VTU QUESTION PAPER SOLUTION

HIGHWAY ENGINEERING(18CV56)

1 a) Explain the different planning surveys to be conducted before finalizing the alignment?

Ans: Engineering surveys

The stages of the engineering surveys are:

a) Map study.

b) Reconnaissance.

c) Preliminary surveys.

d) Final location and detailed surveys.

(a) Map study: - Map study is done to suggest the likely routes of roads. In India topographic maps are available from the survey of India. The probable alignment can be located on the map from the following details available on the map:

- Alignment avoiding valleys, ponds or lakes
- When the road has to cross a row of hills, possibility crossing through a mountain pass.
- Approximate location of bridge site for crossing rivers, avoiding bend of the river.
- When a road is to be connected between two stations one on the top and the other on the foot of the hill then alternate routes can be suggested keeping in view the permissible alignment.
- Suppose the scale of the contour map is known, and then the contour intervals it is possible to decide the length of road required between two consecutive contours keeping the gradient within allowable limits.

(b)Reconnaissance:-

⎪ The second stage of surveys for highway location is the reconnaissance to examine the general character of the area for deciding the most feasible routes for detailed studies.

⎪ During the reconnaissance, the engineer visits the site and examines the general characteristics of the area before deciding the most feasible routes for detailed studies

⎪ Simple instruments are used.

Abney level, Barometer, Tangent clinometer etc. Some of the details to be collected during reconnaissance are given below:

- Valleys, ponds, lakes, marshy, land, ridge, hills, permanent structures and other obstructions along the route, which are not available in the map.
- Approximate values of gradient, length of gradients and radius of curves of alternate alignments.
- Number and types of cross drainage structures maximum flood level and natural groundwater level along the probable routes.
- Soil type along the routes from field identification tests and observation of geological features.
- Sources of construction materials water and location of stone quarries.
- When the road passes through hilly or mountainous terrain, additional data regarding the geological formation types of rocks, dip of strata, seepage flow etc.

(c)Preliminary survey: - The main objectives of the preliminary surveys are:

⎪ To survey the various alternate alignments proposed after the reconnaissance and to collect all the necessary physical information and details of topography, drainage and soil.

⎪ To compare the different proposals in view of the requirements of a good alignment.

⎪ To estimate quantity of earthwork materials and other construction aspects and to work out the cost of alternate proposals.

⎪ To finalize the best alignment from all considerations.

The procedure of the conventional methods of preliminary survey the given steps:

1) Primary survey: - For alternate alignments either secondary traverses (or) independent primary traverses may be necessary.

2) Topographical features: - All geographical and other man made features along the traverse and for a certain

width on either side surveyed and plotted.
3) Leveling work: - Levelling work is also carried out side by side to give the centerline profiles and typical cross sections. The leveling work in the preliminary survey is kept to a minimum just sufficient to obtain the approximate earthwork in the alternate alignments.
4) Drainage studies: -Drainage investigations and hydrological data are collected so as to estimate the type, number and approximate size of cross and drainage structures.
5) Soil survey: - The soil survey conducted at this stage helps to working out details of earthwork, slopes, suitability of materials, subsoil and surface drainage requirements and pavement type and the approximate thickness requirements.
6) Material survey: - The survey for naturally occurring materials like stone aggregates, soft aggregates etc and identification of suitable quarries should be made.
7) Traffic survey: - Traffic surveys conducted in the region from basis for deciding the number of traffic lanes and roadway width, pavement design and economic analysis of highway project.

(d)Final location and detailed survey: -
The alignment finalized at the design office after the preliminary survey is to be first located on the field by establishing the centerline. The detailed survey should be carried out for collecting the information technology for the preparation of plans and construction details.
Location: -
- The centerline of the road finalized in the drawings to be translated on the ground during the location survey.
- Major and minor control points are established on the ground and center pegs are driven, checking the geometric design, requirements. Detailed survey: -
- Levels along his final centerline should be taken at all staked points. Levelling work is to great importance as the vertical alignment.
- A detailed soil survey is carried out to enable drawing of the soil profile.
- The data during the detailed survey should be elaborate and complete for preparing detailed plans, design and estimates of the project.

1 b) Mention the jayakar committee recommendations and its implementations?

Ans: Jayakar Committee
The first World war period and that immediately following it found a rapid growth in motor transport. So need for better roads became a necessity. For that, the Government of India appointed a committee called Road development Committee with Mr. M.R. Jayakar as the chairman. This committee came to be known as Jayakar committee. In 1927 Jayakar committee for Indian road development was appointed. The major recommendations and the resulting implementations were:
- Committee found that the road development of the country has become beyond the capacity of local governments and suggested that Central government should take the proper charge considering it as a matter of national interest.
- They gave more stress on long term planning programme, for a period of 20 years(hence called twenty year plan) that is to formulate plans and implement those plans within the next 20 years.
- One of the recommendations was the holding of periodic road conferences to discuss about road construction and development. This paved the way for the establishment of a semi-official technical body called Indian Road Congress (IRC) in 1934.
- The committee suggested imposition of additional taxation on motor transport which includes duty on motor spirit, vehicle taxation, license fees for vehicles plying for hire. This led to the introduction of a development fund called Central road fund in 1929. This fund was intended for road development
- A dedicated research organization should be constituted to carry out research and development work. This resulted in the formation of Central Road Research Institute (CRRI) in 1950.

CRF:-
- Central Road Fund Scheme was constituted on 1 March 1929.
- The consumers of petrol were charged an extra levy of 2.64 paisa per litre of petrol for the development of the State Roads.
- From this 20% of annual revenue is to be retain as a central revenue for research and experimental work expenses etc.
- Balance 80% is allowed by central govt. to various states based on actual petrol consumption or revenue

collected.
- Distribution of 100% cess on petrol as follows:

o 57.5% for NH o 30%
for SH o 12.5% for safety works on rail-Road crossing
o 50% cess on diesel for Rural Road development
- The accounts of the CRF are maintained by the Accountant General of Central Revenues.
- The control of the expenditure is exercised by the Roads Wings of Ministry of Transport.

IRC:-
- IRC was formed in the year 1934.
- The main objectives are: (a) to provide forum for regular pooling of experience and ideas on all matters that effect the planning, construction and maintenance of roads in India, and (b) to recommend standard specifications to provide a platform for the expression of professional opinion on matters relating to road engineering.
- It publishes journals, research publications, standard codes, specifications, guidelines and other special publications on various aspects of highway engineering.
- Provides a platform for expression of professional opinion on matters relating to roads and road transport.
- Played an important role in the formation of three road development programs in India.
- It works in close collaboration with Roads Wing of the Ministry of Transport.

CRRI
- CRRI was formed in the year 1950 at New Delhi.
- The main objectives of CRRI are:

i) To carry out the basic and applied research for investigation, design, construction and maintenance of different types of roads and runways.
ii)To carry out research on road traffic and transportation, including traffic safety and transport economics.
iii)To render technical advice and consultancy services to various organizations.
iv) To arrange for utilization of results of research by extension unit, display centers etc.
v)To conduct refresher and training courses for staff of other research Institutions, Universities and highway Departments.
vi)To develop labor intensive methods and manual aids for the construction of low-cost all weather roads.
vii)To carry out research on the utilization of locally available materials for construction & maintenance of roads & runways economically.
viii)To develop machinery, tools, equipments & instruments for adopting technologies related to highway.
ix)To spread results by publication of scientific material.

1 c) Write a note on NHDP?

Ans: National Highways Development Project (NHDP)

¬ NHDP's prime focus is on developing International standard roads with facilitiesfor uninterrupted flow of traffic with :

- Enhanced Safety Features
- Better Riding Surface.
- Better Road Geometry
- Better Traffic Management and Noticeable Signage.
- Divided Carriageways and Service Roads
- Grade Separators
- Over Bridges and Underpasses
- Bypasses
- Wayside Amenities

¬ The Government of India has launched major initiatives to upgrade and strengthen National Highways

through seven phases of National Highways Development Project (NHDP), the main components of NHDP are:

¬ NHDP Phase I and II Comprises of the development of National Highways to 4/6 lane standards of the following routes;

(a) Golden Quadrilateral (GQ) connecting 4 major metropolitan cities viz. Delhi-Mumbai-Chennai-Kolkata-Delhi

(b) North South and East West Corridors (NS-EW) connecting Srinagar to Kanyakumari and Silchar to Porbandar with a spur from Salem to Cochin.

(c) Road connectivity of major ports of the country to National Highways.

(d) Other National Highway stretches

¬ NHDP Phase-III The Government has approved 4/6 laning of 12,109 km of National Highways on Build, Operate and Transfer (BOT) basis at an estimated cost ofRs.80,626 crore under NHDP-III.

The phase has been approved in two parts i.e.

Phase-III A consisting total length of 4,815 km at an approved cost of Rs.33,069 crore and Phase-III B, consisting total length of 7,294 km at an approved cost of Rs.47,557 crore.

¬ NHDP Phase-IV This Phase envisages upgradation of about 20,000 km of National Highways to 2-lane with paved shoulders on Public Private Partnership (PPP) basis.

¬ NHDP Phase- V Six laning of 6,500 km of existing 4 lane National Highways under NHDP Phase-V. Six laning of 6,500 km includes 5,700 km of GQ and 800 km of other stretches.

¬ NHDP PHASE- VI envisages development of 1,000 km fully access controlled expressways under Public Private Partnership (PPP) model following DBFO approach.

¬ The Government has approved construction of stand alone Ring Roads, Bypasses, Grade Separators, Flyovers, Elevated Roads, Tunnels, Road Over-bridges, Underpasses, Service Roads etc. on BOT (Toll) mode under NHDP Phase VII in December 2007

2 a) Explain the classification of roads based on the function and location?

Ans: Classification of roads

Roads are classified based on various aspects namely

1) **Based on the carriage way,**

- Paved Roads: These roads are provided with a hard pavement course which should be at least a water bound macadam (WBM) layer.
- Unpaved Roads: These roads are not provided with a hard pavement course of at least a WBM layer. Thus, earth roads and gravel roads may be called as unpaved roads.

2) **Based on Surface pavement provided**

- Surface Roads: These roads are provided with a bituminous or cement concrete surfacing.
- Unsurfaced Roads: These are not provided with bituminous or cement concrete surfacing. Roads which are provided with bituminous surfacing are called as black toped roads and that of concrete are referred to as concrete roads respectively.

3) **Based on Traffic Volume**:

This is further classified as

- Heavy
- Medium
- Light traffic roads.

The limits under each class should be clearly defined and expressed as vehicles per day

4) Based on Load transported or tonnage:

- Class-I or Class-A
- Class-II or Class-B.

The limits under each class should be clearly defined and expressed as tonnes per day.

5) **Based on location and Function**:

- National Highways (NH) – These are the roads that connect major ports, foreign highways, capitals of states and large industrial and tourist centers.
- State Highways (SH) – These are the arterial roads of a state, connecting with NH of adjacent state, district head quarters and important cities within the state. The NH & SH have the same design speed and geometric specifications.
- Major District Roads (MDR) – Roads serving areas of production and markets with main highway of a district. MDR has low speed and design specifications than NH & SH.
- Other District Roads (ODR)- Roads serving rural areas of production and providing them with outlets to market centers, taluk head quarters, block development head quarters or other main roads. These have low design specifications than MDR.
- Village Roads (VR)- These are roads connecting villages or group of villages.

Classification of roads as per third road development plan

1. **Primary system** The primary system consists of two categories of highways, i.e.
   - Expressways – These are separate class of highways with superior facilities and design standards. It is the highest class of roads in the Indian road network. They are mostly six or eight lane controlled access highways where the entrance is controlled by the use of slip roads. India has approximately 1,324 km of expressways. National Expressways Authority of India operating under the Ministry of Road Transportation and Highways will be in charge of the construction and maintenance of expressways.
   - National Highways (NH) – It is one of the important categories of primary roadsystem classification.
2. **The secondary system** – The secondary system consists of two categories of roads. These are:
   - State Highways (SH)
   - Major District Road (MDR)
3. **Tertiary system or rural roads** – The tertiary system are rural roads and these consists of two

categories of roads. These are:

- Other District Roads (ODR)
- Village Roads (VR)

Classification of Urban roads

The urban roads are classified as per their importance such as:

I. Arterial roads

II. Secondary or sub-arterial roads

III. Collector streets

IV Local streets

2 b) Explain the concept behind saturation system of road planning?

Ans: Saturation System:-

In this system optimum road length is calculated for an area based on the concept of attaining maximum utility per unit length of the road. This is also called as maximumutility system. Factors to attain maximum utility per unit length are:

1) Population served by the road network

2)Productivity (industrial and agricultural) served by the road network. The various steps to be taken to obtain maximum utility per unit length are:

Population factors or units: Since, the area under consideration consists of villages and towns with different population these are grouped into some convenient population rangeand some reasoning values of utility units to each range of population serve are assigned.

Population less than 500,

utility unit = 0.25 501 to 1001, utility unit = 0.50

Productivity Factors or units: The total agricultural and industrial products served by each road system are worked out and the productivity served may be assigned appropriate values of utility units per unit weight.

Optimum Road length: Based on the master plan the targeted road length is fixed for the country on the basis of area or population and production or both. And the same may be taken as a guide to decide the total length of the road system in each proposal.

2 c) Write a note on (i) IRC (ii) Urban roads

Ans: (i) IRC:

- IRC was formed in the year 1934.
- The main objectives are: (a) to provide forum for regular pooling of experience and ideas on all matters that effect the planning, construction and maintenance of roads in India, and (b) to recommend standard specifications to provide a platform for the expression of professional opinion on matters relating to road engineering.
- It publishes journals, research publications, standard codes, specifications, guidelines and other special

publications on various aspects of highway engineering.

- Provides a platform for expression of professional opinion on matters relating to roads and road transport.
- Played an important role in the formation of three road development programs in India.
- It works in close collaboration with Roads Wing of the Ministry of Transport.

(ii) Urban roads:

Classification of Urban roads

The urban roads are classified as per their importance such as:

I. Arterial roads
II. Secondary or sub-arterial roads
III. Collector streets
IV. Local streets

Arterial Roads:- These are that roads which connect the town to state highway or a national highway. They pass through the city limits and carry a large amount of traffic and therefore should be planned as straight as possible, avoiding sharp curves. These should not enter into the heart of the city at any cost, should have very few road junctions, which should be controlled by roundabouts or fly-overs. They should have no obstructions such as frontage of buildings, loading or unloading areas, parking places, and pedestrians on the carriage way.

Secondary or Sub-arterial Roads:- Also known as major roads they run within the limits of the town connecting its important centres. They are designed for slow moving traffic and cover a short distance. The sub- arterial roads act as a link between the arterial roads and local roads. The sub-arterial roads should be improved and provided with safety measures at intersections.

Local streets:- These roads, also known as minor roads, are meant to provide approach to the buildings, officers, shops, schools, colleges etc. There should be no through traffic here and so the local roads are not linked with the arterial roads. These roads are used for residential units, shopping and business centres.

Collector streets:- These are meant for collecting the traffic from local streets to arterial streets. Full access is allowed into collector streets from the properties alongside. It is situated in residential, industrial and commercial areas. These streets have few parking restrictions except for peak hours.

3 a)Define alignment and explain the factors controlling alignment?

Ans: Highway alignment

The position or the layout of the central line of the highway on the ground is called the alignment. Centre line is fixed first; them we expand the width

Highway Alignment includes both

a) Horizontal alignment includes straight and curved paths, the deviations and horizontal curves.

b) Vertical alignment includes changes in level, gradients and vertical curves.

Factors for deviation:

1. maximum utility

2. Obstruction

• A new road should be aligned very carefully as improper alignment will lead to increase in construction, maintenance and vehicle operation cost

• Once the road is aligned and constructed, it is not easy to change it due to increase in cost of adjoining land and construction of costly structures by the roadside

The various factors that control the alignment are as follows:

a)Obligatory Points

b)Traffic

c)Geometric Design

d)Economics

e)Other Considerations

The various factors that control the alignment are as follows:

Obligatory points Through Which the Alignment Should Pass

a)Bridge site: The bridge can be located only where the river has straight and permanent path. It should not be curved and skew crossing should be avoided as possible.

b)Mountain: While the alignment passes through a mountain, the various alternatives are to either construct a tunnel or to go around the hills. The suitability of the alternative depends on factors like topography, site conditions and construction and operation cost.

c)Intermediate town: The alignment may be slightly deviated to connect an intermediate town or village nearby.

The various factors that control the alignment are as follows:

Obligatory points Through Which the Alignment Should Not Pass.

a)Religious places: These have been protected by the law from being acquired for any purpose. Therefore, these points should be avoided while aligning.

b)Very costly structures: Acquiring such structures means heavy compensation which would result in an increase in initial cost. So, the alignment may be deviated not to pass through that point.

c)Lakes/ponds etc.: The presence of a lake or pond on the alignment path would also necessitate deviation of the alignment.

Traffic:

¬ The alignment should suit the traffic requirements

¬ The origin- destination data of the area, the desire lines should be drawn

¬ The new alignment should be drawn keeping in view the desire lines, traffic flow pattern etc.

Geometric Design:

Geometric design factors such as gradient, radius of horizontal curve, sight distance etc. also governs the alignment of the highway.

¬ Gradient should be mostly flat.

¬ Radius of curve minimum

¬ Avoid sharp horizontal curves

¬ Avoid sudden changes in sight distance, especially near crossings

¬ Avoid road intersections near bend

¬ No obstructions to visibility

¬ The design standards vary with the class of road and the terrain and accordingly the highway should be aligned.

Economics

• The alignment finalized should be economical. Construction, maintenance, and operating cost should be minimum.

• Balance in cutting and filling- To reduce construction cost

• Avoid very high embankments and very deep cuttings as the construction cost will be very higher in these cases.

Other Considerations Drainage, hydrology, political, monotony and topography

The vertical alignment is often guided by drainage considerations such as sub surface drainage, water level, seepage flow, and high flood levels.

A foreign territory coming across the alignment will necessitate the deviation of the horizontal alignment.

In flat terrain, even though it is possible to have a very long stretch of road which is absolutely straight may be monotonousfor driving.

Additional care on hilly roads

• Stability

• Drainage

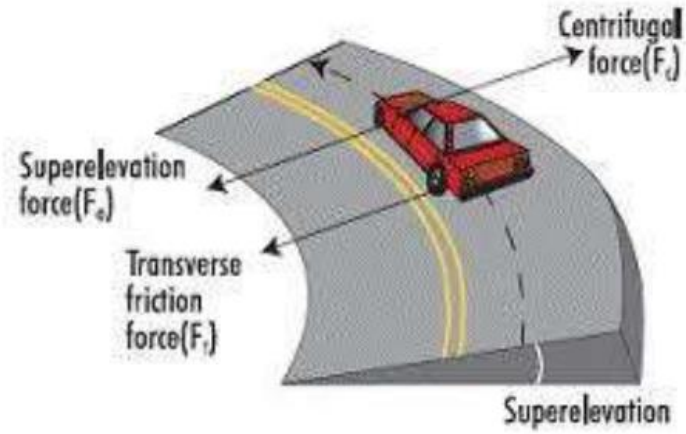
• Geometric design on hilly roads

• Resisting length

3 b) Define super elevation?Explain the attainment of super elevation in the field?

Ans: Definition: Raising of the outer edge of pavement with respect to the inner on a horizontal curve. It is a transverse slope.

In order to counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge, thus providing a transverse slope throughout the length of the horizontal curve. This transverse inclination to the pavement surface is known as **SUPER ELEVATION or CANT or BANKING.**



The super elevation depends upon

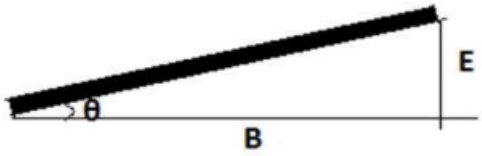
1) Radius of the curve R,
2) Speed of the vehicle V
3) The coefficient of lateral friction f

Super elevation

a) Super elevation is given by

$$e = \tan\theta = \text{Sin}\,\theta = \frac{E}{B}$$

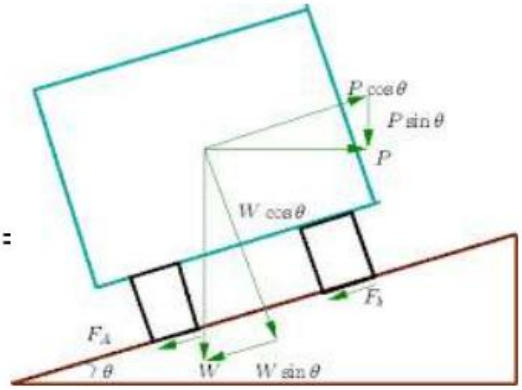
e is the rate of super elevation
E: Total super elevation height



b) General equation

$$e+f = v^2/gR$$

e = rate of super elevation
f = design value of lateral friction coefficient =
v = speed of the vehicle, m/sec
R = radius of the horizontal curve, m
g = acceleration due to gravity = 9.8 m/sec^2



C) Equilibrium super elevation (NO FRICTION)

$$e+\cancel{f}^{0} = v^2/gR$$

Both tyres of vehicle will have same pressure

d) **If there is no super-elevation** provided due to some practical reasons, then e = 0 and becomes $f = v^2/gR$. This results in a very high coefficient of friction.

e) **If e = 0 and f = 0.15** then for safe travelling speed is given by $v = \sqrt{fgR}$ where v is the restricted speed.

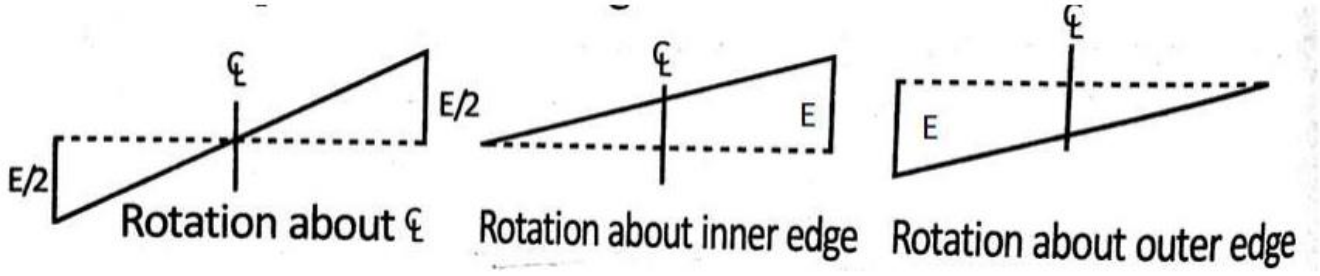
f) Maximum super elevation as per IRC
e max= 7% for plain, rolling and in snow hilly terrain
e max = 10% for hilly terrain not bound by snow

Attainment of Super elevation in the field

(a) Elimination of crown of the cambered section

(b) Rotation of pavement about inner edge, outer edge, centre line

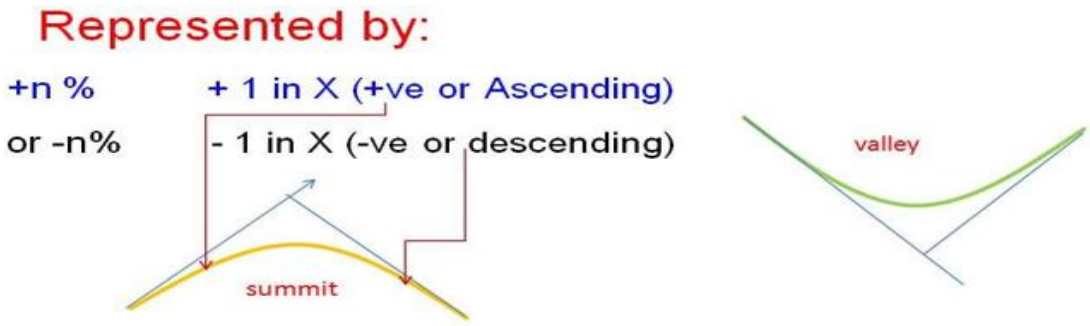
Centre line rotation – no need to shift the Centre, cutting and filling are same. Drainage issue may arise
Rotation about outer edge: Drainage issue may come



4 a) Explain the different types of gradients used in roadways?

Ans: Gradient

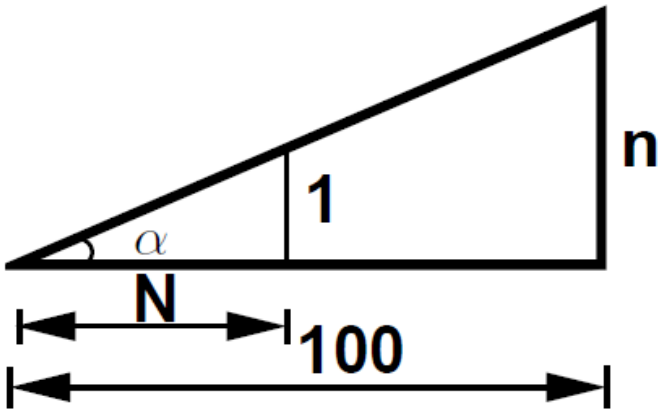
- It is the rate of rise or fall along the length of the road with respect to the horizontal. It is expressed as a ratio of 1 in x (1 vertical unit to x horizontal unit). Some times the gradient is also expressed as a percentage i.e. n% (n in 100).



Gradient is the rate of rise or fall along the length of the road with respect to the horizontal. While aligning a highway, the gradient is decided for designing the vertical curve

- Representation of gradient

  The positive gradient or the ascending gradient is denoted as +n and the negative gradient as -n. The deviation angle N is: when two grades meet, the angle which measures the change of direction and is given by the algebraic difference between the two grades (n1 - (-n2)) = n1 + n2 = 1 + 2. Example: 1 in 30 = 3.33% is a steep gradient, while 1 in 50 = 2% is a flatter gradient. The gradient representation is illustrated in the figure below.



- **Limiting Gradient:** Steeper than ruling gradient. In hilly roads, it may be frequently necessary to exceed ruling gradient and adopt limiting gradient, it depends on
  - ❖ Topography
  - ❖ Cost in constructing the road

- **Exceptional Gradient:** Exceptional gradient are very steeper gradients given at unavoidable situations. They should be limited for short stretches not exceeding about 100 m at a stretch.

- **Minimum gradient:** This is important only at locations where surface drainage is important. Camber will take care of the lateral drainage. But the longitudinal drainage along the side drains require some slope for smooth flow of water.Therefore minimum gradient is provided for drainage purpose and it depends on the rain fall, type of soil and other site conditions.
- A minimum of 1 in 500 may be sufficient for concrete drain and 1 in 200 for open soil drains.

Value of gradient as per IRC

Terrain	Ruling gradient	Limiting gradient	Exceptional gradient
Plain and Rolling	3.3% (1 in 30)	5%	6.70%
Mountainous terrain	5% (1 in 20)	6%	7%
Steep terrain up to 3000m (MSL)	5% (1 in 20)	6%	7%
Steep terrain (>3000m)	6% (1 in 16.7)	7%	8%

4 b) Write a note on i) Shoulder ii) Camber iii)Right of way ?

Ans : Shoulder:

- It is provided along the road edge to serve as an emergency lane for vehicle.
- It act as a service lane for vehicles that have broken down.
- The minimum shoulder width of 4.6 m so that a truck stationed at the side of the shoulder would have a clearance of 1.85m from the pavement edge.
- IRC recommended the minimum shoulder width is 2.5 m
- It should have sufficient load bearing capacity even in wet weather.
- The surface of the should be rougher than the traffic lanes so that vehicles are discouraged to use the shoulder as a regular traffic.
- The color should be different from that of the pavement so as to be distinct.

- **Camber**

Camber is the cross slope provided to raise middle of the road surface in the transverse direction to drain of rain water from road surface. The objectives of providing camber are:

- Surface protection especially for gravel and bituminous roads
- Sub-grade protection by proper drainage
- Quick drying of pavement which in turn increases safety.

Too steep slope is undesirable for it will erode the surface. Camber is measured in 1 in n or n% (Eg. 1 in 50 or 2%) and the value depends on the type of pavement surface. The values suggested by IRC for various categories of pavement is given in Table.The common types of camber are parabolic, straight, or combination of them.

Shape of the cross slope
- Parabolic shape(fast moving vehicle)
- Straight line
- Combination of parabolic and straight line.

Recommended values of camber for different types of road surface

Sl no.	Type of road surface	Range of camber in areas of rain fall range	
		heavy	light
1	Cement concrete and high type bituminous pavement	1 in 50(2%)	1 in 60(1.7%)
2	Thin bituminous surface	1 in 40(2.5%)	1 in 50(2%)
3	Water bound macadam(WBM) and gravel pavement	I in 33(3%)	1 in 40(2.5%)
4	Earth	1 in 25(4%)	1 in 33(3%)

Right of way

Right of way (ROW) or land width is the width of land acquired for the road, along its alignment. It should be adequate to accommodate all the cross-sectional elements of the highway and may reasonably provide for future development. To prevent ribbon development along highways, control lines and building lines may be provided

- The right of way width is governed by:
  - Width of formation: It depends on the category of the highway and width of roadway and road margins.
  - Height of embankment or depth of cutting: It is governed by the topography and the vertical alignment.
  - Side slopes of embankment or cutting: It depends on the height of the slope, soil type etc.
  - Drainage system and their size which depends on rainfall, topography etc.
  - Sight distance considerations: On curves etc. there is restriction to the visibility on the inner side of the curve due to the presence of some obstructions like building structures etc.
  - Reserve land for future widening: Some land has to be acquired in advance anticipating future developments like widening of the road.

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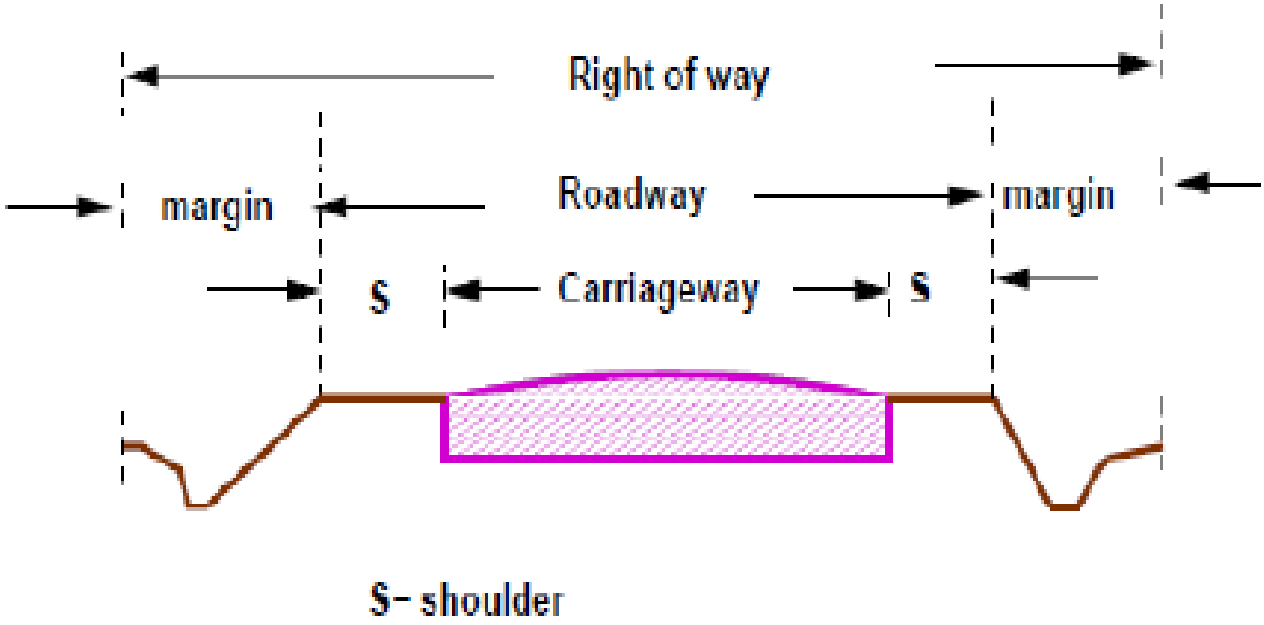


4 c) What concept involved in widening of pavement on horizontal curves?

Ans: Widening of Pavement on Horizontal Curves

- On horizontal curves, especially when they are not of very large radii, it is common to widen the pavement slightly more than the normal width,
- Widening is needed for the following reasons :
  - The driver experience difficulties in steering around the curve.
  - The vehicle occupies a greater width as the rear wheel don't track the front wheel. known as 'Off tracking'
  - For greater visibility at curve, the driver have tendency not to follow the central path of the lane, but to use the outer side at the beginning of the curve.
  - While two vehicle cross or overtake at horizontal curve there is psychological tendency to

maintain a greater clearance between the vehicle for safety.

- Analysis of Extra Widening on Horizontal Curves

  1. Mechanical Widening

  2. Psychological Widening Extra Widening = Mechanical Widening + Psychological Widening.

Mechanical Widening

The widening required to account for the off-tracking due to rigidity of wheel base is called as 'Mechanical Widening' (Wm) and is given by

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

R – Radius of the curve , m

n – No of lanes

l – length of wheel base of longest vehicle, m

Psychological Widening: (Empirical formula)

IRC proposed an empirical relation for the psychological widening at horizontal curves.

$$W_{ps} = \frac{V}{9.5\sqrt{R}}$$

Where,

V : Design speed Kmph

R : radius of curve in m

W_{ps} : psychological widening in meter

5 a) With a neat sketch explain the functions of component parts of pavement?

Ans: Types of pavement

1. Flexible pavement 2. Rigid pavement 3. Semi-rigid pavement

Flexible pavement consists of 4 component parts namely- subgrade, sub base, base and wearing/surface course.

• Flexible pavements will transmit wheel load stresses to the lower layers by grain-to-grain transfer through the points of contact in the granular structure.

• The wheel load acting on the pavement will be distributed to a wider area, and the stress decreases with the depth. Hence, the design of flexible pavement uses the concept of layered system.

The top layer has to be of best quality to sustain maximum compressive stress, in addition to wear and tear.

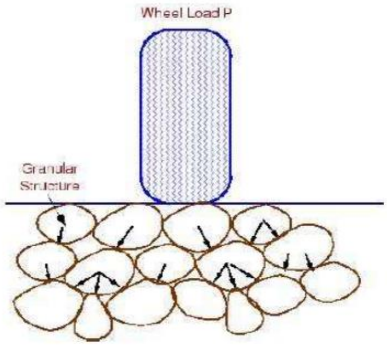
• The lower layers will experience lesser magnitude of stress and low quality material can be used.

Flexible pavements are constructed using bituminous materials.

• These pavements have negligible flexural strength.

• Undulations in the lower layer gets reflected to the surface

Flexible pavement



Load transfer in granular structure

Cross section of Flexible pavement & its component parts

Surface course:-

– Layer directly in contact with traffic loads

– Superior quality material used

– Constructed using dense graded bitumen concrete.

– Provides friction , smoothness , drainage

– Prevent ingress of water to underlying layers.

– Must be tough to resist distortion

– Marshall stability test - to evaluate the optimum bitumen content

Binder Course

– Layer provides bulk of bitumen concrete structure

– Distribute load to the base course

– Low quality materials used compared to surface course

• **Base course** –

Layer immediately beneath the surface of binder course

- Provides additional load distribution

– Contributes to the sub surface drainage

- Crushed stone , crushed slag or other stabilized materials.

- Base course are used under rigid pavement for - preventing pumping

- Protecting the sub grade against frost action

• **Sub Base course**

- Layer beneath the base course

- Provide structural support, improve drainage and reduce intrusion of fines

Sub base and base course are evaluated by strength or stability test like plate load test

Sub grade:-

– Layer of natural soil prepared to receive the stresses.

– At no time soil sub grade should be overstressed,

– Compacted to desirable density at optimum moisture content

– Strength properties of subgrade are evaluated by common test like

– California bearing ratio test

– California resistance value test

– Triaxial compression test

–Plate bearing test

To evaluate the surface course and the pavement as whole – Plate bearing test and Bankelman beam test are carried out.

5 b) List the tests to be conducted on the road aggregate. Explain impact test in details?

Ans: Desirable properties of aggregates and tests on aggregates

• Resistance to crushing or crushing test--Aggregate crushing test

• Resistance to impact or toughness----Aggregate impact test

Resistance to abrasion or hardness----Los angeles abrasion test

Good shape factor to avoid to flaky and elongated particles of coarse aggregates----Shape tests—flakiness index, elongation index and angularity number

Resistance to weathering or durability----Soundness test or durability test

Good adhesion or affinity with bituminous materials in presence of water or less stripping of bitumen coating from aggregates----Specific gravity test and water absorption test, bitumen adhesion test or stripping value test or stripping value test of aggregates.

Angular number to know the requirement of filler material and in turn strength of the aggregates.

Resistance from getting polished or smooth/ slipper--Polished stone value test or accelerated polishing test.

Toughness- Impact test

Resistance of the aggregates to impact is termed as toughness.

⎫ Aggregates used in the pavement should be able to resist the effect caused by the jumping of the wheels from one particle to another at different levels causes severe impact on the aggregates

⎫ The aggregate impact test is carried out to evaluate the resistance to impact of aggregates.

Procedure

Aggregates passing 12.5 mm sieve and retained on 10 mm used

⎫ cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine.

⎫ material is filled in 3 layers where each layer is tamped for 25 number of blows.

⎫ Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 number of blows.

⎫ The crushed aggregate is allowed to pass through 2.36 mm IS sieve

⎫ For wearing course, the impact value shouldn’t exceed 30 percent.

⎫ For bituminous shouldn’t exceed 35 percent.

⎫ For WBM shouldn’t exceed 40 percent (base courses)

6 a) Explain the desirable properties of subgrade soil?

Ans:

Sub grade:-

– Layer of natural soil prepared to receive the stresses.

– At no time soil sub grade should be overstressed,

– Compacted to desirable density at optimum moisture content

– Strength properties of subgrade are evaluated by common test like

– California bearing ratio test

– California resistance value test

– Triaxial compression test

– Plate bearing test

The subgrade soil is the native or base material laid underneath a constructed road, pavement or railway track. It is also called the formation level.

The desirable properties of subgrade soil are:

1. Stability
2. Incompressibility
3. Permanency of strength
4. Minimum changes in volume and stability under adverse conditions of weather and groundwater
5. Superior drainage
6. Ease of compaction

6 b) Distinguish between tar and bitumen?

Ans: Bitumen vs Tar

Bitumen Cutback bitumen:

θ In cutback bitumen suitable solvent is used to lower the viscosity of the bitumen.

θ cutback bitumen is preferred from the environmental point of view also .

θ The solvent from the bituminous material will evaporate and the bitumen will bind the aggregate.

θ Cutback bitumen is used for cold weather bituminous road construction and maintenance.

θ The distillates used for preparation of cutback bitumen are naphtha, kerosene, diesel oil, and furnace oil.

θ There are different types of cutback bitumen like rapid curing (RC), medium curing (MC), and slow curing (SC). θ RC is recommended for surface dressing and patchwork. MC is recommended for premix with less quantity of fine aggregate

Tar

⎪ Obtained by destructive distillation of wood and charcoal

⎪ 5 grades of Tar- RT1, RT2, RT3, RT4, RT5 based on increasing order of viscosity

¬ RT1 used for surface painting under exceptional cold climate

¬ RT2- Standard surface paointing in Indian condiion

¬ RT3- renewal coats, light carpets

¬ RT4- Premixing Tar Macadam base course

¬ RT5- grouting purpose

Bitumen	Tar
Black in color with greenish shade	Black in color
Carbon content is less compared to Tar	Carbon content is high
More adhesive	Less Adhesive
Less susceptible to temperature	More susceptible to temperature
Obtained from fractional distillation of crude petroleum	Obtained from destructive distillation of coal or wood.
Completely soluble in CS_2 and CCl_4	Completely soluble in Toluene
Sp. Gr. range – 0.98 to 1.03	Sp. Gr range – 1.1 to 1.25

7 a) Explain the procedures involved in the preparation of subgrade layer with quality control tests?

Ans: Construction Steps:-

1.Preparation of Sub-grade and Sub-base :- The sub-grade shall consist of coarse grained soil with minimum CBR of 8% and total compacted thickness of 500 mm. It is constructed in 2 layers by compacting the soil at its OMC. The permissible tolerance levels of sub-grade is +20 mm and -25 mm.

2.Construction of drainage layer:- The drainage may be laid directly over the prepared sub grade. If the water table is high, a suitable capillary cut-off may be provided over the sub-grade. This layer shall extent up to the full formation width or up to the side drains.

3. Construction of dry lean concrete (DLC) sub-base coarse:- DLC is the most common type of cement treated sub-base coarse laid over the drainage layer. A minimum thickness of 100 mm is adopted and the recommended thickness is 150 mm.

4.Laying of separation membrane:- An impermeable separation membrane made of PVC is laid between

the DLC sub-base course and the CC slab. The surface of DLC layer is thoroughly cleaned free of grit and dust. This membrane may be nailed to the lower layer.

5.Forms:- Steel channel sections or wooden sections of depth equal to the specified thickness of the CC pavement are used as side forms. These forms are firmly fixed in position and oiled on the inner sides.

6. The CC mixes are prepared in suitable mixing plants and transported to the site.

7. The concrete mix is placed on the prepared sub-base between the side forms, taking care to prevent segregation; mix is spread either by a mechanical paver or by manual methods

8. The compaction is carried out immediately after the mix is spread, using plate vibrators and needle vibrators near the side forms; final compaction and finishing to desired surface profile is done using screed vibrators resting on the side forms.

9. The surface regularity is checked with a 3 m straight edge and corrections are made.

10. The surface finishing is done by transverse strokes of canvas belts; the surface texturing is carried out in transverse direction using steel fibre broom.

11. Curing compound is applied on the surface using sprayer. The curing is continued by ponding with water or covering with a thick blanket of sand kept wet for at least 14 days.

12. Transverse joints are formed by cutting dummy grooves.

13. The side forms are removed after 12 hours.

14. The CC pavement is opened to traffic after 90 days.

7 b)Mention the procedure followed WBM layer preparation along with quality control mentods?

Ans: Water Bound Macadam layer- Construction Steps.

Preparation of Foundation for Receiving the WBM course:- The foundation for receiving the new layer of WBM may be either the sub grade or sub-base or base course. This foundation layer is prepared to the required grade and camber and the dust and either loose materials are cleaned. On existing road surface, the depressions and pot-holes are filled and the corrugations are removed by scarifying and reshaping the surface to the required grade and camber as necessary.

Provision of Lateral confinement:-Lateral confinement is to be provided before starting WBM construction. This may be done by constructing the shoulders to advance, to a thickness equal to that of the compacted WBM layer and by trimming the inner sides vertically.

Spreading of Coarse Aggregates:- The coarse aggregates are spread uniformly to proper profile to even thickness upon the prepared foundation and checked by templates. The WBM course is normally constructed to compacted thickness of 7.5 cm except in the case of WBM sub-base course using coarse aggregate grading no.1 which is of 10.0 cm compacted thickness.

Rolling:-After spreading the coarse aggregates properly, compaction is done by a three wheeled power roller of capacity 6 to 10 tons or alternatively by an equivalent vibratoryroI1q the weight of the roller depends on the type of coarse aggregates.

Application of Screenings:- After the coarse aggregates are rolled adequately, the dry screenings are

gradually over the surface to fill the interstices in three or more applications. Dry rolling is continued as the screenings are being spread and brooming carried out.

Sprinkling and Grouting:- After the application of screenings, the surface is sprinkled with water, swept rolled. Wet screenings are swept into the voids using hand brooms. Ad• screenings are applied and rolled till the coarse aggregates are well bonded and firmly set.

Application of Binding Material:- After the application of screening and rolling, binding material is applied at a uniform and slow rate at two or more successive thin layers. After each application of binding material, the surface is copiously sprinkled with water and wet slurry swept with brooms to fill the voids.

Setting and Drying:- After final compaction, the WBM course is allowed to set over-night. On the next day the 'hungry' spots are located and are filled with screenings or binding material, lightly sprinkled with water if necessary and rolled. No traffic is allowed till the WBM layer sets and dries out.

8 a) Write a note on earthwork cutting and filling?

Ans: EARTHWORK

The subgrade soil is prepared by bringing to the desired grade and camber and by compacting adequately. The subgrade may be either in embankment or in excavation, depending on the topography and the finalized vertical alignment of the road to be constructed.

Excavation is the process of cutting or loosening and removing earth including rock form its original position. Transporting and dumping it as a fill or spoil bank. The excavation or cutting mat be needed in soil, soft rock or even in hard rock, before preparing the subgrade.

When it is required to raise the grade line of a highway above the existing ground level it becomes necessary to construct embankments. The grade line may be raised due to any of the following reasons

i) To keep the subgrade above the high ground water table.

ii) To prevent damage to pavement due to surface water and capillary water.

iii) To maintain the design standards of the highway with respect to the Vertical alignment.

The design elements in highway embankments are:

i) Height

ii) Fill material

iii) Settlement

iv) Stability of foundation, and

v) Stability of slopes

Height : The height of the embankment depends on the desired grade line of the highway and the soil profile or topography. Also the height of the fill is some times governed by stability of foundation, particularly when the foundation soil is weak

Fill Material : Granular soil is generally preferred as highway embankment material. Silts, and clays are considered less desirable. Organic soils, particularly peat are unsuitable. The best of the soils available locally is often selected with a view to keep the lead and lift as low as possible. At times light-weight fill material like cinder may be used to reduce the weight when foundation soil is weak

Settlement

The embankment may settle after the completion of construction either due to consolidation and settlement of the foundation or due to settlement of the fill or due to both. If the embankment foundation consists of compressible soil with high moisture content, the consolidation can occur due to increase in the load. The settlement of the fill is generally due to inadequate compaction during construction and hence by proper compaction this type of settlement may be almost eliminated. Whatever be the type of settlement, it is desirable that the settlement is almost complete before the construction of pavement.

Stability of Foundation-When the embankment foundation consists of weak soil just beneath or at a certain depth below in the form of a weak stratum, it is essential to consider the stability of the foundation against a failure. This is all the more essential in the case of high embankments. The foundation stability is evaluated and the factor of safety is estimated by any of the following approaches

Stability of Slopes-The embankment slopes should be stable enough to eliminate the possibility of a failure under adverse moisture and other conditions. Hence the stability of the slope should be checked or the slope should be designed providing minimum factor of safety of 1.5. Often much flatter slopes are preferred in highway embankments due to aesthetic and other reasons.

8 b) Explain the procedure of concrete roads preparation. Also write the specification of material used along with quality checks?

Ans: Cement concrete pavements- Materials & Construction steps

Materials :- The materials required for the construction of CC pavements may be divided into 2:

(1) selection of basic component materials

(2) mix design and production of pavement quality concrete (PQC) mix.

Basic materials :- These include Portland cement, coarse aggregates, fine aggregates, water and admixtures. Steel is also used in joints.

¬ Portland cement used may be Ordinary Portland cement, Ordinary Portland cement of 53 grade, Portland-Pozzolana cement with fly ash etc.

¬ The properties of coarse aggregates are given below:

Los Angeles abrasion value	< 35%
Combined flakiness and elongation index	< 35%
Soundness test with sodium sulphate Soundness test with sodium sulphate	< 12 % < 18%
Water absorption test	< 3%

¬ Fine aggregates consist of clean natural sand or crushed stone sand or a combination of both. It shall be well-graded.

¬ Water used shall be clean, potable and free from salt, acid oil etc.

¬ Admixtures commonly used are suitable air-entraining agent and super-plasticizers

Preparation of pavement quality concrete mix (PQC):-

¬ Proportioning of the concrete on the basis of strength:- PQC mix is to be designed based on the desired flexural strength of concrete. The relation for flexural strength of the CC mix is $ff = 0.7*\sqrt{fc}$.

¬ Recommended cement content, water content and workability:- Minimum cement content specified by IRC to a flexural strength of 4.5 MPa at 28 days is 360 Kg/m3. The approximate water-cement ratio for M-40 is 0.38. The slump shall be in the range 25 +/- 10 mm.

¬ Mechanised batching and mixing plant:- Batching plant consists of 4 bins, automatic weighing hoppers and scales for CA and FA. For batching by weight automatic weighing devices are provided.

¬ Transporting and placing of concrete:- The CC prepared in the mixing plant is transported to the site by means of tipper trucks.

Construction Steps:-

i) Preparation of Sub-grade and Sub-base :- The sub-grade shall consist of coarse grained soil with minimum CBR of 8% and total compacted thickness of 500 mm. It is constructed in 2 layers by compacting the soil at its OMC. The permissible tolerance levels of sub-grade is +20 mm and -25 mm.

ii) Construction of drainage layer:- The drainage may be laid directly over the prepared sub grade. If the water table is high, a suitable capillary cut-off may be provided over the sub-grade. This layer shall extent up to the full formation width or up to the side drains.

(iii) Construction of dry lean concrete (DLC) sub-base coarse:- DLC is the most common type of cement treated sub-base coarse laid over the drainage layer. A minimum thickness of 100 mm is adopted and the recommended thickness is 150 mm.

(iii) Laying of separation membrane:- An impermeable separation membrane made of PVC is laid between the DLC sub-base course and the CC slab. The surface of DLC layer is thoroughly cleaned free of grit and dust. This membrane may be nailed to the lower layer.

(iv) Forms:- Steel channel sections or wooden sections of depth equal to the specified thickness of the CC pavement are used as side forms.

These forms are firmly fixed in position and oiled on the inner sides.

(v) The CC mixes are prepared in suitable mixing plants and transported to the site.

(vi) The concrete mix is placed on the prepared sub-base between the side forms, taking care to prevent segregation; mix is spread either by a mechanical paver or by manual methods.

(vii) The compaction is carried out immediately after the mix is spread, using plate vibrators and needle vibrators near the side forms; final compaction and finishing to desired surface profile is done using screed vibrators resting on the side forms.

(viii) The surface regularity is checked with a 3 m straight edge and corrections are made.

(ix) The surface finishing is done by transverse strokes of canvas belts; the surface texturing is carried out in transverse direction using steel fibre broom.

(x) Curing compound is applied on the surface using sprayer. The curing is continued by ponding with water or covering with a thick blanket of sand kept wet for at least 14 days.

(xi) Transverse joints are formed by cutting dummy grooves.

(xii) The side forms are removed after 12 hours.

(xiii) The CC pavement is opened to traffic after 90 days.

9 a) With the neat sketchs, explain the different methods of providing subsurface drainage system ?

Ans

Methods of sub surface drainage

The methods of sub surface drainage are lowering of water table, control of seepage and control of capillary rise.

Lowering of water table

• Control of Seepage flow

• Control of capillary rise

– Granular capillary cut off

– Impermeable capillary cut-off

Methods of sub surface drainage

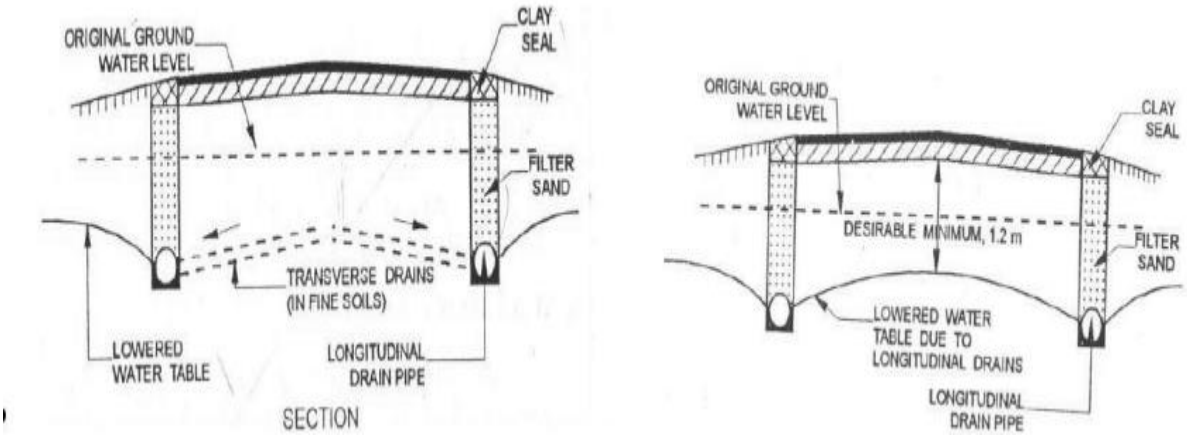
Lowering of water table

• Highest level of WT should be 1.0 to 1.20 m below the sub grade in order to avoid excessive moisture content in the pavement layers.

• In places of high WT, embankment height should be 1.2 to 1.50m above ground level.

• In cases of permeable soil, construct longitudinal drainage trenches with drain pipe and filter sand.

• Wherever soil is less permeable, in addition to longitudinal trench drains, transverse drains are provided

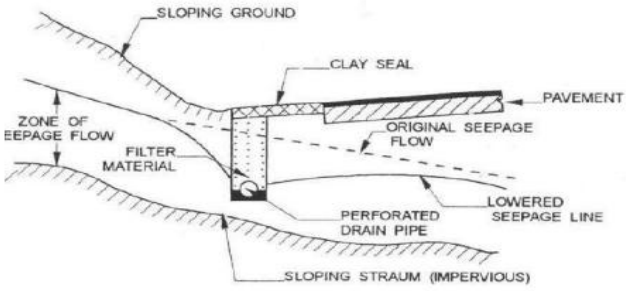


Control of Seepage flow

• Occurs when ground level as well as the impervious strata below are sloping and water seeps by gravity .

• Seepage depends on permeability of the soil and the pressure gradient,

• If the seepage zone depth < (0.6 to 0.9 m) from sub grade level, longitudinal drain in trench filled with filter material and clay seal (impervious cap)may be provided to intercept the seepage flow.

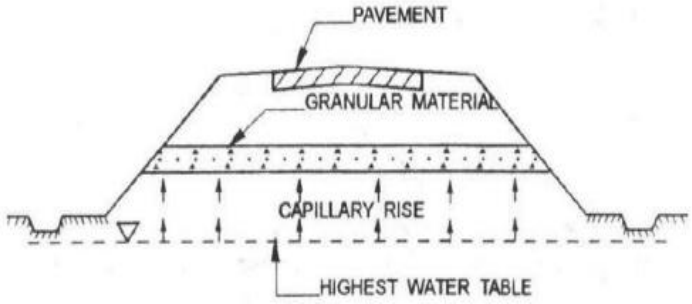


Control of capillary rise

The capillary rise may be checked by providing a suitable capillary cut-off by i) granular capillary cut-off and ii) by impermeable capillary cut-off.

Granular Capillary cut-off :- A layer of granular material is provided during the construction of embankment as shown in fig below. The thickness of this layer should be higher than the anticipated capillary rise within the granular layer

Impermeable capillary cut-off :- In this case, an impermeable membrane or a bituminous layer is inserted in the place of granular blanket during the construction of embankment



9 b) Write a note on i) B-C Ratio ii) IRR method

Ans: Benefit Cost Ratio Method:-

The principle of this method is to assess the merit of a particular scheme by comparing the annual benefits with the increase in annual cost.

Benefit cost ratio = Annual benefits from improvement / Annual cost of the improvement

= (R-R1)/total annual cost of the project

Where, R = Total annual road user cost for existing highway

R1 = Total annual road user cost for proposed highway improvement

The benefit-cost ratios are determined between alternate proposals and those plans which are not attractive are discarded. Then the benefit cost ratios for various increments of added investment are computed to arrive at the best proposal. In order to justify the investment, the ratio should be greater than 1.0.

Rate of return Method

It is the discounted rate which makes the stream of cash flows equals zero. There are number of variations for the determination of rate of return of a highway improvement. In the rate of return method, the interest rate at which two alternative solutions have equal annual cost is found. If the rate of return of all projects are known, the priority for the improvement could be established.

(B0-C0 = B1-C1/(1+i) + B2-C2/(1+i)2 + ….+ Bn-Cn/(1+i)n

Road Research Laboratory (London) has recommended a simplified procedure of rate of return method. The percentage rate of return R is given by

R = [(O+A-M)/ P]*100

Where,

O = Savings in annual road user costs

A = Annual savings in accident costs

M = Additional maintenance cost per annum

P = Capital cost of improvement.

10 a) Mention the significance of highway drainage?

Ans: Significance of Highway Drainage

• An increase in moisture content causes decrease in strength or stability of a soil mass

• The variation in soil strength with moisture content also depends on the soil type and the mode of stress application.

Highway drainage is important because of the following reasons:-

1) Excess moisture in soil sub grade causes considerable lowering of its stability the pavement is likely to fail due to sub grade failure

2) Increase in moisture cause reduction in strength of many pavement materials like stabilized soil and WBM.

3) In some clayey soils variation in moisture content causes considerable changes of sub grade. This sometimes contributes to pavement failure.

4) One of the most important causes of pavement failure by the formation of waves and corrugations in flexible pavements is due to poor drainage.

5) Sustained contact of water with bituminous pavements causes failures due to stripping of bitumen from aggregates like loosening or detachment of some of the bituminous pavement layers and formation of pot holes.

6) The prime cause of failures in rigid pavements by mud pumping is due to the presence of water in fine sub grade soil.

7) Excess water on shoulders and pavement edge causes considerable damage.

8) Excess moisture causes increase in weight and thus increase in stress and simultaneous reduction in strength of the soil mass. This is one of the main reasons of failure of earth slopes and embankment foundations.

9) In places where freezing temperatures are prevalent in winter, the presence of water in the sub grade and a continuous supply of water from the ground water can cause considerable damage to the pavement due in frost action.

10) Erosion of soil from top of un surfaced roads and slopes of embankment, cut and hill side is also due to surface water.

10 b) Explain about surface drainage system?

Ans: The surface drainage design can be divided into 2 phases:

i) Hydrologic analysis ii) Hydraulic analysis.

Hydrologic analysis: The objective to find the maximum quantity of water “Q” expected to reach the drainage

Precipitation can be

i) Run off: part of precipitation that flows over surface Factors effecting the run off θ Intensity or rate of rainfall

θ Types of soil

θ Moisture content in soil

θ Topography of area

θ Type of ground cover: Pavement surface, vegetation

ii) Portion of rain fall seeps inside as infiltrates and meets ground water

iii) Portion water evaporates

i)Hydrologic analysis: Estimation of Q flow of water into drain:

Q: quantity of water of reaching the drainage

$$Q = C\ i\ A_d$$

Where, Q= Run off (m3 /s) C= Run off coefficient (expressed as ratio of run off to rate of rainfall) i= intensity of rainfall (mm/s) Ad = Drainage area in 1000 m2.

10 c) Write a note on BOT and BOOT?

Ans: BOT(Build Operate Transfer):

• It is a form of project financing, wherein a private entity receives a concession from the private or public sector to finance, design, construct, and operate a facility stated in the concession contract.

• Under this scheme the private participant will not be owning the facility. The private participant would be entitled to operate the facility for a specific period during which the revenues from the operation would be shared between the private participant and the Government or the Government will be paid lease charges by the private participant.

• On completion of the specified time the facility will be transferred to the Government.

BOT(Build Operate Transfer): Some or even all of the following different parties could be involved in any BOT project:

• The host government: Normally, the government is the initiator of the infrastructure project and decides if the BOT model is appropriate to meet its needs

• The concessionaire: The project sponsors who act as concessionaire create a special purpose entity which is capitalized through their financial contributions.

• Lending banks: Most BOT project is funded to a big extent by commercial debt. The bank will be expected to finance the project on “non-recourse” basis meaning that it has recourse to the special purpose entity and all its assets for the repayment of the debt.

• Other lenders: The special purpose entity might have other lenders such as national or regional development

banks

• Parties to the project contracts: Because the special purpose entity has only limited workforce, it will subcontract a third party to perform its obligations under the concession agreement.

BOOT(Build Own Operate & Transfer):

1. A BOOT structure differs from BOT in that the private entity owns the works.
2. It is a public-private partnership (PPP) project model in which a private organization conducts a large development project under contract to a public sector partner, such as a government agency.
3. It is often seen as a way to develop a large public infrastructure project with private funding.
4. The public-sector partner contracts with a private developer - typically a large corporation or consortium of businesses with specific expertise - to design and implement a large project.
5. The public-sector partner may provide limited funding or some other benefit (such as tax exempt status) but the private-sector partner assumes the risks associated with planning, constructing, operating and maintaining the project for a specified time period. During that time, the developer charges customers who use the infrastructure that's been built to realize a profit.
6. At the end of the specified period, the private-sector partner transfers ownership to the funding organization, either freely or for an amount stipulated in the original contract. Such contracts are typically long-term and may extend to 40 or more years.

Some advantages of BOOT projects are:

• Encourage private investment
• Inject new foreign capital to the country
• Transfer of technology
• Completing project within time frame and planned budget
• Providing additional financial source for other priority projects
• Releasing the burden on public budget for infrastructure development