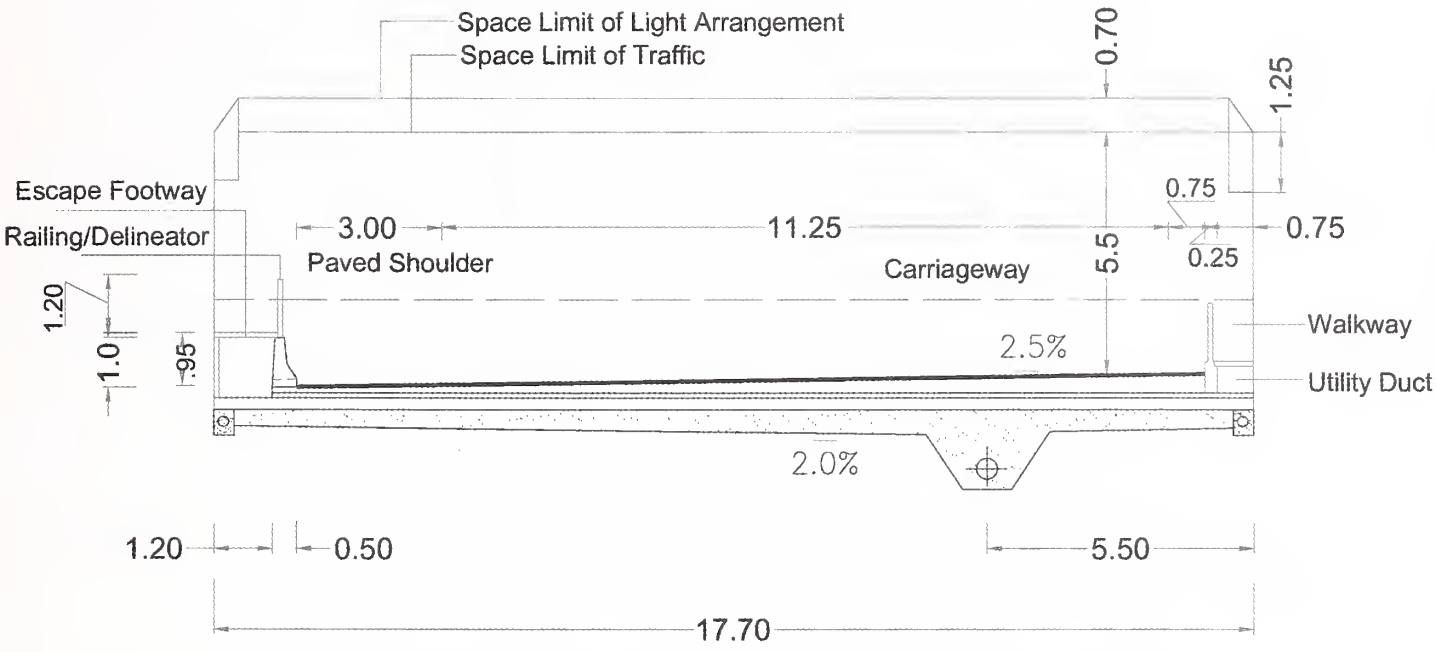


Fig. 7.1 Typical Cross-section of Three Lane Tunnel Cut and Cover Construction

NOTE - All Dimension are in metres

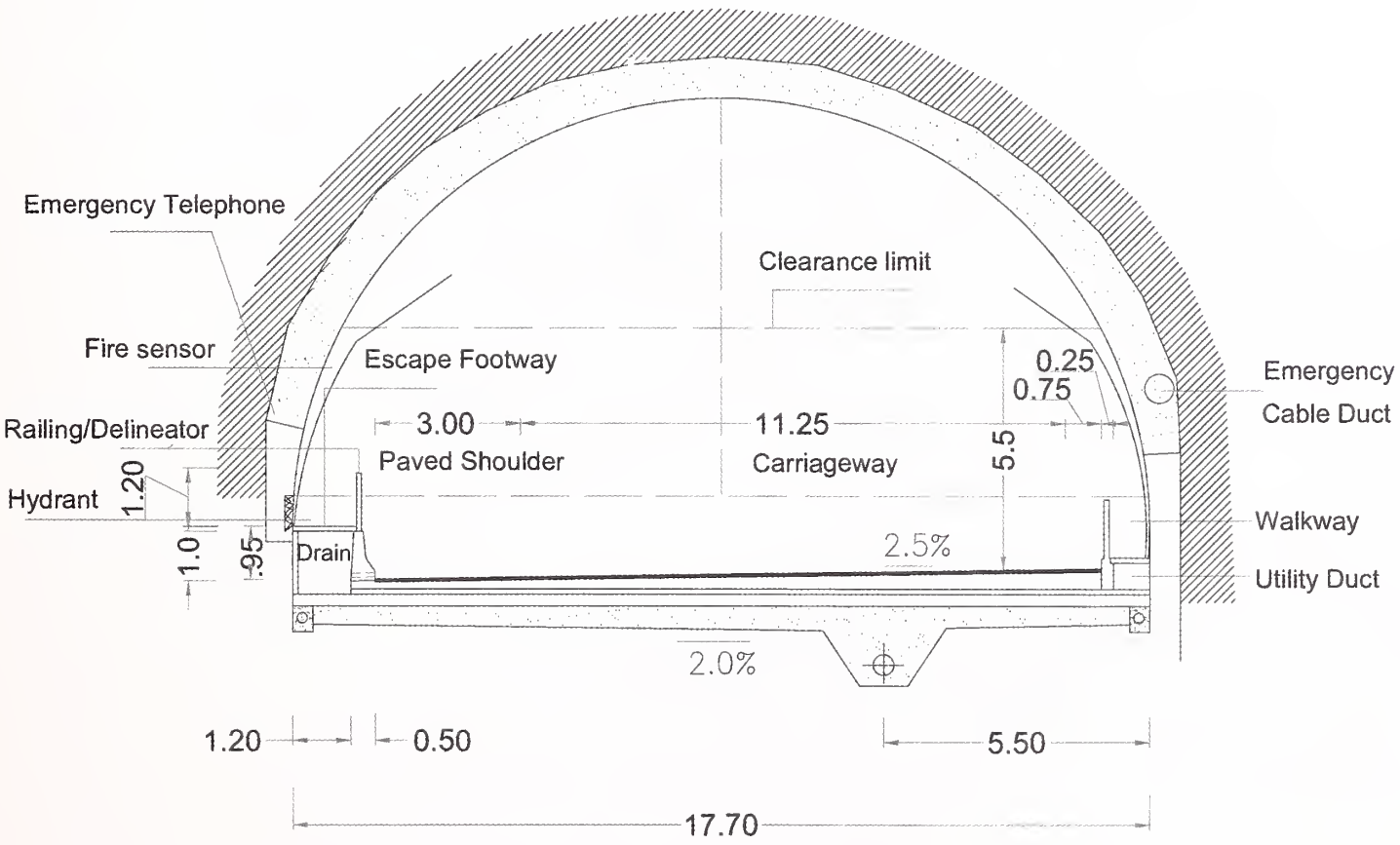


Fig. 7.2 Typical Cross-section of Three Lane Tunnel Mining Type Construction

NOTE - All Dimension are in metres

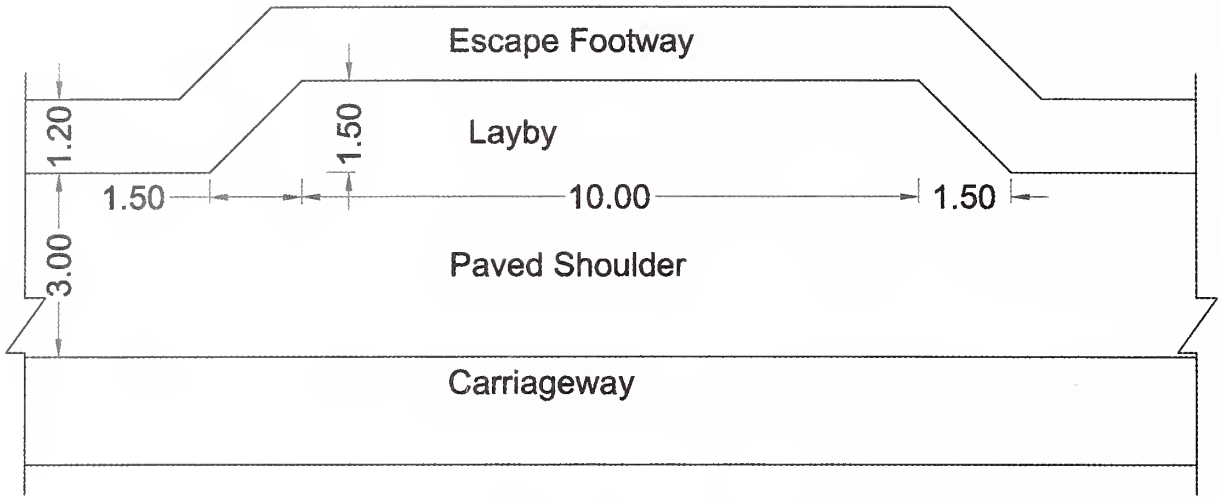
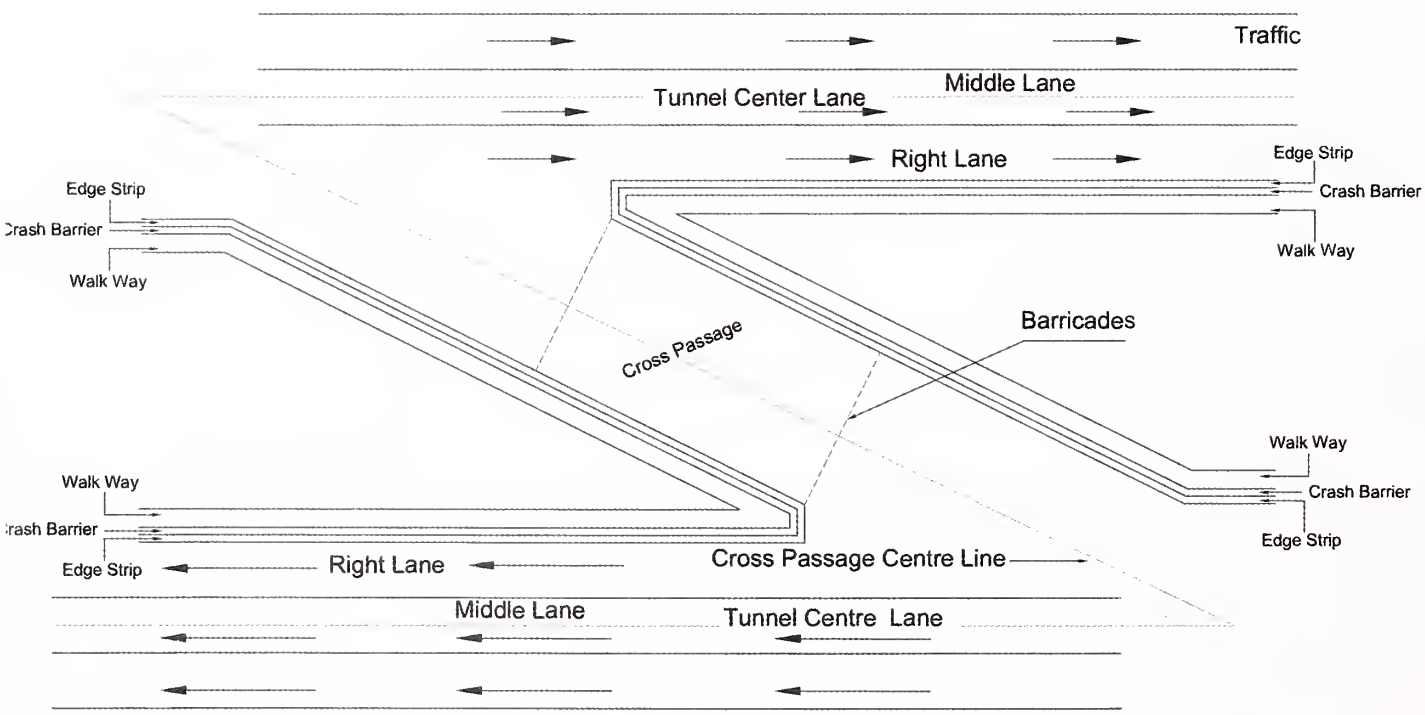


Fig. 7.3 Typical Layby Inside Tunnels Length more than 500 m

(At 750 m Interval)

NOTE - All Dimension are in metres



PLAN

Fig. 7.4 Tunnel Passage

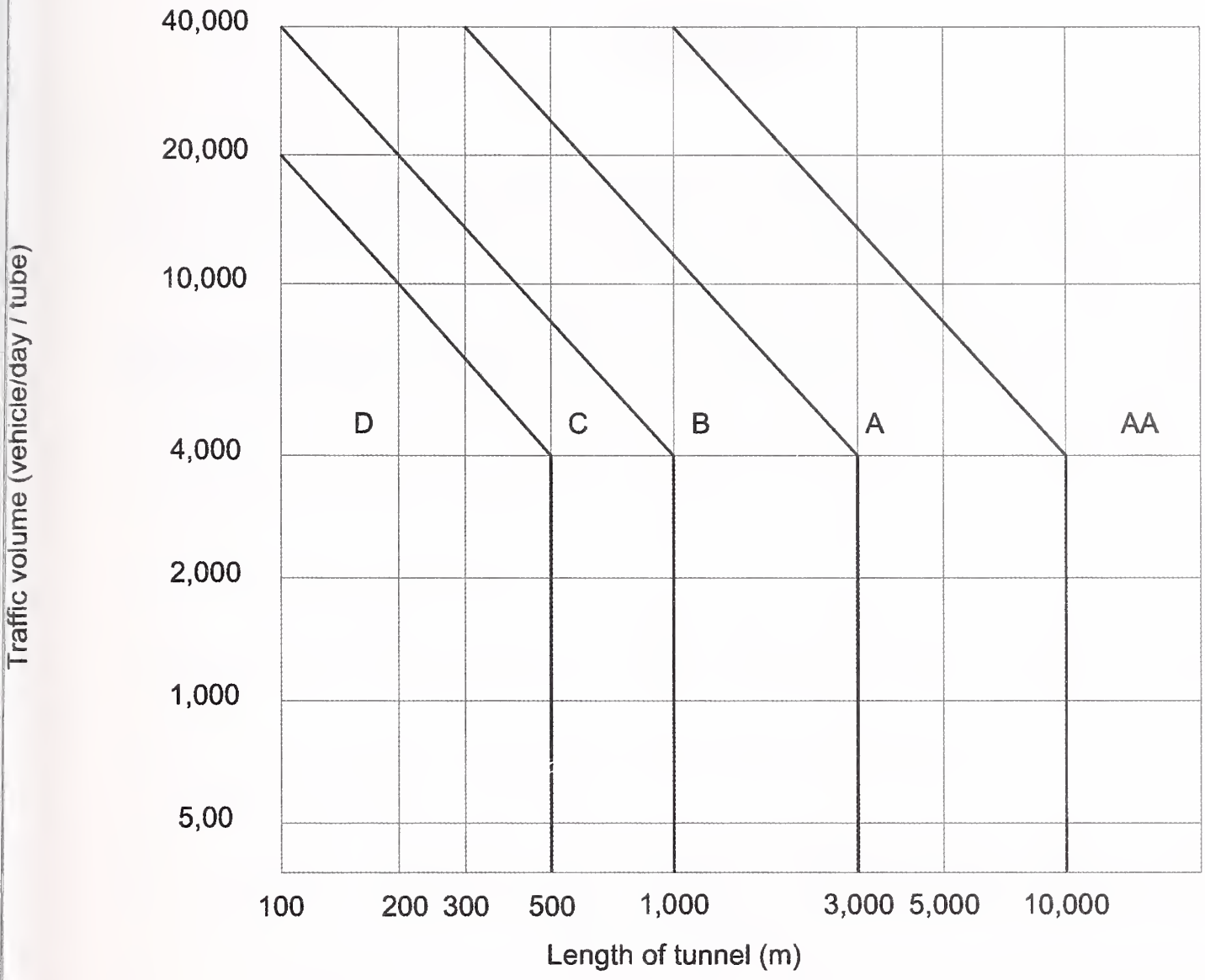


Fig. 7.5 Classification of Tunnels

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 or International Standards, provisions of para 1.10 shall apply.

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
DRAINAGE

9.1 General

9.1.1 The design and construction of surface and subsurface drains for road drainage and drainage for structures shall be carried out in accordance with the requirement of this Section.

9.1.2 For efficient drainage system for the entire Project Expressway 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.

9.1.3 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 provided and if necessary, arrangement for pumping shall also be made.

9.2 Surface Drainage

9.2.1 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.

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

9.2.3 As far as possible, longitudinal slope shall not be less than 0.5 percent for lined drains and 1.0 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

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

9.2.5 The drains shall be provided with CC lining in the following situations:

i) When due to space constraint, the drains are located near the toe of the embankment or near structures.

ii) Flow velocity is more than 1 m/s in silt and sand; and more than 1.5 m/s in stiff clay.

9.3 Median Drainage

9.3.1 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 superelevated sections, the longitudinal drain shall be designed to take the discharge from one side carriageway also.

9.3.2 The flush median shall be paved and provided with camber for drainage across the pavement. In superelevated sections, combination of covered longitudinal and cross drains shall be provided.

9.4 Drainage where Embankment Height is more than 6 Meters

9.4.1 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 Expressway.

9.4.2 Drainage arrangement shall include provision of kerb channel outside the paved shoulder, cement concrete lined chutes along the slopes at designed intervals with energy dissipation basin, side channels at the bottom and 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.

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

9.5 Catch Water Drains

9.5.1 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 sand mortar.

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

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

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

9.6 Sub-surface Drains

9.6.1 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.

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

9.6.3 The sub-surface drains shall be:

i) Close jointed perforated pipes or open jointed un-perforated pipes in trenches with backfill material around pipes.

ii) Aggregate drains consisting of free draining material in the trench without any pipe.

9.6.4 Perforated pipes and un-perforated pipes shall meet the requirements of Clause 309.3 of the MORTH Specifications.

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

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

9.6.7 *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.

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

9.6.9 *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.

9.6.10 Trench excavation, laying of pipe, backfilling, and use of geo-synthetics shall conform to the requirements of Clause 309.3 of the MORTH Specifications.

9.6.11 The drain outlet shall be a free outlet and shall be provided as per Clause 309.3 of the MORTH Specifications.

9.6.12 *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.

9.6.13 Design of subsurface drainage shall be based on a rational basis. Reference may be made to IRC:SP:42.

9.7 Internal Drainage of Pavement Structure

i) The sub-base shall be extended across the shoulders for efficient drainage of pavement.

ii) The granular sub-base shall be of proper design and grading to perform satisfactorily as a drainage layer. The drainage layer shall not have material finer than 75 micron size.

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

9.8 Drainage for Structures

9.8.1 *Culverts and bridges*

9.8.1.1 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.

9.8.1.2 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.

9.8.2 *Grade separators/flyovers/road over bridges*

9.8.2.1 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.

9.8.2.2 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.

9.8.2.3 Typically, water spouts are provided at the kerbs at the rate of one number per 12 sqm of the surface in level portions and one number 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 and abutment locations.

9.8.2.4 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.

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

9.8.2.6 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 the nearest drain.

9.8.2.7 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.

9.8.2.8 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.

9.8.3 *Underpasses and subways*

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.

9.9 Existing Drains, Canals and Minor Waterways

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

9.9.2 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.

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

9.10 When expressway 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 expressway slope endangering the pavement drainage. The drainage channels at the toe of the expressway may have to be adequately protected or reshaped for discharge into these channels. Where the discharge from road drainage is not permitted, separate cross drainage structures are to be provided on both sides of such channels.

9.11 Erosion Control Measures

Erosion control measures in accordance with the provisions of the MORTH Guidelines for Expressways shall be provided. Guidance may be taken from IRC:56 for treatment of embankment slopes for erosion control.

9.12 Survey, Investigation and Design Report

The Concessionaire shall carry out proper surveys and investigations for detailed design of the drainage system. The proposal for drainage system supported with survey investigation report and detailed design report shall be submitted to the Independent Engineer for review and comments, if any.

9.12.1 *Drainage studies*

The survey and investigation and drainage studies shall include:

i) Alignment plan, longitudinal and cross–sections, contour map.

ii) Hydrological data, Drainage area, water shed delineation, direction of flow, location of outfalls, existing surface drains, ground surface condition, rainfall, flood frequency, etc.

iii) Data for hydraulic design of drains.

iv) Geo-technical investigations for sub surface strata, level of water table, seepage flow, etc.

v) Identification of areas requiring sub-surface drainage.

vi) Any other relevant information. Guidance may be taken from IRC:SP:19, IRC:SP:42, IRC:SP:48 and IRC:SP:50.

9.12.2 *Design details*

The report shall include:

i) Estimation of design discharge.

ii) Design of surface drains.

iii) Design of sub-surface drains.

iv) Drainage arrangement plan along with plan, longitudinal section and cross section of drains integrated with cross drainage works and a strip chart.

v) Specifications of drains.

vi) Erosion control measures proposed.

vii) Any additional information as required by the Independent Engineer f review of the drainage system.

SECTION - 10
TRAFFIC CONTROL DEVICES, ROAD SAFETY DEVICES AND ROAD SIDE FURNITURE

10.1 General

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, boundary fences, boundary stones, kilometre stones, etc. MORTH Guidelines for Expressways and Section 800 of MORTH Specifications shall be followed for providing these items unless otherwise specified in this Section.

10.2 Road Signs

The road signs on expressways are required to provide adequate information on lane driving, advance information to exit, location of facilities for road users and also for emergency need for vehicles, Road signs shall be provided as per IRC:67 and Section 800 of MORTH Specifications. Clustering and proliferation of road signs shall be avoided for enhancing their effectiveness.

The traffic signs on expressways should serve distinct functions as below:

i) Give directions to destinations, or highway routes, or to other Expressway interchanges and toll plazas;

ii) Furnish advance notice of the approach to interchanges or toll plaza;

iii) Direct road users into appropriate lanes in advance of diverging or merging movements;

iv) Identify routes and directions for important destinations on those routes;

v) Show distances to destinations;

vi) Indicate access to general motorist services, rest, scenic, and recreational areas; and

vii) Provide other information of value to the road user such as weather, maintenance works and occurrence of accidents.

10.2.1 *Colour of signs*

The Colour of all types of signs except direction informatory signs shall be same as that of Plate-I and Plate-II of IRC:67. For direction informatory signs, it shall be white lettering, border and arrows on blue background. In case of facility signs, black symbol shall be displayed within White Square in blue background.

10.2.2 *Format of legends on overhead and shoulder mounted signs*

The legend on all signboards shall be bilingual-regional/local language and English except on those sign boards located at entry/exit points. Entry/Exit shall have inscriptions in regional/ local language, Hindi and English. The font type shall be as per **Table 10.1.**

Table 10.1 Font Type for Inscription on Expressway Signs

S. No.	Language	Font Type
1)	Hindi	Hindi7
2)	English	Transport Medium
3)	Regional Language	As per Local Practice

10.2.3 *Sizes of signs*

The sizes of various types of signs for design speeds of 80-100 km/hr and more than 100 km/ hr shall be as in **Table 10.2**.

Table 10.2 Sizes of Different Types of Signs for Expressways

Sign	Shape	Size for Speeds between 80-100 km/hr (mm)	Size for Speeds more than 100 km/hr (mm)
STOP Sign	Octagunal	900	1200
GIVE WAY Sign	Triangle	900	1200
Prohibitory Signs	Circle	900	1200
No Parking and No Stopping, No Standing Signs	Circle	900	1200
Speed Limit and Vehicle Control Signs	Circle	1200	1200
Cautionary Signs	Triangle	1200	1200

10.2.4 *Size of letters*

Size of letters shall be such that these are ligible and visible at design speeds. The size of letters for Advance Direction, Flag type direction, reassurance, place identification and Gantry mounted signs for various approach speeds shall be as per **Table 10.3.** For supplementary plates attached with facility signs, regulatory signs or cautionary signs, the letter size shall be 100 mm. The text size of 100-125 mm letter size shall be used in the supplementary plates with some of the regulatory signs depicting information on typical timings like "09:00 am to 08:00 pm" coupled with dates or days as applicable.

Table 10.3 Letter Size of Information Signs(Shoulder and Gantry Mounted)

	Advance Direction Signs (Shoulder Mounted)		Flag Type Direction Signs, Reassurance Signs, Place Identification Signs		Gantry Mounted Signs	
1	2	3	4	5	6	7
Design Speed (km/hr)	'x' height lower case (mm)	'x' height upper case (mm)	'x' height lower case (mm)	'x' height upper case (mm)	'x' height lower case (mm)	'x' height upper case (mm)
66-80	150	210	125	175	200	280
81-100	200	280	150	210	250	350
101-110	250	350	200	280	275	385
111-120	300	420	300	420	300	420

10.2.5 *Sheeting for signs*

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. Class B micro prismatic sheeting can be used for delineator posts.

10.2.6 *Signs on curves*

Wherever the Expressway 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 size of chevron shall be as per IRC:67.

i) The curves with radii upto 1200 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.

ii) The curves with radii 1200 m to 3000 m with deflection angle more than 20 degree shall be provided with Chevrons on outer edge of curve at 75 m spacing

iii) The curves with radii 1200 m to 3000 m with deflection angle less than 20 degree and other curves upto 5000 m radius shall be provided with forgiving type delineator posts at 40 m spacing on outer edge of curves.

10.2.7 *Prohibitory signs*

Required prohibitory sign shall be placed prohibiting the entry of certain types of vehicles into the Expressway.

10.2.8 *Overhead signs*

Locations and size of overhead signs shall be specified in **Schedule-B** of the Concession Agreement. The following conditions may be considered while deciding about the locations of overhead signs:

i) Traffic volume at or near capacity,
ii) Restricted sight distance,
iii) Built up stretches,
iv) Insufficient space for ground mounted signs,
v) Distances of important places and routes at suitable intervals
vi) Before major intersections with another Expressway or National Highway
vii) Approaches to Interchanges
viii) Multi-lane exits
ix) Entry to Toll Plazas

10.2.9 *Siting of signs with respect to carriageway*

It shall be ensured that any sign or any other device erected for traffic control, traffic guidance and/or traffic information shall not obscure any other traffic sign and shall not carry any advertisement.

Signs shall be mounted on gantries, cantilevers, and butterfly or on over bridges with vertical clearances as applicable for vehicular operations.

The sign supports shall be provided on the earthen shoulder and in the central median. Placement of foundation and supporting structures shall be sufficiently away from the paved surface. Overhead gantry and cantilever supports within the clear zone shall be shielded by a safety barrier system.

Overhead guide signs may be, where practicable, mounted on overpass structures above the expressway to minimize the number of potentially hazardous roadside structures. Special designs for the signboard and/or its mounting may be required where an overpass structure is skewed in plan to the line of the Expressway.

For Cantilever mounted signs, the centre of the sign is typically located over the carriageway edge line; however the left edge of the sign shall be positioned no further left than the left edge of paved shoulder. On exit ramps, guide signs shall be located over the relevant lanes. Where a number of signs are erected on gantry, the outer edges of signs shall not extend beyond the outer edges of paved shoulders.

The desirable minimum distance over which signs should be seen is the legibility distance of the principal legend size, plus an additional one third of this distance to allow sufficient time for the driver to see the sign prior to reading its text.

10.2.10 *Mounting height and clearance*

All signs for through traffic shall be provided by overhead gantry/cantilever. Kerb mounted signs supported on GI pipes shall be used at entry/exit of the Expressway or at wayside amenity/toll plaza areas. Overhead signs shall be placed on a structurally sound gantry or cantilever structure made of GI pipes.

Overhead Gantry shall be mounted at 5.5 m height above the highest point on the carriageway and shall be extended over the entire carriageway plus paved shoulder.

Cantilever Gantry shall be mounted at a height of 5.5 m measured from the carriageway of the sign.

Typical overhead mounted and cantilever mounted structures for signs are given in **Fig. 10.1A** and **Fig. 10.1B** respectively.

10.2.11 *Expressway symbol sign*

The expressway symbol sign is shown in **Fig 10.2**.

10.2.12 *Interchange exit numbering*

Interchange numbering shall be used in signing each expressway exit. Interchange exit numbers shall be displayed with each Advance Guide sign, Exit direction sign and Gore sign. The exit number shall be displayed on a separate plaque at the top of the Advance Guide or Exit direction sign.

Interchange exit numbering can be either i) Reference location sign numbering (km-base) or (ii) Consecutive numbering and shall be decided in consultation with the Authority and the Independent Engineer. Typical Exit (km) numbering sign is shown in **Fig 10.3**.

10.2.13 *Advance Guide signs*

The Advance Guide sign gives notice well in advance of the exit point of the principal destinations served by the next interchange and the distance to that interchange. Advance Guide sign should be placed at 500 m, 1 km and at 2 km in advance of the exit. Fractions of kilometers or decimals of kilometers should not be used. Where Advance Guide signs are provided for a right exit, diagram signs should be used.

Fig. 10.4 shows typical Interchange Advance Guide sign.

10.2.14 *Exit direction signs*

The Exit direction sign repeats the route and destination information that was shown on the advance guide signs for the next exit, and thereby assures road users of the destination

served and indicates whether they exit to the right or the left for that destination. Shoulder mounted Exit direction signs shall be installed at the beginning of the deceleration lane and shall be of overhead type over the exiting lane.

The message EXIT ONLY in black on a yellow panel shall be used on the overhead exit direction sign to advise road users of a lane drop situation. **Fig. 10.5** shows typical Exit direction sign.

10.2.15 *Exit Gore signs*

The Exit Gore sign in the gore indicates the exiting point or the place of departure from the main roadway. Consistent application of this sign at each exit is important.

The gore shall be defined as the area located between the main roadway and the ramp just beyond where the ramp branches from the main expressway.

Fig. 10.6 shows typical Exit Gore sign.

10.2.16 *Next Exit supplemental signs*

Where the distance to the next interchange is unusually long, Next Exit supplemental signs shall be installed to inform road users of the next interchange. The Next Exit supplemental sign shall carry the legend NEXT EXIT X km. If the Next Exit supplemental sign is used, it shall be placed below the advance guide sign nearest the interchange.

Fig. 10.7 shows typical Next Exit supplemental sign.

10.2.17 *End of expressway signs*

End of Expressway sign shall be placed at the end of expressway section. In the case where an interchange is located near the start or end of expressway, the roads leading to expressway are treated with expressway type advance exit signs. The advance exit signs are placed on the non-expressway section of the route as shown in **Fig. 10.8**.

10.2.18 *Post-Interchange signs*

If space between interchanges permits, as in rural areas, and where undue repetition of messages will not occur, a fixed sequence of signs should be displayed beginning 150 m beyond the end of the acceleration lane. At this point, a Route sign assembly should be installed followed by a Distance sign as indicated in **Fig. 10.9,** at a spacing of 300 m. If space between interchanges does not permit placement of these three post-interchange signs without encroaching on or overlapping the Advance Guide signs necessary for the next interchange, or in rural areas where the interchanging traffic is primarily local, one or more of the post interchange signs should be omitted.

10.2.19 *Distance sign*

The post-interchange Distance sign shall consist of a two-or three-line sign carrying the names of significant destination points and the distances to those points. The top line of the

sign shall identify the next interchange with the name of the community near or through which the route passes and exit number, or if there is no community, the route number or name of the intersected highway.

Second line is second next exit. The third, or bottom line, shall contain the name and distance to a control city (if any) that has national significance for travelers using the route. When Interchange spacing is more than 10 km, the distance sign shall be provided in between at appropriate location. The distances displayed on these signs should be the actual distance to the destination points and not to the exit from the expressway as shown is **Fig. 10.9**.

Fig. 10.9 shows typical Distance sign.

10.2.20 *Signing by class of interchange*

Full signing of the interchange should also cover all approaches and ramps.

Fig. 10.10 shows significant features of signing plan for Trumpet Interchange.

Fig. 10.11 shows typical layout of Diamond Interchange Sign.

Fig. 10.12 shows typical signing plan for Cloverleaf (system interchange).

10.3 Road Markings

The markings shall be such that these are visible under all circumstances at day and night, wet and dry conditions; must have good contrast with the road surface; must be durable; and must not be so thick that these become a hazard in themselves.

All road markings shall conform to IRC:35 and MORTH Specifications unless specified herein. The markings shall be applied to demarcate carriageway lane, edge line, continuity line, stop line, give way lines, diagonal/chevron markings, zebra crossings and at parking areas using a self propelled machine with satisfactory cut off value capable of applying broken line automatically.

10.3.1 *Material*

Hot applied thermoplastic paint with reflectorising glass beads conforming to Section 800 of MORTH Specifications shall be used as road marking material for the Project Expressway. The material used shall have proven performance to last for at least 3 years.

10.3.2 *Longitudinal markings*

For the Project Expressway designed for 120 km per hour, all curves upto 1000 m radii shall be provided with traffic lane line marking meant for curved sections i.e. with shorter interval as per IRC 35. The traffic lane line shall be continuous for curves having radii less than 700 m.

For the Project Expressway designed for 100 km per hour, all curves upto 700 m radii shall be provided with traffic lane line marking meant for curved sections i.e. with shorter interval as per IRC:35. The traffic lane line shall be continuous for curves having radii less than 450 m.

Minimum width of longitudinal marking shall be 200 mm

a) White colour shall be used for carriageway markings except the ones indicating parking restrictions; for the latter, the colour used shall be yellow conforming to IS colour No. 356 as given in IS 164;

b) White together with black colour shall be used for kerb and object markings;

c) Yellow colour may also be used for the continuous centre and barrier line markings.

10.3.3 *Other road markings*

a) Directional Arrows and Lettering

Lane selection arrows on pavement shall be provided for guiding, warning or regulating traffic to change correct lane for driving. It shall be white colour. Large numerals and letters should be used.

b) Chevron Markings

A series of parallel chevron markings on a pavement zone, surrounded by continuous line, for indicating closed to traffic shall be provided wherever required.

10.3.4 *Length and gap*

Length and gap shall be 1.5 m and 4 m on straight reaches and 1.5 m and 1.5 m on curves.

10.3.5 *Longitudinal marking to toll booths*

The traffic lane marking running through the expressway shall be continued till the toll booth, in such a way that traffic from each lane of Expressway is guided to discharge uniformly to different toll booths. 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.

10.4 Road Delineators

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

10.4.1 All physical objects above the Finished Road Level (FRL) that are falling within 6 m from the carriageway edge line shall be illuminated with Object Hazard Markers (OHM). The objects shall include utility poles, traffic sign posts or parapet or concrete barrier of bridges, culverts, RE wall, 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. The object shall be painted with black and yellow stripes using the paint conforming to IS:164.

10.4.2 The kerbs in the medians/traffic islands and concrete crash barrier over bridges and grade separated structures shall be painted with black and white stripes (white with orange stripes at highly hazardous locations) using the paint conforming to IS:164.

10.5 Reflective Pavement Markers and Solar Studs

The reflective pavement markers (RPM) and solar road studs shall be provided to improve the visibility in night-time and wet-weather conditions. These shall be prismatic retro-reflective type two way markers conforming to ASTM D 4280 and provided as per **Table 10.4**. RPM shall be provided on curves and approaches to major bridges, flyovers and interchanges. The RPM on shoulder edge line shall be Red in colour and that on median edge line shall be Amber colour. RPM shall be provided for traffic lane for all curves less than 1200m radii and shall be white in colour. The RPM on traffic lane line shall be placed at the centre of gap of lane line marking.

Table 10.4 Warrants for Road Studs

Sl. No.	Description of section		Length	Spacing	Location & Colour
1)	All sections of Expressway having horizontal curves	Curve radii upto 1000 m	Curve length including transition with 20 m on either side	9 m	For shoulder and median side edge lines. (Red colour on shoulder side and Amber colour for median side)
2)		Curve radii 1000 m to 2000m		18 m	
3)		Curve radii 2000m to 3000m and critical section		27 m	
4)	All sections of Expressway on vertical grade	Length of highway where vertical gradient is 2% and above and its vertical curves	Length including vertical grade and curves and adjoining 300 m portion on either side	18 m	
5)	All Major/ Minor Bridges, ROBs and all structures (Interchange/ Flyover/VUP)	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 on median side)
6)		Approaches	Approach length including the length of acceleration/ deceleration length if any and 300 m adjoining on either side	18 m	

Sl. No.	Description of section		Length	Spacing	Location & Colour
7	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
8			Chevron/diagonal markings on gorge	6 m	Red Colour for Chevrons/ diagonal markings
9		Continuity line for acceleration/ deceleration lane for entry/ exit of slip	Length of crossable continuity line for lane changing of entry/exit slip roads	8 m	Green Colour for crossable continuity line

10.6 Traffic Impact Attenuators

Traffic Impact Attenuators shall be provided for structural columns of large direction signs, illumination lamp posts, at approaching traffic islands of toll plaza and gore area between diverging roadways. It shall take repeated impacts without any additional recovery procedures and with minimal or no repairs. The attenuators modules shall be moulded from HDPE plastic conforming to the general test acceptance criteria requirement of NCHRP 350 Test Level 3 or EN 1317-3. The space requirement to shield a fixed object should be considered while designing and constructing the attenuators. The design, size, number of modules, etc. of attenuators shall be as per International Standards and location specific duly considering the likely impact. Following general criteria for providing crash attenuators shall be adopted:

a) At 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 locations where the lane changing manoeuvring of vehicles is 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 gore 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 based on severity of the situation shall be indicated in **Schedule–B** of the Concession Agreement. For avoidance of doubt, crash attenuators shall also be provided at other locations as per safety requirement and shall be deemed to be covered in the scope of work.

The work of providing and fixing traffic impact attenuators shall conform to Clause 814 of MORTH Specifications.

Fig. 10.13 shows the area that should be made available for crash attenuators installations.

10.7 Crash Barriers

There are three types of crash barriers viz., rigid (concrete), semi rigid (metal beam -"W" beam and thrie beam type) and flexible (wire rope safety barrier). Crash barriers shall be provided on the roadside and median side as per requirements given hereunder. The specification of various types of crash barriers shall be as per Section 800 of MORTH Specifications unless specified in this Section.

10.7.1 *Roadside safety barriers*

i) **Warrants:** The longitudinal roadside barriers are basically meant to shield two types of roadside hazards i.e. embankments and roadside obstacles and also for preventing the vehicles veering off the sharp curves. Roadside safety barriers shall be provided at the following locations:

   a) On embankments where recoverable slope up to a distance of clear zone applicable for the design speed (refer para 2.17 of this Manual) is not available.

   b) On the retaining/reinforced earth wall abutting the paved/earthen shoulder.

   c) Along all horizontal curves having radii upto 2000 m for complete length of curves including transitions and 20 m further before and after the curve.

   d) In front of roadside obstacles like 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.

ii) Normally on shoulder side, the 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. Wherever a permanent object cannot be removed for some reasons, provision of tandems viz. W-beam metal crash barriers and hazard markers with reflectors must be made. Further, frangible lighting columns and sign posts need to be used for minimizing the severity in case of collision.

iii) Irrespective of type of barrier being used, the slope in front of the crash 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.

10.7.2 *Median barriers*

Warrants: Median barriers shall be provided at the following locations:

a) At the centre of flush type medians;

b) At both ends of bridges, Road Over Bridges and grade separated structures in continuation of crash barriers on structures;

c) To shield fixed objects. If necessary, median barriers shall be flared to encompass a fixed object, which may be a light post, foundation of overhead signs, bridge pier etc.;

d) In the depressed medians having width less than 15 m.

10.7.3 *Crash barrier acceptance standards*

The barrier shall be capable of restraining a vehicle from:

i) a) Penetrating, vaulting over or wedging under the installation;

b) Unless otherwise designed, the barrier must also remain intact so that detached elements and debris will not create hazards for vehicle occupants or other traffic;

c) System must be designed and installed so that spearing does not occur,

ii) The vehicle/barrier collision should result in smooth redirection of the vehicle at an angle so that the vehicle will not create hazard to trailing or oncoming vehicles;

iii) The collision must not result in excessive damage to the vehicle occupants.

iv) On main line expressway; places affecting other railway, important highway and important utility lines and places; adjacent to water bodies the crash barrier shall comply with test level TL-3, TL-4 and TL-5 performance in accordance with NCHRP Report 350, or containment Levels N1, N2, H1 and H2 as per EN 1317-2.

v) For all other places such as interchange ramps, connection to local roads, protection of bridge piers on median and road side, etc., the crash barrier shall comply with at least Test Level TL-2 in accordance with NCHRP Report 350 or containment level N1, N2 as per EN 1317-2.

10.7.4 *Concrete barriers*

a) **Design Aspects**: New Jersey type concrete barriers should be used on flush type median, top of RCC/RE retaining walls abutting the paved/ earthen shoulder and at other locations wherever used. The crash barrier on retaining/RE walls shall conform to the requirements specified for structures in Section–6 of this Manual. The road side/median 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 overlay on the road pavement is anticipated, the foundation step may be increased to 125 mm. However, concrete barrier should have elaborate footing design which is structurally safe unless sufficient earth support is available. **Fig. 10.14** gives typical details of concrete crash barriers.

Suggested flare rates depending upon the design speed are given in **Table 10.5**.

Table 10.5 Flare Rates of Rigid Barriers

Design Speed in km per hour	Flare Rates
120	20:1
100	17:1

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 median barrier within a length of 8 m to 9 m.

10.7.5 *Metal beam crash barriers*

a) **Design aspects:** The metal beam crash barrier shall be of "Thrie" beam type consisting of steel posts and a 3 mm thick "Thrie" 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. 10.15** gives the typical details of "Thrie" beam rail and splices and shall be procured and installed from a reputed manufacturer.

The Thrie beam, posts spacers and fasteners for steel barriers shall be galvanized by hot dip process. Installations of metal beam crash barrier

shall be as per Section 800 of MORTH Specifications. For any structural element and detail not available in this Manual, the details from international guidelines/manuals on Thrie beam which should conform to EN 1317 Part-2 can be adopted.

b) **End treatment**: End treatment shall be such that it does not spear, vault or roll a vehicle for head on or angled impacts. The end treatment shall be as per manufacturer's system and satisfying the test standards as per EN1317-4 or NCHRP 350.

c) **Transition:** The Thrie beam to concrete crash barrier transition shall be carried out by decreasing the post spacing, nesting one rail behind another and using steel section behind the Thrie Beam. The transition between Thrie beam and concrete barrier is detailed in **Fig. 10.16.**

10.7.6 *Wire rope safety barrier*

a) **Design aspects:** The wire rope crash barrier may be of High tension 3-rope or 4-rope wire rope system conforming to the requirements specified in para 10.7.3. The wire rope barrier shall be procured from a reputed manufacturer who shall demonstrate that the product conforms to the relevant standards of acceptance. Typical details of wire rope barrier are given in **Fig. 10.17** and wire rope barrier with ropes interwoven are also presented in **Fig. 10.18**.

b) **End treatment**: The end treatment shall be as per the manufacturer's details conforming to EN 1317 Part 2. The Wire rope to Thrie beam transition is shown in **Fig. 10.19**.The wire rope shall not be provided in conjunction with a rigid or concrete barrier or a parapet. There shall be a transition from wire rope to Thrie beam in-turn to concrete barrier as shown in **Fig. 10.20.**

c) The Wire Rope Safety Barrier shall not be permitted in following situations:

- In the flush type median
- Where a hazard is present within the deflection area of the fence.
- Where total fence length is less than 50 m
- On a horizontal curve of radius 450 m or less.
- On vertical sag curve of radius less than 3 km.
- Where rate of change in setback is steeper than 1 in 10.

10.7.7 *Placement*

The barriers shall be as far away from the traffic as possible and shall preferably have uniform clearance between the traffic and the hazard. The barrier shall have minimum horizontal clearance of 0.250 m from paved surface and 3.0 m from the edge of the travelled way. 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. In case of embankments, a minimum distance of

1000 mm shall be maintained between the barrier and the start of embankment slope or a hazard, unless the crash barrier is attached structurally with structures like retaining walls.

The crash barrier shall be placed in such a way so as to be collided by vehicle directly.

When Wire Rope Safety Barrier is provided in front of a hazard, it shall be so located that it caters to the deflection specified by the manufacturer. 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 wire rope fence shall be 50 m.

10.8 Road Boundary Stones (RBS)

Road boundary stones shall be provided at the boundary on both sides of the Right of Way. These shall be spaced at 100 m intervals. The boundary stones shall be of cement concrete as per Type Design given in IRC:25. The boundary stones shall be painted with cement primer and enamel paint and marked 'RBS' by paint.

10.9 Kilometre and Hectometre Stones

i) The kilometre stones shall be provided at each kilometre on both sides of the Expressway. The design and specification of kilometre stones shall conform to IRC:8. The matter to be written on various kilometre stones and the pattern thereof shall be as specified in IRC:8.

ii) Hectometre (100 m) stones shall be provided at every 100 m distance on both sides of the Expressway. The design and specification of 100 m stones shall conform to 200 m stones of IRC:26. The matter to be written on the 100 m stones shall be as specified in IRC:26

iii) The kilometre and hectometre stones shall be fixed at the edge of the earthen shoulders.

10.10 Fencing

Fencing shall be provided on entire length on either side of the Expressway to prevent entry of pedestrians, animals and vehicles, leaving space for utilities,. The fencing shall be 2.5 m high above ground level and shall comprise of mild steel sections and welded steel wire mesh up to full height, firmly welded with steel section. The fencing posts shall be embedded in concrete of minimum M15 grade and shall be designed to take care of wind forces and other loads likely to occur. All exposed metal surfaces shall be painted with anticorrosive paint.

10.11 Glare Reduction

i) Glare reduction devices shall be installed at the following locations for reducing the headlight glare of opposing traffic at night, which may distract from driving tasks:

a) over the crash barriers in the flush type median

b) In the depressed median of width less than 9 m,

c) On bridges and overpass sections, and

d) On horizontal curves.

Antiglare devices shall be placed at 4 to 6 m spacing.

ii) Installation of glare reduction devices can be omitted in the sections with the following characteristics:

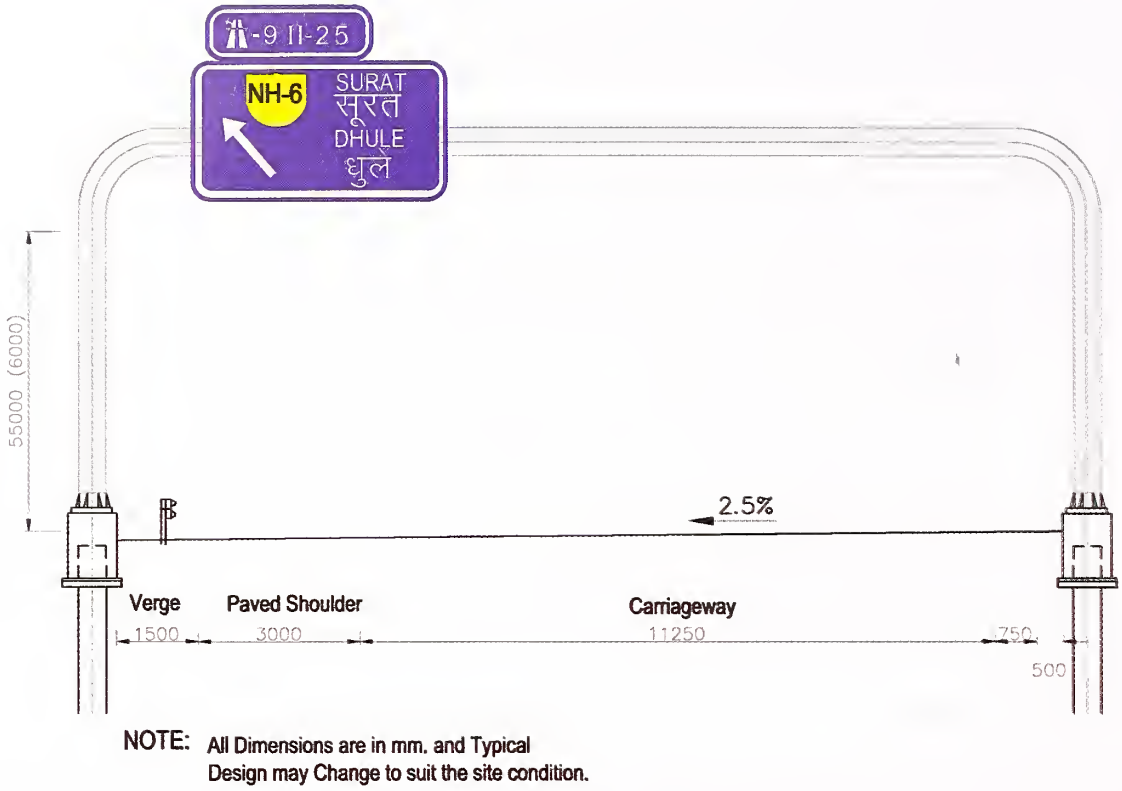
a) The median strip has a width of 9 m or larger.

b) The difference in the elevation of centreline in opposing directions is 2 m or greater.

c) Lighting devices are installed continuously, which regulate use of head lights on high beam.

10.12 Design Report

The Concessionaire shall submit the proposals for traffic control devices, road safety devices and road side furniture together with drawings and details to the Independent Engineer for review and comments, if any. The proposals shall include type, location, material specifications, test reports, installation details and the requisite warranties for satisfactory field performance (as applicable).



NOTE: All Dimensions are in mm. and Typical Design may Change to suit the site condition.

Fig. 10.1A Typical Overhead Mounted Structure

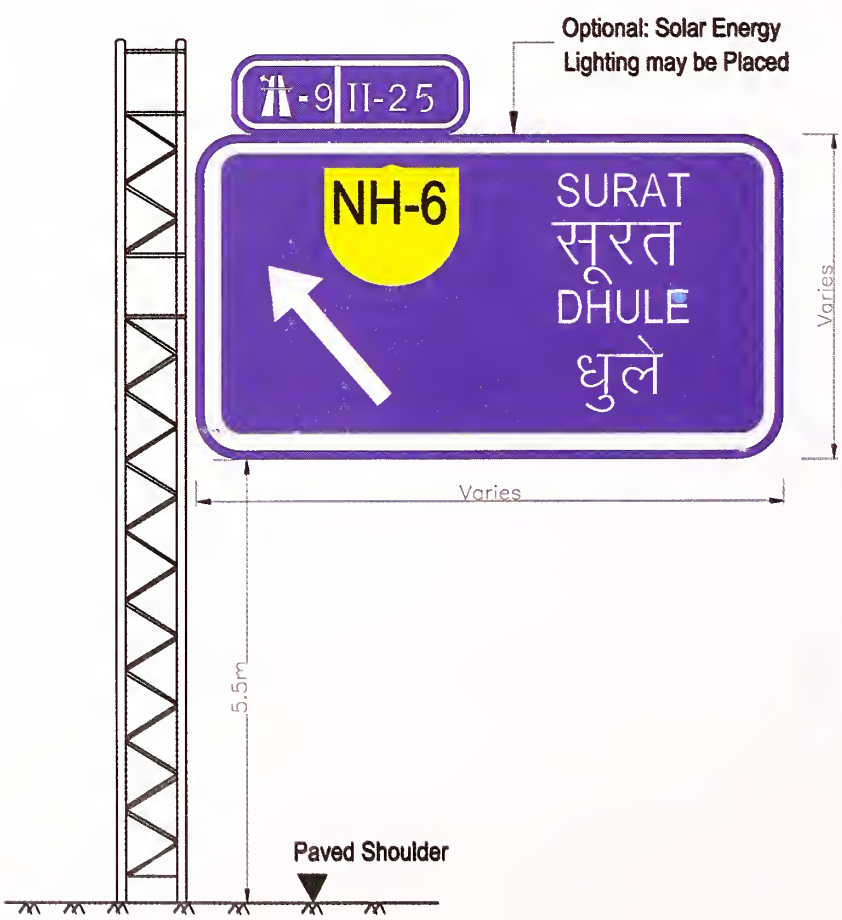


Fig. 10.1B Typical Exit Gore Sign

Fig. 10.2 Expressway Symbol Sign

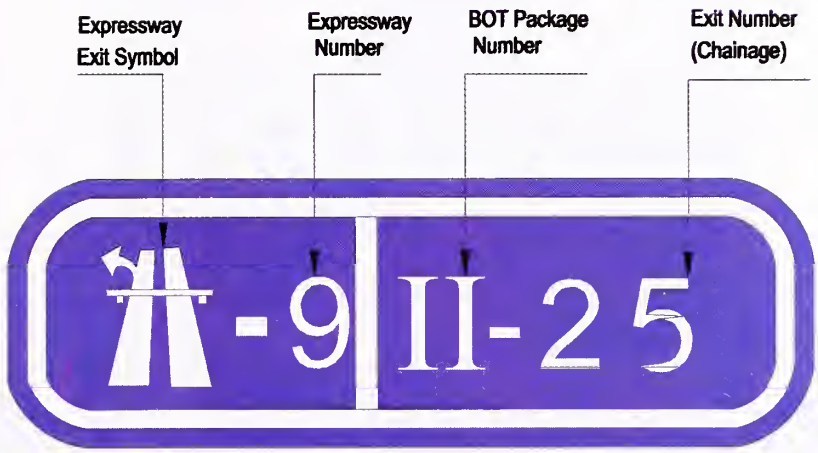


Fig. 10.3 Typical Exit km – Numbering Sign

Fig. 10.4 Typical Interchange Advance Guide Sign

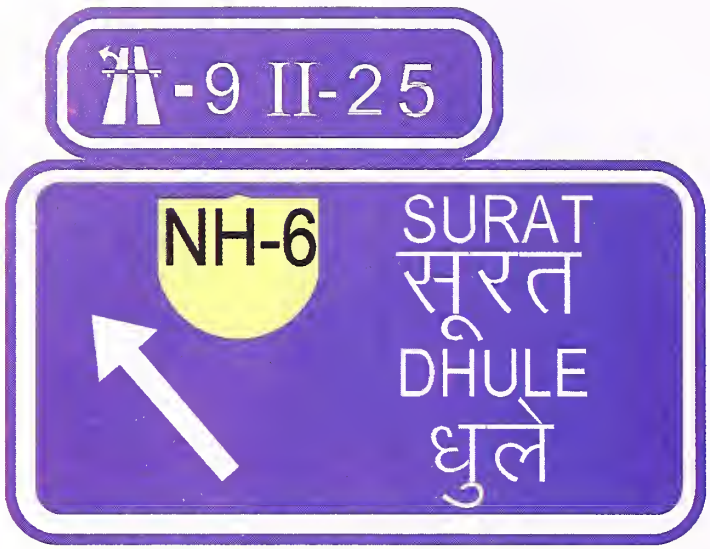


Fig. 10.5 Typical Exit Direction Sign

Fig. 10.6 Typical Exit Gore Sign

Fig. 10.7 Next Supplemental Sign

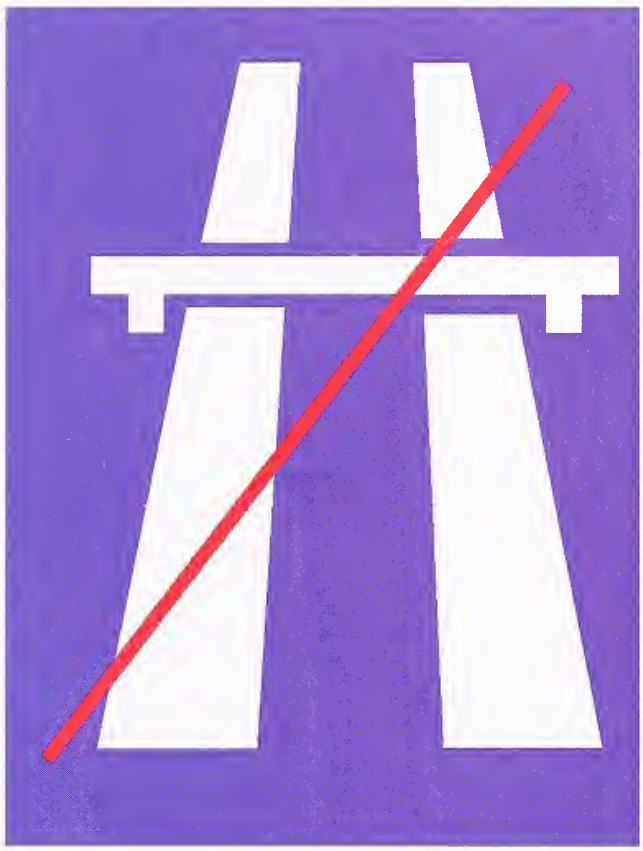


Fig. 10.8 End of Expressway Sign

Fig. 10.9 Typical Distance Sign (Reassurance Sign)

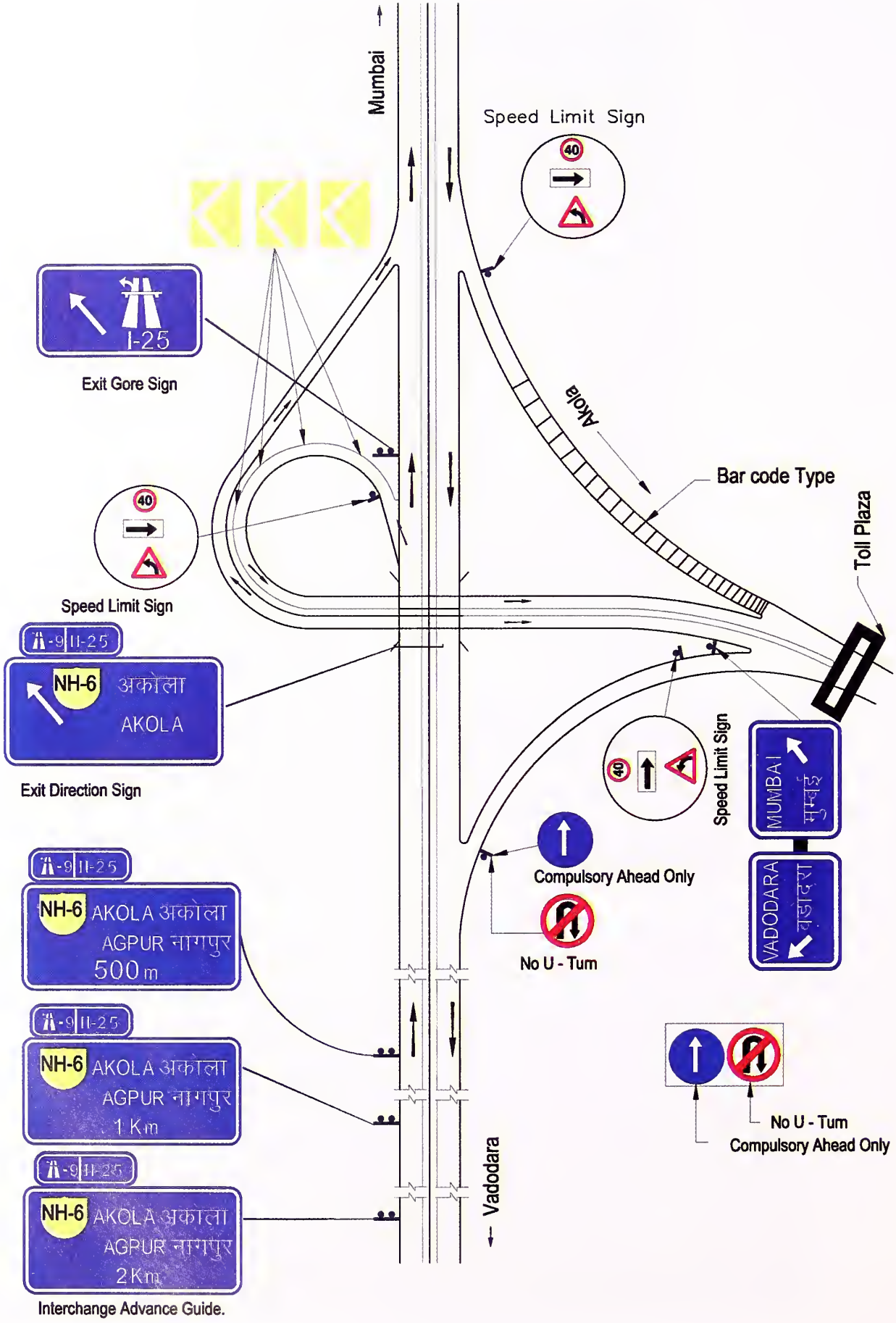


Fig 10.10 Signing Plan for Trumpet Interchange

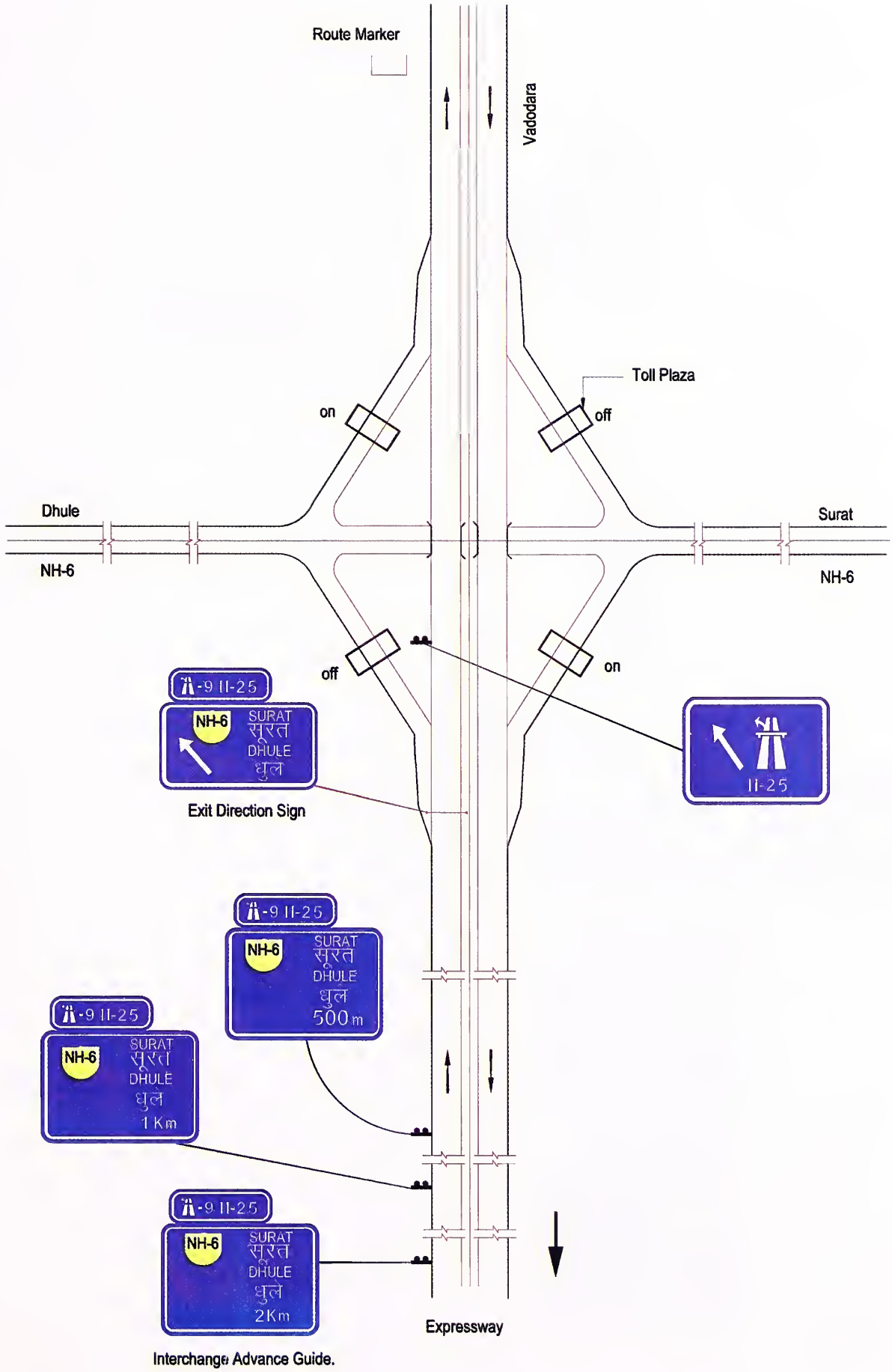


Fig. 10.11 Typical Layout of Diamond Interchange Sign

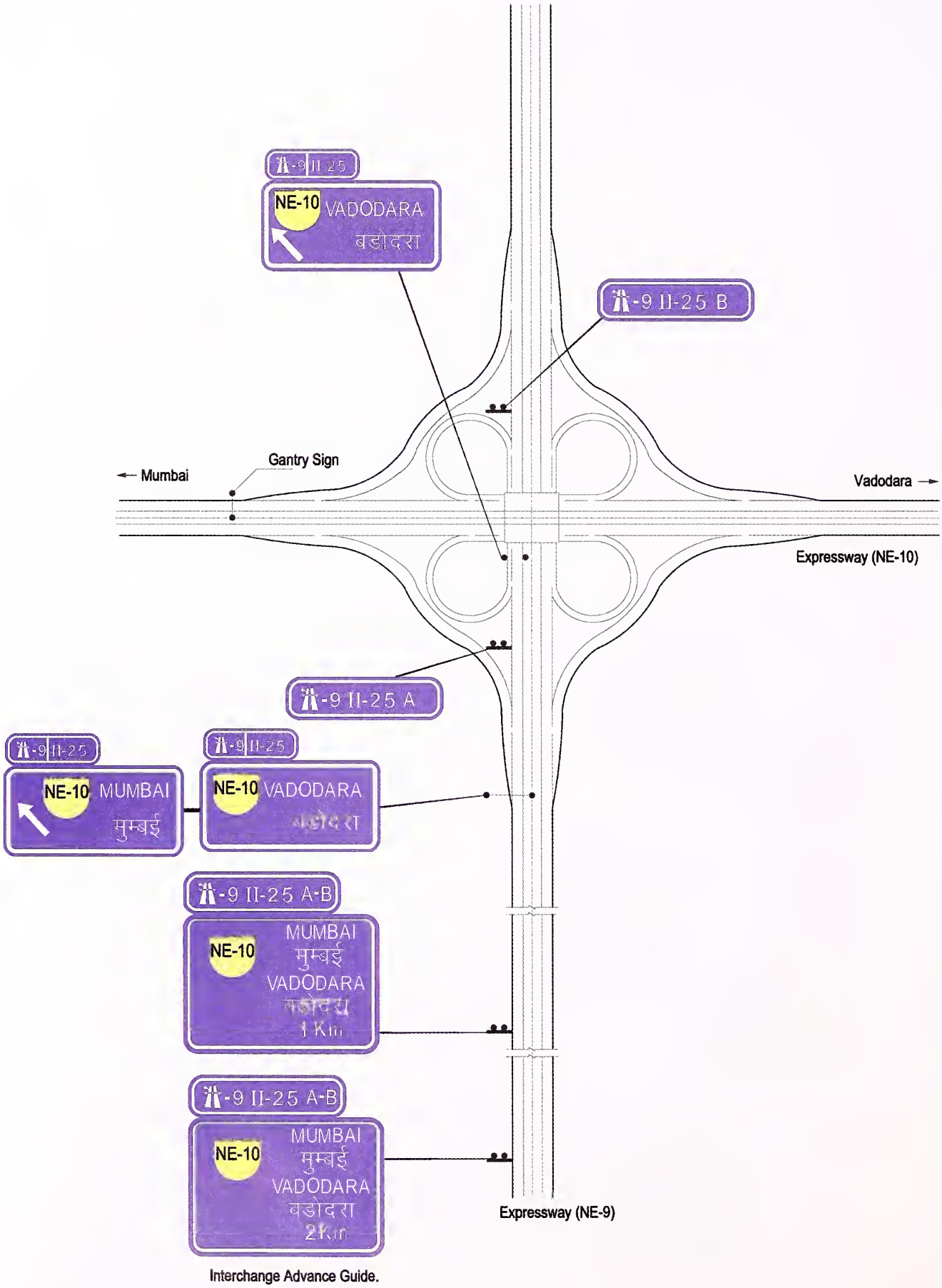


Fig. 10.12 Typical Layout for Full Cloverleaf Interchange Sign

Minimum Space Recquired For Crash Attenuators i.e. Reserve Area (In meter									
Speed of Main Highway (kmph)	Minimum Space						Preferred Space		
	Restricted Conditions			Unrestricted Conditions					
	N	L	F	N	L	F	N	L	F
50	2	2.5	0.5	2.5	3.5	1	3.5	5	1.5
80	2	5	0.5	2.5	7.5	1	3.5	10	1.5
100	2	8.5	0.5	2.5	3.5	1	3.5	17	1.5
120	2	11	0.5	2.5	17	1	3.5	21	1.5

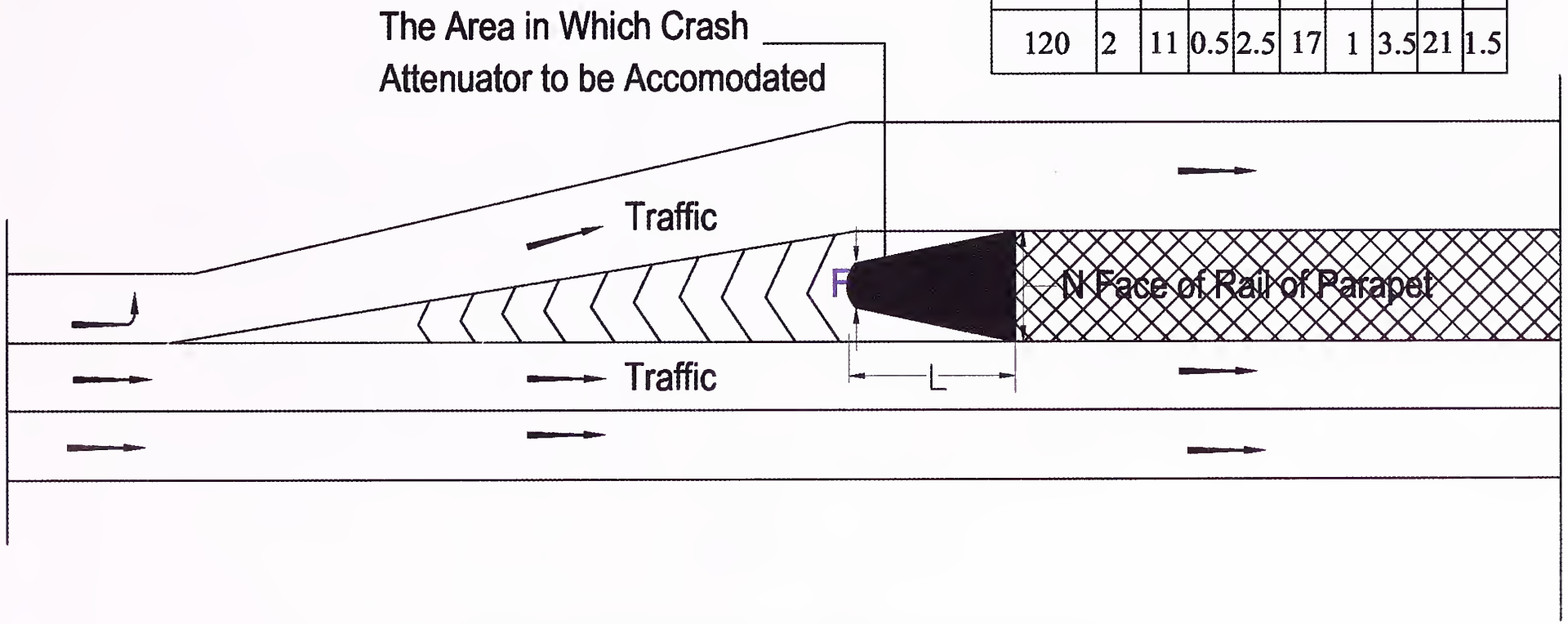


Fig. 10.13 Space Required to Place Crash Attenuators

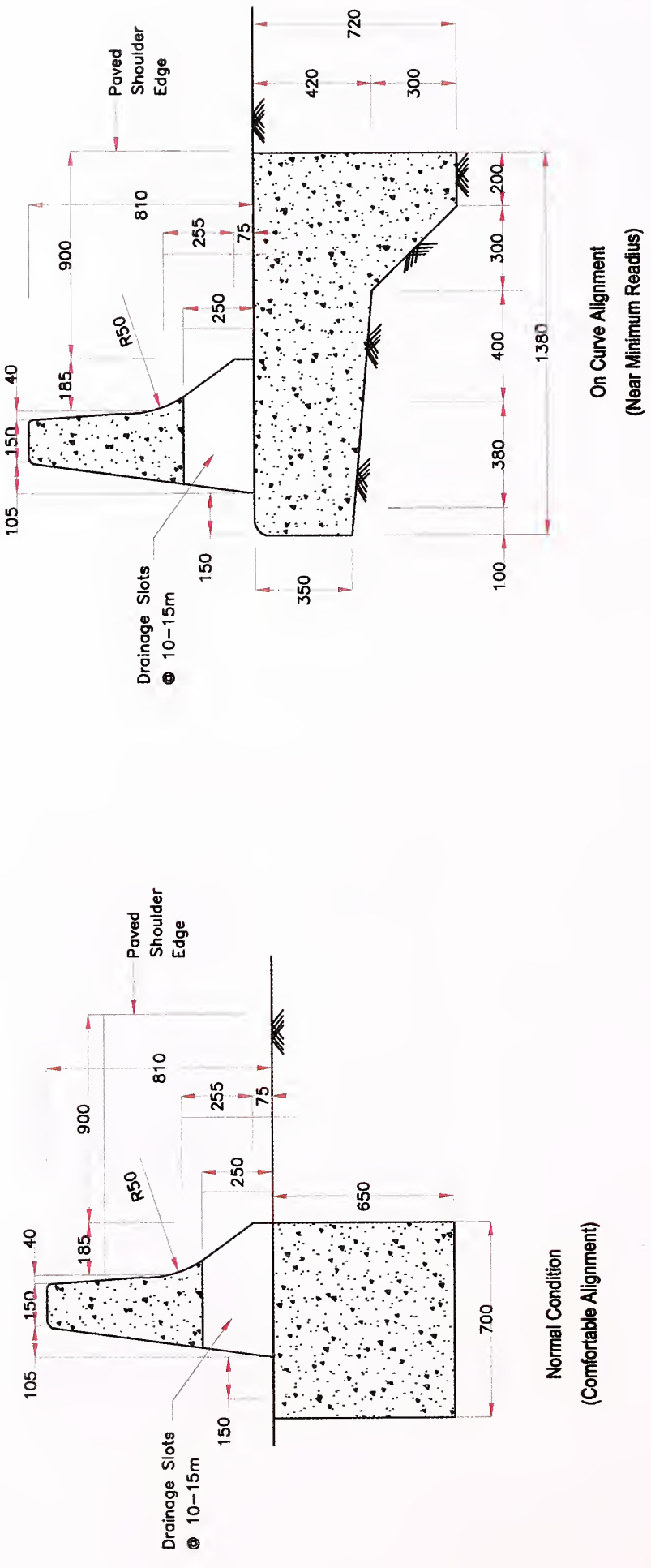
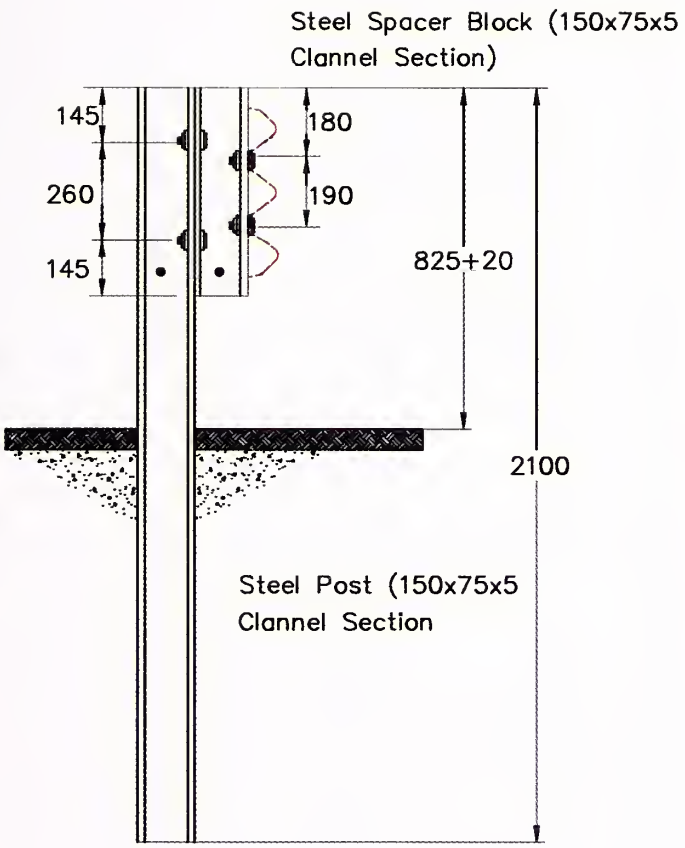
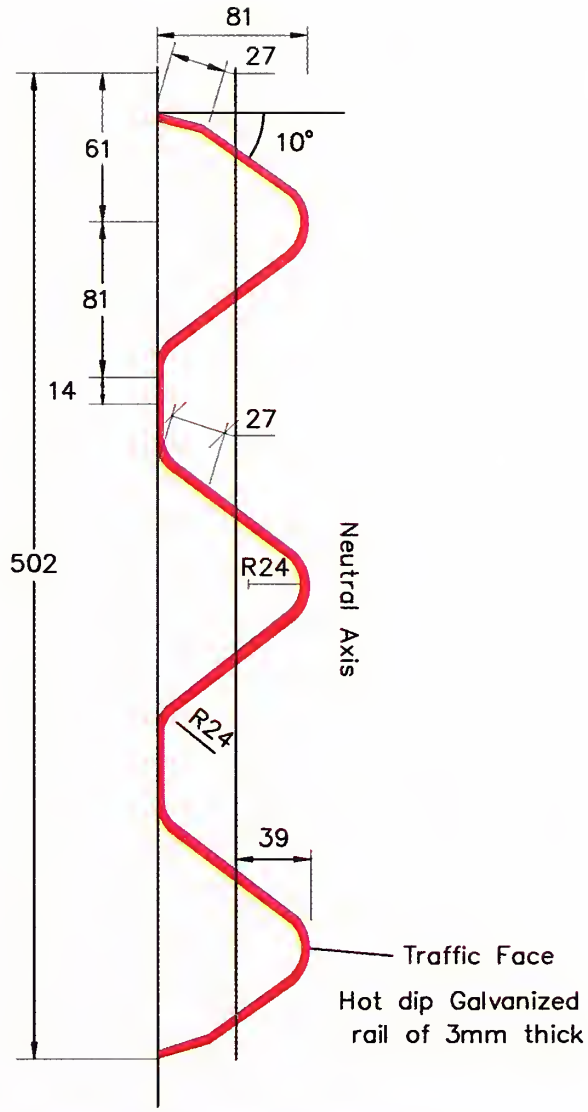


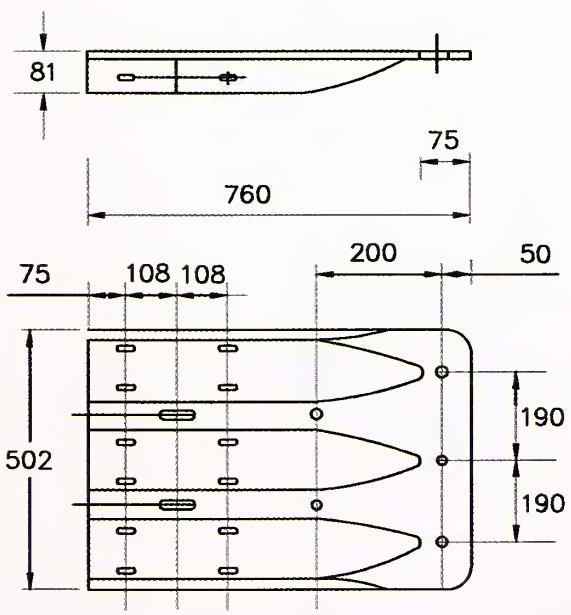
Fig. 10.14 Typical Road Side Concrete Barrier



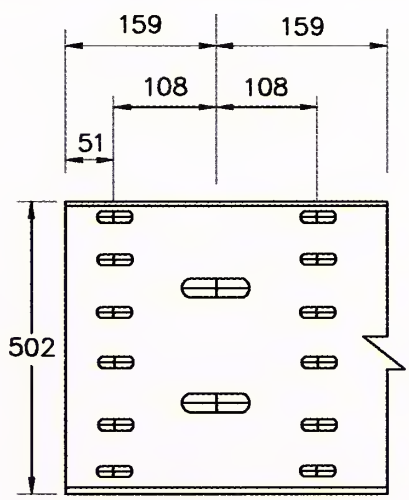
Detail Of Thrie Beam Barrier



Section Through Thrie Beam Rail Element



Thrie Beam Terminal Connector



Rail Splice

NOTE: All Dimensions are in milimeter(mm)

Fig. 10.15 Typical Details of Thrie Beam Structural Elements

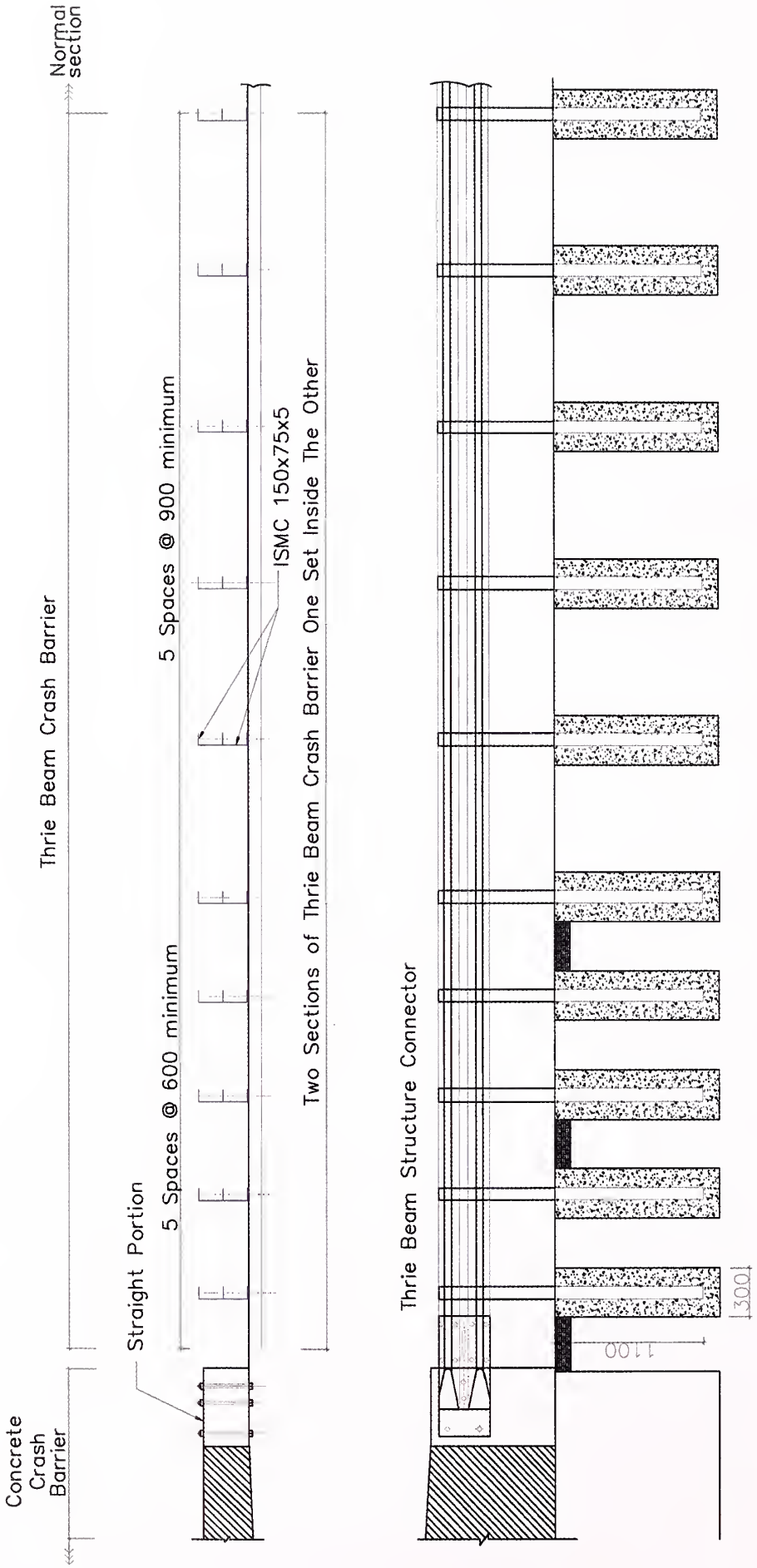


Fig. 10.16 Thrie Beam to Concrete Barrier Connection Details

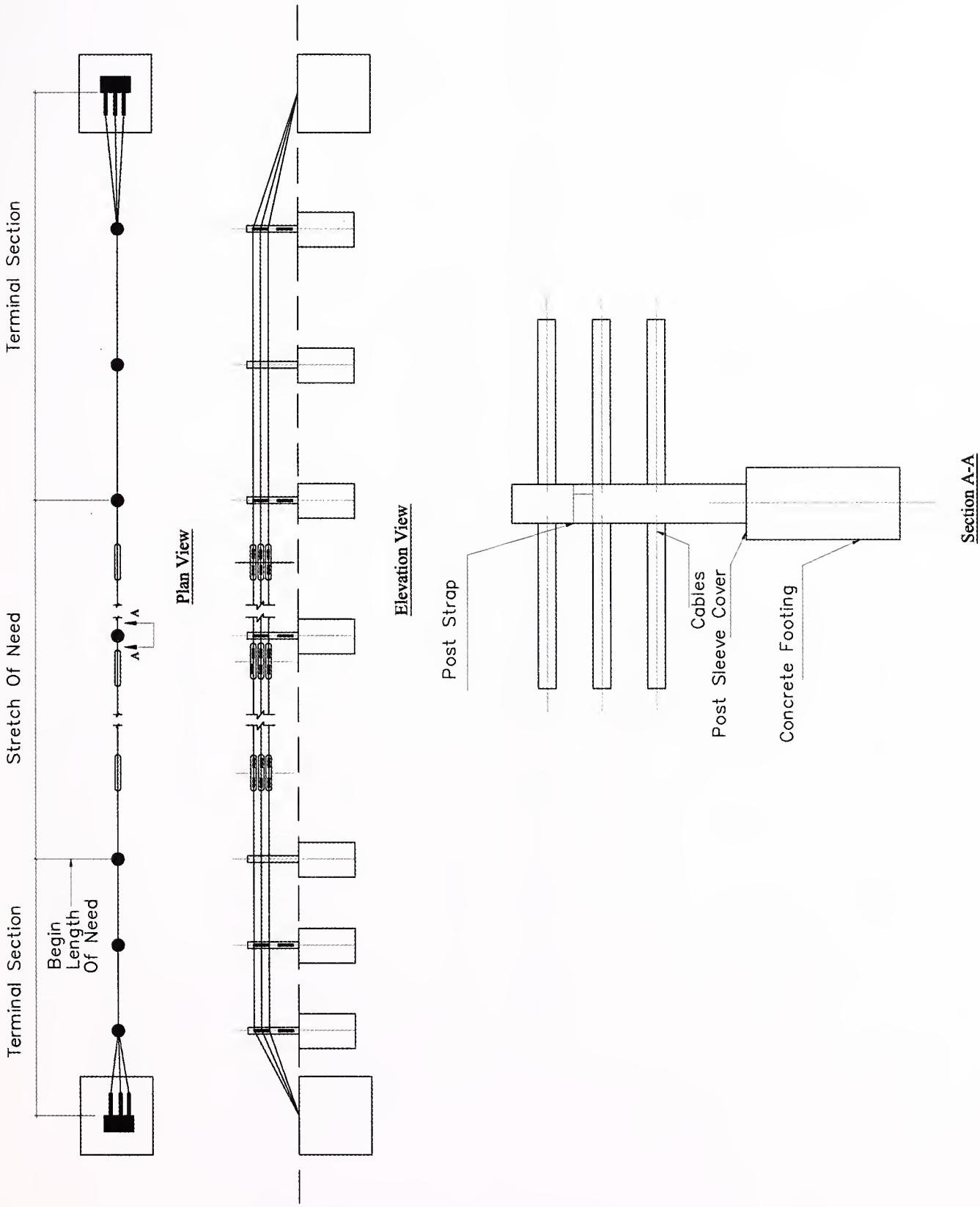


Fig. 10.17 Typical Details of Wire Rope Safety Barrier

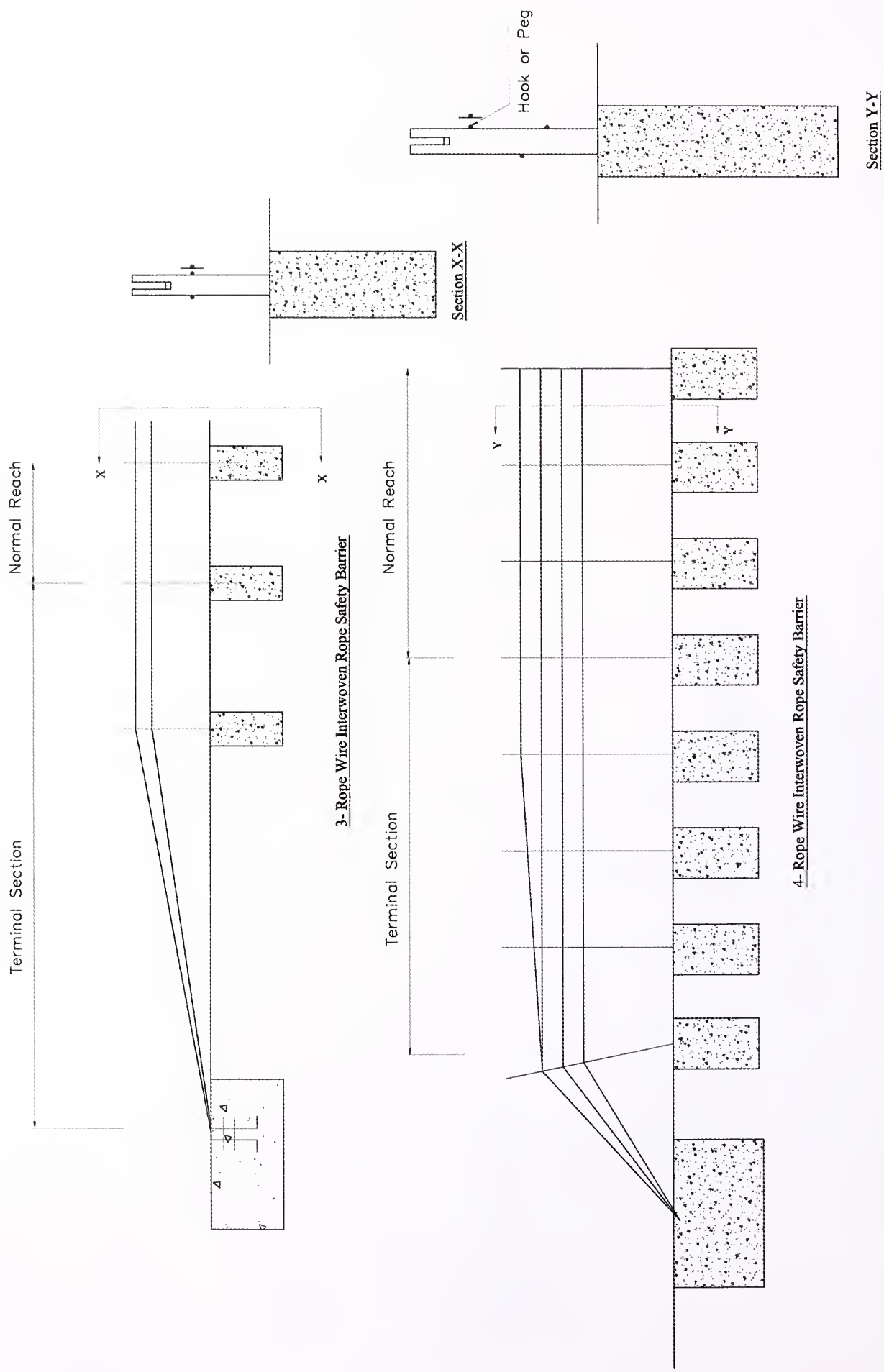


Fig. 10.18 Typical Details of Wire Rope (Interwoven) Safety Barrier

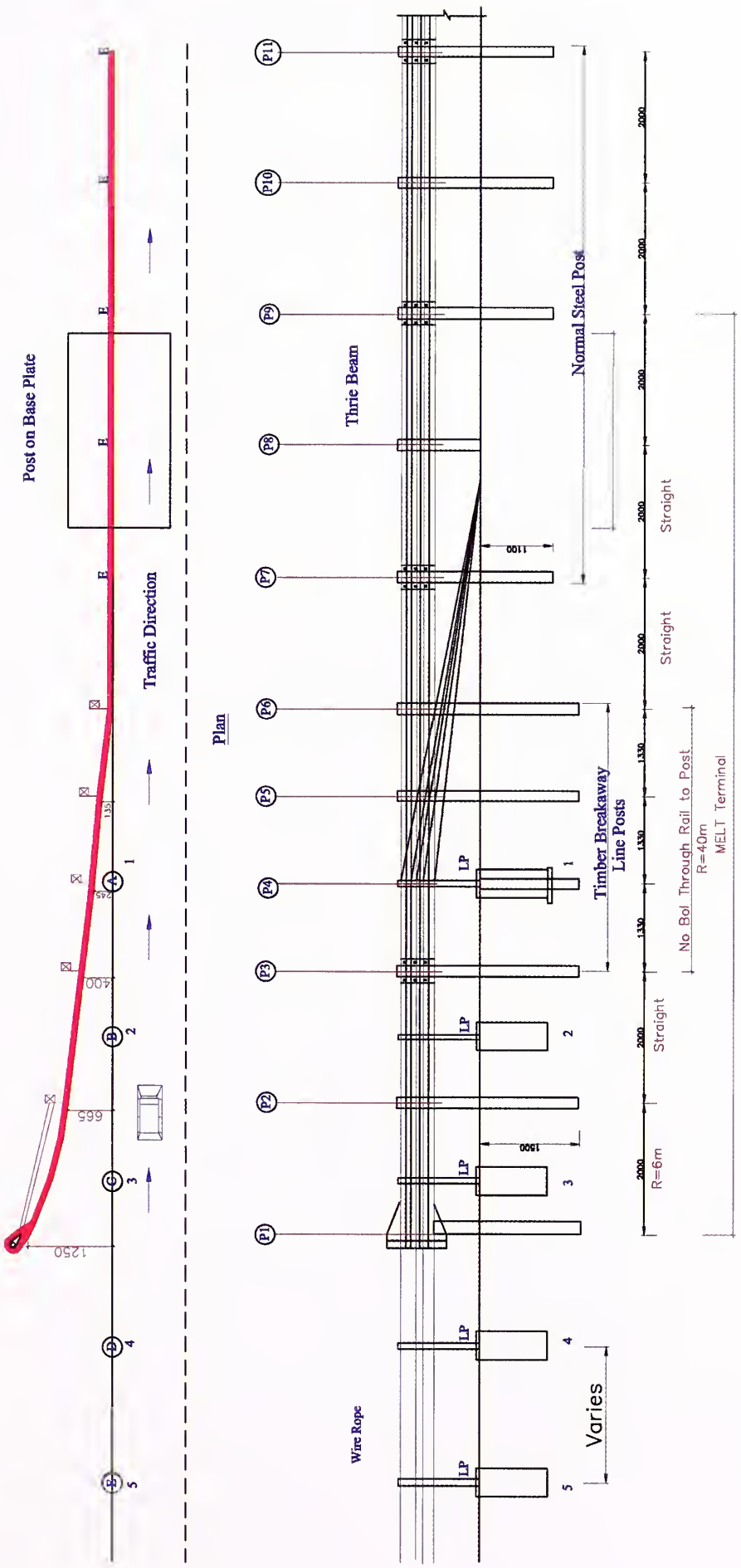


Fig. 10.19 Typical Details of Wire Rope to Thrie Beam Barrier

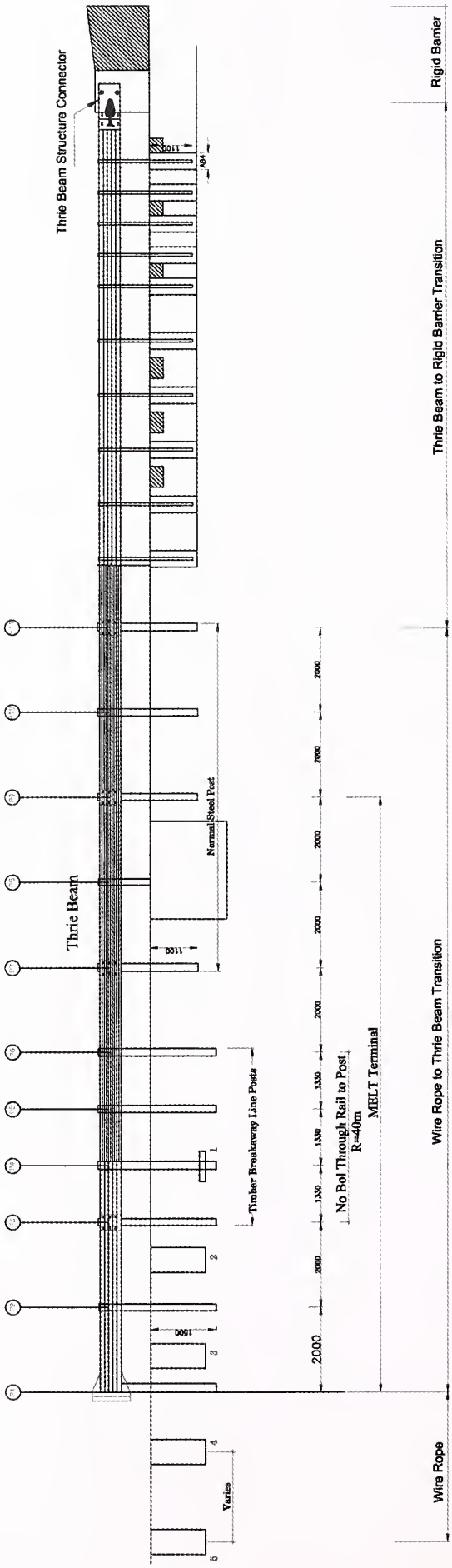


Fig. 10.20 Typical Details on Wire Rope to Rigid Barrier

SECTION – 11
TRAFFIC MANAGEMENT SYSTEMS

11.1 General

Advance Traffic Management Systems (ATMS) shall be provided as per Clause 816 of MORTH Specifications for road and bridge works.

ATMS shall have the following sub-systems.

i) Emergency Call Boxes

ii) Mobile Communication System

iii) Variable Message Signs System

iv) Metereological Data System

v) Automatic Traffic Counter and Vehicle Classification

vi) Video Surveillance System

vii) Video Incident Detection System (VIDS)

Locations of each component of Advanced Traffic Management System shall be as specified in **Schedule–B** of the Concession Agreement.

SECTION – 12
TOLL PLAZAS

12.1 General

The Concessionaire shall provide the Toll Plaza(s) for collection of toll/fee as per the Concession Agreement. The fee collection system shall be electronic toll collection (ETC) system, unless specified otherwise in **Schedule-C** of the Concession Agreement. The design of the Toll Plaza(s) should be aesthetically pleasing. The fee collection staff where it becomes necessary to collect toll fee through cash or smart card should be efficient, courteous and adequately trained before deployment.

12.2 Location of Toll Plaza

The Toll Plaza shall be located at every entry/exit ramp onto/from the Project Expressway. A typical location of a toll plaza, a toll office, and a maintenance office is given in **Fig. 12.1**.

12.3 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 25 years or the concession period whichever is more 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.

12.4 Layout and Design of Toll Plaza

12.4.1 *ETC system*

i) The Concessionaire shall provide the electronic toll collection (ETC) system with a minimum of two toll lanes in each direction for collection of toll/fee through cash or smart card as a back-up; unless specified otherwise in **Schedule-C** of the Concession Agreement. The ETC system shall comprise of self adhesive tag on the wind shield of vehicle getting read by trans receivers at the toll plaza gantry.

ii) The following facilities shall be provided:

a) Antenna system shall be employed on the gantry as the roadside equipment

b) CC TV Cameras shall be installed for enforcement and checking vehicle lincence plates.

12.4.2 *Combination of cash, smart card and ETC system*

Where **Schedule-C** of the Concession Agreement specifies collection of toll/fee through a combination of cash, smart card and ETC system, the Toll Plaza shall comprise of following elements:-

i) **Toll collection sites** – These shall predominantly provide a minimum of three lanes for electronic toll collection (ETC) initially and remaining required number of lanes for collection through a combination of cash and smart card.

ii) **Toll islands** – an elevated platform, typically made of concrete, which provides crash protection devices on the traffic approach side of the toll plaza for toll booths and violation cameras and other equipment.

iii) **Toll 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 the visibility and traffic movement. The canopy shall also provide mounting for signage and ETC equipment, utility access to the toll booths and ETC lanes.

iv) Pavement.

v) Service Area

vi) Administration Block

Fig. 12.2 presents Schematic Arrangement of Services facilities at toll plaza.

Fig. 12.3 and **Fig. 12.4** present Typical Layout of Toll Plaza.

12.4.3 *Layout*

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.

12.4.4 *Width of toll lane*

The width of each ETC toll lane shall be 3.5 m, except for manual/smart card lanes, where it shall be 3.2 m, and the lane width for over dimensioned vehicles, where it shall be 4.5 m.

12.4.5 *Toll islands at the toll plaza*

Between each toll lanes of the toll plaza meant for collection through manual/smart card, toll islands are required to accommodate toll booth. These islands shall be of minimum 25 m length and 1.8 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 shall be painted with reflective chevron markings.

12.4.6 *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. 12.5**.

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 window should be placed at such a height (0.9 m) above ground level 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.

12.4.7 *Tunnel/Overbridge*

For the movement between toll office and toll booths of lane, an underground tunnel/overbridge across all toll lanes shall be provided. Its dimension should 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.

12.4.8 *Number of lanes at toll plaza*

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

i) Semi Automatic toll lane (Manual money transaction) 240 v/h

ii) Smart card lane 360 v/h

iii) ETC lane 1200 v/h

Not less than 2 middle toll lanes shall be capable of being used as reversible lanes to meet the demand of tidal flow. One additional lane on either side shall be provided for over dimensioned vehicles.

Toll plazas shall be designed for projected peak hour traffic of 25 years or the Concession Period whichever is more. Stage construction of toll plaza in respect of number of toll lanes shall be allowed provided the design caters for a minimum period of 15 years. 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 and/or system of collection improved so that the maximum waiting time is brought down to less than three minutes.

At entry and exit of the toll booths, the rate of taper for transition length for the carriageway of expressway and ramp carriageway shall be 1:25 and 1:15 respectively.

12.4.9 *Removable barrier*

Removable type barriers shall be provided for emergency or maintenance area cross over and to accommodate reversible toll lanes.

12.4.10 *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.

12.4.11 *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.

12.4.12 *Equipment for toll lanes*

Toll collection system shall comprise of the following equipment/systems;

i) Automatic Vehicle Counter cum Classifier
ii) Automatic Boom Barrier
iii) Contactless Smart Card Systems
iv) Ticket Printer
v) User Fare Display unit
vi) Close Circuit Television System (CCTV)
vii) Lane Controller
viii) Traffic Light System
ix) Intercom System
x) Over Head Lane Signs
xi) Integrated Toll Management Software

All equipment shall have built-in or external surge protection system.

12.4.13 *Prevention of overloading*

Toll plaza location shall also be provided with system for checking and preventing overloading of vehicles at toll plaza. WIM should be installed at least 500 m ahead of Toll Plaza. Vehicles found to be overloaded shall not be allowed to use the Expressway.

12.4.14 *Pavement*

Concrete pavement shall be provided in the Toll Plaza area including tapering zone, from durability and longtime serviceability consideration. The rigid pavement shall be designed as per IRC:58.

12.4.15 *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 such signs for toll plaza as are not given in IRC:67 and furnish to the Independent Engineer 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 Expressway, 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 two km ahead with repeaters sign 1 km and 500 m ahead. 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.

Appropriate Signs and Signals shall also be provided on the canopy of toll plaza to properly guide the approaching vehicles about the lane in operation, lane applicable to specific category of vehicle, lane with Electronic Toll System, reversible lane, etc. **Fig. 12.6** presents details of Traffic Signs and Road Markings in Toll Plaza

12.4.16 *Road markings*

The road markings shall be used in accordance with Section–10 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.

In order to control overspeeding of the vehicle approaching toll booth, transverse bar markings, as per typical details given in **Fig 12.7** shall be provided.

12.4.17 *Lighting*

The toll plaza shall have lighting system to provide visibility to drivers for the use of facility especially to access the correct service lane and also to the toll collector. Indian Standard 'Code of Practice for Lighting of Public Thoroughfare' IS:1944 shall be followed. This would be done by interior and exterior lighting as indicated below. Power supply shall be from public power supply system, but standby generating set of the capacity to supply the required power shall be provided at toll plaza.

i) **Interior Lighting**: The toll booths and facility building office shall be illuminated adequately. Indoor lighting shall be with fluorescent lamps. Lighting should be provided in such a manner that glare is avoided or minimised. The level of illumination shall be 200 to 300 Lux as per IS:3646 part II.

ii) **Exterior Lighting**: Lighting of the Toll Plaza is important for enhancing the night visibility.

The lighting system shall consist of the following major components.

a) High Mast lighting

b) Lighting on both side approaches to the Toll Plaza

c) Canopy lighting of the Toll Plaza complex

iii) **High Mast Lighting**: Normal low light poles are not able to give the required lighting conditions. It is, therefore, necessary to install high mast. A height of 30 m for the mast is considered suitable to have uniform spread of desired level of illumination in the Toll Plaza area for safe movement of vehicles.

iv) **Highway Lighting**: A minimum requirement of illumination on the road surface of 40 Lux shall be ensured. Lighting in minimum 500 m length on either side approaches of toll plaza shall be provided to enhance the safety at night on the Project Expressway and to make the drivers conscious of their approaching the toll gate. These shall be provided on the mild steel welded tubular pole of 10 m height from road surface and with 2 m overhang.

Sodium Vapour lamp of 200-250 watts should be provided for these poles on both sides at 50 m staggered spacing. There should be provision for flashing signals for foggy weather conditions.

v) **Canopy Lighting**: A higher level of illumination up to 100 Lux by providing 150 watt metal halide lamps shall be provided at the toll gate and at toll booth locations. Halogen lamps 1000watt shall be provided at the selected nodes of space frame of the canopy to ensure uniform illumination of the area.

12.4.18 *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.

12.4.19 *Fire fighting system*

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

12.4.20 *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 Expressway.

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 of future expansion.

12.4.21 *U-Turn ramp*

U-turn ramp shall be installed near the toll plaza for vehicles operated by Operations Management personnel for safe operations as indicated **Fig. 12.2**.

12.5 Toll System

"Closed system of toll collection" shall be adopted. Closed System of tolling means that payment need to be made only at the exit by either charging the same to the On-Board Unit on the wind-screen of the vehicle passing through the ETC lane or depositing the ticket collected at the entry.

A closed toll system has an entrance and exit booth for the toll system and captures all users and revenue of the system. Toll plazas are located at every interchange preventing diversion around main lane toll plazas. Upon entering the toll system, the On-Board Unit on the vehicle of the user is read. In case of manual/smart card collection system, the user receives a ticket. When exiting, the user gives the ticket to the toll collector and is charged a set fee as per policy decision and notification. In case of ETC system, the tag on that vehicle of the user is charged accordingly.

12.6 Report to be submitted

The design and layout of Toll Plaza complex including all facilities shall be submitted to the Independent Engineer for review and comments, if any.

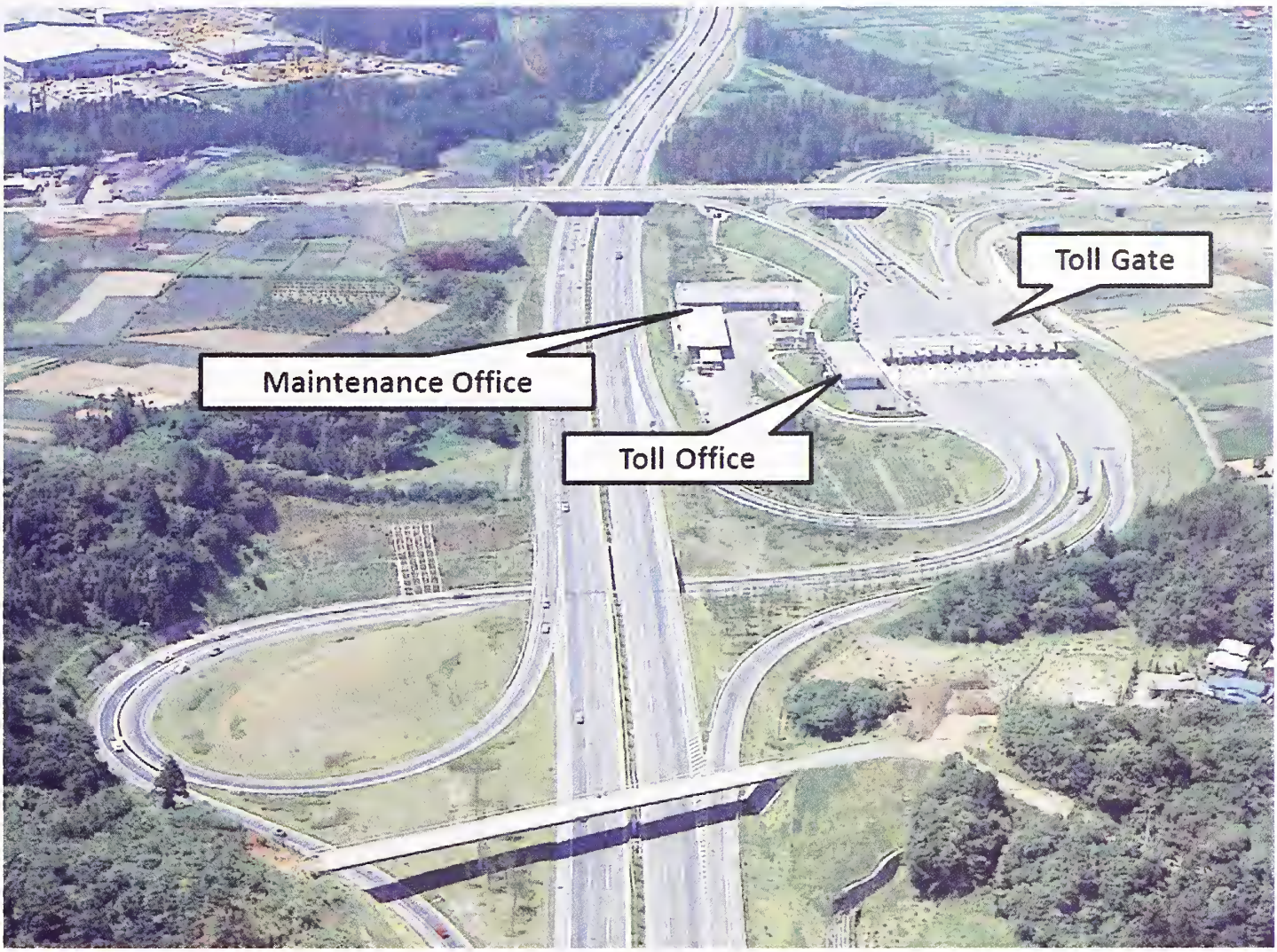


Fig. 12.1 Typical Location of Toll plaza, Toll Office, and Maintenance Office at Trumpet-type Interchange

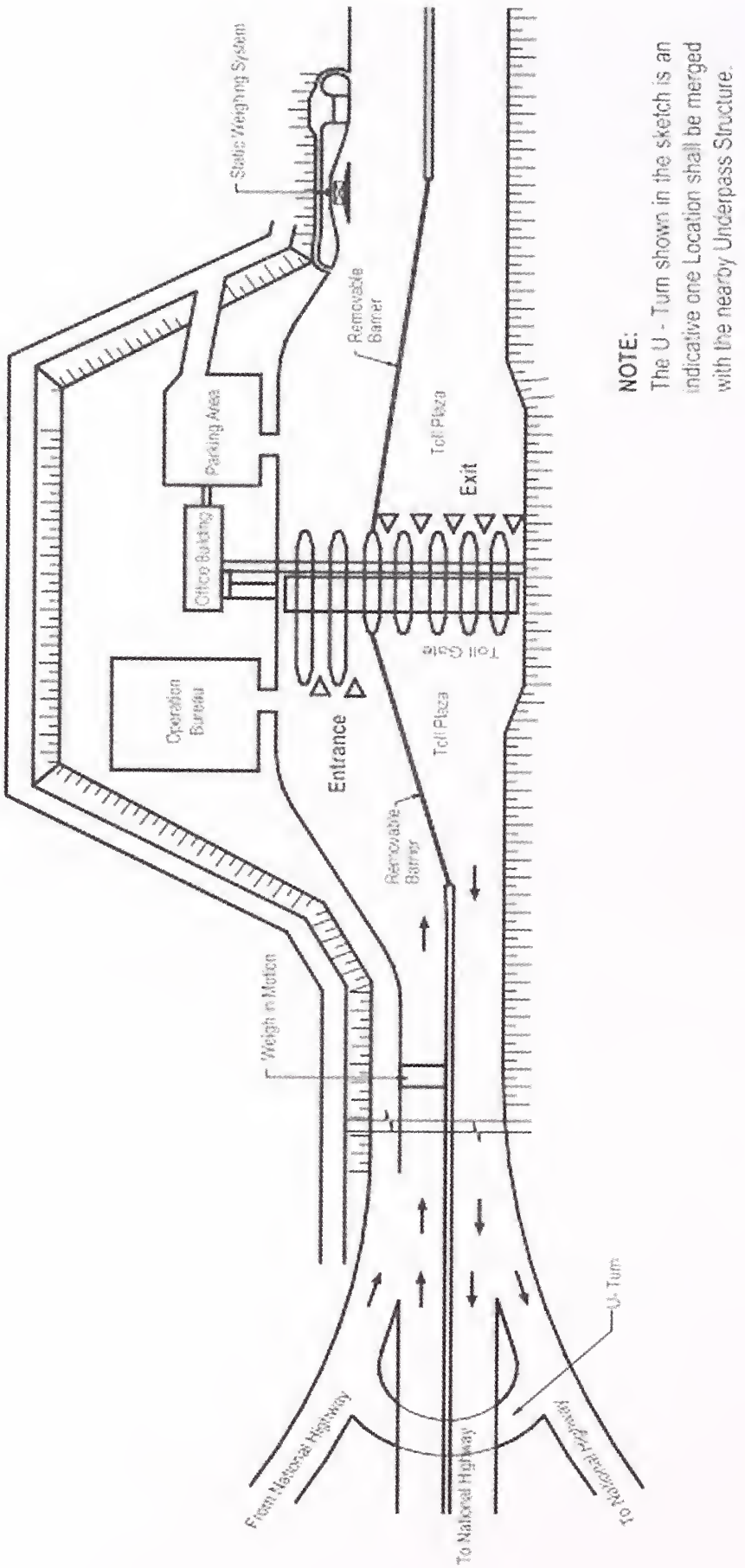


Fig. 12.2 Schematic Arrangement: Service Facilities at Toll Plaza

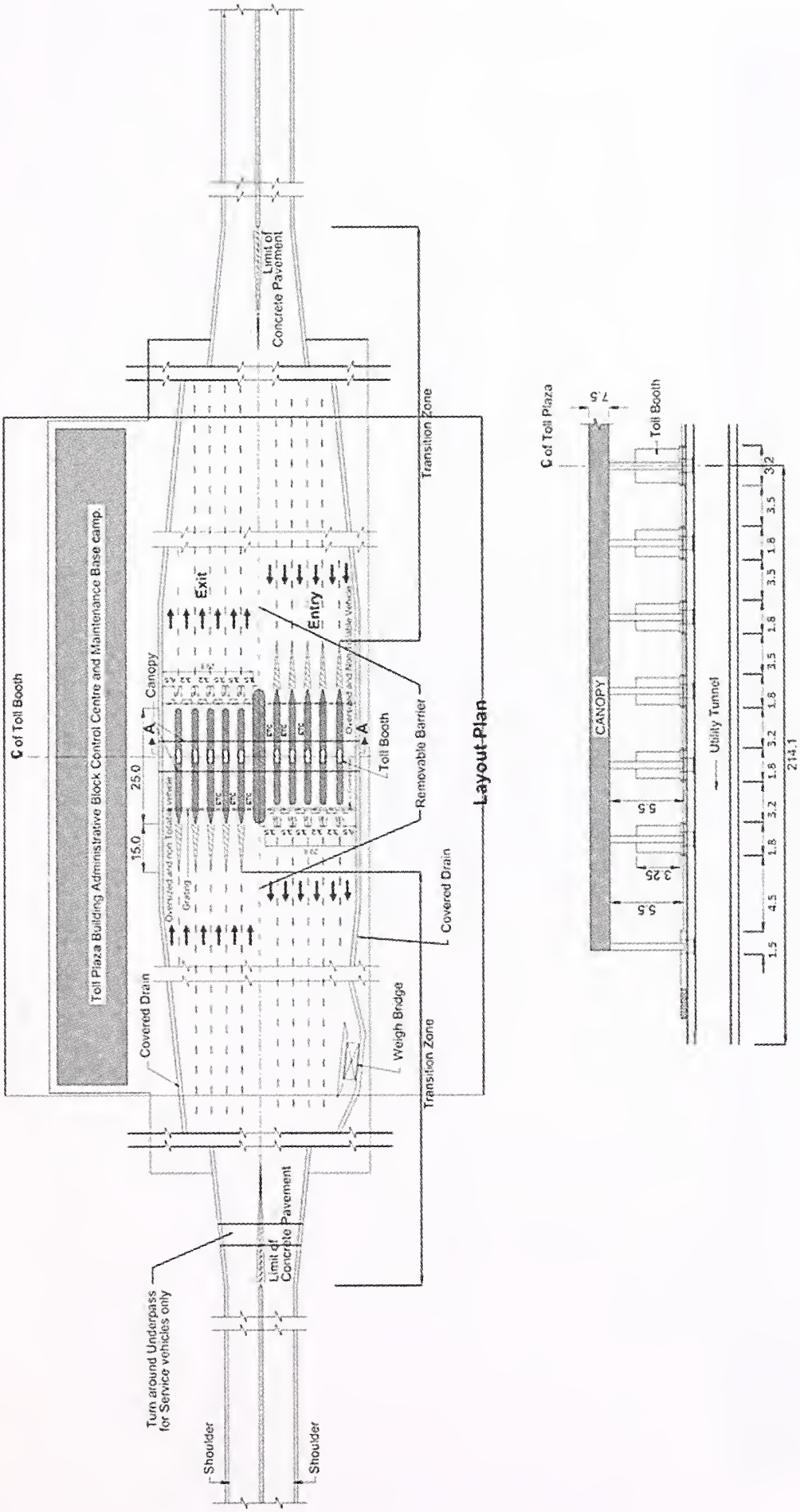


Fig. 12.3 Typical Layout of Toll Plaza

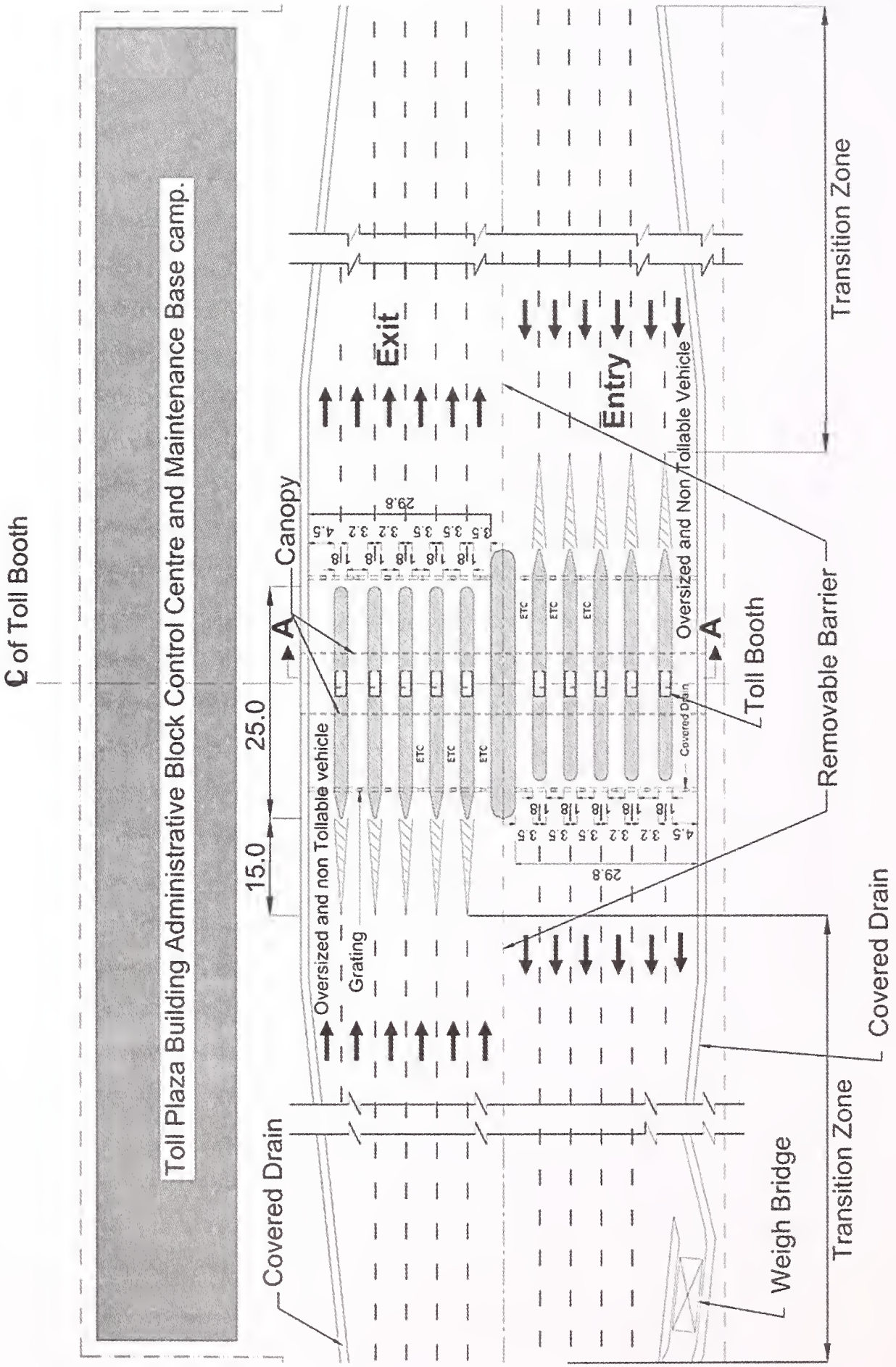


Fig. 12.4 Toll Plaza Area (ETC Lanes at Center)

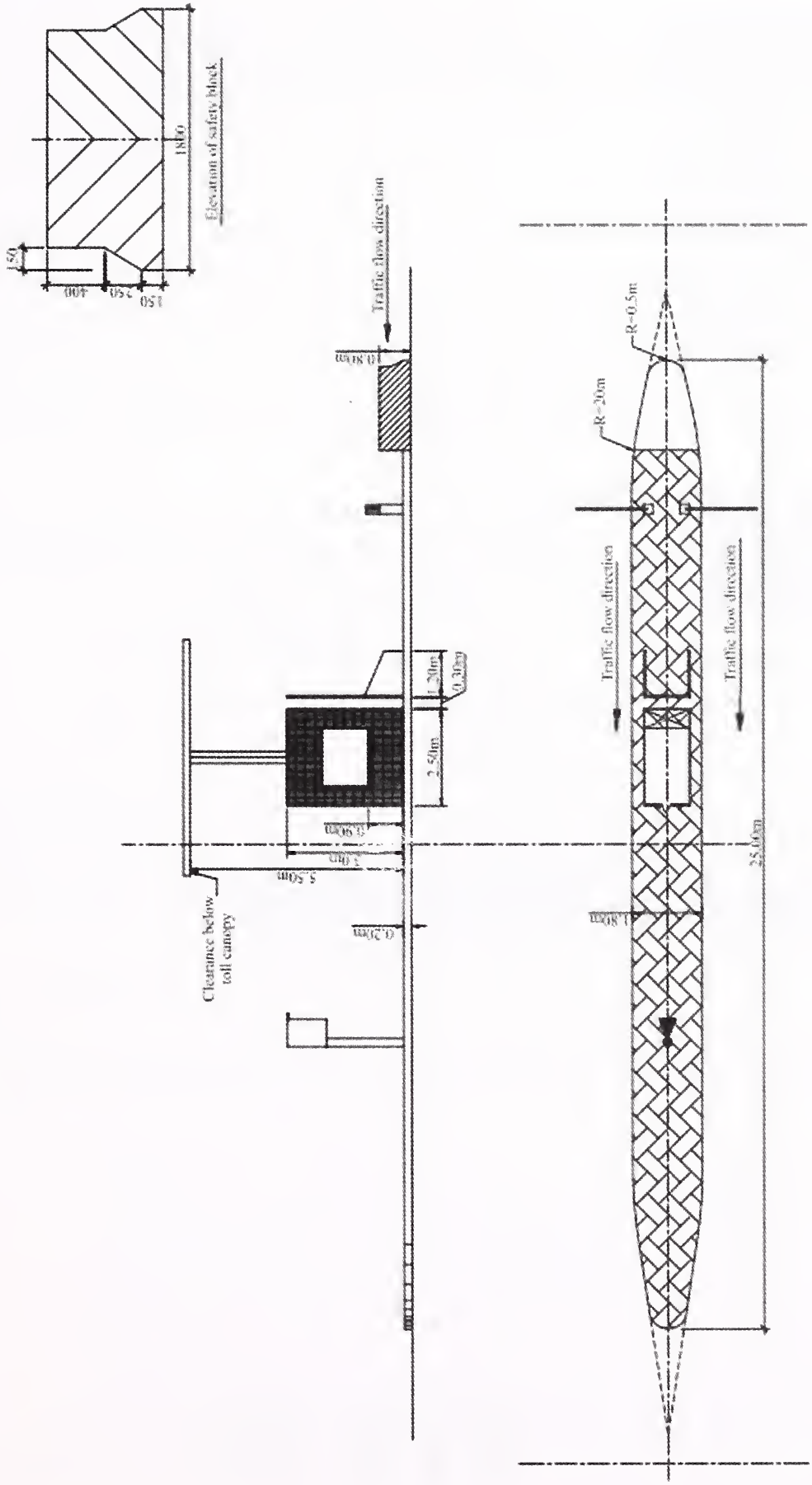
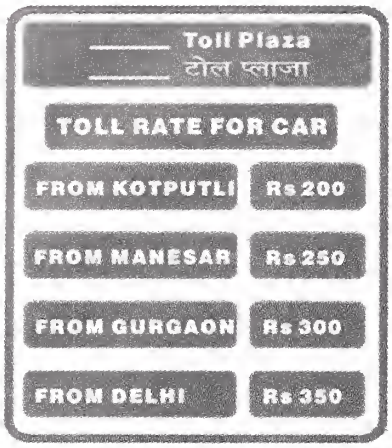
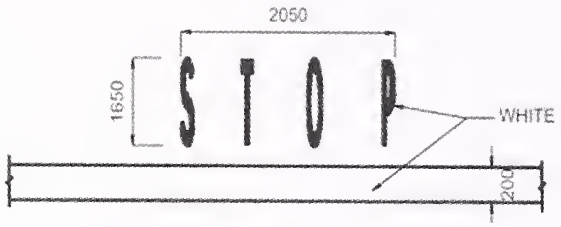


Fig. 12.5 Typical Layout for Traffic Island with Toll Booth

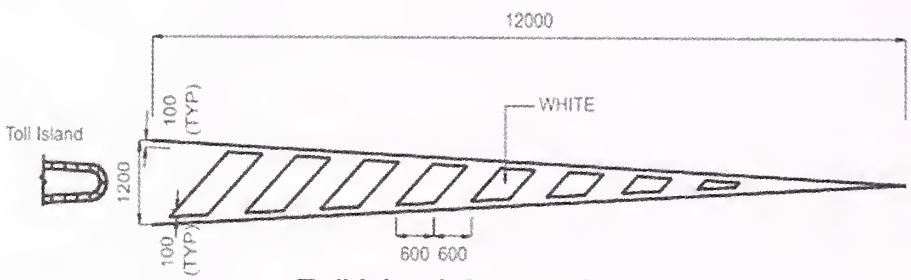


Toll Rate Sign

Toll Plaza Sign

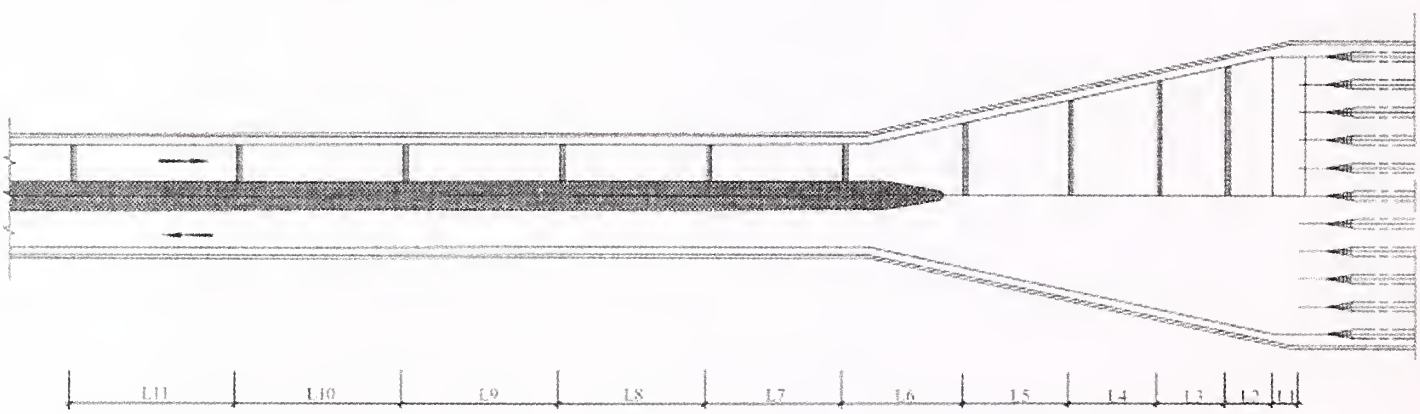


Stop Marking

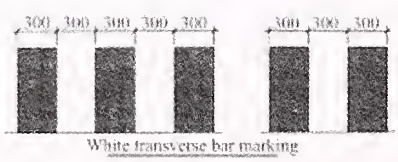


Toll Island Approach

Fig. 12.6 Traffic Signs and Road Markings in Toll Plaza



Distance from previous bar marking (m)	No. of bar markings
L1=5	1
L2=9	1
L3=13	2
L4=17	2
L5=20	2
L6=23	2
L7=26	3
L8=28	3
L9=30	3
L10=32	3
L11=32	3



Note:
Detailed system of road marking as per IRC:35.

Fig. 12.7 Details of Suggestive Transverse Bar Marking for Speed Control at Toll Plaza

SECTION – 13
PROJECT FACILITIES: SERVICE AREAS, PICK-UP BUS STOPS, STATE BORDER CHECK POSTS

13.1 Service Areas

13.1.1 *Introduction*

Service areas shall be planned and provided as wayside amenities for users of the expressways to enable them to stop, take rest and refresh themselves so as to ease their fatigue. These areas also cover facilities for providing fuel for vehicles and emergency requirements without having to exit from the expressway. Thus, provision of service areas and their operation and maintenance are to be an integral part of the Project Expressway for comfortable and safe driving.

13.1.2 *Site spacing*

i) The service areas may be planned at approximately 50 km intervals (This may correspond to roughly 45 minutes of driving). Location of service areas shall be as given in **Schedule–C** of the Concession Agreement.

ii) In addition to the regular service areas, only toilet facilities are also required to be provided. Their locations may be approximately half way (midway) between the service areas. These toilet facilities may be on short laybyes off the expressway shoulders but with proper deceleration and acceleration lanes. Further, such laybyes may not be located on sharp curves or inside of curves. Location of laybyes for toilet facilities shall be as given in **Schedule–C** of the Concession Agreement.

13.1.3 *Service facilities*

The principal users of the expressway are passenger car users, bus users, goods vehicles drivers and other attendants. The service area shall provide the following facilities for the expressway users.

a) For Vehicles

   i) Parking lot: Separate lot for cars, buses and trucks

   ii) Fuel station: Provision for petrol, diesel, CNG, oil, air, etc.

   iii) Garage: For minor repairs and service for vehicles

b) For Passengers/Drivers

   i) Walkways and access roads: Internal circulation, connecting parking lot with toilet blocks and other facilities, access road from/to the expressway

   ii) Green spaces/lawns: May also include picnic tables, benches

   iii) Toilets: Separately for men, women and physically challenged

iv) Kiosks: For cold drinks, water, eatables, public information, photos, batteries, ATM

v) Restaurant/Fast food: Cafeteria, meals, fast food, handwash, (preferably, separate area be earmarked for truckers)

vi) Cubicles, dormitories: Some space for rest and longer stay (especially for truckers). Some space for child care.

vii) Business lounge: Cubicles for internet, fax, photocopying

viii) First Aid: Nursing Aid

ix) Waste receptacles: Bins for waste disposal

x) Others: Toiletries, medicines, tourist information

c) For operation and maintenance of service area

i) Water storage tank, recycling of waste water

ii) Electricity supply

iii) Incinerator

iv) Service roads

v) Sewage disposal

vi) Staff room for O&M personnel

vii) Parking for O&M personnel

13.1.4 *Site location*

i) The location may be decided keeping in view factors such as scenic attributes, availability of utilities (potable water, waste water disposal, telephone, electrical service), potential environment impact, availability of adequate right of way (ROW).

ii) The site should not be less than two km from an interchange unless the site itself is planned and provided as an interchange-cum-service area.

13.1.5 *Size*

i) The size of the service area would depend mainly upon the number of parking spaces needed for cars, buses and trucks. This would be a function of Average Daily Traffic and likely percentage of traffic wishing to stop by the service area. **Annex 13.1** gives broad guidance for assessing number of parking spaces. The size of other facilities like toilets, cafeteria, restaurants for passengers and drivers, lawns, walkway, road access and service facilities would be linked to the number of users on the one hand and availability of land and topography of the area on the other.

ii) The size of the service area would be sum total of areas required to provide the magnitude and level of facilities and amenities indicated in para 13.1.3

above. A minimum area of five hectares shall be provided. The service area upto fifteen hectares is considered generally manageable and this will provide enough space for landscaping and allow for future expansion requirements with growth of traffic on the expressway.

iii) The services of a competent and experienced landscape architect and a transportation professional are essential for assessing the requirements of each of the facility component indicated in para 13.1.3 above and working out suitable layout. Factors such as separation of facilities for passengers and truckers, walking distance from parking lot to toilets, restaurants, etc. and relevant byelaws of local bodies including fire safety, environment, aesthetic and landscaping aspects shall be considered while designing and preparing the layout and design. Typical layouts are indicated in **Fig. 13.1A** to **13.1F**.

iv) Provision of toilets is another key facility which the users look for in service areas. Special care is required for provision of ventilation and light in toilet areas. Separate toilets need to be provided for the persons with disabilities. The number of toilet facilities will depend upon the number of users. No standard guidelines are available in this regard. **Tables 13.1** and **13.2** give the minimum requirements for these facilities linked to the ADT and composition of trucks in the total traffic.

Table 13.1 Number of Toilet Facilities for Car and Bus Users

Percent Heavy Vehicles	ADT-20000 vpd				ADT-40000 vpd			
	Urinals	Men's	Women's	PwD	Urinals	Men's	Women's	PwD
30	8	4	8	2	14	6	12	2
40	8	4	8	2	14	6	12	2
50	6	4	6	2	10	4	8	2
60	6	4	6	2	10	4	8	2

PwD = Persons with Disabilities

Table 13.2 Number of Toilet Facilities for Truck Users

Percent Heavy Vehicles	ADT-20000 vpd				ADT-40000 vpd			
	Urinals	Men's	Women's	PwD	Urinals	Men's	Women's	PwD
30	6	4	2	2	10	6	4	2
40	6	4	2	2	10	6	4	2
50	8	4	4	2	12	8	6	2
60	8	4	4	2	12	8	6	2

PwD = Persons with Disabilities

v) **Annex 13.2** gives the provisions required for persons with disabilities, i.e. physically challenged persons.

13.1.6 *Design considerations*

For design considerations of various facilities, reference may also be made to MORTH Guidelines for Expressways.

13.1.7 *Operation and maintenance*

i) An operation and maintenance plan shall be developed for the service area to ensure that various maintenance activities are appropriately considered as part of ongoing service area operations. During construction, the equipments installed, wiring diagrams, water lines, sewerage, pumps, septic tank, water coolers, lighting fixtures, etc. all shall be documented as to locations, types, models, etc. All these details should be included in the O&M Manual for the Expressway.

ii) A list of emergency contacts with telephone numbers and addresses shall be kept and displayed at the service area.

13.2 Pick-Up Bus Stops

13.2.1 *Introduction*

The operators of bus services plying on the expressway would require facility of bus stops at important towns and village settlements en-route served by the expressway for enabling the passengers to either get down or to pick-up the passengers wanting to get in. Since the expressway is not open to pedestrians, the bus stops have to be located outside the Right of Way of the expressway to ensure safe and unimpeded travel.

13.2.2 *Location*

The pick-up bus stops shall be located at the inter-change points and planned in a manner that passengers are kept away from the expressway facility. The pick-up bus stops shall not be located in the Service Area except where the service area itself is planned at an inter-change point. The location of pick-up bus stops shall be as given in **Schedule–C** of the Concession Agreement.

13.2.3 *Design philosophy*

Basically, the design and layout of the pick-up bus stops may be integrated with local bus services and intermediate public transport (auto rickshaws, taxis, etc.). Adequate transit facility shall be planned and provided accordingly. Being a closed system of tolls to be adopted on expressways, there shall be specially designed access road for buses exiting from the expressway to the bus-stop and thereafter entering the expressway such that the bus does

not leave the access road except for letting the passengers get down from the bus or get into the bus from the pick-up bus stops. **Fig. 13.2** presents a typical functional arrangement of pick-up bus stops at the Expressway combined with local bus stop facility.

13.3 State Border Check Posts

13.3.1 *Introduction*

The state border check posts shall be planned and provided to enable the State Authorities to exercise checks as per Applicable Laws on the vehicles crossing the state border. Such checks may be related to sales tax, VAT, entry tax, tourist permit tax, forest related taxes, etc.

13.3.2 *Location*

The check posts shall be provided on laybyes off the Expressway shoulders with proper deceleration and acceleration lanes. Further, such laybyes will be located immediately after crossing the state border. The location of check posts shall be as given in **Schedule–C** of the Concession Agreement.

13.3.3 *Design consideration*

The design of the check post will be undertaken in consultation with the State Authorities. Normally, a built-up area of 300 sqm would suffice including the toilet facilities. An open area of around 300 sqm adjoining the building block shall be reserved for parking of vehicles. Typical layout is given in **Fig. 13.3**.

Annex 13.1

Broad Guidance for Assessment of Parking Spaces in Service Areas

1) The parking lots shall be provided separately for cars, buses and trucks in the same service area complex.

2) The number of parking spaces depend upon:

   - the total average daily traffic,
   - usage ratio, i.e. the ratio of vehicles likely to use the service area facility,
   - design hour factor, i.e. the peak hour volume in relation to the average flow
   - stay in hours

3) AASHTO, UK Department of Transport and JICA have formulated their own guidelines for assessment of parking lots in Rest Areas. Based on these practices, a simplified approach is given hereunder.

4) Find out the ADT of cars, buses and trucks only for the direction in which the Service Area lies for which the assessment is to be done.

   Then the number of parking spaces will be given by the equation.

   N = ADT x UR x DHF x L

   Where N = number of parking spaces

   ADT = Average Daily Traffic in the direction of service area

   UR = Usage Ratio

   DHF = Design Hour Factor

   L = Stay in Hours

5) The suggestive values of UR, DHF and L for cars, buses and trucks are given in **Table 1** below:

Table 1 Usage Factors Proposed

Type of Vehicle	UR	DHF	L	Number (N) of Parking Spaces (per 1000 vpd of a Particular Class in one Direction)
Cars	0.15	0.10	30/60	7.5 per 1000 cars
Buses	0.20	0.12	24/60	9.6 per 1000 buses
Trucks	0.15	0.12	36/60	10.8 per 1000 trucks

6) An illustrative exercise is now undertaken for a total ADT of 40,000 vpd in both directions with four cases of traffic composition as per **Table 2** and **Table 3**:

Table 2 Broad Composition of Traffic

Class	Percent Composition Assumed			
	Case I	Case II	Case III	Case IV
Cars	75	70	63	50
Buses	5	5	7	10
Trucks	20	25	30	40

Table 3 Number of Parking Spaces for Total ADT of 40,000 vpd in Both Directions

Percent of CVs			Number of Parking Spaces			
Case	Trucks	Buses	Cars	Buses	Trucks	PwD
Case I	20	5	114	10	44	4
Case II	25	5	106	10	54	4
Case III	30	7	96	14	66	4
Case IV	40	10	76	20	88	4

PwD = Persons with Disabilities

7) To begin with, minimum number of parking spaces may be provided considering an ADT of 20,000 vpd in both directions with scope for future expansion in tune with traffic growth and usage experienced at the particular Service Area. The minimum parking spaces to be provided shall be as per **Table 4** below:

Table 4 Minimum Number of Parking Spaces

Percent of CVs		Number of Parking Spaces			
Trucks	Buses	Cars	Buses	Trucks	PwD
20	5	60	5	25	2
25	5	50	5	30	2
30	7	50	7	35	2
40	10	40	10	45	2

PwD = Persons with Disabilities

Annex 13.2

PROVISIONS FOR PERSONS WITH DISABILITIES (PwD)

For this Manual, the disabilities mean which confine individuals to wheel chair for mobility. The standard size of wheel chair as generally considered is 1,050 mm x 750 mm.

At the wayside amenity centres/rest areas, the level of the roads, access paths and parking areas require special considerations as described below:

Access Path/Walk Way: Access path from entry to parking lot and to facility centre shall be minimum of 1,800 mm wide having even surface without any steps. Slope, if any, shall not have gradient greater than 5 percent. Finishes shall have a non slip surface with a texture traversable by a wheel chair as well as for trolley baggage. Kerbs wherever provided should blend to a common level.

Parking: For parking of vehicles, the following provisions are required:

- Surface parking for at least two Car Spaces shall be provided near entrance, with maximum travel distance of 30 m from facility entrance.
- The width of parking bay shall be minimum 3.6 m.
- The signage for reserved space for wheel chair users shall be conspicuously displayed using large sign boards.
- The slope of parking spaces reserved for **Persons with Disabilities (PwD)** on wheel chair especially should not exceed 1 (one) percent gradient. **Fig. 13.1G** presents typical layout.
- Ramp should be complemented by flights of steps, as many people (crutch users) have more difficulty coping with ramps than steps, particularly when descending.
- Landings – every 750 mm of vertical rise, width should be 1800 mm wide to permit wheelchairs to pass. Over short lengths, a minimum width of 1200 mm can be accepted. **Fig. 13.1H** presents typical arrangement.

Ramped Facilities: Ramp shall be finished with non slip material to enter the facility. Minimum width of ramp shall be 1,800 mm with maximum gradient 1V:20H.

Exit/Entrance Door: Minimum clear opening of the entrance door shall be 900 mm and it shall not be provided with a step that obstructs the passage of a wheel chair.

Entrance landing: Entrance landing shall be provided adjacent to ramp with the minimum dimension 1,800 mm x 2,000 mm. the entrance landing that adjoin the top end of a slope shall be provided with floor materials to attract the attention of persons (limited to coloured floor material whose colour and brightness is conspicuously different from that of the surrounding floor materials). Finishes shall have a non slip surface with a texture traversable by a wheel chair.

Flooring:

- Tactile floor blocks should be provided to orient persons with low vision, vision impairment and deaf blind. These blocks should have a colour (preferably canary yellow), which contrasts with the surrounding surface.
- Guide path (line blocks) has straight continuous line and indicate the correct path/ route to follow, leading to building entrances, an amenity, bus stop etc. and should not be located close to manholes or drains, to avoid confusion for persons with vision impairments.
- Warning (dot/blistered blocks) strip provides warning signal to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction and to warn of a corner or junction. Should be placed 300 mm at the beginning and end of the ramps, stairs and entrance.

Lifts: Wherever lift is required, provision shall be kept for at least one space for the wheel chair, with the following cage dimensions (Bureau of Indian Standards). Clear internal depth of 1,100 mm, Internal width of 2,000 mm and Entrance door width of 900 mm.

– A hand rail not less than 600 mm long at 1,000 mm above floor level shall be fixed adjacent to the control panel.

– The lift lobby shall be of an inside measurement of 1,800 mm x 1,800 mm or more.

– The time of an automatically closing door should be minimum 5 seconds and the closing speed should not exceed 0.25 m/s.

– The interior of the cage shall be provided with a device that audibly indicated the floor the cage has reached and indicates that the door of the cage for entrance/ exit is either open or closed.

Toilets: At least one special WC in a set of toilet shall be provided for the use of handicapped with essential provision of wash basin near the entrance.

– The minimum size shall be 1,500 mm x 1,750 mm.

– Minimum clear opening of the door shall be 900 mm and the door shall swing out.

– Suitable arrangement of vertical/horizontal handrails with 50 mm clearance from wall shall be made in the toilet.

– The WC seat shall be 500 mm from the door.

Drinking Water: Suitable provision for drinking water shall be made for the handicapped near the special toilet provided for them.

Signage: Appropriate identification of specific facilities within a building for the handicapped persons should be done with proper signages. Signs should be designed and located so that they are easily legible. To ensure safe walking, there should not be any protruding sign which creates obstruction in walking. Public Address System shall be provided.

The symbols/informations should be in contrasting colour and properly illuminated. A symbol for wheel chair shall be installed at the lift, toilet, staircase, parking areas etc., that have been kept specially for the purpose. **Fig. 13.1J** presents typical signages.

Other Facilities:

Fig. 13.1I, K, L and M present other facility requirements at various usage places.

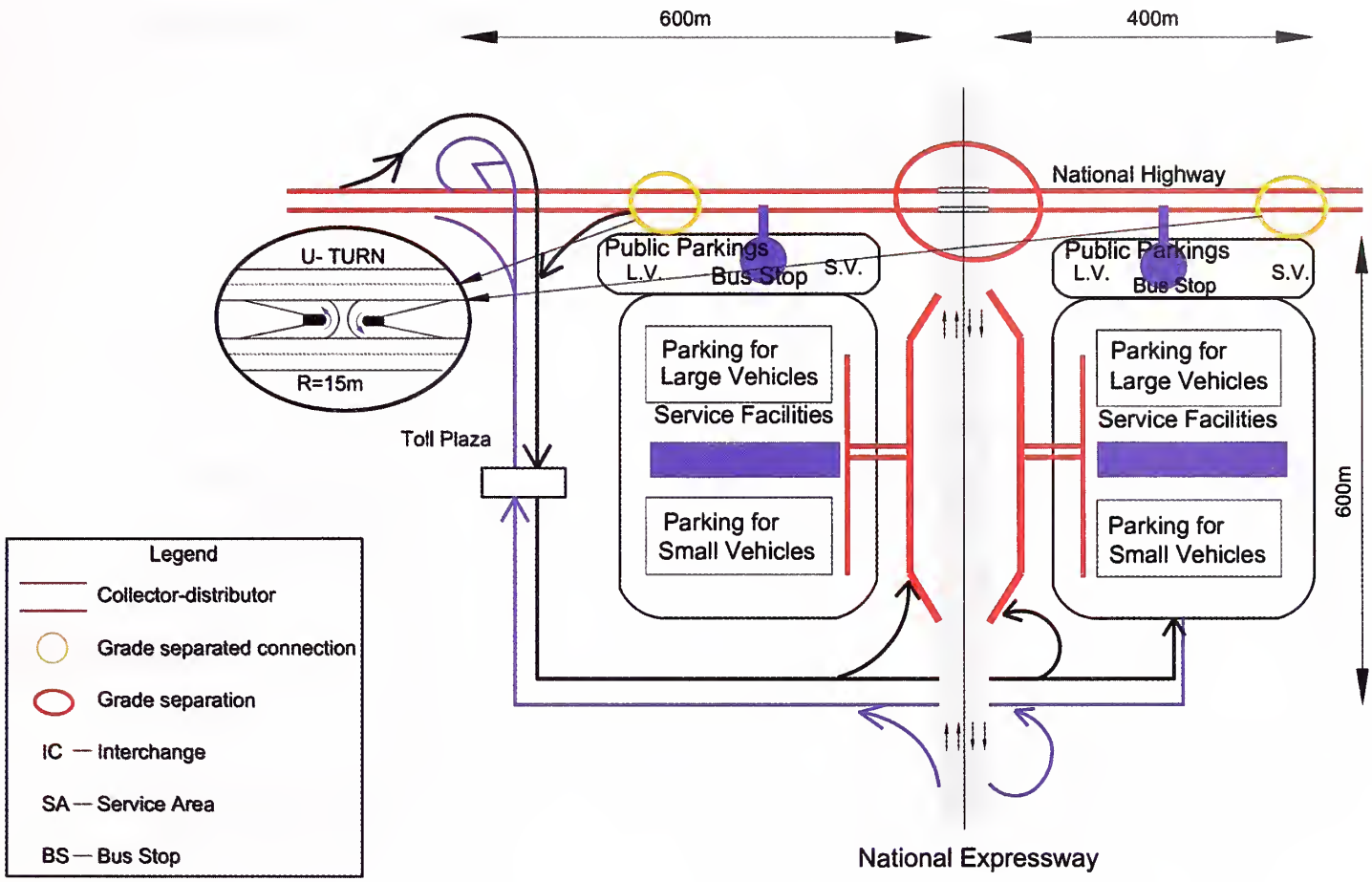


Fig. 13.1A Conceptual Drawing of IC cum SA cum BS

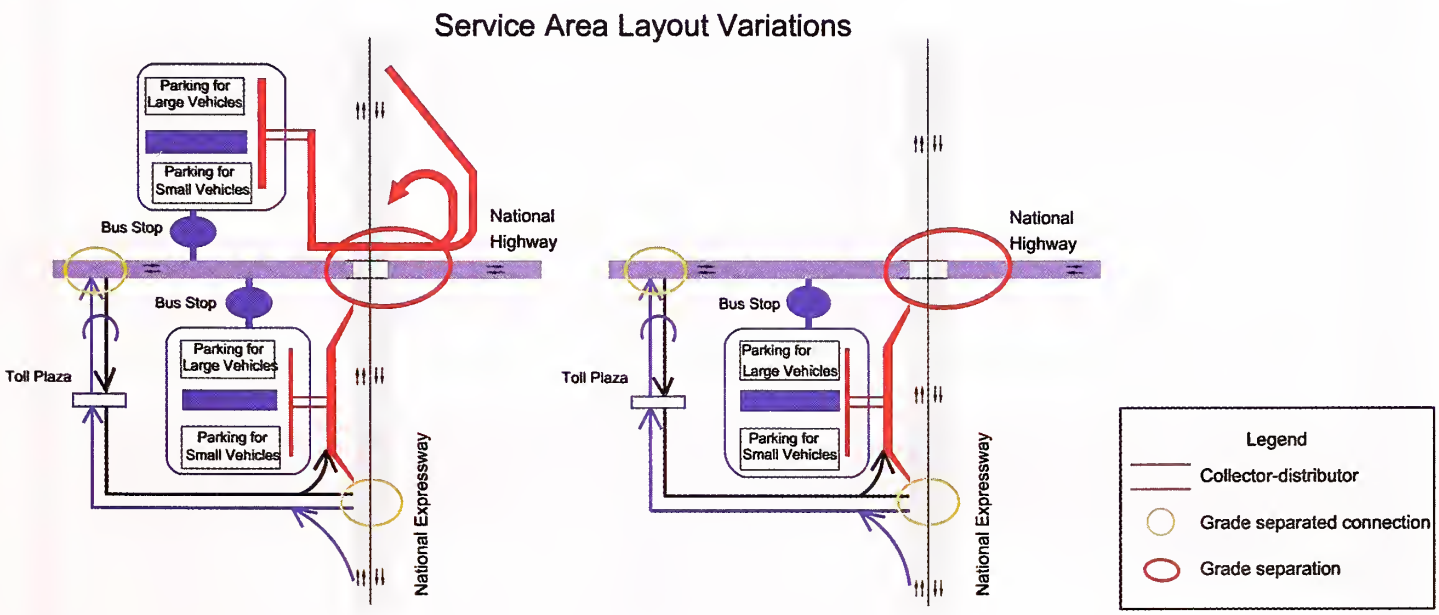


Fig. 13.1B One - Side Located

Fig. 13.1C One - Direction Service for Alternate Exit

Typical Layout of Full-size and Small-size Amenities

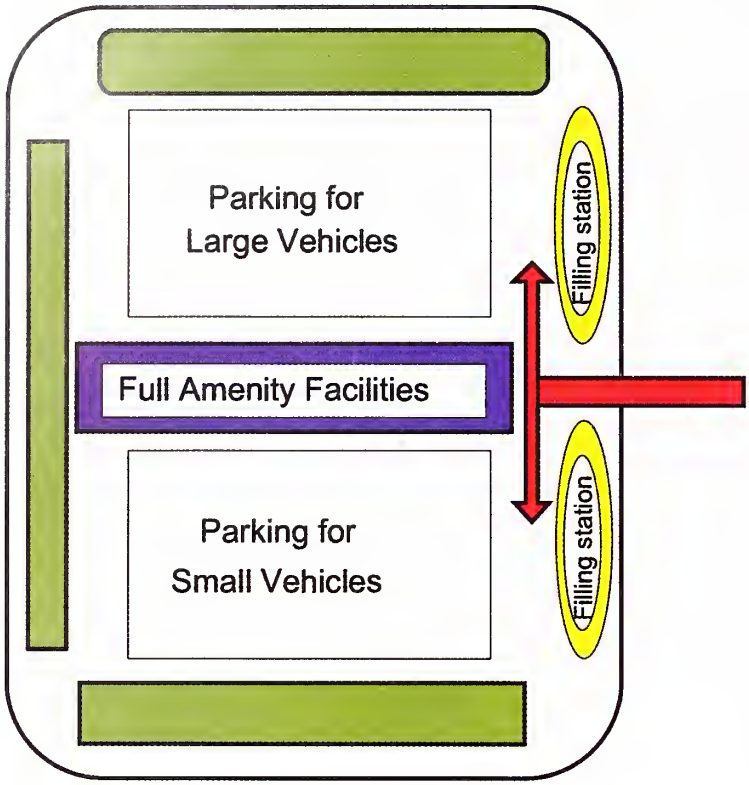


Fig. 13.1D Full-sized Amenity

(Stand-alone when spacing of Interchange > 40km)

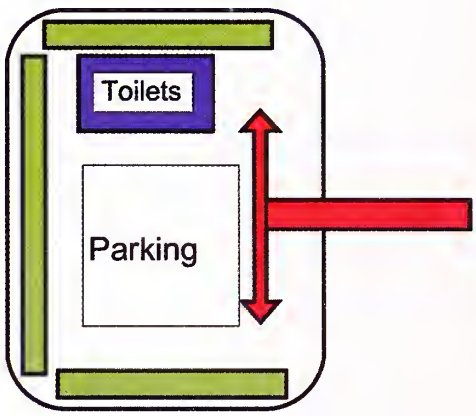


Fig. 13.1E Small-sized Amenity

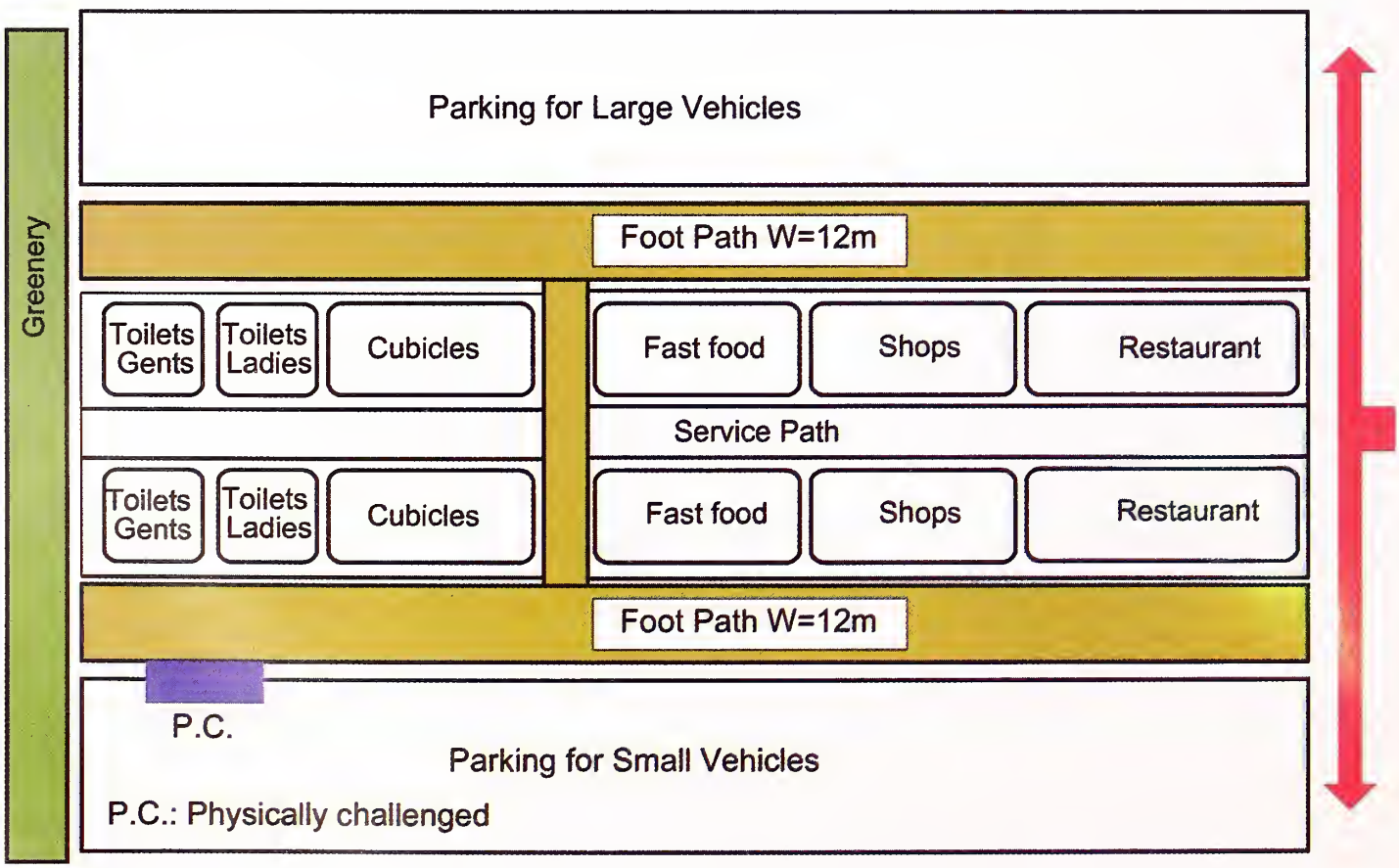


Fig. 13.1F Typical Layout of Service Areas

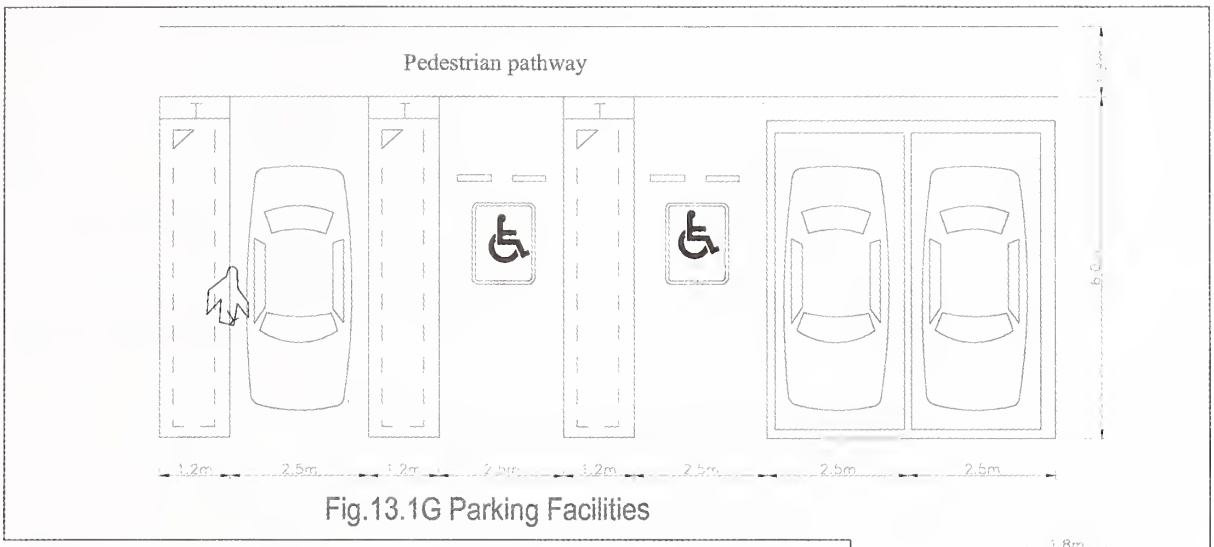


Fig.13.1G Parking Facilities

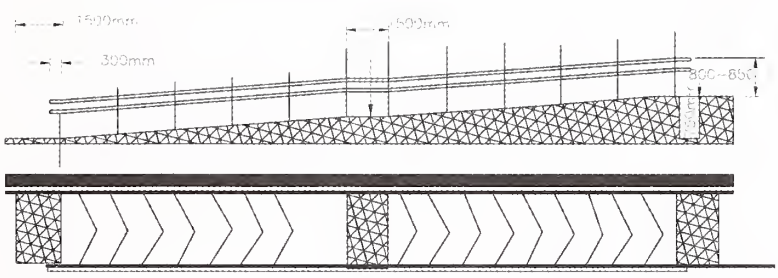
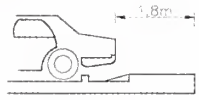
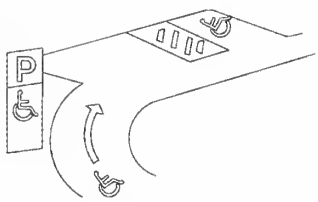


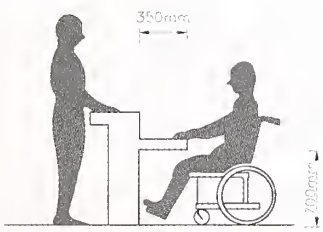
Fig.13.1H Ramp Facilities



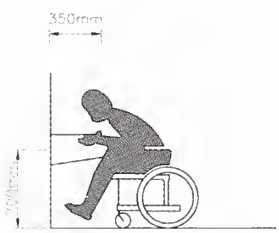
Pedestrian pathway



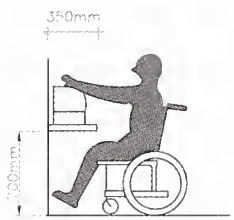
Approach to Parking



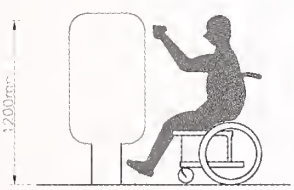
Counter



Drinking Water Fountain

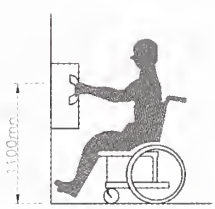


Telephone Stand



Mailbox

Vending Machine



Wall-Mounted Telephone

Fig.13.1I Fcilities

Direction Identification

Toilet

Information

Fig.13.1J Signage Facilities

Provisions For Physically Challenged Persons

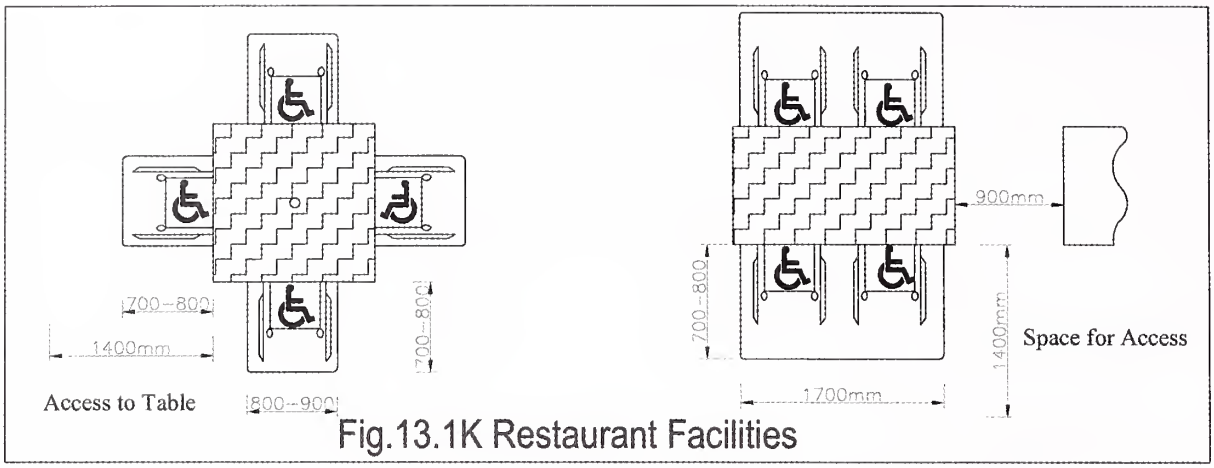


Fig.13.1K Restaurant Facilities

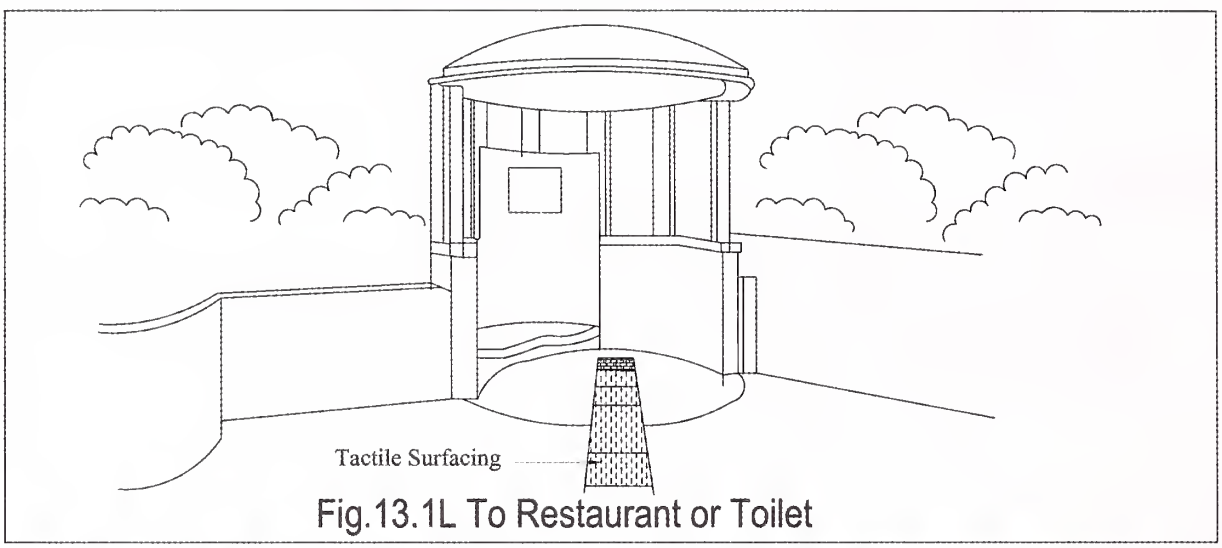


Fig.13.1L To Restaurant or Toilet

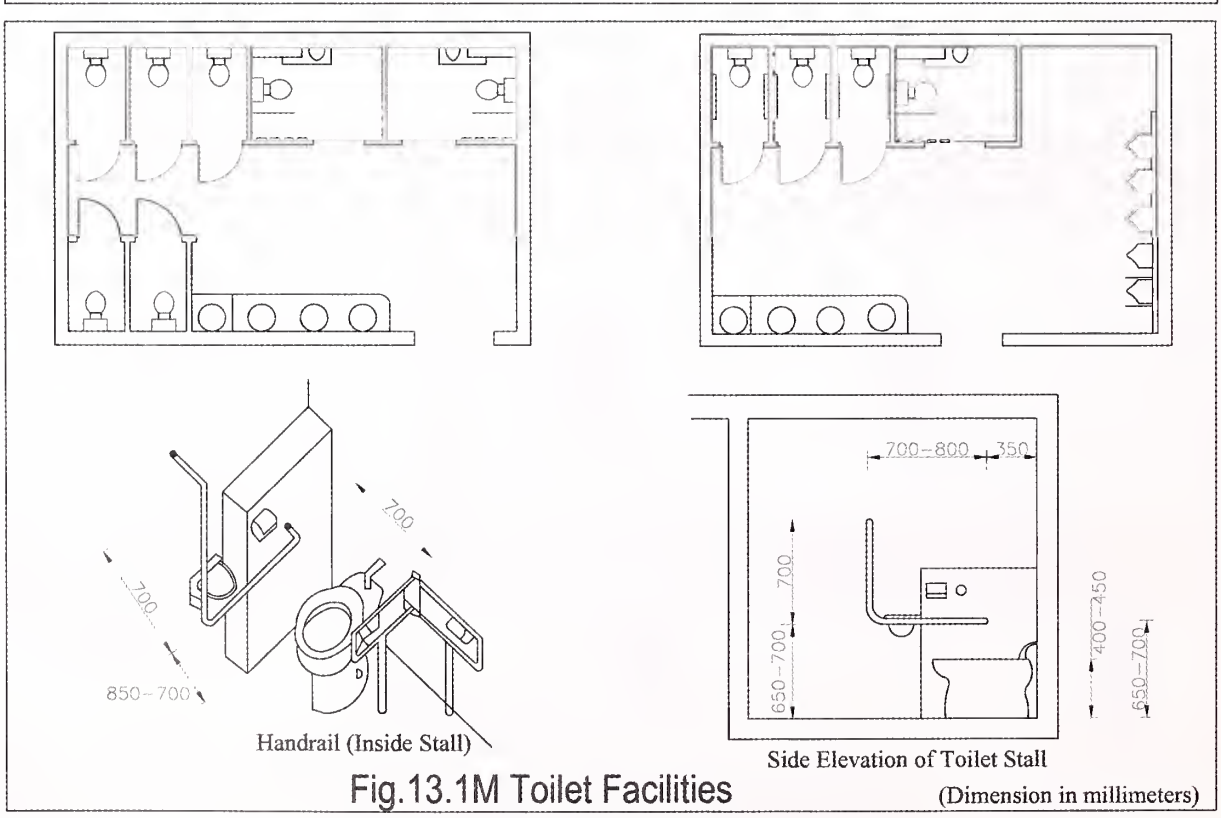
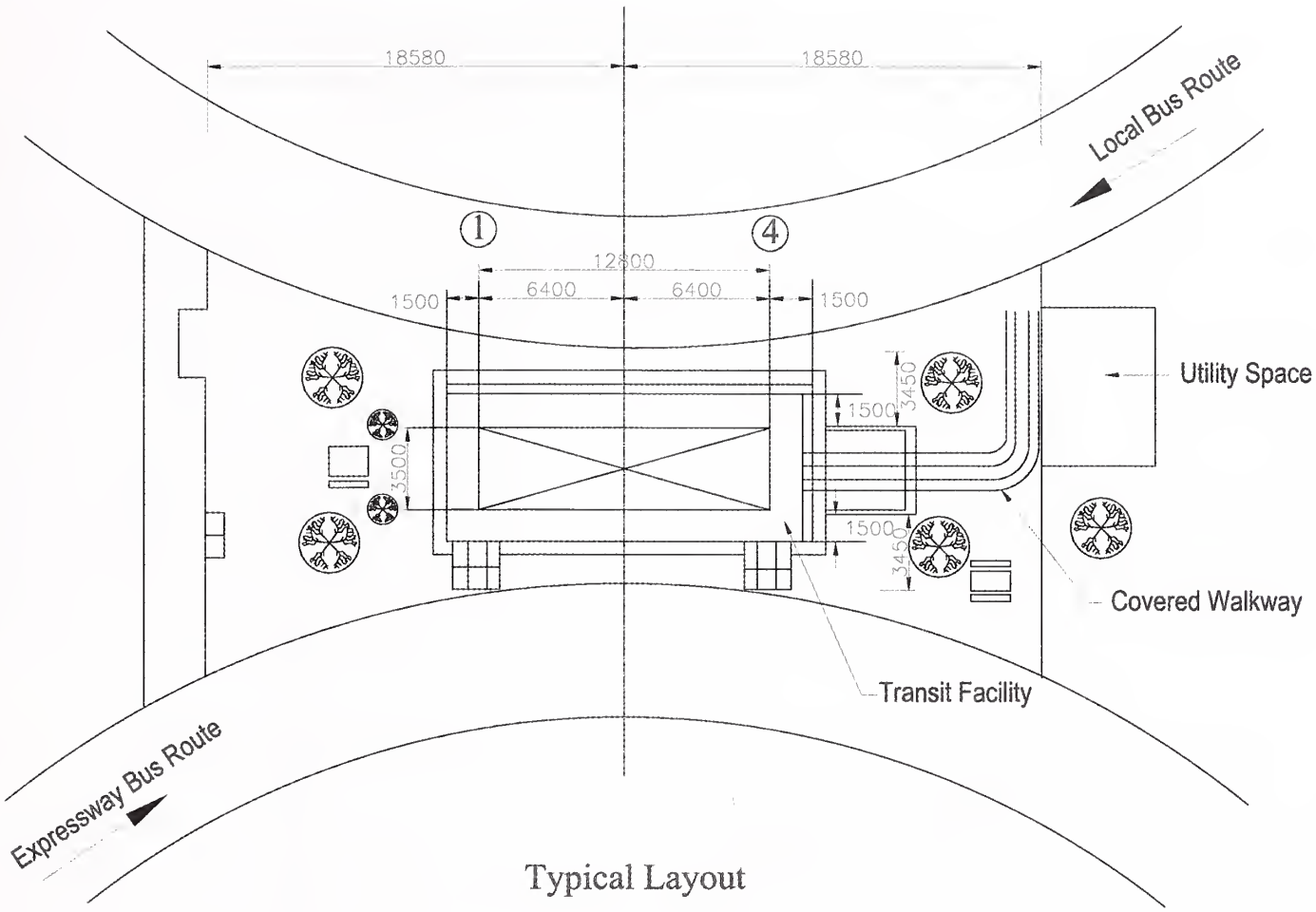
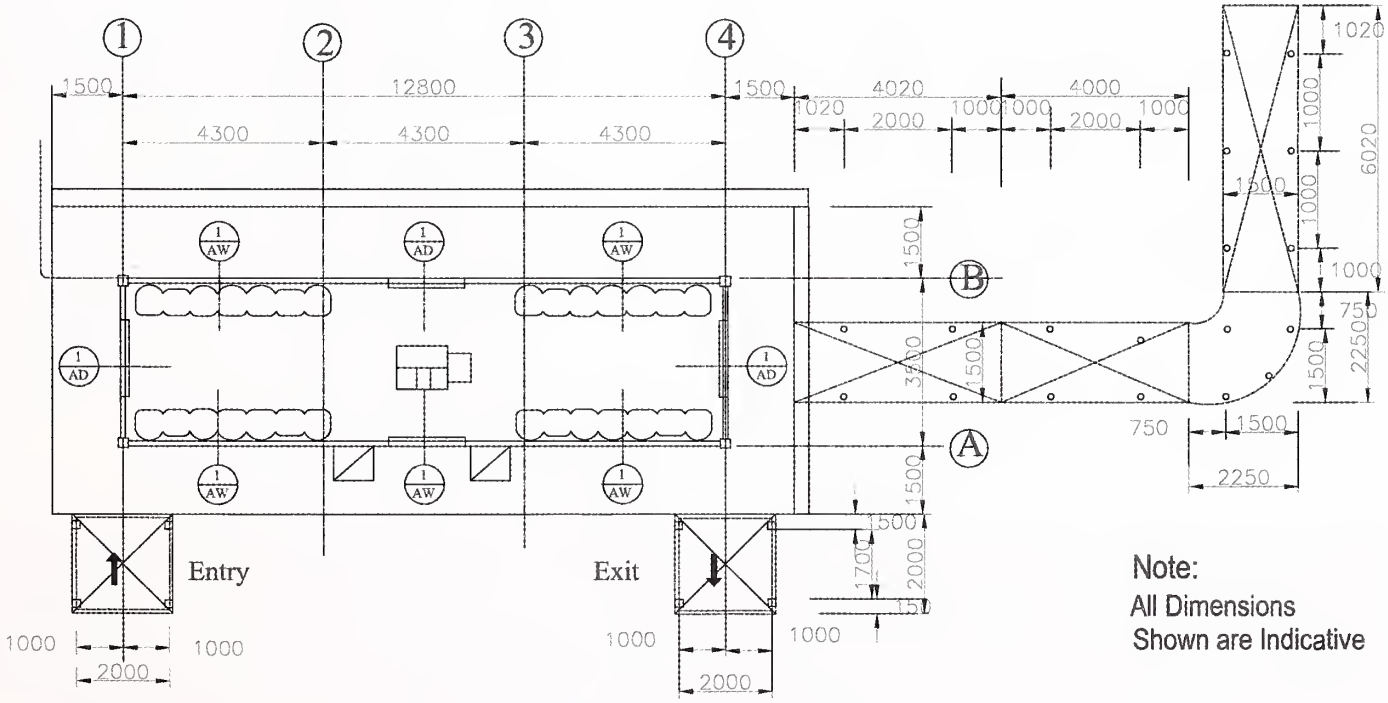


Fig.13.1M Toilet Facilities (Dimension in millimeters)

Provisions For Physically Challenged Persons



Typical Layout



Expressway Transit Facility

Fig.13.2 Typical Functional Arrangement of Expressway Bus Route and Local Bus Route at Bus Stop.

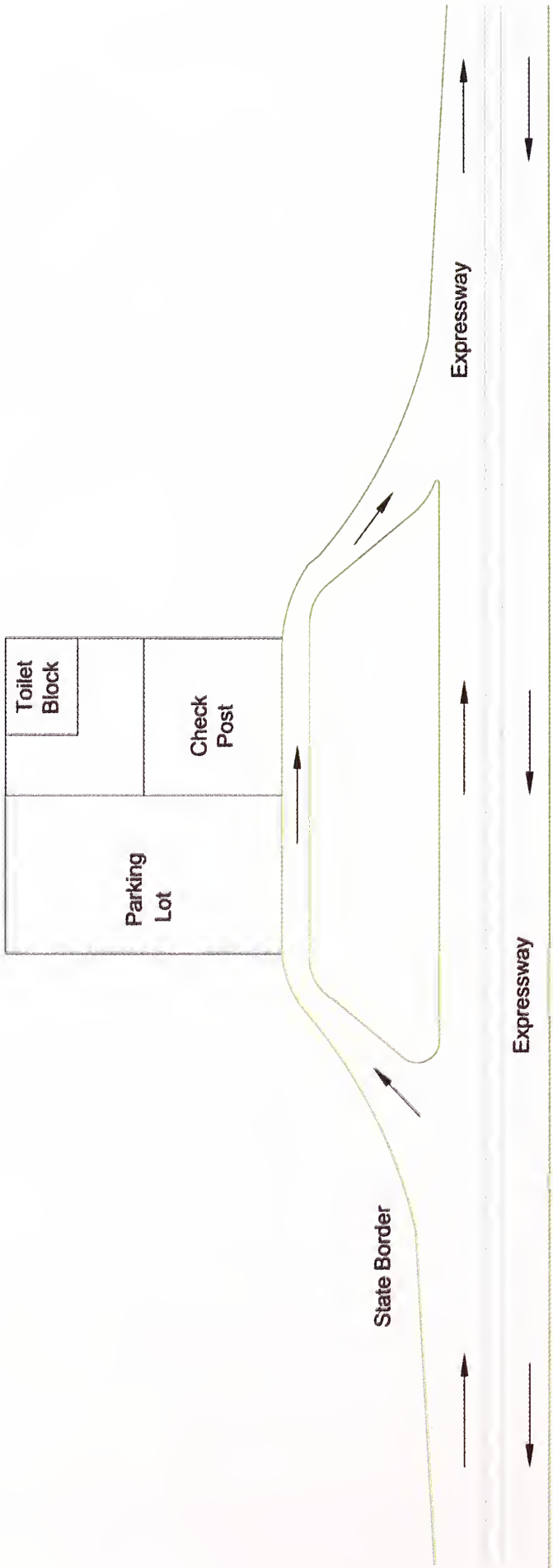


Fig. 13.3 Typical Layout of State Border & Entry Check Post

SECTION – 14
ENVIRONMENTAL AND SOCIAL ASPECTS, LANDSCAPING AND TREE PLANTATION

14.1 Context

Expressway projects are likely to be associated with some adverse environment impacts during construction, maintenance and operation stages. Significant impacts during construction relate to clearing, grading or road bed construction; loss of vegetative cover; foreclosure of land uses; property severance at community/individual levels; changes in natural drainage patterns; changes in ground water table, landslides, erosion, streams, ponds and lake sedimentation, degradation of cultural sites, interference with movements of wild life, live stock and local residents. Many of these impacts can arise not only at construction sites but also at quarries, borrow pits and material storage areas serving the Project Expressway. In addition, impacts can occur due to air and ground pollution from construction plants; dust from construction vehicle movements, noise from construction equipment and blasting, use of pesticides, fuel and oil spills, trash and garbage etc.

14.2 Environmental Management Plan

Many of the direct adverse impacts can be avoided/mitigated at the design stage. Accordingly while the Authority will seek the Environmental clearance for the Project Expressway from the relevant Ministries, Departments; the Concessionaire shall be responsible for implementation of Environmental Management Plan and action plan for undertaking possible mitigation measures in accordance with extant guidelines for highway projects of the Ministry of Environment and Forests (MOEF) and Wildlife Department of the Government of India.

The Authority shall make available to the Concessionaire, the list of conditions and directions stipulated by the MOEF at the time of giving their clearance for the Project Expressway and it shall be the responsibility of the Concessionaire to incorporate the same in its Environmental Management Plan referred to above.

14.3 Landscaping and Tree Plantation

14.3.1 *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 the IRC Guidelines on Landscaping and Tree Plantation. The Authority will specify the number of trees which are required to be planted by the Concessionaire as compensatory afforestation or otherwise in **Schedule–C** of the Concession Agreement. The Concessionaire shall also maintain the trees and shrubs in good condition during the Concession Period as per the maintenance schedule. Plantation shall be at the edge of the Right of Way.

14.3.2 *Design considerations in various locations*

a) **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, entry/exit ramps and cut slopes. Trees shall be placed at a minimum distance of 14 m from the centre line of the left side paved shoulder to provide recovery area for the vehicle that runs off the road.

b) **Plantation in medians**

In the sections of the Project Expressway where median width is more than 3 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.

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 paved median.

c) **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.

d) **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.

14.4 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** of the Concession Agreement. The landscape treatment shall also be provided for special areas as given in IRC:SP:21 (para 8).

14.5 Report to be submitted

The Concessionaire shall submit scheme for Environmental Management Plan (EMP) and for plantation and maintenance of plants and trees to the Independent Engineer for review and comments, if any.

SECTION – 15
LIGHTING

15.1 General

i) The Concessionaire shall provide lighting at locations of the Project Expressway specified in **Schedule-C** of the Concession Agreement, using appropriate system and source of electric power as per the requirements of this Section.

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 Diesel Generator 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.

15.2 Specifications

i) Unless stated otherwise elsewhere in this Manual, the minimum level of illumination on the stretches of the Project Expressway including Toll Plazas, truck lay-byes, interchanges etc. shall be as given in **Table 15.1**.

Table 15.1 Minimum Level of Illumination

Category	Average level	U0	U1	T1
Expressways	25 lux	0.4	0.7	15%

where,

U0: overall uniformity

U1: uniformity along the axis of the road

T1: maximum glare

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 15.2(i) is 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 Expressway 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.

15.3 Lighting Standards

The overall quality of an installation for lighting has several components:

i) Average luminance level: This is all-important, as it not only impinges on the safety benefits but also largely determines the power requirements and hence the running costs. In simpler design processes, and for checking the performance of an installation, this translates into average illuminance level.

ii) Overall uniformity of luminance, or illuminance, both across and along the roadway. Defined as the minimum divided by the average, and designated at U0.

iii) Uniformity of luminance, or illuminance, along the axis of the road, usually an axis which coincides with a typical driver's eye position. Defined as the ratio of the minimum to the maximum, and designated U1.

iv) Glare: As glare has the effect of reducing contrast, a luminary's "glare performance", or optical control, can be expressed in terms of the increase in background luminance necessary to compensate (threshold increment, T1). The lower this figure the better. These percentages are determined by the amount of light the luminaries project near the horizontal. This light also causes problems of sky-glow.

v) Guidance: Whilst glare must be kept under control, a small amount of direct light from the luminaries gives a useful sense of the "run" of the road ahead, and can forewarn the approach of junctions or roundabouts.

15.4 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 Expressway.

15.4.1 *Continuous expressway lighting*

i) Continuous expressway lighting is considered to be warranted on those sections where three or more successive interchanges and cross roads are located with an average spacing of 2.5 km or less, and adjacent areas outside the right-of-way are urban in character.

ii) Continuous expressway lighting shall be provided where for a length of 3 km or more, the expressway passes near an urban area in which one or more of the following conditions exist:

a) Local traffic operates on a complete street grid having some form of street lighting, parts of which are visible from the expressway.

b) The expressway passes near a series of developments such as residential, commercial, industrial and civic areas, schools, colleges, parks, terminals, etc., which includes roads, streets and parking areas, yards, etc. that are lighted.

iii) In rural areas each location must be individually evaluated as to its need for illumination.

15.4.2 *Interchange lighting*

Complete interchange lighting shall be provided on all the interchanges.

15.4.3 *Bridge structures and underpasses lighting*

Lighting shall be provided inside the underpasses. The lighting of bridges and overpasses should be of the same level and uniformity as the roadway.

15.4.4 *Special situations*

Tunnels

Tunnels require the use of lighting or equivalent means to provide adequate roadway and tunnel user visibility necessary for safe and efficient traffic operations. The tunnel lighting shall be designed as per MORTH Guidelines for Expressways, Chapter 13.5 Tunnel Lighting.

Toll Plaza Areas

The lighting in and around Toll Plaza, toll booths, office building, on the approach road, etc. shall be as per Section–12.Toll Plazas of this Manual.

Wayside Amenities

All Wayside Amenities offering facilities should be lighted, including the entrance and exit, the interior roadways, parking areas, and activity areas. Wayside Amenities include Rest Areas, Truck/Bus laybys, and Pick-up bus Stops. The lighting of Wayside Amenities shall be as per Section–13. Project Facilities of this Manual.

Other Specialized Areas

Lighting of other specialized areas should be considered with respect to the needs of the users as well as the requirements of others interacting with the users. These other specialized areas include truck weighing stations, inspections and enforcement areas, park-and-ride lots, toll plazas, and escape ramps.

15.5 Report to be Submitted

The Concessionaire shall submit report containing the proposal for provision of Lighting on the Project Expressway to the Independent Engineer for review and comments, if any.

Appendix – 1

(Refer Clause 1.4)

Sl. No.	*Code/ Document No.*	*Title of the Publication*
1.	IRC:2	Route Marker Signs for National Highways
2.	IRC:3	Dimensions & Weights of Road Design Vehicles
3.	IRC:5	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design
4.	IRC:6	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses
5.	IRC:8	Type Designs for Highway Kilometre Stones
6.	IRC:9	Traffic Census on Non-Urban Roads
7.	IRC:15	Standard Specifications and Code of Practice for Construction of Concrete Roads
8.	IRC:16	Standard Specifications and Code of Practice for Prime and Tack Coat (Second Revision)
9.	IRC:18	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete)
10.	IRC:22	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Second Revision)
11.	IRC:24	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)
12.	IRC:25	Type Designs for Boundary Stones
13.	IRC:26	Type Design for 200-Metre Stones
14.	IRC:30	Standard Letters and Numerals of Different Heights for Use on Highway Signs
15.	IRC:32	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
16.	IRC:34	Recommendations for Road Construction in Areas Affected by Water Logging, Flooding and/or Salts Infestation
17.	IRC:35	Code of Practice for Road Markings
18.	IRC:37-2001	Guidelines for the Design of Flexible Pavements
19.	IRC:37-2012	Tentative Guidelines for the Design of Flexible Pavements
20.	IRC:38	Guidelines for Design of Horizontal Curves for Highways and Design Tables
21.	IRC:44	Guidelines for Cement Concrete Mix Design for Pavements
22.	IRC:45	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges

Sl. No.	*Code/ Document No.*	*Title of the Publication*
23.	IRC:56	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control
24.	IRC:57	Recommended Practice for Sealing of Joints in Concrete Pavements
25.	IRC:58	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways
26.	IRC:67	Code of Practice for Road Signs
27.	IRC:73	Geometric Design Standards for Rural (Non-Urban) Highways
28.	IRC:75	Guidelines for the Design of High Embankments
29.	IRC:78	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure
30.	IRC:83 (Part-I)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings
31.	IRC:83 (Part-II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
32.	IRC:87	Guidelines for Formwork, Falsework and Temporary Structures
33.	IRC:89	Guidelines for Design and Construction of River Training & Control Works for Road Bridges
34.	IRC:103	Guidelines for Pedestrian Facilities
35.	IRC:104	Guidelines for Environmental Impact Assessment of Highway Projects
36.	IRC:107	Tentative Specifications for Bitumen Mastic Wearing Courses
37.	IRC:108	Guidelines for Traffic Prediction on Rural Highways
38.	IRC:111	Specifications for Dense Graded Bituminous Mixes
39.	IRC:112	Code of Practice for Concrete Road Bridges
40.	IRC:SP:13	Guidelines for the Design of Small Bridges and Culverts
41.	IRC:SP:16	Guidelines for Surface Evenness of Highway Pavements
42.	IRC:SP:19	Manual for Survey, Investigation and Preparation of Road Projects
43.	IRC:SP:21	Guidelines on Landscaping and Tree Plantation
44.	IRC:SP:23	Vertical Curves for Highways
45.	IRC:SP:42	Guidelines on Road Drainage
46.	IRC:SP:47	Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)
47.	IRC:SP:49	Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement
48.	IRC:SP:53	Guidelines on Use of Modified Bitumen in Road Construction

Sl. No.	*Code/ Document No.*	*Title of the Publication*
49.	IRC:SP:54	Project Preparation Manual for Bridges
50.	IRC:SP:55	Guidelines for Safety in Construction Zones
51.	IRC:SP:58	Guidelines for Use of Flyash in Road Embankments
52.	IRC:SP:63	Guidelines for the Use of Interlocking Concrete Block Pavement
53.	IRC:SP:69	Guidelines & Specifications for Expansion Joints (First Revision)
54.	IRC:SP:70	Guidelines for the Use of High Performance Concrete in Bridges
55.	IRC:SP:71	Guidelines for Design and Construction of Pretensioned Girder of Bridges
56.	IRC:SP:80	Guidelines for Corrosion Prevention, Monitoring and Remedial Measures for Concrete Bridge Structures
57.	IRC:SP:83	Guidelines for Maintenance, Repairs & Rehabilitation of Cement Concrete Pavements
58.	IRC:SP-85	Guidelines for Variable Message Signs
59.	IRC:SP-88	Road Safety Audit Manual
60.	IRC:SP-89	Guidelines for Soil and Granular Material Stabilization Using Cement Lime and Fly Ash
61.	IRC:SP-90	Manual for Grade Separators and Elevated Structures
62.	IRC:SP-91	Guidelines for Road Tunnels
63.	IRC:SP-93	Guidelines on Requirements for Environmental Clearance for Road Projects
64.	IRC:-	Structural Evaluation and Strengthening of Flexible Road Pavements Using FWD (under print)

Appendix – 2

(Refer Clause 1.11)

List of Paras for preparing schedules of the Concession Agreement (Refer Para 1.11)

Section	***Para***	***Particulars to be specified***
Section 1	1.12(i)	Number of lanes to be providesd for the Project Expressway
	1.16	Utilities to be constructed/shifted
Section 2	2.3	Right of way and land to be acquired
	2.5.1	Type and width median in various stretches
	2.9.2.3	List of sections where radius of curve less than desirable minimum
	2.10.1	Width of underpasses
	2.10.2	Pedestrian and cattle underpasses where vertical clearance shall be 4.5 m
	2.11.1	Width of overpasses and span arrangement
	2.12.2	Location of interchanges
	2.12.3	Location and length of other details and specifications of connecting roads
	2.13.1	Location and other features of grade separated structures
	2.13.2	(i) Type of structure for vehicular underpass or overpass and whether cross road shall be carried at the existing level or raised/lowered. (ii) Stretches where the Project Expressway shall be elevated or viaduct
	2.13.3	Location of light vehicle underpasses
	2.13.4	Location of cattle and pedestrian underpasses or overpasses
	2.15	Distance of fencing from the ROW boundary
Section 3	3.1.1 and 3.2.1	Location and type of grade separated structures, interchanges, other features and land requirements
	3.2.3	Length of viaduct of grade separated structures
Section 5	5.2.1	Type of pavement
Section 6	6.1 (ii)	Provision of structures, initial configuration
	6.1 (vii)	Utility services to be carried over the structures

Section	*Para*	*Particulars to be specified*
	6.4 (iv)	Requirement of special structures like cable stayed/ superstructure bridge, etc.
	6.4(v)	Span length of structures
Section 7	7.1.3	Requirement of Tunnel – Locations, length and number of lanes
Section 10	10.2.8	Location and size of Over Head Signs
Section 13	13.1	Location of Service Areas, Toilet Facilities
	13.2	Location of Pick-up Bus Stops
	13.3	Location of Border Check Post
Section 14	14.3.1	Number of Trees to be planted
	14.4	Locations for landscape treatment
Section 15	15.1 (i) and 15.4	Locations for providing lighting

ANNEXURE

PERSONNEL OF PROJECT PREPARATION, CONTRACT MANAGEMENT & QUALITY ASSURANCE COMMITTEE (G-1)

S.K.. Puri	.....	Convenor
P.K.Datta	.....	Co-Convenor
K.Venkata Ramana	.....	Member-Secretary

Members

A.K. Banerjee	K. Siva Reddy	Palash Shrivastava
A.K. Sarin	K.R.S. Ganesan	R.K. Pandey
A.P. Bahadur	L.P. Padhy	R.S. Mahalaha
Ashok Kumar	M.K. Dasgupta	R.S. Sharma
Ashwini Kumar	M.P. Sharma	R. Chakrapani
Atar Singh	Maj. Gen K.T. Gajria	S.K. Nirmal
Col. A.K. Bhasin	N.K. Sinha	S.V. Patwardhan
D.P. Gupta	P.R. Rao	Varun Aggarwal
Faqir Chand		

Ex-Officio Members

Shri C. Kandasamy	Director General (Road Development) & Special Secretary, MORTH and President, IRC
Shri Vishnu Shankar Prasad	Secretary General, IRC

PERSONNEL OF THE ROAD SAFETY AND DESIGN COMMITTEE (H-7)

Dr. L.R. Kadiyali	.....	Convenor
C.S. Prasad	.....	Co-Convenor
Dr. GeetamTiwari	.....	Member-Secretary

Members

A.P. Bahadur	Manoj Kumar Ahuja
Amarjit Singh	Prof. P.K. Sikdar
B.G. Sreedevi	S.C. Sharma
Bina C. Balakrishnan	The Addl. Director General of Police, Bangalore (Praveen Sood)
D.P. Gupta	The Chief Engineer, (R) S, R&T, MORTH (Manoj Kumar)
Dr. Dinesh Mohan	The Director, Gujarat Engineering Research Institute
Dr. I.K. Pateriya	The Director, Quality Assurance & Research (formely HRS)
Dr. Ravi Shankar	The Director, Transport Research Wing, MORTH
Dr. S.M. Sarin	The Head, TED, CRRI (Dr. Nishi Mittal)
Dr. S.S. Jain	The Joint Commissioner of Police (Traffic), New Delhi
Dr. Sewa Ram	Yuvraj Singh Ahuja

Ex-Officio Members

Shri C. Kandasamy	Director General (Road Development) & Special Secretary, MORTH and President, IRC
Shri Vishnu Shankar Prasad	Secretary General, IRC

(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)