MCE-103 HILLTRANSPORTATION 5 Credits (3-1-2)

UNIT I

Introduction: Special aspects of hill roads, preliminary investigations, Classification of hill roads, Environmental considerations and their impacts

UNIT II

Alignment of Hill Roads: Basic considerations, Survey and requirements of alignments, Gradient and selection of alignments, Future traffic considerations, Cross drainage.

Geometric Design of Hills Roads: Types of hill zones and terrain, Geometric Elements, Width of formation and land, Right of way, Speed limit requirement, Camber, Gradients, Sight distances, Horizontal curves Superelevation
curves, Super-elevations, Transition curves, Pavement widening curves, Hair-pin-bends, Over-takingcrossing places, Vertical curves, Minimum vertical clearance.

UNIT III

Rock Blasting and Cutting Techniques: Rock cutting and blasting, Mechanism of blasting, Explosives for rockblasting and techniques for blasting, Drilling pattern.

Retaining Walls: Types of retaining walls, Stability of slopes, Backpressure on retaining walls, Design of retaining walls

UNIT IV

Drainage in Hill Roads: Drainage of water form hill slope, Roadside drains, Cross drainage, sub surface drainage

Maintenance Problems of Hill Roads: Common problems and their causes, Landslide Problems, Types of Landslides, Measures to prevent landslides, Breast walls

Safety Requirements and Labour Laws: Importance of safety and Labour laws on hill roads, type of accidents,accidents during hill cutting and blasting. Accidents with machines, various safety measures, Remedial measures, Labour regulation laws

LABORATORY WORK

1.Crushing Value Test ofAggregate
2. Impact Value Test ofAggregate
3. Los Angeles Abrasion Value ofAggregate
4. Shape Test (Flakiness Index, Elongation Index) ofAggregate
5. Penetration Test of BituminousSample
6. Softening Point Test of BituminousSample
7. Stripping Test of BituminousSample
8. DuctilityTestofBituminousSample
9. Flash & Fire Point Test of BituminousSample
10. Classified both directional Traffic Volume Study
11. Traffic Speed Study (Using Radar Speedometer orEnoscope)
12. Marshall test

Books & References:

1. Highway Engineering-S.P. Bindra(DanpatRai Publication, NewDelhi)

2. Transportation Engineering (Vol.1)-V.N. Vazirani & S.P. Chandola (Khanna Publications, NewDelhi)

3. Highway Engineering-L.R. Kadiyali& Dr. N.B. Lal (Khanna Publications, NewDelhi)

4.IRC 52:2019

2. DEFINITIONS

2.1. **Steep terrain,** is a terrain where cross slope of the country is generally greater than 60 per cent.

2.2. **Mountainous terrain,** is a terrain with cross slope ranging from 25 to 60 per cent.

2.3. **Rolling terrain,** is a terrain with cross slope between 10 and 25 per cent.

2.4. **Plain terrain,** is a terrain where cross slope of the country is generally less than 10 per cent.

2.5. **Ruling gradient,** is a gradient which in the normal course must never be exceeded in any part of a road.

2.6. **Limiting gradient,** is a gradient steeper than the ruling gradient which may be used in restricted lengths where keeping within the ruling gradient is not feasible.

2.7. **Exceptional gradient,** is a gradient steeper than the limiting gradient which may be used in short stretches only in extra-ordinary situations.

HILL ROAD

- **Classified based on terrain.**

Sr. No	Type of terrain	Cross slope
1	Plain or Level terrain	0 to 10 %
2	Rolling terrain	10 to 25
3	**Mountainous**	**25 to 60**
4	**Steep**	**Above 60**

- Roads located in terrain having Cross slope of 25% or more considered Hill road or Ghat road

HILL ROAD

- **Characteristics**
- Cross slope of 25% or more
- Widely differing elevation
- Steep slope
- Great number of water courses.

HILL ROAD

- **Our objectives**
- Shortest route
- Safe route
- Economy
- Less VOC (Vehicle operating cost)
- Less maintenance.

Problems with Hill Road

- Alignment
- Stability.
- Soil erosion
- Land slides
- Maintenance.
- Drainage.
- Snow fall

Importance of Hill Road

- Economic development.
- Industrial development
- Forest wealth.
- Strategic consideration.
- Tourism

Classification of Hill Road

1)According to Boarder Road Organization. (B.R.O.)

- NH,
- Class-9(6m wide),
- Class-5(4.9 mt wide),
- Class-3 (2.45 to 3.65 mt wide)

2) According to general classification.

- N.H., S.H., MDR, ODR, VR

3) According to use.

- Motor road(for fast vehicle),
- Bridle Road(for pedestrian,horse),
- Village track.

Elementary Principles of Alignment in Hilly area

Features of Good alignment for **Ghat road**

1) Minimum cost
2) Comfortable travel
3) Lower VOC
4) Stable and safe road.
5) Sharp curve with small radius.
6) Easy gradients.
7) Minimum cutting and filling.
8) Minimum walling and bridging.

Elementary Principles of Alignment in Hilly area

Principles for **Ghat road at a glance**

1) Stability. (Common problem land slide)
2) Drainage. (Minimum C.D. works)
3) Geometric standards of Hill Road.
4) Resisting length. (as low as possible)

- Ineffective rise -minimum
- Excessive fall.-minimum

$$Resisting\ length\ = \frac{Actual\ difference\ in\ levels\ between\ the\ two\ atations}{Sum\ of\ ineffective\ rise\ and\ falls\ (in\ excess\ of\ floating\ gradient)}$$

Engineering Surveys for Highway locations

Before a highway alignment is finalised in highway project, the engineering survey are to be carried out. The various stages of engineering surveys are

- **Map study (Provisional alignment Identification)**
- **Reconnaissance survey**
- **Preliminary survey**
- **Final location and detailed surveys**

HILL ROAD-ALIGNMENT SURVEY

- IRC-52
- ALIGNMENT SURVEY
  - 1) Reconnaissance survey and
    Trace cutting (foot path for detail survey)
  - 2) Preliminary survey
  - 3) Determination of final centerline.
  - 4) Final location survey.

MAP STUDY

- From the map alternative routes can be suggested in the office, if the topographic map of that area is available.
- The probable alignment can be located on the map from the fallowing details available on the map.
  - Avoiding valleys, ponds or lake
  - Avoiding bend of river
  - If road has to cross a row of hills, possibility of crossing through mountain pass.
- Map study gives a rough guidance of the routes to be further surveyed in the field

RECONNAISSANCE SURVEY

- To confirm features indicated on map.
- To examine the general character of the area in field for deciding the most feasible routes for detailed studies.
- A survey party may inspect along the proposed alternative routes of the map in the field with very simple instrument like abney level, tangent clinometer, barometer etc.… To collect additional details.
- Details to be collected from alternative routes during this survey are,
  - Valleys, ponds, lakes, marshy land, hill, permanent structure and other obstruction.
  - Value of gradient, length of gradient and radius of curve.

RECONNAISSANCE SURVEY cont..

- Number and type of cross drainage structures.
- High Flood Level (HFL)
- Soil Characteristics.
- Geological features.
- source of construction materials- stone quarries, water sources.

- Prepare a report on merits and demerits of different alternative routs.
- As a result a few alternate alignments may be chosen for further study based on practical considerations observed at the site.

Preliminary survey

Objective of preliminary survey are:

- To survey the various alternative alignments proposed after the reconnaissance and to collect all the necessary physical information and detail of topography, drainage and soil.
- To compare the different proposals in view of the requirements of the good alignment.
- To estimate quantity of earthwork materials and other construction aspect and to workout the cost of the alternate proposals.

Methods of preliminary survey:

a) **Conventional approach**-survey party carries out surveys using the required field equipment, taking measurement, collecting topographical and other data and carrying out soil survey.

Preliminary survey cont…

- Longitudinal and cross sectional profile.
  - Plain Terrain` : 100 – 200m
  - Rolling Terrain : 50m
  - Hilly Terrain : 30m
- Other studies
  - Drainage, Hydrological survey, soil survey, Traffic and Material survey.

b) Modern rapid approach-

By Aerial survey taking the required aerial photographs for obtaining the necessary topographic and other maps including details of soil and geology.

- Finalise the best alignment from all considerations by comparative analysis of alternative routes.

Final location and detailed survey

- The alignment finalised at the design office after the preliminary survey is to be first located on the field by establishing the centre line.

Location survey:

- Transferring the alignment on to ground.
- This is done by transit theodolite.
- Major and minor control points are established on the ground and centre pegs are driven, checking the geometric design requirements.
- Centre line stacks are driven at suitable intervals, say 50m interval in plane and rolling terrains and 20m in hilly terrain.

Final location and detailed survey cont..

Detailed survey:

- Temporary bench marks are fixed at intervals of about 250m and at all drainage and under pass structure.
- Earthwork calculations and drainage details are to be workout from the level books.
- Cross sectional levels are taken at intervals of 50-100m in Plane terrain, 50-75m in Rolling terrain, 50m in built-up area, 20m in Hill terrain.
- Detail soil survey is to be carried out.
- CBR value of the soils along the alignment may be determined for design of pavement.
- The data during detailed survey should be elaborate and complete for preparing detailed plans, design and estimates of project.

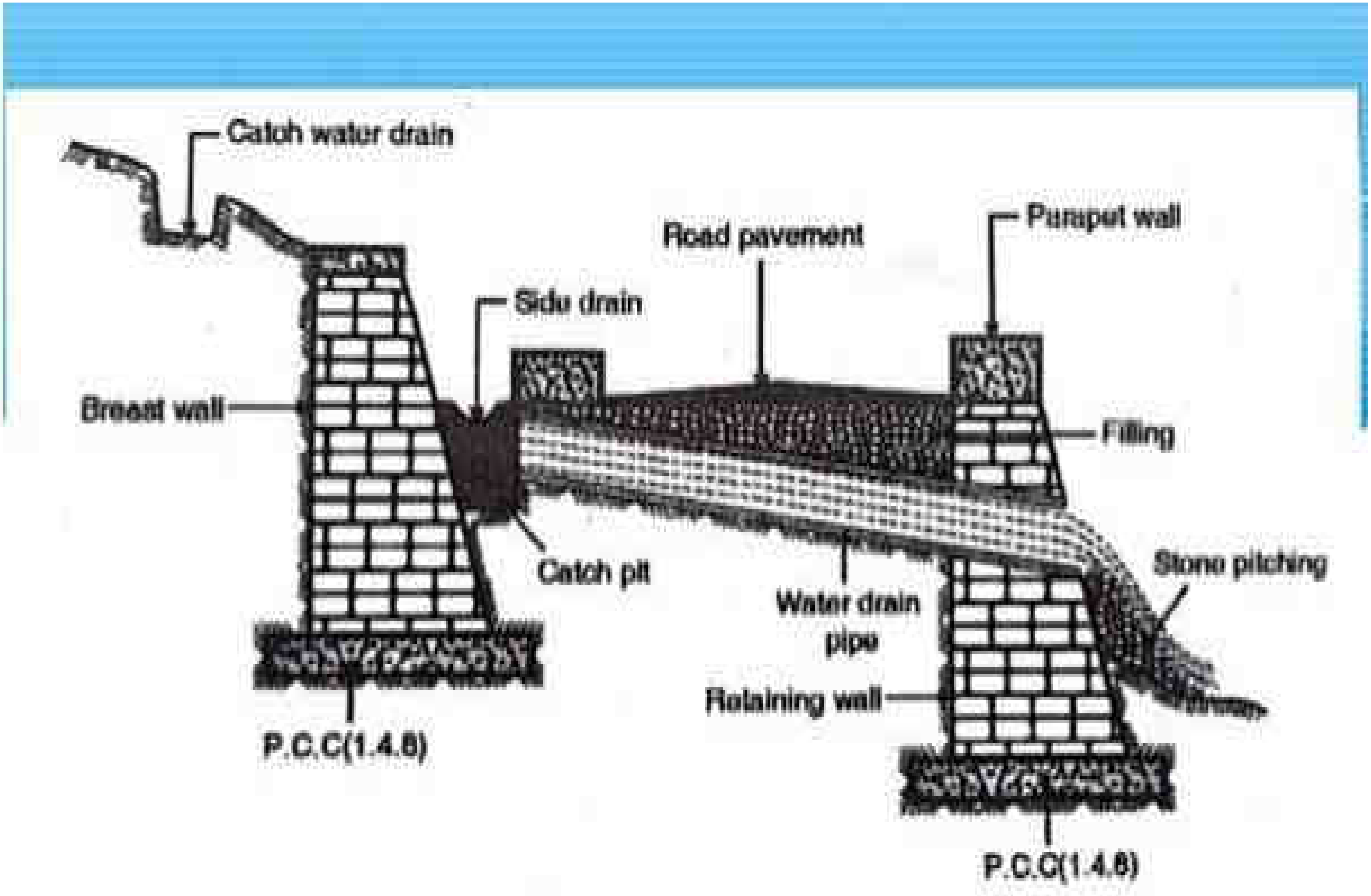
Drawing and Report

- Key map
- Index map
- Preliminary survey plans
- Detailed plan and longitudinal section
- Detailed cross section
- Land acquisition plans
- Drawings of cross drainage and other retaining structures
- Drawings of road intersections
- Land plans showing quarries etc

New highway project

- Map study
- Reconnaissance survey
- Preliminary survey
- Location of final alignment
- Detailed survey
- Material survey
- Geometric and structural design
- Earth work
- Pavement construction
- Construction controls

Components of Hill roads



Elementary Principles of Alignment in Hilly area

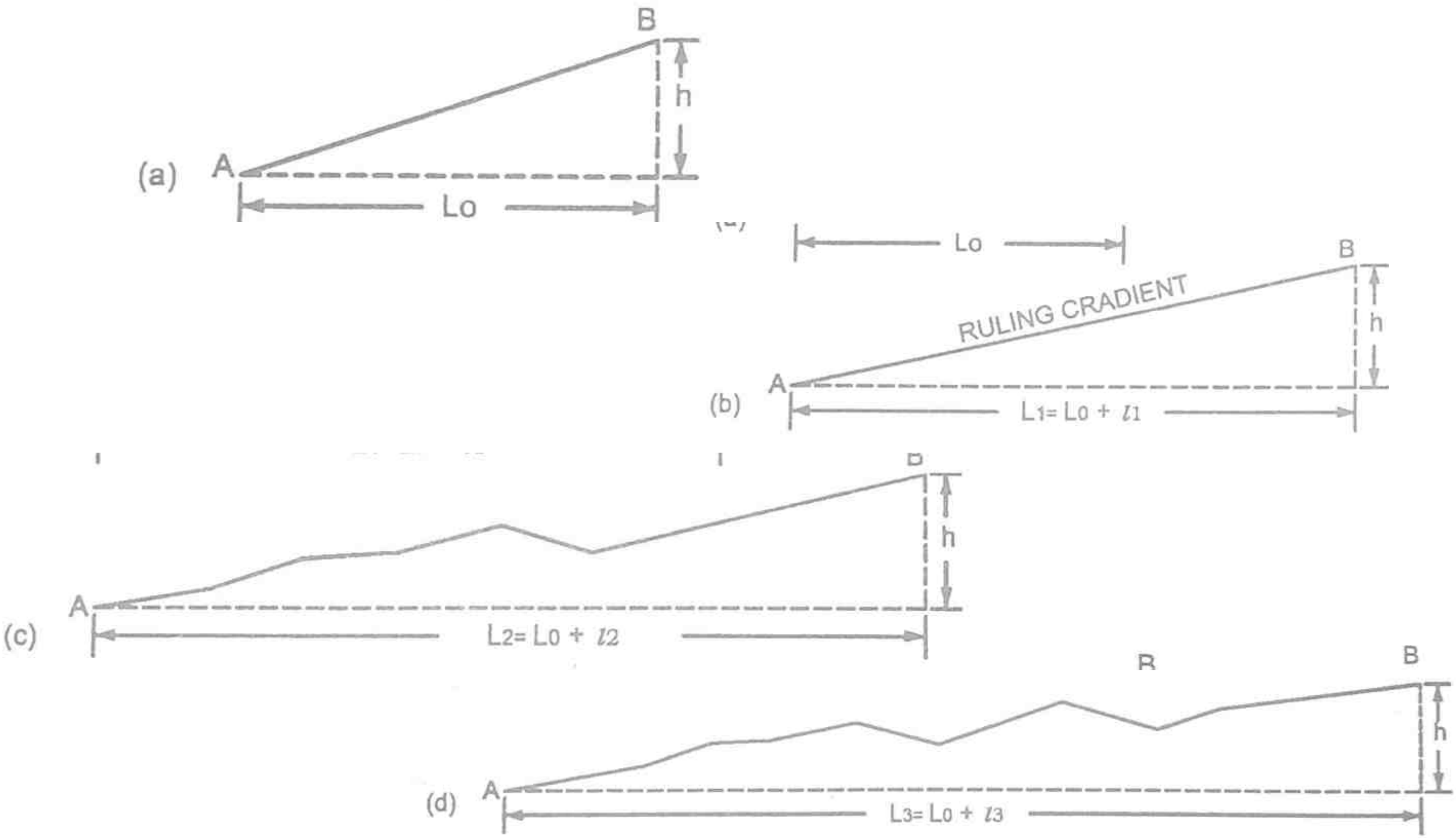


Table 19.2. Environmental Parameters for Highway Projects

1. Surface Water Quality
2. Air Quality
3. Seismology/Geology
4. Hydrology and Drainage
5. Soils
6. Erosion (Landslides, snow slides/drift, etc.)
7. Land Quality and Land Use
8. Fisheries and Aquaculture
9. Forests
10. Terrain and Topography
11. Terrestrial Wild life
12. Noise
13. Aesthetics
14. Industries
15. Habitat
16. Resettlement
17. Archeological/Historic Significance sites
18. Public/Private Institutions of repute
19. Religious sites/places
20. Architectural sites
21. Public health
22. Socio-economic aspects
23. Agriculture and farming

The guidelines prescribe the following procedure for assessing highway projects tally.

ı) **Environmental Impact Assessment (EIA)**

This is a procedure for bringing out the potential effects of human activities on environmental systems, identifying positive and negative effects resulting from the construction of projects considering various alternative sites or options and drawing out a list of parameters relevant to the project.

›) **Environmental Impact Statement (EIS)**

The environmental impact assessment is to be followed by Environmental Impact Statement. The basic objective of the EIS is to identify, predict and evaluate the likely impacts of a given activity and then prepare necessary action plans to eliminate or mitigate the adverse impacts as a part of the overall environment management plan. EIS should cover the following:

i. A brief discussion of the project.

ii. Description of the existing environment.

iii. Likely impacts of the proposed project both adverse and beneficial; reversible, short/long term impacts.

iv. Mitigation, protection and enhancement measures.

v. Consideration of alternatives.

vi. Effect of no - change alternative.

These steps are necessary to predict the likely adverse consequence which will result not only in avoidable loss of natural resources but also additional expenditure. To cite an instance, absence of catchment area treatment may lead to loss of fertile top soil, flash floods and reduction of live storage of reservoirs. The adverse consequences result in loss of national assets such as land, water, forests and a vast variety of plants and animals.

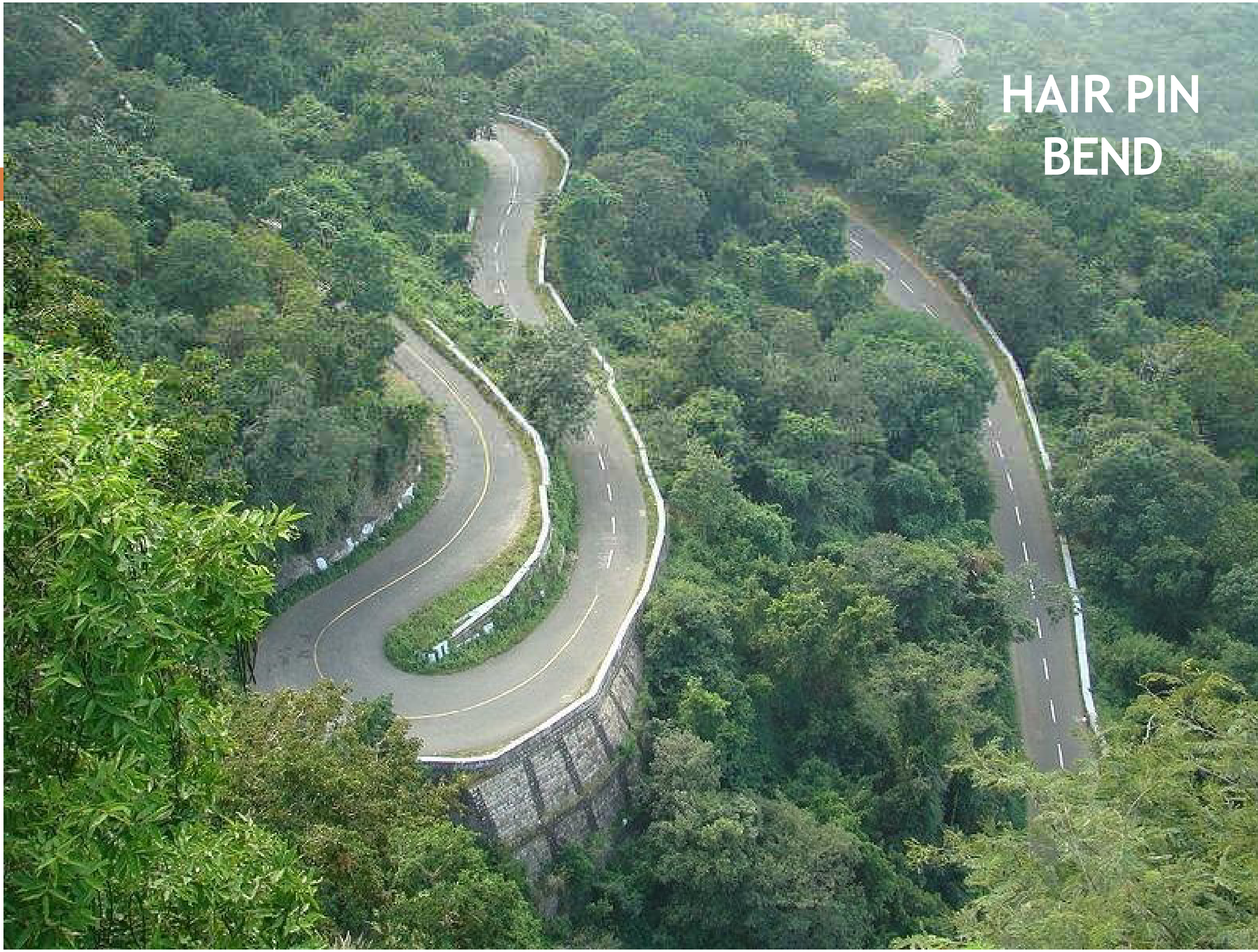
:) **Environment Management Plan (EMP)**

The Environment Management Plan is an implementation plan for carrying out mitigation, protection and enhancement measures as are recommended by the EIS. The EMP gives details as to how these measures should be operated, the resources required and the schedule for implementation.

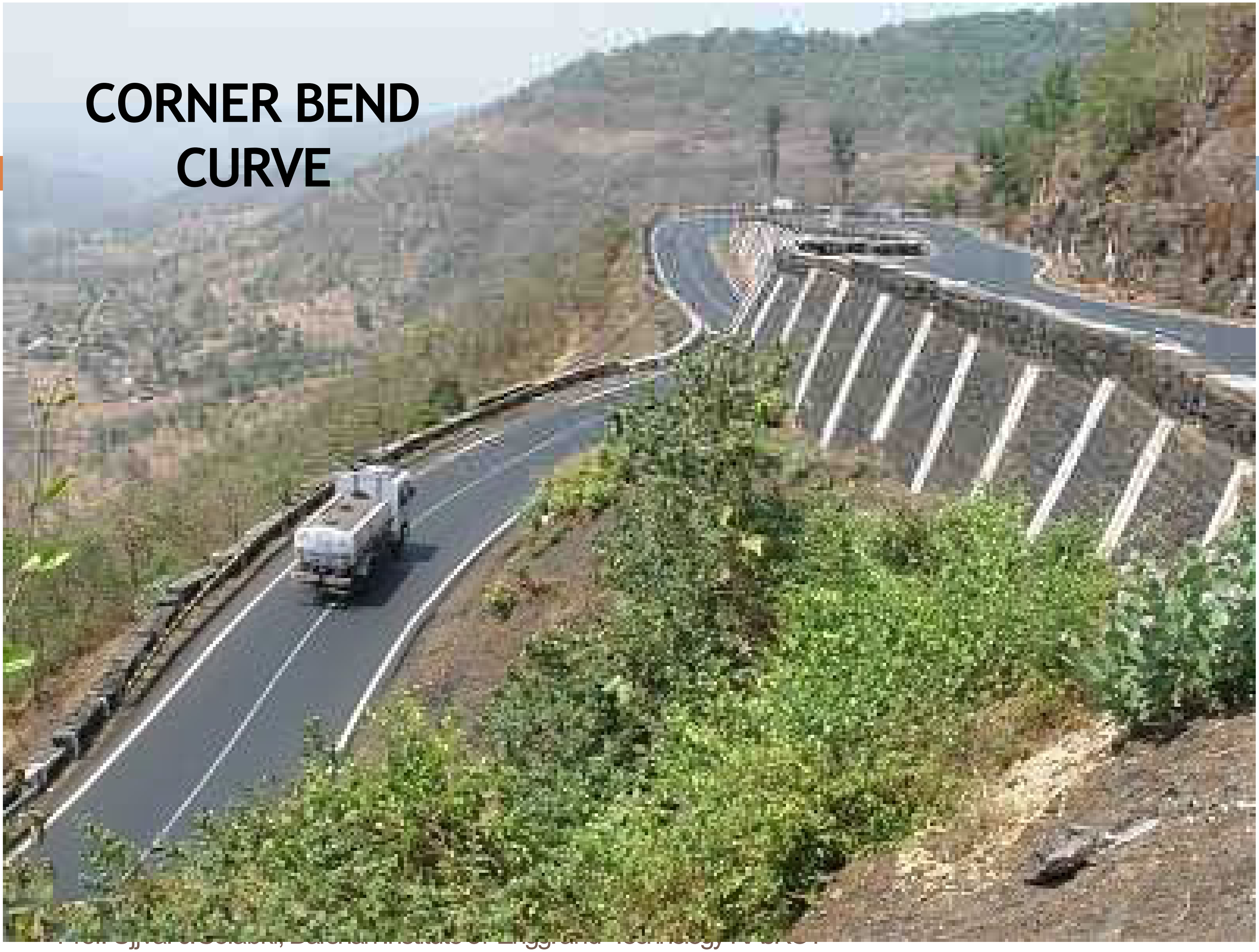
Types of Curves in alignment of Hill Road

- Hair pin Bend
  - Min straight length-20mt,
  - Min design speed 20 kmph
  - Min. R=14mt, e= 1in 10
  - Gradient =Min. 1 in 200, Max 1 in 4o
- Corner bend
- Salient curve
- Re-entrant curve

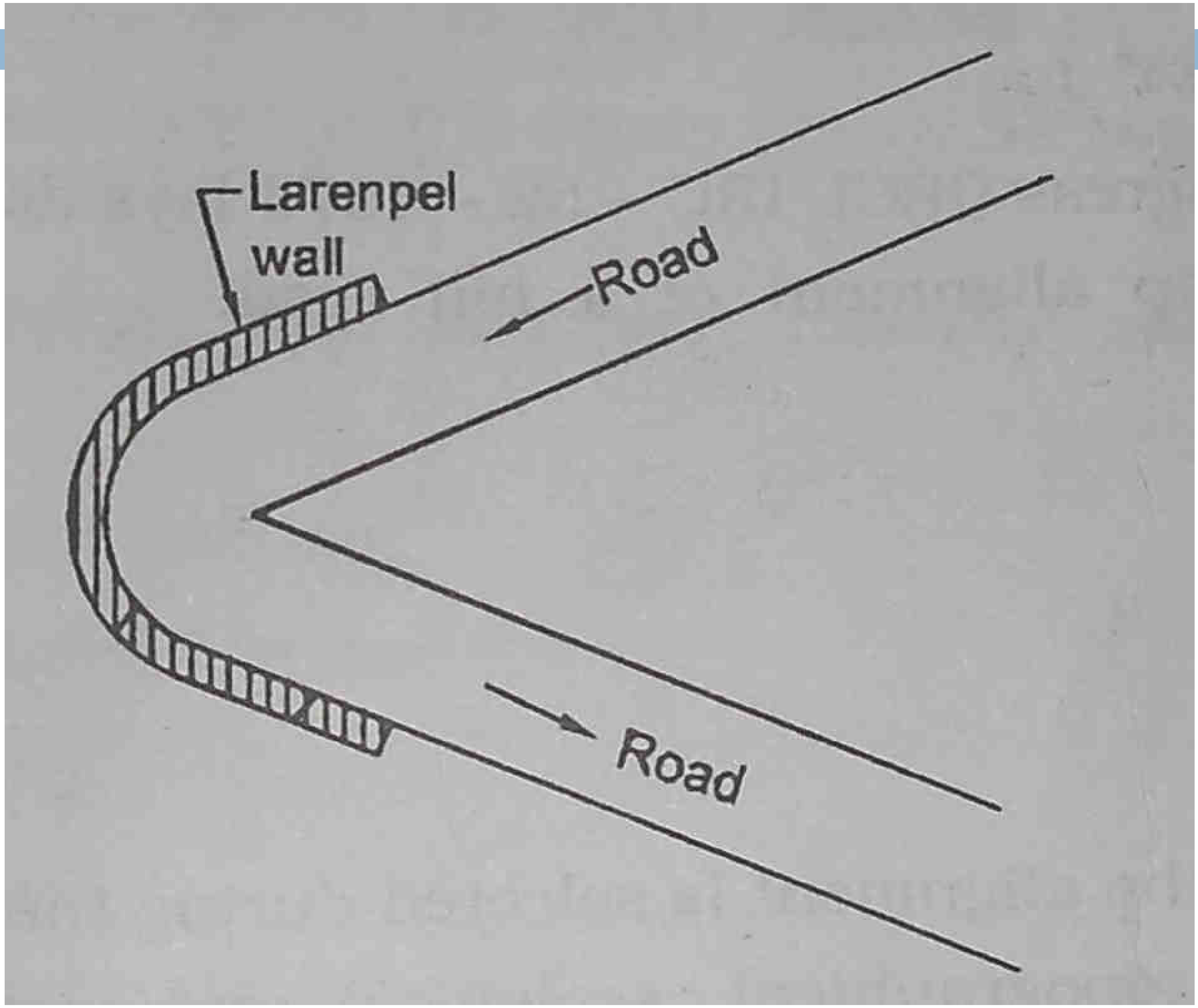
HAIRPIN BEND CURVE


HAIR PIN
BEND

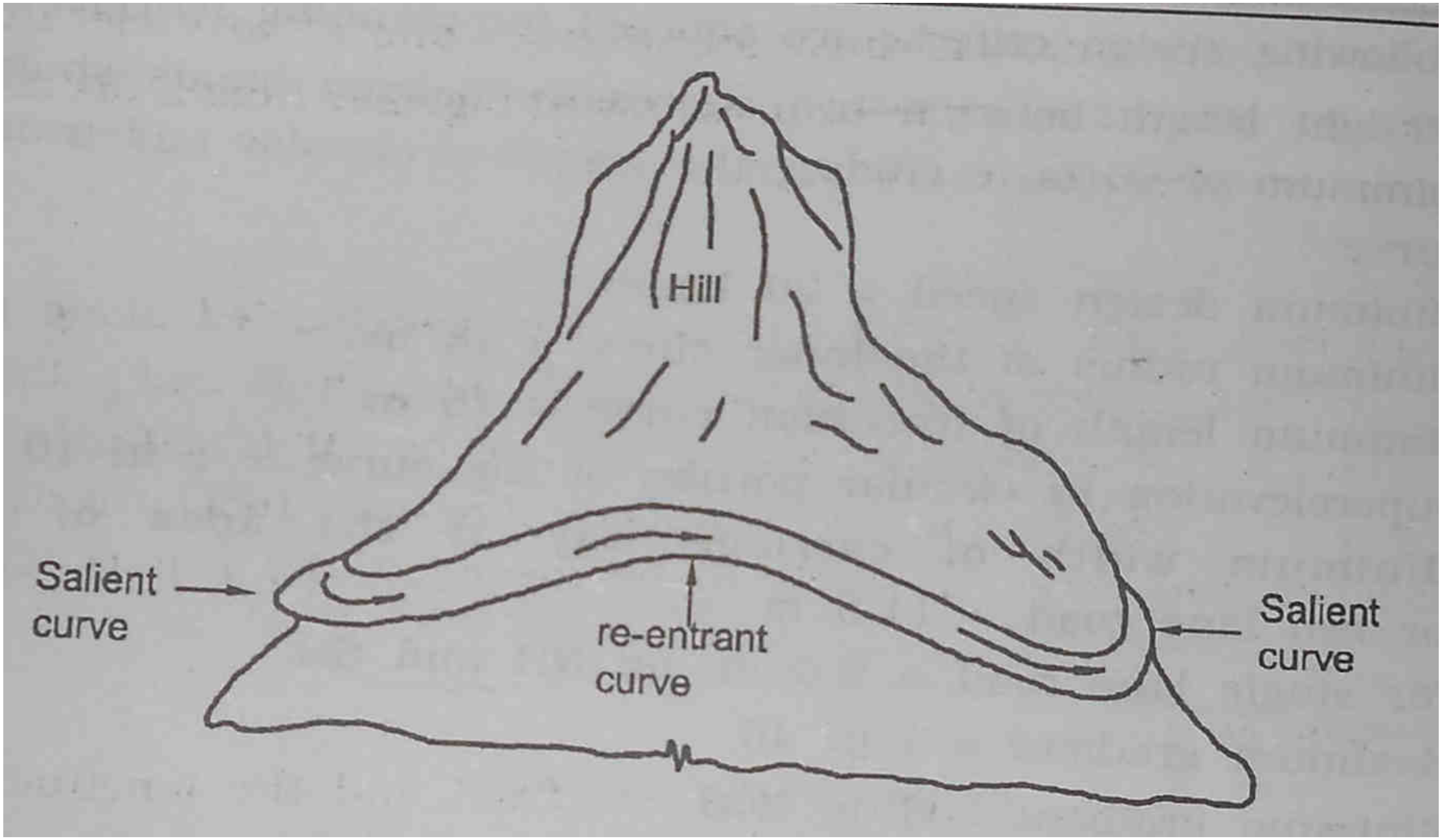
CORNER BEND CURVE



Corner band



Salient curve (Convex curve) and Re-entrant curve(Concave curve)



GEOMETRIC DESIGN STANDARDS OF HILL ROAD

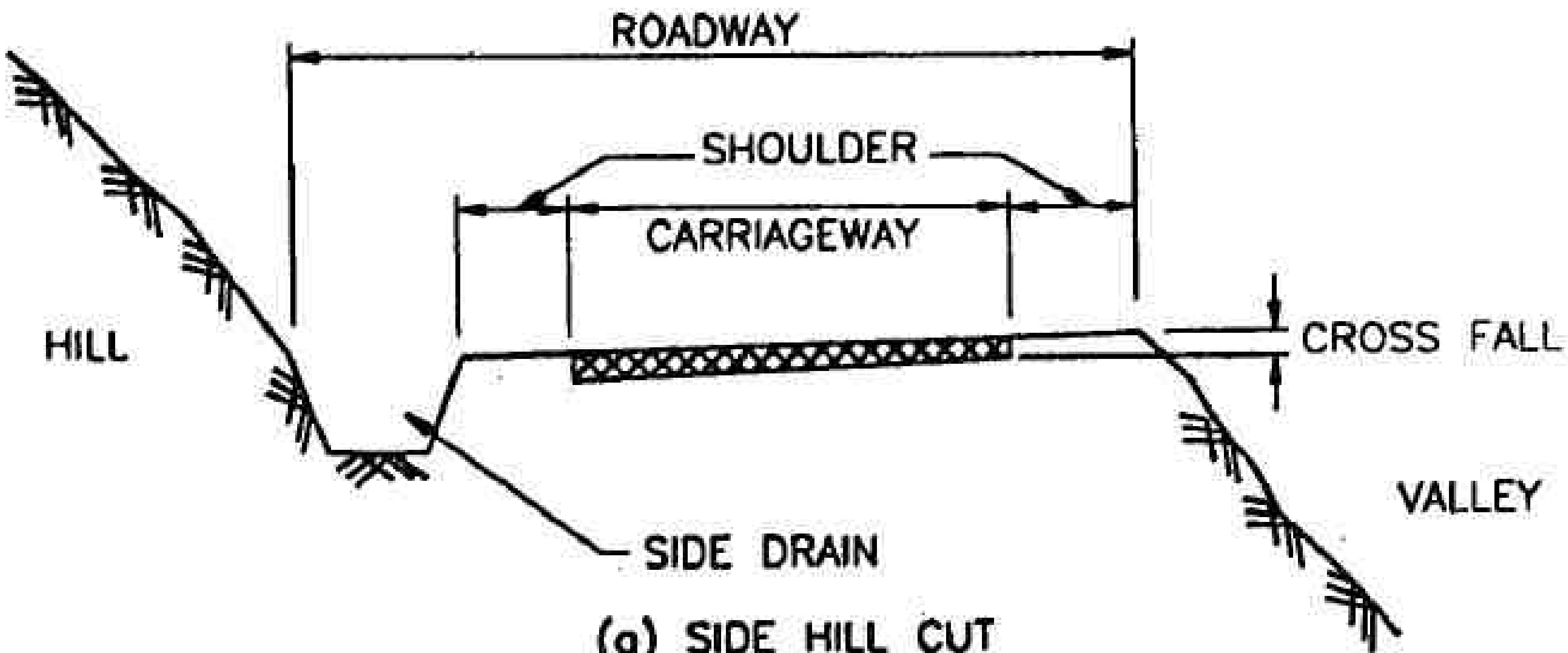
- Width of carriage way, Shoulder, Roadway and land.
- Camber.
- SSD(same).
- OSD
- Gradient.
- Superelevation.
- Radius of horizontal curve
- Widening of curve
- Transition curve

Pavement width

Table 4.1. Recommended Design Service Volumes for Hill Roads

S. No.	Type of Road	Design Service Volume in PCU/day		
		Carriage-way width	For low curvature (0-200 degrees per km)	For high curvature (above 200 degrees per km)
1.	Single lane	3.75 m	1,600	1,400
2.	Intermediate lane	5.5 m	5,200	4,500
3.	Two lane	7 m	7,000	5,000

Hill Road cross section



(a) SIDE HILL CUT

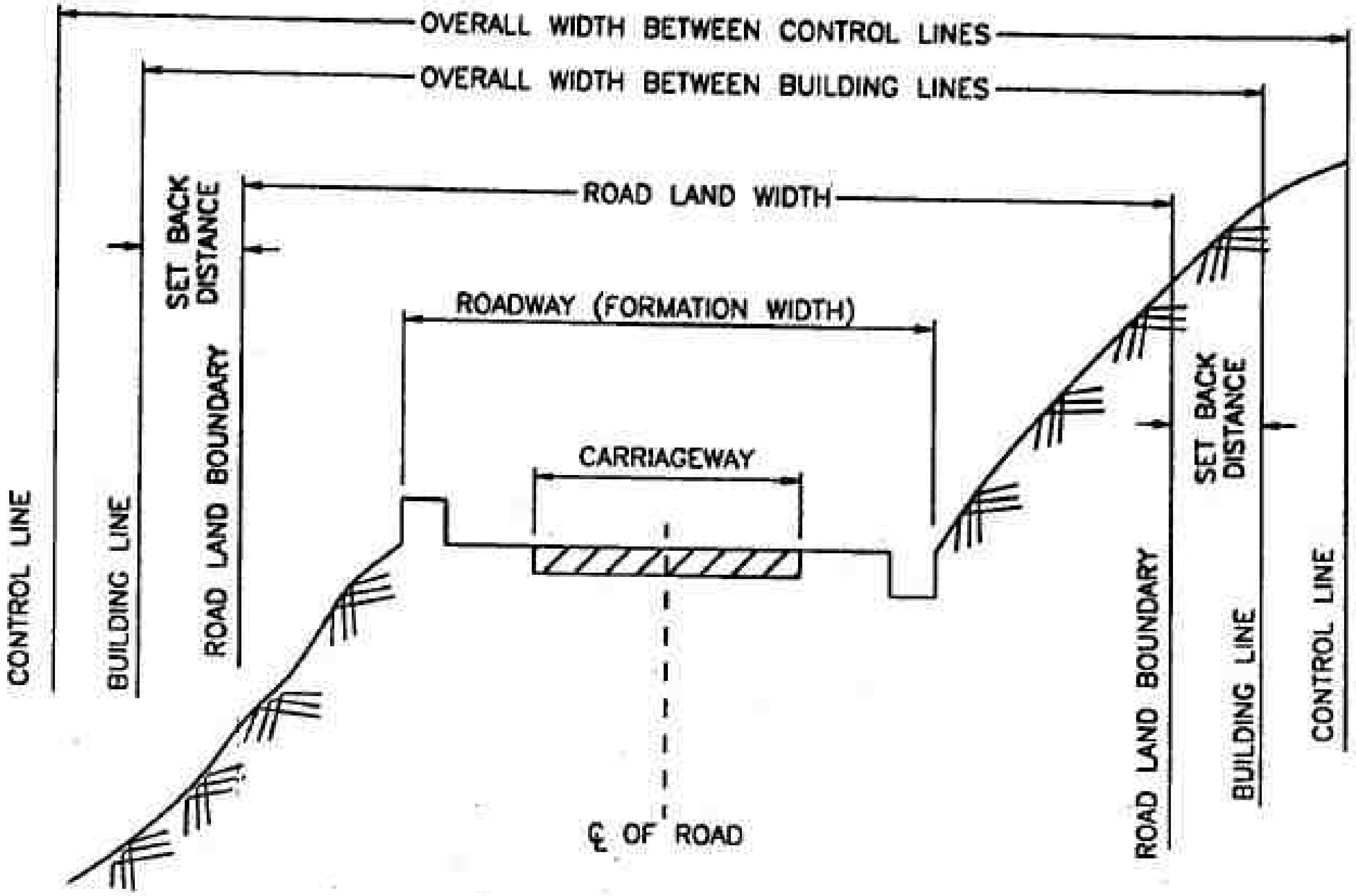


FIG. 6.3. ROAD LAND

DESIGN SPEED FOR HILL ROAD

6.3.1. The design speeds for various categories of hill roads are given in Table 6.1.

Table 6.1. Design Speed (km /h)

Sl. No.	Road Classification	Mountainous Terrain		Steep Terrain	
		Ruling	Min	Ruling	Min
1	National and State Highways	50	40	40	30
2	Major District Roads	40	30	30	20
3	Other District Roads	30	25	25	20
4	Village Roads	25	20	25	20

Camber

Camber/crossfall on straight section should be as follows :-

a.	Earth road	-	3 to 4 per cent (1 in 33 to 1 in 25)
b.	Gravel or WBM surface	-	2.5 to 3 per cent (1 in 40 to 1 in 33)
c.	Thin bituminous surfacing	-	2.0 to 2.5 per cent (1 in 50 to 1 in 40)
d.	High type bituminous surfacing	-	1.7 to 2.0 per cent (1 in 60 to 1 in 50)

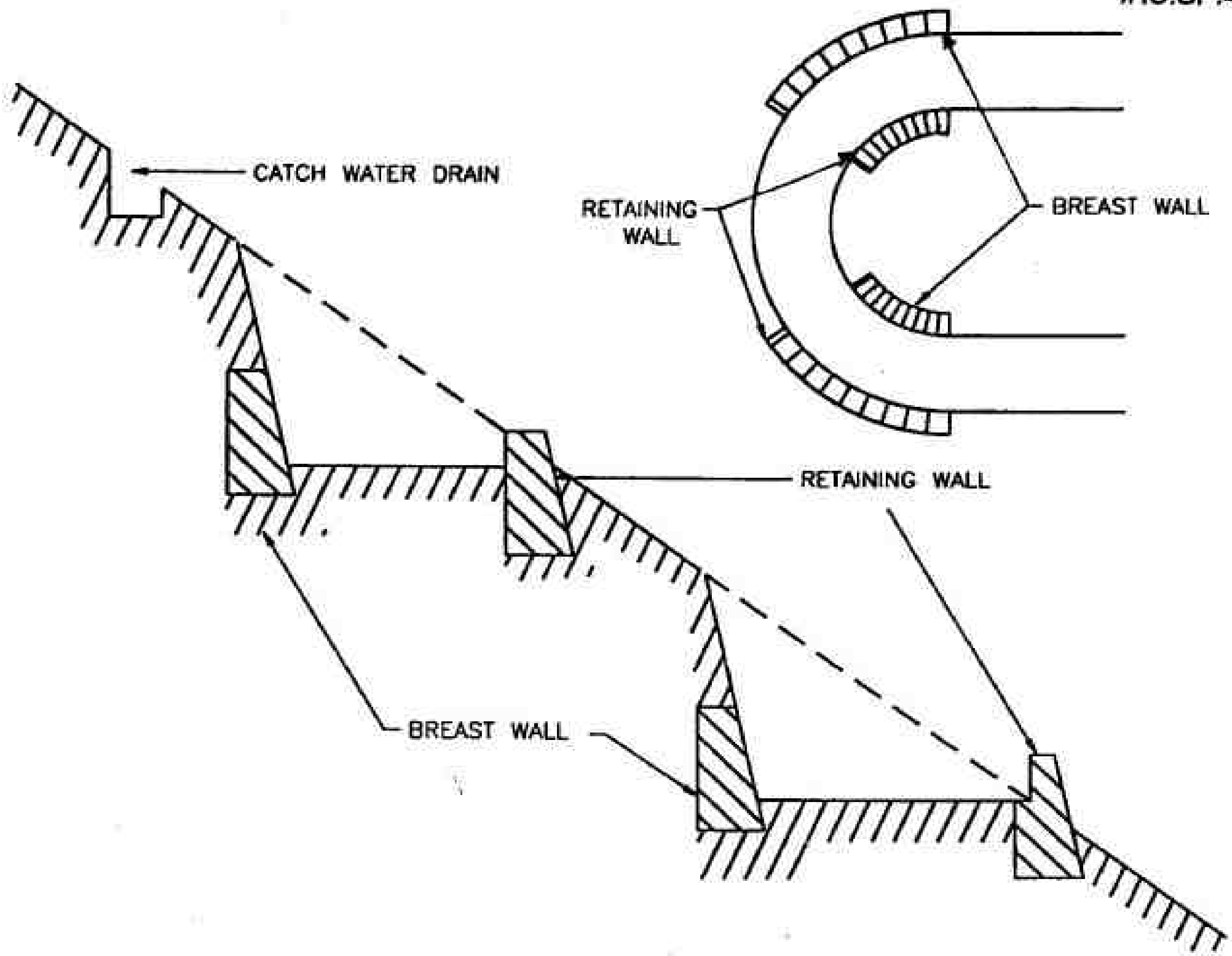


FIG. 7.13. TYPICAL ZIG

Sight distance

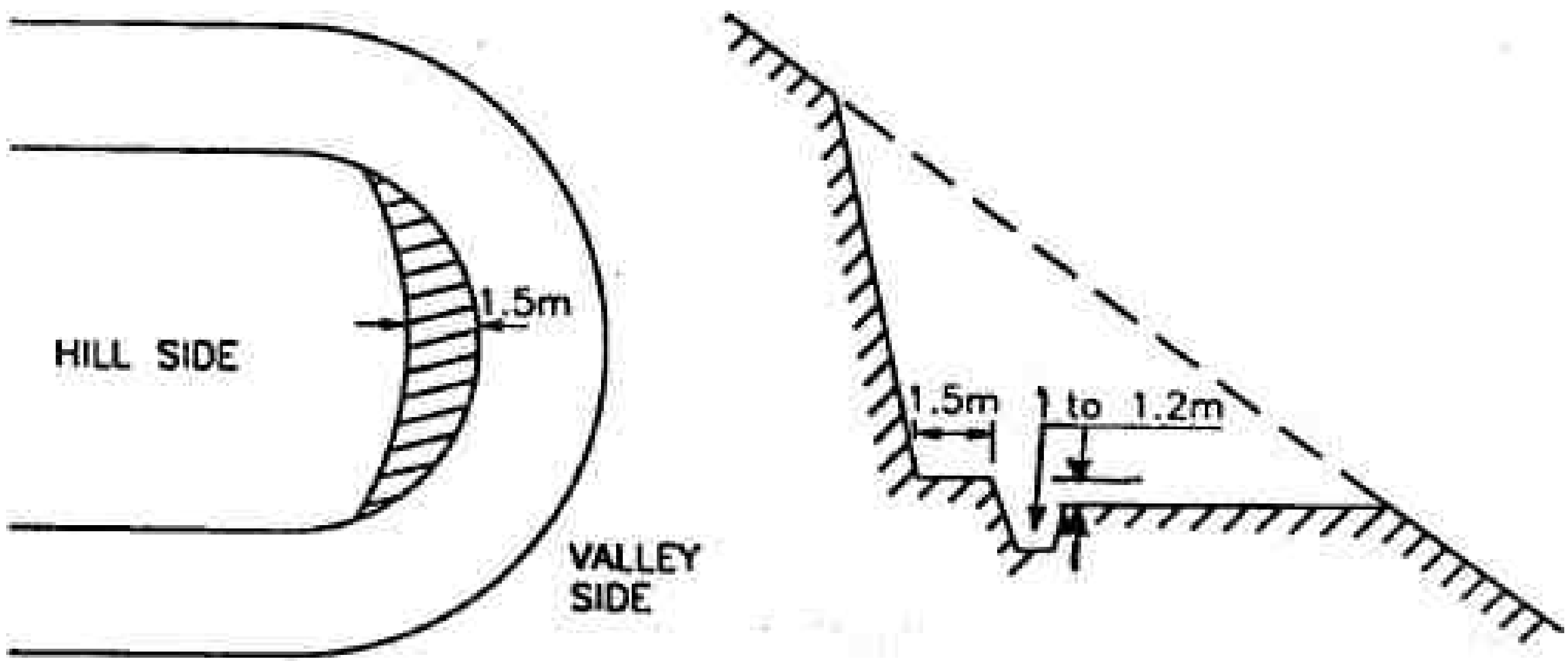
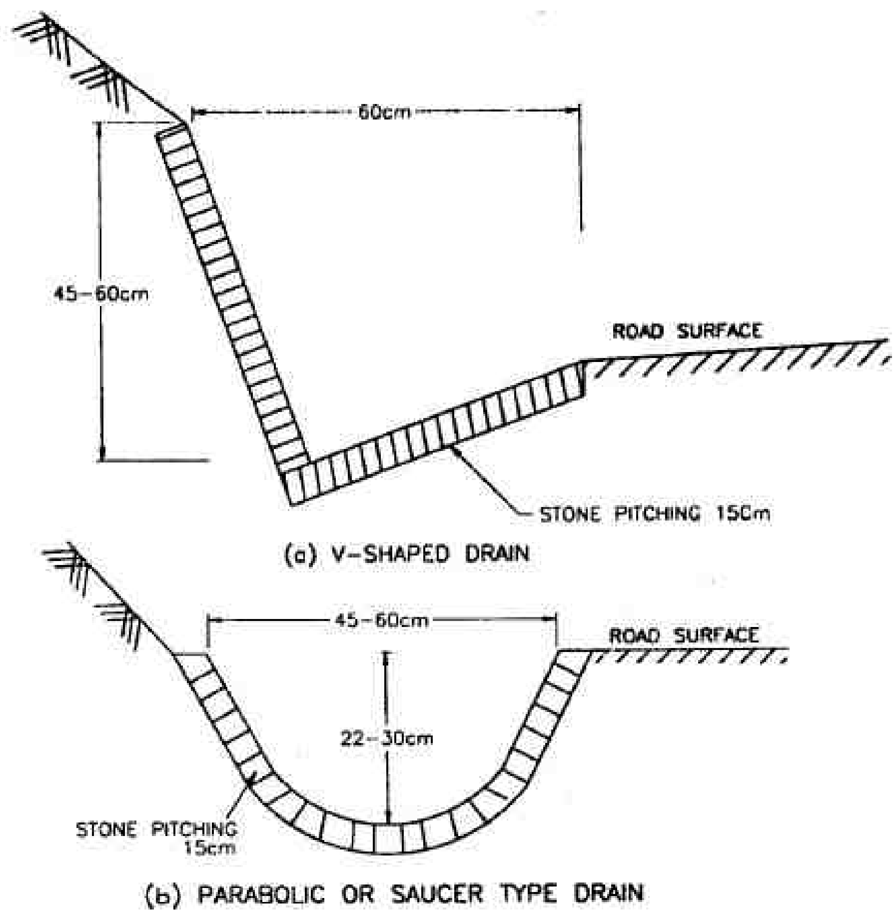


FIG. 7.14. VISION BERM

Drainage in Hill Road- surface drainage



Drainage in hill road

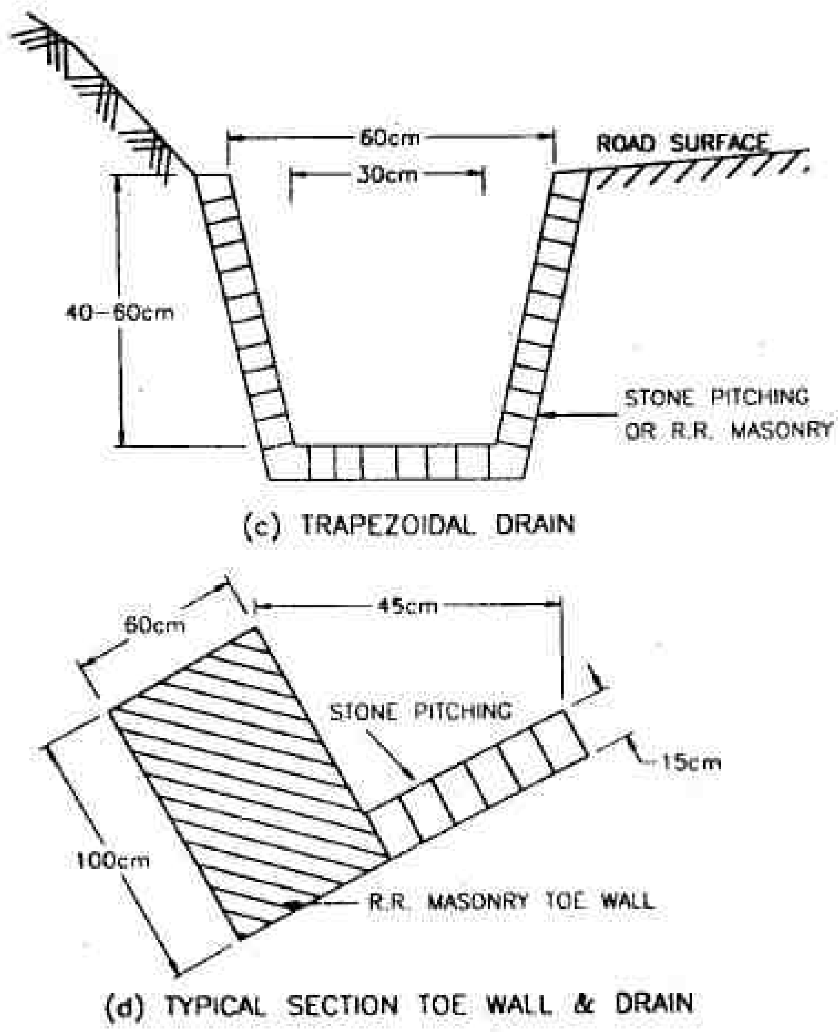
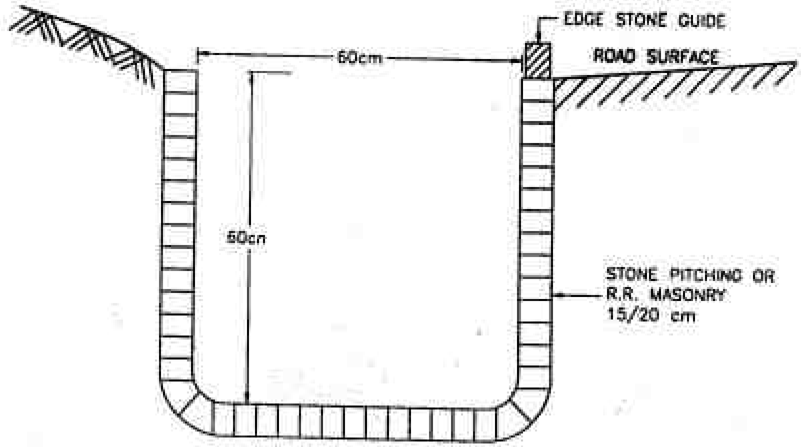
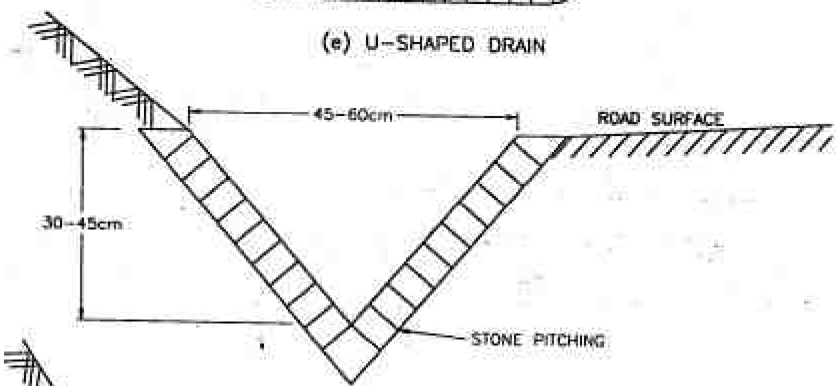


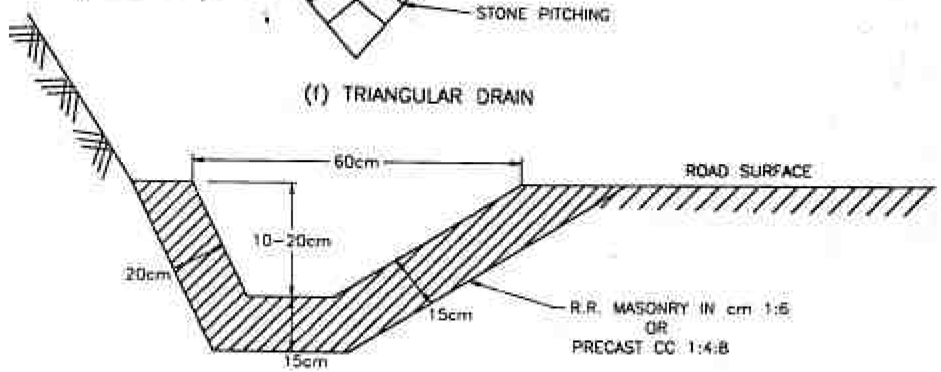
FIG. 8.2. SIDE DRAINS



(e) U-SHAPED DRAIN



(f) TRIANGULAR DRAIN



(g) KERB AND CHANNEL DRAIN

Drainage

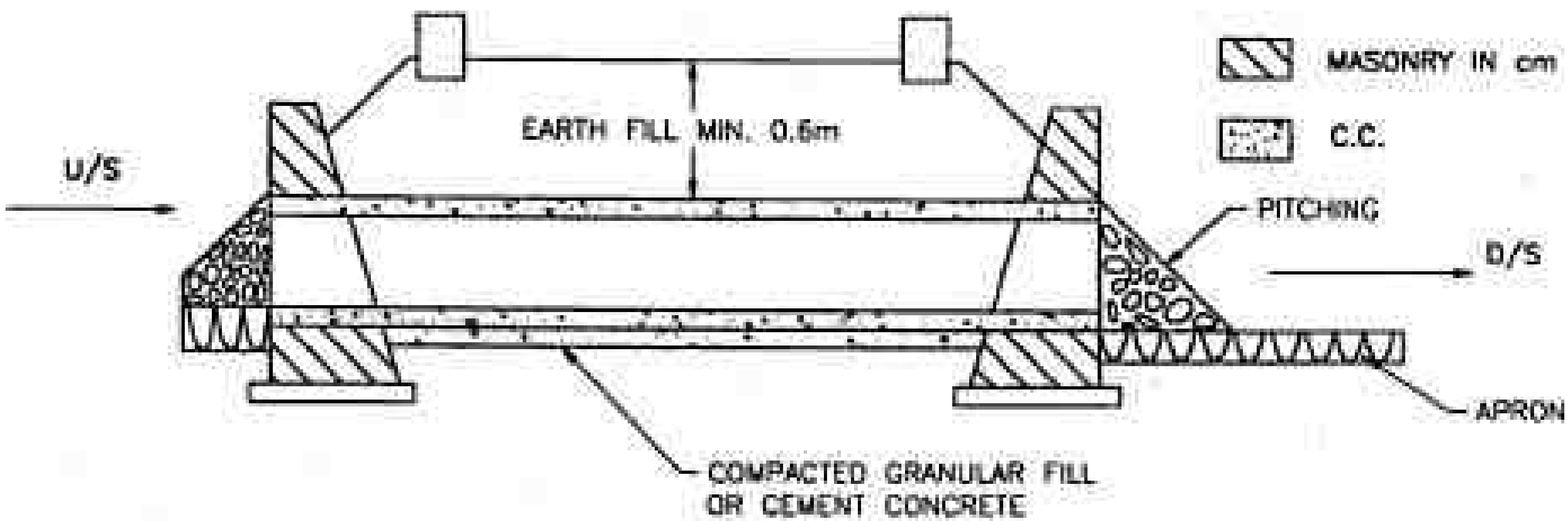


FIG. 8.17. CULVERT IN EMBANKMENT - PIPE CULVERT

MAINTENANCE PROBLEMS IN HILL ROAD

- 1) Maintenance of drainage structures
- 2) Snow clearance.
- 3) Control of avalanches*.

  * (large mass of loosened snow, Earth)
- 4) Prevention of land slides.
  - (i) Falls (free flow)
  - (ii) Slides (shear failure)
  - (iii) Flows (movement within displaced mass)
  - (iv) complex land slides (combination)

Possible solution to prevent land slides

(i) Effective drainage measure

(ii) Slope treatment

(iii) Construction of buttress at toe and retaining wall

(iv) Realignment

PROTECTIVE WORKS FOR HILL ROAD

- 1) Retaining wall.
- 2) Parapet wall.

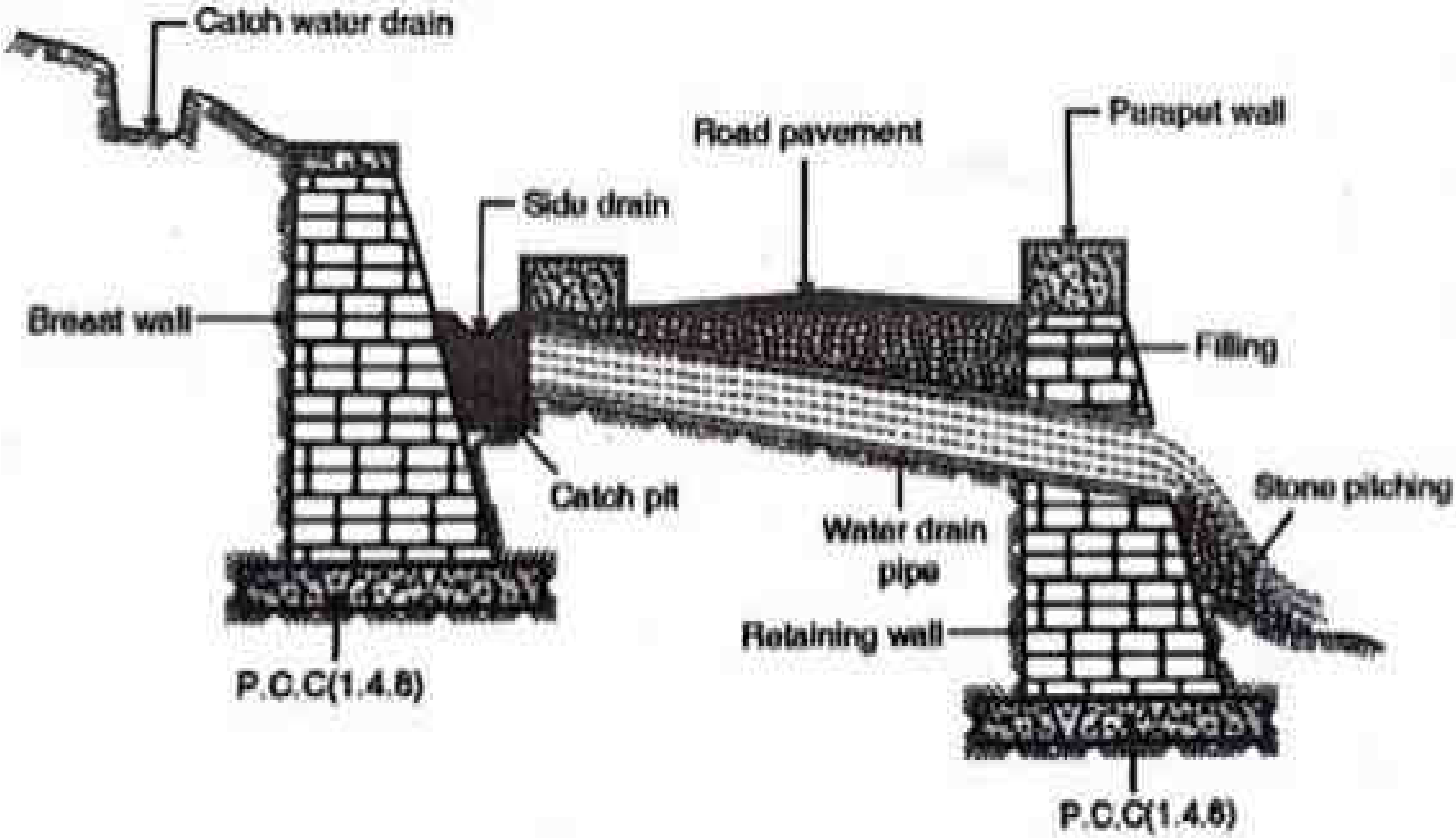

Catch water drain
Road pavement
Parapet wall
Side drain
Breast wall
Filling
Catch pit
Stone pitching
Water drain pipe
Retaining wall
P.C.C(1.4.8)
P.C.C(1.4.8)

Table 6.2. Design values of stopping and intermediate sight distance for various speeds

Speed (km/h)	Design values - metres	
	Stopping sight distance	Intermediate sight distance
20	20	40
25	25	50
30	30	60
35	40	80
40	45	90
50	60	120

Table 6.3. Criteria for measuring sight distance

Sl. No.	Sight Distance	Driver's eye height	Height of object
1	Safe stopping distance	1.2 m	0.15 m
2	Intermediate sight distance	1.2 m	1.2 m

Table 6.5. Widths of Carriageway, Shoulder and Roadway

	Highway Classification	Carriageway width (m)	Shoulder width (m)	Roadway width (m)
a	National Highways and State Highways			
	i. Single lane	3.75	2 x 1.25	6.25
	ii. Double lane	7.00	2 x 0.9	8.8
b	Major District Roads and other District Roads	3.75	2 x 0.5	4.75
c	Village Roads	3.00	2 x 0.5	4.00

6.8.2. Superelevation

6.8.2.1. Superelevation is required to be provided at horizontal curves to counter the effects of centrifugal force and is calculated from the formula :-

$$e = \frac{V^2}{225\,R}$$

where

e	=	superelevation in metre per metre width of roadway
V	=	speed of vehicle in KMPH and
R	=	radius of curve in metres

The above formula assumes that the centrifugal force corresponding to three-fourth of design speed is balanced by superelevation and one-fourth counteracted by the side friction between the tyres of vehicles and the road surface.

6.8.2.2. Superelevation obtained from the above formula should, however, be kept limited to the following values :-

a.	In snow bound areas	-	7%
b.	In hilly areas not bound by snow	-	10%

.6. **Camber/Cross Fall**

.6.1. Generally, the pavement in straight reaches should be provided with a crown in the middle and urface on either side sloping towards the edge. In case of winding alignments where straight sections are ew and far between, a uni-directional cross fall towards the hill side may be given having regard to factors uch as the direction of superelevation at the flanking horizontal curve, easy drainage and problem of erosion f downhill face etc. Typical section of road with camber and cross-fall is given in Fig. 6.4.

.6.2. Camber/crossfall on straight section should be as follows :-

a.	Earth road	-	3 to 4 per cent (1 in 33 to 1 in 25)
b.	Gravel or WBM surface	-	2.5 to 3 per cent (1 in 40 to 1 in 33)
c.	Thin bituminous surfacing	-	2.0 to 2.5 per cent (1 in 50 to 1 in 40)
d.	High type bituminous surfacing	-	1.7 to 2.0 per cent (1 in 60 to 1 in 50)

Curves

Def: The geometrical arcs provided at the change of alignment or gradient of roads are called curves

Types of curves

1: Horizontal curves: (i) Simple curves (II) Compound curves (iii) Reverse curves (Iv) Transition curves

2: Vertical curves: (I) Summit curves (II) Valley curves

Horizontal curves

Horizontal curves : The curves provided at the turning points in the alignment of roads are called horizontal curves.

Vertical curves: The curves provided at the change of gradient (in vertical plane) of a road are called vertical curves.

6.8.3. Minimum curve radii

6.8.3.1. On a horizontal curve, the centrifugal force is balanced by the combined effect of superelevation and side friction. Basic equation for this condition of equilibrium is as follows:-

$$\frac{V^2}{gR} = e + f$$

$$\text{or} \quad R = \frac{V^2}{127\,(e+f)}$$

where

v	=	vehicle speed in metres per second
V	=	vehicle speed in Km/hr
g	=	acceleration due to gravity in metres/Sec^2
e	=	Superelevation in metre
f	=	Coefficient of side friction between vehicle tyre and pavement (taken as 0.15)
r	=	Radius in metres

Table 6.7. Minimum Radii of Horizontal Curves for Various Classes of Hill Roads

Classification	Mountainous terrain				Steep terrain			
	Areas not affected by snow		Snow bound areas		Areas not affected by snow		Snow bound areas	
	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)	Ruling Min (m)	Absolute Min (m)
National Highways and State Highways	80	50	90	60	50	30	60	33
Major District Roads	50	30	60	33	30	14	33	15
Other District Roads	30	20	33	23	20	14	23	15
Village Roads	20	14	23	15	20	14	23	15

Note: Ruling minimum and Absolute Minimum Radii are for ruling design speed and minimum design speed respectively.

6.8.4.2. Minimum length of the transition curve should 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:

$$L_s = \frac{0.0215\, V^3}{CR}$$

where

L_s = length of transition in metres
V = speed in Km/h
R = radius of circular curve in metres
$C = \frac{80}{75+V}$ (subject to a maximum of 0.8 and minimum of 0.5)

ii. The rate of change of superelevation (i.e. the longitudinal grade developed at the pavement edge compared to through grade along the centre line) should be such as not to cause discomfort to travellers or to make the road appear unsightly. The formulae for minimum length of transition on this basis are:

For Plain and Rolling Terrain :

$$L_s = \frac{2.7\, V^2}{R}$$

For Mountainous and Steep Terrain :

$1.0\, V^2$

6.8.5. **Widening at curves**

6.8.5.1. At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage of vehicles. The widening has two components i.e. Mechanical widening to compensate the extra width occupied by the vehicle due to tracking of rear wheels and Psychological widening to permit easy crossing of vehicles, since vehicles tend to wander more on curve. Both the components are to be taken care of in double lane and mechanical components on single lane roads. However, at blind curves double-laning may be considered.

6.8.5.2. Extra width to be provided on horizontal curves is given in Table 6.9.

Table 6.9. Widening of Pavement at Curves

Radius of Curve (m)	Upto 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra Width (m)						
Two-lane	1.5	1.5	1.2	0.9	0.6	Nil
Single-lane	0.9	0.6	0.6	Nil	Nil	Nil

➢ ***Vertical Curves:***

- The vertical curves used in highway may be classified into two categories:

a. Summit curves or crest curves

b. Valley curves or sag curves

a. Summit curves or crest curves:

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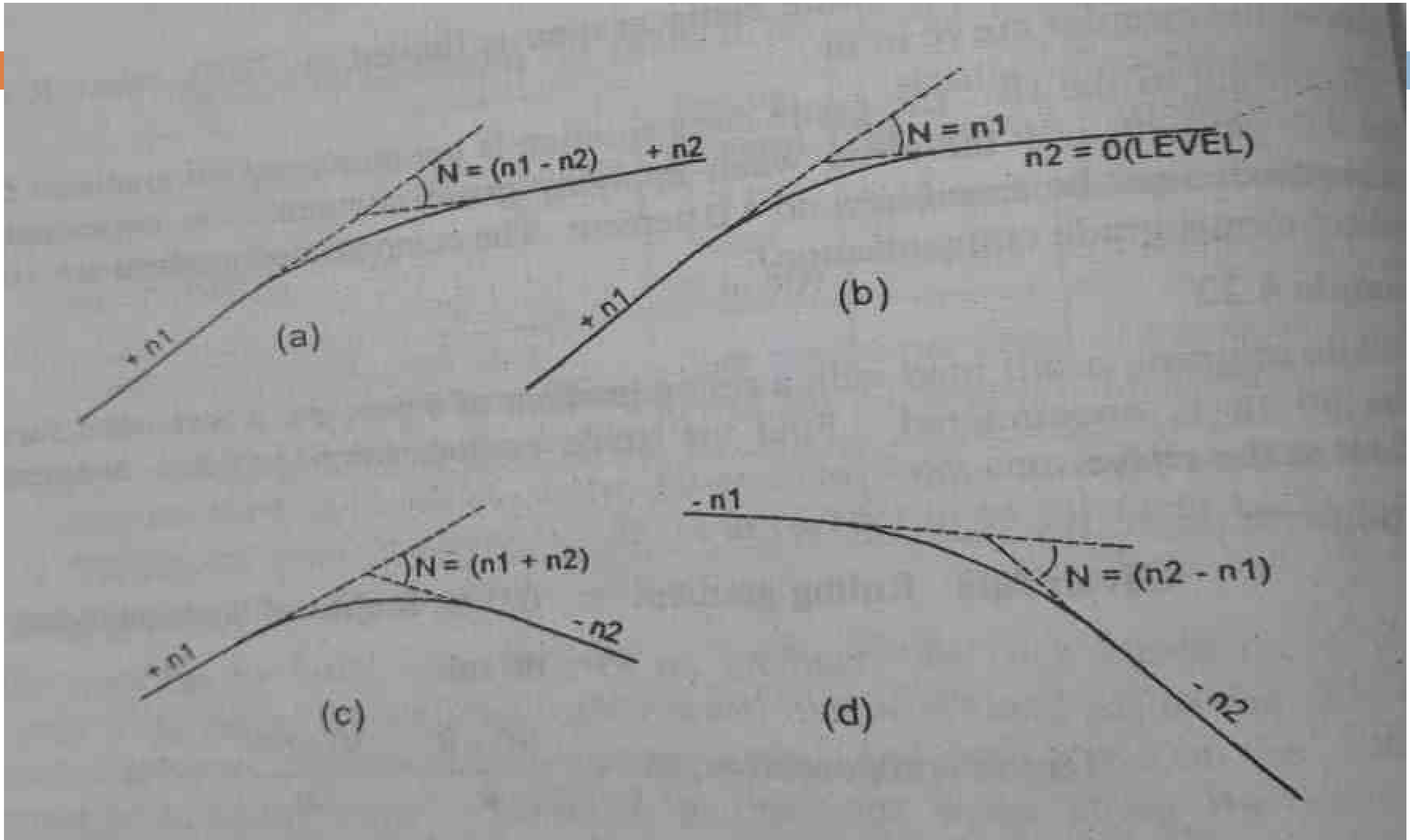

Fig. 4.34 Types of summit curves

b. Valley curves or sag curves:

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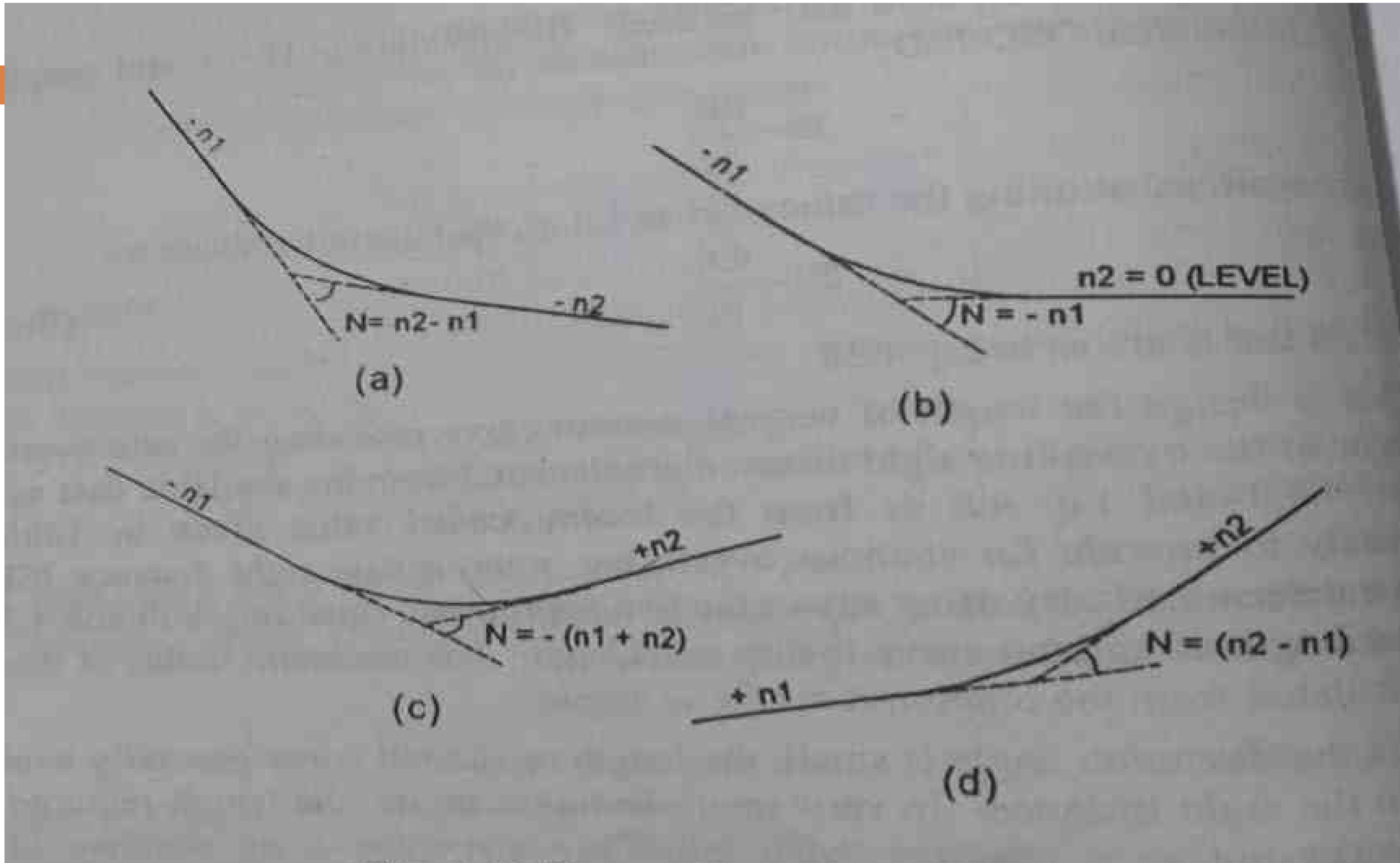

Fig. 4.36 Types of valley curves

➢ ***Length of summit curve:***

- While designing the length the parabolic summit curves, it is necessary to consider SSD and OSD Separately.

- Length of summit curve for stopping sight distance (SSD):

Two cases are considered in deciding the length:

a. When L>SSD

b. When L<SSD

a. When L > SSD

The general equation for length of curve is given by:

$$L = \frac{NS2}{[\sqrt{2H} + \sqrt{2h}]2}$$

- Substituting the value of H=1.2m and h=0.15m,

$$L = \frac{NS2}{4.4}$$

b. When L < SSD

The general equation for length of curve is given by:

$$L = 2S - \frac{\left[\sqrt{2H} + \sqrt{2h}\right]2}{N}$$

- Substituting the value of H=1.2m and h=0.15m,

$$L = 2S - \frac{4.4}{N}$$

- The minimum radius of the parabolic summit curve is calculated from relation **R=L/N**

• Length of summit curve for overtaking sight distance (OSD):

‘ Two cases are considered in deciding the length:

a. When L > OSD

b. When L < OSD

a. When L > OSD

The general equation for length of curve is given by:

$$L = \frac{NS2}{8H}$$

- Substituting the value of H=1.2m,

$$L = \frac{NS2}{9.6}$$

b. When L < OSD

The general equation for length of curve is given by:

$$L = 2S - \frac{8H}{N}$$

- Substituting the value of H=1.2m,

$$L = 2S - \frac{9.6}{N}$$

where,

- N= deviation angle i.e. algebraic difference between two grade
- H=height of driver eye above carriageway i.e. 1.2 m
- h=height of object above carriageway i.e. 0.15 m
- L=length of summit curve, m
- S=sight distance i.e. SSD or OSD

➢ ***Length of valley curve:***

- The important factors to be considered in valley curve design are:

a. Impact free movement of vehicles at design speed or comfort to passenger.

b. Providing adequate sight distance under head lights of vehicles for night driving

c. Locating lowest point of valley curve for providing suitable cross drainage facilities

•The valley curve and its length are designed as a transition curves to fulfill two criteria:

‘

a. Allowable rate of change of centrifugal Acceleration or comfort conditions

b. Required head light sight distance for night driving

a. Length of valley transition curve for comfort condition:

Total length of valley curve is given by:

$$L = 2\left[\frac{Nv3}{C}\right]^{1/2}$$

If ‘V’ is in kmph,

$$L = 0.38(NV3)^{1/2}$$

where,

- v or V= design speed in m/sec or kmph
- C=allowable rate of change of centrifugal acceleration=0.6 m/sec3
- L=length of valley curve=2Ls
- N= deviation angle i.e. algebraic difference between two grade

b. Length of valley curve for head light sight distance:

- The length of valley curve for head light sight distance may be determined for two condition:

a. When L > SSD

b. When L < SSD

a. When L > SSD

The general equation for length of valley curve is given by:

$$L = \frac{NS2}{[1.5 + 0.035S]}$$

b. When L < SSD The general equation for length of valley curve is given by:

‘

$$L = 2S - \frac{[1.5 + 0.035S]}{N}$$

where,

N= deviation angle i.e. algebraic difference between two grade

L=total length of valley curve, m

S=SSD, m

Example 4.4

Calculating the stopping sight distance on a highway at a descending gradient of 2% for a design speed of 80 kmph. Assume other data as per IRC recommendations.

Solution

Total reaction time t may be taken as 2.5 seconds and design coefficient of friction as f = 0.35.

$$V = 80 \text{ kmph}; n = -2\% = -0.02, G = 9.8 \text{ m/sec}^2$$

$$v = \frac{80}{3.6} = 22.2 \text{ m/sec}$$

SSD on road with gradient is given in Eq. 4.3 and 4.4.

From Eq. 4.3, $$\text{SSD} = vt + \frac{v^2}{2g(f \pm n\%)} = 2.2 \times 2.5 + \frac{22.2^2}{2 \times 9.8(0.35 - 0.02)}$$

$$= 55.5 + 76.2 = 131.7 \text{ m say } 132 \text{ m}$$

Alternatively, using Eq. 4.4

$$\text{SSD} = 0.278\, V.t + \frac{V^2}{254(f \pm 0.01)n}$$

$$= 0.278 \times 80 \times 2.5 + \frac{80^2}{254(0.35 - 0.02)} = 55.6 + 76.4 = 132 \text{ m}$$