GOVT.POLYTECHNIC, BOLANGIR

DEPARTMENT OF CIVILENGINEERING

LECTURE NOTE

ON

HIGHWAY ENGINEERING

SEMESTER-4TH

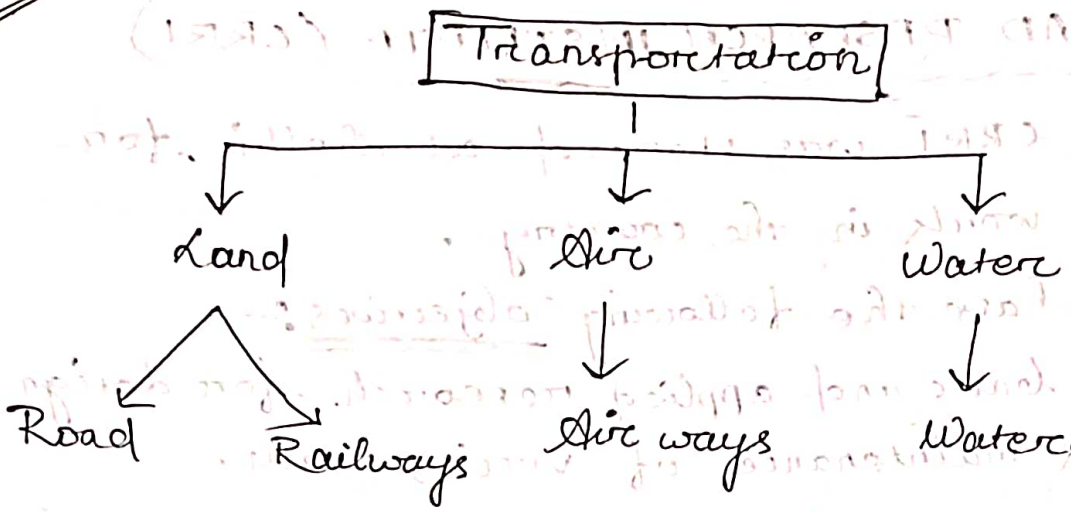
PREPARED BY:

Abinash Biswal
lect (Civil)

Chap-1

INTRODUCTION

Dt - 22/2/23



Importance of Highway Transportation :-

(i) Roads can be constructed to connect in remote villages specially in hilly region where provision of railways becomes uneconomical.

(ii) Roads can be constructed at lower initial cost than other modes of transport.

(iii) Roads are used by various means of transport like private car, two wheelers, cycles etc.

(iv) The cost of mainterance is also cheapers than railways track, airports and harbours.

(v) Road transport offers quick and assured deleiveries.

(vi) Road transport proride door-to-door service.

(vii) It permits simpler packaging of goods to be transported.

(viii) It has a high employment potential.

(ix) It helps in maintaining law and order in a country.

(x) It have helped in opercation related to flood and femine relief.

(xi) It help in tourism development.

CENTRAL ROAD RESEARCH INSTITUTE (CRRI)

⇒ In 1950, the CRRI was started at Delhi for road research work in the country.

⇒ The institutes have the following objectives:-

- To carry out basic and applied research for design, construction and maintenance of various roads.
- To carry out research on traffic safety and transportation economics.
- To develop new machinery, tools, equipment and instruments for highway engineering.
- To provide technical advice and consultancy services to various organisation.
- To provide library and documentation service.
- To research on utilisation of materials for constn. and maintenance of roads.

⇒ The institute is headed by a Director and has various wings:-

(i) Bridges projects.
(ii) Soil and Geotechnical Engineering
(iii) Rigid pavement
(iv) Flexible pavement
(v) Extension
(vi) Traffic and transportation
(vii) Workshop
(viii) Environment and safety.

INDIAN ROAD CONGRESS:- (IRC)

Dt-23/2/23

→ The IRC was established by the central govt. in 1934 as per the recomendation of the Jayakar Committe which is formed in 1927.

→ The IRC was constitute to provide a forum for regular pooling of experiences and ideas on all matters affecting the construction and maintenance of roads in India.

→ Presently the IRC has become the active body to recomended specification regarding design and construction of roads and bridges.

→ IRC works in close collaboration of road wings of ministry of surface transport & govt. of India.

→ IRC publish journals, standard specification and guideline on various aspects of highway engineering.

→ The technical activity of IRC are carried out by experts in each subject.

FUNCTION OF IRC:-

⇒ The IRC is a body of professional highway engineers having following functions:—

→ The IRC is to provide forum for experienced of collective opinions of it's members for all matters affecting the construction and maintenance of roads in India.

→ To promote the use of standard specification and practices.

→ To suggest improved method of planning, design, construction maintenance and administration of roads.

→ To conduct periodical meeting to discuss technical question regarding roads.

→ To make laws for the development / improvement, maintenance and protection of roads.

→ To furnish and maintain libraries and museums for increases or encourage the science of road making.

ROAD WINGS OF MINISTRY OF SURFACE TRANSPORT:-

→ It handles the road matters of the central govt..

→ It is headed by director general.

→ The director general is assist by two additional director general, one for road and another for bridges.

→ A no. of chief Engineers (CE), Superintending Engineer (SE), ~~Assistance~~ Executive engineer (EE) and Assistant Executive Engineer (AEE) were appointed.

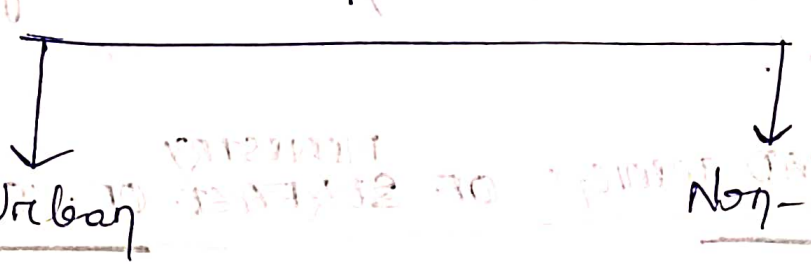
→ The road wings has a chief engineer for North-east region posted at Guwahati and a

Liasion - cum - Inspection organisation consist of Superintending Engineer (SE) and Executive Engineer (EE) in the various state.

FUNCTION OF ROAD WINGS OF ~~SURFACE~~ MINISTRY OF SURFACE TRANSPORT :-

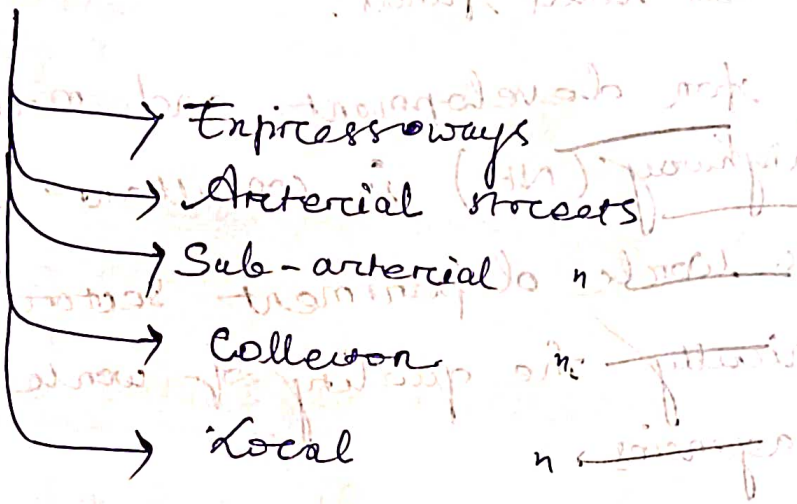
- To control funds approved by central govt. for the development of National highway (NH).
- To control the central road funds.
- To prepares plan for development and maintenance of National highway (NH) in consultant with state. PWD's (Public work department sector).
- To observed technically the quality of work executed by the agencies.
- To administrate matters regarding road research.
- To examine technically the project of road and bridges prepared by the state PWD's.
- To exadminister the central road progress other than National highways (NH) in the union territories.

Classification of Roads



(i) Urban :-

→ fall within in the jurisdiction of municipalities and cantonment boards.



(a) Express ways :-

→ The main function of expressways is to provide for movement of heavy traffics at high speed.

(b) Arterial Streets :-

→

(c) Sub-arterial Streets :-

→

(d) Collector Streets :-

→ These are intended for collecting and distributing the traffic to and from local streets and also for providing access to the arterial streets.

(e) Local Streets :-

→ These streets do not carry large volume of traffic.

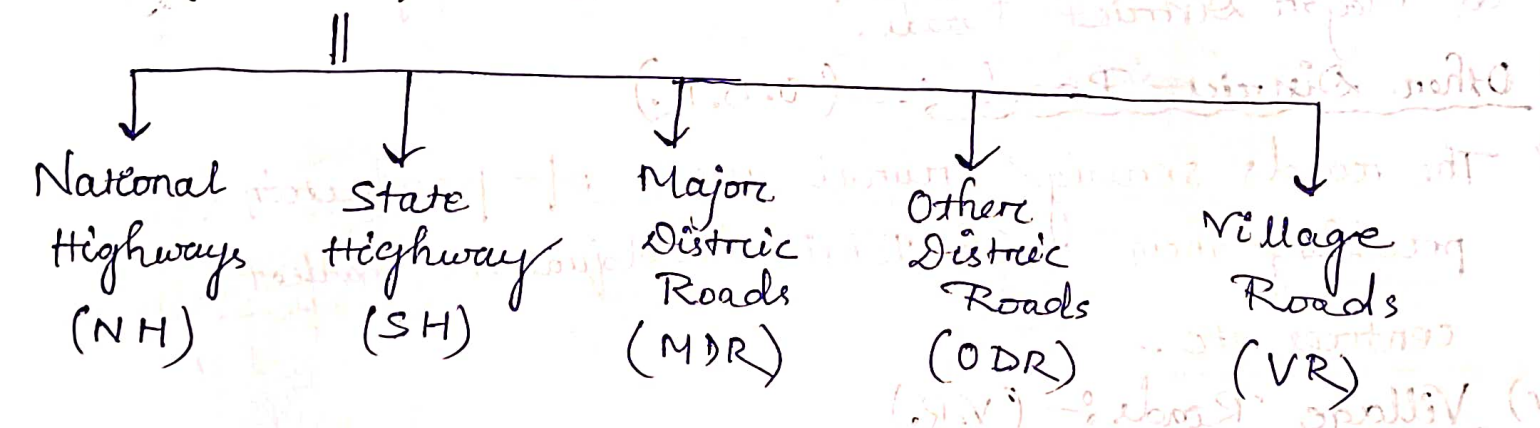
(ii) Non-Urban :-

→ Also known as rural roads.

→ They are classified into 5 categories.

→ It is popularly known as IRC classification.

IRC Classification :-



(i) National Highways :- (N.H.)

→ It's the main highways running through the country by connecting state capitals, ports, foreign highways, large town etc. are known as National Highways.

→ These highway constitute the main arteries of road transport in the country.

→ The highway connecting Amritsar - Ambala - Delhi is denoted as NH-1.

(ii) State Highways :- (S.H.)

→ The highway that connects district headquaters and important cities within the state or connecting them with national highways of adjacent states are known as State Highways.

→ These are also considered as main arteries of commerce by road within a state.

(iii) Major District Roads :- (M.D.R.)

→ The important roads within the district serving areas of production and markets and connecting therewith each other or with highways and railways are known as Major District Roads.

(iv) Other District Roads :- (O.D.R.)

→ The roads serving rural areas of production and providing them with Tehsil headquaters, market centres etc..

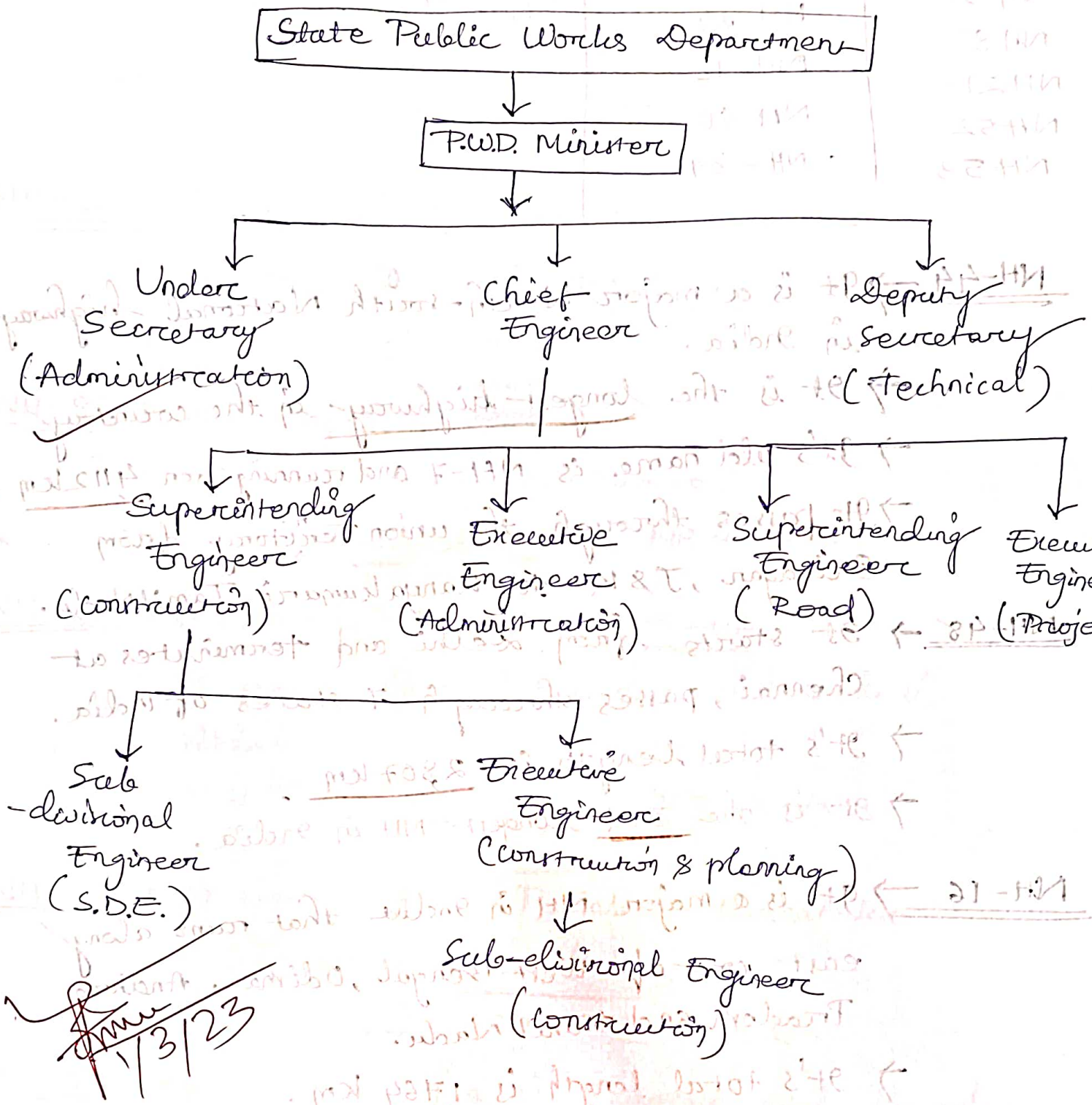
(v) Village Roads :- (V.R.)

→ They connecting villages or group of villages with each other or with nearest district roads, main highways etc.

→ Very imp. from the point of view of rural area development.

→ The construction and maintenance of these roads are responsible for local district authority.

ORGANISATION OF STATE HIGHWAY DEPARTMENT :-



1/3/23

→ There are

NH44	NH - 1	NH - 544
NH-48	NH -4	NH- 31
NH-16	NH-4	NH- 65
NH-66	NH- 11	NH-21
NH-30	NH -19	NH- 34
NH-2	NH -24	
NH-8	NH-12	
NH-27	NH-40	
NH-52	NH - 39	
NH-53		

NH-44 → It is a major North-south National highway in India.

→ It is the longest highway in the country.

→ It's old name is NH-7 and running over 4112 km

→ It passes through the union Territory from Srinagar, J&K to Kanyakumari, Tamil Nadu.

NH-48 → It starts from Delhi and terminates at Chennai, passes through 7 states of India.

→ It's total length is 2,807 km.

→ It is the 3rd longest NH in India.

NH-16 → It is a major NH in India that runs along east coast of West Bengal, Odisha, Andhra Pradesh and Tamil Nadu.

→ It's total length is 1764 km.

→ It is the 7th longest NH in India.

NH-66 → It starts from Pondicherry and joins at Krishnagiri, Tamil Nadu.
→ It's total length is 1640 km.
→ It is the 9th longest NH.

NH-30 → It connects Sitarganj in Uttarakhand with Vijaywada in Andhra Pradesh.
→ It's total length is 1,984 km.
→ It is the 5th longest NH in India.

NH-2 → It runs from Assam to Mizoram.
→ It's total length is 1,465 km.
→ It is the 8th longest NH.

NH-8 → It's length is 1428 km.
→ It connects Delhi to Mumbai.
→ It is the 10th longest NH in India.

NH-27 → It's total length is 3,507 km.
→ It starts from Porbandar and ends in Silchar.
→ It is the 2nd longest NH in India.

NH-52 → It starts from Punjab to Karnataka.
→ It's length is 2,317 km.
→ It is the 4th longest NH in India.

NH-53 → It connects Hajira in Gujarat and Paradeep port in Odisha.
→ It's length is 1795 km.
→ It is the 6th largest NH in India.

NH-1 → It connects New Delhi & Punjab.
→ It's length is 534 km.
→ It is the 19th largest NH.

NH-4 → It connect Mumbai to Bangalore.
→ It's length is 1235 km.
→ It is the 13th longest NH.

NH-11 → It's length is 848 km.
→ It connect Agra to Bikaner.
→ It is the 17th longest NH.

NH-19 → It passes from Delhi to Kolkata.
→ Busiest NH in India.
→ It's length is 1269 km.
→ It is the 12th longest NH.

NH-24 → Connects New Delhi to Lucknow.
→ It's length is 438 km.
→ It is the 21st longest NH.

NH-12 → It's length is 675 km.
→ Runs entirely in west Bengal.
→ It is the 18th longest NH.

NH-40 → It's length is 408 km.
→ It connects from Kurnool (AP) to Ranipettai (TN).
→ It is the 22nd longest NH.

NH-39 → Passes through the MP, UP and Jharkhand.
→ It's length is 869 km.
→ It is the 16th longest NH.

NH-544 → It's length is 340 km.
→ It connect from TN to Kochi at Kerala.
→ It is the 23rd longest in NH.

NH-31 → It's length is 968 km.
→ It connects from Barhi (Jharkhand) to Guwahati (Assam).
→ It is the 14th longest NH.

NH-65 → It's length is 926 km.
→ It connects from Machillipatnam, AP to Pune, Maharashtra.
→ It is the 15th longest NH.

NH-21 → Connects from Jaipur (Rajasthan) to Agra and UP.
→ It's length is 465 km.
→ It is the 20th longest NH.

NH-34 → It's length is 1426 km.
→ From Gangotri in Uttarakhand to MP. (Passing through UP).
→ It is the 11th longest NH in India.

List of State Highway (SH) in ODISHA:-

SH01 → Phulbani - Nayagarh - Khurdha
SH03 → Nuapada - Padmapur - Sohela
SH04 → Rayagada - Koraput
SH09 → Salepur - Pattamundai - Chandbalali - Bhadrak

SH 12 → Kandarpur – Parcaclep

SH 14 → Boudh – Baripecha.

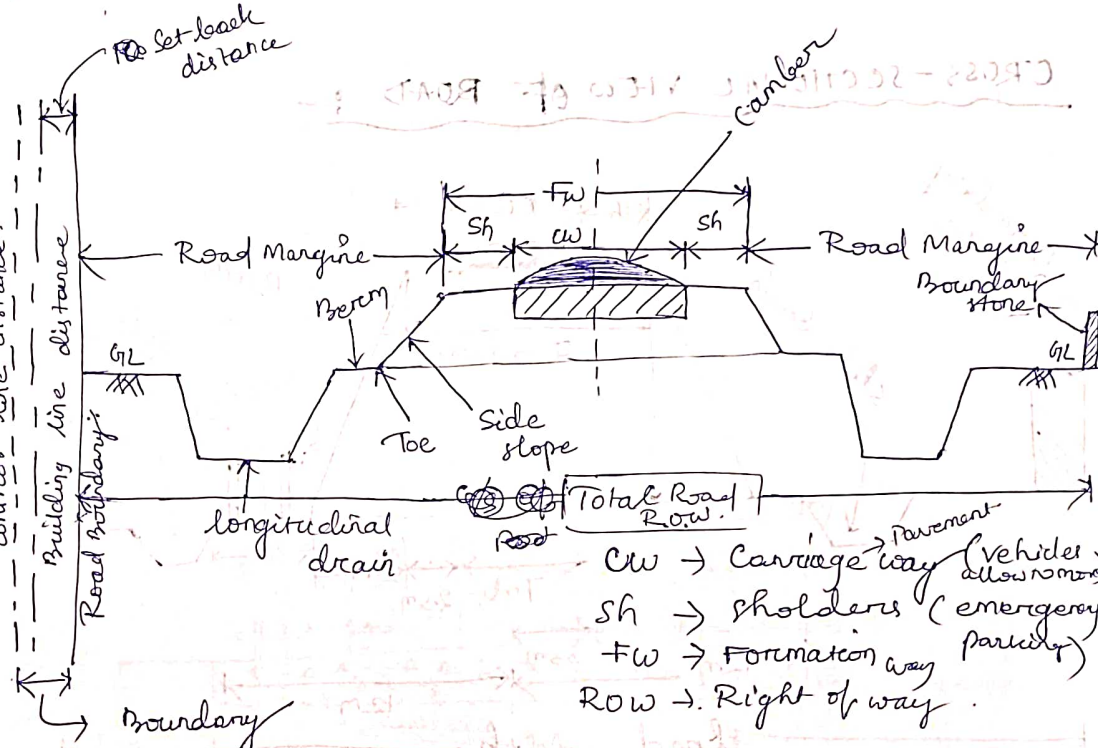
SH 15 → Sonepur – Sambalpur

SH 17 → Padnapur – Behrampur

SH 42 → Sindhkela – Kantabanji – Patnagarh – Bolangir

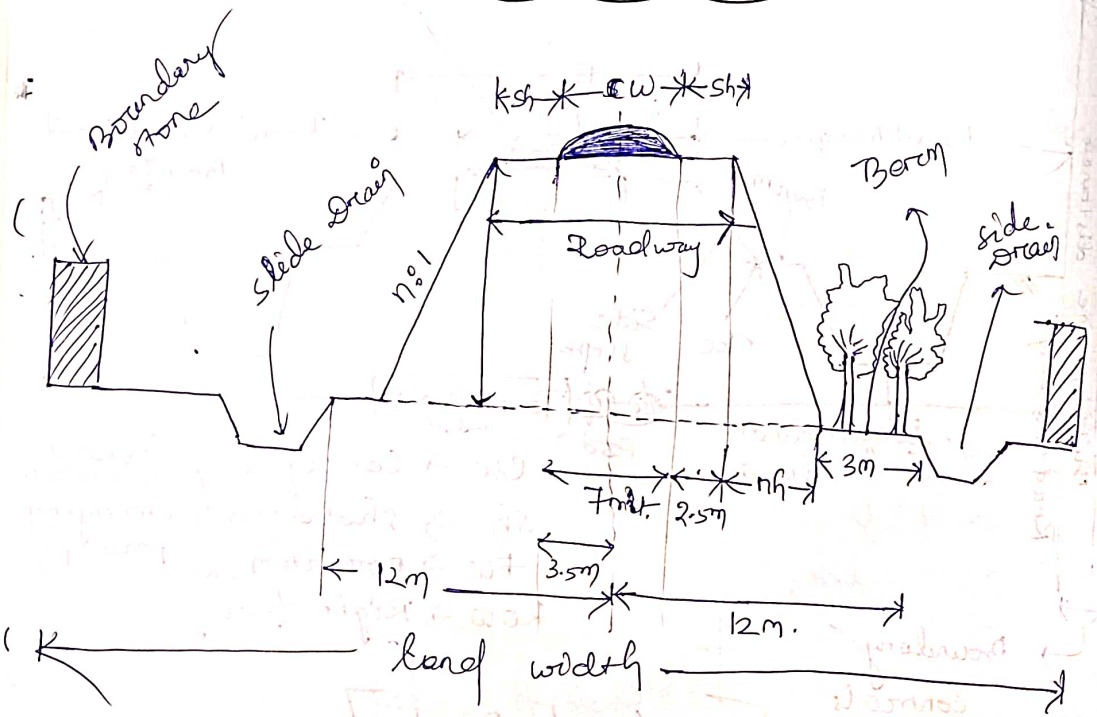
GEOMETRIC OF ROAD

Dt 2/3/22



C/s of Road in Embankment

CROSS-SECTIONAL VIEW OF ROAD :-

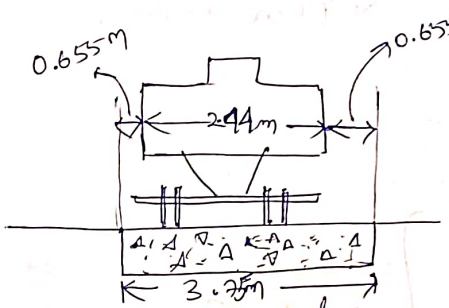


(C/S of Road in Embankment)

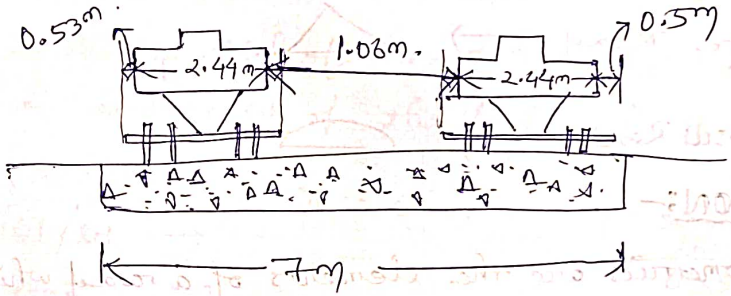
Formation way = cw + sh + sh
= 7m + 2.5m + 2.5m
= 12mt.

A/c to drainage system, flooding system, the height (h) should be maintained.

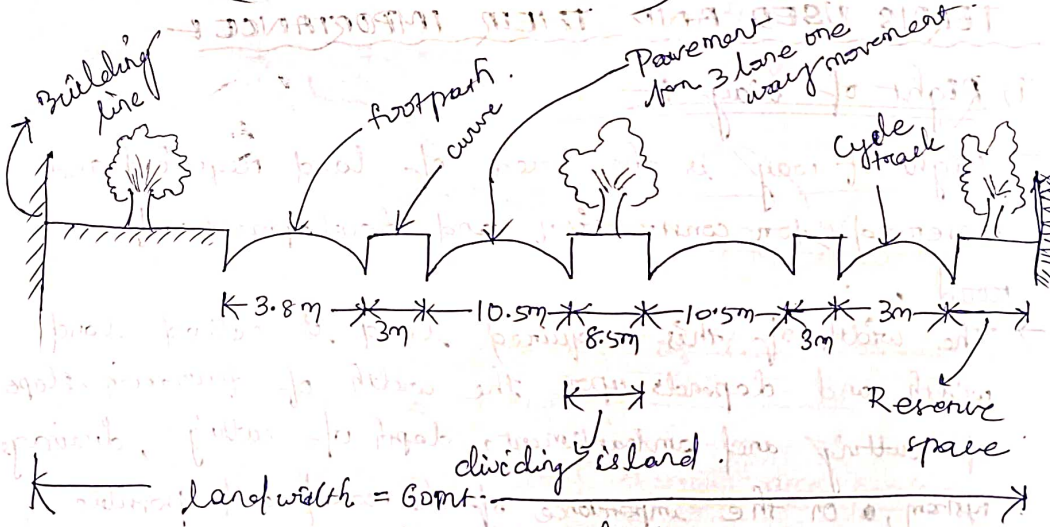
WIDTH OF THE PAVEMENT OR CARRAIGE WAY :-



(Single lane pavement)



(Two lane Pavement)



[C/S of dividing highway in urban area]

SH, NH → 145m (30-60)
MDR → 25m (25-30)
ODR → 15m (15-25)
VR → 12m (12-18)
} Plane terrain

SH, NH → 24m
MDR → 18m
ODR → 15m
VR → 9m.
} Hilly area.

Concrete Road → 

Bituminous Road. → 

INTRODUCTION:-

→ Road geometrics are the elements of a road which are visible to road users.

TERMS USED AND THEIR IMPORTANCE:-

(i) Right of Way :-

→ Right of way is the area of land required and reserved for construction and development of road.

→ The width of this acquired land is called land width and depends upon the width of formation, slope of cutting and embankment, depth of cutting, drainage system, on the importance of the road and possible future development.

→ It is necessary to disallow the building activities upto "building lines" with sufficient set back from the road boundary.

→ The overall width requirements between the building lines and control lines recommended by the IRC for diff. localities

(ii) FORMATION WIDTH :- / Roadway width

→ It is the sum of widths of carriageway or pavement, shoulders and separators if any.

→ It is the top width of the highway embankment or the bottom width of the highway cutting excluding side drains.

	Single lane	Two lane	Single lane	Two lane
NH / SH →	12mtr	12mtr	6.25	8.8
MDR →	9mtr	9mtr	4.75	-
ODR →	7.5mtr	9mtr	4.75	-
VR →	7.5mtr	"	4.00	-

(Plane terrain) (Mountain terrain)

(iii) ROAD MARGINS :-

→ Road margin are the portions of land on either side of roadway of a road.

→ The areas included in the road margin are parking lane, drive way, cycle track, footpath, slope etc.

Carriageway is the width of the roadway constructed for movement of vehicle.

→ It depends on width of traffic and no. of lanes required.

→ The no. of lanes required in a highway depends on the traffic volume and traffic capacity.

→ As per IRC, the max^{m} width of a vehicle is 2.44m and carriage way width for single lane traffic is 3.75m.

Parking Lanes :-

→ There are provided in roads to allow kerb parking.

→ The width of parking lane should be sufficient.

Driveways :-

→ There connect the highway with commercial establishment like fuel station, service stations etc.

→ There should be properly designed and located, fairly away from an intersection.

Cycle Tracks :-

→ There are provided where the volume of cycle traffic on the road is very high.

→ Width - 2m is provided for cycle track.

Foot Path :-

→ In urban areas where the vehicle's traffic is very heavy, footpaths are provided to avid accident.

(v) **SHOULDERS :-**

→ These are the portions of the roadway betⁿ the outer edges of the carriageway and edges of the top surface of embankment.

→ Provided along the road edge to serve as an emergency for vehicle to be taken out of the road.

→ Act as service for bicycling vehicles.

→ Minimum shoulder width = 4.6m

(vi) **SIDE SLOPES :-**

→ These are the portions of the roadway betⁿ the outer edges of the carriage way and edges of the top surface of embankment.

→ Provided along the road edge to serve as an emergency for vehicle to be taken out of the road.

→ Act as services.

(vi) **SIDE SLOPES :-**

→ Side slopes are the slopes provided to the slides of the earthwork of a road in embankment or in cutting for it's stability.

→ Method of drainage are provided and the nature of soil in earthwork and climatic condⁿ also provided. are the factors that affecting the design of side slopes.

★ KERBS:-

→ Kerbs are the boundaries between the pavement and shoulder or foot path.

→ Also provided in ~~between~~ pavement and traffic separator ~~or~~ ~~etc~~.

→ It may be of 3 types:-

(a) Low or Mountable Kerbs:-

→ Also called class I Kerb.

→ As the height of this type of kerb is low, it allows the driver to enter the shoulder area with little difficulty.

→ The height of this type of kerbs is 70 to 80mm.

(b) Low speed Barrier or Urban parking Kerb:-

→ Also called class II Kerb.

→ It prevents parking vehicles to the foot path.

→ But an emergency vehicles can climb over it and can be parked on footpaths or shoulders.

→ It's height is 150 to 200mm.

(c) High speed barrier kerbs:-

→ Also called class III.

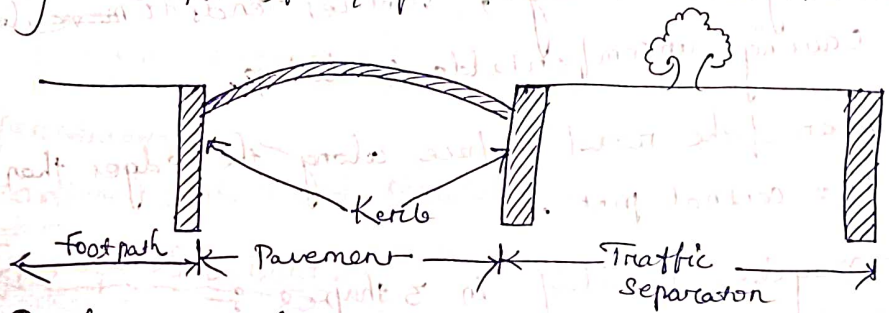
→ It is generally used in critical location such as bridges and hill regions.

→ It's height is 230 to 450mm.

d) Submerged Kerb:-

→ Provided in rural roads at pavement edges between pavement edges and shoulders.

→ These are in the form of Brick or concrete blocks.



★ Camber:- (Provided at the middle part with regards to edges)

→ Camber is the transverse slope provided to the road surface to drain off the rain water from road surface.

→ Also called "Cross-slope".

→ On straight road, the camber is provided by raising the centre of carriage way with respect to edges.

→ The rate of camber is generally designated by 1 in n which means that the transverse slope is in the ratio of '1' vertical to 'n' horizontal.

→ It mainly depends on the types of road surface and amount of rainfall.

	heavy	light
Cement concrete → & high bituminous	1 in 50	1 in 60
Thin bituminous	1 in 40	1 in 50
Gravel	1 in 33	1 in 40
Earth	1 in 25	1 in 33

	h	l
Worn →	1 in 33	1 in 40
Earth →	1 in 25	1 in 33

Excessive camber is not desirable because :-

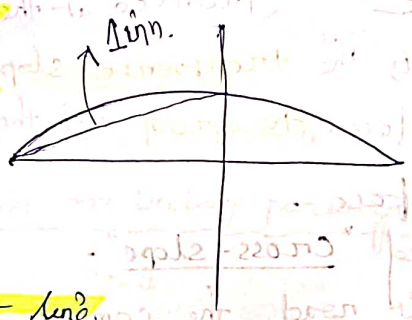
(i) Rapid flow of water results into formation of cross cuts.

(ii) During overtaking, vehicles tends to drag, causing uncomfortable conditions.

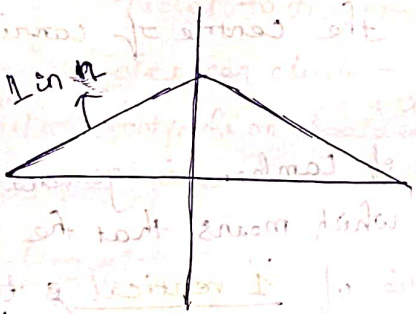
(iii) Wear of the road surface along the edges than the central part.

⇒ It may be provided in 3 shapes :-

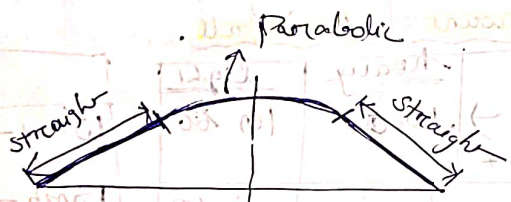
(i) Parabolic



(ii) Straight line



(iii) Combination of parabolic & straight :-

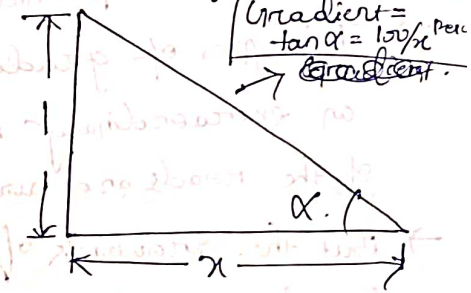


★ Gradient :-

→ Gradient is the longitudinal slope provided to the road surface along it's length.

→ It is expressed as ratio of 1 in x (one unit vertical and x unit Horizontal), also expressed by percentage (%).

→ Gradient in the road should not be very steep.



Types of Gradient :-

(i) Ruling Gradient
(ii) Limiting "
(iii) Exceptional "
(iv) Minimum "

(i) Ruling Gradient :-

→ The gradient which is generally adopted while making the alignment of road is called as "ruling gradient".

⇒ This is used for designing the road because it gives max^m safety at minimum cost.

→ Ruling gradient values of 1 in 30 on plain terrain, 1 in 20 on mountainous terrain and 1 in 16.7 on steep terrain has been recommanded by IRC.

(ii) Limiting Gradient :-

→ It is more steeper than ruling gradient.

→ It is usually used in hilly terrain and rolling terrain.

(iii) Exceptional Gradient :-

→ The gradient which is steeper than limiting gradient is called exceptional gradient.

→ This types of gradient is generally used in an extraordinary situation where shorter lengths of the roads are available.

→ But the drawback of an exceptional gradient is that it required more fuel consumption and has more friction loss.

(iv) Minimum Gradient :-

→ The minimum desirable slope which is essential for the effective drainage of rainwater from the surface of the road known as a minimum gradient.

Purposes of providing Gradient :-

→ To connect two stations with each other, which are located at different levels.

→ To make the earthwork required for the road economy. economic by balancing cutting & filling.

→ To construct the side drains economically.

Factors affecting gradient :-

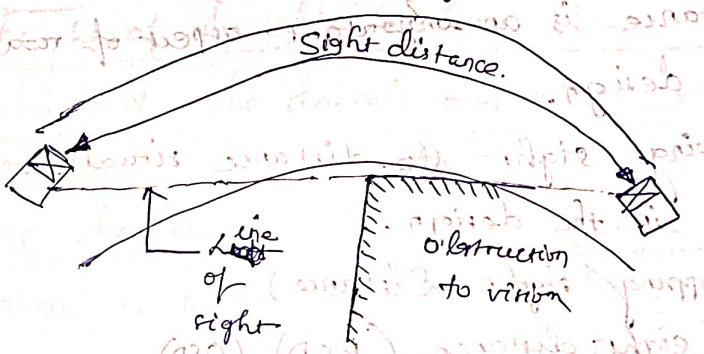
1. Nature of ground.
2. Drainage required
3. Nature of traffic.
4. Type of road surface.
5. Road & railway interaction
6. Safety required.
7. Bridge Approaches.

Dt- 6/4/23
5th sem

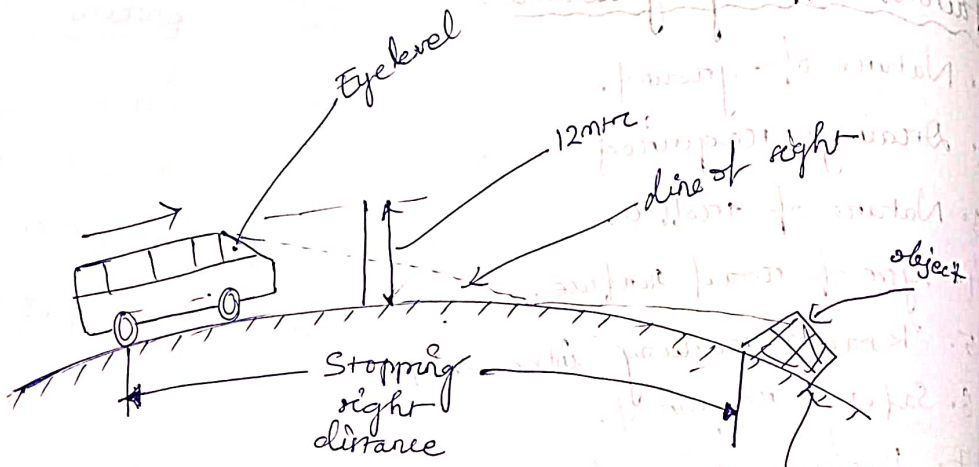
Sight Distance (SD) :-

→ Sight distance is the actual distance along the road at which a driver has visibility of stationary or moving objects from a specified height above the carriage way.

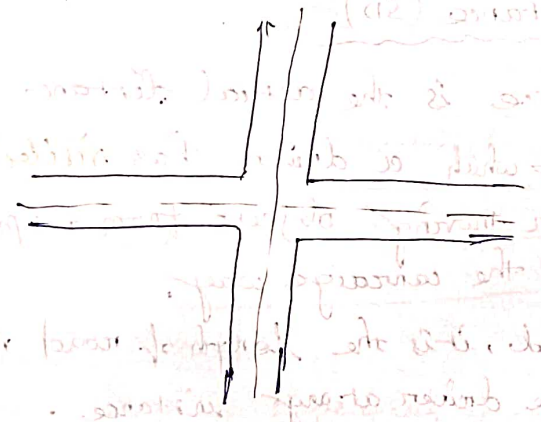
→ In other word, it is the length of road visible ahead to the driver at any instance.



(a) Sight distance of horizontal curve.



(b) sight distance at



→ Sight distance is an important aspect of road geometric design.

→ The following sight distance situations are considered in the design.

i) SSD (Stopping sight Distance)

ii) Passing sight distance (PSD) (OSD) overtaking

(iii) Sight distance at Intersection (SDI).

Apart from the above sight distance, the following sight distance are considered by the IRC in highway design:-

iv) Intermediate sight distance (ISD)

v) Head light sight distance (HLSD)

i) Stopping sight distance (SSD) :-

→ Stopping sight distance is the minimum sight distance available on a road to stop vehicle without collision. This is also sometimes called non-passing sight distance.

⇒ The sight distance available on a road to a driver at any instances depends on

(i) features of the road i.e, the horizontal alignment & vertical ~~alignment~~ profile of the road, traffic condⁿ.

(ii) height of the object above the road surface.

(iii) height of the driver's eye above the road surface.

→ IRC has suggested the height of eye level of driver as 1.2mtr & the height of the object as 0.15mt. & above the road surface for the purpose of measuring SSD.

following factors :—

(i) Total reaction time of the driver.
(ii) Speed of vehicle.
(iii) Efficiency of breaks.
(iv) Slope of road surface.
(v) Frictional resistance betn the road & the tyres.

(SSD for different speed as per IRC)

Design speed (kmph)	20	25	30	40	50	60	65	80	100
SSS (Safe stopping sight distance (mt)	20	25	30	45	60	80	90	120	180

* Reaction time :- It is time taken by the driver from the instant the object is visible to the driver to the instant the breaks are effectively applied.

→ The total stopping distance of a vehicle is the sum of lag distance & breaking distance.

∴ Stopping distance (SD) = lag distance + Breaking distance

$$SD = \left[vt + \frac{v^2}{2gf}\right] mt$$

↳ applicable for level area.

where → v = speed of the vehicle in m/sec
t = Reaction time in sec
f = Design coefficient of friction
= 0.4 to 0.35 for 20 to 100 kmph speed.
g = Acceleration due to gravity = 9.8 m/sec²

If speed is V kmph then stopping distance.

$$S.D. = \left[0.278vt + \frac{v^2}{254f}\right] mt$$ for level road.

SSD at slope is calculated by.

$$SD = \left[vt + \frac{v^2}{2g(f \pm 0.01n)}\right] mt.$$

when n = gradient in %. and v in m/sec.

If speed is V kmph.

then $S.D. = \left[0.278vt + \frac{v^2}{254(f \pm 0.01n)}\right] mt.$

* Lag distance :-

→ It is the distance travelled by the vehicle during the total reaction time

* Breaking distance :-

→ It is distance travelled by the vehicle after the application of the breaks, to a stead stop position.

Ex-1 :- Calculate the safe stopping distance for design speed of 60kmph for (a) two way traffic, in two lane road, (b) two way traffic in a single lane road.

Assume co-efficient of friction as 0.4 & reaction time of driver as 3.0 sec.

Soln :- Given data,

$V = 60$ kmph

$f = 0.4$

$t = 3.0$ sec

Stopping distance (SD) $= 0.278 Vt + \frac{V^2}{254 f}$

$= 0.278 \times 60 \times 3.0 + \frac{(60)^2}{254 \times 0.4}$

$= 50.04 + 35.43$

$= 85.47$ mt.

(a) When there is two way traffic in a two lane road.

$\boxed{SSD = SD = 85.47 \text{ mt.}}$

(b) When there is single lane road & traffic is two way stopping sight distance.

$\boxed{SSD = 2 \times SD}$

$= 2 \times 85.87$

$= 170.94$ mt.

(4M)

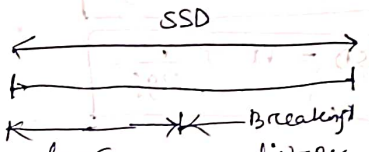
Dt-13/4/23 (Kshirsagar)

SSD

OSD

ISD = 2 SSD

HSD = 2 SSD.



$D_L = Vt$ $\quad D_B = \frac{V^2}{2gf}$

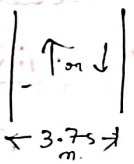
SSD = Lag distance + Breaking distance

$= Vt + \frac{V^2}{2gf}$ (t = reaction time = 2.5 sec)

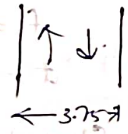
One lane = 3.75 m

(n x 3.5m)

One lane one way →



One lane two way →



two lane one way →

two lane two way →

Notes

(1) one lane one way, $\boxed{SSD = Vt + \frac{V^2}{2gf}}$

(2) One lane two way, SSD becomes 2SSD.

$\boxed{SSD = 2\left(Vt + \frac{V^2}{2gf}\right)}$

$2gf$

(4) Two lane two way, $SSD = Vt + \frac{V^2}{2gf}$

Q Calculate the safe stopping sight distance for design speed 50 kmph

(a) two way traffic on a two lane road

(b) Two way " " single "

Assume co-efficient of friction as 0.378

Reaction time of driver as 2.5 sec.

Soln Given data,

$V = 50$ kmph

$f = 0.37$

$t = 2.5$ sec.

Note

1 kmPH = 0.278 m/sec

(a) Stopping sight distance $= Vt + \frac{V^2}{2gf}$

$= 50 \times \frac{1000\text{ m}}{3600\text{ sec}} \times 2.5\text{ sec} + \frac{\left(50 \times \frac{1000}{3600}\right)^2}{2 \times 9.81 \times 0.37}$

$= 61.29$ m.

(b) Two way traffic on a single lane,

$2SSD = 2 \times 61.29$

$= 122.58$ m.

Q Calculate the stopping sight distance for a design speed of 100 kmPH. Take total reaction time is 2.5 sec and coefficient of friction is 0.35.

Ans:- Given data.

Design speed of vehicle = 100 kmPH (V)

$= 100 \times 0.278 = 27.8$ m/sec

Reaction time = 2.5 sec (t)

Coefficient of friction = 0.35 (f)

for one lane one way road,

stopping sight distance $= Vt + \frac{V^2}{2gf}$

$= 27.8 \times 2.5 + \frac{(27.8)^2}{2 \times 9.81 \times 0.35}$

$= 182.04$ m.

for one lane two way,

stopping sight distance = 2 x stopping sight distance

$= 2 \times 182.04$

$= 364.08$ m.

3.93×10^{-3}

$\frac{(0.278V)^2}{2gf} = \frac{(0.278)^2 V^2}{2 \times 9.81 \times f}$

$= \frac{V^2 \times 3.93 \times 10^{-3}}{f}$

$= \frac{V^2}{\frac{1}{3.93 \times 10^{-3}} \times f} = \frac{V^2}{254 \times f}$

Gradient → slope along the road

Camber → " across " "

$$SSD = vt + \frac{v^2}{2g(f \pm \frac{0.01N}{\wedge})}$$

(+ Ascending gradient)
(− Descending ")

$$= 0.2878\,vt + \frac{(0.278v)^2}{2g(f \pm 0.01N)}$$

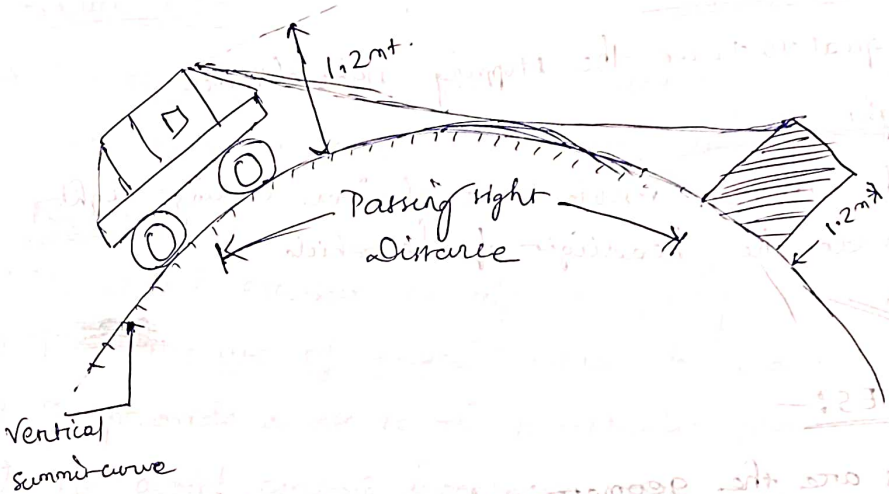
$$\boxed{SSD = 0.278\,vt + \frac{v^2}{254(f \pm 0.01N)}}$$

Dt - 20/4/23

Passing or Overtaking sight Distance :-

→ It is the minimum distance open to the view of the driver of a vehicle intending to overtake a slow vehicle ahead with safety against the traffic of opposite direction.

→ PSD is the distance measured along the centre of the road which a driver with his eye level at 1.2m above the road surface can see the top of an object 1.2m above the road surface.



→ the minimum PSD depends upon the following factors:-

(i) Speed of the overtaking, overtaken and the vehicle coming from opp. direction.

(ii) Slope of the road.

(iii) Rate of acceleration of overtaking vehicle.

(iv) Spacing bet" vehicle

(v) Skilled and reaction time of the driver.

Intermediate SD →

→ It is equal to twice the stopping sight distance.

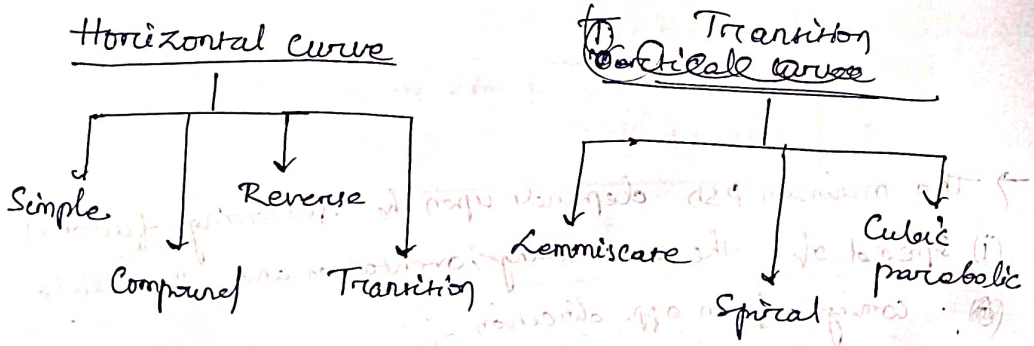
Headlight SD →

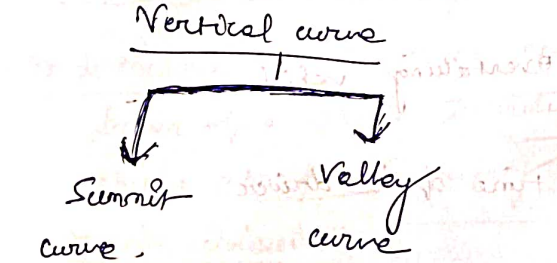
→ It is the distance visible to a driver during night driving under the headlight of the vehicle.

Dt - 4/5/23.

CURVES :-

→ Curves are the geometrical arcs provided at the change in gradient and alignment of a road.





Length of transition curve :-

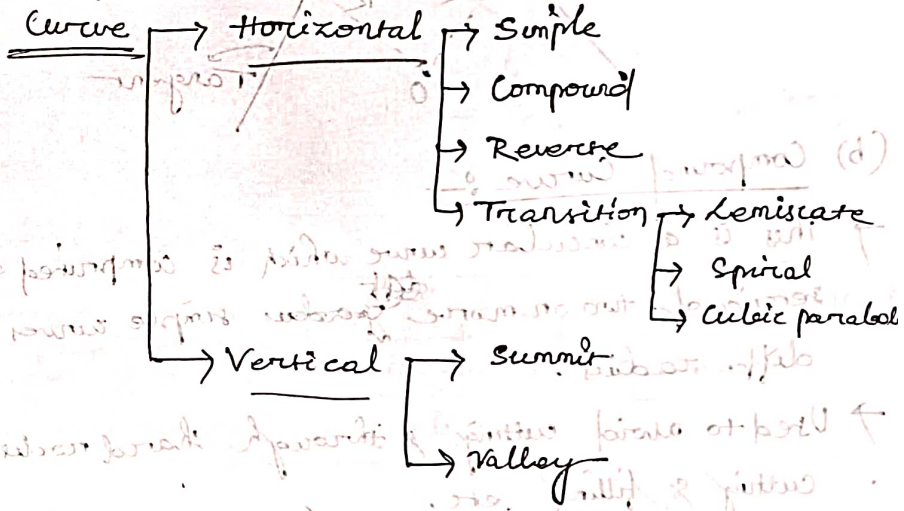
$$L_S = \frac{0.0215 V^3}{CR}$$

:- Curves :-

→ Curves are the geometrical arcs provided at the change in gradient or alignment of a road.

Necessity :-

→ To avoid excessive cutting & filling
→ To make use of existing road, bridge etc.
→ To provide access to the particular place.
→ To avoid certain important structures.
→ To avoid costly land.



(1) Horizontal Curve :-

→ It is a curve which is provided change in direction to the centre line of a road.

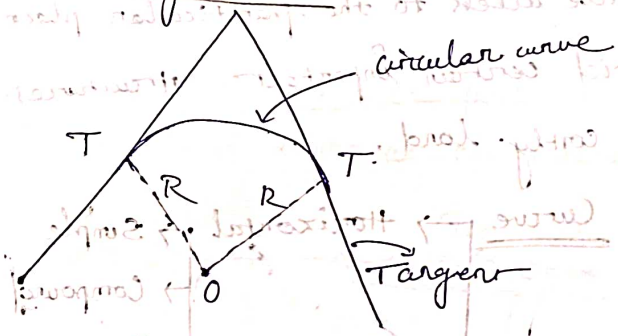
→ The min. radius of a horizontal curve is depends on the design speed of the road.

(a) Simple Curve :-

→ A circular curve which consists of a single arc of uniform radius.

→ This curve is expressed in terms of degree of the curve.

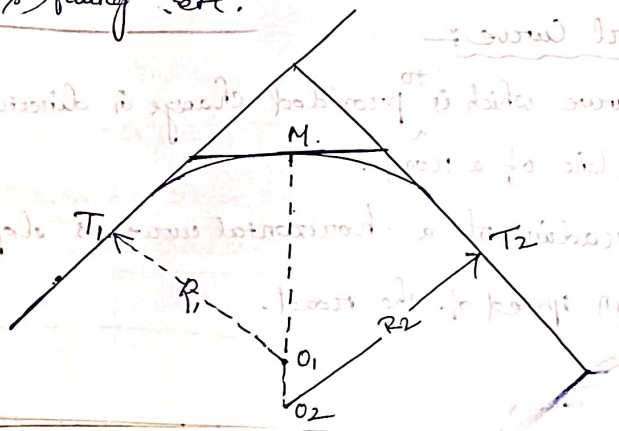
→ This type of curve is suitable for large radius and for slow moving traffic.



(b) Compound Curve :-

→ This is a circular curve which is comprised of two a series of two or more simple curves of diff. radius.

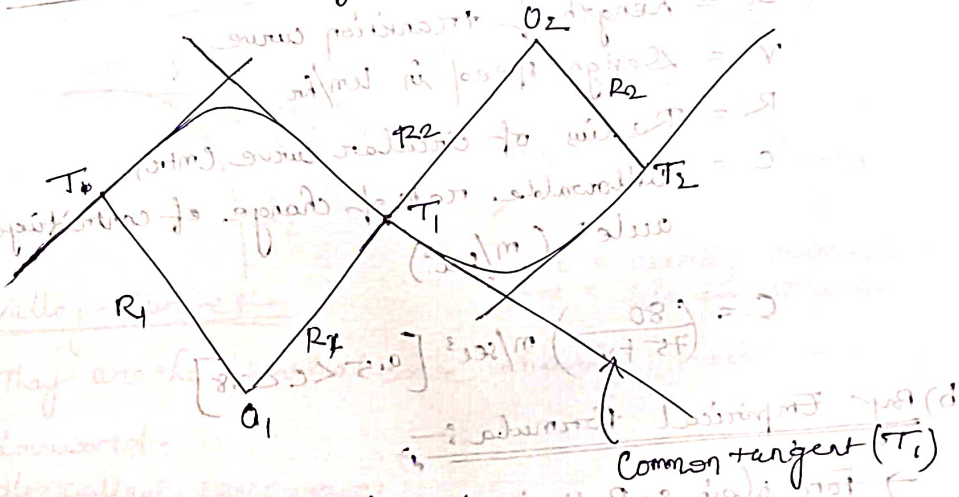
→ Used to avoid cutting through hard rocks, heavy cutting & filling, etc.



(c) Reverse Curve :-

→ Consist of two simple curves of same or diff. radius which turn in opposite direction.

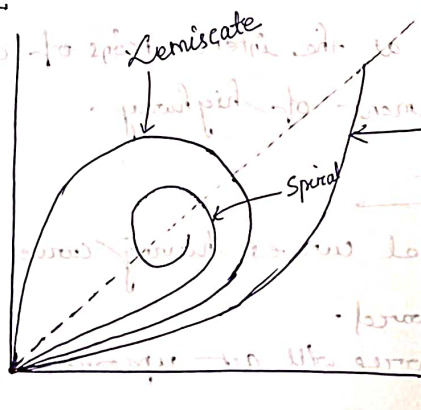
→ Suitable for hilly regions.



(d) Transition Curve :-

→ This generally introduced on highways, b/t a straight and circular curve to provide ease and gradual change in direction of a road alignment.

Types :-



Length of Transition Curve :-

(a) Rate of change of centrifugal accel^n :-

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

Where, L_s = Length of transition curve
V = Design speed in km/hr
R = Radius of circular curve (mtrs).
C = Allowable rate of change of centrifugal accel^n (m/sec^3).

$$C = \left(\frac{80}{75 + V}\right) m/sec^3 \quad [0.5 < C < 0.8]$$

(b) By Empirical formula :-

→ For plain & Rolling terrain

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

→ For mountainous, and steep terrain

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

(ii) Vertical Curves :-

→ The curves provided at the intersections of diff. grades in the vertical alignment of highway.

(a) Summit Curve :-

→ They are the vertical curves having curves having their convexity upward.
→ The centrifugal force will act upwards against gravity when a fast moving vehicle travels along a summit curve and there will be no problem of discomfort to the passengers.

(a) $N = (n_1 + n_2)$, $+n_1$, $+n_2$.

(b) $N = n_1 + n_2 = 0$ (Hogging)

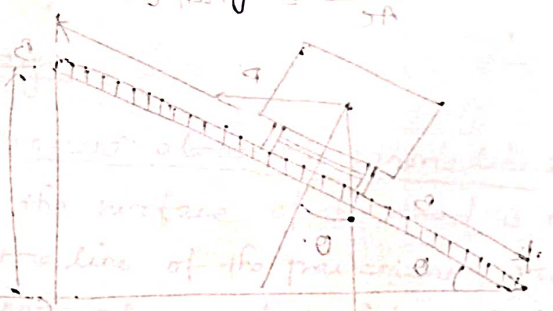
(c) $-n_1$, $N = (n_2 - n_1)$, $-n_2$

(d) $N = (n_1 + n_2)$, $+n_1$, $-n_2$

+ve = ascending gradient
−ve = descending gradient

(b) Valley Curve :-

→ They are the vertical curve having their convexity downward.
→ Also called sag curves.
→ The centrifugal force acts downwards adding to the pressure on the suspensions in addⁿ to the self weight of a vehicles moving on the curve.



Super Elevation :-

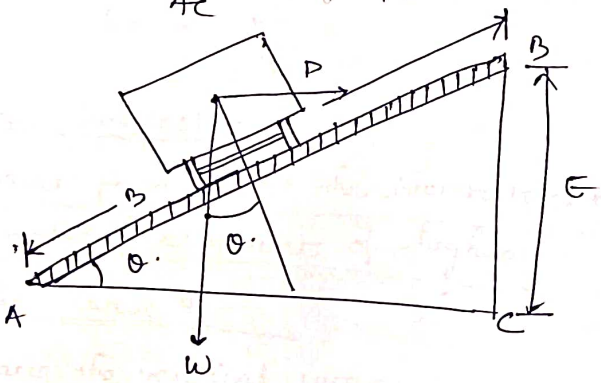
→ Super elevation is the inward transverse slope provided throughout the length of the horizontal curve by raising the outer edge of the pavement with respect to inner edge.

→ This is also called cant or banking and denoted by 'e'.

→ It is provided to counteract the effect of centrifugal force and to reduced the tendency of the vehicle to overturn or skid.

→ The super elevation expressed as the ratio of the height of outer edge w.r.t the horizontal width of the pavement.

$$\theta = \frac{BC}{AC} = \tan\theta.$$



$$e = \tan\theta \approx \sin\theta = \frac{BC}{AB} = \frac{E}{B}.$$

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

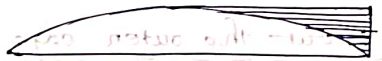
$$e = \frac{V^2}{127R}$$

Methods of providing Super elevation :-

⇒ In four stage,

the outer half of the camber is gradually raised until is is level, thereby eliminating the crown of the cambered section.

(a) Normal camber



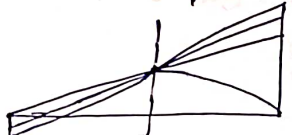
(b) Outer half raised

(c) Super elevation equal to camber.

⇒ In Second stage,

(i) Revolving Pavement about the centre line:

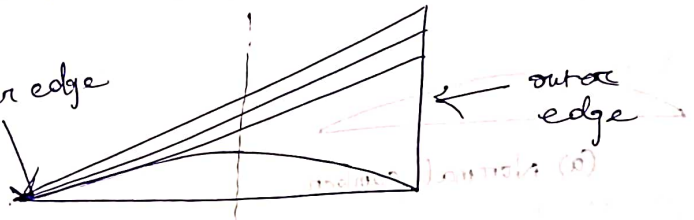
→ In this method, the surface of the road is rotated about the centre line of the pavement, gradually lowering the inner edge and raising the upper edge by keeping the level of the centre line unaltered.



(ii) Revolving: Pavement about the inner edge

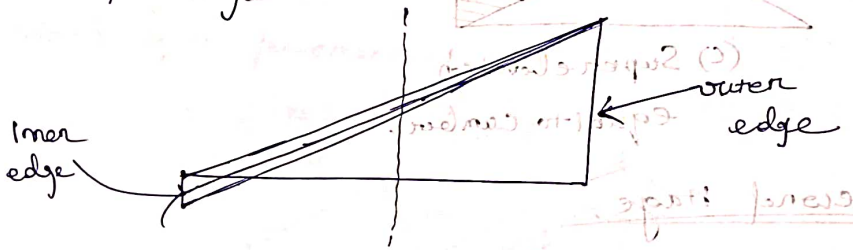
→ The surface of the road is rotated about the inner edge, raising the centre and the outer edge.

→ Method of revolving about the inner edge is preferred in very flat terrain in order to avoid the drainage.



(iii) Revolving Pavement about the outer edge:-

→ This method is, the surface of the road is rotated about the outer edge depressing the centre and the inner edge.



Dt 18/5/23

Widening: (W)

↳ Mechanical widening (W_m) (Off tracking widening)

↳ Psychological " (W_p)

$$W_m = \frac{nl^2}{2R}$$

$$W_p = \frac{V}{9.5\sqrt{R}}$$

(l = length of wheel base of larger vehicle = 6.1 m (normal))

(R = Radius of the curve)

(n = No. of lane)

$l = 6.1$ m → as per IRC.

V = Speed of vehicle (KMPH)

Total widening = $W_m + W_p$.

$$W = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$R < 50$ m → sharp curve (widening provide in both the inner & outer side).

$R > 50$ m → (only in inner side)

Q Find the widening necessary for a horizontal curve in two lane road having $R = 100$ m, wheel base = 6.1 m, pavement width = 7 m, Design speed = 70 KMPH.

Sol^n :- Given data,

$R = 100$ m, $V = 70$ KMPH

$l = 6.1$ m

$n = 2$

$$W = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$= \frac{2 \times (6.1)^2}{2 \times 100} + \frac{70}{9.5\sqrt{100}}$$

$$= 1.108 \text{ m}$$

∵ Hence $R > 50$ m, so, widening is provided in outer side only, i.e, $W = \frac{1.108 \text{ m}}{2}$

$$= 0.554 \text{ m}$$

Superelevation

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

$g = 9.8 \text{ m/s}^2$

$R = m$, $V = \text{KMPH} = \frac{1000}{3600}$ m/s

e_{max}

$e = 7\%$, $e = 0.07$ → plain / Rolling terrain

$e = 10\%$, $e = 0.10$ → Hilly terrain

$f = 0.15$

Step-1 mix traffic design:

↳ Reduce the speed of vehicle to 75%

$V \rightarrow 0.75V$

Assume e → Equilibrium superelevation

$f \rightarrow 0$.

$$e = \frac{(0.75V)^2}{gR}$$

Check, $e < e_{max}$ → Provide e designed value

$e > e_{max}$ → Provide e_{max}

Step-2

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

$$\Rightarrow f = \frac{V^2}{gR} - e_{design}$$

$f > 0.15$ → 0.15 will be provided.

$f < 0.15$ → f will be provided.

Step-3

V limit

$$e_{deg} + f = \frac{(V_{limit})^2}{gR}$$

$$\Rightarrow V_{limit} = \sqrt{gR(e_{deg} + F)}$$

Q Design the rate of superelevation on a highway in plain terrain with design speed 100 KMPH with radius of curve 500 m each

Ans:- Given data,

$V = 100 \text{ KMPH} = 100 \times \frac{1000}{3600} = 27.78$

$R = 500$ m

For mix traffic design,

$$e = \frac{(0.75 \times 27.78)^2}{9.81 \times 500} = 0.085 \text{ m}$$

For check,

$e > e_{max}$.

So, the rate of super elevation (e) = 0.07 m.

Q For a circular curve of radius 200 m, the coefficient of lateral friction of 0.15 and the design speed is 40 km/hr. The equilibrium super elevation (for equal pressure on inner and outer wheel) would be :-

Soln $R = 200\ m$

$f = 0.15$

design speed (V) = 40 km/hr = $40 \times \frac{1000}{3600}$

$e = ?$

For equilibrium super elevation, $f = 0$

$$e = \frac{(0.75V)^2}{gR}$$

$$= \frac{\left(0.75 \times 40 \times \frac{1000}{3600}\right)^2}{9.81 \times 200}$$

$$= 0.035$$

2022 (Practice for Semester)

1(b) Diff^n bet^n bitumen & tar :-

Bitumen	Tar
→ Solid or semisolid, black, sticky substances obtains from the distillation of crude petroleum.	→ black solid mass formed during the distillation of coal, wood etc.
→ has a low degree of toxicity	→ has a high degree of toxicity
→ more resistive to water and acid.	→ less resistive to water & acid.
→ Consists of moderate % of carbon.	→ Consist of high % of carbon

(d) Traffic Density :-

→ No. of vehicles occupying a unit length of the lane of the roadway at a given instant.

→ Unit = Vehicles/km.

(e) Seal Coat :-

→ A coat of bituminous material applied during construction to a bituminous macadam or concrete for sealing the surface of pavement.

→ It is very durable, flexible & water resistance.

Prime coat → in bet^n WMM & DBM

Tack coat → in bet^n DBM & WC.

Seal coat → in above of WC.

$$SD = Vt + \frac{V^2}{2gf}$$

For one lane two ways → SSD = 2SSD

For two lane two way → SSD = SSD

For one lane one way → SSD = SSD

For two lane one way → SSD = SSD

Q. Calculate SSD.

$V = 50 \text{ kmph} = \left(50 \times \frac{1000}{3600}\right) \text{ m/sec}$

$f = 0.35$

$t = 2.5 \text{ sec}$

$$SD = Vt + \frac{V^2}{2gf}$$

$$= \left(50 \times \frac{1000}{3600}\right) \times (2.5) + \frac{\left(50 \times \frac{1000}{3600}\right)^2}{2 \times 9.81 \times 0.35}$$

$$= 62.81 \text{ m}.$$

for two way traffic on a two lane road

$SSD = SSD = 62.81 \text{m} =$

for two way traffic on a single lane,

$SSD = 2SSD = 62.81 \times 2 = 125.62 \text{m} =$

— x —

Kerbs :- They are the boundaries bet^n carriageway and shoulders or footpath

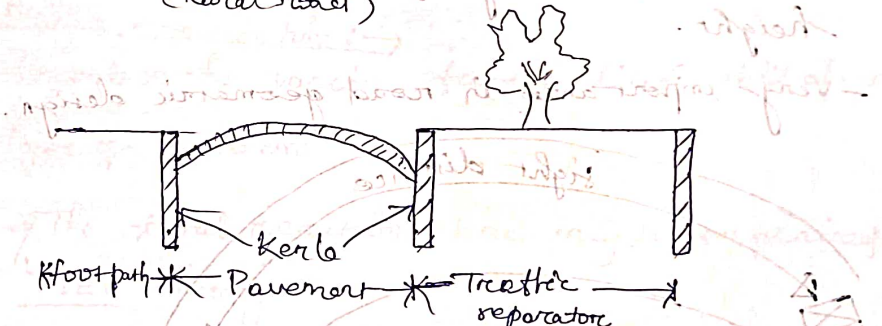
- Also provided as traffic separator.
- They are of 3 types :-

(i) Low & mountable kerbs. (class I)

(ii) Low speed barrier kerbs (class II)

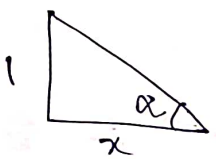
(iii) High speed barrier kerbs (class III) (Bridge & hilly)

(iv) Submerge kerbs (class IV) (Rural road)



Camber :-

Gradient :→ It is the longitudinal slope provided at the road surface along it's length.



→ It can be expressed as 1 in x (1 in vertical & x in horizontal) or in percentage (%).

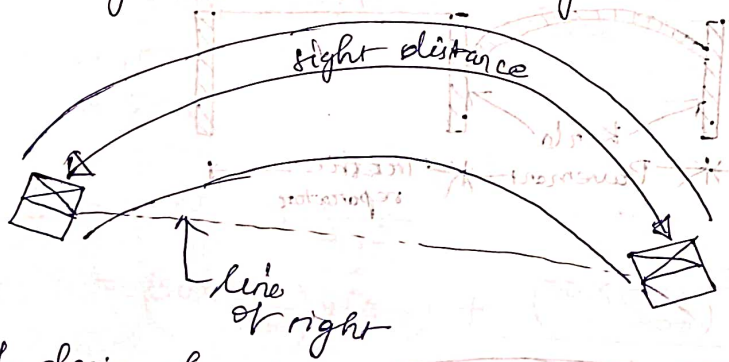
→ Gradient shouldn't be very steep.

→ It is provided to connects the roads at diff. level.

→ There are 4 types of gradient
(i) Rolling (iii) Exceptional
(ii) Limiting (iv) Minimum.

SD :- It is the distance along the road at which the driver has a visibility of stationary or moving object from a specified height.

- Very important in road geometric design.



5 types of design should be consider :-
(i) SSD
(ii) OSD / PSD
(iii) Sight distance at intersection
(iv) Intermediate SD.
(v) Headlight SD

Total Reaction time for a driver :-

→ It is the time taken from the instant the object is visible to the driver eye and the instant the brake is efficiently applied.

→ The reaction time can be split up into 2 parts:
(i) Perception time
(ii) brake reaction time

(i) **Perception time** :→ The time required by the driver to realise that the brakes are to be applied.

→ It is time that the objects comes to the line of sight of the driver to the instant he realised that the vehicles need to be stopped.

(ii) **Brake reaction time** :→

→ depends on the various factors like skill of driver, type of problems etc.

→ The total reaction time may be explained by 'PIEV' theory.

i.e, Perception time
Intellection time
Emotion time
Volition time.

→ Perception time :-

→ It is time from the object comes to the instant the line of sight of the driver to the instant to realise to applied brake ai to stop the vehicle.

→ It is the requirey by the driver to realise the brakes are to be applied.

→ Intellection time :-

→ The time required for driver to understand the situation.

→ Emotion time :-

→ It is the time elapsed during the emotional reaction and the distrubance like fear, anger or any other feeling with reference to the situation.

→ It depending upon the situation and the types of problems / condition.

→ Volition time :-

→ It is the time taken by driver for final action → that is brake appl?

→ At last the PIEV time of a driver is totally depends on psychological & physical characteristics of driver, types of problem involved, environmental etc.

→ The total reaction time of a driver may vary from 0.5 seconds for simple situation and 3 to 4 seconds in complex problems.

PSD / OSD :-

→ It is the minimum distance at which the view of a driver of a vehicle is intending to overtake the slower vehicles ahead with safety against the traffic coming from opp. direction.

→ depends on : → traffic cond'
→ sloping of road
→ spacing bet' vehicle
→ speed of overtaking
→ skilled and reaction time of driver.

Curves

→ They are the geometrical are provided in change in gradient and alignment of a road.

Horizontal → Simple
→ Compound
→ Reverse
→ Transition → Spiral
→ Lemniscate
→ Cubic parabola

Vertical → Summet
→ Valley

Simple → A circular curve which consist of a single arc of uniform radius.
→ Suitable for large radius and for slow moving vehicle.

Compound → Consist of combined series of two or more simple curve of diff. radius
→ Used to avoid excess cutting & filling
→ Different centre point are there.
→ Diff. tangent point also.

Reverse → Consist of two or more simple curve of same or diff. radius which is in opposite direction.
→ Suitable for hilly region.

Transition → Introduced in highway in bet' a straight and circular curve to provide ease and change in alignment of road and direction.
→ It's function is to provide comfort for passengers.
→ It has to increase designed super elevation at a desirable rate.
→ It has to enable the driver to turn the steering gradually for his own comfort and security.
→ Introduced centrifugal force bet' tangent point and circular curve, avoiding sudden jerk on the vehicle.

CBR Value →

Impact Value → $\frac{W_2}{W_1} \times 100$
(Cylindrical metal measure)
(Cylindrical cup) W_2 = Sieve on 2.36 mm sieve (Passing)
W_1 = weight of aggregate sample (?)

Abrasion Value → $\frac{W_1 - W_2}{W_1} \times 100$ (2.5kg)
(Los angeles abrasion m/c)
(500 times revolution) W_1 = Weight of aggregate sample
W_2 = weight of aggregate sieve on 1.7mm sieve. (Retained)

Crushing Value test → $\frac{W_2}{W_1} \times 100$ (3.5kg)
(Cylindrical measure)
(Cylinder in appearance)
W_2 = sieve on 2.36 mm sieve (passing)
W_1 = Sample of 3.5kg.

Necessity of Road Drainage work :-

→ Due to variation of moisture content in the soil, it causes variation in volume of subgrade and leads to failure of the road pavement.

→ Excess moisture content in the soil sub-grade causes a reduction in it's stability.

→ If the stability of the soil sub-grade fails due to poor drainage, the pavement structure is likely to fails due to subgrade failure.

→ The entrance of water causes a reduction in the bearing capacity of the sub-grade like WBM and stabilized soil.

→ The stagnation of water on the surface of the pavement reduces strength of the pavement.

→ Due to poor drainage of road, water remains in the bituminous material for longer time causing formation of pot holes.

→ Poor and improper surface drainage work causes erosion of soil from top of the road, slope

→ In rigid pavement, the failure occurs by mud pumping due to presence of water in sub-grade

→ Due to excess water, the shoulders and pavement structure gets damaged.

Sub-surface Highway Drainage :-

→ Sub-grade may be damaged by sub-soil water. Sub-soil water may come up by capillary action to the subgrade from water table.

→ Subgrade should be of self drainage materials so that it may pass off the percolation water that comes to remain dry and stable.

→ But if subgrade is of top soil, underground discharging the free water to the subgrade so it have to constructed about $1\frac{1}{2}$ or 2' below the formation level to carry away the water from the subgrade.

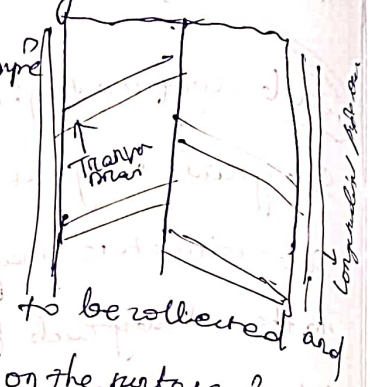
→ Cross-drain is in the form of trapezoidal trenches filled with selected rubble. Depth is not more and discharge is small.

→ The pipes are surrounded by filter material and water of subgrade passes through the open joints of pipes and enters the lateral drains and discharge

into the longitudinal drain.

The diff method of subgrade drainage :-

1. Longitudinal drain Trenches and pipe
2. subgrade drain.



Surface Drainage :-

→ The surface ~~water~~ of water is to be collected and then disposed off. The water on the surface is first collected in longitudinal drain, generally in side drain and then water is disposed to the nearest stream and valley.

→ For the preparation of surface drainage we should keep in mind various things like, seeing the amount of rainfall and slope of the camber is to be provided etc. to drain out the surface water.

→ The shoulders of the rural roads are constructed with suitable cross slopes so that the water is drained across the shoulders to the side drain. They are generally open drain of trapezoidal shape.

→ The side drain should be parallel to the alignment of roads so they are called longitudinal drain.

→ In embankments the longitudinal drain are provided as one on both side of the road.

→ In underground due to limitation of road, the ~~side~~ drain should be provided as underground longitudinal drain.

→ Drainage of surface water is all the more imp in hill roads. In hill roads disposal of water is very important.

Numericals.

Given data

$V = 50$ km/hr $= 13.9$ m/s

$f = 0.37$

$t = 2.5$ sec

Stopping distance = lag distance + breaking distance

$$= Vt + \frac{V^2}{2gf}$$

$$= 13.9 \times 2.5 + \frac{(13.9)^2}{2 \times 9.81 \times 0.37}$$

$$= 61.4 \text{ m}$$

(i) for one lane two way $= 2SSD = 2 \times 61.4 = 122.8$ m

(ii) for two lane two way $= SSD = 61.4$ m.

2. Given data:

Design speed of highway = 60 kmph (V)

Pavement width = 7.0 m

Length of wheel base = 7.0 m

Radius of horizontal curve = Rulling min. radius

$$= \frac{V^2}{127(f+e)}$$

$$= \frac{60^2}{127(0.015+0.07)}$$

$$= 128.8\ m$$

$$\simeq 129\ m.$$

No. of lane = 2

We = Mechanical widening + Psychological widening (widening)

$We = W_m + W_s$

$$\Rightarrow We = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

$$\Rightarrow We = \left(\frac{2\times 7^2}{2\times 129}\right) + \frac{60}{9.5\sqrt{129}}$$

$$= 0.933\ m$$

Total width of pavement = 7 + 0.93 = 7.93 m

3. Given data,

Design speed = 100 kmph = $\frac{100\times 1000}{3600}$ m/s

$t = 2.5$ sec

$f = 0.35$

$$SSD = Vt + \frac{V^2}{2gf}$$

$$= \frac{100\times 1000}{3600}\times 2.5 + \frac{\left(\frac{100\times 1000}{3600}\right)^2}{2\times 9.81\times 0.35}$$

$=$

4. Given data,

e = super elevation

f = coefficient of friction

g = Acl. due to gravity

V = design speed.

we know,

$$e + f = \frac{V^2}{g.R}$$

$$\Rightarrow e + 0.15 = \frac{\left(\frac{100\times 1000}{3600}\right)^2}{9.81\times 250}$$

$$\Rightarrow e = 0.1646 \Rightarrow \boxed{e = 16\%}$$

Here, e is exceeding the maxm limit of 7%,

therefore speed need to be restricted.

Assume super elevation to be 7%,

$$0.07 + 0.15 = \frac{V^2}{gR}$$

$$\Rightarrow V = \sqrt{(0.07 + 0.15)\, 9.81 \times 250}$$

$$\Rightarrow V = 23.22 \text{ m/s}$$

$$\Rightarrow V = 83.62 \text{ kmph}$$

Q2 (a) Given data,

overtaking vehicle as A_2

overtaken vehicle as B_1

overtaking speed = 70 kmph. (V_A)

overtaken " = 40 kmph (V_B)

for two way traffic,

$$OSD = d_1 + d_2 + d_3$$

$$d_1 = V_B T \quad \text{(Assume } T = 2 \text{ sec)}$$

$$d_1 = \frac{40 \times 1000}{3600} \times 2 = 22.2 \text{ m}$$

$$d_2 = V_B T + 2S$$

where, $S = (0.7 \times V_B + 6)$

$$= \left(0.7 \times 40 \frac{\times 1000}{3600} + 6\right)$$

$$= 13.8 \text{ m}.$$

$$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 13.8}{0.99}} = 7.48 \text{ sec}$$

$$d_2 = \left(\frac{40 \times 1000}{3600} \times 7.48\right) + (2 \times 13.8)$$

$$= 110.71 \text{ m}$$

$$d_3 = V^* T = \left(\frac{70 \times 1000}{3600}\right) \times 7.48$$

$$= 145.45 \text{ m}.$$

$$OSD = 22.2 + 110.71 + 145.45$$

$$OSD = 278.36 \text{ m}$$

(b) Minimum length of overtaking zone = 3 (OSD)

$$= 3 \times 278.36$$

$$= 835.08 \text{ m}$$

Bull-Dozer → Blade width = 2 to 8.5m
Blade height = 0.6 to 2m.

Grader → Blade with the wheel base.
length of blade = 3.5m
eff n n = 2.75m

Rigid-Pavement deficiency:

(i) Buckling of slab
(ii) Corner cracking or breaking
(iii) D-cracking
(iv) Longitudinal cracking
(v) Random cracking
(vi) Transverse cracking
(vii) Crazing (120° cracks)
(viii) Bending or wrapping
(ix) Spalling
(x) Joint failure
(xi) Spalling (Due to traffic action)

WBM	WMM
→ stands for water-bound macadam.	→ Wet-mix macadam
→ less durable than WMM.	→ more durable than WBM.
→ Material used are of size 90-20mm	→ 20-4.75mm crushed on stone dust
→ Prepared at site/field	→ Prepared in mix plant
→ Quantity is measured in m^3	→ measured in m^2.
→ water contenation is more.	→ less
→ Coarse aggregate, screening, binder	→ Coarse aggregate, binder

2 marks

Arboriculture:

→ The highway engineers with his ingenuity and patience can achieve wonderful results with small cost and beautify road.
→ Road Arboriculture is one of the architectural effect which adds to the overall appearance of road.
→ planting of tree is most essential.