CHAP-1 # HIGHWAY Date:- 10/12/2019

INTRODUCTION

For rapid economic, industrials and cultural growth of any country, a good system of transportation is very essential.

Transportation system comprises of good network of roads, railways, well developed water ways and airways.

ADVANTAGES OF ROADS

- Road transport offers quick and assured deliveries.
- Road transport provides door-to-door service.
- Road transport permits simpler packaging of goods to be transported.
- Road transport has a high employment potential.
- Road transport is the only economical means for short.
- Roads help in maintaining law and order in a country.
- Roads have helped operations related to flood and famine relief.

CENTRAL ROAD RESEARCH INSTITUTE (C.R.R.I.)

In 1950 the central road research institute was started at delhi for road research work in the country.

→ This is one of the chain of national laboratories under council of scientific and industrial research in India.

The institute has the following objectives:-

→ To carry out basic and applied research for design construction and maintained of the various roads.

→ To carry out research on traffic safety and transport economics.

→ To provides technical advice and consultancy services to varies organisations.

→ To provide library and documentation service to various organisations.

The institute is headed by a director and has the following wings:-

→ General projects
→ Documentation
→ Soil and Geotechnical Engg
→ Flexible pavements
→ Rigid pavements
→ Extension
→ Workshop
→ Electronic instrumentation
→ Environment and safety

INDIAN ROAD CONGRESS (I.R.C)

The indian road congress was established by the central government in 1934 as per the recommendations of the jayakar committee.

The I.R.C was constituted to provided forum for regular pooling of experience and ideas on all affecting the construction and maintenance of roads in india.

FUNCTION OF INDIAN CONGRESS

The I.R.C is a body of professional highway engineers having this following function:-

→ To promote the use of standard specification and practices.

→ To conduct periodical meetings to discuss technical questions regarding roads.

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

→ To furnish and maintain libraries and museums for encouraging the science of road making.

I.R.C CLASSIFICATION OF ROADS

highways (N.H.)

highways (S.H)

(iii) Major District roads (M.D.R)
(iv) Other District roads (O.D.R)
(v) village roads (V.R)

(i) National Highways (N.H)

The main highways running through the length and breadth of this country connecting state capitals points, foreign highways, large towns, etc is known as national highways.

→ The road connecting capital of state is known as N.H)

(ii) State Highways (S.H)

The road connecting one town with another town is known as state highway.

(iii) Major District Highways/Roads (M.D.R)

The important road with in the district serving areas of production and markets and connecting these with each known as major District road.

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

Other district roads are road serving rural areas of production and providing them with outlet to

(5)

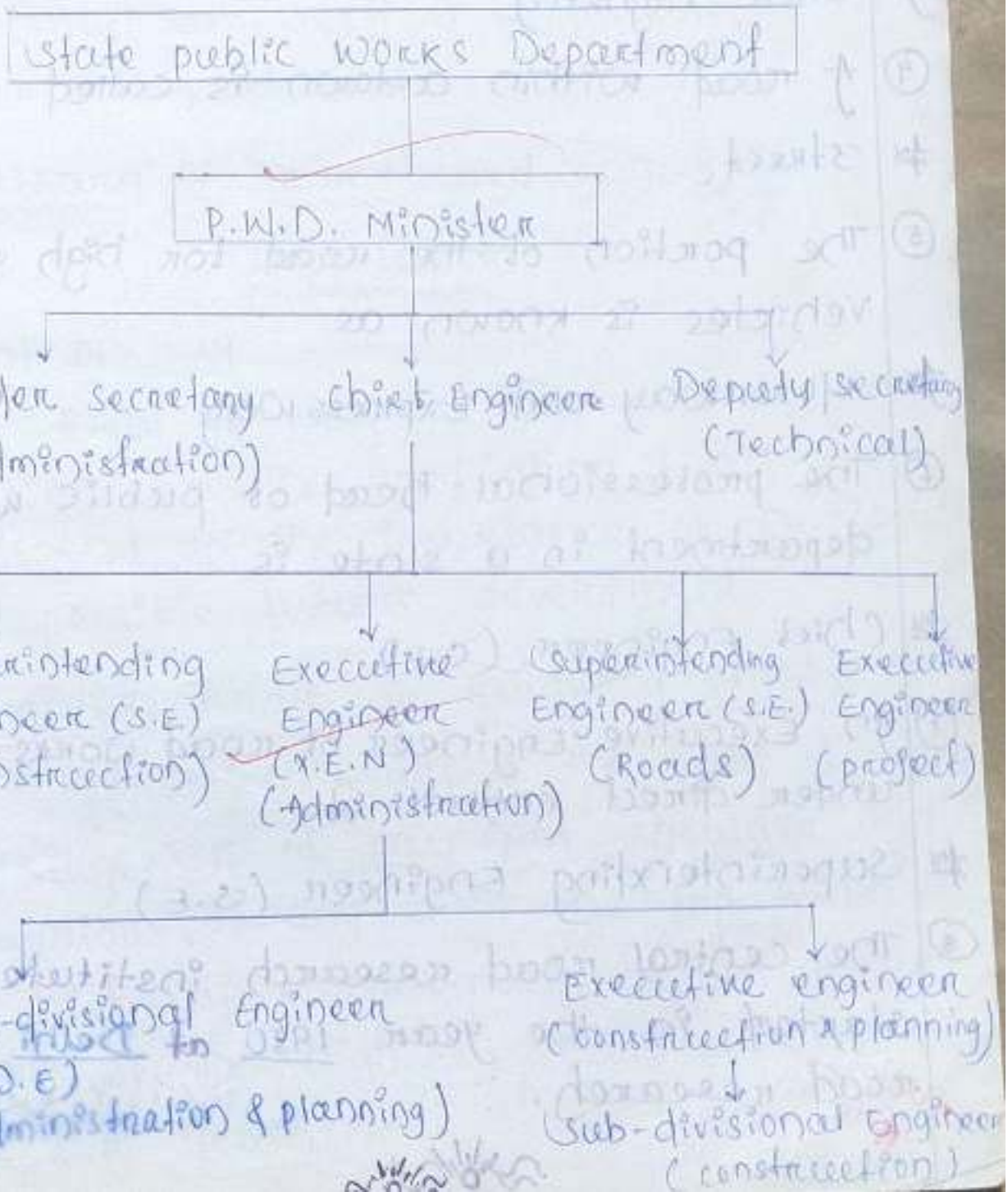
quarters, market centres, etc.

(v) Village Roads (V.R)

→ road with in a town is called village road

Organisation of state highway department

The organisation chart of state highway department is given in table.



(6)

(1) The indian road congress came into existence in

Ans 1934

(2) The road connecting capitals of states is known as

Ans National highway

(3) The road connecting one town with another town is designated as

Ans State highway

(4) A road within a town is called

Ans street

(5) The portion of the road for high speed vehicles is known as

Ans Motorway and Expressway

(6) The professional head of public works department in a state is

Ans Chief Engineer (C.E)

(7) An Executive Engineer of road works is under direct control of

Ans Superintending Engineer (S.E)

(8) The central road research institute was started in the year 1950 at Delhi for road research.

ROAD GEOMETRICS

INTRODUCTION

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

Road geometrics can be broadly classified under following headings:-

(i) Cross-section elements
(ii) Sight distance considerations
(iii) Horizontal and vertical alignments
(iv) Intersection elements

Glossary of Terms used and their Importance

1) Right of Way

Right of way is the area of land, require for the road along it alingment. It depend on the importance of the load and possible future development.

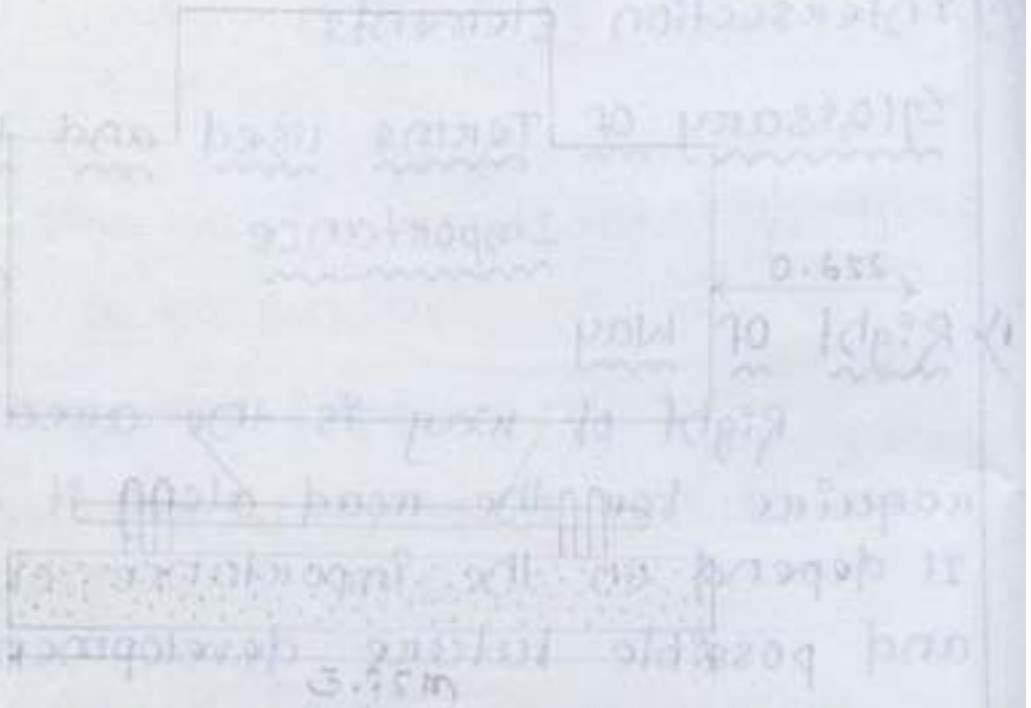
2) Formation Width or Roadway Width

Formation width is the sum of width carriageway of pavement, shoulder and separators, if any it is the top width of the highway embankment or the bottom width of the highway cutting excluding the side drains.

3) Road Margins

Road Margins are the portions of land on either side of road way of a land/road. The various elements included in the road margins are parking lane, frontage road, drive way, cycle track, footpath, guard rail and embankment slope.

4) Width of pavement or Carriageway



Carriageway is the width of the road way constructed for movement of vehicular traffic. Carriageway width depends on the width of traffic lane and number of lanes required.

→ The number of lane required in a highway depends on the traffic capacity of each line.

9

→ As per I.R.C specification, the maximum width of a vehicle is 2.44 m and carriage way width for single lane traffic is 3.75 m.

Parking lanes

These are provided in urban roads to allow kerb parking.

→ parallel parking should be allows as far as possible.

Frontage Roads

These are provided to give access to properties along an important highway.

Drive Ways

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

Footh path

In urban areas where the vehicular as well as pedestrian traffic are heavy, Footh paths are provided to avoid accident.

Cycle Tracks

These are provided in urban areas where the volume of cycle traffic on the road is very high.

Guard Rails

These are provided at the edge of the shoulder. When the road is constructed on a bill of height more than 3m, to prevent the vehicles from running off the embankments.

5) shoulders

shoulders are the portions of the roadway between the outer edges of the carriageway and edges of the top surface of embankment or inner edges of the side drains in cuttings.

6) Side slopes

Side slopes are the slopes provided to the side of earthwork of a road in embankment or in cutting for its stabili

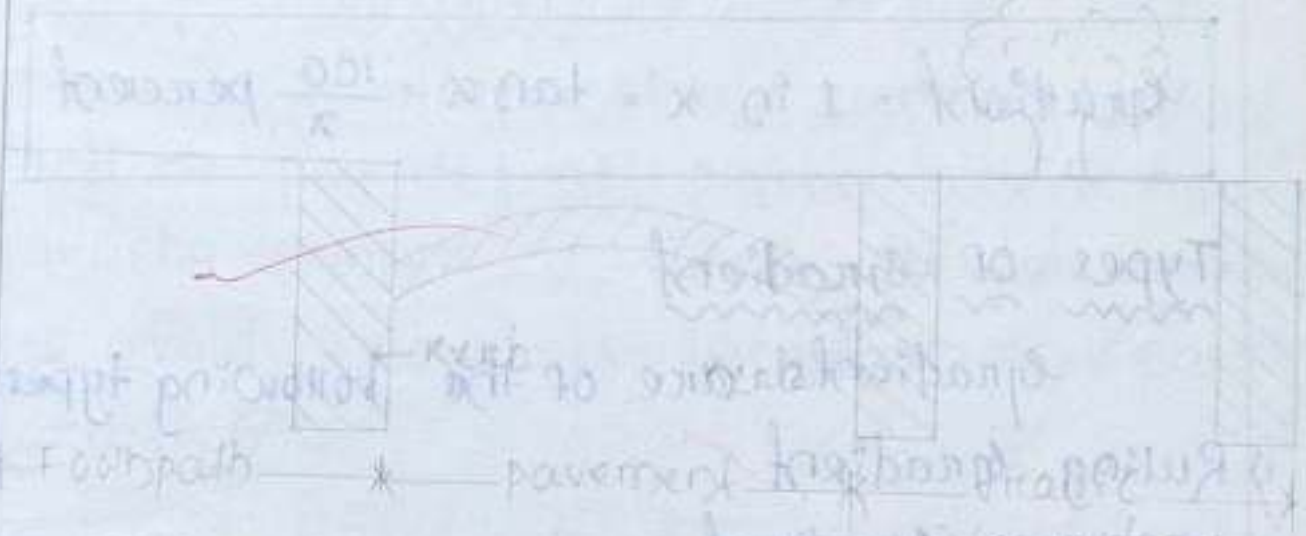
7) Side slopes in a road are so designed as to keep the earthwork stable in embankment or in cutting.

In cutting

(a) Hard rock - Nearly vertical
(b) Medium rock - $\frac{1}{12}:1$ to $\frac{1}{16}:1$
(c) Soft rock - $\frac{1}{1/4}:1$ to $\frac{1}{8}:1$
(d) Disintegrated rock - $\frac{1}{2}:1$ to $\frac{1}{14}:1$
(e) Ordinary soil - $1:1$ to $\frac{1}{2}:1$

7) Kerbs

Kerbs are the boundaries between the pavement and shoulder or foothpath. Kerbs are also provided between pavement & traffic separator or dividing island.



8) Formation Level

Formation level is the reduced level of the finished surface of the earthwork for a road in cutting or in embankment.

9) Camber

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

10) Gradient

Gradient is the rate of rise or fall of road surface along its length with respect to the horizontal.

It is longitudinal slope provided to the road surface along its length.

$$\text{Gradient} = 1 \text{ in } x = \tan\alpha = \frac{100}{x} \text{ percent}$$

Types of Gradient

Gradients are of the following types:

1) Ruling Gradient
2) Limiting Gradient
3) Exceptional Gradient
4) Minimum Gradient

1) Ruling Gradient :- Ruling gradient is the maximum gradient within which designer

attempts to fix the vertical profile of the road.

→ Ruling gradient is also known as design attempts.

→ During selection of ruling gradient for the purpose of design, following factors are kept in mind:-

i) Length of grade
ii) Type of terrain
iii) speed of vehicle
iv) pulling power of vehicle

→ Ruling gradient values of 1 in 30 on plain and rolling terrain, 1 in 20 on mountain terrain and 1 in 16.7 on steep terrain has been recommended by I.R.C.

2) Limiting gradient

It is steeper than ruling gradient and is provided at places where topography compels to adopt steeper gradient to avoid enormous increase in cost in gradients.

3) Exceptional gradient

Exceptional gradient is steeper than ruling gradient and may be provided in short lengths of the road in some extra-ordinary situations.

→ It should not exceed 60 metres in one ki meter of road length.

4) Minimum Gradient

It is the minimum desirable slope essential for effective drainage of rain water from the road surface.

→ The minimum gradient would depend upo rainfall, run-off, type of soil, topograph and other site conditions.

Design speed

Design speed is the maximum safe speed of vehicles assumed for geometri design of highway. This is the most impo tant factor controlling the geometric design elements of highways.

i) Class of the road and terrain
ii) Width and clearance requirements of road.
iii) Sight distance required
iv) Type of curve along the road
v) Nature, type and intensity of traffic

Average running speed

→ Average running speed is the speed maintained by vehicle over a particular section of a road.

→ This is calculated by dividing the distance travelled by a vehicle with actual running time.

→ The relationship between design speed and average running speed is very important as most of the vehicle travel at speed very close to the average running speed.

Sight distance (S.D)

Sight distance is the actual distance along the road at which a driver visibility of stationary or moving objects from a specified height above the carriage way. In other words, it is the length of road visible ahead to the driver at any instance, on straight road, there is no problem or obstruction to the visibility.

But sight distance may have been obstructed due to sharpness of horizontal curve, By objects obstructing vision at the inner side of the road or at vertical summit curve or road intersections.

The following sight distance situations are considered in the design:

i) Stopping sight distance
ii) passing sight distance
iii) Sight distance at intersection

1. The total stopping distance of a vehicle is the sum of lag distance and braking distance

∴ stopping distance = Lag distance + braking distance

$$\therefore SD = \left[vt + \frac{v^2}{2gf}\right] m \quad \text{---------(1)}$$

where,

v = speed of vehicle in (M/sec)

t = Reaction time in sec

f = Design co-efficient of friction
= 0.4 to 0.35 for 20 to 100 kmph speed

g = acceleration due to gravity
= 9.8 m/sec²

2. If speed is V kmph, then stopping distance

$$\therefore SD = \left[0.278Vt + \frac{V^2}{254f}\right] M \quad \text{---------(2)}$$

where,
M for level road

3. Stopping distance at slopes calculated by using the formula

$$\therefore SD = \left[vt + \frac{v^2}{2g(f \pm 0.01n)}\right] \quad \text{---------(3)}$$

Where n = Gradient in %, and v in m/s

4. If speed is v kmph,

Then $$\therefore SD = \left[0.278\, vt + \frac{v^2}{254(f \pm 0.01n)}\right] \quad \text{--- (4)}$$

(ii) Stopping sight Distance

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

The stopping sight distance depends upon the following factors:-

(i) Total reaction time of the driver
(ii) Speed of vehicle
(iii) Efficiency of brakes
(iv) Slope of road surface
(v) Frictional resistance between the road and the tyres.

(iii) passing or Overtaking sight Distance

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

of opposite direction.

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

The minimum passing sight distance depends upon the following factors

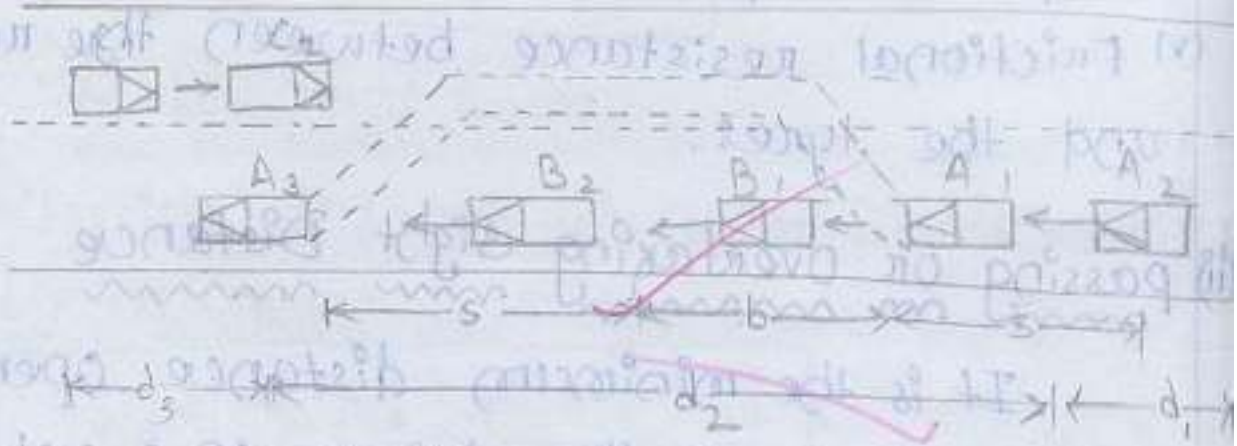
(a) Speeds of the overtaking, overtaken and the vehicle coming from opposite direction.

(b) Slope of the road

(c) Rate of acceleration of overtaking vehicle

(d) Spacing between vehicles

(e) Skill and reaction time of the driver.



Overtaking Manoeuvre

* The relative position of three vehicles A, B and C

* Vehicle A running at design speed tries to overtake a slow moving vehicle B on a two lane road while the third vehicle C comes from the opposite direction.
* Then the passing sight distance required for vehicle A = $d_1 + d_2 + d_3$
* Where d_1 is the distance travelled by the vehicle A during the reaction time from position A_1 to A_2.
* d_2 is the distance travelled by the vehicle A from A_2 to A_3 during the actual overtaking operation.
* d_3 is the distance travelled by oncoming vehicle C from C_1 to C_2 during overtaking operation of vehicle A.

Overtaking sight distance as per I.R.C.

S.No	Speed (kmph)	Time component (secs) For overtaking Manoeuvre	For opposing vehicle	Total	Safe Overtaking sight distance (metres)
1.	40	9	6	15	165
2.	50	10	7	17	235
3.	60	10.8	7.2	18	300
4.	65	11.5	7.5	19	340
5.	80	12.5	8.5	21	470
6.	100	14	9	23	640

Que Calculate the safe stopping distance for design speed of 60 kmph for (a) two way traffic in two lane road, (b) two way traffic in single lane road. Assume co-efficient of friction as 0.4 and reaction of driver as 3.0 sec.

Sol? Given data,

$v = 60$ kmph

$f = 0.4$

$t = 3.0$ sec

Stopping distance $= \left[0.278\, vt + \frac{v^2}{254f}\right]$

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

$= \left[50.04 + \frac{3600}{101.6}\right]$

$= [50.04 + 35.43]$

$= 85.47$ m

(a) when there are two way traffic in a two way lane road stopping sight distance,

$S.D = 85.47$ m

(b) when there is single lane road and traffic is two way, $= S.D \times 2$

$= 2 \times 85.47$

$= 170.94$ m

Que Calculate the stopping sight distance on a highway at a descending gradient of 4% for a design speed of 60 kmph. Assume reaction time of driver 2.5 sec and co-efficient of friction between tyre and road surface 0.4.

Sol Given

$V = 80$ kmph

$t = 3.0$ sec

$f = 0.4$

$g(n) = 0.4$

$$\text{Stopping sight distance} = 0.278\,Vt + \frac{V^2}{254(f \pm 0.01n)}$$

$$= \frac{0.278 \times 80 \times 3.0 + (80)^2}{254(0.4 \pm 0.01n)}$$

$$= 66.72 + \frac{6400}{254(0.4 \pm 0.04)}$$

(n will be -ve because gradient is descending)

$$= 66.72 + \frac{6400}{254(0.4 - 0.04)}$$

$= 66.72 + 69.99 = 136.71$ m

① The portion of the road surface which is used by the vehicular traffic is known as

Ans Carriage Way

② A portion of the roadway used by the pedal bicyclist only is called

Ans Cycle track

③ A portion of the traffic way that is used by the pedestrians only is called

Ans Footpath, sidewalk and footway

④ As per I.R.C. the camber on cement concrete road should be

Ans 1 in 60 to 50

⑤ The highest point on carriage way is known as

Ans Crown

⑥ Camber in the road is provided for

Ans Effective drainage

⑦ The recommended safe coefficient of friction is

Ans 0.15

⑧ The rate of rise or fall of a road along its

(23)

alignment is known as

Ans Gradient.

(9) The minimum land width required for National and State highways in built up area should be

Ans 24.4 m

(10) Excessive camber on road may cause

Ans slip of the speedy vehicles

(11) As per I.R.C the carriage way width for two lane traffic should be

Ans 7.5 m

(12) As per I.R.C the maximum width of a vehicle

Ans 2.44 m

(13) As per IRC the slope of earth in cutting

Ans 1:1

(14) The value of ruling gradient in plains as per IRC is

Ans 1 in 30

(15) The maximum design gradient for vertical profile of a road is

Ans Ruling gradient

(16) The width of shoulders provided on a road side varies between 1.2 m and

Ans 1.8 m

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CHAP-3

ROAD MATERIALS

SOIL

Function of soil as Highway subgrade

The soil as highway subgrade has following functions :-

(a) To act as an integral part of the road pavement.

(b) To provide stability and durability to the road pavement under adverse Climatic and loading conditions.

(c) To provide adequate support to the road pavement.

(d) To provide proper drainage to rain water percolating through the pavement.

Properties of soil as a Highway Materials

* It should remain stable in adverse conditions.
* It should be incompressible.
* It should maintain the permanent strength
* Soil should have good drainage properties to avoid excessive retention of Moisture
* Soil should be easily compactible.

The C.B.R value is then calculated by

the following reaction:-

$$CBR = \frac{P_T}{P_S} \times 100$$

where,

P_T = corrected test load corresponding to chosen penetration

P_S = standard load for the same penetration as for P_T.

AGGREGATES

* Aggregate is the major component use in road construction.
* Aggregate have to bear stresses occuring on the roads and have to resist wear due to abrasive action of traffic.
* It is used in granular bases and sub-bases, bituminous constructions and in cement concrete pavements.

Types of Aggregate

In general the aggregate are of following two types;

i) Natural aggregates
ii) Artificial aggregates

(i) Natural Aggregates

Rocks are main source of natural aggregate for road makings.

The road makings aggregate in india fall into the following geological groups.

(a) Igneous rocks, formed by the cooling of molten material.

(b) Sedimentary rocks, formed by deposition of granular material.

(c) Metamorphic rocks, formed by transformation of igneous or sedimentary rock due to heat and pressure.

(ii) Artificial Aggregates

* Brick ballast is the most commonly used artificial aggregates in india.
* Broken brick ballast is soft and water absorbent, hence over burnt as aggregates.
* This is very commonly used in WBM base courses in gangetic plains of Northern India.
* Ballast furnace slag is also used as an aggregate in india and abroad.

BINDERS

* The function of the binder is to act as adhesive between the chippings and the road surface, as a water-sealant and as a dust proofing agent.

* The viscosity of the binder should be such that at the time of application it should be fluid enough to permit uniform spraying.

Binders used for road construction

The following material are used as binder for road construction:-

(i) Bitumen
(ii) Tar
(iii) Cement

1) **Bitumen**:- It is defined as a viscous liquid or solid, consisting essentially of hydrocarbons and their derivatives, which is soluble in carbon disulphide.

→ Bitumen is substantially non-volatile and softens when heated.

It is black or brown in colour and has water proofing and adhesive properties.

Properties of Bitumen

Bitumen should have the following properties to act as a road material:

(a) The bitumen should be fluid enough at the time of mixing to coat the surfaces.

(b) It should be durable.

(c) It should have low temperature susceptibility.

(d) It should be ductile and brittle.

(e) It should have good affinity to the aggregates and should not be stripped off in the presence of water.

Types of Bituminous Materials

The following are the various types of bituminous materials used in the road construction.

(a) Tar
(b) Asphalt
(c) Emulsion
(d) Cutbacks

Tar

* Tar is a by product of the destructive distillation of coal.

* The first step for the production of tar is the carbonization of coal and coal tar is obtained as a by product, coal tar is refined by distillation to get road tar.

* Road tar is a viscous liquid, black in colour and contain 12 to 15% of bitumi-nous contents.

Comparison between bitumen and Tar

Bitumen

→ It is dark brown or black in colour.
→ It is obtained from crude petroleum or from natural deposits.
→ It is costlier than tar.
→ It takes less time to set.
→ It is less temp susceptible.
→ Bitumen coated aggregates can't be stripped easily.
→ Bitumen contains low percentage of carbon than tar.
→ Bitumen does not have any toxicity.
→ It is useful for road construction.

Tar

* It is dark brown or black in colour.
* It is obtained from the destructive distillation of wood or coal.

→ It is cheaper than bitumen.
→ It takes more time to set.
→ It is more temp susceptible.
→ Tar coated aggregates can be stripped easily.
→ Tar contains higher % age of carbon than bitumen.
→ Tar posses phenol which is toxic.
→ It is used for roofing materials and joint fillers.

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Tests on road aggregate

The following tests are carried out in order to decide the suitability of the road aggregate in construction.

(1) Impact test :- This is a test, designed to evaluate the resistance of aggregates to fracture under repeated impacts.

→ since vehicle loads cause impact, this test gives an indication of the performance of aggregates to resist being crushed under impact.

→ The test is carried out either on a cylind

cal stone specimen or on stone aggregates.

→ Impact test which is carried out on aggregates is known as the aggregate impact test.

→ This test has been standardized by BIS (IS : 5640 - 1970)

(ii) Abrasion test :- This test is performed for measuring the abrasion resistance of aggregate.

→ The top layers of a pavement get abraded due to the movement of traffic.

→ A material which is highly abrasion resistant has a long life.

Some of the more widely used abrasion tests on aggregates are as follows :- (a) Los Angles abrasion test
(b) Dorry abrasion test
(c) Deval abrasion test

(iii) Crushing strength test

This is also called aggregate crushing test. One of the modes in which a pavement can fail is by crushing (severe stresses).

→ This test is made to determine the aggregate crushing strength. The test has been standardized by BIS (IS: 2386-part)

→ In this test, the aggregate is put under gradual applied load and resistance to crushing of aggregate is measured.

→ Aggregate with low crushing values are preferred for high quality pavement.

Then aggregate crushing value is determined as follows:-

$$\text{Aggregate crushing value} = \frac{W_2}{W_1} \times 100\%$$

where,

W_1 = weight of the aggregate sample taken for test

W_2 = weight of the crushed aggregate passing through sieve size 2.36mm

(iv) Water absorption test

This test is performed to determine the water absorption values of the aggregates. Water absorption depends on the pores in the aggregates.

→ The more the water absorption, the higher the voids.

→ This gives the dry weight of the aggregate.
→ Difference in weight at dry and saturated aggregate is the amount of water absorbed.

percentage water absorption = $\frac{W_1 - W_2}{W_2} \times 100$

where,

W_1 = weight of saturated aggregate

W_2 = weight of oven dry aggregate

→ Aggregate having water absorption above 0.6% is unsatisfactory.

(v) Soundness test

This test is carried out to determine the resistance of aggregate to weathering action, soundness test can be performed in two ways: (a) Alternate wetting & drying

(b) Freezing and thawing

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CHAP-4 ROAD PAVEMENTS

The road pavement is the actual surface on which the vehicles will travels it purpose is a fold (i) to provide friction for the vehicles (ii) to transfer normal stresses to the under laying soil.

pavement consist of layers of pavements material.

Types of road pavement

Road pavements are generally classified into 2 types:-

(i) flexible pavements

(ii) Rigid pavements

(i) flexible pavements

It can be defined as a pavement layer comprising of a mixture of aggregate and bitumen, heated and mixed properly and then laid compacted on a bed of granular layer.

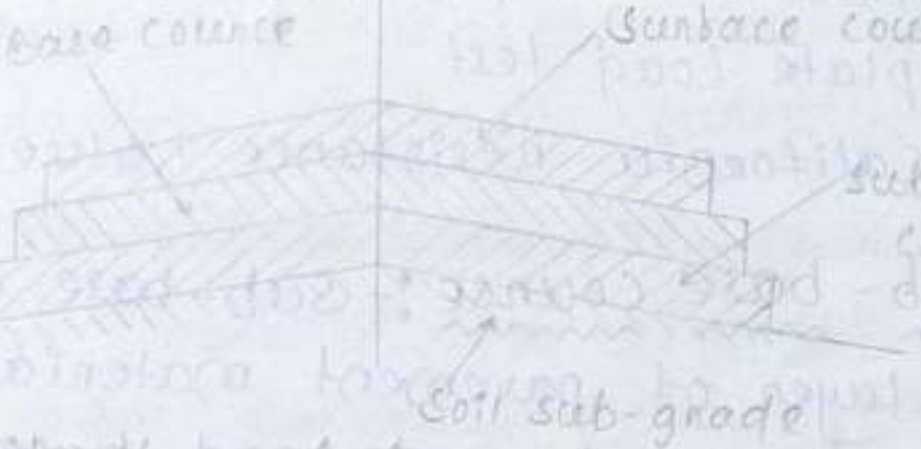
(ii) Rigid pavements

Rigid pavements are associated with rigidity or flexural strength or slab action so the load is distributed over a wide area of subgrade soil.

→ Cement concrete is the best examples of rigid pavement.

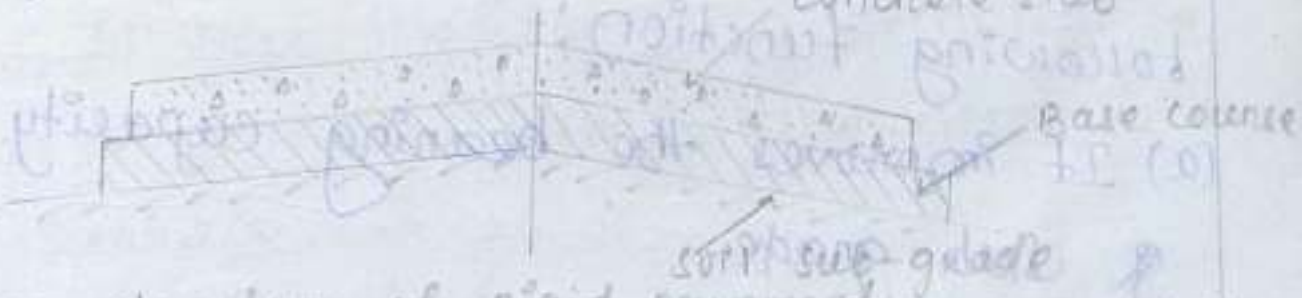
flexible pavement of 4 components :-

(i) Sub-grade
(ii) Sub-base course
(iii) Base-course
(iv) Surface course



Rigid pavement consist of 3 components :-

(i) Sub-grade
(ii) Base-course
(iii) Cement concrete slab



Functions of pavement components

(i) Sub-grade :- Sub-grade is a layer of natural soil or filled soil prepared to receive the pavement materials over it.

→ Functions of sub-grade is to transfer the entire load coming to it to the earth mass and to provide a good support to the pavement surface.

The following tests on soil are carried out to find out its strength:-

(a) CBR test
(b) Triaxial compression test
(c) plate load test
(d) California resistance value test

(ii) Sub-base course :- Sub-base course is a layer of pavement material provided between sub-grade and base course.

→ It is provided as an additional layer when the sub-grade is of poor quality.

The sub-base course has the following function:-

(a) It improves the bearing capacity of sub-grade.

(b) It checks the capillary rise of sub soil water.

(c) It prevents sub-grade material from working up into the base course.

(d) It eliminates frost heave in frost affected area.

(iii) Base course :- It is a layer of pavement material between surface course and sub base course.

It serves following functions :-

(a) It acts foundation for the road pavement and transfers the traffic load to the sub-base course.

(iv) Wearing course :- Wearing course is the topmost layer of the pavement structure. In flexible pavement normally as bituminous surfacing is used as a wearing course and in rigid pavements the cement concrete acts like a base course as well as wearing course.

It has the following functions :-

(a) It provides smooth and dense riding surface.

(b) It resists pressure exerted by tyres.

(c) It takes up wear and tear due to the traffic.

(d) It provides a water tight layer against

COMPARISON OF FLEXIBLE AND RIGID PAVEMENTS

SL.NO	Point of comparison	flexible pavements	Rigid pavements
01	Design precision life	Design is less precise.	Design is more precise
02	Life	It has less life.	It has more life.
03	Initial cost	Initial cost is less.	Initial cost is more.
04	maintenance	It requires more maintenance.	It requires very little maintenance.
05	stage construction	fit for stage construction.	Not fit for stage construction.
06	penetration of water	It is less impervious.	It is more impervious
07	sub-grade	A good sub-grade is essential.	A good sub-grade is not required.
08	opening of traffic after construction.	It can be opened to traffic immediately after construction.	To open for traffic due to curing.
09	Night visibility	Black top pavements provide poor visibility at night.	It provides good visibility at night.

Infiltration of surface water.

Sl No	Points of comparison	Flexible pavements	Rigid pavements
10.	Tractive resistance	It offers more tractive resistance.	It offers less tractive resistance
11.	Glaring effect	It does not cause glare under sunlight.	It can cause glare under sunlight.

Rigid pavement

Advantages

* It is very easy to clean and practically dust free.
* The resistance to traffic is low.
* It has long life with extreme durability.
* It has low maintenance cost.
* It can withstand any amount of traffic.
* Ability to be placed directly on poor soils.

Disadvantages

* It has high initial cost.
* Joints required for contraction & expansion.
* Generally rough riding quality.
* High repair costs.

Flexible pavements

Advantages

* Adaptability to stage construction.
* Availability of low cost types that can be

easily built.
* Ability to be easily opened and patched.
* Easy to repair frost heave and settlement.
* Resistance to the formation of ice glaze.

Disadvantages

* Higher maintenance costs.
* Shorten life span under heavy use.
* Damage by oils and certain chemicals.
* Weak edges that may require curbs or edge devices.

SUB-GRADE PREPARATION

The various operations involved in the preparation of sub-grade are as follows:- (A) site clearance
(B) Earthwork
(C) Compaction and consolidation
(D) Checking sub-grade

(A) Site clearance: This operation includes removal and disposal of trees, shrubs, etc. which come within the formation width of the road and are required to be removed.

(B) Earthwork:- After site clearance, the second step is the earthwork for the preparation of sub-grade. The earthwork for

construction of a road includes.

(i) Earthwork in embankment

(ii) Earthwork in cutting or excavation.

(i) Earthwork in Embankment :- When formation level of the road is above the natural ground level, embankments are required to be made.

(a) Making profile of embankment :- profile of embankment are established by using posts and strings erected at 30 m intervals for guidance of Labour. The profile of an embankment.

Fill Material :- Granular soil is generally preferred as highway embankment material. Fine soils like silt and clay are less desirable as embankment material as these take more time to settle

(b) Stripping and storing of top soil :- After establishing the embankment profile, the top soil of the area, where embankment is to be constructed, is stripped and stored for covering embankment slopes.

(c) Compaction of original Ground :- In places where the density of soil is less than 90% of

procten's density, the original ground is loosened to a depth of 0.5 m. It is then watered and rolled in layers of 250mm to get 100% of procten's density.

(d) Benching of steep slopes :- On hill side slopes it is necessary to bench the surface of the hill slope with a height of 0.5 m and width 1.5 m to 3.0 m to provide stability to the embankment.

(e) Deposition of soil :- Soil for embankment is deposited in layers. The depth of each layer is restricted to 250 mm.

(f) Compaction :- Compaction of the fill is carried out to achieve the required density. The selection of compaction equipment depends upon the type of soil to be compacted and availability of equipment.

Borrow Pits

* Borrow pits should be rectangular in shape and should be dug as near to the road boundary as possible.
* No borrow pits should be dug within 5m of the toe of the final embankment.

* Depth of borrow pits should not be more than 450 mm in temporarily acquired land.
* Borrow pits should not be dug within 0.8 km of towns and villages.

(ii) Earthwork in cutting or Excavation:-
Excavation is the process of cutting or loosening and removing earth including rock from its original position, transporting and dumping it as fill or spoil bank.

(D) Checking of sub-grade :- Trueness of the sub-grade is checked after its preparation. surface levels of the sub-grade along the road alignment is checked by using a levelling instrument.

Type of base course :-
According to the method of construction, the various types of base courses of flexible pavements are:-
(1) Brick or stone soling
(2) Macadam base course
(3) Stabilized soil base course

(1) Brick or stone soling: Brick soling is the layers of brick laid directly on the sub-

grade. Bricks are laid either on edge or flat in one or more layers.

(2) Macadam base course :- The macadam base courses are of the following types:

(i) Water bound macadam (W.B.M)

(ii) Grouted or penetration macadam

(iii) Bituminous macadam.

(i) Water Bound Macadam :- Water bound construction should consist of clean, crushed or broken aggregates mechanically interlocked by rolling and bounded together with screening, binding material and water.

Materials used For W.B.M

The most common and durable material for use as aggregates in W.B.M is broken stone aggregates, crushed slag, overburnt brick aggregates and naturally occurring aggregates such as kankar or laterite are also used.

The screenings also known as "choke" materials, fill in the voids left in coarse aggregates. When they are compacted and help to cement the stone

aggregates together.

Method of construction

The sub-grade or sub-base on which W.B.M base course is to constructed should be prepared to the specified grade and camber. The prepared base should be free of dust and ruts.

(ii) Grouted or penetration Macadam:- This is also called built-up spray grout base course. penetration macadam base course are of two type:-

① Full grouted macadam in which the binder is allowed to penetrate to the full depth.

② Semi-grouted macadam in which the binder is allowed to penetrate to the half depth.

Wet-Mix Macadam

This is new method where aggregates are mixed with water before laying and the wet mix is laid and then rolled.

→ Wet roads are superior than WBM in

all aspects.

(iii) Bituminous constructions

① Preparation of base:- The existing base is prepared by correcting its camber and grade. The surface is then properly cleaned to free it from dust and loose materials.

② Application of prime or tack coat:- A layer of liquid binder is applied over the cleaned surface before spreading the premix.

③ Preparation of premix and spreading:- The premix is prepared in a hot mix plant with desired quality control. The spreading is done by using mechanical paver.

④ Rolling:- After laying mix rolling is done by using 8 to 12 tonnes roller. The rolling is started from edges and progressed towards centre.

SOIL STABILIZATION

Soil stabilization is a process of treating a soil to improve its stability and bearing capacity for using the soil

as construction material.

→ This is a method of changing the soil properties by use of controlled compaction, proportioning or the addition of suitable admixtures.

Purpose of soil stabilization

Stabilization of soil is practiced in road construction for one or more of the following objectives;

(i) To bring economy in road construction.
(ii) To increase the strength of pavement layers like sub-bases, base course, etc.
(iii) To alter permeability characteristics.
(iv) To reduce the tendency of swelling or shrinkage due to change in moisture content.
(v) To reduce compressibility and settlement.
(vi) To reduce frost susceptibility.
(vii) To increase the stability of earth work in embankment as a whole.
(viii) To make use of locally available inferior quality materials.

Methods of soil Stabilization

Following are the commonly used

Methods of soil stabilization:

(i) Mechanical stabilization
(ii) Lime stabilization
(iii) Cement stabilization
(iv) Fly ash stabilization

(i) Mechanical stabilization

Mechanical stabilization of soil involves two operations:-

(a) Changing the composition of soil by addition or removal of certain constituents.

(b) Densification or compaction.

The stability of a granular soil having negligible amount of fines can be increased by mixing with certain proportion of binder soil.

→ The granular fraction provides strength and hardness.

→ The fine fraction provides cohesion, water retention capacity and also acts as a filler.

(ii) Lime stabilization

Hydrated lime is very effective in treating high plastic clayey soil. When clayey soils with high plasticity are

treated with lime, the plasticity index of soil is decreased and soil becomes friable and easy to be pulverized.

→ The amount of lime required for coarse grained soils is 2 to 8% and for plastic soils lime required is 8% to 20% by weight of soil.

The various factors which effect the properties of soil-lime are :-

(a) Type of soil
(b) Lime cement
(c) Type of lime
(d) compaction and curing
(e) Admixture

(iii) Cement stabilization

The soil stabilized with cement is known as soil cement. soil cement can be used as a sub-base or base course of all types of pavements.

→ The cementing action is the result of chemical reactions of cement with silica content of soil during hydration.

→ In coarse grained soils, the stabilization is due to the development of bond at the point of contact of hydrated cement

and compacted soil particles

→ In fine grained cohesive soils, the stabilization is due to the reduction of plasticity and formation of matrix enclosing clay lumps.

The various factors which influence the properties of soil cement are:-

(i) Nature of soil
(ii) cement content
(iii) conditions of mixing
(iv) compaction and curing
(v) Admixtures

(iv) Fly ash stabilization

Stabilization of soil and pavement bases with soil fly ash is an increasingly popular option for design engineers.

→ Fly ash stabilization is used to modify the engineering properties of locally available materials and produce a structurally sound construction base.

→ Both non self-cementing and self-cementing coal ash can be used in stabilization application.

SURFACE DRESSING

Surface dressing is a process whereby a thin film of bituminous binder is sprayed on the road surface, covered with a coat of stone aggregates and well rolled.

→ This is one of the cheapest and simplest of bituminous surfaces and is widely adopted in india.

Surface dressing performs following functions:-

(a) It provides a water proof layer to prevent infiltration of surface water.

(b) It provides a dust free road surface over a base course.

(c) It protects the base course.

(d) It increases the skid resistance capacity of smooth surfaces.

(i) PREMIX CARPET OR BITUMINOUS CARPET

A bituminous carpet is a open-graded pre-mix prepared from stone aggregates and bitumen binder with pre-mixed sand bitumen seal coat.

20 mm. This type of construction is usually recommended for surface course.

(ii) SEMI DENSE CARPET

→ dense asphaltic concrete is very costly specifications for mix-design aggregates gradation, binder, content and stability.

→ while this specification undoubtedly yields returns for the investment.

→ At the same time, the authorites may feel that an open-textured surface such as a 20 mm chipping carpet may not be meeting the requirements of traffic and climate.

Bituminous Concrete

It is a dense graded premixed bituminous mix which is well compacted to form a high quality pavement surface course.

→ It consists of a carefully proportioned mixture of coarse aggregates, fine aggregates, mineral filler and bitumen and the mix is designed by an appropriate method such as the Marshall method to

fulfill the requirement of stability, density, flexibility and voids.

* state the IRC specification for width of carriage way for various classes of roads.

Ans IRC specification for carriage way width

Single lane - 3.75 m.

Two lane, No kerbs - 7.0 m

Two lane, Raised kerbs - 7.5 m

Intermediate carriage - 5.5 m

multi-lane - 3.5 m

* What is superelevation?

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

* Explain CBR test.

Ans California Bearing Ratio (CBR) test

* This is a penetration test developed by the California division of highways for evaluating the stability of soil subgrade and other flexible pavement

materials.

* The laboratory CBR apparatus consists of a mould 150 mm diameter with a base plate and a collar, a loading frame with the cylindrical plunger of 50 mm dia and dial gauges for measuring expansion of soaking and the penetration values shown in figure.

* penetration test consists of causing a cylindrical plunger of 50 mm diameter to penetrate a pavement component material at 1.25 mm/minute.

* The load causing 2.5 mm and 5.0 mm penetration are recorded. These loads are expressed in percentage of standard load.

* Generally the standard load values are 1370 and 2055 kg respectively of 2.5 and 5.0 penetration.

* The CBR value is calculated using the below equation :-

$$CBR, \% = \frac{\text{Load sustained by the specimen at 2.5 or 5.0 mm penetration}}{\text{Load sustained by standard aggregates at the corresponding penetration level}} \times 100$$

Specification of material Required for the construction

Cement, coarse aggregates, fine aggregates and water are required for the construction of plain cement concrete slabs. In case of reinforced cement concrete slabs, steel wire fabric or bar mats are used as reinforced.

* Cement used for most of the works is ordinary portland cement conforming to all tests as per IS 269.
* Rapid hardening cement is also used to reduce curing time in case of urgency.
* Nowadays portland blast furnace slag cement is more preferred than ordinary portland cement.
* Coarse aggregates used are crushed stone or gravel conforming all tests as per IS 383. The aggregates should be clean, hard and free from harmful materials like iron, coal, clay, mica, etc.
* The physical requirements of coarse aggregates are given in below.
* The maximum size of coarse aggregates should not be more than 1/4th of the slab thickness.

* Generally slab thickness of less than 150mm is used, so the maximum size of coarse aggregates should around 40 mm.
* Fine aggregates used shall preferably be natural sands.
* Crushed stone flours may also be used as fine aggregates in concrete.

Grounting

(i) Grounting is the process of deposition of dryroard mixture concrete or cement waste on the near the gaps of tiles of the floor during it filling with cement.

(ii) Fills the spaces in between the tiles & provides finished look of floor or wall

Types of Grouting

(i) Cementicous Grout:- This is the most common type of grout used for grouting

(ii) pox - Grout

Fresh
25.01.20

CHAP-5 HILL ROADS

Date:

INTRODUCTION

A terrain can be classified into following four groups - based on the cross-slope.

Terrain	Cross-slope %
Level	0 - 9.9
Rolling	10 - 24.9
Mountainous	25 - 60
Steep	above 60

The terrain having cross-slope of more than 25% comes under hilly terrain. The road laid in the area having cross-slope of 25% or more is called a hill road or that road.

Classification of Hill Roads

Generally hill roads are classified as

(i) National Highways (N.H)
(ii) State Highways (S.H)
(iii) Major district roads (M.D.R)
(iv) Other district roads (O.D.R)
(v) Village roads (V.R)

Hill roads can also be classified as:-

(i) Motor roads
(ii) Bridle roads
(iii) Village paths

(i) Moton Roads

Moton roads from main communication system in hilly region, All sorts of traffic can use this roads. These roads can have one or more than one lane width.

(ii) Bridle paths

These paths are used by pedestrians and mule traffic. Bridle paths serve as feeder roads to moton roads.

(iii) Village paths

The communication between villages and other working areas in hilly regions is established through village paths or tracks.

COMPONENT OF A HILL ROAD

Following are the components of a hill road: (a) Retaining wall

(b) Breast wall

(c) Parapet wall

(d) Catch water drain

(e) Cross-drain

(f) Side drain

(g) Road bed

(57)

(a) Retaining wall :- The wall constructed down slope side of the hill road to resist the pressure of earth fill and traffic load coming on the road is known as retaining wall.

(b) Breast wall :- The wall construction on the side of road way in order to retain earth from slip-page is called breast wall.

(c) parapet wall :- The wall constructed above the formation level of a hill road usually towards the down hill side is known as parapet wall.

(d) Catch-water Drain :- The drain provided high up on the hill slope side in order to intercept and divert the water from the hill slope is called catch water drain.

(e) Cross-Drain :- Constructed to drain off rain water from one side of the road to the other side.

(f) Side Drain :- Side drain is provided on the road side usually at the foot of hill slope, to collect and drain of water

from hill slope as well as from road surface.

(g) Road bed:- Road bed is the pavement portion of the hill road.

TYPICAL CROSS-SECTION OF HILL ROADS:-

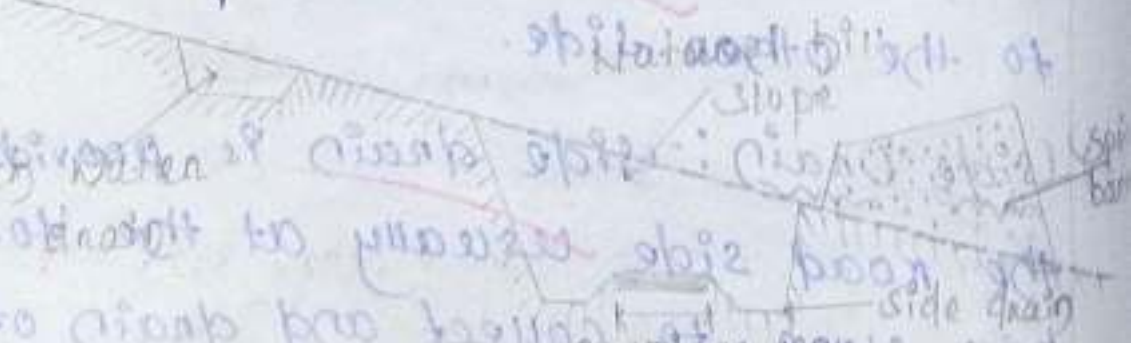
(i) partly in cutting & partly in Filling

The cross-section of a hill road partly in cutting and partly in filling.

→ when cross-slope of the hill is not very steep, the best section of the road shall be partly in cutting and partly in filling usually in this type of formation, the best section of the road.

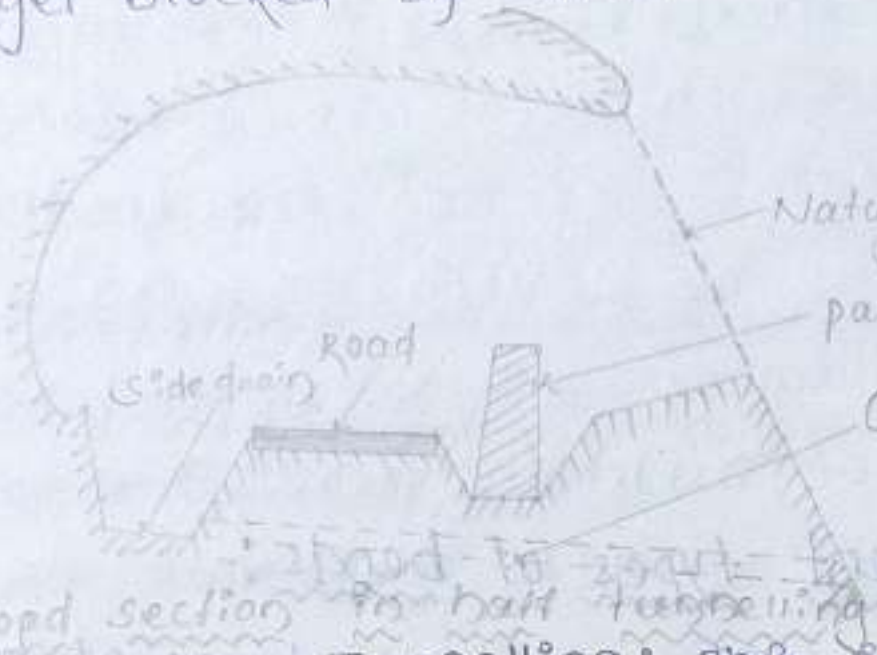
→ shall be 2/3 in cutting and 1/3 in filling

(ii) Road completly in cutting:- The section of a hill road completly in cutting is shown in below. when the cross-slope of the hill is very steep, the road is located in full cutting.



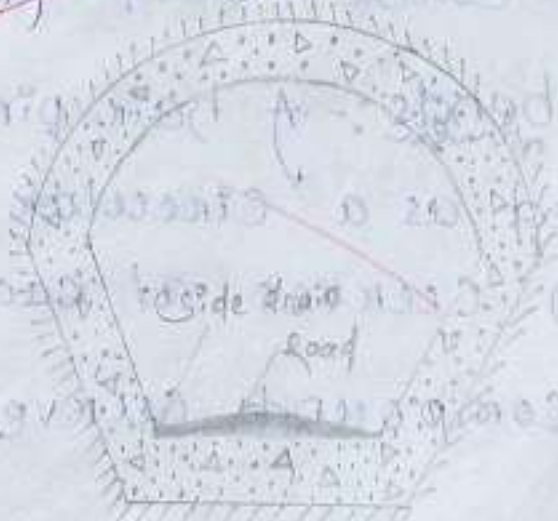
(iii) Road in Half Tunnelling :- The section of hill road in half tunnelling is shown in below. If alongwith steep slope hill side is sound and solid, road can be constructed in half tunnelling.

→ This type of construction is advantageous for high altitude hill roads as they do not get blocked by snow.



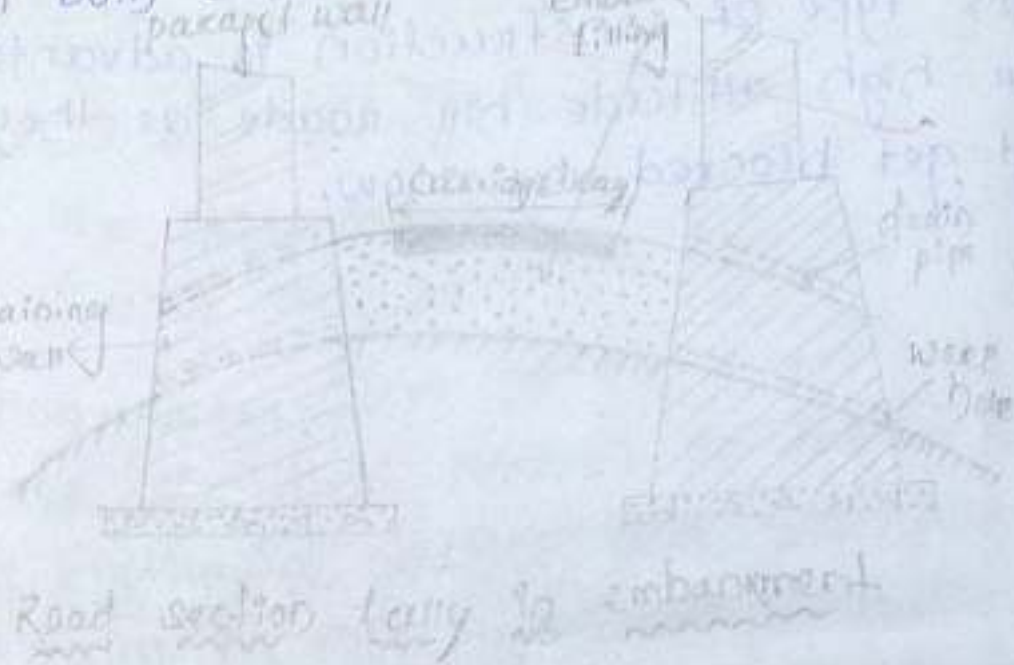
Road section in half tunnelling

(iv) Road in full Tunnelling :- This is constructed when there is no other alternative for the economy of the hill road project.



Road section of full tunnelling

(iv) Road fully in Embankment:- This type of construction is done when cross-slope of a hill is very small. In case of heavy filling retaining walls are constructed on both sides of the road.



Road section fully in embankment

Different types of bends:-

The following types of bends are 2 types:- (i) Hair pin bend
(ii) Corner bend

(i) Hair pin bends:- A hair pin bend should be designed as a circular curve with transition curves at each end.

→ Circular compound curve may also be provided.

→ Inner and outer edges of the road way should be concentric with respect

to centre line of the pavement.

→ If a large number of hair pins have to be introduced, in that case a minimum of 60 m intervening length between two consecutive bends should be provided to enable the driver to negotiate the alignment smoothly.

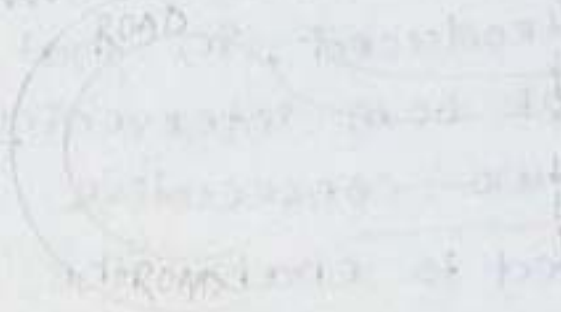
→ Actually this length depends upon the slope of the hill to avoid costly protective measures between the upper & lower arms of bends.

→ Within limits of the available turning angle, it is very difficult to layout curves following normal geometric standard of design.

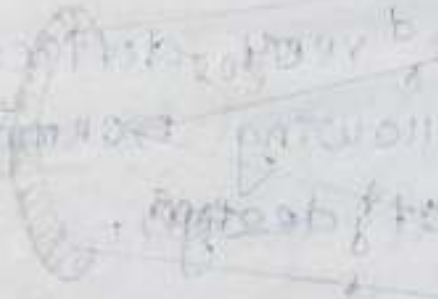
Vertical Curves:- For smooth transition at grade changes, vertical curves are introduced. Both summit curves and valley curves should be designed as square parabolas.

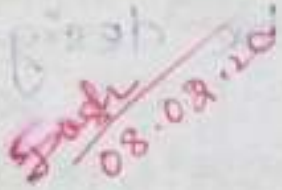
Bends in Hill Roads:- Due to the topography of the terrain a number of sharp curves of very small radius such as Hair pin bends, corner bends,

Serpentine curves, etc; have to be provided.



Corner bends :- One to form or cause to form a curve, as by pushing or pulling. two to turn or cause to turn from a particular direction. The road bends left past the church.





CHAP- CONSTRUCTION EQUIPMENT

Construction Equipment

The type of equipment to be used in a highway projects depend upon the scope of work.

Generally for construction of flexible road pavement following plant and equipment are based:-

(i) Tractors
(ii) Scrapers
(iii) Bulldozers
(iv) power shovels
(v) Rollers
(vi) Gradens
(vii) Hot mix plants
(viii) paver finisher
(ix) Ripper
(x) Dumpers
(xi) Draglines

(i) TRACTOR

Tractor uses:- Tractor have many uses as construction equipment, their primary purpose is to pull or push loads.

→ They are also used as mounts for many types of accessories, such as front-end shovels, rippers, bulldozers blade trenchers, etc.

TYPES

Tractor are divided into 2 types:-

(A) Crawler tractor

(B) Wheel tractor

Selection of a Tractor

(a) The size required for a given job.

(b) The type of footing over which it will operate i.e., low tractive efficiency or high tractive efficiency.

(c) The smoothness and firmness of haul road.

(d) The length of haul

(e) The type of work it will do at the completion of a certain job.

A) CRAWLER TRACTORS

* Crawler tractor are usually rated by weight and power.

* The weight is important on many project because the maximum tractive effort that a unit can provide is limited to the product of the weight and co-efficient of traction for the unit & the road surface.

(B) WHEEL TRACTORS

* The main advantages of wheel tractor over Crawler tractor is the higher speed, that may exceed (50km/hr).
* However, the pulling effort of wheel tractor is less than the crawler tractor.

These are of two types:-

(a) Two wheel tractors - Mounted on two wheels

(b) Four wheel tractors - Mounted on four wheels

Advantages of Two wheel & Four wheel Tractor

Two wheel Type

* less rolling resistance because of the elimination of the extra axle.
* Fewer types to provide and maintain.
* Higher traction
* Increased maneuverability

Four wheel Type

* Due to better steering properties, it gives more confidence to the driver.
* Can work as an independent unit when separated from the trailing unit.

* Less tendency to bounce on rough roads.
* can be driven at greater speed.

(ii) SCRAPERS

* Tractor pulled scrapers are very important equipment of earth moving field.
* This equipment can dig load, haul and discharge materials independently i.e., without taking any help from other equipment.

TYPES OF SCRAPER

Scraper are of two types :-

(i) Crawler - tractor scraper
(ii) wheel - tractor scraper

wheel- tractor scraper is further divided into the following:- (a) single engine
(b) Twin engine
(c) Two-bowl engine
(d) multibowl engine
(e) Elevating scraper

(i) Crawler - tractor scraper:-

* The crawler tractor scraper is economy for short haul distances.
* Due to the low speed for a crawler tractor, its use is uneconomical for

a large haul distance.

ii) Wheel-tractor scraper:-

* Due to its high speed, wheel-tractor scraper is more economical than the crawler type.
* The wheel type scraper cannot deliver good tractive effort in loading.

iii) BULLDOZERS

* The bulldozer, often called dozer, is largely employed for excavating and moving the earth.
* It consists of a blade mounted at the front of a tractor which may either be wheel mounted or mounted on crawler tracks.

Classification of Bulldozers:-

On the basis of Blades direction:-

(a) Bulldozers:- These are mounted with blades, perpendicular to the direction of travel.

→ It pushes the earth forward.

(b) Angle dozers:- These are mounted with the blades set as angle with the direction of travel.

→ It pushes the earth forward and to either side.

→ The angle of inclination of the blade is kept upto to 65° with the direction of motion the bulldozer.

ON THE BASIS OF MOUNTINGS

(a) Wheel - tractor Mounted bulldozer:
(pneumatic wheel)

(b) Crawler - tractor Mounted bulldozer:
(chain - crawlers)

According to method of Raising and Lowering the blades :- (a) cable controlled
(b) Hydraulic controlled

Advantages of cable controlled bulldozers

The following advantages are claimed by cable controlled bulldozer:-

(a) It is simple in operation.
(b) It is easy to repair the control.
(c) It's installation is simple and easy.
(d) It can be used for bigger capacity machines.

Advantages of Hydraulic Controlled

(a) position of blade can be maintained more accurately.

(b) To force the blade into the ground, high down pressure on the blade is produced in addition to its weight.

Output of the Bulldozer :- The theoretical capacity of the blade is given by the size of the blade, nature of the soil, etc.

Comparison between Crawler mounted & Wheel mounted Bulldozers :-

(a) Wheel mounted bulldozers have greater speed than Crawler.

(b) Crawler mounted bulldozers are most compact.

(c) Crawler type bulldozers are more powerful than wheel-mounted dozers and can perform heavier jobs of hauling and digging.

(d) Due to more tractive effort, Crawler-mounted dozers can operate on soft footing.

(e) The operator has less fatigues with wheel mounted bulldozer.

(f) Crawler mounted bulldozer can travel over muddy surfaces.

(g) Wheel mounted bulldozers give more output when considerable travelling is

dope.

(b) Crawler type dozers can operate even in rocky and wheele types are likely to get badly damaged.

Uses of bulldozers on a project:-

(a) To level earth this.
(b) To clear construction site of debris
(c) To clean floors of the borrow pits.
(d) To back-fill trenchers.
(e) To clear the site.
(f) To make pilot roads
(g) To maintain haul roads
(h) To move earth for haul distances from 80 to 100 metres.
(i) To construct temporary roads through difficult areas.
(j) To help load tractor pulled scrapers.

(iv) POWER SHOVELS

The name shovels is often used for a specific type of excavating machine fitted with a short-length boom & working with forward strokes.

→ precisely speaking shovel is a general term used with reference to a class

of machine which have a common type of operating and tracking mechanism.

If,

Size of Dipper - 5 cubic metre

Swelling of soil - 25%.

Can fill the dipper up to struck volume

Then bank measure volume

$$\Rightarrow \frac{5}{1+0.25} = 4 \text{ cum}$$

Types of power shovels

power shovels are following types:-

(i) Crawler mounted

(ii) Truck mounted

(iii) Wheel mounted

(v) ROLLERS

Roller is one of the essential equipment required for road construction.

→ It is used for compaction of soil & road macadam.

Rollers can be following three types:-

(a) smooth wheeled rollers

(b) pneumatic tyred rollers

(c) sheep's foot rollers

vi) GRADERS

Grader is a self propelled machine

which has its blade within the wheel base. (vii)
→ The length of blade is about 3.5 m, but its effective length during spreading becomes 2.75 m. (viii)

→ The blade is supported on machine frame work and is capable of turning, tilting, raising and lowering.

→ A 100 to 150 HP grader is a popular size. The graders are used for a number of purposes:-

(i) for spreading heaped earth into layers.
(ii) for maintaining cross-section of the embankment.
(iii) for shaping the cross-section during construction

(vii) HOT-MIX PLANT

A hot-mix plant may be stationary, semi-mobile or fully mobile plant. It consists of the following components:- (i)

(i) cold aggregate feed system
(ii) Dryer for heating and drying the aggregate
(iii) Screens for separating the various sizes of heated aggregates.
(iv) Bins for storing heated aggregates & filler
(v) Bitumen storage and heating tanks.
(vi) Device for weighing different elements of the mix, i.e., binder, filler and aggregate.

(vii) Mixer.

(viii) PAVER FINISHER

A paver finisher is used for laying hot mix concrete. It is self propelled and is capable of laying bitcominous concrete to any desired thickness.

→ It can precisely compact the laid concrete by means of a vibrating screed.

→ The hot mix is stored in a hopper of the paver by using dumpers.

→ The paver finisher operates at speeds of 1.5 to 10 m/min.

→ The mat width is adjusted in the range of 2 to 5 m.

→ 45 to 75 tonns/hr capacity paver finisher are used for road works.

(ix) TIPPER

Tippers are suited for the rough and terrible of mining and quarrying operations, as well as for carrying bulk loads in construction & infrastructure industries.

→ They specialise in the transportation of various loose bulk materials around worksites and beyond.

(x) DUMPERS OR DUMP TRUCKS

Dump trucks are also called dumpers. These are used for hauling many types of materials.

→ These trucks are self propelled.

→ Dump truck is fitted with a trolley at the rear which can be tilted.

→ The trolley is fitted with the help of one or two hydraulic operated pistons.

(xi) DRAGLINES

Draglines are used to excavate earth and load it into hauling units such as trucks, tractor pulled trollies etc.

→ They are used to deposit the excavated earth on the banks, earthen bunds or on earthen dams etc.

→ The machine is so called because its main operation is that of dragging the bucket against the material to be dug.

→ Draglines are of the following types:

① Crawler Mounted

② Wheel Mounted (self-propelled)

③ Truck Mounted

④ Walking Dragline

BITUMEN BOILERS

Bitumen boilers are needed for heating bitumen obtained in solid form. Boilers of a wide range of capacity are available.

BIS has standardized boilers of capacity 100 to 10,000 litres.

Fuse
28.02.20

CHAP:- # ROAD MAINTENANCE

INTRODUCTION

When a constructed is opened to traffic, its various components are subjected to wear and tear.

→ Certain defects may also creep in due to the faulty design and improper quality of construction of road.

TYPES OF MAINTENANCE

Maintenance are following three types:

(1) Routine

(2) Recurrent

(3) periodic

(1) Routine :- Routine maintenance does not depend on traffic level. It consists of grass cutting, drain cleaning, maintenance of culverts and bridges etc.

(2) Recurrent :- Recurrent maintenance depends on traffic level and consist of patching and grading of roads.

(3) periodic :- periodic maintenance consists of surface dressing and overlaying at intervals of greater than only year.

General causes of pavement failure

The following are the causes of failure of any pavement :-

(a) Bad quality of construction material.

(b) Faulty design and improper quality control of construction.

(c) Inadequate road drainage system.

(d) Increase in wheel load.

(e) Settlement of fill material of embankment.

Failure of flexible pavements

The localized deformation or settlement of any one of layers of flexible pavement leads to the failure of the entire pavement.

The failure in flexible pavement may be due to :-

(a) sub-grade failure

(b) Base course failure

(c) Wearing course failure

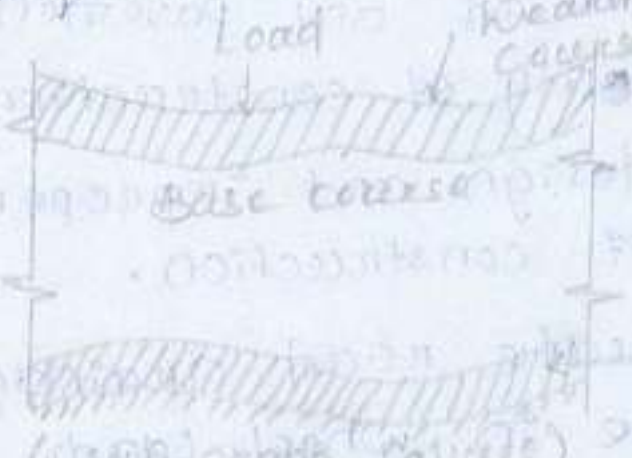
(a) **sub-grade failure** :- The excessive deformation in sub-grade soil is one of the main cause of pavement failure.

The basic reasons of sub-grade.

failure are :-

(i) Excessive stress application

(ii) Inadequate road drainage



(b) Base course failure :- The following are main types of base course failure

(i) Inadequate stability

(ii) Loss of binding action

(iii) Crushing of base course material

(iv) Lack of lateral confinement of base course

(v) Insufficient wearing course

(vi) Loss of material from base course

(vii) Inadequate road drainage

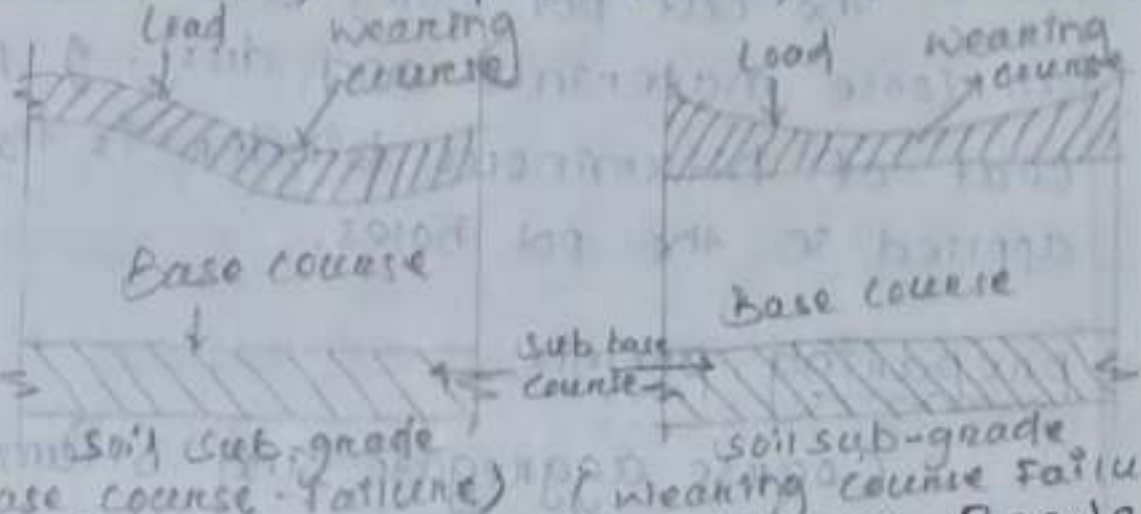
(c) Wearing course failure :- The failure in wearing course is mainly due to the following reasons :-

(i) Lack of proper mix design

(ii) use of inadequate quantity of binder

(iii) use of intention quantity of binder

(iv) Inadequate quality control
(v) volatilization and oxidation of binder



Maintenance of Bituminous Roads

The maintenance work of bituminous roads consist of :-

(i) patch repairing work
(ii) surface treatment
(iii) Resurfacing

(i) patch repairing work :- patch work is carried out when localized pot holes are developed on the surface of the road, repairing of pot holes are carried out in following stages :-

(a) Cutting of pot holes

The pot holes are marked on the road surface. Cutting of marked areas is done in rectangular shape and all the affected materials are then removed from it.

(b) Cleaning of pot holes

The cut pot holes are cleaned of all loose materials and dust. A prime coat of bituminous binder is then applied in the pot holes.

(c) preparing premix

Coarse aggregate and bitumen are mixed in desired proportion to get a premix.

(d) filling the premix

The premix is filled in the prepared pot hole and is compacted by using rammer.

(ii) Surface Treatment :-

Bituminous pavement becomes slippery and patchy due to bleeding of excess bitumen, used during construction in the surface course.

(iii) Resurfacing :-

When the pavement surface is totally worn out and develops a poor riding surface, laying of an additional surface course on the existing surface

may be more economical. Resurfacing operation consists of clearing the road surface, applying seal coat, applying aggregate chips and rolling.

Maintenance of cement concrete roads

Cement concrete roads need very little of maintenance if they are properly designed and constructed.

→ In this type of roads, the main detect is formation of cracks.

→ The cracks developed in the road should be seriously examined and causes are ascertained before any remedial measure is suggested.

Treatment of cracks

→ The common detect noticed in a cement concrete road slab is the appearance of cracks.

→ Cracks can be structural cracks, contraction cracks, shrinkage cracks, warping cracks and corner cracks.

→ The cracks are of varying width fine cracks or hair cracks are not harmful and do not need immediate maintenance

Maintenance of Traffic control Devices

→ The main object of providing traffic control devices is to provides, convenient and economical movement of vehicles and persons on road.

→ For maintenance of traffic signals, the traffic signal lights are cleaned time to time to remove the dust and any defect in the light system is rectified.

→ painting and repairing of traffic islands are carried out as a part of its maintenance work.

Maintenance of shoulders

→ shoulders give lateral support to the pavement and provide room for vehicle when crossing and overtaking on narrow pavements.

→ shoulders are properly maintain to keep them stable, smooth with proper cross slope and in level with the edges of the pavement.

→ These pits are immediately filled with soil and compacted. Where road is constructed on high fillings side slope

of fillings should be protected by pitching or treating.

Maintenance of joints

→ The weakest parts of cement concrete pavement are the joints.

→ Most of the failure in the cement concrete pavements are observed at or near the joints.

→ Therefore, periodic inspection is to be done to see that the filler & sealer materials used in the joints are intact

→ During winter the joint gap opens up due to contraction of CC slab. These open up joints are cleaned properly and refilled with joint sealer material.

TRAFFIC SIGNALS

Signal Indications:- The types & sequence of signal indications vary in different countries. British, American and Indian practice are as below:

1) **American practice:-** As per American practice, road signal sequence is red, green & yellow.

→ Red indication prohibits entry into the section, whereas green permits entry.

→ Yellow indication warns the traffic about the termination of green movement and the red indication is about to commence.

(2) British practice :- In British practice, the signal sequence is red, green and amber.

→ Red signal indicates the denial of entry of traffic into the intersection.

→ Green signal indicates the permission to entry into the intersection.

→ Amber signal indicates that the red signal is about to commence and green signal is terminated.

(3) Indian practice :- In India practice, an amber period of 2 secs is provided as a transition interval between termination of green signal & exhibition of red signal.

Types of Traffic signals

Traffic signals are of following types

(i) Fixed time automatic signals
(ii) Manually operated signals
(iii) Traffic actuated signals

Advantages of Traffic signals

The various advantages of traffic signals when properly designed, located and operated are given below :-

(i) Traffic signals help for an orderly movement of traffic.

(ii) They can increase the traffic handling capacity of the intersection.

(iii) They can reduce certain types of accidents like pedestrain accidents and right angled collisions.

(iv) They provide for continous or nearly continuous movement of traffic along a given route under favourable conditions.

(v) Traffic regulation by signals is proper & economical as compared to traffic police control.

(vi) They can be used to allow safe movement of slow moving traffic by interrupting heavy traffic at regular intervals.

(vii) The signal indications can be seen easily at night or in foggy weather.

Disadvantages of traffic signals

Some of the disadvantages of traffic signals are listed below:-

(i) They cause delay to vehicles at intersections during off peak hours.

(ii) They increase the frequency of rear end collision.

(iii) During signal breakdown, there is serious and wide-spread traffic difficulties

during peak hours.

TRAFFIC SIGNS

Traffic signs are one of the traffic control devices. According to the motor vehicle Act, 1988, the state governments are required to erect traffic signs as per the I.R.C. standards.

Classification of Traffic signs

Traffic signs

- Warning signs
- Regulatory signs
  - Prohibitory signs
  - Mandatory signs
- Information signs
  - Indication signs
  - Direction & advance direction signs
  - Place & route identification signs

CHAP- ROAD DRAINAGE

INTRODUCTION

Road drainage is the process of interception and removal of water from over, tender and vicinity of the road surface. for safe and efficient design of road, road drainage is very important.

NECESSITY OF ROAD DRAINAGE

Road drainage work is necessary because of the following reasons :-

(a) Variation in moisture content in expansive soils causes variation in the volume of sub-grade and contributes to the failure of pavement.

(b) Excess Moisture content in soil - sub grade causes considerable lowering of its stability.

(c) The entrance of water causes reduction in bearing capacity of soil sub-grade like WBM and stabilized soil.

(d) Due to poor drainage, waves and corrugation are formed in flexible pavements which causes failure of pavement.

(e) Due to poor drainage of road, water remain in contact with the bituminous material for longer time causing stripping of bitumen from aggregates and formation of pot holes.

Requirements of a good road drainage work

Requirements of a good road drainage work are as follows :-

(i) The surface water from the shoulder and carriage way should effectively drain off before percolating to the sub-grade.

(ii) Seepage and other source of underground water, if any, should be intercepted & drained off by the sub-surface drainage system.

(iii) Surface water flowing across the road pavements should not develop cross cut or erosion of road surface.

(iv) Maximum level of ground water table should be maintained well below the level of sub-grade, preferably by least 1.2 m.

(v) Road formation should be designed in such a way that it should be 600mm above the H.F.L. at all points.

Road Drainage Work

Road drainage work, adopted for intercepting, removing and controlling of surface and sub-surface water, from entering into the pavement structure, are classified as follows :-

(a) Surface drainage
(b) Sub-Surface drainage
(c) Cross drainage

(a) Surface Drainage

Surface drainage is the removal and diversion of surface water from the road way and adjoining land.

Methods of providing surface Drainage

Steps generally taken to provide effective surface drainage are as follows :-

(a) providing a impervious pavement surface.
(b) providing sufficient cross slope or camber to the pavement.
(c) providing shoulders of rural roads with sufficient cross slope.
(d) providing longitudinal drains (side drains) on one or both sides of the road.
(e) keeping height of the road embankment at-least 1.2m above H.F.L of the area.

(b) Sub-Surface Drainage

Sub-Surface drainage is the system of diversion or removal of excess soil water to the groundwater.

Under the following conditions the sub-surface drainage system is recommended:

(i) When there is danger of rise of capillary water to the pavement structure.

(ii) When the pavement structure is subjected to the action of spring.

Methods of providing Sub-surface Drainage

The following methods are adopted for sub-surface drainage:-

(i) Lowering the water table

(ii) Control of seepage flow

(iii) Control of capillary rise.

(i) Lowering the water table

In order that the sub-grade and pavement layers are not subjected to excessive moisture, the highest level of the water table should be at-least 1.0 to 1.2 m below the level of sub-grade.

(ii) Control of Seepage flow

Where surface of ground and impervious strata below it are sloping towards the road, seepage flow is likely to reach road sub-grade and affect its strength.

(iii) Control of capillary Rise

In water logged areas, there is a possibility of water rising upto the sub-grade from the water table by capillary action and softening it.

Some of the suitable capillary cut-off layers to check capillary rise are:-

(a) Sand blanket extending over the full embankment width.

(b) Heavy duty tar felt.

(c) polythene envelope.

(d) Bituminous stabilized soil.

(c) Cross-drainage works

The function of the cross-drainage works is to discharge water, collected in side drains or that of natural streams, across the road from one side to other as quickly as possible.

→ The adequate functioning of a road depends to a large extent on the effectiveness of cross-drainage work.

→ The commonly used cross-drainage structures are the culverts & small bridges

Storm Water Drains

A storm water drain or sewer is infrastructure designed to drain excess rain and ground water from impervious surfaces such as paved streets, car parks, parking lots, footpaths, sidewalks, and roofs.

→ Storm drains vary in design from small residential dry wells to large municipal systems.

→ Drains receive water from street gutters on most motorways, freeways and other busy roads, as well as towns in areas with heavy rainfall that leads to flooding and coastal towns with regular storms.

SIDE DRAINS

Side drains are longitudinal drains provided parallel to the road for collecting and disposing the surface water. They are generally trapezoidal in shape provided by cutting the sub-grade soil at a suitable distance from the road surface.

Generally, the side drains are classified

into two groups:- (i) closed or covered drains
(ii) open drains

(i) Closed Drains:- Closed drains are provided in places where there is restriction of space and construction of open drains are undesirable.

Closed drains are of two types:-

(a) Drains provided with gratings
(b) Jelly drains.

(a) Drains provided with gratings:- These drains are usually provided in urban areas.

→ Water drained from the pavement surface is carried forward in longitudinal direction between the kerb and the road pavement for distances.

(b) Jelly drains:- Jelly drains are closed drains filled with filter material. These drains are trapezoidal in shape and are filled with filter materials like layers of gravel and sand.

(ii) Open Drains:- These drains are generally provided in rural areas where there is

no restriction of space and the road is subjected to light traffic.

→ These are also trapezoidal in shape.

→ The bed width of such a drain varies from 0.5 to 1.0 m and depth 0.15 to 0.5 m depending upon the topography of the area.

Side ditches for Surface Drainage

Diversions may be included in a drainage system to prevent surface runoff from sloping land from reaching a flat or depressional area.

→ Diversion ditches are located at the base of a slope to intercept and carry surface flow to an outlet.

→ Their side slopes range between 2 to 1 & 4 to 1 and they should be kept in sod.

Intercepting Drains:- A drain that intercepts and diverts water before it reaches the area to be protected. Also called certain drain.

→ Drainage interceptors are referred to by other names, including interception traps, interceptor tanks and filter tanks

Pipe drains in hill roads

Water drained from the pavement surface can be carried forward in the longitudinal direction between the kerb and the pavement for short distances which may be collected in catch pits at suitable intervals and lead through underground pipes.

→ Drainage of surface water is all the more important in hill roads.

Drains in cutting embankment

It is necessary to provide side drain on one side or both sides, when road is constructed in embankment.

→ side drains should be at least 2.0 m away from bottom edge of an embankment.

→ Depth of side drains is kept 1.0 to 1.5 m to prevent the entry of drain water into the embankment.