chapter-1

Introduction.

→ Highway engineering is an engineering of civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people & goods.

→ Highway Engineering became prominent towards the latter half of the 20th century after World war II.

→ standards of highway Engg are continuously being improved.

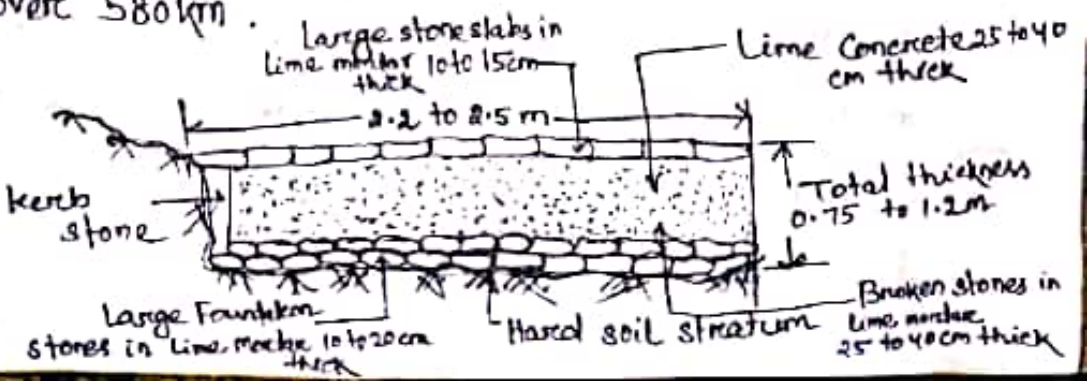
→ Highway engineers must take into account future traffic flows, design of highway intersections/ interchanges, geometric alignment & design, highway pavement materials & design, structural design of pavement thickness, and pavement maintenance.

Order of Road development.

1. Roman Roads.

→ Roman started 1st time construction of roads in large scale.

→ In 312 BC they constructed Appian way of length over 580km.



(Typical cross section of Roman Road)

Main features of Roman Roads are:

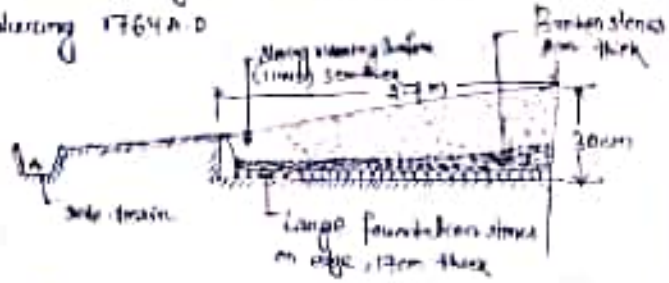
(i) They were built straight regardless of gradients.

(ii) Total thickness was as high as 0.75 to 1.2 metres

(iii) The wearing course consisted dressed large stone-blocks set in lime mortar.

(2) Tresaguet Construction

"Pierre Tresaguet" developed roads in France during 1764 A.D



[Typical Cross Section of Tresaguet Construction]

Main features are:

(i) Thickness was of the order of 30cm.

(ii) Consideration was given to subgrade moisture and drainage of surface water.

(iii) The top wearing surface was made up of angular stone having a cross slope of 1 in 36 to the surface to facilitate surface drainage

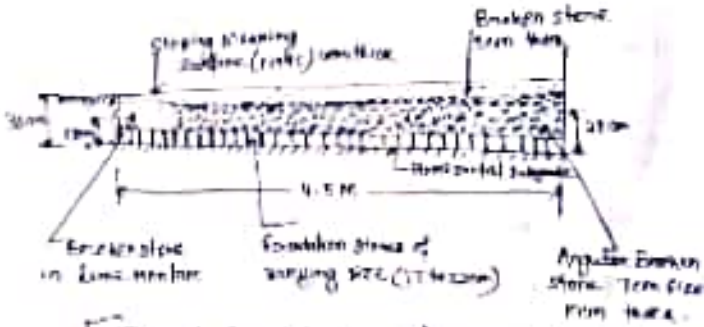
(iv) Shoulder sloping was also provided of the order of 1 in 30.

(3) Metcalf Construction: (1717-1810)

"John Metcalf" was working in England & he followed the instruction of Robert Phillips.

(4) Telford Construction

His work started in early 19th century in England



[Typical Cross section of Telford's construction 1820 A.D]

Main features are:

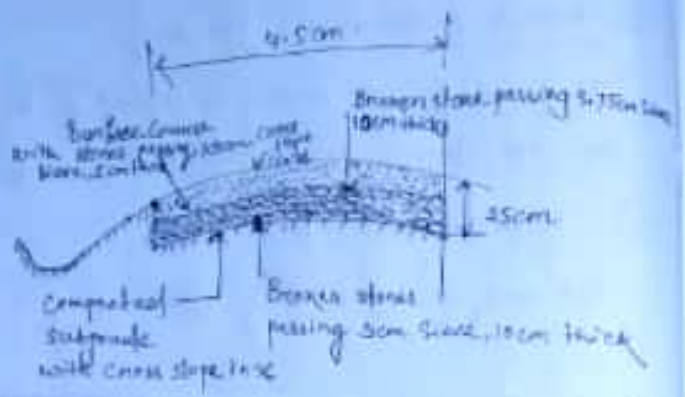
(i) He provided level subgrade of width 9 metres.

(ii) A binding layer of wearing course 45cm thickness provided with cross slope of 1 in 45

(iii) Thickness of foundation stone varied from 17cm at edges to 22 cm at the centre.

(5) Macadam construction:

- 1815 onward he started in England but his new concept came in 1827.
- Thus was the 1st method based on scientific thinking.



Typical Cross Section of Macadam's Construction

Main Features are:

(i) Macadam was the first person who suggested that heavy foundation stones are not at all required to be placed at the bottom layer. He provided stones of size less than 5cm for uniform thickness of 10cm.

(ii) The importance to subgrade drainage & compaction was given so that the subgrade was completed and prepared with cross slope of 1 in 36.

(iii) The size of broken stone for the top layers was decided on the basis of stability under animal drawn vehicles.

(b) Water bound Macadam (WBM)

In this method the broken stones of the base course and surface course are bound by the stone dust in the presence of moisture.

Macadam Method	Telford method
(i) The subgrade was given a cross slope of 1 in 36 to facilitate subgrade drainage.	(i) The subgrade was kept horizontal & hence subgrade drainage was not proper.
(ii) The bottom layer of pavement on the sub base course consisted of broken stones of less than 5cm size to uniform thickness equal to 10cm only.	(ii) Heavy foundation stones of varying sizes, about 15cm, to provide the edges & stone towards the centre were hand packed & prepared to serve as sub base course.
(iii) Base & Surface courses consisted of broken stones of smaller sizes to compacted thickness of 10 & 5cm respectively and the top surface was given a cross slope of 1 in 36.	(iii) Then layers of broken stone were compacted over the foundation stones before laying the wearing course 15cm thick with a cross slope of 1 in 45.
(iv) The total thickness of pavement construction was kept uniform from edge to center to a minimum value of only 25cm.	(iv) The total thickness of construction varied from about 35cm at the edge to about 41cm at the center.

Modern Road developments in India

(i) British government passed a resolution in 1927, in response to which Jayakar Committe was constituted in 1927.

(ii) Jayakar Committee proposed that an extra tax should be levied on petrol to develop a fund called "central road fund".

Recommendations made by Jayakar Committe are:

1. The road development in the country should be considered as a national interest as this has become beyond the capacity of provincial governments and local bodies.
2. An extra tax should be levied on petrol from the road users to develop a road development fund called Central road fund.
3. A semi official technical body should be formed to pool technical knowledge from various parts of the country and to act as an advisory body on various aspects of roads.
4. A research organisations should be instituted to carry out research and development work and to be available for consultations.

Most of the recommendations made by Jayakar committee were accepted & following steps were taken.

5. The central Road fund was formed in 1929.
6. A semi official technical body known as Indian road congress (IRC) was formed in 1934.
7. In 1939 Motor vehicle act was started & in 1950 CRRI (central Road Research Institute) was started.

Other Measures taken are:

8. National highway act was brought in 1956.
9. Highway Research Board was setup in 1973, with view to give proper direction & guidance to road research activities in India.
10. National transport policy committee in 1978.
11. IRC has played important role in the formulation of the last three 20 years road development plans in India.

1. First 20 years Road plan (1943-63)

(i) It is known as Nagpur Road plan.

(ii) The Nagpur road plan formulae were prepared on the basis of "star & grid" pattern.

(iii) The total road length of 4,32,273 km with a density of 16 km of road length per 100 km² area could be available by 1969.

(iv) All the roads were classified into 5 categories
① NH ② SHR ③ MDR ④ VR
⑤ Tr ⑥ ODR

(v) The length of the railway tracks in the area was considered within the road length. Hence net road length is calculated by subtracting length of railway

track from the length of metalled road

② Second 20 years road plan (1961-1981)

Bombay 2nd plan

(i) At the end of plan, the target road length aimed was 32km per 100 square km area.

(ii) Maximum distance of any place in a developed or agricultural area would be 6.4 km from a metalled road and 2.4 km from any category of roads.

(iii) Every town with population above 2000 in plains and above 1000 in semi-hill areas should be connected by metalled road.

(iv) 1600 km Express ways have been considered in this plan within proposed target of NH.

(v) Length of railway track is considered integrated in the road system and hence it is subtracted to get the road length.

(vi) A development factor of 5% is provided for future development.

(vii) This is also known as Bombay Road plan

③ Third 20 years Road plan (1981-2001)

(i) This is also known as Lucknow road plan

(ii) Roads are classified into primary, secondary and tertiary road systems.

(iii) The overall road density was targeted at 82km per 100 square km area.

(iv) The NH network should be expanded to form square grids of 100km sides so that no part of the country is more than 50km away from a NH.

(v) Express ways should be constructed along major traffic corridors to provide fast travels.

(vi) There should be improvement in environmental quality & road safety.

(vii) Primary road system includes

(a) Express ways &

(b) NH

Secondary road system includes

(a) SH

(b) MDR

Tertiary road system includes

(a) ODR

(b) VR.

IRC

(1) It means Indian Road Congress.

(2) It was setup by the govt of India in Dec 1934 on recommendations of Jayakar Committee.

(3) The objective of promoting & encouraging the science for building & maintenance of roads.

(4) It also provides a national forum for sharing of knowledge & pooling of experience on the entire range of subjects dealing with construction & maintenance of roads & bridges.

(3) IRC has now about 13500 members comprising of engineers of all ranks from central & state govts.

Functions of IRC

IRC a body of professional highway engineers provides the following services.

(i) It provides a forum for expression of collective opinion of its members for all matters affecting the construction & maintenance of roads in India.

(ii) It promotes the use of the standard specifications & practices.

(iii) It provides with the suggestions for the better methods of planning, designing, construction, administration & maintenance of roads.

(iv) It conducts periodical meetings to discuss technical problems regarding roads.

(v) It makes the laws for the development improvement & protection of the roads.

(vi) It flourishes and maintains libraries & museums for encouraging the science of road making.

Ministry of surface transport

(1) The ministry of surface transport was a branch of the Govt. of India.

(2) It was the apex body for the formulation & administration of the rules, regulations & laws relating to surface transport in India.

(3) The department of surface transport, within the ministry of transport, was renamed as the ministry of surface transport with effect from 22 October 1986.

(4) The next development was that this ministry was reorganized into the department of shipping & the department of road transport & highways.

(5) This took place on the 15 October 1999.

(6) The ministry was bifurcated into the ministry of shipping & ministry of road transport & highways, with effect from 17 November 2000.

Central road research Institute (CRRI)

(1) Central road research Institute or CRRI established in 1950.

(2) It is constituent laboratory of India's council of scientific & industrial Research.

(3) The CRRI is located in New delhi & conducts research & development in the areas of design, construction, maintenance & management of airport runways.

(4) It also works in area of traffic & surface transportation planning.

IRC classification of roads

The followings are the classification of roads according to IRC

① Based on location

Urban Roads

(a) Arterial roads = The primary function of an arterial road is to deliver traffic from collector roads to freeways or expressways

(b) Sub arterial roads = gives connecting arterial roads to areas of development, and carrying traffic laterally from one part of a neighbourhood to another.

(c) Collector streets = gives a low to moderate capacity road which serves to move traffic from local streets to arterial roads.

(d) Local streets = A street that is primarily used to gain access to the property bordering it

Non Urban Roads =

(a) National highways (NH) = These are network of inter-state roads that is owned by the ministry of road transport & highways. Eg: NH 66 Panvel-Goa

(b) State highways (SH) = These are ordinary roads that link important cities/towns & district headquarters within the state to nearest NH with other SH of neighbouring states.

(c) District roads (DR) =

(i) Major district roads (MDR) = These are major roads within a district, connecting Taluka headquarters & major rural areas to district headquarters.

(ii) Other district road (ODR) = These are roads serving rural areas of production & providing them easy access to nearest centres (Taluka/small) headquarters

(d) Village roads (VR) =

→ These roads serve as the feeder roads of the other highways as well as the roads for inter-village movements

→ They pass through rural areas connecting the villages to one another & to the nearest district roads, SH, NH & highways etc.

② Based on loading

① Class 70R = Can carry 70 tonnes of load at 80 km interval

② Class AA = Can carry 70 tonnes of load at 600 km interval

③ Class A = Can carry extreme loads on Permanent roads

④ Class B = Can carry little lesser loads than Class A roads

③ Based on condition =

① Paved or Unpaved Roads

Paved Road

→ A road with a hard smooth surface of bitumen or tar

→ It is a kind of suitable for travel

Unpaved Road

→ A road not covered with a firm level surface of asphalt, concrete etc.

→ Basic services & facilities are not hard to come by, roads may be unpaved or non existent

→ Improved unpaved roads include gravel roads, laterite roads murram roads & macadamized roads

(13) Surfaced or unsurfaced roads

Surfaced roads:-
Unsurfaced roads are the ones that have gravel surface, chip seal, tarmac or concrete.

→ Asphalt driveways are the best examples of surfaced roads

Unsurfaced roads:-

→ Roads not having a fine macadam (asphalt) surface.

→

Organisation of state highway department:-

(i) The state highways in India are network of roads maintained by the state governments.

(ii) It is constructed and managed by the state public works department.

(iii) The state highways are usually roads that link important cities, towns and district headquarters within the state & connect them with national highways or state highways of neighbouring states.

(iv) Independent of the NHDP program, state governments have been implementing a number of state highway projects since 2000.

chapter No:-

ROAD GEOMETRICS :-

(a) The geometric of highway should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost.

(b) Geometric design of highways deals with the following elements

(1) Cross-section elements (width of pavement, formation & land etc.)
(2) Sight distance considerations
(3) Horizontal alignment details
(4) Vertical alignment details
(5) Intersection elements

Important factors/terms govern the geometric design

(1) Design speed :- This is the most important factor controlling the geometric design elements.

→ It is decided on the basis of type of road and class of road such as NH, SH, MDR etc. & topography of the region

→ It is a selected speed used to determine the various geometric design features of the roadway

(2) Topography :-

Design speed or ruling speed of NH & SH on different terrains are as follows

(a) Plain terrain (cross slope upto 10%) - 100 kmph
(b) Rolling terrain (cross slope upto 25%) - 80 kmph
(c) Mountainous terrain (cross slope of 25% - 60%) - 40 kmph

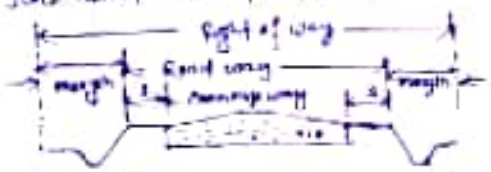
③ Design hourly volume & capacity :-

It may be uneconomical to design the road facilities for the peak traffic flows, therefore a reasonable value of traffic volume is decided for the design which is called the design hourly volume.

Cross section elements :-

① Right of way :- The right of way is the total land area acquired for the construction of the roadway.

→ Its width should be enough to accomodate all the elements of the roadway cross section, and also expansion of road width in future for road development.



S = Shoulder

(A typical diagram of Right of way)

② Formation width :-

→ The formation width of a road is the sum of the widths of roadway + lanes + verges + shoulders.

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

(A typical diagram of formation width)

ROAD MARGIN :-

→ Road margins are the various cross sectional elements of the road except the carriageway or pavement width.

→ Various road margins are ~~shoulders~~, foot paths, cycle tracks, frontage paths, driveways, lay byes, side slopes & guide rails.

④ Road shoulders :- (i) They are provided along the road edge to serve as an emergency lane for vehicle compelled to be taken out of the pavement or roadway.

(ii) The minimum width recommended by IRC is 2.5m

(iii) Desirable minimum width of shoulders is 4.6m.

⑤ Parking Lanes :-

(i) They are provided on urban roads to allow kerb parking.

(ii) 3.0m width is required for parallel parking.

⑥ Lay byes :-

They are provided near public conveniences with guide maps to enable drivers to stop clear of the carriage way.

(iii) They should be 3.5m wide of at least 5m length with 15m end tapers on both side.

(4) Bus bays

- They once provided to avoid conflict with moving traffic
- They should be located 75m away from the intersections.

(5) Drive ways

(i) These are used to connect the highway with commercial establishment like fuel stations, service stations etc.

(ii) They should be away from the intersections.

(6) Cycle tracks

A minimum width of 2.0m is provided and width may be increased by 1.0m for each additional cycle lane.

(7) Foot Path :-

(i) A minimum width of 1.5m is provided.

(8) Guard rails :-

They are provided at the edge of shoulder when the road is constructed on a fill so that vehicles are prevented from running off the embankment especially when the height of the fill exceeds 3m.

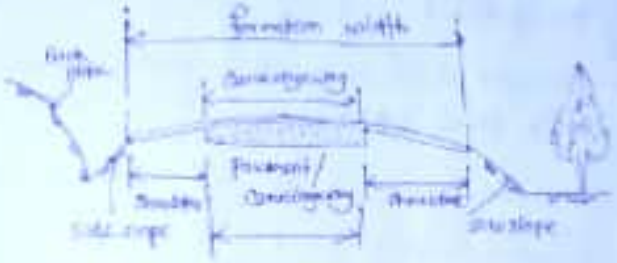
(9) Carriage way

(i) It is the width of the road which is used by the traffic for moving on it.

(ii) It is generally central portion of the total land width and is paved and surfaced with bituminous concrete for service to the road users.

(iii) Width of carriageway depends on the number of the lanes in the road which again depends on the class of the highway.

(iv) If it is higher level road like NH then it will need more numbers of lanes & therefore the carriageway width will be more.



Side slopes :-

Side slope is defined as the slope of the cut or fill expressed as the ratio of horizontal distance to vertical distance.

[Diagram shown above]

Kerbs :-

(i) Kerbs indicate the boundary between the carriage way and the shoulder or islands or foot paths. Kerbs are different types.

(ii) Low or mountable kerbs :- such type of kerbs allow the drivers to enter shoulder area with little difficulty.

The height of this kerbs is about 10cm above the pavement edge with a slope which allows the vehicle to climb easily.

(i) Guard kerb type kerbs :-

(i) When the number of pedestrians is high, these kerbs are provided.

(ii) Their height is 15cm above the pavement edge.

(ii) Barrier type kerbs :-

(i) These are designed to discourage vehicles from leaving the pavement

(ii) Their height is of 20cm above the pavement edge with a steep batter.

Formation level :-

(i) The formation level is the level at which excavation cease and construction commences

(ii) It is the lowest point of the path structure

(iii) It is the prepared ground on which the sub-base layer is laid.

Camber :-

(i) Camber is the slope provided to the road surface in the transverse direction to drain off the rain water from the road surface.

(ii) The requirement of camber of a pavement depends upon

(a) The type of pavement surface

(b) The amount of rainfall

(iii) The camber may be given a parabolic, elliptical or straight line shape.

Types of road surface	Slopes. Heavy rainfall	Light rainfall
1. Cement Concrete & high type bituminous surface	2.0 in.	1.7 in.
2. Thin bituminous surface	2.5 in.	2.0 in.
3. water bound macadam & gravel pavement	3.0 in.	2.5 in.
4. Earth	4.0 in.	3.0 in.

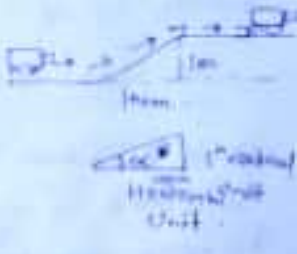
Gradient

(i) A gradient means the degree of inclination.

(ii) It usually means ratio of distance from horizontal plane to change of horizontal way of inclination.

Gradient on Roads

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



Design speed

(i) Design speed is a selected speed used to determine the various geometric features of the roadway.

(ii) The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, & the functional classification of the highway.

Design speed

Road	plain		Rolling		Mountainous		Steep	
	desirable	min.	desirable	min.	desirable	min.	desirable	min.
Expressways	120	100	100	80	80	60	80	60
NH & SH	100	80	80	65	50	40	40	30
MDR	80	65	65	50	40	30	30	20
ODR	65	50	50	40	30	25	25	20
VR	50	40	40	35	25	20	25	20

Average running speed

(i) Average running speed, also called speed mean speed is defined as the length of the route segment divided by the average running time of the vehicles to traverse the segment.

(ii) Running time includes only the time the vehicles spend in travel on the route.

Sight distance

SD is the length of road visible ahead to the driver at any instance.

Following are the three situations

1. Stopping or absolute minimum sight distance
2. Safe overtaking or passing sight distance
3. Safe sight distance for entering into uncontrolled intersections.

- Apart from above three situations, the following sight distances are considered by the IRC in highway design.

(i) Intermediate sight distance: This is defined as twice the stopping sight distance. When overtaking sight distance can not be provided, intermediate sight distance is provided to give limited overtaking opportunities to fast traveled vehicles

(ii) Head light sight distance: Distance visible to driver during night under head lights. This is important for up gradients & ascending Stretch of the valley curves

1. Stopping sight distance (SSD)

(Non passing sight distance) sight distance available on road depends upon

(i) Features of the road
(ii) Height of driver's eye above the road
(iii) Height of the object above road

IRC has suggested the height of eye level of driver as 1.2m & the height of object as 0.15m above the road surface

Stopping distance depends upon following factors

(a) Total reaction time of driver
(b) Speed of the vehicle
(c) Efficiency of brakes
(d) Friction
(e) Gradient of road if any

Total Reaction time

It consist of
(a) Perception time
(b) Brake reaction time

(i) Perception time is the time required for driver to realize that brakes must be applied.

→ Brake reaction time depends upon skill & type of problem.

PIEV Theory

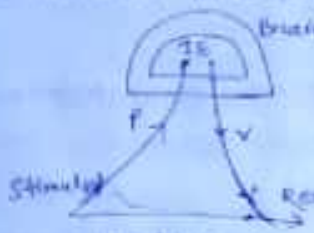
The total reaction time is split into 4 parts

(i) Perception → Time required to perceive an object

(ii) Intellection → Time required to understand the situation

(iii) Emotion → Time elapsed during emotional reaction

(iv) Volition → Time taken for final action



P-Perception
I- Intellection
E- Emotion
V- Volition

Reflex action

Reaction time & PIEV Theory

Total reaction time varies from 0.5 sec to 4 sec.

→ Stopping distance of vehicle is the sum of (lag distance + Braking distance)

A- Lag distance: Distance travelled by vehicle during reaction time.

IRC recommends a value of 2.5 sec for total reaction time.

$$\text{lag distance} = vt \quad (v \text{ in m/sec})$$
$$= 0.278\,vt \quad (V \text{ in km/hr})$$

time t is total reaction time in seconds.

B. Braking distance(l): Distance travelled by vehicle after application of brakes

$$l = \frac{v^2}{2gf}$$ when v in m/sec

$$l = \frac{V^2}{254 f}$$ when V in km/hr.

Hence total stopping sight distance (SSD)

= lag distance + braking distance

$$\Rightarrow SSD = vt + \frac{v^2}{2gf}$$ (v in m/sec)

$$SSD = 0.278\,Vt + \frac{V^2}{254 f}$$ (v in km/hr)

V is in m/sec

Effect of gradient:

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

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

where n = % of gradient.

for ascending use +ve sign & for descending use -ve sign

Q-1 Calculate the minimum sight distance required to avoid a head on collision of two cars approaching from the opposite directions at 30 & 60 kmph. Assume a reaction time of 2.5 seconds, co-efficient of friction 0.7 & a brake efficiency of 50% in either case.

soln

Stopping

Given data

$t = 2.5$ seconds

$f = 0.7$

Brake efficiency = 50%.

$V_1 = 30$ kmph $= 30 \times \frac{5}{18} = 24.99 \approx 25$ m/sec.

$V_2 = 60$ kmph $= 60 \times \frac{5}{18} = 16.67$ m/sec.

As the brake efficiency is 50% the wheels will skid through 50% of the braking distance & rotate through remaining distance. Therefore the value of co-efficient of friction developed f may be taken as 50% of the co-efficient of friction, i.e. $f = 0.5 \times 0.7 = 0.35$

The stopping distance for the car having speed V_1 is SD_1

$$SD_1 = V_1 t + \frac{V_1^2}{2gf} = 25 \times 2.5 + \frac{25^2}{2 \times 9.8 \times 0.35}$$

$$= 153.6 \text{ m}.$$

For second car of speed V_2

$$SD_2 = V_2 t + \frac{V_2^2}{2gf} = 16.67 \times 2.5 + \frac{16.67^2}{2 \times 9.8 \times 0.35}$$

$$= 82.2 \text{ m}$$

sight distance to avoid head-on-collision of the two approaching cars.

$$= SD_1 + SD_2 = 153.6 + 82.2 = 235.8 \text{ m}$$

Ans

Q-2 Calculate the value of (i) Head light sight distance & (ii) Intermediate sight distance for a highway with a design speed of 65 kmph. Assume suitably all the data required.

soln

$V = 65$ kmph

Assume $f = 0.36$, $t = 2.5$ seconds

Head light sight distance $= SSD = 0.278 V t + \frac{V^2}{254 f}$

$$= 0.278 \times 65 \times 2.5 + \frac{65^2}{254 \times 0.36} = 91.4 \text{ m}$$

Intermediate sight distance $= 2 \times SSD = 2 \times 91.4$

$= 182.8$ m.

Overtaking sight distance (OSD)

The minimum distance required for overtaking operation with safety.

→ OSD is also called safe passing distance available

speed of overtaking/overtaken vehicle coming from opposite direction.

→ The spacing between overtaking & overtaken vehicle.

→ Skill & reaction time of driver.

→ Rate of acceleration of overtaking vehicle.

→ Gradient of road, if any

(Overtaking Manoeuvre)

let,

d_1 = Distance travelled by overtaking vehicle A during the reaction time of driver from position A_1 to A_2

d_2 = Distance travelled by the vehicle A from A_2 to A_3 during actual overtaking operation in time T seconds

d_3 = Distance travelled by oncoming vehicle C from C_1 to C_2 during overtaking operation of A i.e. T seconds

let t = 2 seconds

$S = 0.7V_b + 6$ V_b in m/sec

$S = 0.2V_b + 6$ V_b in km/hr

V_b = speed of slow vehicle

$b = V_b T$

(2) $d_2 = b + 2S = V_b T + \frac{1}{2} a T^2$

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

(3) $d_3 = VT$

Imp. Total

$OSD = d_1 + d_2 + d_3 = V_b t + (V_b T + 2S) + VT$

here V_b in m/sec.

Imp.

$OSD = d_1 + d_2 + d_3 = 0.278 V_b t + 0.278 V_b T + 2S + 0.278 VT$

Here V_b is in km/hr.

$T = \sqrt{\frac{4S}{a}}$ where a is in m/sec2

$T = \sqrt{\frac{14.4S}{a}}$ where a is in kmph/sec.

If V_b is not given

then $V_b = V - 16$ (kmph)

$V_b = V - 4.5$ (m/sec) Combination

Q3 The speed of overtaking & overtaken vehicles are 70 & 40 kmph, respectively on a two way traffic road. If the acceleration of overtaking vehicle is 0.99 m/sec^2

(a) Calculate safe overtaking sight distance.

(b) Mention the minimum length of overtaking zone &

(c) Draw a neat sketch of the overtaking zone & show the position of the sign post.

Soln

Given data

$V_t = 70$ kmph $= 70 \times \frac{5}{18} = 19.4$ m/sec

$V_b = 40$ kmph $= 40 \times \frac{5}{18} = 11.1$ m/sec

$a = 0.99$ m/sec^2

$d_1 = V_b t = 11.1 \times 2 = 22.2$ m ——— (1)

$d_2 = V_b T + 2.5$ ——— (2)

$S = 0.7 V_b + 6 = 0.7 \times 11.1 + 6 = 13.8$ m.

$T = \sqrt{\frac{4S}{a}} = \sqrt{\frac{4 \times 13.8}{0.99}} = 7.47$ seconds

Putting in eqn (2)

$d_2 = 11.1 \times 7.47 + 2 \times 13.8 = 110.5$ m.

$d_3 = VT = 19.4 \times 7.47 = 144.9$ m

(a) OSD $= d_1 + d_2 + d_3 = 22.2 + 110.5 + 144.9$

$= 277.6$ m ≈ 278 m.

for two-way traffic

(b) minimum length of overtaking zone $= \frac{2}{3}$ OSD

$= \frac{2}{3} \times 278 = 834$ meters

Desirable length of overtaking zone

$= 5 \times 0.5D = 5 \times 278 = 1390$ m.

(c)

SP_1 = sign post "overtaking zone ahead"

SP_2 = sign post "End of overtaking zone"

(Overtaking zone)

Q4 Calculate the safe overtaking sight distance for a design speed of 96 kmph. Assume all other data suitably.

Soln

OSD $= d_1 + d_2$ for one way traffic

$= d_1 + d_2 + d_3$ for two way traffic.

$V = 96$ kmph

Assume $V_b = V - 16 = 80$ kmph

$A = 2.5$ kmph/sec, $t = 2$ second

$d_1 = 0.278 V_b t = 0.278 \times 80 \times 2 =$

$d_2 = 0.278 \times V_b T + 2.5$

$S = 0.2 V_b + 6 = 0.2 \times 80 + 6 = 22$ m

$T = \sqrt{\frac{4S}{A}} = \sqrt{\frac{4 \times 22}{2.5}} = 11.9$ seconds

$d_2 = 0.278 \times 80 \times 11.3 + 2 \times 22 = 235.312$ m.

$d_3 = 0.278 \times VT = 0.278 \times 96 \times 11.3 = 301.57$ m

OSD on one way traffic road

$= d_1 + d_2 = 44.8 + 295.312 = 340.112$ m.

O.D on two way traffic road $= d_1 + d_2 + d_3$

$= 44.8 + 295.312 + 301.52 = 641.632$ m

Curves:

Necessity of curves:

Curves are needed on highways, railways and canals for bringing about gradual change of direction of motion.

They are provided for following reasons:

(i) To bring about gradual change in direction of motion.

(ii) To bring about gradual change in grade & for good visibility

Horizontal curves

① Simple curve

→ A curve having the same radius throughout and is a single arc of a circle, with two tangents meeting at the intersection.

(Simple curve)

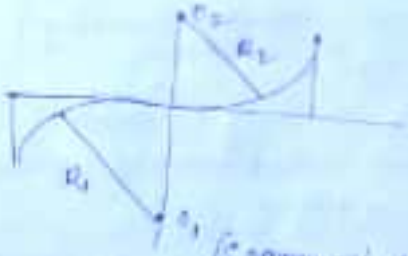
② Compound curve

A compound curve has two or more simple curves with different radii that bend the same way & are on the same side of a common tangent

(Compound curve)

③ Reverse curve

Also called a serpentine curve, it is the arrangement of a compound curve & two simple curves bent in opposite directions, one on opposite sides of the common tangent



(Compound curve)

Vertical

Valley curve

Also called sag curve, this curve dips down & then rises back up. These are placed in case of hills.

→ This is the opposite of summit curve.

Summit curve

- It is also called as crest curve.
- This curve rises and then dips down.
- Curve forms at the peak of hills.
- This is opposite of valley curve.

Transition Curve

- It is usually a horizontal curve in plan to provided to allow transition from a straight alignment to a circular curve gradually.
- In other words, it is a curve which connects a path infinite radius & finite R.
- Transition curves are usually provided between a straight & curved track/roads

Functions

(i) To introduce gradually centrifugal force to avoid jerk.
(ii) Comfort & security of drivers.
(iii) To gradual introduction of superelevation & extra widening.
(iv) To improve aesthetic appearance of the road.

In horizontal curves

Centrifugal force $P = \frac{wv^2}{gR}$

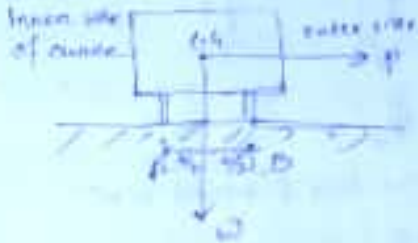
$\frac{P}{w} = \frac{v^2}{gR}$

P is known as centrifugal ratio or impact factor

centrifugal force acting on a vehicle negotiating a horizontal curves has two effects

1. Tendency to overturn the vehicle outwards about the outer wheels
2. Tendency to skid the vehicle laterally outwards

(i) Overturning effect



Equilibrium conditions for overturning will occur when,

$Ph = W\frac{b}{2}$

Hence for no overturning

$\left(\frac{P}{W} = \frac{v^2}{gR}\right) \leq \frac{b}{2h}$

(ii) Transverse skidding effect

Frictional force $= fW$

Centrifugal force $P = \frac{Wv^2}{gR}$

For no skidding :

Centrifugal force $\leq$ frictional force

$\left(\frac{P}{W} = \frac{v^2}{gR}\right) \leq f$

SUPER ELEVATION

It is a transverse slope to counter act the centrifugal force to reduce the tendency of the vehicle to overturn or skid.

Super elevated Pavement section

$$e = \frac{NL}{ML} = \tan\theta$$

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

Where B = Pavement width

E = Relative elevation of the outer edge

Calculation of super elevation

For equilibrium

$$P\cos\theta = W\sin\theta + f(W\cos\theta + P\sin\theta)$$

$$P[\cos\theta - f\sin\theta] = W\sin\theta + fW\cos\theta$$

$$\frac{P}{W} = \frac{\tan\theta + f}{1 - f\tan\theta} = e + f \quad \text{(since } \theta \text{ is small)}$$

$$e + f = \frac{P}{W} = \frac{V^2}{gR} \qquad V \text{ in m/sec}$$

$$\boxed{e + f = \frac{V^2}{127R}} \qquad V \text{ in kmph}$$

R = Radius in m

e = Rate of super elevation = $\tan\theta$

f = Design value of lateral friction = 0.15

Super elevation design

Step 1 Fix the design speed (V in kmph)

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

Step 2 If calculated value of $e < 7\%$ (0.07), the value is obtained is provided.

If it is exceeded 7% then provide max^m value of e is 7%

Step 3 Check f

$$f = \frac{V^2}{225R} - 0.07$$

If $f < 0.15$, the value of $e = 0.07$ is safe.

Step 4 Find allowable speed (kmph)

$$e + f = 0.07 + 0.15 = \frac{V_a^2}{225R}$$

$$V_a = \sqrt{33.75R} \quad \text{(kmph)}$$

If allowable speed (V_a) is higher than design speed

V then design is adequate & provide e = 0.07
$f = 0.15$

If $V_R < V$ then the speed is limited to V_R kmph & appropriate warning sign & speed limit sign are installed.

→ Maximum super elevation

e_{max} = 0.07 (7%) for plain & rolling terrain.
= 0.1 (10%) for hilly terrain
= 0.04 (4%) for urban roads with frequent intersection

Extra Widening of Pavement

Widening is provided for the following reasons.

(a) To avoid off tracking
(b) At speed higher than design speed to encounter transverse sliding
(c) To account rigidity of wheel base
(d) To increase the visibility at curves
(e) While overtaking to encounter psychological widening.

Extra widening (W_e) Pavement consist of
(i) Mechanical widening (W_m)
(ii) Psychological widening (W_{PS})

$W_e = W_m + W_{PS}$

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

n = no of lanes
l = length of wheel base in m
R = mean Radius

Er.- Gayatri Jena

Chapter - 03 ROAD MATERIALS

Different types of road materials in use.

1. Soil
2. Aggregates.
3. Binders.

(1) Soil

(i) The soil is considered as one of the principal highway materials.

(ii) Soils are mainly of mineral matter formed by the disintegration of rocks, by the action of water, frost, temperature & pressure.

(iii) Basic characteristics.

(i) Based on individual grain size, soils are gravel, sand, silt & clay

(ii) The characteristics of soil grains depend upon the size, shape, texture, chemical composition & electrical charges on the surface of fine soil particles.

(iii) Moisture and dry density influence the engineering behaviour of soil mass.

Desirable properties. - If a soil is to be used as highway materials should possess the following properties

1. Stability
2. Incompressibility
3. Permanency of strength
4. Minimum charges in volume & stability
5. Good drainage
6. Ease of compaction

② Aggregates :-

(i) Aggregates are a component of composite materials such as concrete & asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

(ii) Aggregates can either be natural or manufactured.

(iii) Aggregate is used for base & sub base courses for both flexible & riged pavement.

(iv) By volume, aggregate generally accounts for 92 to 96 % of bituminous concrete & about 70 to 80% of portland cement concrete.

Desirable properties for highway Road constructions are.

1. Strength
2. Hardness
3. Toughness
4. Shape of aggregates.
5. Adhesion with bitumen
6. Durability etc.

③ Binders.

The materials used in road construction for binding together the road aggregates and providing a smooth and impermeable surface for movement of vehicular traffic is called Binders.

The common binders used in road construction are:
(1) Cement (2) Bitumen (3) Tar.

Function of binders.

The various objectives achieved by binders in road construction are:

1. It acts as a cushion for the road surface & absorbs the kneading and abrasive action of wheel loads
2. It makes the road surface impermeable i.e it seals the surface against ingress of water.

function of soil as highway subgrade.

→ The unconsolidated mineral material of earth is known as soil. Soil plays many important roles in construction of highway.

→ for highway subgrade soil serves the following functions:-

(1) To provide an adequate support to the road Pavement.

(2) To provide stability to the road pavement.

(3) To provide good drainage of rain water Percolating through the road pavement.

(4) Soil should ~~not~~ not deflect excessively due to dynamic loading.

(5) ~~Should~~ soil should have permanency of strength and possesses minimum changes in volume when loading takes place.

California Bearing Ratio :-

→ This test is penetration test developed for evaluating the stability of soil subgrade & other flexible pavement materials.

→ The test can be performed in laboratory on prepared samples or in-situ on location.

→ It is important to appreciate that this test, being of an empirical in nature, is valid

Procedure

1. Sieve the sample through 20mm IS sieve.
2. Take 5kg of sample of soil specimen.
3. Add water to the soil in the quantity such that optimum moisture content or field moisture content is reached.
4. Then soil & water are mixed thoroughly.
5. Spacer disc is placed over the base plate at the bottom of mould & a coarse filter paper is placed over the spacer disc.
6. The prepared soil water mix is divided into 5. The mould is cleaned & oil is applied. Then fill one fifth of the mould with the prepared soil. The layer is compacted by giving 56 evenly distributed blows using a hammer of wt 4.89kg

(7) The top layer compacted soil is scratched. Again 2nd layer is filled & process is repeated. After 3rd layer, collar is also attached to the mould & process is continued.

(8) After 5th layer collar is removed & excess soil is struck off. Remove base plate & invert the mould. Then it is clamped to base plate.

(9) Surcharge wt of 2.5 kg is placed on top surface of soil. Mould containing specimen is placed in position on the testing machine.

(10) The penetration plunger is brought in contact with the soil & a load of 4kg is applied so that contact betn soil & plunger is established. Then dial readings are adjusted to zero.

(11) Load is applied such that penetration rate is 1.25 mm/min. Load at penetration of 0.5, 1, 1.5, 2, 2.5, 3.4, 5, 7.5, 10 & 12.5 mm are noted.

$$\% CBR = \frac{\text{Load (or pressure) sustained at 2.5 or 5 mm penetration}}{\text{Load (or pressure) sustained at by standard aggregate corresponding pressure level.}} \times 100$$

Significance of CBR.

(1) It is generally used to classify & evaluate the soil subgrade & base coarse materials for the flexible pavement.

(2) This test is empirical & the results can not be accurately related with any fundamental properties of the material.

(3) As per IRC recommendation the min. value of CBR required for a subgrade should be 8% (eight percentage).

Testing of aggregates.

The following tests are conducted for identifying the characteristics of aggregate.

(1) Abrasion test.

Abrasion test is carried out to test the hardness of stones.

Tests are of following type.

(i) Los Angeles abrasion test.
(ii) Devel abrasion test
(iii) Dorry abrasion test.

(i) Loss Angeles abrasion test.

(i) Due to the movements of traffic the road stones used in the surfacing course of pavements are subjected to wearing action at the top surface.

(ii) Resistance to wear or hardness is hence an essential property for road aggregates, especially when used in wearing course.

(iii) Thus road stones should be hard enough to resist the abrasion due to the traffic.

Test Procedures.

(i) 5 to 10 kg ~~agg~~ weight aggregates are taken.

(ii) The aggregates is placed in the los angeles abrasion machine along with the specified abrasive charge.

(iii) The machine is rotated at a speed of 30 to 33 rpm (revolution per minute) for 500 to 1000 revolutions.

(iv) Then the abraded aggregate is sieved on 1.7 mm IS sieve and the weight of powdered aggregate passing is taken.

(v) The abrasion value is expressed as the percentage loss in weight due to abrasion.

(vi) Co-efficient of hardness $= 20 - \frac{\text{Loss of wt. in gm}}{3}$

(vii) The result of the abrasion test expressed as the percentage wear or the % passing 1.7 mm sieve expressed in terms of the original weight of the sample.

(viii) The abrasion value of good aggregates for high quality pavement materials should be less than 30%. However for base course in WBM it may be 50 %.

(2) Impact test:

(1) Impact test is used to measure the toughness of aggregates.

(2) Toughness of aggregates mean it can sustain the instantaneous load, and vibrations and shock on the aggregate.

Test Procedure:

(i) The test sample consists of aggregates sized 10 mm to 12.5 mm. Aggregates may be dried by heating at 100-110°C for a period of 4 hours and cooled.

(ii) Sieve the material through 12.5 mm and 10 mm IS sieves. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.

(iii) Pour the aggregates to fill about just 1/3rd depth of measuring cylinder.

(iv) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod. Add two more layers in similar manner so that cylinder is full. & compact 25 ~~gentle~~ times through tamping in each layer.

(v) Strike off the surplus aggregates.

(vi) Determine the net weight of the aggregates to the nearest gram (w).

(vii) Place the aggregate full mould under impact machine centrally.

(viii) Raise hammer and freely fall on the aggregate. Sample 15 times with a interval not less than 1 sec.

(ix) ~~Hammer~~ i Remove aggregate and sieves in 2.36mm IS sieves.

(x) Weigh the fraction passing the sieve to an accuracy of 1gm. Also weigh the fraction retained in the sieve.

(xi) Aggregate Impact value (I.V) $= \frac{w_2}{w_1} \times 100$.

(xii)

Impact value	Classification,
(1) < 20 %.	Exceptionally strong.
(2) 10-20 %.	Strong.
(3) 20-30 %.	satisfactory for road surfacing.
(4) > 35 %.	Weak for road surfacing.

(3) Crushing strength test.

(i) Aggregates possessing resistance to crushing under gradually applied crushing load or having low aggregate crushing value are preferred.

(ii) The stone aggregates used for the construction of road pavements should possess satisfactory resistance to crushing under the roller during construction and under the application of heavy wheel loads on the pavements during its service life.

Test Procedure

(i) Take a dry aggregates passing 12.5 mm IS sieve and retained on 10mm sieve is filled in cylindrical vessel filled in 3 equal layers.

(ii) A crushing load of 40 tonnes is applied at a rate of 4 tonnes/minute and the crushed aggregate is sieved on 2.36 mm I.S sieve.

(iii) Aggregate crushing value $= \frac{W_2}{W_1} \times 100$

where W_2 = Crushed material passed 2.36 mm sieve.

W_1 = Sample material.

(iv) The crushing value for surface course should be less than 30%. and should not exceed 45% for base course.

(4) Water Absorption test.

(i) Water absorption gives an idea on the internal structure of aggregate.

(ii) Aggregates having more absorption are more porous in nature and are generally considered unsuitable, unless found to be acceptable based on strength, impact and hardness tests.

Procedure

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Procedure for Aggregate coarser than 6.3 mm.

(1) About 2kg of aggregate sample is taken, washed to remove fines and then placed in wire basket. The wire basket is then immersed in water, which is at a temperature of 22°c to 32°c.

(2) Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second.

(3) The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour.

(4) The basket and aggregate are weighed while suspended in water, which is at a temperature of 22°c to 32°c.

(5) The basket and aggregate are removed from water & dried with dry absorbent cloth.

(6) The surface dried are also weighed.

(7) The aggregate is placed in a shallow tray and heated to 100 to 110°c in the oven for 24 ± 0.5 hours. Later, it cooled in an air-tight container and weighed.

Calculation

weight of saturated aggregates in air W_1 g.

weight of over dry aggregates in air W_2 g.

water absorption (%) = $\frac{W_1 - W_2}{W_2} \times 100$

water absorption value in percentage of aggregates are considering upto 3%.

Soundness test

This test is intended to study the resistance of coarse & fine aggregates to weathering action and to judge the durability of coarse aggregate.

Procedure

1. Take individual samples in a wire mesh basket & immerse it in the solution of sodium sulphate or magnesium sulphate for not less than 16 hrs nor more than 18 hrs, in such a manner that the solution covers them to a depth of at least 15mm.
2. After completion of the immersion period, remove the samples from solution and allow it to drain for 15 mins & place it in drying oven.
3. Dry the sample upto constant mass & then remove & cool it in room temp.
4. After cooling again immerse it in the sol^n in step-1
5. Repeated same process upto 5 to cycles.
6. Then sample has been cooled & wash it. This may be determined when there is no reaction of wash water with barium chloride.
7. Then dry in over in 105°c to 110°c temp & weigh it.
8. Sieve the fine aggregates over the same sieve on which it was retained before test.
9. Sieve the coarse aggregate over the sieve.

size of aggregate	sieve used to determine loss.
63mm to 40mm	31.5mm.
40mm to 20mm	16.mm.
20mm to 10mm	8mm
10mm to 4.75mm	4mm

→ max^m loss 12%.

chapter-4

Gayatri Jena

ROAD PAVEMENTS.

There are two types of pavements based on design considerations i.e. flexible pavement & rigid pavements.

Flexible Pavements.

(i) This can be defined as the one consisting of a mixture of asphaltic or bituminous material and aggregates placed on a bed of compacted granular material of appropriate quality in layers over the subgrade.

(ii) Water bound macadam roads and stabilized soil roads with or without asphaltic toppings are exemples of flexible pavements.

(iii) The design of flexible pavement is based on the principle that for a load of any magnitude, the intensity of a load diminishes as the load is transmitted downwards from the surface by virtue of spreading over an increasingly larger area, by carrying it deep enough into the ground through successive layers of granular material.

(iv) flexible pavements are those, which on the whole have low or negligible flexteral strength and are rather flexible in their structural action under the loads.

(v) The flexible pavement layers may reflect the non recoverable as well as recoverable deformation

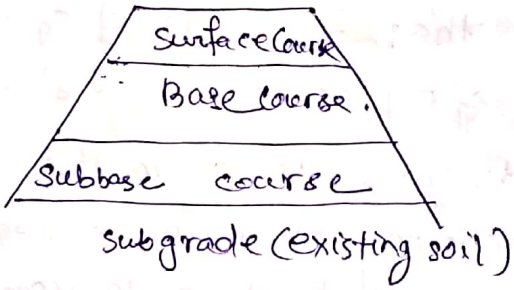
of the lower layers including the subgrade on to the upper layers and also to the pavement surface.

(VI) Thus if the lower layer of the pavement or soil subgrade gets deformed or undulated to somewhat similar pattern.

(VII) The vertical compressive stress is maximum on the pavement surface directly under the wheel load and is equal to the contact pressure under the wheel.

(VIII) It consists of four layer/course.

(a) Wearing course / surface course.
(b) Base course
(c) Sub base course.
(d) Subgrade course.



(flexible pavement cross section)

merits

The following are the advantages of flexible pavement.

(1) Adjust to limited differential settlement
(2) Easily repaired.
(3) Additional thickness added any time.
(4) Non skid properties do not deteriorate.

(5) Tolerates a greater range of temperature.

Demerits

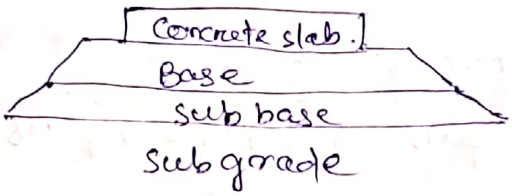
(1) Loses some flexibility and cohesion with time.
(2) Needs resurfacing sooner than PC concrete.
(3) Not normally chosen where water is expected.
(4) Higher maintenance costs.
(5) Shorter life span under heavy use.
(6) Damage by oils & certain chemicals.

Rigid pavements.

(i) Rigid pavements are those which possess noteworthy flextural strength or flexural rigidity.
(ii) The rigid pavements are generally made of portland cement concrete and are therefore called 'cc pavements'.
(iii) plain cement concrete pavement slabs made of specified strength characteristics are laid, with or without steel reinforcement at the joints.
(iv) most common material used for the design and construction of rigid pavements is high quality plain cement concrete meant for the pavement, generally called "Pavement Quality Concrete' (PQC).
(v) The cc pavement slabs made of PQC are generally expected to sustain upto 45 kg/cm^2 of flexural stresses.

(vi) In rigid pavements the stresses are not transferred from grain to grain to the lower layers as in the case of flexible pavement layers.

(vii) It consists of four layers including concrete slab.



(Rigid pavement cross-section.)

Merits / Advantages

1. Durability is good rigid.
2. Pavement is good.
3. Life cycle of rigid pavement is long.
4. Withstand repeated flooding & surface water.
5. Good subgrade is not required.

Demerits

1. May lose skid surface with time.
2. May fault at transverse joints.
3. Large layer thickness.
4. The setting is so slow.

Subgrade preparation.

(1) setting out is the process of extracting information from the construction drawings, and pegs, Profiles or other marks are then set to control the construction works and to ensure that each features in drawings are constructed.

setting out alignment of road.

The alignment of road should be according to map or drawing such that every point regarding the necessity of should be fulfilled.

So after identifying the area on which road is constructed should align the road way path property for the next method of road construction.

→ The site should be cleared properly, setting out bench marks, control pegs for embankment & cutting.

(i) After completion of site clearance / embankment the limits of sub-grade shall be marked by fixing pegs on both sides at regular intervals.

(ii) The chainage boards and working bench mark shall be set outside the limits of construction areas.

Selection of Material & Borrow areas / Borrow pits

Material :-

The material used in subgrade shall be soil, moorum, gravel, a mixture of these or any other material approved by the engineer.

→ It shall be free from logs, stumps, roots, rubbish & any other material detrimental to the stability of structure.

→ The roadway material shall be obtained from source nearby roadway excavation area.

Borrow pits

Borrow pits are dug along the alignment of a road for using its material in the construction of embankment for road. Borrow pits should not be dug within 0.8 km of towns & villages.

Dewatering

If the foundation of the embankment is in area with stagnant water, it is feasible to remove it by bailing out or pumping.

Stripping & storing top soil :-

In localities where most of the available embankment materials are not conductive to plant growth, the top soil from all areas of cutting shall be stripped to specified depths not exceeding 150 mm & stored in a stock piles of height not exceeding 2m for covering embankment slopes.

Compacting ground supporting embankment/subgrade.

Where necessary, the original ground shall be levelled to facilitate placement of first layer of embankment, scarified, mixed with water & then compacted by rolling so as to achieve minimum dry density.

→ In case difference in subgrade level and ground level is less than 0.5m & the ground does not have 97% relative compaction, the ground shall be loosened upto a level 0.5m below the subgrade level, watered & compacted in layers to not less than 97% of dry density.

Spreading materials in layers & bringing to appropriate moisture content:

① The embankment & subgrade material shall be spread in layers of uniform thickness not exceeding 200mm.

② Checking of subgrade.

Trueness of the subgrade is checked after its preparation.

Surface level of the subgrade along the road alignment is checked by using a levelling instrument.

As per IRC, the actual level of subgrade should not differ from the drawing by more than 25mm.

The transverse profile like camber is checked by using a template.

Equipment used for subgrade preparation :-

The following equipments are used for subgrade preparation.

1. Tractore
2. Bulldozer -
3. Greadere
4. shovel - most powerful & giant excavating machine
5. Rollere
6. Dumper
7. Dragline.

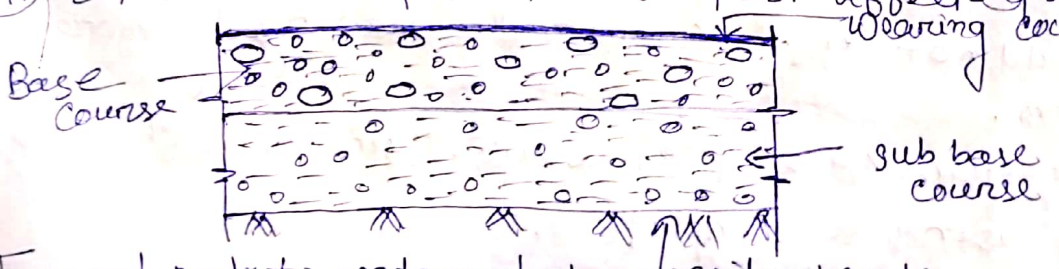
Sub-base Course.

Necessity of sub-base :-

(1) Sub-base course is a layer of pavement material provided between sub-grade and base course.
(2) It is provided as an additional layer when the sub-grade is of poor quality.
(3) It consists of broken stones, slag, broken burent bricks etc.
(4) At the sub base course it is desirable to use small size aggregates for proper interlocking.

The sub base course has the following feenction:

(i) It improves the bearing capacity of sub-grade.
(ii) It checks the capillary rise of sub soil water.
(iii) It prevents subgrade material from working up into the base course.
(iv) It eliminates frost heave in frost affected area.



Component parts of a road pavement structure

The sub base course should be stabilized with the required stabilization.

Soil stabilization.

Definition.

* Soil stabilization is a process of treating a soil to improve its stability and bearing capacity for using construction material.
* This is a method of changing the soil properties by the use of controlled compaction, proportioning or the addition of suitable admixtures.

Purpose of soil stabilization.

Stabilization of soil is practised 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 earthwork in embankment as a whole.
(viii) To make use of locally available inferior quality materials.

Methods of soil stabilization / Types of soil stabilization.

Following are the commonly used types of soil stabilization

(1) Mechanical stabilization.
(2) Cement stabilization
(3) Lime stabilization
(4) Flyash stabilization.

(1) Mechanical stabilization.

(1) Mechanical stabilization of soil involves two operations:
(i) Changing the composition of soil by addition or removal of certain constituents.
(ii) Densification or compaction.

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

(3) Similarly the stability of fine grained could be improved by mixing a suitable proportion of granular materials.

(4) For mechanical stabilization, where the primary purpose is to have a soil resistant to deformation and displacement under loads, soil material can be divided into two fractions, the granular fraction and fine soil fraction.

(5) The granular fraction provides strength & hardness

(6) The fine fraction provides cohesion, water retention capacity & also acts as a filler

(7) If the soil collected from one source does not meet the gradation and plasticity requirements of a job, it becomes necessary to mix materials from more sources for obtaining the desired mixture. The

(8) The blending of materials is done by making trial combinations.

(2) Cement stabilization.

(i) The soil stabilized with cement is known as soil cement.

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

(iii) In coarse grained soils, the mechanism of stabilization is due to the development of bond at the point of contact of hydrated cement and compacted soil particles.

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

(v) Soil cement can be used as a sub-base or base course of all types of pavements.

(vi) The various factors which influence the properties of soil cement are:

(a) Nature of soil.
(b) Cement content
(c) Conditions of mixing
(d) Compaction & curing
(e) Admixtures.

(3) Lime stabilization.

(1) Hydrated lime is very effective in treating high plastic clayey soil.

(2) When clayey soil with high plasticity are treated with lime, the plasticity index of soil is decreased and the soil becomes friable and easy to be pulverized.

(3) Sandy soil can also be stabilized with lime.

(4) Lime imparts some binding action in granular soils.

(5) Soil-lime is quite suitable as sub base course for high types of pavements and base course for pavements with low traffic.

(6) Soil-lime cannot be used as surface course, due to poor resistance to abrasion & impact.

(4) Fly Ash stabilization :-

(i) Fly ash materials have binding properties, so this also are used for the stabilization of soil.

(ii) Fly ash is the waste material generated from the thermal power plants.

(iii) So the use of fly ash makes the soil stabilization cheaper.

(iv) Fly ash is a biproduct from burning coal which makes steam to generate electricity.

(v) When burning coal, combustion particles rise out of the combustion chamber with flue gasses. They are captured in filters to prevent them from reaching the atmosphere & collected for disposal or beneficial reuse. These particles are called fly ash.

(vi) There are two types of fly ash, class C & class F.

(vii) Class C has self cementing properties & is used in the production of concrete as a substitute for portland cement, & as a chemical stabilizing & modifying agent to dry &/or strengthen poor soils.

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Base Course.

→ Base course is a layer of pavement material between surface course and sub-base course.

→ Generally large size particles like boulders, bricks are used as base course.

→ This course is considered as the most important component of pavement structure because it has to bear the impact of traffic transferred through wearing course.

Preparation of Base Course.

(i) If there is a sub-base course, the base course is constructed directly above this layer. otherwise, it is built directly on the top of the subgrade.

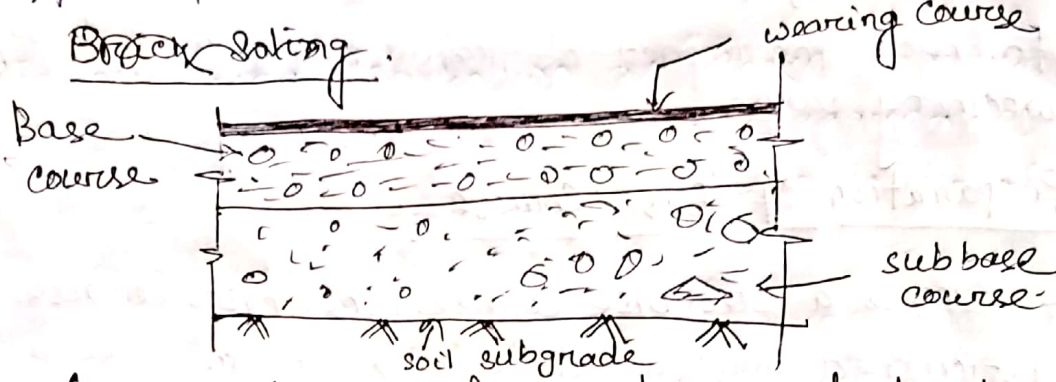
(ii) Typical base course thickness ranges from 100 to 150 mm (4 to 6 inch) and is governed by underlying layer properties.

(iii) Generally consisting of a specific type of construction aggregate, it is placed by means of attentive spreading & compacting to a minimum of 95% relative compaction, thus providing the stable foundation needed to support either additional layers of aggregates or the placement of an asphalt concrete wearing course which is applied directly on the top of the base course.

(iv) Aggregate base (AB) is typically made of a receipe of mixing different sizes of crushed rock together forming the aggregate which has certain desirable properties.

(v) 20 mm or 3/4 in aggregate Base, class 2, is used in roadways & is an aggregate made of a specific recipe of different sizes & quality of rock inclusive of 20mm (3/4 inch) to fine dust.

(vi) An aggregate is normally made from newly quarried rock, or it is sometimes allowed to be made from recycled asphalt concrete &/or portland cement concrete.



(Component parts of a road pavement structure).

Brick Soling :-

(i) The word "soling" is derived from "sole".

(ii) "Sole" means a base on which something rests.

(iii) In road construction works,

"Brick soling" means the lowest layer of road, which is built with bricks and sand.

(iv) Brick soling is the layers of brick laid directly on the subgrade.

(v) Bricks are laid either on edge or flat in one or more layers.

(vi) The thickness of soling depends upon the traffic conditions.

Stone soling

(i) In stone soling, stones are proper shape and size are taken and arranged on the prepared subgrade by hand.

(ii) stones are laid on their wider faces in such a way that their tops conform to the profile of pavement.
(iii) Voids of larger of stones are filled with smaller stones.
(iv) Stone soling is extended at least 15cm beyond the proposed pavement width on either side.
(v) Stones are then compacted by using heavy roller.
(vi) A layer of sandy soil of 25 mm thickness is spread over the stones, watered & compacted by using 6 to 8 tonnes roller.

Metalling

(i) Applying gravel, or metalling has had two distinct usages in road construction.
(ii) The term road metal refers to the broken stone or cinders used in the construction or repair of roads or railways, and
(iii) This word metalling derived from the latin word metallum which means both "mine" & quarry.
(iv) It is compacted with a certain thickness in base course so to achieve desirable strength.

Water bound macadam.

(i) water bound macadam construction should consist of clean, crushed or broken aggregates mechanically interlocked by rolling & bounded together with screening binding material & water.
(ii) The most common & durable material for use as

aggregates in WBM is broken stone aggregates, crushed slag, overburnt brick aggregates & naturally occuring aggregates such as kankar or laterite are also used.

(iii) The coarse aggregates used in W.B.M construction are of following sizes: 90mm to 40mm size, 63mm to 40mm & 50mm to 25mm sizes are used for surface course.

(iv) The screening also known as "choke" materials, fill in the voids left in coarse aggregates after they are compacted and help to cement the stone aggregates together.

(v) Generally screenings are of same materials as the coarse aggregates.

Wet mix Macadam.

(i) wet mix macadam consist of laying, spreading and compacting of clean, crushed, well graded granular materials on a prepared & approved granular Sub-base.

(ii) The material is well-~~graded~~ mixed with water and rolled to a dense mass.

(iii) ~~It~~ shall be laid on one or more layers as per line & level, grade & cross section

(iv) The thickness of single compacted wet mixed macadam (WMM) Base shall not be less than 75 mm.

(v) maximum thickness of single compacted layer base can be upto 250 mm upon approval of engineer.

Bituminous Construction:

(i) In bituminous constructions, bituminous materials are used in preparation of base course.

(ii) materials that are bound together with bitumen are called bituminous materials.

(iii) The use of bituminous materials were initially limited to road construction, now have spread over the area of roof construction, for industrial purposes, carpet tiles, paints & as a special coating for water proofing.

The following are the different construction techniques are used

1. Surface dressing & seal coat
2. Interface treatments like prime coat & tack coat.
3. Grouted or penetration type construction
   - (a) penetration macadam
   - (b) Built up spray macadam
4. Premix which may be any of the following
   - (a) Bituminous bound macadam
   - (b) Carpet
   - (c) Bituminous Concrete
   - (d) Sheet asphalt or rolled asphalt
   - (e) mastic asphalt.

Surfacing:

Surface dressing: The surface dressing work is done only in dry & clear weather when the atmospheric temperature is above 16°C.

(i) Premixed Carpet.

(i) It is used for surface course.

(ii) Open graded, should be covered by suitable seal coat.

(iii) The premixed carpet consists of all aggregates passing 20mm & retained on 6.3mm sieve

(iv) Premix Carpet (PC) is the oldest hot mix in India.

(v) It is good, economical, bituminous wearing course mixed to be placed in road construction.

(ii) Semi dense Carpet.

(i) The semi-dense bituminous concrete (SDBC) mixes have neither dense nor open graded characteristics.

(ii) It consists of the so called pessimum voids when they are fully constructed.

(iii) When the semi dense bituminous concrete is employed with bitumen macadam (BM) layer, there is chances for the penetration of rain water through the SDBC & reach the bitumen macadam.

(iv) This will create the separation of aggregates and the bitumen in the BM layer.

(v) This will cause stripping & the scaling of SDBC, etc

(vi) The scaling later with time will result in the potholes on the road.

Bituminous Concrete / Asphalt concrete (AC)

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

(ii) The AC consists of a carefully proportioned mixture of course aggregates, fine aggregates, mineral fillers & bitumen & mix is designed by an appropriate method (Marshal method)

(iii) The IRC has provided specification for 40 mm thick AC surface course for highway pavements.

Mastic Asphalt

(i) Mastic Asphalt is a mixture of bitumen, fine aggregates & filler in suitable proportions which yields a voidless & impermeable mass.

(ii) It can absorb vibrations & has a property of self healing of cracks without bleeding.

(iii) It is a suitable surfacing material for bridge deck slabs.

(iv) It should be spread at a temp of about 200°C to a thickness bet^{n} 2.5 to 5.0 cm.

(v) No rolling is required in this.

Grouting

(i) Grouting is the process through which the dense fluid which is used to fill the gaps or used as reinforcement in the cracks on the roads pavement.

(ii) Grouted is generally a mixture of water, cement & sand & is employed in pressure grouting, embedding rebar in masonry walls, filling voids & sealing joints on the roads

(iii) It is often color tinted when it has to be kept visible & sometimes includes fine gravel when being used to fill large spaces.

Prime Coat

(i) Bituminous prime coat is the first application of low viscosity liquid bituminous material over an existing porous or absorbent pavement surface like WBM base course.

(ii) The main object of priming is to plug in the capillary voids of the porous surface and to bond the loose minerals particles on the existing surface using a binder of low viscosity which can penetrate into the voids.

(iii) Usually MC or SC cutbacks are used.

(iv) The primed surface is allowed to cure for at least 24 hours, during which period no traffic is allowed.

Rigid pavements.

(i) Rigid pavements posses noteworthy flexible strength or flexural rigidity.

(ii) These transfer the load through slab action but not grain to grain as in case of flexible pavements.

(iii) These consists of 3 layers
- (a) Cement concrete slab
- (b) Base course
- (c) Soil subgrade.

(iv) The rigid pavements are made of portland cement concrete either plain, reinforced or prestressed.

(v) The plain cement concrete are expected to take up about 40kg/cm² flexural stress.

(vi) These are designed using elastic theory, assuming pavement as an elastic plate resting over an elastic or a viscous foundation.

Concept of concrete roads as per IRC specification

Sub base for rural roads as per IRC : SP : 62-2004

(1) It provides a uniform and reasonably firm support.

(2) It ~~prevent~~ prevents mud-pumping on subgrade of clays & silts.

(3) It acts as a levelling course on distorted, non-uniform and undulating subgrade.

(4) It acts as a capillary cut-off.

Thickness of sub base:

(1) For a designed wheel load of 51 kN, 150 mm thick WBM or GSB may be provided.

(2) For a designed wheel load of 30 kN, 75 mm thick WBM or GSB may be provided.

Note: When the above type of sub-base is provided, effective k value may be taken as 20% more than k value of the subgrade.

(3) A plastic sheet of 125 micron thick shall be provided over the sub-base to act as a separation layer between the sub-base & concrete slab.

Chapter No-05

Gayatri jena

HILL ROADS.

Introduction -

→ A terrain can be classified into following four groups based on the cross slope:

Terrain.	Cross slope (%)
plain or level	0 - 10
Rolling	10 - 25
Mountaneous	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

or What road.

→ Selection of a suitable alignment of a hill road is a complex job.

→ To decide the road alignment thorough knowledge of the geological formations of the area is essential.

→ Geometric standards of plain roads cannot be adopted in hill roads.

→ In the hill alignment massive and costly protective works are required at many places resulting in heavy expenditure.

→ In the maintenance of hill roads prevention of soil erosion and landslides of hill slopes is a major problem.

classification of hill roads.

Generally hill roads are classified as:

(i) National highways.
(ii) state highways
(iii) Major district roads.
(iv) Other district roads
(v) Village roads.

Hill roads can also be classified as.

(i) motor roads → Main
(ii) Bridle paths → Paths used by pedestrians & mule traffic
(iii) Village paths → communication between villages and other working areas in hill regions.

Component of hill road.

(i) Retaining wall
(ii) Breast wall

(iii) Parapet wall
(iv) Catch water drain
(v) Cross drain
(vi) Side drain - It is provided on the road side, usually at the foot of hill slope to collect drainoff water.
(vii) Road bed → It is pavement portion of the hill road.

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.

→ This type of wall is constructed in case the cross-section of the road is partly in cutting and partly in filling.

→ In order to permit easy drainage the retaining wall should be built in dry stone masonary.

→ The high retaining walls can be built of brick masonary or cement concrete.

→ The top width of retaining wall should not be less than 600mm, while the bottom width should not be less than 0.4 times the height of the retaining wall.

→ Top width should be at least 750 m.

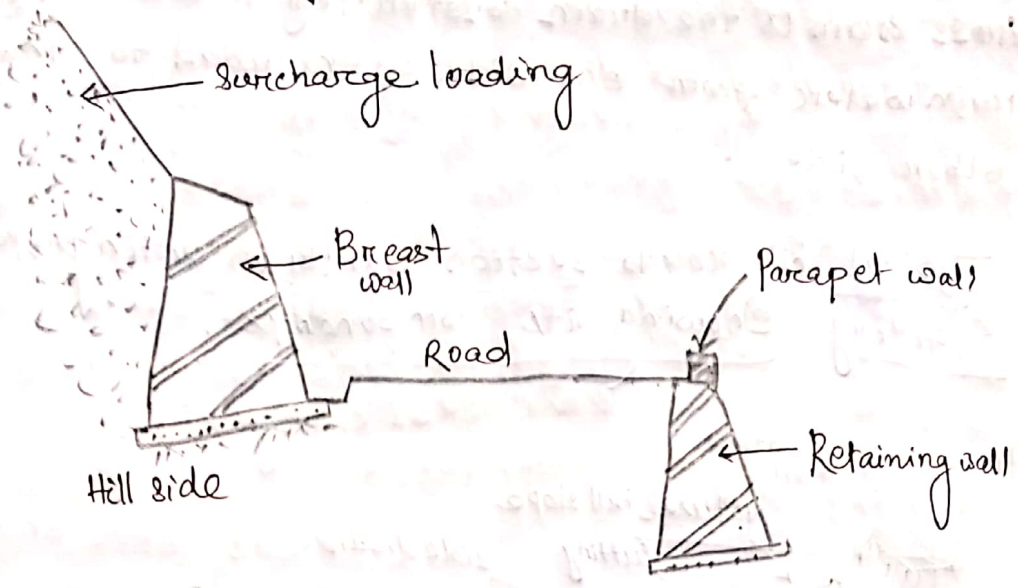
Breast wall.

→ The wall construction on the uphill side of roadway in order to retain earth from slippage is called breast wall.

→ This wall has back face vertical and front face batter.

→ The top width of breast wall should be 600mm thick.

→ This type of wall is constructed of stone masonary brick masonary or cement concrete.



[cross section of a hill road]

Parapet wall :

→ The wall constructed above the formation level of a hill road usually towards the down hill side is known as parapet wall

→ Parapet walls are provided to give protection, physical and psychological, to the motorists while travelling on roads with steep valley slopes.

→ This type of wall should not be made continuous but suitable gap is provided in between.

→ Generally the walls are 3.6 m long with gaps of 1.5 m.

Catch water drain.

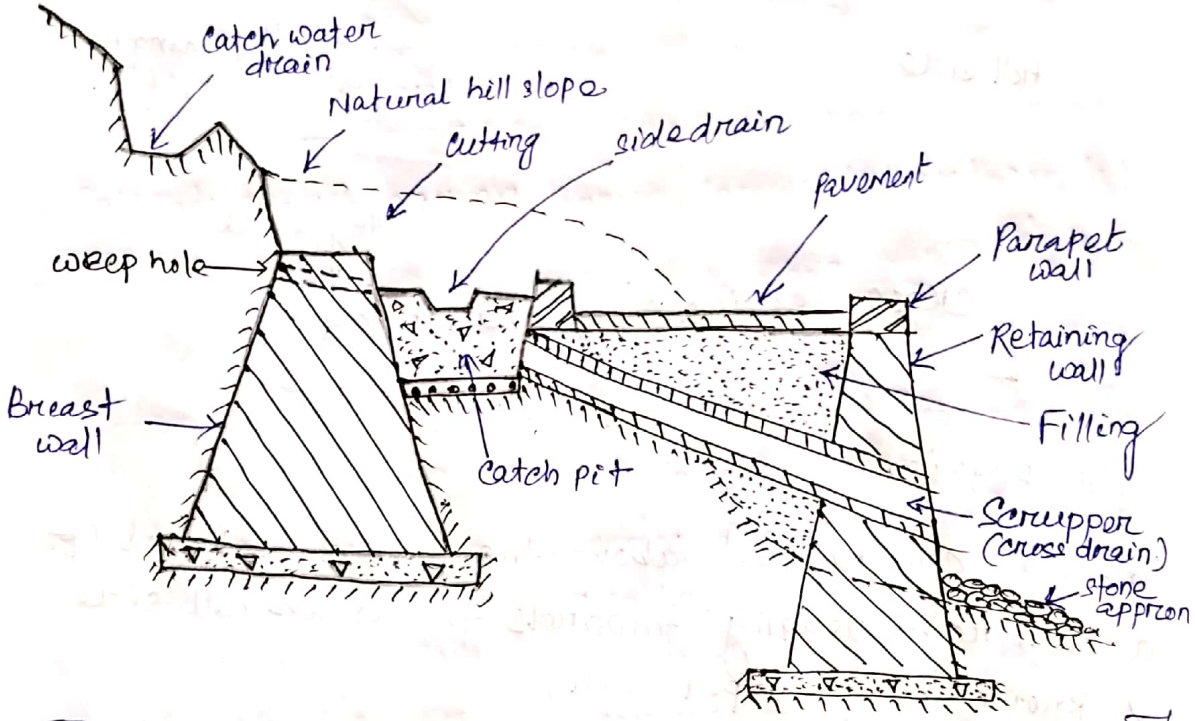
→ The drain provided high up on the hill slope side in order to intercept and divert the water from hill

slope is called catch water drain

Cross drain

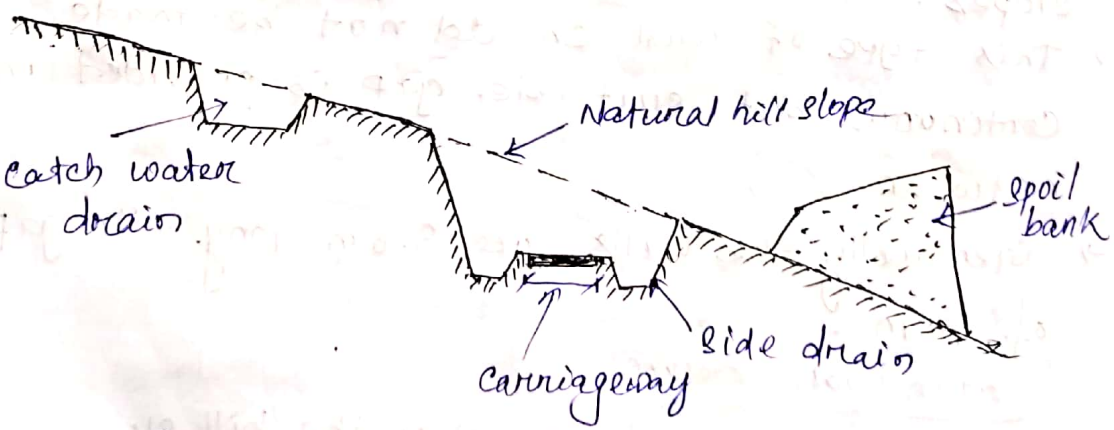
Cross drain is the drain constructed to drain off rainwater from one side of the road to the other side.

Typical hill roads section partly in cutting & partly in filling showing its components.



[Typical cross sections showing all details of a typical hill road partly in cutting and partly in filling]

Hill road completely in cutting



[Section of hill road completely in cutting]

Different types of bend / curve on hill roads :

The curves which are commonly used in hill roads are as follows :

(i) Hair pin curves.
(ii) Re entrant curves
(iii) Salient curves

(i) Hair pin curves.

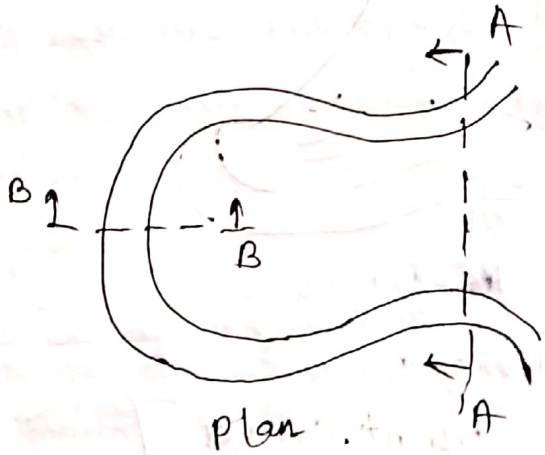
→ This is a compound curve in a hill road which changes its direction through an angle of 180° or so, on the same side down the hill.

→ The curve confirms the shape of a hair pin so it is called a hair pin curve

→ The bend is just like hair pin is located on a hill side having the minimum slope and maximum stability.

→ It must be safe from view point of landslides and ground water.

→ IRC recommended that where a number of hair pin bends have to be introduced a minimum intervening length of 60m should be provided between successive bends.



Plan

Re-entrant curves.

→ Re-entrant curve at the valley of a hill having its concavity outwards.

→ The centre of curvature of a re-entrant curve lies away from the hill side.

→ it is provided to negotiate a deep but narrow valley, forming an open bend re-entrant curves provide adequate visibility and are less dangerous.

Salient curves.

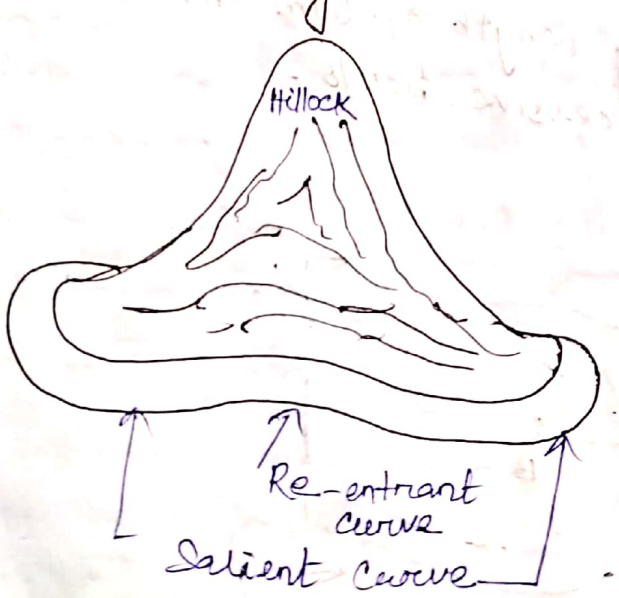
→ Salient curves having their convexity outwards.

→ The centre of curvature of this type of curve lies towards the hill side.

→ The bend formed by the salient curve in a hill road is known as corner bends.

→ These curves are very dangerous as they donot provide adequate visibility.

→ A parapet wall is provided at the outer edge of this type of curve to prevent the vehicles from falling down hill slopes.



[Re-entrant & salient curves]

chapter-06

Gayatri Jena

ROAD DRAINAGE

Introduction :-

→ Road drainage is the process of interception & removal of water from over, under and vicinity of the road surface.

→ For safe and efficient design of road, road drainage is very important.

→ The stability of road pavements can be maintained only if their surface and foundation bed remain in dry condition.

→ During rains, part of the rain-water flows on surface and part of it percolates in the subgrade or any other layer of ~~water flows~~ the pavement.

→ If this water is not removed it may cause the road pavement failure.

Necessity of road drainage work

Road drainage work is necessary because of the following reasons.

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

(ii) Excess moisture content in soil subgrade causes considerable lowering of its stability.

(iii) The entrance of water causes reduction in bearing capacity of soil subgrades like WBM & stabilized soil.

(iv) Due to poor drainage, waves and corrugations are formed in flexible pavements which causes

failure of pavement.

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

(vi) In rigid pavements failure occurs by mud pumping due to the presence of water in fine subgrade soil.

(vii) Poor drainage work causes erosion of soil from the top of unsurfaced road, slopes etc.

(viii) The Shoulder and pavement edges get damaged due to excess water.

(ix) Increase in moisture content causes increase in weight and thus increase in stress & simultaneous reduction in strength of the soil.

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 the other as quickly as possible.

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

→ Quick drainage prevents water from penetrating into the soil sub-grade & thus prevents failure.

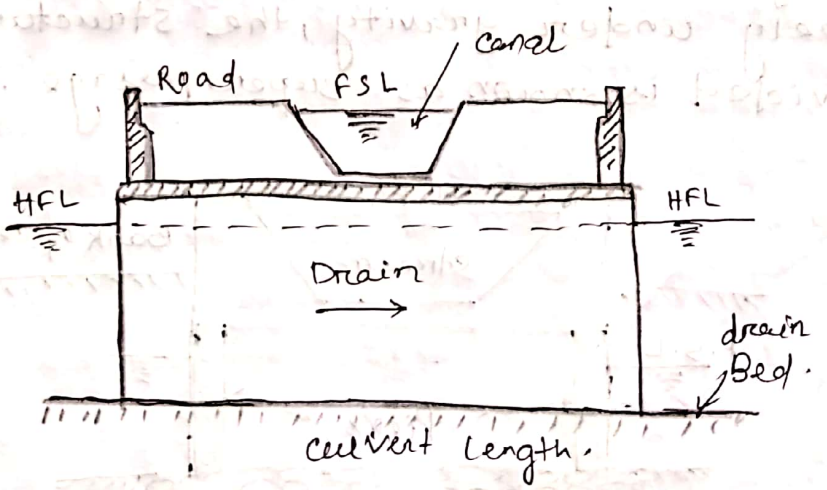
→ The structures constructed at the crossing point for the easy flow of water of the canal and drainage in the respective directions, are known as cross drainage works.

Thus the cross drainage works are classified depending upon the bed levels of the canal & drainage as follows.

① Aqueduct and syphon aqueduct.
② Super passage & canal syphon
③ Level crossing.

① Aqueduct

when the bed level of the canal is higher than the higher flood level (H.F.L) of the drainage, then the cross drainage work (or structure) is said to be aqueduct.



[Aqueduct]

syphon aqueduct

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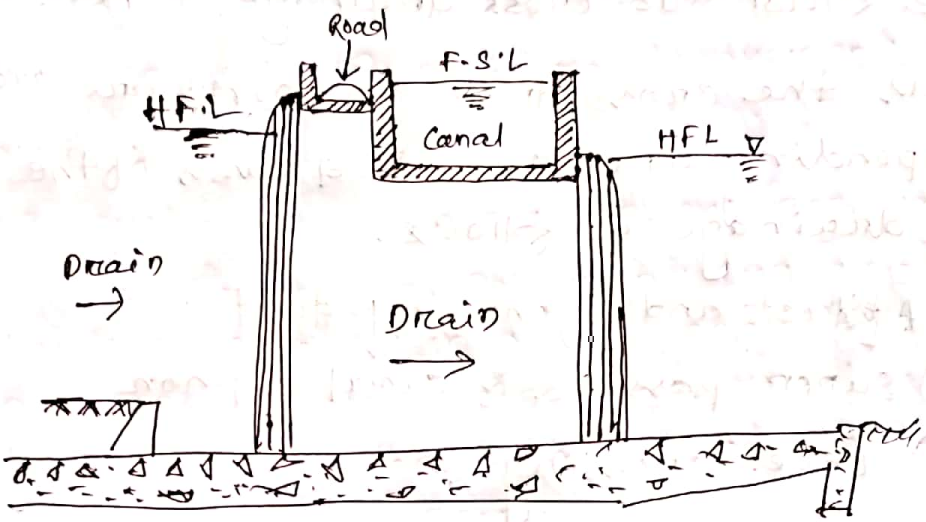
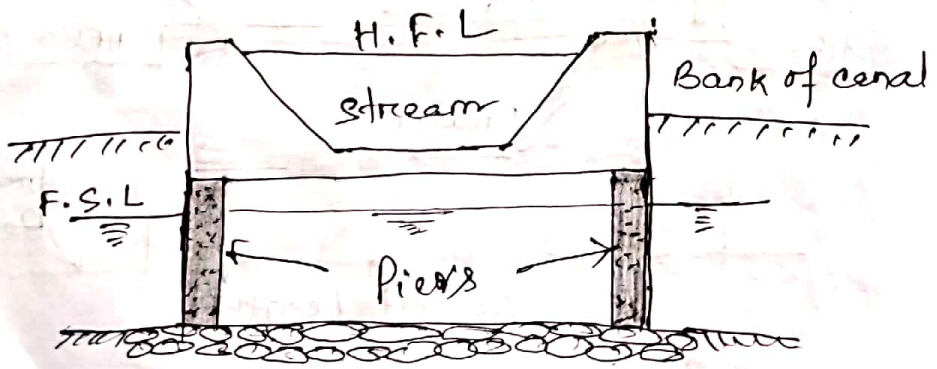
In case the bed level of the canal is below the highest flood level (H.F.L) of the drainage so that the drainage water passes through the aqueduct barrels under syphonic action, then the structure provided is known as syphon aqueduct.



[syphon aqueduct]

Super passage

When FSL of the ~~drainage~~ canal is much below the bed level of the drainage trough, so that the ~~the~~ canal water flows freely under gravity, the structure provided is known as super passage.



[super passage]

Canal syphon.

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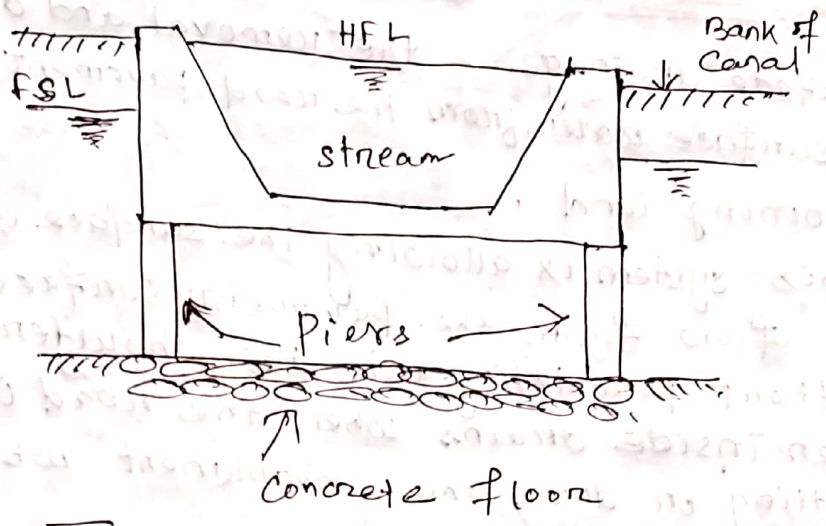
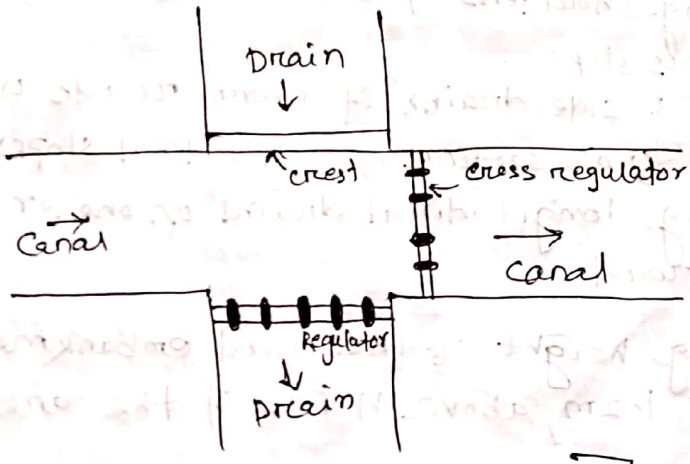
When the FSL of the canal is much above the bed level of the drainage trough, so that the canal water flows under syphonic action under trough (drain), the structure provided is known as canal syphon.



[Canal syphon]

Level crossing

When the bed level of the canal and that of the drainage are at the same level, the structure provided is called level crossing. This is a type of cross drainage works in which the canal water and drain water get intermixed.



[Level crossing]

Road drainage works are classified as follows.

1. Surface drainage
2. Sub surface drainage
3. Cross drainage.

(1) Surface drainage.

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

→ This system is allowing the surface water to flow from the pavement surface without percolating into the shoulders & then inside drains when the road is in cutting or down the embankment when it is in embankment.

→ The water is first collected in side drains and it is disposed off at the nearest stream, valley of water course.

Methods of providing surface drainage:

steps generally taken to provide effective surface drainage are as follows.

(i) Providing a impervious pavement surface.
(ii) Providing a sufficient cross slope or camber to the pavement.
(iii) Providing shoulders of rural roads with sufficient cross slope.
(iv) Providing side drains of rural roads with suitable cross section & longitudinal slopes.
(v) Providing longitudinal drains on one or both sides of road.
(vi) Keeping height of the road embankment atleast 1-2m above H.F.L of the area.

sub surface drainage.

→ sub-base surface drainage is the system of diversion or removal of excess soil water to the ground water.

→ The main function of sub surface drainage is to keep the variation of moisture in subgrade soil to a minimum.

Methods of providing sub-surface drainage.

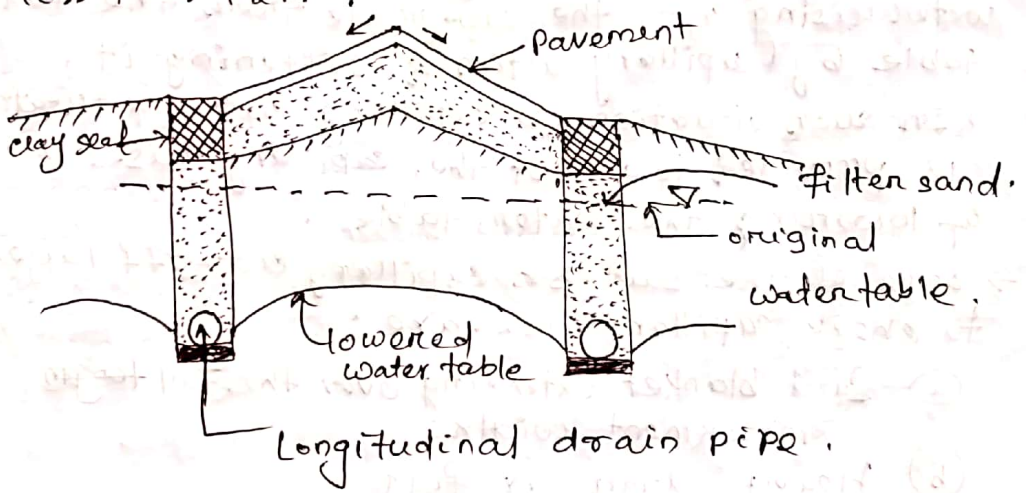
The following methods are adopted for sub-surface drainage:

(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.

→ At places where water table is high, the best remedy is to make the road formation in embankment of height not less than 1.2 m.



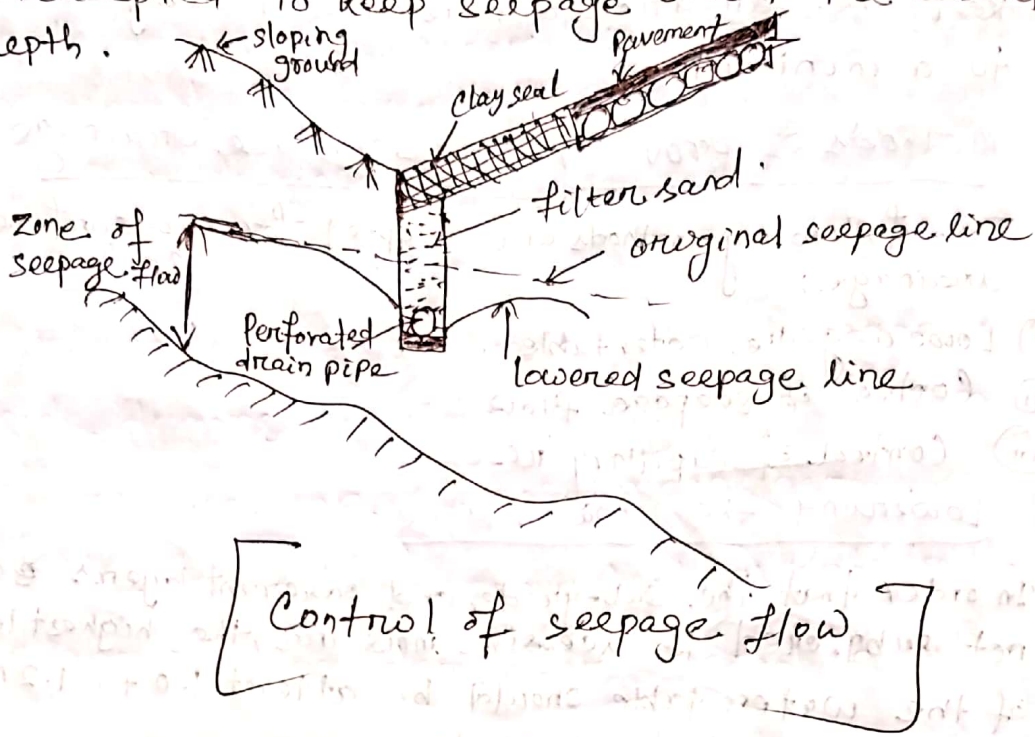
[Lowering of water table by using longitudinal drain & filter sand]

(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 the road sub-grade

and affects its strength.

→ If the seepage zone is at a depth less than 60 to 90 cm from the road subgrade, it should be intercepted to keep seepage line to the desired depth.



[Control of seepage flow]

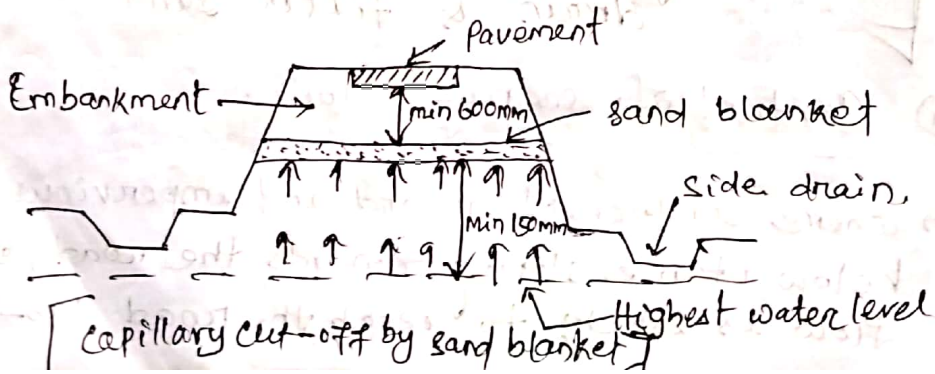
(iii) Control of Capillary Rise:

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

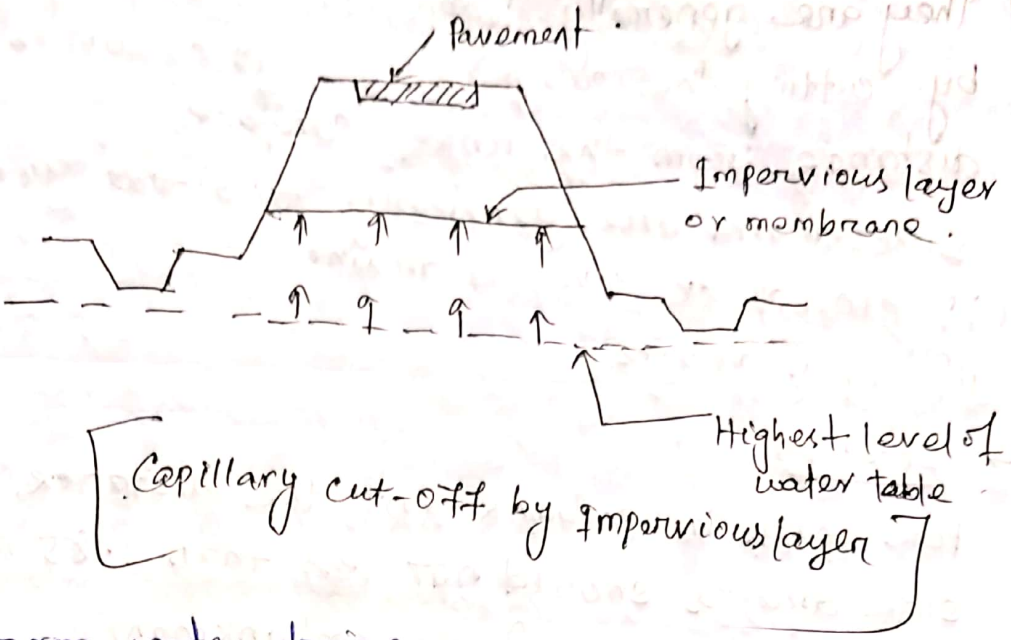
→ In such situations, a capillary cut off treatment is provided to arrest the capillary rise instead of lowering the water table.

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

(a) Sand blanket extending over the full length embankment width.
(b) Heavy duty tar felt
(c) polythene envelope
(d) Bituminous stabilized soil.



[capillary cut-off by sand blanket]



Storm water drains.

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

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

→ storm drains often cannot manage the quantity of rain that fall in heavy rains or storms.

→ There are two main types of storm water drain inlets.

(i) side inlets
(ii) Grated inlets.

→ Many inlets having gratings or grids to prevent people, vehicles, large objects or debris from falling into the storm drains.

Side drains.

Side drains are more commonly known as ditches from which the water is led away in mitre drains.

→ These are longitudinal drains provided parallel to the road for collecting & disposing the surface

water.

→ They are generally trapizoidal in shape provided by cutting the subgrade soil at a suitable distance from the road surface.

Side drains are generally two ~~cat~~ groups

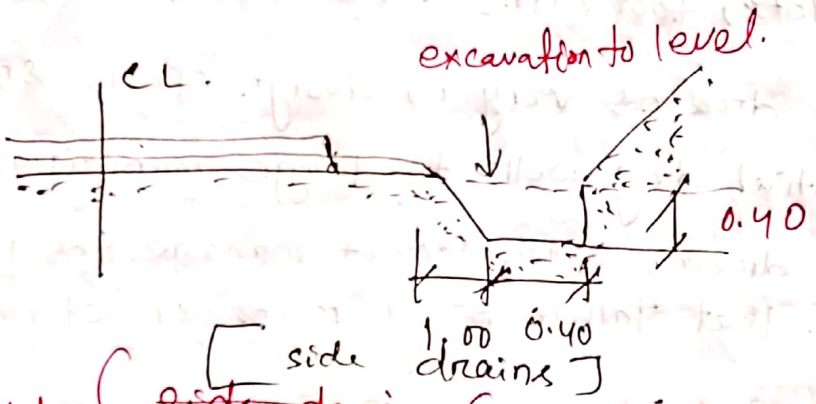
(i) closed or covered drains

(ii) Open drains

→ Location

For roads in embankment the distance of side drains should not less than 1.85 m from the toe of the embankment.

→ Side drains are provided just after the edges of shoulder for road in cutting.



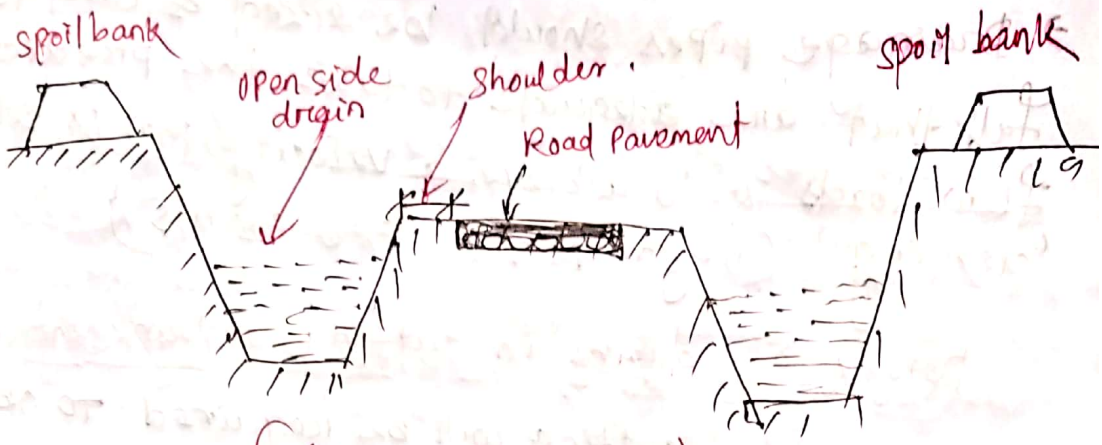
[side drains]

side ditches ~~(side drain (one ditch only))~~

The size of side ditches must therefore be sufficient to cope with the run off of water.

→ When a road with 4½ 4 ½ m formation width is to be provided with a 5% compacted (camber (7% loose) the size of ditch should be.

When there are ditches on both sides of the road ~~the of~~ each side ditch can be reduced to 0.3 m.



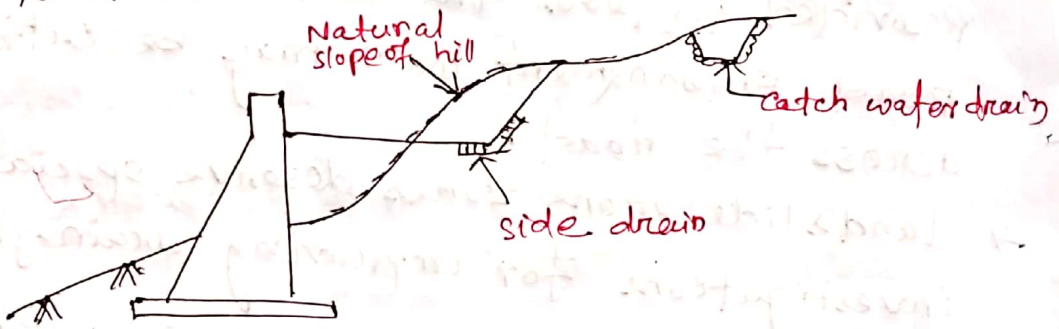
(Open side drain)

Intercepting drain.

→ A drain located between the water source and Protected area.

→ Intercepting drain also known as catch-water drains.

→ These are provided in the uphill slope of hill roads to intercept the water and lead it to a natural water stream.



[Intercepting Drain]

Pipe drains in hill roads

water drained from the pavement surface can be carried forward in the longitudinal direction between the kerb & the pavement for short distances which may be collected in catch pits at suitable intervals & lead through under-ground pipes.

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

→ Drainage pipes should be sized & laid to falls that are adequate to take the predicted flow loads & to achieve a velocity that is self-'cleaning' (regarded as 0.75 m/s)

Details of drains in cutting embankment.

→ Embankment & cutting will be required to obtain a satisfactory alignment on all but the lowest standard of road embankment will be needed.

(i) To rise the road above flood & water level:
(ii) In sidelong ground.
(iii) Across gullies.
(iv) At the approaches.

→ Suitable cross drainage channels should be provided to lead the water across the road embankment which may be cutting across the road.

→ Landslide prone zones deserve special investigations for improving drainage.

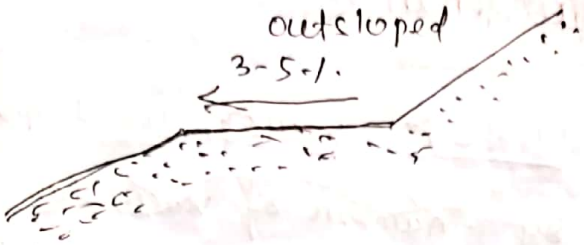
→ Relatively poor embankment soils can perform satisfactorily if drainage is considered in the design.

→ Consideration should be given to deal with the precipitation on the embankment and cut slopes so that erosion is not caused.

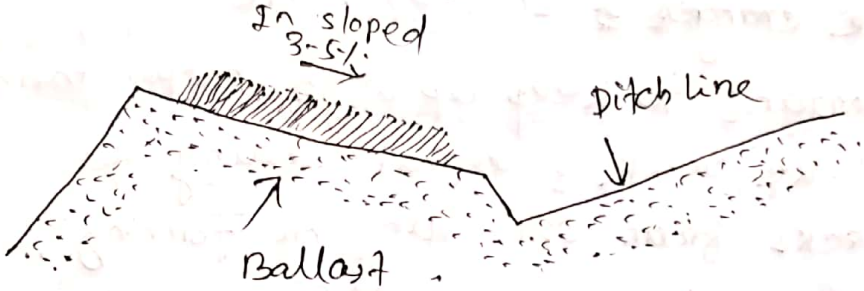
→ Longitudinal drainage should also be ensured, despite the provision of adequate cross-slopes, for better internal drainage of pavement layers, especially granular materials

and ~~it~~ in cert sections.

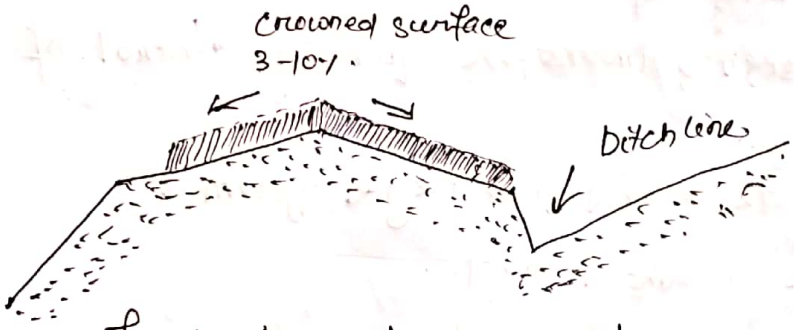
Typical cross sections



typical for temporary roads with dirt surface (no ballast).



Typical cross-section for permanent roads with or without ballast or ditch line.



fastest water removal.
Requires water control on both sides.

(Typical cross section of different roads for drainage.)

Road Maintenance

By Gayatri Jena

Common types of road failures :- Causes :- Introduction

→ Pavement failure is caused by a number of variables including ~~including~~, water intrusion, stress from heavy vehicles, expansion & contraction from seasonal temperature changes & sun exposure.

→ It is important to keep up with proper maintenance like crack & asphalt sealing to prevent cracks from spreading or forming.

Types Causes

→ The following are the causes of failure of any pavement.

(i) Bad quality of construction material.
(ii) faulty design & improper quality control of construction.
(iii) Inadequate road drainage system.
(iv) Increase in wheel load.
(v) Settlement of fill material of embankment.

failure of flexible pavement.

The failure in flexible pavement may be due to
(i) Sub-grade failure
(ii) Base course failure.
(iii) Wearing course failure

These includes :-

(1) Map cracking

This is the most common type of failure of the bituminous surfacing and occurs due to local weak spot.

(2) Longitudinal cracks

These cracks are developed along the length of the pavement.

(3) Also Edge cracking

It forms along the edge of a road & is typically caused by water damage, insufficient base materials & heavy road usage.

(4) Block cracking

→ It is formed by seasonal temperature differences that cause the asphalt to expand and contract.

→ It forms when the asphalt surface is too ~~hor~~ rigid.

5 Joint cracking

Joint cracking forms along asphalt overlay projects where a flexible concrete base is paved over.

→ over time the concrete sub-base will expand & contract causing cracks to form along the joints of the concrete

6. Potholes

→ These are formed through prolonged water intrusion from existing cracks in the surface.

Remedy

→ Once a pothole is formed a patch can be applied to the ~~surface~~ road surface.

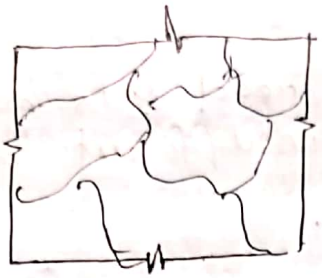
7. Rutting

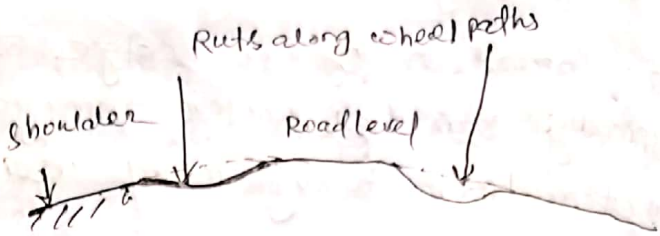
Rutting is channeled depressions in an asphalt surface that form over time from exceeded weight limits & improper base construction

→ It is due to repeated movement of iron wheeled load & heavy traffic wheel load.

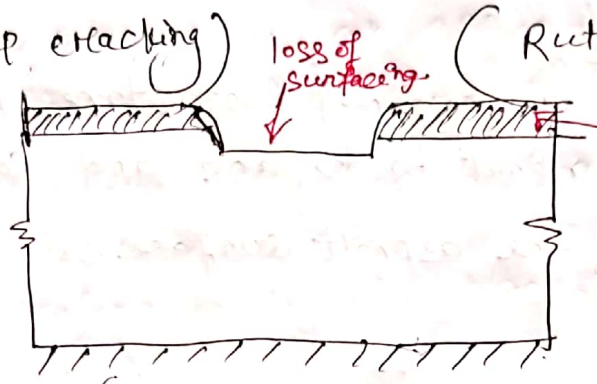
Remedies

→ Proper strengthening of subgrade layer by compaction.
→ Providing proper drainage system.
→ Proper designing of different layer of road.





(map cracking)



(formation of pot holes)

Maintenance of bituminous Roads

It consists of

(i) Patch repairing work.
(ii) Surface treatment.
(iii) Resurfacing

Maintenance of cement ~~Concrete~~ roads:

(i) Treatment of cracks / filling cracks.
(ii) Maintenance of joints.
(iii) maintenance of shoulders.
(iv) Maintenance of traffic control devices.

(i) Patch repairing works.

Patch work is carried out when localized potholes are developed on the road surface.
These consist of following stages.

(i) Cutting of pot holes → Cutting of marked area (ii) is done in rectangular shape & all the affected materials are then removed from it.

(ii) clearing of pot holes :- The cut pot holes are cleaned of all loose materials & dust.
↑ prime coat is then applied in the pot holes.

(iii) Preparing Premix :-
coarse aggregate & bitumen are mixed in desired proportion to get a premix.
→ while preparing premix it should be ensured that prepared premix is similar to original construction.

(iv) filling the premix.
The premix is filled in the pot holes and compacted by using rammer.
→ when pot holes is more than 75mm deep, filling should done in two to three layers.

(2) Surface treatment
If the road surface becomes slippery & patchy due to bleeding of excess bitumen.
That can be rectified by spreading aggregates chips or sand on the road surface & Rolling should be done to develop permanent bond.

(3) Resurfacing
when the pavement surface is totally worn out and develops a poor riding surface, laying of an additional surface coarse on the existing surface may be more economical.
→ Resurfacing operation consists of cleaning the road surface, applying seal coat, applying aggregate chips & rolling.

Maintenance of cement Concrete roads.

(i) Treatment of cracks / filling cracks.
(ii) Maintenance of joints / Repairing joints.
(iii) Maintenance of shoulders.
(iv) Maintenance of traffic control devices.

(i) Filling cracks

→ first cleaned the cracks after identying.
→ cleaned by the cracks by using stiff brush, a sharp tool or by pressure blower.
→ Then kerosine oil is applied on the cleaned cracks for proper bonding of sealing material.
→ Then cracks filled with liquid bituminous material.
→ The sealing material is placed upto 3mm above road level.

(ii) Repairing joints.

→ The weakest parts of cement concrete pavement are the joints.
→ During summer, the sealer material is squized out dece to expansion of cc slab.
→ During winter, the joint gap opens up due to contraction of cc slab.
→ The open up joints are cleaned properly & refill with joint sealer material.

(iii) Maintenance of shoulders.

→ If shoulders are not properly maintained, damage may occur to the pavement as well as to vehicles.
→ shoulders are properly maintained to keep them stable & smoth.
→ During rainy season, shoulders are generally damaged & large pits are developed.
→ These pits are immediately filled with soil & compacted.

(iv) Maintenance of traffic control devices.

The main object of providing traffic control devices is to provide safe, convenient & economical movement of vehicles & persons on the road.

→ The periodic maintenance of those ~~vehicle~~ devices is very essential to avoid any road accident.

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

→ Painting & repairing of traffic islands are carried out.

Traffic study

Basic concepts

Traffic engineering :- Traffic engineering is that phase of transportation engg which deals with planning, geometric design & traffic operations of roads, streets & highways, their networks, terminals etc.

Scope of traffic engg.

It consists

(i) Traffic Surveys.
(ii) Transportation planning
(iii) Geometric design.
(iv) Traffic control.
(v) Administration & management.
(vi) Research.

Traffic Survey

It is conducted to assess traffic characteristics & to collect other data necessary to meet the future traffic needs.

It includes:

(i) Origin & destination study
(ii) Speed & travel time Counts,
(iii) Traffic volume measurements.
(iv) Parking study
(v) Accident study
(vi) Highway capacity study.

Traffic Safety

→ Road traffic safety refers to the methods & measures used to prevent road users from being killed or seriously injured.

→ Typical road users include pedestrians, cyclists, motorists, vehicle passengers, horse riders, & passengers of an road public transport.

→ (mainly buses & trains).

→ Regulation of road users.

motor vehicle users -

→ Dependent on jurisdiction, drivers age, road type & vehicle type, may be required to pass a driving test, conform to restrictions on driving after consuming alcohol or drugs, uses of mobile phones & speed limits.

→ These all should be in mind of a doriver when ~~driv~~ during doriving a vehicles.
→ while government has primary responsibility for providing safe roads, the challenges of development & equity requires that all segments of society engage & contribute including private seetors.

Traffic Control signals.

~~The signals are classi~~

→ Traffic signals are the signalling devices positioned at road intersections, pedestrian crossings & other locations to control flows of traffic.
→ The signals are classified into the following types.

(i) Traffic control signals.
   (a) fixed time signal
   (b) Manually operated signal
   (c) Traffic actuated (automatic) signal.
(ii) Pedestrian signal
(iii) Special traffic signal.

Types of traffic signal system.

simultaneous system.

→ All the signals show the same indication at the same time.
→ As the division of cycle is also the same at all intersections, this system doesnot work satisfactorily

Alternate system.

→ Alternate signals or group of signals show opposite indications in a route at the same time.

→ More satisfactory than simultaneous system.
simple
~~flexible~~ Progressive system.

→ A time schedule is made to permit as nearly as possible a continuous operation of groups of vehicles along the main road at a reasonable speed.

Flexible Progressive System :-

→ In this system it is possible to automatically vary the length of cycle, cycle division & the time schedule at each signalised intersection with the help of a computer.

→ This is the most efficient system of all the four types.

→ Traffic control signals have three coloured light (Red, green, yellow) glows facing each direction of traffic flow.

Red light means :- for "stop"
Green light means - for "Go".
Amber/Yellow light means - for "clearance time".

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chapter-05.

Construction Equipments -

By Jayatra Jena

Preliminary ideas of the following plant & equipment:

① Hot Mixing plant.

(i) Asphalt Drum mix plant, more popularly known as Hot mixing plant in India, is ~~our forte~~.

(ii) ~~With almost 40 years of ex~~ Throughout India & overseas, contractors are using asphalt drum mix plants to produce millions of tons of quality asphalt.

(iii) It blends together aggregates and bitumen to produce the hot mix paving material.

(iv) The aggregates here can be single sized material, finer aggregates are also added along with mineral filler material.

(v) The unique design features makes it most efficient in terms of operational costs, & ensures close control of the quality of output.

(vi) Hot mix plant is designed for road contractors who are very looking for a strong & reliable machine for their important construction projects.

(vii) It will help to make homogenous mix of base or sub base layers before laying of hot mix asphalt.

② Tipper.

(i) A dump truck, known also as a dumper truck or tipper truck,

(ii) It is used for taking dumps (such as sand, gravel or demolition waste) for construction as well as coal.

(iii) A typical dump truck is equipped with an open-box bed, which is hinged at the rear & equiped with

hydraulic rams to lift the front, allowing the material in the bed to be deposited (dumped) on the ground behind the truck at site of delivery.

(iv) In Australia & Newzealand it is known as tipper.

Tractors

(i) A Tractor is an engineering vehicle specially designed to deliver a high tractive effort at slow speeds, for the purposes of hauling a trailer or machinery such as used in construction

(ii) Tractor have many uses as construction equipment, their primary is to pull or push loads.

(iii) Tractors are divided into two major types.

(a) Crawler - These are usually rated by weight & power

(b) Wheel This type of tractors are widely used for most uneven & rough surface.

(b) Wheel.

The main advantages of wheel tractors over crawler tractor is the higher speed.

→ However, the pulling effort of wheel tractor is less than crawler tractor.

Scrapper

(i) Tractor pulled scrapers are very important equipment of earth moving field.

(ii) This equipment can dig load, haul & discharge materials independently i.e without taking any help from other equipment.

(iii) During temporary breakdown of any one of parts of it, other operations can be performed by the machine.

(iv) The Scrapers have the ability to deposit their load in uniformly thick layers which facilitate the spreading operations also.

(v) Scrapers are of two types
(a) Crawler-tractor Scraper
(b) wheel tractor Scraper.

Bulldozers.

(i) It may be used for clearing site, opening up pilot roads, moving earth for short haul distances of about 100m.

(ii) A bulldozer is a tractor equipped with a substantial metal plate used to push large quantities of soil, sand, rubble, or other such material during construction or conversion work.

(iii) It is typically equipped at the rear with a claw-like device to loosen densely compacted materials.

(iv) It is ~~usually~~ usually a crawler tractor.

(v) It can be found on a wide range of sites, mines & quarries, military bases, heavy industry factories, engineering projects & farms.

Dumpers.

i) A dumper is a vehicle designed for carrying bulk material, often on building sites.

ii) Dumpers are distinguished from dump trucks by configuration: a dumper is usually an open 4-wheeled vehicles with the load skip ~~can tip~~ in front of the driver, while a dump truck has its cab

in front of the load.

(iii) They are normally diesel powered.

(iv) Dumpers with rubber tracks are used in special circumstances and provide more even distribution of weight compared to tires.

(v) Modern dumpers have payloads of upto 10 tonnes.

Shovels.

(i) A shovel is a tool used for digging, lifting & moving bulk materials such as soil, coal, gravel, snow, sand or ore.

(ii) A tool resembling a spade with a broad blade and typically upturned sides.

(iii) Most shovels are hand tools consisting blades are usually made of sheet steel or hard plastics.

(iv) & are very strong.

(iv) Shovel handles are usually made of wood or glass reinforced plastics.

(v) The handles are usually riveted in place.

Graders

(i) A grader is a construction machine with a long blade used to create a flat surface.

(ii) Graders are mostly been used in road construction & maintenance of dirt roads and gravel roads.

(iii) The grader typically consist of three axles, with the engine and cab situated top, the rear axles at one end of the vehicle & a third axle at the front of the vehicle with the blade in between.

(iv) Roller dragline.

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

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

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

(iv) The constructional advantage of the machine is that it can dig and dump over longer distances than a shovel can do.

(v) The output of a dragline is only about 70 to 80% of that of a power shovel.

(vi) ~~The dragline is of~~

Asphalt Mixer.

(i) This machine is used for laboratory mixing of bituminous materials to prepare the specimens to be used for various asphalt tests.

(ii) It is widely used in road construction laboratories, testing laboratories, & in research institutions.

(iii) A asphalt mixing plant is a plant used for the manufacture of asphalt, macadam & other forms of coated roadstone, sometimes collectively known as blacktop or asphalt concrete.

Tar boilers.

(i) A tar boilers are widely used in road highways construction & development industry.

(ii) It is small in size and are easy to shift.

(iii) Tar boiler is a kind of boiler used to make the tar into liquid form.

(iv) So tar boiler is used larly in road construction of flexible pavement.

Road Pavers.

(i) A ~~paver~~ Road paver is a piece of construction equipment used to lay asphalt on roads, bridges, parking lanes and other such places.

(ii) It lays the asphalt flat and provides minor compaction before it is compacted by a roller.

(iii) It is also known as paving machine.

(iv) The asphalt paver was developed by Barber Greene Co.

Modern Construction equipments for roads.

The following are also some modern or powerful road construction equipment.

(1) Motor Grader.

(i) Commonly referred to as road graders or maintainer, ~~motor~~ g

(ii) Motor grader is an equipment used to create

flat surfaces for asphalt to be placed on.

(2) Asphalt mixing plant.

It is an important road construction machinery used for the manufacture of asphalt concrete & other forms of coated road-stone used in road construction project.

The plant combines mineral aggregates, sand & a filler - in correct proportions, heats the mixture & then coats it with a binder.

(3) Asphalt Paver.

(i) It is also known as asphalt finisher or paver finisher.

(ii) It is used to layer asphalt on the surface of a road, bridges etc.

(4) Excavator.

(i) It is also known as diggers.

(ii) It is used for excavating earth & rocks & loading them onto dump trucks.

(5) Truck Crane

(i) Truck cranes are important road construction machines.

(ii) These cranes are usually mounted on the back of a lorry to assist with lifting requirements within a road construction site.

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