Topic(s) to be covered	Introduction - Highway planning - stages of Highway planning - Significance of Highway planning.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
L01	Gain knowledge on Highway planning.	Understand

Teaching Learning Material	Student Activity
Chalk / Talk.	Listen

Lecture Notes

Introduction:-

- Roads are considered as the essential, cost effective & easiest mode of transportation.
- It is easily available & accessible to all the places of the country.

Highway improvements are used in the,

a) Development of Industries & Commerce
b) " " Agriculture
c) " " National Resources
d) Increase in medical services etc.

Highway planning:-

- In India, the percentage of road users has increased from 26% to 82% from 1951 to 2013.
- Total Goods traffic by road transport has increased to about 60%.

Stages of Highway planning:-

(a) Traffic survey & Analysis:-

Some of the goals that are generally investigated are

- Removal of through traffic from residential area.
- Revaluation of public Transport.
- Minimum demolition of Houses & general environment.
- operational feasibility.

(b) Forecast Analysis:-

- Transport plan involve planning for 20-25 years
- 20 years plan known as Bombay plan was evolved.
- forecast Analysis also includes, Population forecast Can be done by study of past trends.

(c) Evaluation:-

- for a given set of goals & policies a no. of alternate transport plans are feasible.
- Evaluation of each of alternative has to be done to select the

programme adoption:-

> Selection & adoption of the best alternate plan depends upon the evaluation study.

Continuing study:-

> Uncertainty is always associated with highway planning & the plans/policies which are relevant today may not remain as such in the future. Hence, the process needs constant iteration & feedback.

Significance of Highway planning:-

- To provide safe, efficient, economic, comfortable & speedy movement of people & Goods.
- To plan for expected future developments & social Needs.
- To optimize the Usage of Roads with available Resources.
- To create Road development program from financial Considerations.

Topic(s) to be covered	Road development Plan. First Twenty year - Second Twenty year - Third Twenty year Road development plan.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand Various Road developmend plan.	Understand.

Teaching Learning Material	Student Activity
Chalk / Talk	Listen

Lecture Notes

- Road Developmed Plan.
  1. First Twenty Year Road Development (Nagpur road plan 1943 - 1963)
  2. Second Twenty year Road development (Bombay road plan 1961 - 1981)
  3. National Transport policy Committee (1978)
  4. Third Twenty year Road development (Lucknow road plan) 1981 - 2001

- Lucknow Road plan:-
  Due to change in planning during the second Twenty year plan (1961 - 1981), the preparation of third

Year plan (1981-2001) got delayed and the document was finally during the 45th annual session & the golden jubilee Celebra of the Indian Road Congress in February 1985 at Lucknow This plan is also called as Lucknow Road Plan.

- Objectives:-

1. The Villages with a minimum population of 500 should also be Connected by Road network.
2. Less Industrial areas should also be Connected Road, Inorder to develop the small scale Industries & to attract the growth of Industries.
3. The NH length should be Increased to form a Square grid of 100 km side.
4. Expressway should be Constructed between the maj traffic cities to Increase the speed of travel.
5. Energy Conversation through Road Improvements mu be given a high priority.
6. Road Safety Measures must be Undertaken to Con & bring down Road accident Rates.

- Important features

a) Improvement of transportation facilities in Villa
b) Conservation of energy
c) Preservation of Environmental quality
d) Improvement in road safety.

per the Third Twenty year plan, the National Highways were signed based on the Concept of 1 km length per 50 km² area. ce the total length of NH in an area can be obtained by ding the total area by 50.

The third twenty year plan aimed at increasing the total road length from 15,00,000 km in the 1981 to 24,00,000 km by the year 2001.

This plan increased the road density of 82 km/100 km² area. The length of various categories of roads are calculated as under.

1. Length of the National Highway $L_1 = \frac{\text{Area (in km}^2\text{)}}{50}$.

2. Length of the State Highway $L_2 = \frac{\text{Area (in km}^2\text{)}}{25}$

3. Length of the major district roads $L_3 = \frac{\text{Area (km}^2\text{)}}{12.5}$

4. Total Road length, $L_4 = 4.74 \times$ No. of towns & villages.

5. Rural Road length, L_5 = Total Road length $L_4 - (L_1 + L_2 + L_3)$

Lecture No. 3 HIGHWAY ALIGNMENT

Topic(s) to be covered	Introduction - objective - factors influencing highway alignment.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
Lo1	Understand the factors influencing highway alignments.	Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

- Introduction: -
  - Location of a Highway is the position occupied by a road which is called the alignment of the road.
  - The alignment specifically represents the Centre line of the road & the Vertical grade.

- Objectives of an Ideal Alignment are discussed below.
  1. Direct - It should be as short & direct possible between the terminal points.
  2. Interference - The alignment should not interfere to the maximum extend with agri & Industries.

- Factors influencing highway alignment.

- Traffic:-

- Traffic requirement is the prime factor to be considered. This comprises of type of vehicles it has to cater & the volume of traffic it has to handle. Vol. of traffic is an important factor which is essentially the qty. of movement per unit of time at a specified location. Origin of the volume of traffic & destination study should be carried out. The proposed new alignment should also taken into Account the traffic flow patterns. The future plan as per the national road plan should also be conside

- Geometric Design:-

- In straight reaches the gradient may be steep.
- Extra widening of the road along the curve, the super elevation to be provided.
- Line of sight, sight distance. and stopping sight distance which will be available at every section should be studied.
- overtaking operation of vehicles should be smoo for the permissible speeds of the vehicles on the road at the selected alignment.

- Economy:-

The economic aspects of road alignment, the initial cost, maintenance cost & vehicle operation cost should be taken into account.

. The Initial Cost of Construction may be reduced by slightly altering the alignment such that the Construction of Embankment or Cutting may be avoided or atleast reduced.

. A balance alignment may be made by equalizing the Cost of Cutting & Construction of embankment.

Other Considerations:-

Factors like drainage, Hydrological factors, monotony, etc also govern the final alignment. Drainage Considerations, Subsoil Condition, Cross drainage work, Crossing may also affect the alignment. Border Roads may pose special problems according to the relation with the neighbouring Countries.

Obligatory factors:- The points which Controls the alignment of a highway is called obligatory Controlling points.

(a) positive factors:-

In order to satisfy the obligatory points through which the road alignment should pass. may Cause the alignment to deviate from the shortest or the economical path. such as Hill, river Crossing, etc.

(b) Negative factors Condition may also arise in practice that make to deviate from short route. such as Religious places, Monuments, Unsuitable land, large water body & agricultural land.

.. Obligatory factors

i) Points through which alignment should Pass

ii) " " " " shouldnot Pass.

I- points through which alignment should pass.

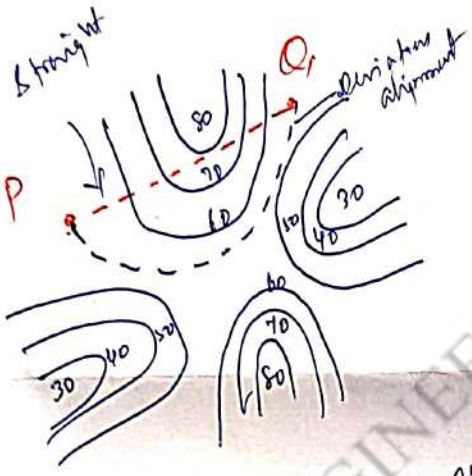
1. Hill Pass 2. A bridge site 3. Intermediate town with transport.

① Hill Pass- When an Alignment is to Cross a Hill or a mountain, There are three option to pass the hill

(i) Cutting a tunnel

(ii) Go around the hill

(iii) Deviate till a suitable hill pass is available.



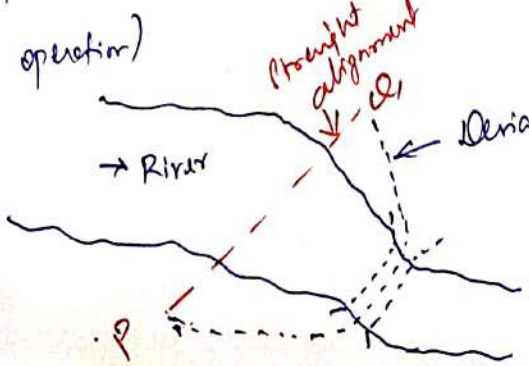
Deviation of an Alignment through a Hill.

② Fig 2 shows the deviation of an alignment across a river bridge. The Road bridge Cross a rover can be located only places where,

(i) The river has straight & permanent path (Stability of bridge)

(ii) The river has less width (Cost reduction)

(iii) Road Approaches to the bridge should be as straight as possible (easy operation)

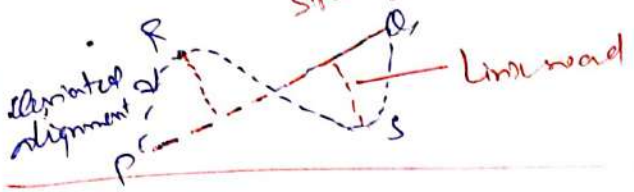


The requirement of Ideal should pass through the no. of town & villages, without increasing the cost Considerably.

- The Alignment should Connect Intermediate town & other places
- PQ split into PR & RQ
- City R should be have population with Reasonable traffic.

③ Intermediate town with traffic

Straight alignment



The

- The road alignment is to be changed to keep away from Certain points & places.

eg.

1) Religious places:- & Monumental buildings

The obligatory points should be avoided in the alignment in religious places (Temple mosque & church)

2) Costly structures.

Acquisition of Costly structures takes more cost for Compensating resulting in increased of Construction.

3) Unsuitable Grounds.

Marshy, peaty & water logged areas are generally not Suitable for Road Construction & should be avoided as far as possible.

Topic(s) to be covered	Classification of Roads. Express Highway - National Highway - State Highway - MDR - ODR & Village Roads.

Lecture Outcome (LO)		
	At the end of this lecture, students will be able to	Bloom's Level
L_{01}	Gain knowledge of Classification of Indian Roads	B-Tz - Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen

Lecture Notes

- Classification of Roads

1. Primary System - It Consists of 2 roads
   a) Express Highway
   b) National Highway
2. Secondary System - It Consists of 2 roads
   a) State Highway
   b) Major District Roads
3. Tertiary System or Rural roads
   a) other district road (b) Village Roads.

Express Ways:- i) Specially Constructed for fast moving Vehicles having Road width of 4 to 6 lanes [27m to 31m].
ii) These are Constructed with divided Carriage ways. Controlled access, grade separation at Cross Road & fencing.
iii) It is Constructed and owned by Central Govt. in India.
eg - a) The Golden Quadrilateral [Connecting Chennai, Delhi, Kolkata & Mumbai]
b) North South Corridor [Connecting Kashmir to Kanyakumari]
c) East-West Corridor [Connecting Silchar (Assam) to Porbandar Gujarat]

- Design standards for express Highway

i.	Design speed	–	120 km/Hr
2.	Land width	–	90m
3.	Road width	–	34m (6 lane) & 27m (4 lane)
4.	Median	–	6m
5.	Carriage way width	–	2x11m (6 lane) & 2x7.5m (4 lane
6.	Gradient	–	2.5%.

National Highways:-

- Roads Having Heavy traffic Intensity of more than 30,000 Passenger Car Units (PCU) Connecting different State Capitals, major ports, large Industrial areas & tourist Centres are called as National Highway.

(i) National Highway should form the frame work of roads
(ii) The responsibility of Construction & Maintenance of the "NH" rest with Central Govt. Department (CPWD).
iii) All the "NH" are assigned as a specific Number
eg NH 45B – Trichy – Madurai – Aruppukottai – Tuticorin

State High Ways:- [Roads with Heavy traffic Intensity of > 10,000 PCU & less than 30,000 PCU, formed width 15m]

- Are Arterial Roads of States, Connecting up with national Highway of adjacent State, district Head quarters.
- These are main Roads of Commercial Intrest to move goods within a state.
- These Roads are of two lanes & have similar C/s as that of "NH".
- Construction & maintenance of these roads are Handled by State Govt. PWD.

SH25 - Trichy Namakkal Road - 77.40km

Major District Roads:- [Roads with Traffic density < 10,000 PCU & > 5000 PCU]

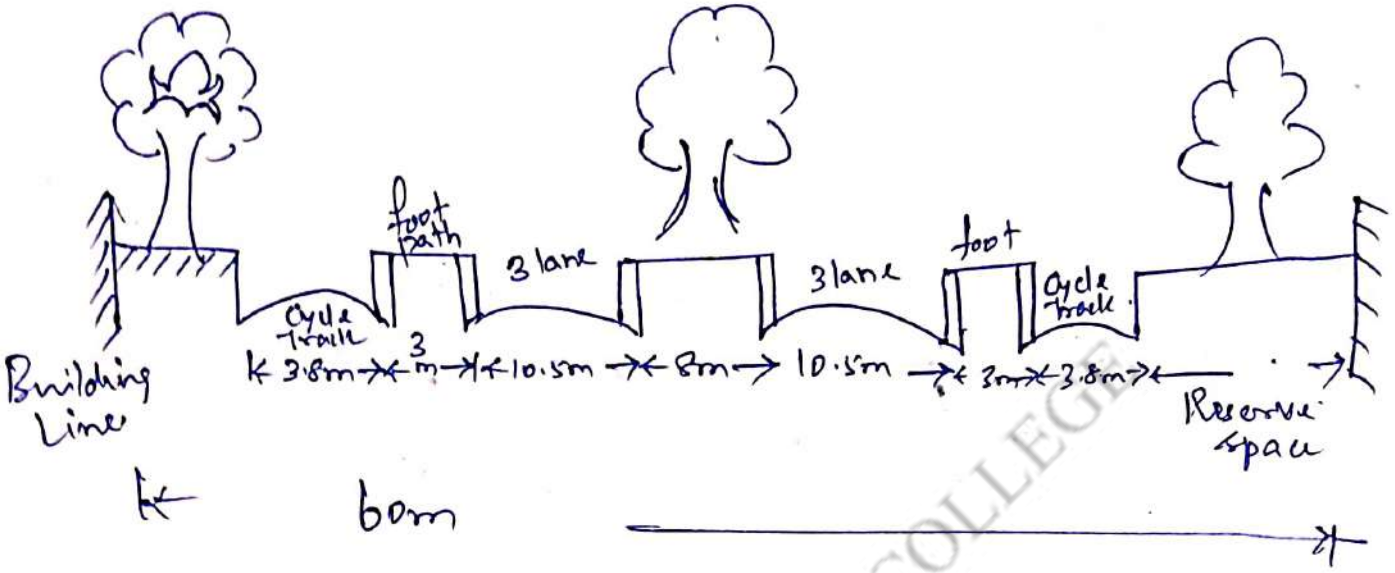
- These Roads Connect all important towns of a district with Head quarters. [Minimum width of road is 15m]
- Also Connect the areas of production, market, railway station & State Highways.
- Construction & Maintenance - Carryout by Highway Dept. first MDR along with SH.

Other District Roads:-

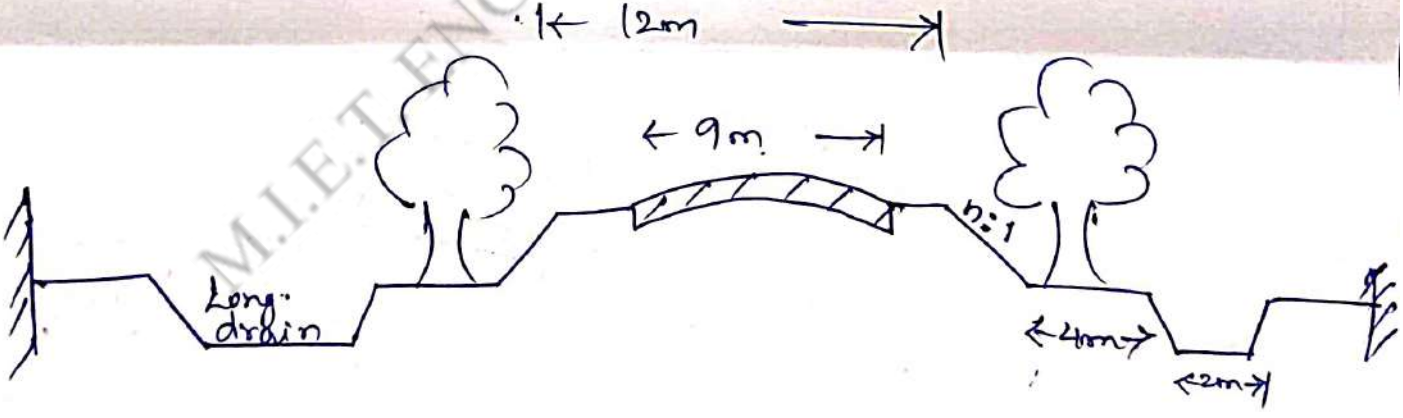
- These Roads Connect a town with other towns or Villages of a district.
- Road with traffic density < 5000 PCU are Categorised as Other District Roads.
- These Roads are built & maintained by Municipal Boards & Corporations.

Village Roads:-

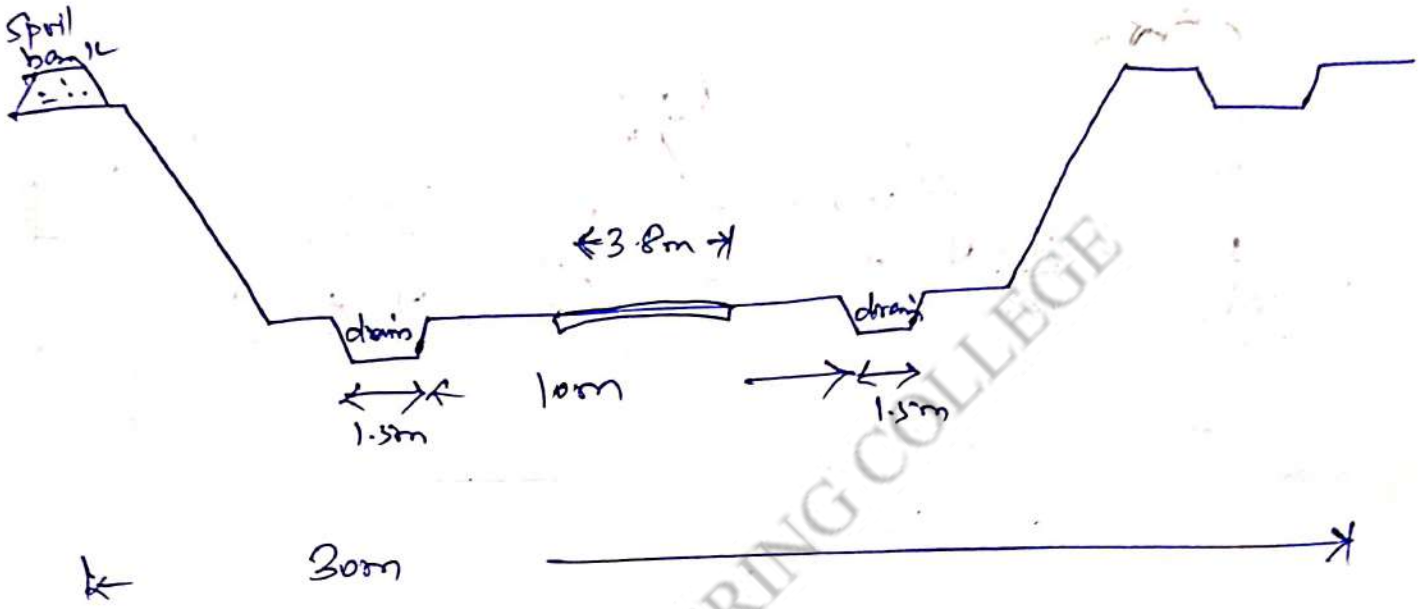
- These Road Connect Villages & group of Villages with each other
- They are generally of Unmetalled Road, Connected by Kacha Road.
- These Roads are maintained by Village panchayat.
- It also Connects the places with nearby Railway station.



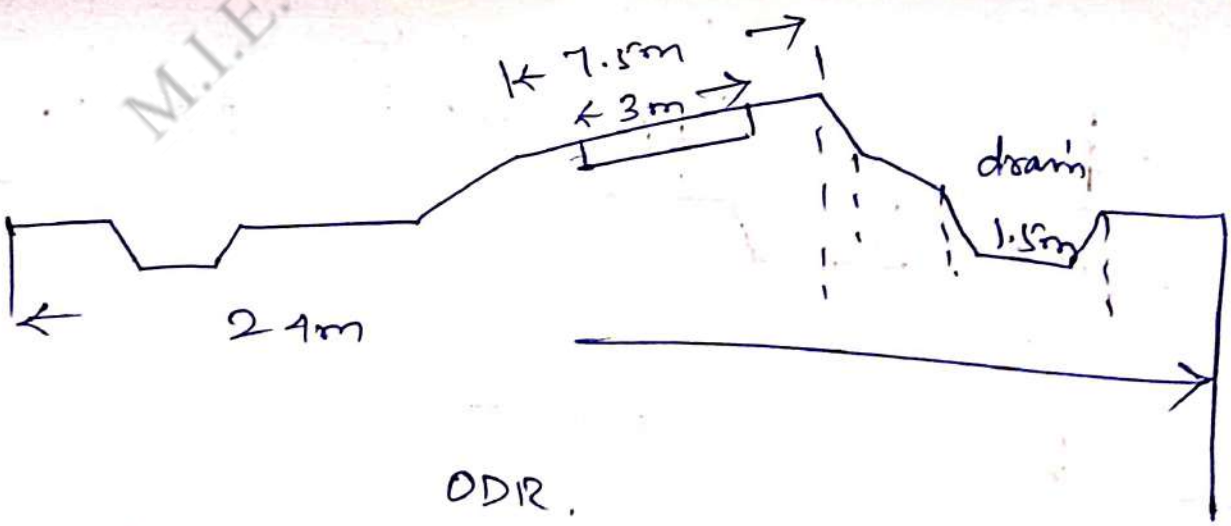
NH



SH



C/S ODR.



ODR.

Lecture No. 5 Cross sectional Elements

Topic(s) to be covered	c/s elements of Highway - Right of way - Carriage way - Kerb - Camber - Shoulder - parking lane.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	Gain knowledge on c/s elements of highway.	Understand

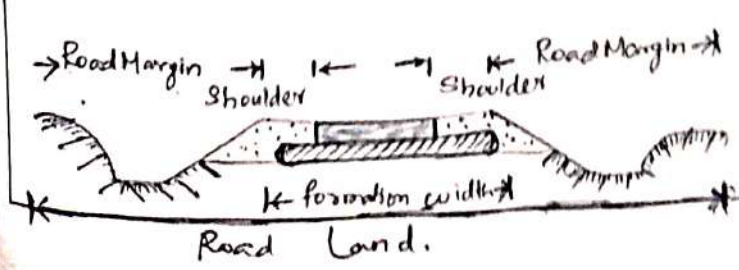
Teaching Learning Material	Student Activity

Lecture Notes

HIGHWAY CROSS SECTIONAL ELEMENTS

The Visible features across the Road are called c/s elements & these elements depend on the following

1. Type & classification of Road
2. Design Speed
3. Expected traffic Volume etc.

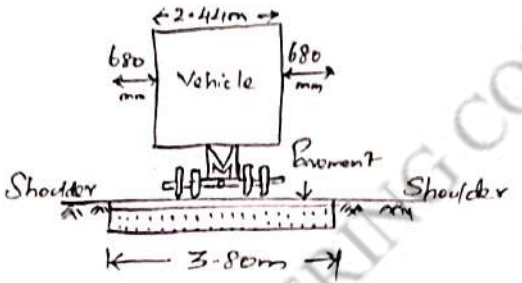


C/s of Road in embankment

Various C/s elements are 1. Right of way 2. Carriage way 3. Medi
4. Camber 5. parking lanes 6. kerb

1. Right of way :- (Road land) - Road land is the area of land acq along the road alignment by the highway organizations. When the land has constructed, there are chances of developments a its routes & chances for widening of road in future. Hence t required width of land width given by IRC be acquired in the initi stage considering the future development & future expansion.

2. Carriage Way :- The No. of lanes will decide the width of pavement Width of the carriage way & the width of the traffic lane is defined as the longitudinal strip of the carriage way for the safe movem of vehicle.



Carriage way width for single lane road.

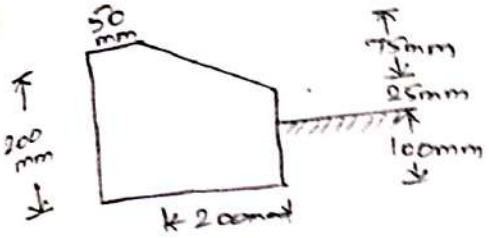
3. Median (or) Traffic Separator :- There are highway structure, used to separate the traffic moving in opposite directions. Medians are provided for the following purposes

1. To avoid head on collison between vehicles moving in opposite directions.
2. To provide the protection for pedastrains.

As per IRC ,i) Minimum width for National Highway - 5m
ii) " " " Rural " - 3m
iii) Long Bridge - 1.2m to 1.5m.

4. Kerb :- Kerbs are the structure, provided to show the boundary between the road pavement & shoulder. The kerbs are shown in fig.

Types

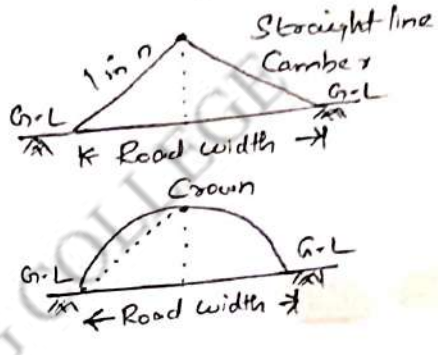


Class I kerbs – low kerb (10cm)
Class II " – Urban Parking (15cm)
Class III " – High speed barrier (20cm)

Camber:- The c/s of the Road surface shows the Convexity upward at the Highest point on the Curved Road surface is Called as Crown. Camber It is defined as the slope of line joining the Crown & the edge of the Road surface.

Types of Camber i) Straight Camber

ii) Parabolic Camber



Shoulders:- The width of Carriageway is extended on both sides in Rural Roads are Called shoulders. The minimum shoulder width, recommended by the IRC is 2.50m & however it is desirable to have a minimum shoulder width of 4.60m. It is provided To act as a service lane for repaired Vehicle & to serve as an emergency lane for the Vehicle to move out of the pavement.

Parking lanes:- The provision made for the parking purpose of Vehicle provided in Important urban Roads which allows the on Street parking, is Called parking lanes. Parking lanes are provided parallel to the Road.

Lecture No. 6 : ONGOING HIGHWAY DEVELOPMENT AT NATIONAL LEVEL.

Topic(s) to be covered	ongoing highway development - National highway development plan.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
L6	Understand the ongoing Road development plan in India.	Understand

Teaching Learning Material	Student Activity
Chalk Talk	Listen.

Lecture Notes

The Govt. of India takes up the development works of National highway through a five year plans. Ministry of Indian Government had prepared through IRC, a 'Road development Plan 2021 - Vision - 2021' for the period of 20 years (2001-21) in Nov 2001.

The important features of the Vision 2021 are as follows.

1. Expressway - All the expressways are to be finished at the end of 2021 having all features & most of the National Highways are to be Converted into expressway.

- National Highway:-

By the end of 2021, the density of highway is to be
to 1,00,000 km & all the NHs are to have a minimum of 4
Construction of by passes will reduce the length of the high
& hence additional provisions of by passes are also to be
included with Improved the drainage facilities.

- State Highway, District Roads & Village Roads:-

By the end of 2021, Considerable improvement in SH,
District Road & Village Road is planned. An additional
25000km length of Roads in SH, District Roads & 60000km
additional length of Village Roads are to be Completed.

Pradhan Mantri Gram Sadak Yojna (PMGSY)

S.No	Type of Road	Achievement till 2000 km	Target at 2021
1.	Expressway	—	15766
2.	NHs	57700	80000
3.	SHs	124300	160000
4.	MDRs	2994000	320000
5.	ODRs		No Target Suggest

- National Highway development plan (NHDP)

The National Highway development Programme has
been started to upgraded the existing highways, Connecting
the four major Cities of India. i, Chennai, Delhi, Mumbai,
& Kolkata by Golden Quadrilateral & North-South &
East West Corridors Connecting Kanyakumari at South
with Srinagar at North.

The Various phases of the NHDP are as follows.

Phase I :- Golden Quadrilateral project
- Connecting Chennai, Delhi, Mumbai & Kolkata.
- Length of GQ, is about 6000km.

phase II - North - South & East - West Corridor
- Length of about 7300 km.

phase III - Construction of 10,000 km of National Highway

phase IV - Widening of 20,000 km of NH to two lane roads

phase V - Construction & Widening of 6 lane highways of 6000km.

phase VI - Construction of 2000 km of expressway.

Improvement in Riding Quality Programme.

The Central Govt is the responsible for the Road safety & quality aspects of National Highways, the Ministry of Road & Transport and Highway (MORTH) allocated the funds for maintenance of NHs. The improvement in RQP aims to cover the entire NH network in the next 5 to 10 years.

Lecture No. 7 ENGINEERING SURVEY FOR ALIGNMENT.

Topic(s) to be covered	Map study - Reconnaissance Survey - Preliminary Survey - Final location Survey.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Engg. Surveys for Highway Alignment.	BT2 - Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Engineering Survey for alignment Comprise of 4 stages.

1. Map study
2. Reconnaissance Survey
3. Preliminary Survey
4. Final location Survey.

Map Study:-

(i) At this stage different data in the form of Maps, aerial photographs, Charts or graphs, etc are Collected.

(ii) With a Careful study of the maps at the office, it is

able to get the basic details to fix serious alternate alignments.
- Further details of these alignments may be obtained on the site.
- Possible alignments can be decided based on the following details available on the map.
  1. Alignment bypassing valleys, lakes or ponds.
  2. Availability of mountain pass in a mountain range.

- **Reconnaissance Survey:-**
  - The objective of this survey is to examine the general characteristics of the area with a view, to select the possible alternative alignment of the road.
  - The No. of possible alternate routes may be worked out by using this survey.
  - operations involved in this survey are
    (a) Study of map (b) Availability of resources
    (c) Ground or Topological study.
  - The data collected in this survey are assembled through maps, pictures, reports & interview.

- **Preliminary Survey:-**
  - The preliminary survey is conducted to prepare a base line, keeping in view the physical information, which influences the proposed location.
  - The propose is to prepare the plans matching with accurate base line.
  - The accuracy of the final centre line depends on the accuracy of the preliminary survey.

The following points are to be considered during preliminary Survey

1. The traverse line should run along the proposed Centre line of the Road.
2. For accuracy, 50m Chain should be used
3. Offsets from Important Structures are to be marked accurately.
4. The radii of the Horizontal Curves, tangent points are to be marked accurately, inorder to locate the perfect alignment.

Final location Survey:-

- It Consists of fixing up the Centreline of the proposed highway on the ground with neccessary horizontal & Vertical Controls.
- It is also helpful in Collecting the necessary information for Road design estimates & preparation of detailed working drawings.

The main operations involved in the final location Survey are

1. Staking out of the final Centreline to the field
2. Detailed leveling.

In order to stake out the final Centre line of the alignment to the field, a transit theodolite is used at all Horizontal Intersection points & at all intermediate points on long tangents.

Nowadays, the modern surveying equipment like Total station, EDM, GPS are used to Carry out the field work.

Lecture No. 8

Conventional & Modern Method of Surveying.

Topic(s) to be covered	Conventional - primary traverse - levelling - soil survey. Modern methods - photogrammetry surveying.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Co1	Understand the Conventional & modern methods of surveying for highway alignment.	$L3_2$ - Understand

Teaching Learning Material	Student Activity
Chalk & Talk.	Listen

Lecture Notes

- Conventional Method of surveying:-

  (i) primary Traverse - An open traverse is conducted along the alignments. The length of centre line should be measured by using chaining method.

  (ii) Topo graphical features:- are recorded after establishing the centre lines by the primary traverse. All details along the centre line are surveyed & plotted.

- **Levelling Works:-** Simultaneously levelling work is also to be carried out to get the central line profiles & typical c/s.

- **Hydrological data:-** The next step is to decide, the type, No. & size of cross drainage works/structures. for this necessary Hydrological data are collected.

- **Soil survey** - The final decision of the alignment depends on the type of soil on which the max. length of road alignm passes. Soil samples collected on the soil survey are used to get the soil consistency & classification.

- **Modern method of survey:-**

Photogrammetry is defined as the science or art of obtaining measurements, needed for Highway survey by means of photography. photogrammetry is based on Aerial photographs is a basic working tool for the Highway Engineer.

It is intended to encompass procedures for photo interpretation & for converting single photographic into composite ones and into maps. Application of remote sensing helps in

(i) location survey
(ii) planning
(iii) Geometric design
(iv) rights of way
(v) traffic studies
(vi) Drainage
(vii) soil classification & identification
(viii) Earth work measurement.

Vertical Aerial photographs taken with the camera pointed nearly straight down are useful for highway mapping purposes. The Area to be Covered is photographed in parallel runs with the individual pictures lapped both in the direction of flight & between successive runs.

The factors to be Considered for the purpose of preparing maps are:

(i) Local length of aerial Camera. (ii) Desired Combination of map scale.

iii) Contour Intervals (iv) Ratio of map scale to photograph scale.

- Several Instruments are available for Converting data from aerial photographs to maps. They are multiplex, stereoscopic plotters, Autograph. All the Instruments utilize the Concept that, when the area Common to a pair of matched photograph is viewed through a stereoscope, the topography is seen in relief.

- Surveying using photogrammetric techniques have been Coupled now a days with Computer and digitizer to produce digital terrain models. Using this the Horizontal & Vertical positions of the ground surfaces or other topographic features are transferred directly to a Computer data bank. The information Can then be recalled to develop profiles, Cross sections, Cut and fill earth work quantities using appropriate Computer softwares.

Lecture No. 9

INSTITUTIONS FOR HIGHWAY

Topic(s) to be covered	Indian Road Congress - National Highway Authority of India - Ministry of Road Transport & Highways

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
:01	Understand Various Institution for Highway at National Level.	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

Indian Road Congress:-

In 1934, on the recommendation of Indian Road development Committe [Jayakar Committee] formed a technical, semi official body of Highway Engineers called IRC for the development of Road in India.

Objectivis of the IRC:-

a) IRC promotes & encourages the science & practice of building & maintenance of Roads.

- It provides a Channel for the expression of Collective Information opinion of its member regarding the road transp
- It promotes the use of standard specifications and to prepare specifications.
- It advises regarding education, experiment & research Connected with roads.
- It establishes, furnishes & maintains libraries & Museums for furthering the Science of road making

National Highway Authority of INDIA - 1988.

- NHAI is an Autonomous agency of the Govt. of India
- It is responsible for the transport management of a network of over 1,00,000 km of NH in India.

The Govt. of India has launched major initiatives to upgrad & Strengthen the NH through various phases.

Phase I - It was approved by CCEA [Cabinet Committee on Economic affairs] in Dec 2000 at an estimated Cost of Rs 300 billion.

- It Comprise mostly of Golden Quadrilateral (5846km), NS-EW Corridor, port Connectivity).

phase II - In Dec 2003, a cost of Rs 54339 Crores approved by CCEA
- It Comprise mainly NS-EW Corridor (7300km).

phase-III - In 2005 & 2006, Govt. of India has approved phase II.
- To upgrade 12109km of NH

phase IV - It Includes widening of 2000km
- It will Convert Single lane into 2 lanes with paved shoulders.

phase V - CCEA has approved in Oct 2006, to upgrade existing 4 lane Highway (6600km) to six lanes.

phase VI - 1000km of expressway will develop at a Cost of 167 billion rupees. (Nov 2006)

phase VII - CCEA has Approved on Dec 2007 for 700km of ring roads, Bypass & flyovers at an Estimated Cost of 16760crores.

Ministry of Road Transport & Highway:-
- It is an organization Under the Central Govt.
- Task of formulating & administering policies for Road Transport, NH, & research with a view to increase the mobility & efficiency of the road transport in the country.

Wings 1. Road wing 2. Transport wing.

Road wing:- It deals with the development & maintenance of NH in the Country.

Transport wing:- It deals about Road transport issues.

Lecture No. 01

UNIT-II
Horizontal Curves.

Topic(s) to be covered	Curves - factors affecting Curve - Types of Horizontal Curves. - Simple Curve - Compound Curve - Reverse Curve - Transition Curve.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	understand Curves used in highway alignment their factors & types	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen

Lecture Notes

• Curves:-

Curves are the place in highway used to change the direction of traffic.

• Factors affecting the design of Curve

i) Friction
ii) Design Speed
iii) Maximum Super elevation
iv) Impact factor.

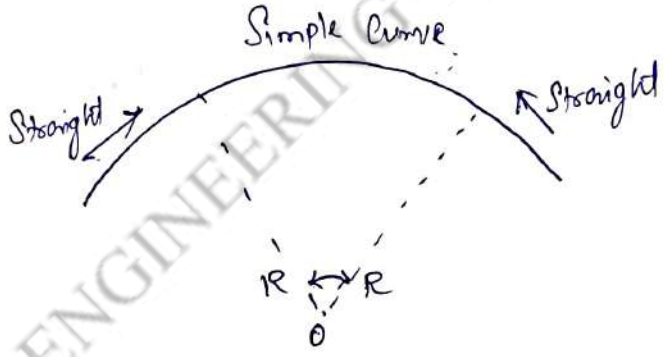
- Types of Horizontal Curves:-

The Horizontal Curves are Classified into four Categories.

i) Simple Curve
ii) Compound Curve
iii) Reverse Curve
iv) Transition Curve.

Simple Curve:-

A Simple Curve is defined as a Circular Curve of single radius Connecting two Straight lines as shown in fig.



- The length of the Curved portion in a highway is based on the degree of Curvature.
- Simple Curve is laid where there is less traffic of moving Vehicles & less traffic Volume.

- Compound Curve:-

A Compound Curve is defined as the Combination of two simple Circular Curves of different radii, turning in the same direction and joining at one Common junction

- This Curve is provided where there is no possibility for providing simple Curves.

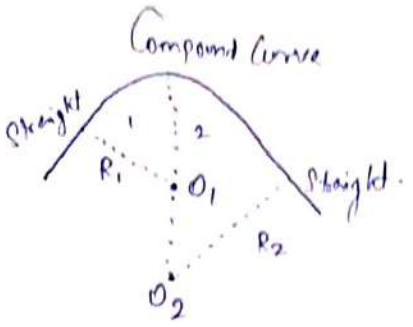


fig: 2

- Reverse Curve:-

A Reverse Curve is basically a Compound Curve with a Common tangent at the junction. It Consists of two Circular arcs turning in opposite direction with the Common tangent point.

Such Curves are preferred in situation where the Straight have their angle Intersection too acute.

Drawbacks:-

a) Steering of Vehicles in Reverse Curve is very dangerous.

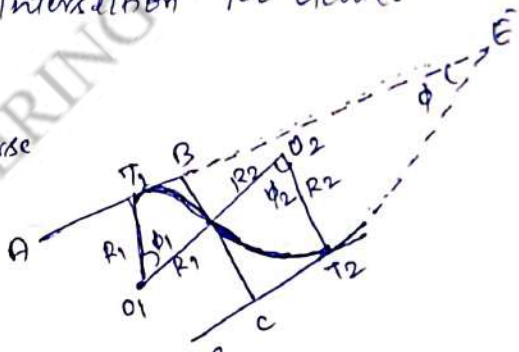


fig: 3

- Transition Curves:-

- Transition Curve is a type of Curve which is introduced between a straight & Circular Curve.

Primary purpose of transitional Curve is to enable Vehicles moving at high speed, to make change from tangent section to the Straight Curved Section and again to tangent section in a safe and Comfortable mode.

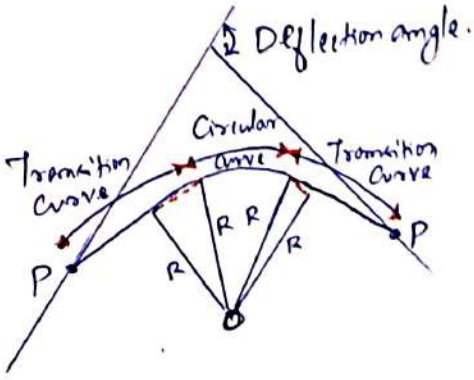


fig: 4

At the end of this lecture, students will be able to gain	Bloom's Level
CO1 knowledge on Super elevation.	K1 & K2 Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen

Lecture Notes

• Super elevation - 'e'

- In order to counter balance the centrifugal force the outer edge of the road is raised which is known as super elevation or cant or banking.

. This transverse slope provided throughout the length of the Horizontal Curve.

$$e = \frac{\text{Height of outer edge}}{\text{Horizontal width of pavement}}$$

. The super elevation 'e' is expressed as the ratio of Height of the outer edge with respect to the Horizontal width.

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

e - Super elevation
R - Radius of curve

NOTE: If Centrifugal ratio $\frac{P}{W}$ is less than b/2h - Sliding will not occur.
" " " " $\frac{P}{W}$ is greater than b/2h - overturning may occur.

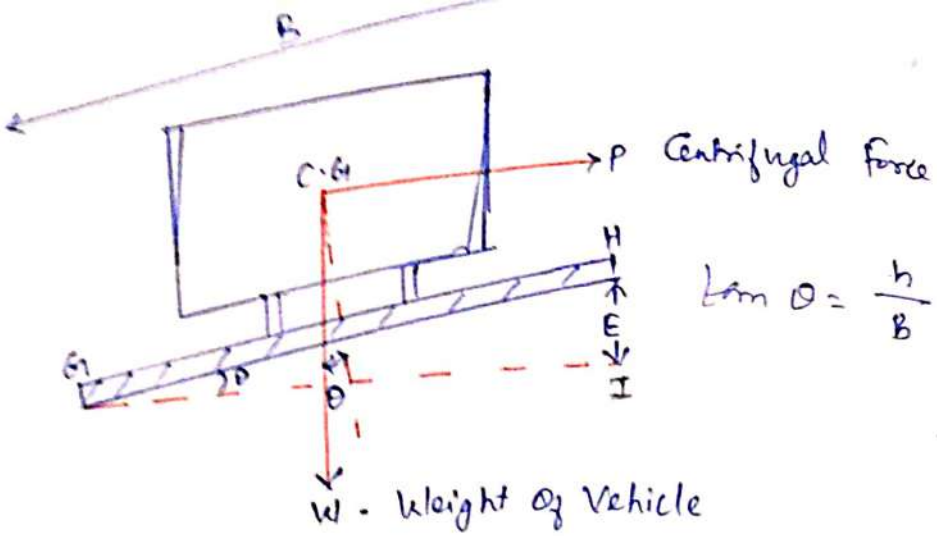


fig: Super elevated section of pavement

- Design of Super elevation:-

In the design of Super elevation the following to be Considered:

(i) For a mixed traffic, the super elevation provided for the speedy Vehicle with f=0 is safer for most of Vehi

(ii) Super elevation based on lateral friction would be unsa for fast moving Vehicle.

(iii) Limiting Maximum Super elevation - 0.07 are ado
For Hilly roads - 0.10

- Design steps

Step (i) Super elevation for 75% design speed (v m/s
V kmph) is Calculated neglecting the friction(

$$e = \frac{(0.75v)^2}{gR} \quad (or)$$

$$e = \frac{(0.75V)^2}{127R} = \frac{V^2}{225R}$$

Step 2:- If the Computed Value e is less than 7% then Computed Value is provided.

If the Value is greater than 7%, then provide Super elevation

Step 3:-

Compute the Coefficient of friction developed for the maximum Value of e = 0.07 & the full value of design speed from

$$f = \left[\frac{V^2}{gR} - 0.07\right]$$

(or)

$$f = \left[\frac{V^2}{127R} - 0.07\right]$$

If the Computed f Value is < 0.15, then super elevation (7%) is safer for the design speed. If not f = 0.15 is Computed.

Step 4:-

The Allowable speed for the given Curve for the max. Super elevation of 7% & friction of 0.15, that is

$$e + f = 0.07 + 0.15 / 0.22$$

i.e., $$e + f = \frac{V_a^2}{gR} \quad (\text{or})$$

$$\boxed{e+f = \frac{V_a^2}{127R.}} + \boxed{f = \frac{V^2}{127R} - e}$$

Note:-

1) If the Calculated allowable speed > design speed then e = 0.07 is provide

2) " < Design speed, it is limited to Valmph.

Suggested Questions / Assignments / Home works / any

1. Define Super elevation.
2. write the formula used for super elevation
3. Write short notes on Super-elevation.

Text Books / Reference Books

S.No	Title	Author	Publisher
1.	Highway Engineering	Dr. Purushothamaraj.P	Sri Krishna

Any other suggested Materials

—

- Merits:
  1) It increases the stability of fast moving vehicles passing the curves.
  2) It reduces the intensity of stress on foundation
  3) It distributes the equal pressure on tyres.
  4) It provides smooth & safe travelling to the vehicles.

Lecture No. 03 — Transition Curve.

Topic(s) to be covered	Calculation the length of transition Curve. - factors - Design.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
CO1	design of transition Curve for a highway alignment	Apply.

Teaching Learning Material	Student Activity
Chalk	Listen

Lecture Notes

Calculation of length of transition Curve:-

The design of length of transition Curve is based on 3 factors to be Considered.

(i) Rate of change of centrifugal allelevation is to be developed gradually.

(ii) Rate of Introdution of designed Super elevation.

(iii) Minimum length of Curve by IRC.

(i) Rate of change of acceleration $C = \frac{\text{Centrifugal Acceleration}}{\text{Time}}$.

If the design speed is in kmph (V), then IRC recommends

$$C = \frac{80}{(75+V)}$$

N - Rate of change of super elevation.
W - width of pavement

(ii) Length of transition curve is $L_s = \frac{0.0125 V^3}{CR}$

(If the design speed V is in kmph.)

1. Calculate the length of the transition curve and shift using following data:

Design Speed = 60 kmph (V)

Radius of Circular Curve = 200m (R).

Rate of super elevation introduced = 1 in 150

Pavement width including extra widening = 7.5m. (W+We)

Solution:-

(a) Rate of change of Centrifugal acceleration $C = \frac{80}{75+V}$

$$= \frac{80}{75+60}$$

$$C = 0.592 \text{ m/sec}^2.$$

(ii) Length of transition Curve is $L_s = \frac{0.0125 V^3}{CR}$

$= \frac{0.0125 \times 60^3}{0.59 \times 200} = 40.74m.$ — (1)

(iii) Super elevation $e = \frac{V^2}{225R}$ (or) $\frac{(0.75V)^2}{127R}$

$e = \frac{60^2}{225 \times 200} = 0.079 > 0.07$

Hence take e as 0.07.

(iv) Check for safety against Skidding $e+f = \frac{V^2}{gR}$ (or) $\frac{V^2}{127R}$

$f = \frac{V^2}{127R} - e = \frac{60^2}{127 \times 200} - 0.07 = 0.0717.$

$f = 0.0717 < 0.15$ (max. allowable) Hence e rate 0.07 is safe for skidding

(v) With the design speed of 60kmph, width of pavement at Curve = 7.5m.

$B = W + We = 7.5m.$

$E = eB = 0.07 \times 7.5 = 0.525m$

Rate of Super elevation introduced $\frac{1}{N} = \frac{1}{150 \times 0.07 (7.5)}$

$N = 150$ (Rate of Change of Superelevation)

$L_s = \frac{EN}{2} = \frac{0.525 \times 150}{2} = 39.375m.$ — (2)

$L_s = eN(W+We)/2$ (or) $= 0.07 \times 150 (7.5)/2$

$= 39.375m$ Minimum Values of L_s as per IRC $= \frac{2.7V^2}{R} = \frac{2.7 \times 60^2}{200} = 48.6m.$ — (3)

Result 1) Adopt highest value of above three as $L_s = 48.6m$ or $50m$.

Result - 2. Shift $S = \frac{L_s^2}{24R} = \frac{50^2}{24 \times 200} = 0.5208m.$

Lecture No. 04 Unit-2

Widening on Curves.

Topic(s) to be covered	Concept – Necessity – Mechanical widening – Psychological widening – Total widening.

Lecture Outcome (LO)		
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on widening on Curves	Understand

Teaching Learning Material	Student Activity
Chalk/Talk	Listen

Lecture Notes

- Widening of pavement on Curves:-

Extra widening on Curve is defined as the Concept of providing an extra width of pavement on Horizontal Curves, having the radius of less than about 300m. It is also Called Widening of Pavement.

Extra widening = Mechanical widening + Psychological widening.

- Necessity of widening of pavement on Horizontal Curve

1. A Vehicle has a rigid base and only the front wheel of the Vehicle can be turned. On Curve if the front wheel changes its direction, the rear wheel does not follow the same path, as that of front wheels. (Off tracking).

2. At high speed on Curves, some transverse skidding may occur if the rear wheel may move on the outside the path moved by front wheels.

3. At Curves with higher Radius, the driver not to follow the Central path of the lane but to follow the outerside at the beginning of the Curve. (Psychological widening).

4. When two Vehicles Cross (or overtake) each other at the Horizontal Curve, To increase the safety psychologically, an additional width should be provided

- Mechanical widening:-

Mechanical widening is provided to account for off - tracking due to the rigidity of the wheel base. The movement of Vehicle is shown in Fig.

(1) Calculate the Super elevation to be provided for a horizontal curve with a radius of 400m (R) for a design speed of 100kmph (v). If e is restricted to 0.07. Calculate the Coefficient of lateral friction (f).

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

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

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

$$= \frac{100^2}{127 \times 400} - 0.07$$

$$f = 0.127.$$

(2) Compute the additional width req for a horizontal curve of a state highway with a ruling min. radius.

$V = 100$ kmph

$n = 2$ lanes

pavement width $= 7$m.

Wheel base of truck $= 6$m (l)

max. $e = 0.07$

Skid Resistance $f = 0.15$

W.K.T $e+f = V^2/127R$ ... 1

$$R = \frac{V^2}{127(e+f)} = \frac{100^2}{127(0.07+0.15)} = 357.9m \approx 360m.$$

- Additional width req $\boxed{W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}}$

$$= \frac{2 \times 6^2}{2 \times 360} + \frac{100}{9.5\sqrt{360}}$$

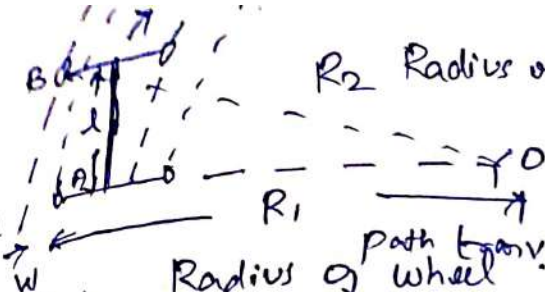
$$= 0.10 + 0.56$$

$W_e = 0.66m.$

- Total pavement width = Actual width + We

$$= 7m + 0.66$$

$$= 7.66m.$$



R_2 Radius of path traversed by the outer front wheel. (m)

R_1 Radius of path traversed by the outer rear wheel. (m)

W_m mechanical widening.

$$W_m = OC - OA = OB - OA$$

$$= R_2 - R_1$$

From $\triangle OAB$ $\quad OA^2 = OB^2 - BA^2$

$$R_1^2 = R_2^2 - l^2$$

But $\boxed{R_1 = R_2 - W_m}$

Substitute for R_1 the above equation.

$$(R_2 - W_m)^2 = R_2^2 - l^2$$

Re arranging $\quad l^2 = W_m (2R_2 - W_m)$

$$\text{i.e.} \quad W_m = \frac{l^2}{2R^2 - W_m} = \frac{l^2}{2R}$$

For n no. of traffic lane $\quad \boxed{W_m = \frac{nl^2}{2R}}$

Psychological widening As per IRC recommend $W_{ps} = \frac{V}{9.5\sqrt{R}}$

Total widening $\quad W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$

R - mean radius of curve
l - length of wheel base
6 - b. lm.

Topic(s) to be covered	Definition - Types - Stopping sight distance - Overtaking sight distance - Safe sight distance at Intersection.

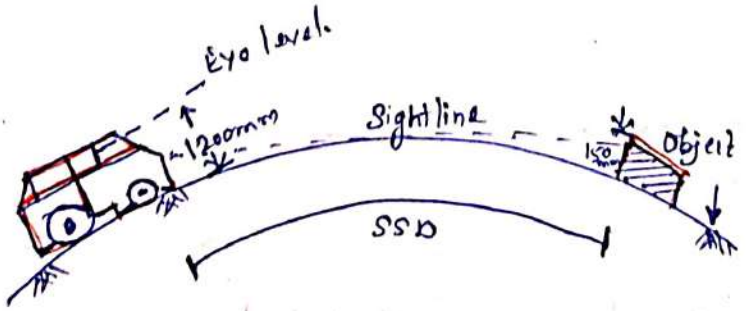
	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
L01	Gain knowledge on sight distance.	Understand

Teaching Learning Material	Student Activity
Chalk/Talk	Listen.

Lecture Notes

Definition:-

Sight distance is defined as the actual distance along the road surface, upto which the driver of the vehicle from a specified height above the carriage way has visibility of stationary or moving objects.



Stopping sight Distance.

• Types of Sight Distance:-

(a) Stopping sight distance (SSD)

(b) Safe overtaking " (OSD)

(c) Safe sight distance at Intersection (ISD).

SSD:-

The sufficient distance required for a driver travelling at the design speed (v), to stop the vehicle, in case of any obstruction on the road ahead without collision is called Stopping sight distance.

- IRC recommended the Height of the eyelevel of driver as 1.2m
- Height of object is 0.15m above the road surface.
- A motor vehicle can be stopped depends on the following factors.
  a) Total reaction time of the driver
  b) Speed of the vehicle
  c) Break efficiency
  d) Frictional resistance b/n the road & tyres.
  e) Gradient of road, if any

Based on PIEV theory, the Total reaction time of the driver is the sum of perception, Intellection, Emotion & Volition time.

$$SSD = Vt + \frac{v^2}{2gf} \text{ (m)}$$

Stopping sight distance = lag distance + Break distance.

if speed of Vehicle (kmph)

$$SSD = 0.278\,Vt + \frac{V^2}{254f}$$

OSD:- [Over taking sight distance]

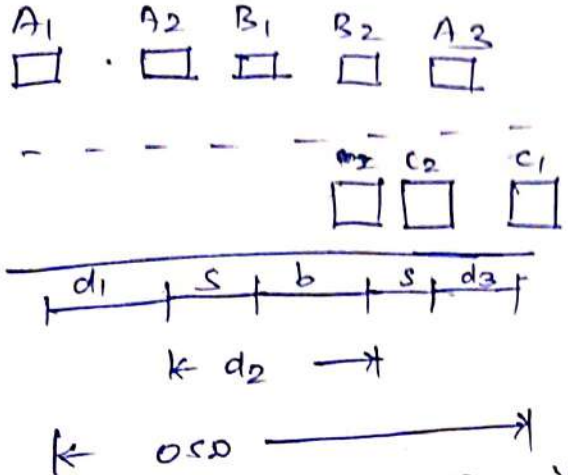
Concept:-

In roads, if all the vehicles are travelling in design speed, then there should not be any overtaking process.

In Mixed traffic it is necessary for the fast moving vehicle

The minimum distance ... of the driver of a Vehicle, intending to overtake slow Vehicle is known as minimum overtaking sight distance.

Analysis of Overtaking sight Distance:



V_b - Overtaking Vehicle
t - Reaction time of driver.

d_1 = Velocity × time = $V_b \times t$ (m)

d_2 = $V_b \cdot T + 2S$ + $S = 0.7 V_b + 6$ (m) + $T = \sqrt{\frac{4 \cdot S}{a}}$ in sec.

$d_3 = V \times T$ and $OSD = d_1 + d_2 + d_3$

$OSD = (V_b \times t) + (V_b \times T) + 2S + V \cdot T$

Where S - minimum spacing b/n Vehicles & T - Time

- **Intermediate sight distance:-**
  It is defined as the twice the Stopping sight distance.

$$ISD = 2 \times SSD.$$

- **Over taking Zones:-**

Note: OSD - Overtaking sight distance.
= $(d_1 + d_2)$ for one way traffic
= $(d_1 + d_2 + d_3)$ for two way traffic

Overtaking Zone length : 3 to 5 OSD. (min) (max)

Topic(s) to be covered	Design of Overtaking distance & overtaking zone on highway alignment

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Apply the design condition for the design of OSD in a highway alignment	Apply

Teaching Learning Material	Student Activity
Chalk/Talk	Listen.

Lecture Notes

The speed of overtaking & overtaken vehicles is 80 and 50 kmph. On a 2 way traffic road, the acceleration of overtaking vehicle is 0.99 m/sec².

1. Calculate the safe OSD
2. Mention the minimum length of overtaking zone
3. Draw the sketch of overtaking zone with all details.
4. Calculate the OSD for one way traffic for the above details.

Solutions:-

Step (i) OSD for Two way traffic

$$OSD = d_1 + d_2 + d_3$$

and

$$d_1 = V_b \times t$$

$$d_2 = V_b \cdot T + 2S$$

$$d_3 = V \cdot T.$$

Where

$$S = 0.7 V_b + b$$

$$T = \sqrt{\frac{4.S}{a}}$$

- Velocity of the overtaking vehicle. $V = 80$ kmph.

$$V = \frac{80 \times 1000}{3600} \quad \begin{matrix} (m) \\ (s) \end{matrix}$$

$$V = 22.22 \text{ m/sec.}$$

- Velocity of the overtaken Vehicle $V_b = 50$ kmph.

$$V_b = \frac{50 \times 1000}{3600}$$

$$V_b = 13.88 \text{ m/sec.}$$

With $d_1 = V_b \times t$ Where t - Total reaction time of the driver (2.5 sec assumption)

$d_1 = 13.88 \times 2.5 = \boxed{34.7\text{ m}}$

$\boxed{S = 0.7\,V_b + 6 \text{ in m.}}$

$= (0.7 \times 13.88) + 6$

$\boxed{S = 15.71\text{m}}$

$\boxed{T = \sqrt{\frac{4.S}{a}}} = \sqrt{\frac{4 \times 15.71}{0.99}} = \boxed{7.978\text{seconds}}$

a - acceleration of overtaking vehicle is 0.99 m/sec² (Given)

$\boxed{d_2 = V_b.T + 2.S}$

$= (13.88 \times 7.97) + 2\,(15.71)$

$= 110.62 + 31.42$

$\boxed{d_2 = 142.04\text{m.}}$

$\boxed{d_3 = V.T}$ in m $= 22.22 \times 7.97 = 177.09\text{m.}$

(a) Overtaking Sight distance OSD $= d_1 + d_2 + d_3$

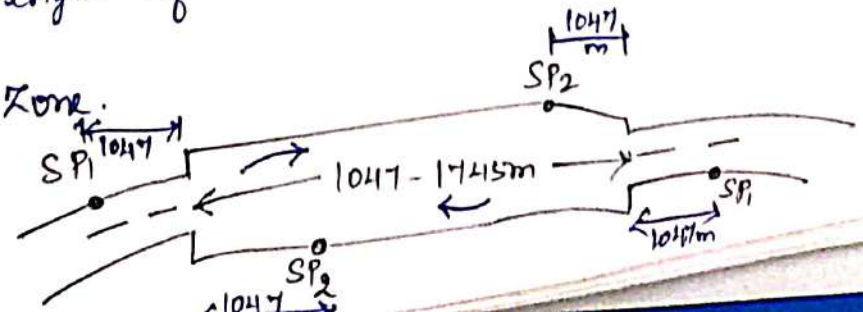
$= 34.7 + 142.04 + 177.09$

OSD $= 348.83\text{m}$

(b) Minimum length of overtaking Zone $= 3 \times OSD = 3 \times 348.83 = 1046.$

" Desirable length of " " $= 5 \times OSD = 5 \times 348.53 = 1744.$

(c) overtaking Zone.



No. 07 Stopping Sight distance. design.

Part(s) covered	Design a geometric element of SSD on a highway.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	design Stopping Sight distance for Highway.	Apply.

Teaching Learning Material	Student Activity
Chalk Talk	Listen.

Lecture Notes

The design speed of the Vehicle is 70 kmph & Coefficient of friction is 0.35. If the total reaction time of the driver is 2.5 seconds. Calculate.

(i) SSD for two way 2 lane road
(ii) " " " " single lane road
(iii) " " " " 2 lane road with an ascending gradient 2%.
(iv) SSD for 2 way 2 lane road with breaking efficiency of 75%.

Solution:

i) Stopping sight distance (SSD)

$$SSD = V \cdot t + \frac{v^2}{2gf} \quad \text{(m/sec)} \qquad 0.278 V_t + \frac{V^2}{254 f} \quad \text{(kmph)}$$

Given data:

$V = 70$ kmph.

$f = 0.35$

$t = 2.5$ seconds

$$SSD = 0.278 V_t + \frac{V^2}{254 \times f}$$

$$SSD = (0.278 \times 70 \times 2.5) + \frac{70^2}{254 \times 0.35}$$

$$SSD = 48.65 + 55.12$$

$$\boxed{SSD = 103.77 \text{m.}}$$

ii) SSD for 2 way traffic with single lane road.

= 2 x SSD for 2 way 2 lane road

= 2 x 103.77

$$\boxed{\text{SSD 2 way traffic with single lane} = 207.54 \text{m.}}$$

(iii) SSD for an ascending gradient.

Length of SSD Considering gradient $= 0.278\,V.t + \left[\frac{V^2}{254\,(f \pm 0.01n)}\right]$

For Ascending gradient

Length of SSD $= 0.278 * V * t + \left[\frac{V^2}{254(f+0.01n)}\right]$

n = slope of the road & $f = 0.35$

$n = 2\%$ (Given). $2/100 = 0.02$

$$SSD = (0.278 \times 70 \times 2.5) + \left[\frac{70^2}{254\,(0.35 + 0.02)}\right]$$

$f = 0.35$ Given.

$n = 2\%$ $\therefore$ $0.01 \times n = 0.01 \times 2 = 0.02$.

$= 48.65 + 52.14$

$= \boxed{100.79\text{m}.}$

(iv) SSD with breaking efficiency

Frictional factor Considering the breaking efficiency $f' = 0.35 \times \frac{75}{100}$

$f' = 0.2625$

SSD for 2 way 2 lane road $= 0.278\,V.t + \frac{V^2}{254 f'}$

$= (0.278 \times 70 \times 2.5) + \frac{70^2}{254 \times 0.2625}$

$= \boxed{122.14\text{m}.}$

M.I.E.T. Engineering College

Unit - II

Gradient

Lecture No. 08

Topic(s) to be covered	Definition - Factors Considered - Types of Gradient - Ruling gradient - Limiting gradient - Exceptional gradient - Average gradient - Floating gradient - Minimum Gradient.

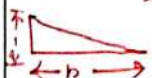
	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
LO1	Gain knowledge on Gradient & its Various types used in highways.	Understand.

Teaching Learning Material	Student Activity
Chalk / Talk.	Listen.

Lecture Notes

Gradient:-

- Gradient may be defined as the rate of rise or fall along the length of the highway.



- Expressed as 1 vertical Unit to 'N' Horizontal Unit

Factors Considered:-

(i) Nature of the traffic
(ii) Nature of the land
(iii) Type of the pavement surface.

Types of Gradient:-

1. Ruling Gradient
2. Limiting
3. Exceptional
4. Average "
5. floating
6. Minimum Gradient.

IRC recommend
1 in 30 - Plain Terrain
1 in 20 - Mountainous
1 in 16 - steep Area.

1. Ruling Gradient:-

(Design Gradient)

- Ruling gradient is defined as the permissible, design gradient, in the alignment of the highway & its value fixed in such a way that all Vehicles can travel the long distance without any fatigue.
- Max. Gradient used to design the Vertical profile of Highway.
- It depends on terrain, length of the grade, speed, pulling power of Vehicle.

2. Limiting Gradient:-

- Is defined as the Maximum gradient, Steeper than Ruling gradient, which is used for limited grade length and where the ruling gradient is not feasible.
- It is used for short Stretches of Road & it can be Covered by the Vehicle due to Momentum, Hence it is called Momentum Gradient.

The following are the drawbacks

(i) It reduces the load Carrying Capacity of the Vehicles
(ii) It Consumes More power Consumption for Vehicles.
(iii) It Creates inConvenient to the pedestrains & animals.
(iv) It Increases the wearing of Road Surface due to the high Velocity of Surface water.

1 in 20 - plain Terrain & 1 in 16.7 for Mountainous & 1 in 14.3 - Steep

3. Exceptional Gradient:-

It is sometime necessary to provide the Steeper greater than limiting or Maximum gradient & it is Called exceptional gradient.

plain

1 in 15 - plain	&	1 in 14.3 - Mountainous	&	1 in 12.5 - Steeper Area

It is provided under the following situations.

(i) for short distance of road not exceeding 60 m in 1 km. (-1 in 16.7)
of road length.

(ii) Under some extraordinary situations & unavoidable circumstances in hilly regions.

4. Average Gradient:-

- The total rise or fall between any 2 points on the road, divided by the road length is called the average gradient.

- It is also used to determine the approximate length of the highway, especially in hilly country.

5. Floating Gradient:-

If a vehicle is passing through a descending gradient at constant speed & come across, an ascending gradient, such that it maintain same speed without application of brakes, then such a gradient is called floating gradient.

6. Minimum Gradient:-

The lowest gradient (0.05%) provided to drain the surface water along the surface of the road, in which the road (Longitudinal section of road)
with zero gradient is not sufficient for the efficient removal of surface water on the road. The minimum gradient depends on the following factors.

1. Nature of the ground
2. Intensity of rainfall
3. Type of the road surface.

For cc drains - 1 in 500 & soil drains 1 in 200 is suitable.

M.I.E.T. Engineering College, Trichy

Subj: Highway Engineering
CE3303 / Water supply & Waste water engineering

Lecture No. 09

Unit-V
Pavements.

Topic(s) to be covered	Definition - purpose of pavement - Components of a pavement - Typical function of pavements.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	Gain knowledge on Highway pavement	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

- Pavement:-

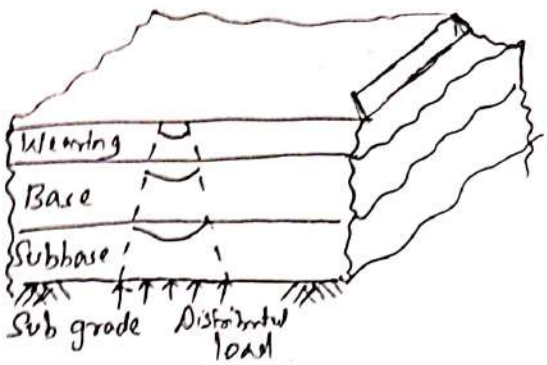
In Highway Engineering, the term pavement means that, the layers which are included to form a highway or Road.

- Purpose:-

1. To keep the elastic deformation of the pavement within the permissible limits.
2. To provide the safe, smooth and comfortable journey for the Road users.

- Components of a pavement :-

i) Wearing surface
ii) Base Course
iii) Sub base
iv) Sub grade
v) Road base



- Wearing Surface :-
  - Surface Course is the uppermost layer of the highway.
  - Its thickness is very low when compared to other layers.
  - It resist the abrasion of wheel on the vehicle, impacts caused by the wheel loads & weather effects on Road Surface.
- Base Coat - layer of Hard stone provided in b/n Base & wearing Course. To transmit load over the large area of the base course.
- Base Course :-
  - Is the layer of selected material (Boulders/Bricks) above the sub base (provided in double layer)
  - It is laid to support the surface of the highway.
  - It is designed to distribute the wheel loads over the sub base or Road bed.

• Sub base:- (Granular)
- It is also the layer of selected material placed between the subgrade & base course to support the base course.
- It improves the bearing capacity of subgrade.
- It improve drainage and keep check on capillary rise of subsoil water.

• Sub-grade:- The finished & compacted earthwork.
- It is the layer on the road bed
- On which the pavement structure and shoulder are constructed.

• Road bed:-
- Road bed is defined as the graded portion of a highway within top & side slopes prepared as foundation for the pavement structure.

• Function of pavement Components.
The General function of a pavement Component is given as,
1. Traction (இழுவை)
2. Protection (பாதுகாப்பு)
3. Distribution. (சமநிலைமாக) பகிர்ந்தளித்தல்

• Pavements types
1. flexible - Change shape without rupture (நெகிழ்வு)
eg- Bituminous concrete
Cheap, easy
2. Rigid - Can't change shape without rupture.
Road slab
Depression.
eg. Concrete.

Lecture No. 01 UNIT-III.

HIGHWAY CONSTRUCTION MATERIAL.

Topic(s) to be covered	Soil – Characteristics - Aggregate - Bitumen.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Highway Construction Materials.	Understand

Teaching Learning Material	Student Activity
Chalk / Talk.	Listen

Lecture Notes

- Highways are constructed primarily on soil, which plays a major role as a foundation & a load distribution media.
- The Mineral Aggregates of different sizes are used in various capacities as base course, Sub-base course, Coarse aggregate for Concrete.
- Cement & Bituminous materials are used for Construction & Surfacing.

- Is an Unconsolidated material resulted from disintegration of
- Soil deposits Constitute an assemblage of solid particles with formation of Certain pore or Void spaces.
- Soil as a highway material should have the following pr
  a) Short & long term stability of the subgrade
  b) Compressibility within permissible limits
  c) Adequate permeability
  d) Compaction should be ease & economical.
- knowing the properties of a soil as a construction material is essential.
- Suitability of soil is ascertained from various laboratory & field tests.

Soil Group	Stability property	Max. dry density g/cm³	Drainage
A-1	High stability Very good to excellent subgrade	2.03 (min)	Excellent Good.
A_3	Stable when Confined. Good to subgrade	1.92 - 2.03	Excellent
A_2	Suitable when dry. Very good to subgrade	1.92 - 2.08	Good to fair.

- Soil classification groups

Aggregates:-

- Coarse Aggregate form the major portion of the pavement structure
- Aggregate bear the stresses due to Vehicle movement / traction force of Vehicles.
- Aggregates are obtained by Crushing rock to the required sizes.
- Many property of the Aggregate depend mostly on the quality and parent rock.
- Aggregate should posses adequate strength
- It should be hard enough to resist the wear
- It should be tough enough to withstand Impact load.
- Aggregate should withstand all seasons.

Bitrminous Material:-

- Bitumen is a hydrocarbon material found in Gas, liquid, solid form.
- It is a Complex organic material soluble in Carbon disulphide.
- Bituminous materials are widely used in highway Construction because of their dual qualities.
  1. Binding property
  2. water proofing property.

- Type of Binder

	Application.
30/40	- Penetration macadam in normal Summer temperature & in plains.
	- Bituminous Macadam " " " " " "
60/70	- Hot mix Asphaltic Concrete in " " "
80/100	- Surface dressing, Seal Coat & premixed Chipping Carpet
	- Penetration macadam in Summer temperature & in plains.

Lecture No. 42 TEST ON SOIL

Topic(s) to be covered	Test on soil - Core Cutter Method - California bearing Ratio method - plate bearing test

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on on soil test.	Understand

Teaching Learning Material	Student Activity
Chalk/talk	Listen

Lecture Notes

Test on Soils.

1. Field density tests
   a) Core Cutter method
   b) Sand Oreplacement "
2. California Bearing Ratio test
   a) Laboratory test
   b) field test
3. plate bearing test.
4. Dry density & moisture Content - Standard proctor Compaction test.

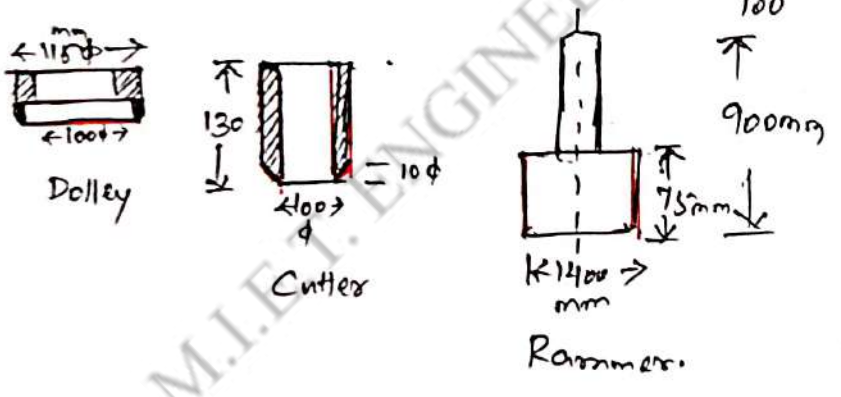
Core Cutter Method:-

- The Inner dimensions of the Core-Cutter is Measured & its Volume found (V_c) & Weight of the Cutter is found without dolly.
- The Cutter is placed on the levelled surface. The dolly is positioned the Cutter. & it is advanced into the soil by Rammer until about 15mm of the dolly protrudes above the surface.
- The soil around the Cutter is dug. The top & bottom of Cutter are trimmed by means of a palatte knife & Straight
- The Cutter with soil & without dolly is weighed (M_{sc})
- The soil is removed from the Cutter & the water Content

$$\text{Bulk density } \rho = \frac{M_s - M_c}{V_c}$$

$$\text{Field density } \rho_d = \frac{\rho}{1+\frac{w}{100}} \text{ g/cc.}$$

w- % of field wate



All dimensions are in

California Bearing Ratio:-

- Is developed by the California State Highway Department of USA for the evaluation of Subgrade Strength for roads pavements.
- It is expressed as the % of force per unit area required to Penetrate a soil mass with a Circular plunger of 50mm dia at a rate of 1.25mm/min.

The mould along with the specimen is placed on the testing Machine. The required No. of surcharge weights to stimulate the intensity of loading equivalent to the base material and pavement is placed.

The plunger is set to touch the specimen with a seating load of 4kg. A load on the plunger is applied at the rate of 1.25mm/min. Loads are noted at different penetration level. till 12.5mm.

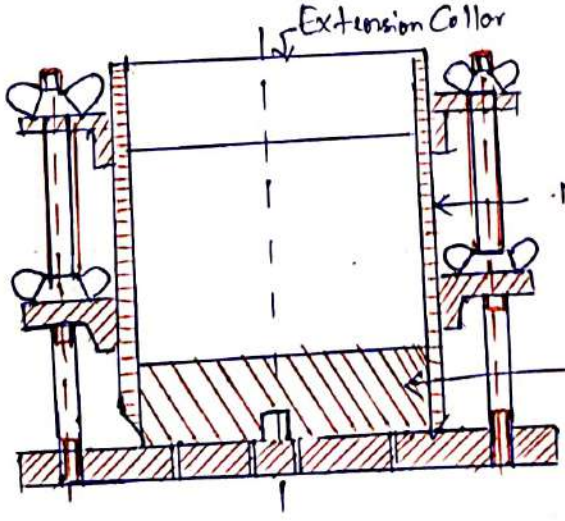
Soil samples are taken for moisture content determination. As a check the test may be conducted on the rear side of the specimen.

CBR Value

The load penetration curve is plotted. A correction shall be made. The CBR values are usually calculated for penetration of 2.5mm & 5mm.

$$CBR = \frac{P_T}{P_s} \times 100. \qquad \frac{\text{Total load}}{\text{Std. load}} \times 100.$$

P_T - Corrected unit test load



MOULD WITH EXTENSION COLLAR.

Lecture No. 23

Test for Aggregate.

Topic(s) to be covered	SHAPE TEST - flakiness Index - elongation Index - Water absorption test - crushing Value test.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Test on Aggregate for Road works	Understand.

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

Test for Road Aggregate.

- In order to decide the suitability of the road aggregates, the following tests are carried out.

1. Shape test
2. Water Absorption test
3. Specific gravity test
4. Crushing Value test.
5. Impact Value test. : $\frac{\text{wt. of. oven dried sample}}{\text{wt. of. fraction passing 2.36mm sieve}} \times 100\%$

1) Shape test:-

These are Mechanical measures of particle shape in terms of flakiness index & elongation index.

Flakiness index:-

1. Separate the aggregate into individual percentages obtained on specified sieve size.
2. passing at least 200 particles from the individual percentage through the sieves.
3. It is having elongated slots whose width are in terms of the individual mean dimension.

Flakiness index is the total weight of the material passing the various sieves, expressed as percentage of total weight of sample taken.

2) Water Absorption test:-

1. The Aggregate sample is soaked in distilled water for 24 hours.
2. It is taken back from water, it is surface dried in air.
3. The sample is placed in an oven for drying for about 24 hours at 100°c - 110°c. & it is weighed.

Water absorption is expressed as the % of water absorbed in terms of oven dried weight of the aggregates.

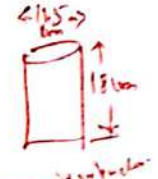
Base Course 45% Surface Course - 30%

25. Crushing Value test:-

It is defined as the strength measurement of the resistance of an aggregate, to crush under a gradually applied compressive load. The test is carried out on aggregate sample of size between 10-12 mm, dried at 100°C - 110°C for a period of about 4 hours.

The Aggregate is placed in 3 equal layers, each layer being tamped 25 times by the temper in a standard steel cylinder (of 150mm dia) with a base plate & plunger.

A load of 40 tonnes is gradually applied to the aggregate material over a period of 10 minutes. After the application of load, the sample is taken balle & the weight of material passing through 2.36mm IS Sieve is determined.

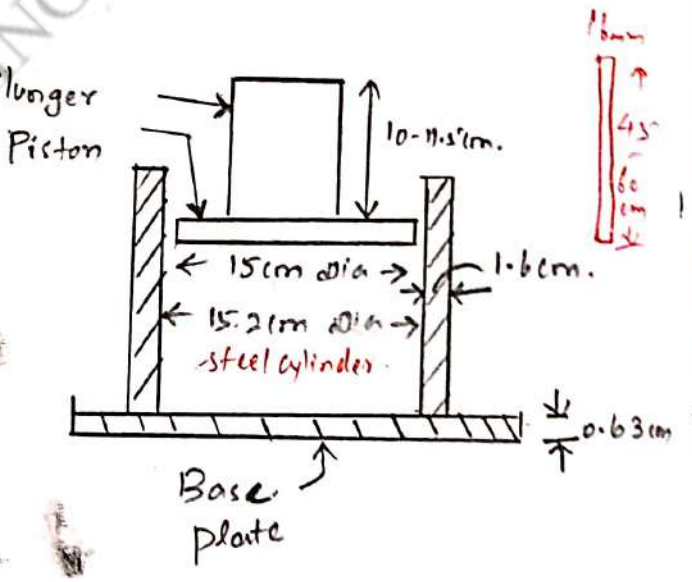


$$\text{Crushing Value} = \frac{W_2}{W_1 - W} \times 100 \%$$

W_2 - Wt. of aggregate passing through IS Sieve of 2.36mm size (kg)

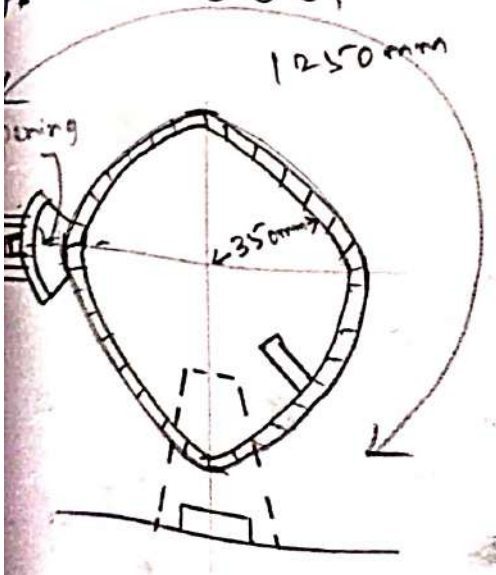
W_1 - Wt. of sample taken (kg).

W - empty cylinder weight.



Agg toughness

Abrasion test:-



(1) The specified weight of the aggregate specimen (5 - 10kg) is placed in the cylinder along with the abrasive charge. The machine is noted at a speed of 30-33 revolution per minute. for the specified no. of. revolutions (500-100 revolutions)

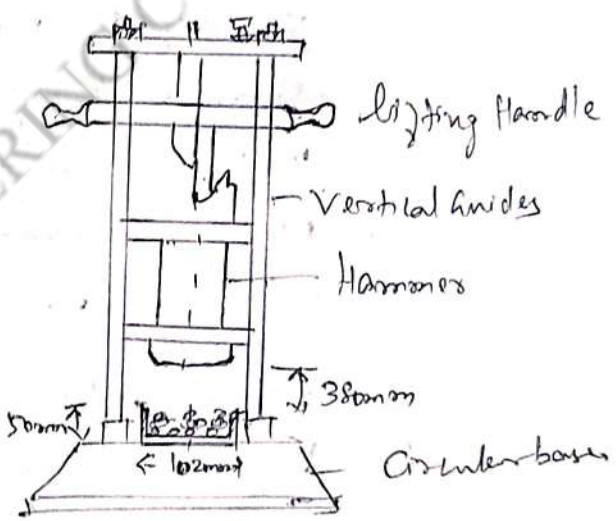
The abraded agg. is sieved on 1.7mm IS Sieve & the weight of powdered aggregate (W_2) passing through sieve is found.

$$\text{Abrasion Value} = \frac{W_2}{W_1} \times 100$$

Note:- Agg. Abrasion Value upto 30% is allowed for high quality

Impact test:

- Sample is placed in the cup
- It is compacted by a single tamping of 25 strokes of tamping rod.
- The Hammer is raised 380mm above the Aggregate in the cup.
- It is allowed to fall freely over the aggregate for a total of 15 blows.
- After Completion of impact load the material is passing on 2.36mm I.S. sieve



- Impact = $\frac{W_2}{W_1} \times 1000$

W_2 = wt. of sample aggregate passing through 2.36mm sieve

W_1 = wt. of dry sample

Note: Base Course - 45
Surface " - 30

Unit - II
BITUMEN.

Topic(s) to be covered	Definition. Objectives — Types of Bitumen. Test on Bitumen.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand various test to be carried out for an bituminous material	Understand

Teaching Learning Material	Student Activity
Chalk / Talk.	Listen.

Lecture Notes

BITUMINOUS MATERIAL:-

also called binders used in combination with mineral aggregate.

Objectives:-

1. Binding effect
2. Cushion
3. Resistance to weathering actions
4. Sealing of Surface.

Types:-

1. Bitumen 2. Tar 3. Tar - Bitumen.

Cutback Bitumen - Is a liquid binder
- obtained by dissolving a bitumen with Solvent.
- Used in surface of soil aggregate Road.

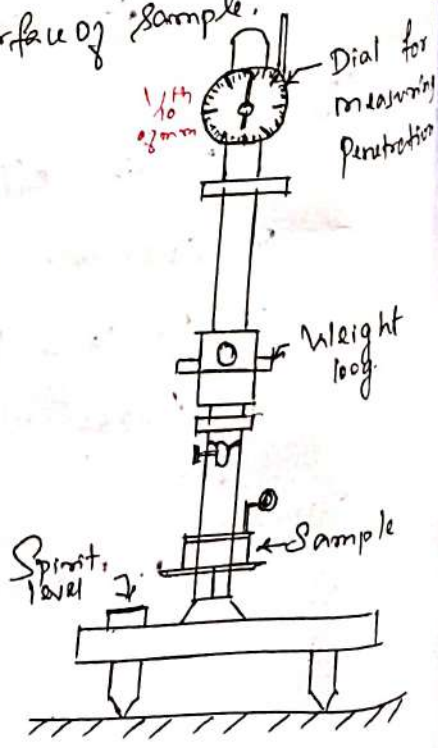
Tar
- It is a Viscous liquid, blaile in Colour
- obtained by destructive distillation of Organic ma

- **Test on Bituminous Binders:-**

1. Consistency Test - i) Standard penetration test. ✓
   ii) Ductility Test ✓
   iii) Viscosity Test ✓
2. Composition Test
3. Flash & fire point Test:
4. Specific gravity Test.

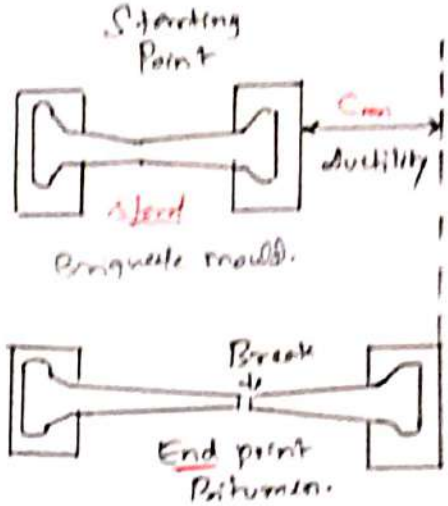
Penetration Test:-

1. This test is Carried out with a standard penetrometer as shown in
2. The sample is Heated to about 85°c - bitumen is in semi liquid
3. It is transferred to a Container of height more than 15mm.
4. The Needle point just touches the Surface of sample.
5. The Needle is then released & allowed to penetrate into the bitumen sample. for 5 Seconds.
6. If the penetration Value of the bitumen is in the range of 30-40 Under Standard test condition, it is graded as 30/40.
7. In India 30/40, 60/70 & 80/100 grade bitumen are used.



Ductility Test:-

- It is carried out to indicate the binding property of bitumen and its ability to withstand shocks under the effect of traffic loads.
- The test specimen is cast in the brass mould with a min. width of 10mm x 10mm.
- The specimen is cooled in air & water bath at a temp. of 25°C for 90 minutes.
- Then the sample is tested by pulling the clips at their ends.



Ductility Test.

Eg | Individual test | Ductility
1 | 0 | 41
2 | 41 | 41
3 | | 72.3
4 | | 33

Avg = 71+72.3+33/3 = 72 cm

Water Content Test:-

If bitumen contains water, the bitumen will foam, when it is heated beyond 100°C.

i) The specimen of known weight is mixed in a pure petroleum distillate free from water. It is then heated & water is distilled off. The condensed water is collected & its weight is recorded. The water content of the specimen is expressed as a percentage of the weight of condensed water to the weight of original sample.

Flash & fire point Test:-

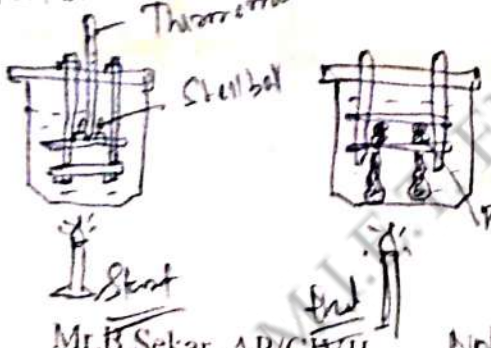
The material is filled in the cup & heated at a uniform rate of 5°C per minute. A small flame is passed periodically across the surface of the heated material. The temperature at which the vapour given off from the binder first burns with a blume flame called flash point of the binder. If the heating is continued until the vapour continue to burns for 5 seconds, that temperature is called fire point. The flash point value of most penetration grade bitumen is about 177°C.

1) Pensky - Martens closed cup
2) Thermometer
3) Candle.

Softening Point Test – Is the temp. at which the substance attains a particular degree of softening.

Apparatus

a) Ring & Ball setup
b) Beaker
c) Burner
d) Thermometer
e) water.



Test:-

i) The bitumen sample is taken in the brass ring
ii) It is suspended in water at a particular temp.
iii) A steel ball is placed upon the bitumen & the water is heated at a rate of 5°C/min.
iv) The Bitumen will start melting & start flowing down.
v) At a particular temp. the softened bitumen touches the metal plate at a specified distance below the ring is recorded

Note:

paving job - 35° - 70°C

Unit-IV

Lecture No. 5 Design of flexible pavement [IRC]

Topic(s) to be covered	Design procedure for design of flexible pavement using IRC method.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand the design procedure for designing a flexible pavement using IRC	Understand

Teaching Learning Material	Student Activity
Chalk / Talk	Listen.

Lecture Notes

IRC Method of flexible pavements: Design.

- IRC : 37 – 2001 recommended the following design procedure for the design of flexible pavements.

(a) Design Approach and Criteria:

Repeated application of traffic loads cause following Pavement problems.

1. Vertical Compressive strain at the top of Subgrade leads to permanent deformation at the pavement Surface during design life.

2. Horizontal tensile strain at bottom of the bituminous layer causes fractures of the bituminous layer during design

3. Pavement deformation within bituminous layers.

(b) Estimation of design traffic.

(c) Data Requirement.

In order to design the flexible pavement. following

- No. of. Commercial Vehicles per day - 24x7 Count
- Traffic Growth Rate - Annual Growth rate is 7 (Assumption)
- Design life in No. of. years - For NH/SH - 15
  For Express/Urban Road - 2
  For other roads - 10
- Vehicle Damage factor (VDF) - It is the equivalent axles / Commercial Ve
- Distribution of Commercial traffic over a Carria

(d) Assumptions:-

Following assumptions are made in the design the flexible pavement.

1. If the traffic flow in 2 directions varies Signifi Higher value is taken for design procedure.
2. The Design is applied to the Complete Carriage Width.

- The traffic in each direction is half of the sum of volume of traffic, at a particular section of the road.

(e) Computation of design traffic section:-

$$N_s = 365 \left[(1+r)^n - 1 \right] \times A \times F \times D$$

Where N_s - No. of Commercial Vehicle / day - Considering No. of lanes.

r - Annual Growth rate (0.075)

n - Design life of the pavement (10-15 years)

F - Vehicle damage factor.

A - Initial traffic in the year of Completion of Construction of road

$$A = P(1+r)^x$$

P - No. of. Commercial Vehicles in the last Count.

x - No. of. years after last Count.

- Design of Sub-grade:-

  * Design of subgrade Consists of

    - Compaction Requirements of Roads
    - Dry density & moisture Content Calculation.

- Design of Sub-base

  - The Material used for sub base Course CBR Value of 20% for Cumulative traffic upto 2msa & 30% for traffic > 2msa.
  - WBM with 2msa - 225mm thk, WBM > 10msa - 300mm thk
  - Provide 75mm BM layer precedes the DBM binder Course. BM of 1mm is Considered equivalent to 7mm DBM.

Lecture No. 6 Unit - IV

Design of Rigid Pavements.

Topic(s) to be covered	Design of rigid pavement - Design Parameter - Design procedure.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	gain knowledge on design of rigid pavements	Understand

Teaching Learning Material	Student Activity
Chalk talk	Listen

Lecture Notes

- Design of Rigid pavements

The design of rigid pavement is influenced by Materials & its properties.

1. plain Concrete:-
   - low cost design of pavement design
   - Carried out with short slabs.
   - Used for light travelled roads

2. Reinforced Cement Concrete:-
   - This pavement Consists of steel mesh/mat
   - Adaptable to most of the traffic & Climatic Conditions

- Pre Stressed Concrete:-
  - Pavements are in the form of long lengths which are Compressed by jacks or tendons.
  - These pavements are costly & they are used to Modern transverse Cracks Completely. by keep the Concrete pre-Compressed.

- Design parameters for Rigid Pavements:-
  1. Traffic parameters
     (a) Design wheel load (DWL)
     (b) Traffic Intensity (TI)
  2. Environmental Parameters.
     (a) Difference in temperature
     (b) Intensity of Rainfall.
  3. Foundation strength & Characteristics
  4. Characteristics of Concrete.

- IRC Method - Design procedure:-
  1. Various design parameters such as wheel load Value - & properties of Concrete are selecte

1c- Radius of Modulus of composite section

2. Joint spacing and lane width are decided

3. The tentative design thickness of the pavement slab is selected.

4. Maximum temperature stress for the critical edge region from the equation.

$$\sigma_{te} = \frac{E\alpha(\Delta t)}{2}.C$$ & C is Calculated.

5. The residual available strength of Concrete for supporting traffic loads is Calculated.

6. The Edge stress and factor of safety is Calculated.

7. In case of available factor of safety, is less than greater than 1, the slab thickness is adjusted & the steps from 3 to 6 is repeated for making the factor of safety is one or little more.

8. Based on Corner load stress, the adequacy of thickness in the Corner region is checked.

9. The slab thickness (hs) is adjusted for traffic intensity. The adjusted design thickness 'h' may be Calculated from

$$h = hs + hz$$

The value of h_z may be obtained from the table.

Traffic classification	A	B	C	D	E	F	G
h_z (cm)	-5	-5	-2	-2	0	0	2

Lecture No. 7 Unit - III

Highway Drainage

Topic(s) to be covered	Drainage – Sources of entering water the road structure – Surface drainage – Catch basin – Inlets – Subsurface drainage.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
LO1	Gain knowledge on Highway Drainage.	Understand

Teaching Learning Material	Student Activity
Chalk / Talk.	Listen

Lecture Notes

Drainage!-
- Is defined as the interception & removal of water from an Area.

Highway drainage!-
- Is defined as the process of removal of excess water from road surface & also from subgrade.

Sources of water - Entering the road Structure!-

1. Capillary action of water
2. Floods due to Heavy rains
3. Direct falling of rain water on the road surface.

- Surface drainage - objective is to remove rain water from the Co

- Catch-basin:-

A Catch basin is a structure in the form of a Chamb which is provided along the sewer line to admit Clear rain water free from silt, grit, debris etc. into the Combined se

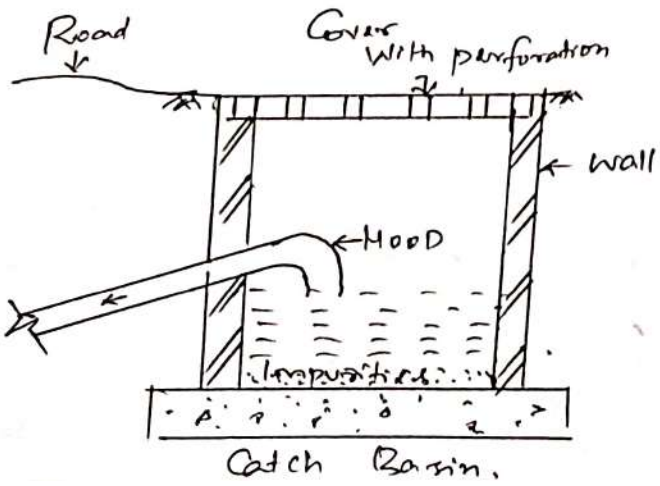
objective

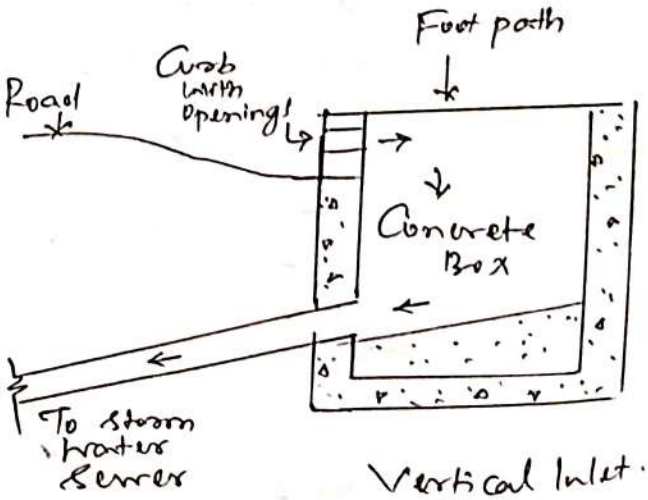
1. It prevents the entry of silt, grit, debris etc, Comb in the rain water.
2. It prevents the escape of sewer gas.

It consists of a Chamber Constructed of walls. At the bo of Basin, space is provided for the accumulation of Impu At the top, Cover with perforation is fixed & the pavem edge are kept to admit rain water into the basin.

- In lets:-

An Inlet is simply a Concrete box. It may have gra or openings in Vertical direction or in Horizontal direct An Inlet is an opening through which storm water is ado & Conveyed to the storm water sewer It is loca by the sides of roads at a distance of about 30-60 The Inlets are Connected to near by roam Holes by pipe





- **Subsurface drainage:-** The objective is to keep the Highest water table level below the level of subgrade.

(a) **Methods to Control Capillary rise:-**

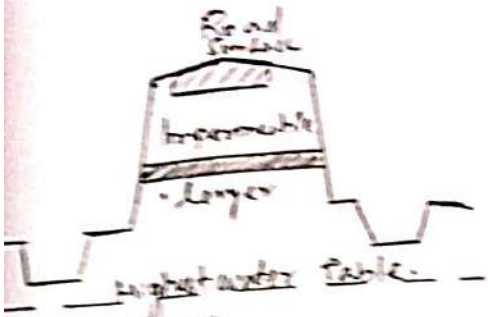


Fig (i)

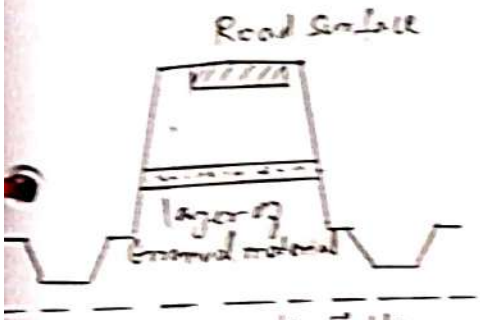


Fig. (ii)

Where there are chances for water to reach the level of subgrade through the capillary rise, it becomes Necessary to arrest such action by providing suitable Capillary cut off between the subgrade & Highest water table level. When the Construction of Road in embankment is in progress, the Capillary cut off may be provided in any one of the following ways. [Fig (i) & (ii)]

(i) Inserting an Impermeable or a bituminous layer.

(ii) providing a layer of granular material of suitable thickness. (Fig (ii))

(b) **Methods to Control Seepage flow:-**

If the ground is sloping & the seepage zone is at a depth of about 1 to 2 m from the edge of road, the perforated drain pipe with filter material is provided in Fig (2) to lower the seepage line.

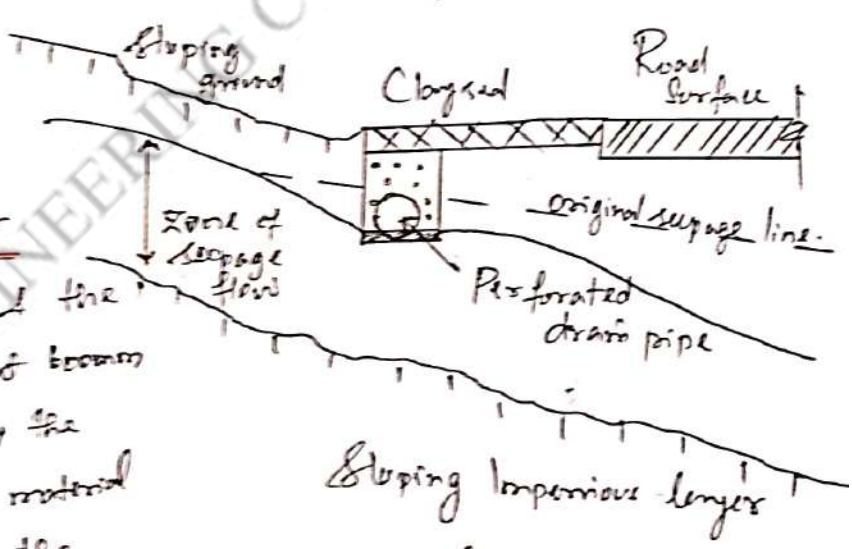
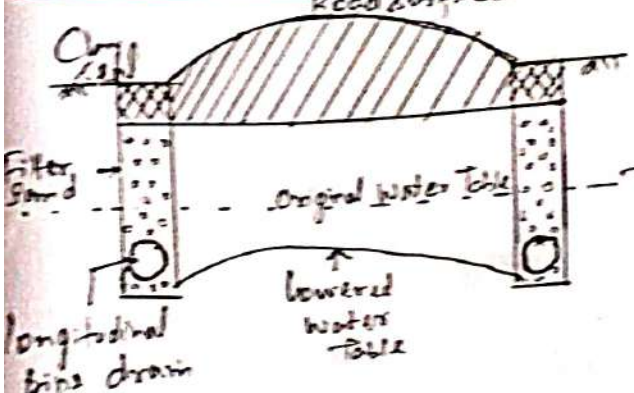


Fig (2).

Methods to lower water table.



Pipe drains on either side

- longitudinal sub surface drains are placed below the surface of the ground in the permeable saturated stratum.
- pipe drains may be Vetrified clay with open joints butting against each other
- They may be constructed of Cement Concrete with Covering perforated sheet.

Lecture No. 08

UNIT-III.

PAVEMENT EVALUATION

Topic(s) to be covered	Pavement evaluation - Methods of pavement evaluation - Rebound deflection test - Strengthening of pavement.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
Lo1	evaluate pavements using various Methods for a highway.	Understand

Teaching Learning Material	Student Activity
Chalk talk	Listen.

Lecture Notes

- Pavement Evalnation! -

It is defined as the study of various factors such as Subgrade support, pavement Composition. & its thickness, traffic loading & Environmental Conditions.

- Methods of pavement evaluation! -

1. Methods based on deflection Criteria.
2. Methods based on Serviceability.

Re Bound Deflection Test:-

The performance of a flexible pavement is related to its rebound deflection. Its Concept is pavement Structure deforms elastically under the design test load.

The Benkelman Beam is used for measuring the deflection of flexible pavements under the action of moving loads.

If the rebound deflection value of any highway is high, then the section gives poor performance & has shorter life. The sections which show low rebound deflection may need little maintenance & posses longer life.

Non destructive testing methods can also be used to assess the load carrying capacity of the pavements.

Based on Serviceability Rating:-

This method takes into account the physical measurement like longitudinal & transverse profile of the pavement surface extent of unevenness, patching & cracking etc... These physical measurements are evaluated to a predetermined scale. The following equation gives value of PSI [present serviceability index]

$$PSI = 5.03 - 1.91 \log(1+SV) - 1.38^2 (RD)^2 - 0.01\sqrt{C+P}$$

for flexible pavements.

For rigid pavements

$$PSI = 5.41 - 1.80 \log(1+SV) - 0.09\sqrt{C+P}$$

The SI has been used to serve as a measure of a pavement ability to serve high speed high volume mixed traffic, as indicated on a scale of 0 to 5.

From 0 to 1	Very poor
From 1 to 2	poor
From 2 to 3	fair
From 3 to 4	Good
From 4 to 5	Very Good.

Strengthening of pavement:-

Is defined as the process of giving the additional strength to the pavement. The preventive strengthening can be carried out through the regular observation & study of pavement performance.

The process of strengthening of pavement by increasing the thickness of the pavement is called overlay.

For effective & economical strengthening of pavement, the following factors are to be considered.

1. The field study, to know the types of prevailing distress & its distribution.
2. The general appraisal of the subgrade & the environmental conditions.
3. Determination of design requirements for preventive & [illegible] based on the collected data.

Lecture No. 9 Unit - IV

Strengthening of Pavement

Topic(s) to be covered	Overlays - flexible overlay over flexible pavement - Rigid overlay over rigid pavement & flexible pavement.

	Lecture Outcome (LO)	
	At the end of this lecture, students will be able to	Bloom's Level
LO1	Gain knowledge on Strengthening of pavement	Understand

Teaching Learning Material	Student Activity
Chalk / talk	Listen

Lecture Notes

- Flexible overlay over flexible pavement.

The overlay design thickness is defined as the difference between the Calculated design thickness & the thickness of existing pavement.

Process of strengthening the pavement by increasing the thickness of the pavement is called overlay.

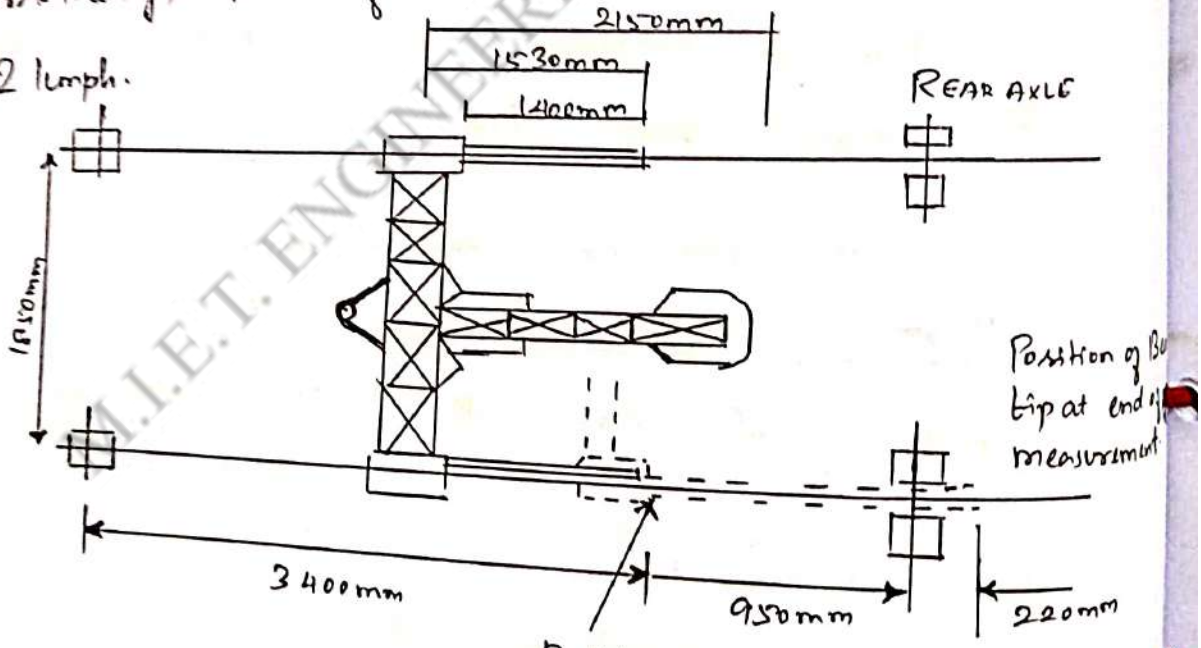
Overlay design thickness = Design thickness Calculated - Thickness of existing pavement.

Benkelman Beam method is used to calculate the overlay thickness by using an empirical formula $h_0 = \frac{R}{0.1794} \log_{10} \frac{\Delta_1}{\Delta_0}$

h_0 - overlay thickness in cm; Δ_1 - Characteristic deflection of existing pavement; Δ_0 - allowable deflection

• Deflectograph is the equipment, used to take the deflection measurements over about 2 lakms of Carriageway per day. The deflectograph equipment is shown in fig. 1 it consists of a special lorry, a deflection beam assembly located beneath its body and an associated automatic recording system.

When measurements are taken, the beam assembly rests on the Carriage way. when the maximum deflection has been recorded by electrical transducers located near the beam pivot, the beam assembly is pulled forward at about twice the speed of the vehicle. The deflectographs measures automatically, the deflection at 3.8m intervals. at a vehicle of 2 kmph.



Deflectograph.

• RIGID OVERLAY OVER RIGID PAVEMENT :-

The modulus of sub grade reaction of the

existing flexible pavements is determined for the design of rigid overlay over rigid pavement. Based on this value & the design wheel load, the thickness of rigid overlay is calculated by using the standard methods.

Widening & Strengthening have often to be carried out as a simultaneous process. widening is done by water bound macadam construction on each side in layers of 7.5cm thickness. This is the first step of operation.

Strengthening the layers:-

A Bituminous strengthening layer over a tack coat would be ideal. With the high cost of bitumen a bituminous macadam layer costs, little more than the normal WBM costs.

The old black top surface should be peeled off the thin bituminous layer which is normally carried out by pick axes then the laying of WBM, strengthening the layers.

Rigid overlay over flexible pavement

For the design of this combination, the existing rigid pavement is evaluated. The design thickness requirement is calculated as per any one of the design method.

Thickness of the rigid overlay rigid pavement

$$h_0 = (Ch_d^2 - C h_r)^n$$

h_0 - rigid overlay th (cm)
h_d - design thickness (cm)
h - existing pavement th (cm)
C - factors.