Section 2

Geometric Design and General Features

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GEOMETRIC DESIGN AND GENERAL FEATURES

2.1 General

(i) This Section lays down the standards for geometric design and general features for upgrading the existing state highways/major district roads to two-lane with or without paved shoulders.

(ii) (a) Stretches passing through built up areas shall normally be provided with 4-lane divided carriageway (Fig. 2.2). Such stretches shall be indicated in Schedule-B of the Concession Agreement. Additional land, if any, required for 4-laning shall be acquired by the Government and where the land is yet to be acquired, the date of handing over the land to the Concessionaire shall be indicated.

(b) Where there are constraints of existing ROW width or difficulty in acquiring land along the existing alignment in built up areas, the Government may specify construction of a bypass instead of 4-laning. The alignment of the bypass shall be specified by the Government. The land for the bypass shall be acquired by the Government and where the land is yet to be acquired, the date of handing over the land to the Concessionaire shall be indicated. The bypass shall be access controlled, unless specified otherwise. In case, the Government decides to provide two-lane carriageway for the bypass, the same shall be placed eccentrically with respect to the ROW to facilitate proper widening to four lanes in future.

(iii) The geometric design of the Project Highway 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.

(iv) As far as possible, uniformity of design standards shall be maintained throughout the length. In case of any change, it shall be effected in a gradual manner.

(v) Where the existing road geometrics are deficient with respect to minimum requirements and its improvement to the prescribed standards requires acquisition of additional land, such stretches shall be specified in Schedule-B of the Concession Agreement. Additional land as required shall be provided by the Government.

(vi) Existing horizontal curves, which are found deficient in radius, layout, transition lengths or superelevation shall be corrected to the specified standards.

(vii) Any deficiencies in the vertical profile in respect of grades, layout of vertical curves and sight distance shall be corrected to meet the minimum specified requirements.

2.2 Design Speed

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

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

Table 2.1 : Design Speed

Nature of Terrain	Cross slope of the ground	Design speed (km/hr)	
		Ruling	Minimum
Plain	Less than 10 per cent	100	80
Rolling	Between 10 and 25 per cent	80	65
Mountainous	Between 25 and 60 per cent	50	40
Steep	More than 60 per cent	40	30

section of Project Highway.

2.2.3 In general, the ruling design speed shall be adopted for the various geometric design features of the road. Minimum design speed shall be adopted where site conditions are restrictive and adequate land width is not available. The Concessionaire shall improve the alignment as per the requirement for ruling design speed as and when the Government provides land. Such stretches shall be indicated in Schedule-B of the Concession Agreement. Land for such stretches shall be provided by the Government not later than five years from the date of commercial operation (COD). Abrupt changes in design speed shall be avoided.

2.3 Right of Way

The Right of Way (ROW) is the total land width required for the Project Highway, to accommodate the roadway (carriageway and shoulders), side drains, service roads, tree plantation, utilities, etc. The ROW available for the Project Highway shall be as given in Schedule-A of the Concession Agreement. The Government should acquire additional land accordingly. The land to be so acquired shall be indicated in Annexure II of Schedule-A of the Concession Agreement. The desirable Right of Way for Non-urban & Urban areas should be as prescribed in IRC:73 & IRC:86 respectively.

2.4 Lane width of Carriageway

The standard lane width of the Project Highway shall be 3.5 m.

2.5 Shoulders

2.5.1 *Width of Shoulders*

The normal shoulder width shall be as per table 2.2.

Table 2.2 : Width of Shoulder

Type of Section	Width of Shoulder (m)		
	Plain and Rolling Terrain (Either side)	Mountainous and Steep Terrain*	
		Hill side	Valley side
Open country with isolated built up area	2.5 m	1.0 m	2.0 m
Built up area	2.5 m	1.0 m	2.0 m

**exclusive of parapets and side drains*

2.5.2 *Type of Shoulder*

The type of shoulder shall be as below:

(i) In the built up section, the shoulder shall be fully paved or footpath shall be provided where specified in Schedule-B of the Concession Agreement.

(ii) In open country with isolated built up area, and where average daily traffic is less than 8,000 PCUs in plain terrain or 6,500 PCUs in rolling terrain, the shoulder shall be covered with 150 mm thick layer of granular material conforming to the requirements given in para 5.9.10.

(iii) In open country with isolated built up area and having plain or rolling terrain and where average daily traffic is greater than 10,000 PCUs in plain terrain or 8,000 PCUs in rolling terrain, 1.5 m width adjacent to the carriageway shall be paved in accordance with para 5.9.9 of this Manual and balance 1.0 m shall be covered with 150 mm thick layer of granular material.

(iv) In open country having mountainous/steep terrain, the shoulders shall be of locally available hard material.

2.6 Roadway Width

2.6.1 The width of roadway, unless specified otherwise, shall be as follows:

Plain/Rolling Terrain	–	12.0 m
Mountainous and Steep Terrain	–	10.0 m (exclusive of parapets and drains)

2.6.2 On horizontal curves with radius up to 300 m, width of pavement and roadway shall be increased as per Table 2.3.

Table 2.3 : Extra Width of Pavement and Roadway

Radius of Curve	Extra Width
Upto 40 m	1.5 m
41-60 m	1.2 m
61-100 m	0.9 m
101-300 m	0.6 m

2.7 Camber or Crossfall

2.7.1 The camber or crossfall on straight sections of road carriageway and shoulders shall be as per Table 2.4.

Table 2.4 : Camber/Crossfall in percentage for different Surface Types

Category of surface	Annual Low rainfall (less than 1500 mm)	Annual High rainfall (more than 1500 mm)
Bituminous	2.5 %	2.5 %
Cement Concrete	2.0 %	2.0 %
Metal/Gravel	2.5 %	3.0 %
Earth	3.0 %	4.0 %

2.7.2 The two-lane roads shall be provided with a crown in the middle. On horizontal curves, the carriageway shall be superelevated.

2.7.3 The camber for earthen shoulders on straight portions shall be at least 0.5 per cent steeper than the slope of the pavement and paved shoulder subject to a minimum of 3.0 per cent. On super elevated sections, the shoulders shall have the same crossfall as the carriageway.

2.8 Horizontal Alignment

2.8.1 While designing the horizontal alignment, the following general principles shall be kept in view:

(i) Alignment should be fluent and it should blend well with the surrounding topography.

(ii) On new roads, the curves should be designed to have largest practical radius, but in no case less than ruling value corresponding to ruling design speed.

(iii) As a normal rule, sharp curves should not be introduced at the end of long tangent since these can be extremely hazardous.

(iv) The curves should be sufficiently long and they should have suitable transitions to provide pleasing appearance.

(v) Reverse curves shall be avoided as far as possible. Where unavoidable, sufficient length between two curves shall be provided for introduction of requisite transition curves.

(vi) Curves in the same direction, separated by short tangents known as broken back curves, should be avoided as far as possible.

(vii) To avoid distortion in appearance, the horizontal alignment should be coordinated carefully with the longitudinal profile.

(viii) Hairpin bends on hilly terrain should be avoided as far as possible.

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

2.8.3 *Superelevation*

(i) Superelevation shall be provided on curves as per details given in IRC:73 corresponding to the design speed adopted.

(ii) Superelevation shall be limited to 7 per cent.

(iii) Superelevation shall not be less than the minimum specified cross fall/ camber.

2.8.4 *Radii of Horizontal Curves*

The desirable minimum and absolute minimum radii of horizontal curves for various classes of terrain are given in Table 2.5.

Table 2.5 : Minimum Radii of Horizontal Curves

Nature of terrain	Desirable minimum	Absolute minimum
Plain	360 m	230 m
Rolling	230 m	155 m
Mountainous	90 m	60 m
Steep	60 m	30 m

The radius of horizontal curves for various terrain conditions shall not be less than the desirable values given in Table 2.5 except where site conditions are restrictive and adequate land is not available. Where such restrictions exist, the radius of curve shall not be less than the specified absolute minimum value.

2.8.5 *Transition Curves*

Minimum length of transition curve shall be determined from the following two considerations and the larger of the two values adopted for design:

(i) The rate of change of centrifugal acceleration should not cause discomfort to drivers. From this consideration, the length of transition curve is given by:

$Ls = 0.0215\ V^3/CR$,

Where:

Ls = Length of transition curve in metres,
V = Speed in km/hr,
R = Radius of circular curve in metres,
C = 80/(75 + V) (subject to a maximum of 0.8 and minimum of 0.5)

(ii) The rate of change of superelevation should be such as not to cause discomfort to travelers. Further, rate of change should not be steeper than 1 in 150 for roads in plain/rolling terrain, and 1 in 60 in mountainous/steep terrain. The formula for minimum length of transition on this basis is:

$Ls = 2.7\ V^2/R$

2.9 Sight Distance

2.9.1 Visibility is an important requirement for the safety of travel on roads. For this, it is necessary that sight distance of adequate length is available in different situations, to permit drivers enough time and distance to control their vehicles so that chances of accidents are minimized.

2.9.2 On two-lane roads, normally intermediate sight distance should be available throughout. The attempt should, however, be to provide overtaking sight distance in as much length of the road as possible. In stretches where even intermediate sight distance is not available, the safe stopping sight distance should be provided as a last resort. Traffic signs depicting "Overtaking Prohibited:" shall be installed at all such locations.

2.9.3 The recommended sight distances for various speeds are given in Table 2.6.

Table 2.6 : Sight Distances for Various Speeds

Speed (km/hr)	Stopping sight distance (m)	Intermediate sight distance (m)	Overtaking sight distance (m)
100	180	360	640
80	120	240	470
65	90	180	340
50	60	120	235
40	45	90	165
30	30	60	120

2.9.4 The requisite sight distance shall be available across the inner side of horizontal curves.

2.9.5 Where horizontal and summit curves overlap, the design shall provide for the required sight distance, both in the vertical direction, along the pavement and in the horizontal direction on the inner side of curve.

2.10 Vertical Alignment

2.10.1 The vertical alignment should provide for a smooth longitudinal profile. Grade changes should not be too frequent as to cause kinks and visual discontinuities in the profile. The ruling and limiting gradients are given in Table 2.7.

Table 2.7 : Recommended Gradients

Nature of terrain	Ruling gradient	Limiting gradient
Plain and rolling	3.3%	5.0%
Mountainous	5.0%	6.0%
Steep	6.0%	7.0%

2.10.2 Gradients up to the value corresponding to ruling gradient shall be adopted, as far as possible. Limiting gradients shall be adopted only in very difficult situations and for short lengths.

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

2.10.4 For design of vertical curves and its co-ordination with horizontal curves, reference may be made to IRC:SP:23.

2.11 Lateral and Vertical Clearance at Underpasses

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

2.11.1 *Lateral Clearance*

(i) Full roadway width at the approaches including service roads, if any, shall be carried through the underpass. Provision shall also be made for future expansion of the cross road for at least next 10 years.

(ii) Guardrails shall be provided for protecting vehicles from colliding with the abutments/piers and the deck of the structures.

2.11.2 *Vertical Clearance*

Vertical clearance at underpasses shall not be less than the values given below:

(i) Vehicular underpass 5.5 m

(ii) Pedestrian and Cattle underpass 3.0 m

2.12 Lateral and Vertical Clearance at Overpasses

Wherever any structure crosses over the Project Highway, the minimum clearances at overpasses shall be as follows:

2.12.1 *Lateral Clearance*

Full roadway width including service roads, if any, shall be carried through the overpass structure. Provision shall also be made for future widening of the Project Highway. The abutments and piers shall be provided with suitable protection against collision of vehicles. Guardrails shall be provided on abutment side and on sides of piers for this purpose. The ends of guardrails shall be turned away from the line of approaching traffic.

2.12.2 *Vertical Clearance*

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

the Project Highway to the nearest surface of the overpass structure.

2.13 Service Roads

2.13.1 Service roads wherever required to be constructed by the Concessionaire, shall be specified in Schedule-B of the Concession Agreement.

2.13.2 Service roads shall be constructed and maintained in accordance with the provisions of the Concession Agreement. The width of service roads shall be minimum 5.5 m.

2.13.3 The crust composition of service roads shall not be lower than that specified in IRC:37 for 1 (one) msa design traffic.

2.14 Grade separated Structures

2.14.1 The type, location, length, number and the openings required to be provided for various types of grade separated structures shall be as specified by the Government in Schedule-B of the Concession Agreement.

2.14.2 *Vehicular Underpass/Overpass*

The vehicular underpass/overpass structures shall be provided at the intersection of the Project Highway with all roads carrying an average daily traffic of more than 15,000 PCUs, unless specified otherwise. 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. Type of the structure shall be specified in Schedule-B of the Concession Agreement.

2.14.3 *Cattle and Pedestrian Underpass/ Overpass*

(i) In certain stretches, underpasses/ overpasses for crossing of cattle and pedestrians shall be provided at locations indicated in Schedule-B of the Concession Agreement.

(ii) The width of Pedestrian or Cattle crossing shall not be less than 5 m.

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

2.15 Typical Cross-Sections

2.15.1 Typical cross-sections of Project Highway are given in Figs. 2.1 to 2.5. These shall be adopted for various locations, as applicable.

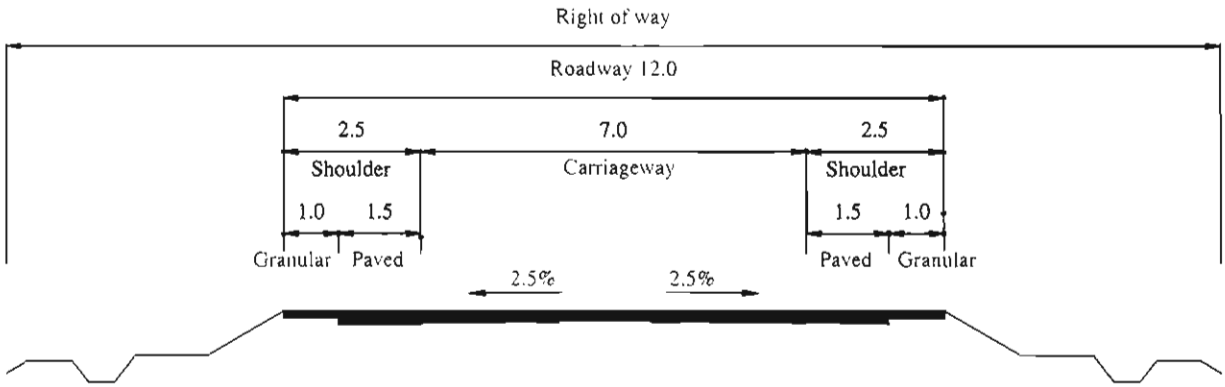
2.15.2 Where cross-section changes from two-lane to four-lane, a transition of 1 in 15 to 1 in 20 must be provided, as prescribed in IRC:73 (Cl. 6.6.2) & IRC:86 (Cl. 6.2.7).

2.16 Capacity of two-lane highway

The design service volume of two-lane highway for different types of terrain shall be as given in Table 2.8.

Table 2.8 : Design Service Volume of Two-lane Highway in PCUs per day

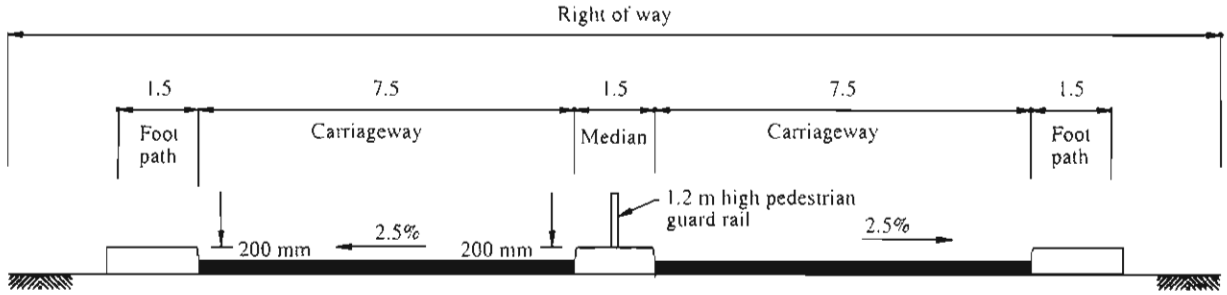
Nature of Terrain	Design Service Volume in PCUs per day	
	without paved shoulder	with minimum 1.5 m paved shoulder
Plain	15,000	18,000
Rolling	11,000	13,000
Mountainous and Steep	7,000	9,000



Note:
All dimensions are in metres.

Typical cross section
(Open country-plain/rolling terrain)
2-lane carriageway (with paved shoulders)
without service road

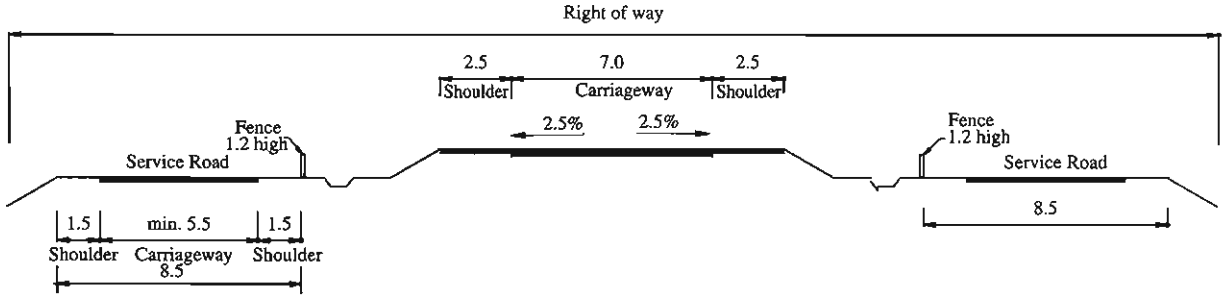
Fig. 2.1



Note:
All dimensions are in metres except as shown otherwise.

Typical cross section
(Built-up area)
4-lane divided carriageway with footpath

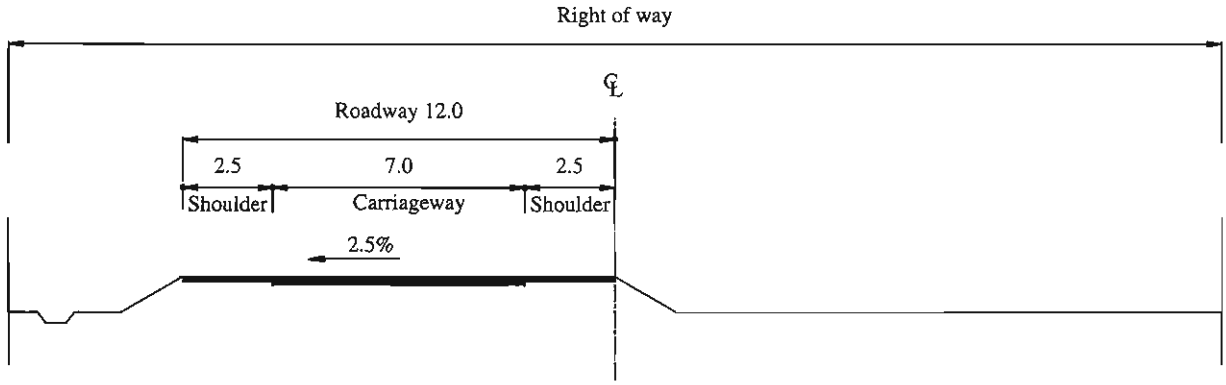
Fig. 2.2



Note:
1. All dimensions are in metres.
2. Dimensions of footpath and service roads are minimum and higher may be adopted as per requirement.

Typical cross section
2-lane carriageway with service road

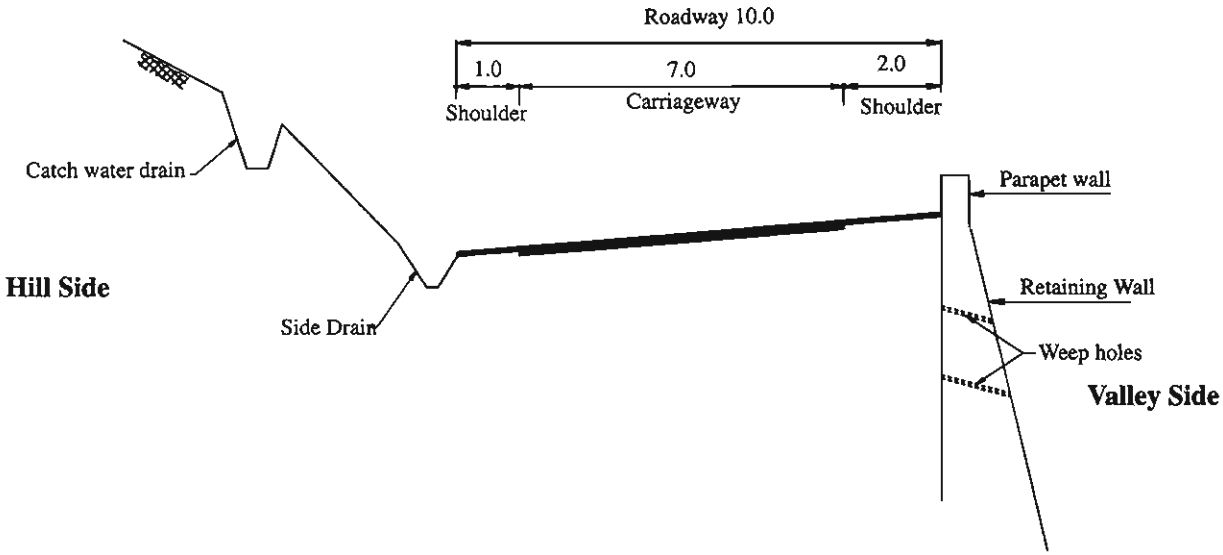
Fig. 2.3



Note:
All dimensions are in metres.

Typical cross section
(Plain/rolling terrain)
Eccentrically placed 2-lane bypass

Fig. 2.4



Note:
1. All dimensions are in metres.
2. Shoulders covered with locally available hard material (Paved shoulders in built up area).

Typical cross section
(Mountainous terrain)
2-lane carriageway

Fig. 2.5