

5/02/25

UNIT-2.

TRANSPORTATION ENGINEERING

HIGHWAY

2. Highway development in India

- (i) ancient Road (25-30 century BC)
- (ii) Roads in mughal periods
- (iii) British Rule (1861)

(Jayakar committee 1928)

Chair person $\Rightarrow$ M. R. Jayakar

fund $\Rightarrow$ [Central Road fund CRF]
1929

Indian road Congress 1934

[motor vehicle act 1939]

the evolution of road development.

1. Nagpur road plan. (1940-1963)

- (i) The first revision road plan to take known as Nagpur road plan. (1940-1943)
- (ii) The target road length in the Nagpur road plan is 16 km 100 m² area of the country.

(iii) The Nagpur road development plan was first for a time period 1943 to 1963. The it was active 3 years earlier.

(iv) The target road length in Nagpur road plan was 538700 km.

(v) The pattern which is used in road for Nagpur road plan was star and grid.

2. Bombay road plan (1961-1981)

- (i) The second 20 years plan was finished for the time period of (1961 to 1981). It was popularly known as Bombay road plan.

(i) The target road plan for Bombay road plan was almost 35 crore

(ii) The total length of Bombay road plan was 105700 km or 32 m 1100 km²

(iii) The construction of express way of about 1600 km is also included in it.

(iv) Golden Quadrilateral was also included in it (Delhi, Kolkata, Chennai, Mumbai)

3. Lucknow road plan (1981-2001)

(i) The third 20 years road plan is also known as Lucknow road plan.

(ii) The targeted road length was 88 km 1100 km²

(iii) The pattern used in 3rd year road development was square and block pattern.

Topic # Road classification by IRC

1. National highway (NH)
2. State highway (SH)
3. Major district road (MDR)
4. Other district road
5. Village Road (VR)
7. National highway

They are main highways running through the length and breadth of India connecting major & ports, serve highway 'corridor' of major state and large industrial and tourist centre including road network. The distance of traffic all the national highway are covered. The respective quality for example. NH is National highway connecting cities, canton, industrial and commerce.

Class 125

2. State highway

They are road of a state connecting the national highway of adjacent state, district road, highway and imp city with the state, the NH and SH have some differing speed and geometrical design specification.

3. Major district Road.

They are important road with in a district surveying area of production and market and connecting with the other major road on main highway of the district. The major district road have major lower speed.

4. Other district Road.

They are roads surveying rural areas of production and provide them with outlet to market centres, head quarters, block cluster and headquarters and other main road.

5. Village Road

They are roads connecting villages or group of villages with each other to the nearest road of a higher category.

Highway Alignment

The position of the center line of the highway on the layout of the plan highway the on the ground is called highway alignment.

- Highway alignment is generally of 2 types
- (i) Horizontal alignment
 - (ii) Vertical alignment

(A) Horizontal alignment:-

This covers the horizontal part of the road i.e. its shape on curved path. Top view of the road alignment gives horizontal alignment of the road.

2. Vertical alignment:-

This deals with the gradient, slope and the bending of gradient, front view and side view of the road alignment make you understand about vertical alignment.

Factors affecting highway alignment

1. Obligatory points :- (Control points)

The control points governing highway alignment are called obligatory points. At points where the alignment should pass and where the alignment should not pass.

(i) Alignment should pass

- (a) Road are constructed for the development of area a small deviation in alignment can be acceptable if highway passes through the towns, villages, cities, etc.

- (b) The Alignment passing through the mountains it is recommended to look for the best alternative then to construct the tunnel or go around the hills.

(ii) Alignment should not pass.

- (a) The selection of the choice depend upon factor like topography, site condition, construction and operation cost.

(ii) Alignment should not pass.

- (a) It is always recommended to avoid the alignment on small lake, ponds and aquatic alignment upto some extent where construction of bridge or etc.

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Survey for highway alignment

1. MC Study :-

- The study of the topographical map is done to find out the possible route of the road following interrelations between the road, valley, land, and water.
- When the road has to cross a river or hills, materials in that case suitable alternatives should be decided.

2. Reconnaissance Survey :-

reconnaissance

Simple Survey instrument are used in this A procedure following are the interrelation obtain from the Reconnaissance survey.

1.

A number of cross drainage structures.

Value of gradient, length of gradient and radius of circular curve soil type and sources of construction material.

3. Preliminary Survey

- Survey instrument are used during the preliminary survey.
- To collect necessary physical information and detail of topography, drainage and soil.
- To compare different layout is used of the requirement of good alignment to estimate the quantity of costs were.
- To finalized the best alignment.

4. Detailed Survey

Temporary bench mark is fixed at all important structure and drainage structure. Level along the final center line should be taken with great importance, complete preparation of the plan, drawing and estimation of the project is done.

7.

Construction element of highway

1.

Consider on center line it is the cross slope provided to rise the middle of the road. Surface is transfer to drain of rain water from

road surface. The objective of providing kerbs on road surface is:

- Surface protection by the specially for ground and ultimate road.
- Individual protection by proper drainage.
- Least drying of pavement which is then increase safety.
- Types of kerbs.

(1) Barbed 2. Straight 3. Combination of Barbed and straight



2. Width of carriage way.

- Width of carriage way and width of pavement depends upon the width of traffic lanes and number of lanes.

- Width of traffic lane depends on the width of vehicle and the clearance.

- The maximum permissible width of vehicle

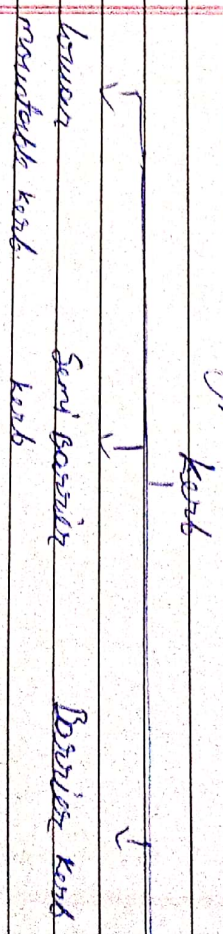
is 2.44m and the desirable sight clearance for single lane traffic is 0.68m

These require minimum of lane with 3.75m for a single lane road.

IRC Specification for carriage way width.

1. Single lane 3.75m
2. Two lane, no kurb 7.0m
3. Two lane with kurb 7.5m
4. Intermediate carriage way 5.5m
5. Multi lane 3.5m

Kerb: Kerb indicates the boundary between the carriage way and the shoulder (and foot path) and are three types of kerb.



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11. Sight Distance.

Sight Distance is a length of road visible to a driver at any location on the distance available at any location on the road. The way in which a driver's vision is affected by the pavement surface has visibility along the roadway on meeting object. The sight distance between the driver and the object is measured along the road or surface.

12. Types of sight distance.

1. Stopping sight distance.

The minimum distance visible to driver a head on the sight distance available on a highway at any spot should be of sufficient length to safely stop a vehicle travelling at design speed without collision with any other vehicle. This is the stopping sight distance. It is also called absolute minimum sight distance.

2. Total reaction time of the driver.

- (i) Speed of vehicle
 - (ii) Distance of break
 - (iii) Distance between the road and the vehicle
 - (iv) Gradient of the road.
 - (v) Type of the road.
 - (vi) Total reaction time of driver.
- The total reaction time may be explained with the help of P.T.E.V. Theory.

P-Perception :-

It is the time required for the sensation received by the eyes on cars of the driver to be transmitted to the brain through the nervous system and signal sent to the word it is the time required to perceive an object in situation.

I - Intuition

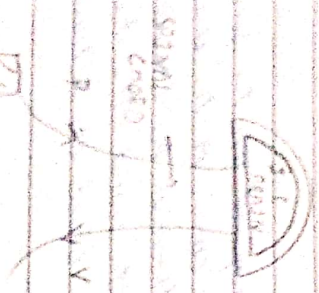
It is the time required for the driver to understand the situation it is also the time required for comparing different things and regrouping.

1 - Braking

It is the time elapsed during mechanical retardation and other useful retarding force is applied on any other mechanical retarding force. The retardation force is applied on the car for a particular distance. The retardation force is applied to the car.

V - Retardation force

It is the time taken by the car for the final velocity such as applying brakes.



17

Stopping sight distance = lag distance + Braking distance.

18 lag distance:

The distance traveled in reaction time.

19 Braking distance:

When brakes are applied to a vehicle and the vehicle actually stops.

20 formula

lag distance = vt

Braking distance = $\frac{v^2}{2gf}$

$SSD = vt + \frac{v^2}{2gf}$ (v = m/s) condition

"V" is in km/h
If we convert

$$SSD(m) = 0.278vt + \frac{v^2}{254f} \quad / \quad 0.278v + \frac{v^2}{254(f \pm 0.01n)}$$

In slopes

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

where $V =$ speed of vehicle

$f' =$ coefficient of friction (0.35) depending upon road

$g =$ acceleration due to gravity 9.81

$n' =$ braking efficiency

$\Rightarrow$ for two lane one way
 $SSD = SSD''$

$\Rightarrow$ for one lane two way
 $SSD = 2 \times SSD''$

Q1. Calculate SSD on a level road for design speed of 50 km/h for two way on a two lane traffic.

Two way traffic on single lane road assume efficiency of $f' = 0.37$ and reaction time of driver as 2.5 s

Sol:- $V = 50 \text{ km/h}$

$$f = 0.37$$

$$t = 2.5 \text{ s}$$

$$SSD = 0.278 \times 50 \times 2.5 + \frac{(50)^2}{254 \times 0.37}$$

$$= 61.351 \text{ m}$$

Q2

$$SSD = 2 \times SSD''$$
$$\Rightarrow 2 \times 61.351$$
$$\Rightarrow 122.70 \text{ m}$$

Q3. Calculate the minimum sight distance required to avoid a head on collision of two cars approaching from the opposite direction 90 km/h and 60 km/h assume a reaction time of 2.5 s. coefficient of friction 0.7 and a braking efficiency of 50% in both cases.

Sol:-

$$V_1 = 90 \text{ km/h}$$

$$V_2 = 60 \text{ km/h}$$

$$t = 2.5 \text{ s}$$

$$f = 0.7 \times \frac{50}{100}$$

$$= 0.7 \times 0.5$$
$$= 0.35$$

$$SSD_1 = 0.278 \times 90 \times 2.5 + \frac{90^2}{254 \times 0.35}$$

$$= 153.663 \text{ m}$$

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$$SSD_2 = 0.278 \times 60 \times 2.5 + \frac{60^2}{254 \times 35}$$

$$\Rightarrow 82.194 \text{ m}$$

$$SSD = SSD_1 + SSD_2$$

$$= 153.663 + 82.194$$

$$\Rightarrow 235.8 \text{ m}$$

Q3 Calculate the stopping sight distance on highway of a

deceleration of 2.2 for design speed 60 km/h

assume reaction time of 2.55 and decaying

effect of friction 0.35

$$\text{Sgt } n = 2.7, \quad \frac{2}{100} = 0.02$$

$$t = 2.5$$

$$f = 0.35$$

$$V = 80 \text{ km/h}$$

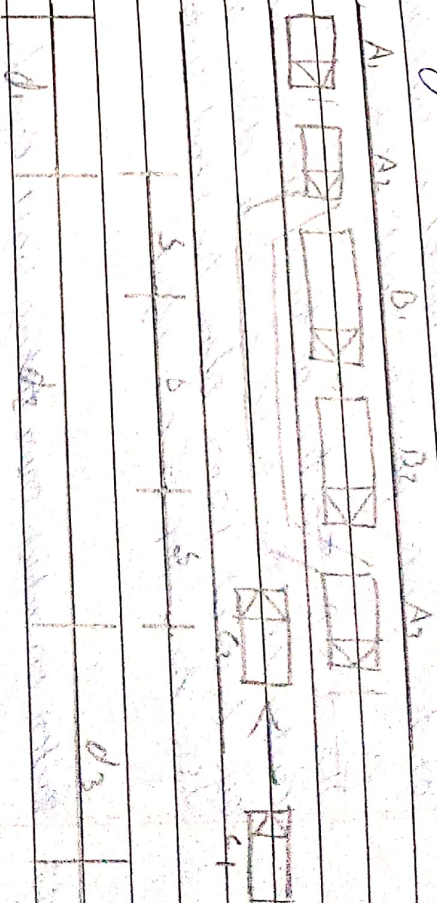
$$\Rightarrow$$

$$80 \times 2.5 + \frac{80^2}{254 \times (0.35 - 0.02)}$$

$$0.278 \times 80 \times 2.5 + \frac{80^2}{254 (0.35 - 0.02)}$$

$$\Rightarrow 131.95 \text{ m}$$

Overtaking sight distance



If all the vehicles travel on road at a design speed then there should be no need for overtaking.

In fact all vehicles do not move at the design speed as each vehicle driver is free to travel at lower speeds and this is partially true under mixed traffic condition.

In such cases it's necessary for fast moving vehicle to overtake on pass the slow moving vehicle.

The minimum distance apart to the vision of the driver of a vehicle intending to overtake slow vehicle ahead with safety against the traffic of opposite direction is known as minimum overtaking sight distance or the safe passing sight distance.

The OSD is the distance measure along the center of the road which a driver with his eye level at 1.2m above the road surface can see the top of an object.

Factors on which overtaking sight depend.

- Speed of overtaking vehicle, speed of overtaken vehicle and the vehicle coming from opposite direction if any.
- Distance between overtaking and overtaken vehicle
- Skill and reaction time of the driver.
- Rate of acceleration of overtaking vehicle.
- Gradient of the road.

Analysis of overtaking

Analysis of OSD on a two way road

Overtaking sight distance is divided into 3 parts:-
① D_1 is the distance travelled by the overtaking vehicle A, during the reaction time of the driver from position A to A₂.

② D_2 is the distance travelled by the vehicle "A" during the actual overtaking operation. Travel from A to A₃.

③ D_3 is the distance travelled by oncoming vehicle "C" during the actual overtaking operation. Travel from position C to C₂.

$$OSD = D_1 + D_2 + D_3$$

$$D_1 = V_R T^R \quad (A)$$

$$D_2 = V_R T + 2S \quad (A)$$

$$D_3 = V T \quad (C)$$

m/s

$$OSD = V_R T + V_R T + 2S + V T$$

Always unit is "m"

$$T = \sqrt{\frac{u_s}{A}}$$

m/s

$$OSD = V_6 t + V_6 T + 2S + VT$$

$$11.11 \times 2.5 + 11.11 \times 7.45 + 2 \times 13.77 + 19.44 \times 7.45$$

$$\Rightarrow 232.91 \text{ m}$$

Q Calculate the overtaking sight distance for a design speed of 96 km/h and speed of overtaking vehicle is 80 km/h if the acceleration of vehicles is 2.5 km/h².

Given

$$V_0 = 96 \text{ km/h}$$

$$V_d = 80 \text{ km/h}$$

$$A = 2.5 \text{ km/h}^2$$

$$t = 2.5$$

$$S = 0.2 \times 80 + 6$$

$$= 22$$

$$T = \frac{\sqrt{14.4422}}{2.5}$$

$$= 3.11.25$$

$$OSD = 0.2 \times 80 \times 2.5 + 0.2 \times 80 \times 3.11 + 2 \times 22 + 0.2 \times 80$$

$$OSD = 654.4 \text{ m}$$

Overtaking zone.

It is desirable to construct highways in such a way that the length of road while ahead away point is sufficient for safe overtaking. It is practicable and there may be distance where the safe overtaking distance is not provided. In such zone where overtaking is not safe, no passing or overtaking is permitted. However, overtaking opportunity for vehicle moving at design speed should be given at frequent intervals as possible. This zone which is meant for overtaking is called overtaking zone. The minimum length of overtaking zone should be 3 times of the safe overtaking sight distance. For one way road, it is desirable that the length of overtaking zone is kept 5 times of OSD in two way and one way road.

Traffic study.

1) Traffic volume

It is the number of vehicle moving in a specified direction on a given lane. That passes a given point on cross section during specified time it is

express as number of vehicles per hour.

3. Traffic density:-

It is the number of vehicles occupying a unit length of the road way at a given instant. It is usually expressed as vehicle per km. The high traffic density will be when the vehicle are packed at short still spaces on a given road.

4. Traffic capacity:-

Traffic capacity of a road is the ability of the road when in traffic to allow maximum traffic flow in both directions. It is expressed as the maximum number of vehicles per hour in a roadway that can pass a given point in both directions under certain conditions. The traffic capacity is of two types.

(i) Basic capacity

It is the maximum number of passenger cars that can pass a certain point during one hour under the most ideal road condition.

(ii) Result capacity

It is the maximum number of vehicles that can

pass a given point during one hour under existing road condition.

5. Traffic volume study

The object of traffic volume study are

- (i) To study the present traffic volume for improvement and upgradation of roads.
- (ii) For economic design on strategic or road way layout.
- (iii) For analysis of patterns, trends and state of growth of each vehicular class.
- (iv) For planning roadway capacity and control of traffic operation and control of existing facilities.
- (v) For planning one way streets and other regulating measures.
- (vi) To plan and design new facilities.
- (vii) During transport study, at intersection are used for introducing traffic control devices for improvement of the intersection itself.

Methods of calculating

Traffic volume study

Traffic volume count may be carry out in manually or by using mechanical or automatic counters.

1. manual count

This method employs a list team at a predetermined location of the selected road and intersection. by this method it is possible to obtain all the details of the classified traffic data within command be collected by mechanical or automatic counters. It is possible to obtain detail such as:

(i) classification of different types of vehicle and their count at desired time interval

(ii) direction wise movement including turning movement of each vehicle class at intersection

(iii) classified vehicle count with number of passenger.

(iv) Number of commercial vehicle (H.V and L.V) with detail of loads.

2. Automatic traffic counter:

This may be either fixed or permanent type or portable type of counter. The total number of vehicle can automatically record in the desired period by pressing the

Prescription or traffic volume data.

1. ADT (Actual average daily traffic)

It is obtained by determining average daily traffic volume recorded for all the 365 days of the year. This data is useful in deciding the productive importance of a road. This is also useful for determining the growth rate of different vehicle class

2. ADT (Average daily traffic)

When the traffic volume count are carry out for a few days the average daily traffic volume is obtain is called average daily traffic.

If horizontal curve is small, it is not recommended.

Methods are used which are provided to change the direction of road where vehicle travels. A horizontal curve is called as a change from one straight line to another. The center of gravity of the vehicle enters the curve is given by $\left[P = \frac{WV^2}{gR} \right]$

where P = centrifugal force, W = weight of vehicle, V = speed of vehicle, g = acceleration due to gravity, R = radius of curve.

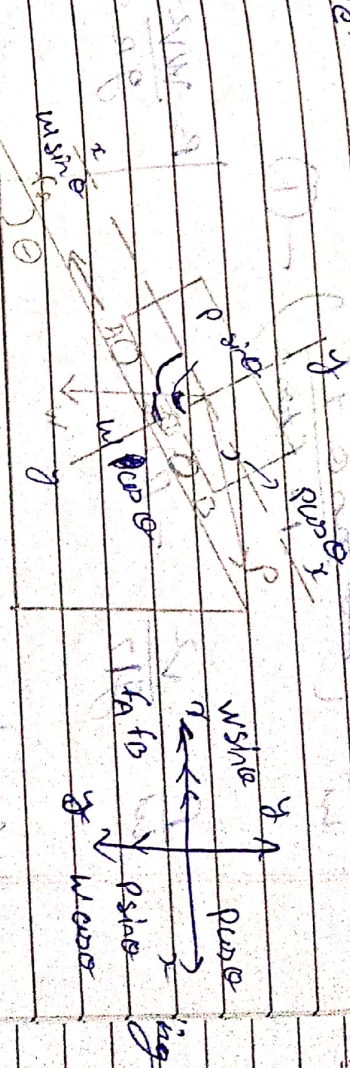
The centrifugal force acting on a vehicle travels a horizontal curve has to be offset.

(ii) tendency to overturn the vehicle at road A. i.e. about the outer wheels.

in tendency to skid the vehicle laterally outward.

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If Super elevation (e) / cant is provided slope provided super elevation to counter the effect of centrifugal force and to reduce the tendency of vehicle to overturn and skid laterally outward by raising the pavement outer edge with respect to inner edge it is represented by 'e'.



$$F_A = F_{RA}$$

$$\sum \tau = 0$$

$$F_B = F_{RB}$$

$$P \cos e - W \sin e - F_A - F_B = 0$$

$$P \cos e = W \sin e + F_A + F_B$$

$$P \cos e = W \sin e + F_{RA} + F_{RB}$$

$$F_{RA} = W \cos e$$

$$P \cos e = W \sin e + F_{RA} + F_{RB}$$

$$F_{RB} = P \sin e$$

$$P \cos e - F_{RB} = W \sin e + F_{RA}$$

$$P (\cos e - \sin e) = W (G \sin e + F_{RA})$$

Travel speed or the overall speed is the effective speed of travel on it is obtained by dividing the route length by the total travel time including stopped ways.

O & D study (origin and destination) :-

This study is carried out mainly for following reasons.

• Plan the road network or other facilities for vehicles traffic.

• Plan the mode of different modes of transportation for trip

• Demand of consumer.

• This study of vehicles traffic determine the number of vehicles and their origin and destination.

• O & D study gives information like actual direction of travel, selection of route and length of the trip.

Origin and destination study :-

Methods of O & D study :-

1. Road Interview method :-

The vehicle are stopped at selected interview

2. License plate method :-

In the road.

stopped for interview their will be delay in their travel and their will be congestion

in that when some of the vehicle are

quickly the main draw back of this method

is simple and the team can be trained

in short duration and the field organization

In this method the data can be calculated

one recorded.

vehicle the details of good being transported

in each vehicle in the case of commercial

type of vehicle, number of passenger

or intermediate storage purpose of the

of origin and destination, route, location

collected include the place and the time

entered in the form. The information

to questions are collected on the spot and

station by a group of person and the answer

and station are marked at the location

of entry and out of all the roads leading

is and out of the area. In addition some

important intermediate observation station are

also selected in advance with group of

people at the observation station are given

time and they note the license plate numbers of the vehicle entering and leaving the area at the time, separately recording sheets are maintained for each direction of movement for a specified time interval after the collection of field data has been completed will be office computation and analysis by tracking in vehicle number and its time. This method is easy and quick as far as the field work is concerned. This method is suitable for small area the method involves lot of computation in tracking the trips to the network of stations.

3. Return point and method:-

Large business point and with station address, one distributable to the road use at some selected points along the route on roads are made to the journey of the vehicles. The question to be field by the road user is printed on the survey. The distribution stations are along with a request for cooperation and response of the study. No distributing station for the road may be selected. Some vehicles have to stop for, till back on signs to the road by set suitable when the traffic is very light.

4. Log on car method

only a part of road user may prefer to travel, the correct conclusion drawn may not represent the entire population.

In this method a recorded card is struck on the vehicle as it enters the area under study. When the car leaves the area the other observations are recorded on the log. This method is useful when the traffic is heavy and moves continuously but this method gives only information regarding the points of entry and exit and the time taken to travel the area.

5. Home Interview method:-

This method is preferred when traffic and transportation requirement are to be planned for a city but to have complete coverage of entry cross-section of the population is very expensive and time taking. A random sample of 5% - 10% of population is selected depending on the total number of residence. The residence are visited by the trained person and they collect the travel

data from each sensor the data collected will be useful either for planning the road network or other road-way facility for the vehicles traffic on the road. The mass transportation requirement of the passengers trip.

Winding of pavement:-

On horizontal curve specific when they are not of very large radii it is common to wind the pavement slightly more than the normal width. The object providing extra winding on pavement are as follows:-

- an automobile has a right wheel such as car, bus or truck whose only the front wheels can be turned. When the wheel test the turn only the front wheel can move and the rear following the path because if which off tracking may
- at speed on turn then the design speed when the super elevation and lateral friction developed are not fully reliable to counter act the out ward due to the centrifugal force some sliding may occur

and the rear wheel may take path on the outside up the track.

The path traced by the wheel of a trailer in the case of the trailer unit is also likely to be on a outer side of the central path of the wheels depending on the speed.

In order to take curved path with large radii to have a greater tendency not to follow the central path at the beginning but to use the outside at the beginning of a curve.

Two vehicles cross on overtake at H.7 curve there is a psychological tendency to maintain a greater clearance between the vehicles than on straight road.

#

Horizontal transitioning curve:-

A transitioning curve has a radius which decreases from the design radius of the circular curve.

object of transition curve:-

- To introduce gradually the centrifugal forces

between the street road and the beginning of circular curved road involving sudden on the vehicle

To enable the curve from the steering gradually from heel to toe smoothly process.

To impress the of the road.

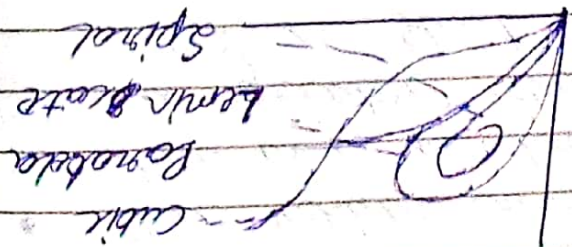
To enable gradual introduction of elevation and extra widening

3 types of transition curve.

1. Spiral

2. Lemniscate

3. Cubic parabola



Vertical alignment

gradient (slope) - gradient is a ratio of rise on fall along the length of the road with respect to horizontal. it is expressed as the ratio of 10

Inf ① In the various steps involved in a new highway project.

Ans: Steps involved in new highway project.

Planning and ~~controlling~~ study

Land acquisition and legal approvals

Detailed engineering Design

Silt preparation and analysis.

Subsidiary and base course construction

Construction of Bridges, Tunnels and Interchange

Installation of safety features.

Find together and listing

2. Allopatry and sympatry - hybrid study

- Conduct traffic survey and analysis to determine the need for the highway.

• said the test will be based on topography, population shifts and environmental impact.

- perform environmental impact assessment to analyse
- sustainability.
- conduct soil and geotechnical test

2. Land acquisition and legal approval.

- Industry and map to land require from the highland separate land and separate

- official legal approvals from authorities, municipal and government agency.

3. Detailed engineering design

- design the highway, alignment, including lanes, curves and slope

- ~~curbs and curbs~~ place the pavement type (flexible asphalt or rigid concrete)

- Design bridges, tunnels, interchange, and culverts if needed.

4. Site preparation and construction

- clean and remove vegetation, debris and obstacles.
- excavate and fill areas to level the ground surface.
- compact the soil to increase strength and stability.

5. Subbase and base course construction.

- Lay a subbase layer of crushed stone or sand to provide support.
- Compact the subbase to increase load bearing capacity.
- Add the base course using stronger aggregates for durability.

6. Pavement construction.

- Apply a binder layer for adhesion.
- Lay and compact asphalt (flexible pavement) or prime concrete (rigid pavement).
- Smooth the surface and allow curing.

7. Construction of bridge, tunnels and interchanges.

- Build bridges over rivers or railways.
- Excavate tunnels through mountains or ~~the~~ ^{under} the ground.
- Construct flyovers and interchanges for smooth traffic flow.

8. Installation of safety features and signs.

- Install road signs, speed limit boards and traffic signals.
- Place guardrail beams at sharp curve and At street light and reflective road marker for visibility.
- Construct ^{cross} ~~pedestrian~~ ^{cross} crossings and foot path in populated areas.

9. Final

- Best
- Time
- Cost

Shear test

1. Thickness test - Thickness index of aggregate is the percentage by weight of egg particles the test specimen the thickness of which is less than 315 or 0.6 of their max dimension. This test is applicable to sizes larger than 6.3 mm standard thickness gauge is used to gauge the thickness of aggregates. The thick egg are those which pass through the elongated state of the thickness gauge which has elongated slit with each dimension equal to 0.6 times.

2. Elongation Index - Elongation Index of an egg is the percentage by weight of particles the greatest dimension of which is its length. This is greater than 4/5 or 1.8 times the max dimension standard length gauge is used to gauge the greatest dim. or length of the egg sample the elongation index is used to gauge the size of egg greater than 6.3 mm.

Procedure:-

- The sample of agg to be tested is sieved through a set of sieves and separated into specified size ranges.
- The largest size of agg particles from each of the size ranges is then individual passed through the appropriate gauge or the length gauge. The length would be 1.8 times the size of egg.

Aggregate

Properties of aggregate:-

- The portion of elongated agg having length greater than the specified gauge from each size range is weighed.
- The total weight of total weight of the sample as a percentage of elongation index taken to standard elongation index.
- Resistance to impact or toughness.
- Resistance to abrasion or hardness.
- Resistance from getting polished or smooth.
- Resistance to crushing or crushing strength.
- Good shape factor to avoid too flaky and elongated particles.
- Resistance to weathering.
- Good adhesion with bituminous material is because of water.

Test on aggregate:-

1. Impact test - The agg impact test is carried out to evaluate the resistance to impact of agg to further further repeated impact the test has been standardized ISTA.

Equipment -

The egg impact testing machine consist of a metal base and a cylindrical steel cap of internal dia. 102 mm and depth 50 mm in which egg is placed.

A cylindrical metal hammer of weight 13.5-14 kg having a free fall from a height of 380 mm.

Aggregate specimen passing thru 12.5 mm sieve and ~~and~~ settle on 10 mm sieve.

Procedure -

The aggregate specimen passing thru 12.5 mm sieve and settle on 10 mm sieve. It will in the cylindrical mould is 3 layers by tamping each layer by 25 blows by the tamping rod.

The sample is weighted on tares to 10 grams of impact testing machine are compacted by tamping rod 25 times.

The hammer is raised to a height of 380 mm above the upper surface and allowed to fall freely.

After subjecting the test specimen to 25 blows the crushed egg is sieved on 2.36 mm sieve.

The aggregate impact value is expressed as the percentage of the passing 2.36 mm sieve to the total weight of the sample.

Impact value = $\frac{W_1}{W_2} \times 100\%$

where W_1 = fine fraction of egg 2.36 mm sieve
 W_2 = weight of powder + weight of egg passing thru 12.5 mm sieve and retaining.

W_1 = weight of + mould

Impact value 8. Toughness property.

Egg Impact value 7.

Toughness property

less than 10

exceptional tough

10-20

very tough

20-30

good for pavement.

Above 35

worst for pavement.

2-4 Abrasion value test -

The principle of Los angles abrasion test is to find the percentage wear due to relative rubbing action between the egg and the steel ball used as abrasive material on change.

The machine consist of a hollow cylinder closed at both end having inside diameter 750 mm and length 500 mm and mounted to rotate about its horizontal axis.

- A removable steel shell of 80 mm radius fitted on the cylinder.
- The abrasive charge consisting of test item dia 19 mm and weight 39 gm. The number of spins to be used and the weight is specified based on grading.
- The specified weight of aggregate specimen of desired grading is taken and placed in the machine along with the specified abrasive charge.
- The machine is rotated 30-33 RPM for the number of 500-1000 revolution.
- The abraded agg is then sieved on 1.75 mm ~~is~~ at 75 sieve and the weight of the powdered agg is taken.
- The result of abrasion test expressed as the % wear to the original weight of the sample.

$$\text{Abrasion value} = \frac{w_2}{w_1} \times 100$$

w_1 = original wt. of sample.

w_2 = fine powder wt. of agg

The loss of abrasion value of good agg acceptable for bituminous concrete and other high quality pavement material should be

less than 30%. for cement concrete pavement maximum value is 35% and for granular base aggregate 50%.

3. Crushing test:-

- Crushing test the agg crushing value provides a relative measure of resistance to crushing under gradually applied load. agg passing through 75 mm sieve and less than 1.75 mm are used for high quality pavement.

The apparatus for the standard test consists of a steel cylinder 152 mm dia. with a base plate and a plunger compression testing machine, cylindrical mortar of dia. 115 mm - 180 mm, tamping rod and sieves.

Dry agg passing from 12.5 mm sieve and retained on 75 mm sieve is filled into cylindrical mould in 3 equal layers by tamping 25 times each. The test sample is designated (agg) and placed in the test cylinder in three equal layers tamping 25 times.

The plunger is placed on the top of the specimen and the load of 40 TN is applied at a rate of 4 TN per min not more than 10 min.

- The crushed agg. is removed and sieved on 2.36mm IS sieve.
 - The crushed material which passes the sieve is weight equal to 425 gm.
 - The aggregate crushing value is the percentage of the crushed material passing 2.36mm sieve to the original weight of the specimen.
 - Crushing value = $\frac{w_2 + w_3}{w_1} \times 100$
 - The stone agg. used for base course shall not exceed 45% and the value for surface course shall be less than 30%.
 - For cement concrete pavement subgrade the crushing value should be more than 30%.
- ### # Bitumin:-
- Properties of bitumin:- They are very commonly used in surface course of pavement. They are also used in the binder and base course of flexible pavement. The desirable properties of bitumin are as follows:-
- The viscosity of bitumin at the time of mixing with agg. be adequate.

- The bitumin binder should be ductile.
 - The bitumin binder should not be highly temperature susceptible.
 - The bitumin binder should have good adhesion and cohesion property.
- ### # Test on bitumin:-
1. Penetration Test:-
 - The consistency of bitumin material varies depending upon the several factors such as temperature, consolidation etc. At temperature ranges between 25°C to 50°C most of the parking bitumin grade remains in semi-solid state.
 - The penetration test they widely use described in bitumin different grade.
 - The penetration test determine the consistency of these material. The basic principle of the penetration test is the measurement of the penetration of a standard needle in a bitumin sample within at 25°C during 5 sec.
 - The total weight of needle assembly is 100 gm.

Procedure:-

- The penetrometer consists of a penetration needle which is attached to a dial.
- On the scale of penetration needle it penetrates into the bitumen sample.
- The bitumen sample is ^{stone} contained in a container to a depth of 50mm. The sample container one then placed in a controlled water bath at a temperature of 25°C for 1 hour.
- The sample with container is taken out and placed in the penetrometer and the needle is adjusted to make contact with the surface of the sample.
- The dial is set to 0 and the needle is released for 5 sec and the final reading is noted.
- At least 3 penetration test is conducted.
- Penetration that is most commonly adopted to determine the grade of bitumen, softer the bitumen grades will be the penetration value.
- Soler denotes that the penetration of binder ranges between 80-100.

- The penetration grades of bitumen binders are generally denoted as 80/100, 60/70, 30/40 grade bitumen.

2. Viscosity Test:-

Viscosity is the resist of fluid resistance to flow. In the case of bitumen viscosity determines the ability to coat aggregates and its performance under different temperature. Condition the viscosity test is done consistently and with ability of bitumen at specific temperatures.

Procedure

- Heat the bitumen sample to a fluid state.
- Pour into a viscometer tube and allowed it to settle.
- Place the viscometer in a water bath maintained at 60°C .
- Apply or return to measure flow through the capillary tube.
- Repeat the time taken for a fixed volume to pass through calculate the viscosity using the equation.

$$\text{Absolute viscosity} = K \times t$$

$\left\{ \begin{array}{l} K = \text{calibration constant} \\ t = \text{Time or flow} \end{array} \right.$

3. Ductility test

Ductility test of bitumen measured the distance to which a standard sample of bitumen can be stretched before breaking. In this test determine the bitumen's ability to undergo deformation without breaking which is crucial for pavement performance.

Procedure

- Heat the bitumen to pouring consistency 75-100°C.
- Coar of into a liquid mould placed on a metal plate griddle to prevent sticking.
- Allow them to cool at room temperature and then placed the mould in the water bath at 37°C for 30 minutes.
- Remove the mould site leaving the bitumen strip in the place.
- Mounted the sample to the ductility testing machine and start the machine to pull the sample a part at a uniform speed of 5mm/minute.
- Record the elongation at which the bitumen cracks breaks and measure the distance which gives the ductility value.

The minimum ductility value for road bitumen is 50cm.

The difference between bitumen and Tar

Bitumen

Tar

1. Bitumen is found in black to brown colours

Tar is usually found in brown colours.

2. Bitumen is obtained from fractional distillation of crude oil

Tar is obtained by destructive distillation of coal or wood.

3. Bitumen shows resistance to tar stains more easily and curing road and also has not retained in presence of water

Tar stains more resistance to weathering action

4. It shows more resistance to weathering action

It shows less resistance to weathering action

5. Free carbon content is less

Free carbon content is more.

6. Less temperature susceptibility more temperature susceptibility.

Temperature susceptibility

Construction of earth road :- An earth road is type of road constructed using locally available soil without the addition of bitumen or concrete. It is commonly used in rural area and villages.

Steps of construction of earth road.

- conduct a topographic survey to determine the best alignment for the road.
- Choose a location of proper drainage minimum SWP to avoid erosion.
- Remove vegetation, trees large rocks from the path.
- Remove through soil to expose firm soil.
- level the ground and compact the natural soil and maintain a proper camber for water runoff.
- Select suitable soil for filling the gaps and avoid clayey and silty soil spread the soil in layers.
- compact each layer using roller or tamping equipment.

11/03/25

UNIT-3 RAILWAY Engineering

Permanent way

The combination of rails fitted on sleepers and resting on ballast and subgrade is called railway track or permanent way.

Requirement of permanent way.

- The gauge should be correct and uniform.
- The rail should be in proper level in a straight track. The rail should be in the same level.
- The alignment should be correct.
- The gradient should be uniform and gentle as possible.
- The track should have enough lateral strength.
- The rails and sleeper elevation on wheel should be proper degree.
- Drainage system must be perfect, Joint including joint and crossing should be properly degree.
- There should be adequate provision for easy removal and replacement of rails.

Gauges:-

The gauge of a railway track is defined as the clear distance between the inner faces of the two rails. The distance between the inner faces of a pair of wheels is called wheel gauge.

Types of Gauges:-

Types of Gauges:- width of gauge.

1. Broad Gauges are 1.67m standard gauges

2. Metre Gauge (moderate) 1.07m

3. Narrow Gauge (Hills) 0.76m

4. Light Gauge (villages) 0.61m

Selection of Gauge:- A line is chosen on the basis of the following factors:-

(i) Cost of construction:-

(ii) Volume and nature of traffic:-

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(iii) development of area

(iv) physical factors of country

(v) speed of movement

Uniformity of Gauge

Gauge to be used in a particular country should be uniform throughout as far as possible because it will avoid many difficulty experience in a non uniform system. The uniformity of gauge results in following advantages:-

- The delay, cost and hardship in transferring passengers and goods from the wheel of one gauge to another is avoided.

- As transiting is not required there is no breakage of goods.

- Difficulty in loading and unloading are avoided and labourer expense are saved.

- Possibility of theft and misplacement will be less than one wheel to another is avoided.

- During peak periods, movement of goods, passengers and equipment from one wheel to another is avoided.

Gauges

The gauge of a railway track is defined as the clear distance between the inner faces of the two rails. The distance between the inner faces of a pair of rails is called track gauge.

Types of gauges:

Types of gauges: width of gauge.

1. Broad gauges are 1.675m standard gauges.

2. Metre gauge (narrowed) 1.0m

3. Narrow gauge (Hills) 0.76m

4. Light gauge (villages) 0.61m

Selection of gauge :-

(i) Cost of construction :-

(ii) Volume and nature of traffic

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(iii) development of area

(iv) physical features of country

(v) speed of movement

Uniformity of gauge

Gauge to be used in a particular country should be uniform throughout as far as possible because it will avoid many difficulties. The experience in a non-uniform system. The uniformity of gauge results in following advantages:

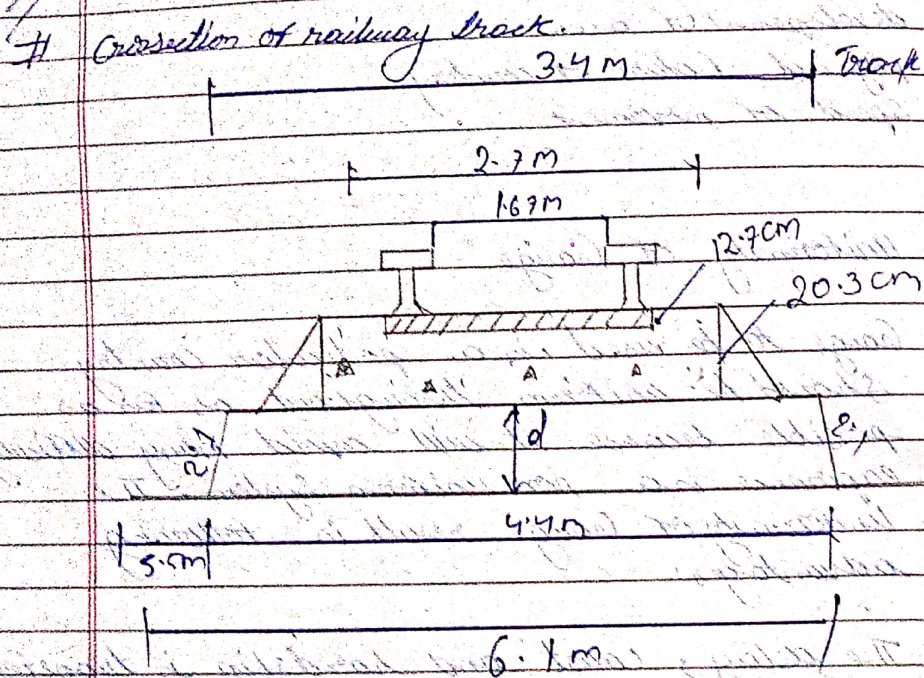
- The delay, cost and hardship in transferring passengers and goods from the rail of one gauge to another is avoided.

- No transhipping is not required there is no shortage of goods.

- Difficulty in loading and unloading are avoided and labour expense are saved.

- Possibility of theft and misplacement of goods from one rail to another is eliminated.

- During peak military movement no time is wasted in personnel and equipment from one rail to another if gauge is uniform.

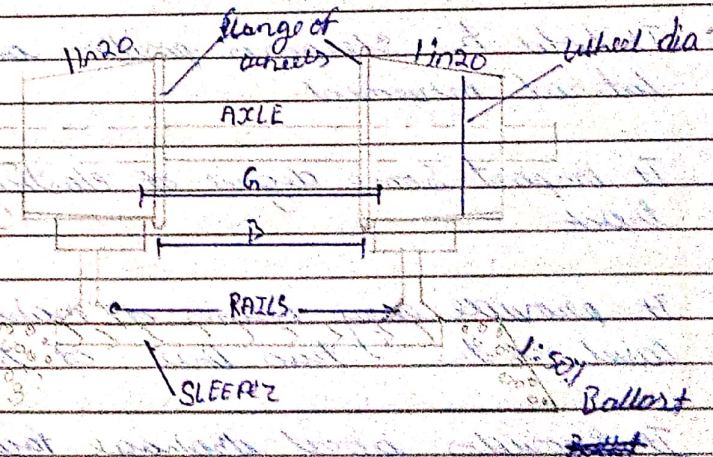


Coning of wheels:-

The distance between the inside edges of wheel flanges is generally kept less than the gauge of the track, so there is a gap between the wheel flange and rails nearly equal to 1 cm. On either side normally the tread of wheels is absolutely at center of the head of the rail, as the wheel is coned to keep it in this central position automatically. This wheel are coned at a slope of $1/20$.

The advantage of coning of wheel are:-

- To reduce the wear and tear of the wheel flanges and rail which is due to rubbing action of flanges with side faces of the rail head.
- To provide a possibility of lateral movement of the axle with its wheel.
- To prevent the wheels from slipping to some extent.



Railway track material:-

Ballast:-

Ballast is a granular material usually broken stone or brick, barker, gravel or sand. placed below and around the sleepers to transmit

load from sleeper to the subgrade and at the same time allowing drainage of the track. The lateral stability of a track depends on the ballast.

Function of ballast

- It transfers the load from the sleeper to the subgrade.
- It holds the sleeper in position and prevents lateral movement.
- It imparts some degree of elasticity to the track.
- It provides easy means of maintaining the track level of the two lines of the track.
- It provides good drainage facility below the sleeper and helps to protect the top surface of the formation.

Requirement of Good ballast.

- It should be able to withstand hard packing without disintegrating.

- It should not make the track dusty or muddy due to powder under dynamic wheel load but should be capable of being

It should allow easy drainage with minimum shakage and the voids should be large enough to prevent capillary action.

- It should offer resistance to abrasion and weathering.

- It should not produce any chemical action with rail and metal sleeper.

- The size of stone ballast should be 5 cm for wooden sleepers, 4 cm for metal sleepers and 2.5 cm for turn out and cross overs.

- The ballast should be easily available and economical.

Types of ballast

1. Broken Stone Ballast :-

This is the best material for the ballast and almost all important tracks are provided with

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Stone ballast: Broken stone satisfy all the specification and requirement of the good ballast. The best stone ballast is non porous, hard and angular in shape. It has high durability and load bearing capacity. For stability graded broken stone ballast is better than ungraded one. Graded stone of 5.0 cm to 1.25 cm size is found to provide maximum stability. It is mainly used in main line track, high speed rail, and heavy load railway network.

2. Gravel or river pebbles

Gravel comes next in the rank for its suitability for use as ballast and it is used in large quantity in other country. It is obtained either from river bed or from gravel pits.

The smooth pebbles are broken otherwise they are liable to displace the sleeper due to smoothness of its surface and the packing does not hold. They are easily available and cheaper than stone ballast. Good drainage property is properly graded.

3. Sand ballast

It is a good material as ballast as it is cheap and provides good drainage. Sand ballast also produces a silent track and has been found to be good for packing. The great drawback of the sand is its blowing effect due to vibration. There fore maintenance of the track is difficult. The coarse sand is preferred to fine sand. It is not suitable for high speed track it is generally used in light traffic area, temporary track and desert area.

4. Marmum

It is the soft aggregate red in colour and it is found in tropical region. The best marmum for ballast is that which contains large quantity of small laterite stone. It is recommended as a ballast for siding and main track when they are newly laid. When marmum ballast is finally laid on the track it forms flaked under the stone ballast.

5. Brick ballast

When there is no stone or substitute available for use as ballast on burnt bricks are broken into small sizes and used. It powders easily and gives dusty track. Railways track laid on brick ballast mostly through Rusted. It is cheaper than crushed stone and it is widely available.

6. Ashes

7. Kankar

8. Blast Furnace Slag

9. Selected earth ballast

Sleepers :-

Sleepers are members generally laid transverse to the rails on which the rails are supported and fixed to transfer the load from rail to the ballast and the subgrade below.

Function of sleeper

- To hold the rails to correct gauge
- To hold the rail in proper level in turnout and cross overs.

- To act as an elastic medium between the ballast and rails to absorb the vibration of moving loads.

- To distribute the load from the rail to the ballast
- They also provide means to rectify track geometry during service life

Requirement of sleepers

- The sleeper to be used should be economical.
- The fitting of the sleeper should be easy and maintenance operation should also be easy.
- The weight of sleeper should not be too heavy or too light for easy handling.
- The design of sleeper should be such that the gauge alignment of track can be easily adjusted and maintained.
- The bearing capacity of sleeper should be very high.

Classification of sleeper

- Sleeper can be classified according to the material used in the construction which are as follows.

I (i) Timber or wooden sleeper.

Wooden sleepers are regarded to be best as they fulfill almost all the requirement of an ideal sleeper. The life of timber sleepers depend on their ability to resist wear, decay, attack of white ants and quality of timber.

Advantages

- Timber is easily available in all parts of India.
- Fitting of sleepers is easy and simple.
- These sleepers are able to resist the shocks and vibration due to heavy moving loads.
- Wooden sleepers are easy to lift, lay and maintain.
- These wooden sleepers are suitable for all types of ballast.
- They are best for track circuited operation and they are economical where they are available.

Disadvantage

- The sleepers are subjected to wear, decay, attack of white ants, and warping, cracking and splitting etc.
- It is difficult to maintain the gauge in the case of wooden sleepers.
- Wooden sleepers have minimum service life (12 to 15 years).

(ii) # Metal sleepers

Due to growing scarcity of wooden sleepers, high cost and short life metal sleepers have been adopted. Metal sleepers are either of steel or cast iron. Cast iron is in greater use than steel for sleepers because it is less prone to corrosion. The metal sleeper should resist the tensile and compressive stress.

They should provide sufficient area for ballast for track circuiting insulation should be possible.

- Metal sleepers should provide sufficient grip on the rail and ballast to prevent the dislocation of train.

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Advantage

- metal sleepers are uniform in strength and durability.
- In metal sleeper the performance is lesser creep occurrence.
- metal sleepers are economical, as life is longer and maintenance is easier.
- metal sleepers are frequent and reusable and replacement is not required.
- They have good scrap value easy in manufacturing and fire resistance.

Disadvantage

- more ballast is required than other type of sleepers.
- fitting required are greater in number.
- metals are liable to rusting or corrosion.
- metal being good conductor of electricity interfere with track circuiting.
- metal sleepers are not suitable for bridges, level crossing and in case of painting and crossing of this sleepers are only suitable for stone ballast.

③# Cast Iron Sleepers:-

Cast Iron sleepers have been extensively used in India and in South America they are of following types.

- i) Pot on barrel sleeper
- ii) Plate sleeper
- iii) Box sleeper
- iv) Combination of plate and box type
- v) Rail free duplex sleeper

④# Concrete sleepers:-

This sleepers are made of strong homogeneous material, impervious and is unaffected by chemical attack of atmospheric gases or subsoil salt. It is molded easily to size and shape required by systematic investigation to withstand the stresses produced by fast and heavy traffic. This sleepers are mainly of two types.

- i) Reinforced concrete sleepers
- ii) Pre stressed concrete sleepers

Advantages of concrete sleepers are natural strength and they are free from rusting and decay and they are free from insects etc.

Rail

The Rails on the track can be considered as steel girder for the purpose of carrying axle load. They are made of high carbon steel to withstand wear and tear.

Function

Rails provide a hard, smooth and unchanging surface for passage of heavy moving load.

- Rail bears the stresses ^{force} develop due to heavy vertical load, and braking forces.

- Rail material used is such that it gives minimum wear to avoid replacement charges and failure of Rail.

- Rails transmit the load to sleeper.

Composition of Rail

2. For ordinary Rail

Carbon	0.55% to 0.68%
Manganese	0.65% to 0.90%
Silicon	0.05% to 0.37%
Sulphur	0.05% or below
Phosphorus	0.06% or below

2. For Rail on pointing and crossing:-

Carbon	0.5 to 0.6 %
Manganese	0.95 % to 1.25 %
Silicon	0.05 % to 0.20 %
Sulphur	0.06 % or below
Phosphorus	0.06 % or below

Requirement of rail

1. They should be of proper composition.

2. The vertical stiffness should be high enough to transmit the load to the sleeper.

3. The rail should be capable of withstanding lateral forces.

4. The head must be sufficiently thick to bear the load.

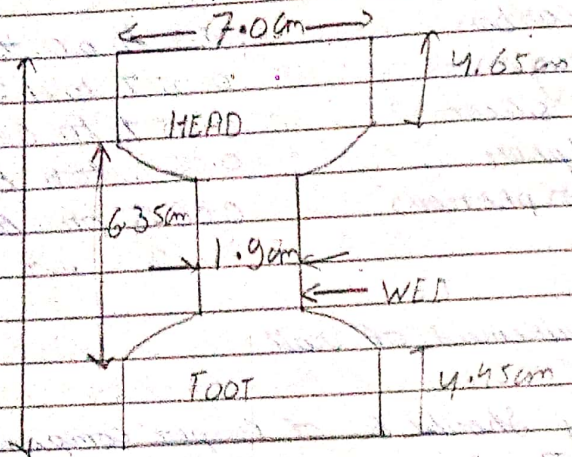
5. Bottom of the head and top of the foot of rail should be ~~stool~~ so shaped to enable the fish plate to transmit the vertical load.

6. Relative distribution of material of rail in head, web and foot must be balanced.

Types of rail

There are 3 types of rail.

1. Double headed Rail



This rail are used in the early stage of rail road development. They are divided into 3 parts upper table, network, lower table. The upper table and the lower table are the same and they are introduced to double the service life of the rail. When the upper table wore out the rail could be inverted and flipped over a chair so that the lower table could be used. However this plan soon proved to be wrong as the contact between the lower table and the chair caused the surface of lower table to become rough and unable to run trains smoothly.

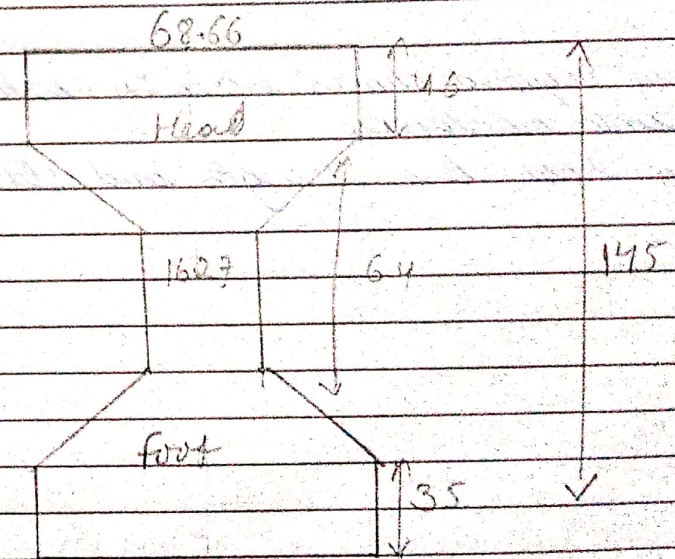
Merits:-

- Initially thought to be least cost effective.
- easy to manufacture due to its symmetrical shape.

demerits:-

- both leads wear out due to contact with wheels and sleepers.
- It is costly
- It requires more material.
- It requires separat chair for support.

2. Bull headed



This type of rail has 3 part head, network, feet. Steel is used to build this rail. The head is larger than the feet and the feet hold the wooden keys that hold the rails in place. The Sole purpose of feet is to provide the required strength and stiffness to the rails.

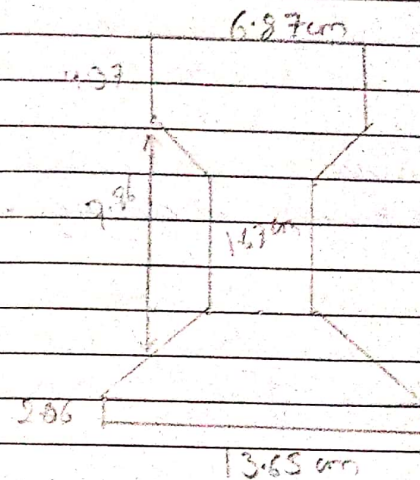
merits:-

- Stronger than double headed rail making it more durable.
- They keep better alignment and give more solid and smoother track.
- The rails are easily disconnected from sleepers.

demerits:-

- They required chairs increasing installation cost and maintenance.
- They have less strength and stiffness.

3. Flat footed Rail.



This rail was invented by Charles ~~the~~ Vignoles in 1836. They are divided into 3 part head, web and foot. This type of rail road has become increasingly popular and about more than 90% of rail lines in the world uses this. They don't require any chair and can be nailed directly to the sleepers. They are not effective. They are cheaper than bull headed rails. The weight of train wheel is distributed over a large number of sleepers and therefore over a wider area.

merits:-

- most stable and strong.
- It is suitable for heavy load and high speed train.

- It is used in continuous welded rails.
 - It is easier to install.
- demands.

- It is more expensive.
- It is difficult to repair if damaged.

Selection of rail.

- Speed of train
- The gauge of the track
- Axle load and nature of traffic
- Spacing of sleepers
- Maximum load coming on the top of the rail.

Length of rails.

The Rails of longer length are preferred to smaller length of rail because they give more strength and economy for a railway track because the weakest point of a track is the joint between two rails. Lesser the number of joints lesser would be the number of fish plates and this would lead to lesser maintenance cost, smooth running of train and

more comfort to the passenger. Though the length of rail is desired to be long, however, the length is governed by the following factors.

- The length of rail is so chosen that the maintenance cost is most reasonable.
- It depends upon the transportation facility so only those rail lengths are possible which can be transported by the longest wagen available.
- To some extent the length is limited by the facility of lifting and handling during loading and unloading of wagen.
- More the length of rail ~~more~~ more will be the gap required for expansion of rail but it doesn't affect more.

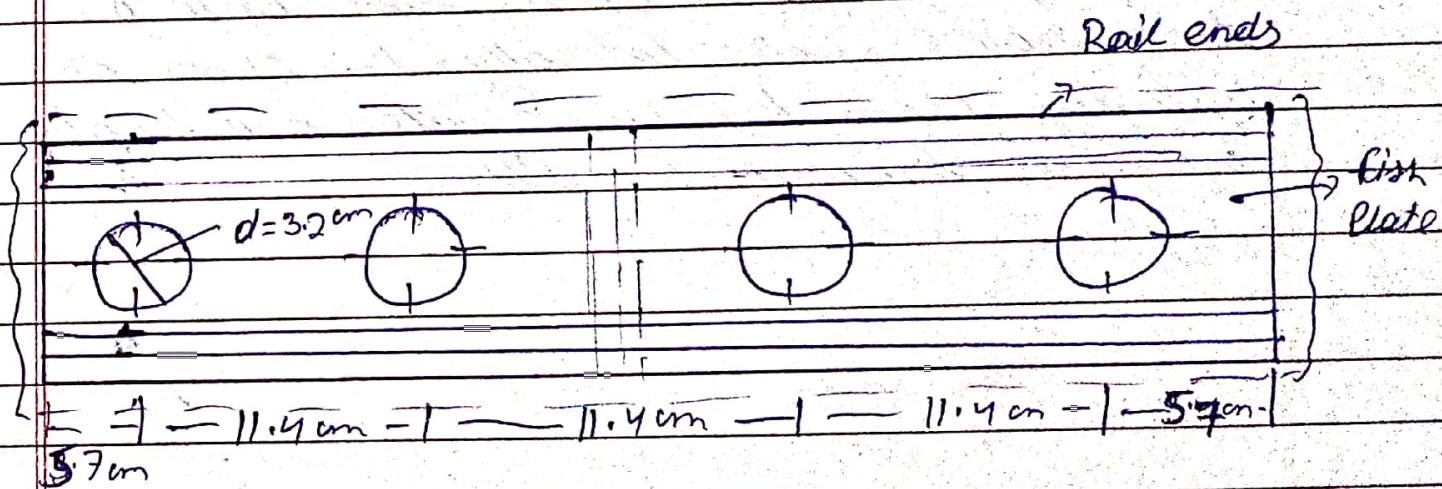
On Indian railway the standard ~~two~~ length are

(i) for bridge gauge	12.8m (13m)
(ii) for meter gauge	11.89m (12m)

- They must be of such a section to mean the stresses due to lateral and vertical bending movement
- They should hold the ends of the rail both laterally in line and vertically in level.
- They should be provided against the wear of fish plate due to expansion and contraction.

Section of fish plate:-

various section have been designe to mean the stresses due to lateral and vertical bending.



2. Chair's:-

(i) cast iron chair:-

for holding double headed and bull headed

5/04/25

classmate

Date

Page

UNIT- 4

Point and crossing and station yards.

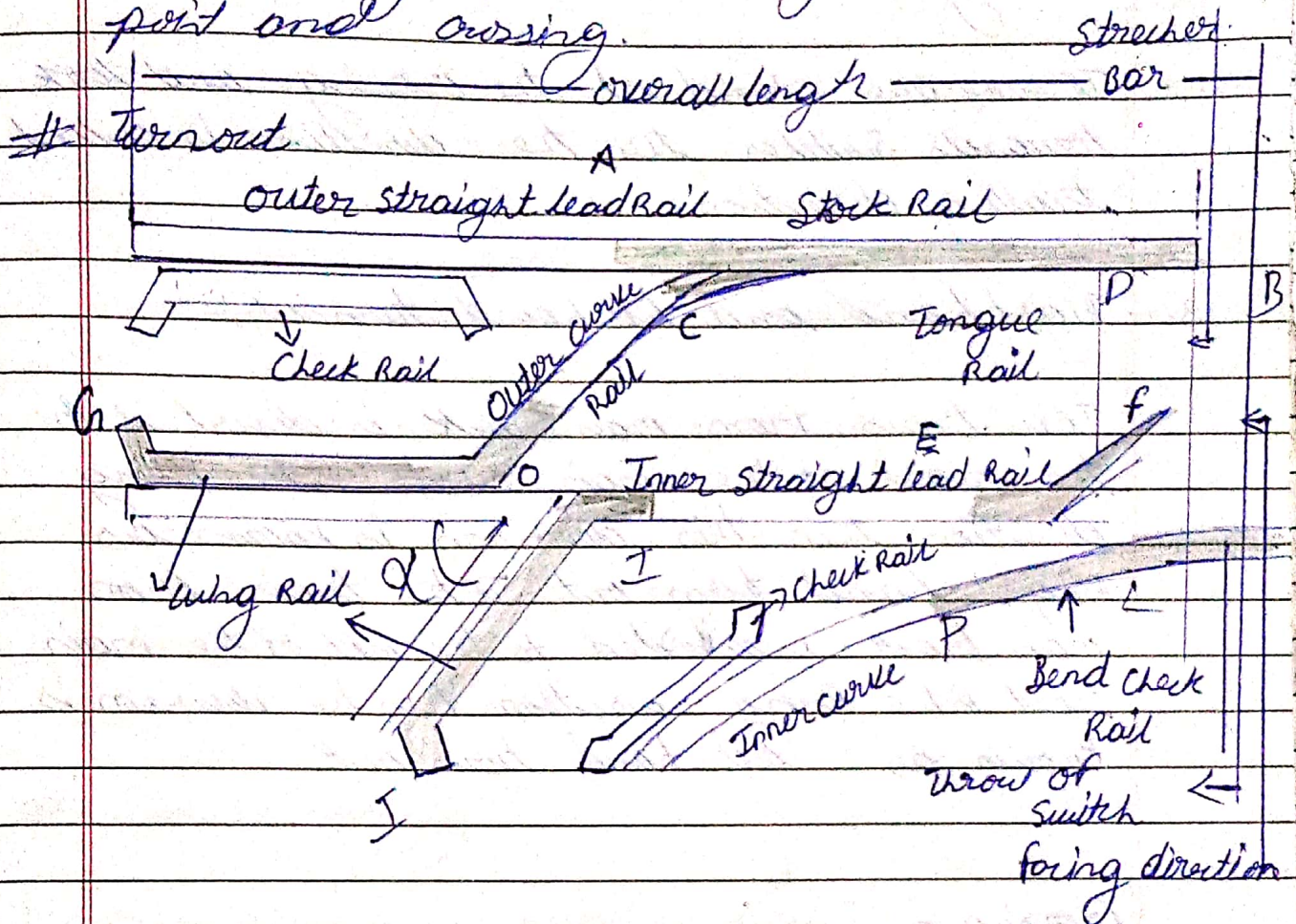
Point and crossing

Points, crossing, turn outs and such related terms or arrangement by which different routes either parallel or diverging are connected and afford the means for trains to move from one route to another. This connection are not only useful for train to move from one route to another but also help for shunting work in station yards.

necessary for point and crossing

In the case of roads the facility of turning of vehicle from one path to another does not required any special arrangement as the wheel have no flanges. The direction of movement of vehicle is controlled by the driver and the steering but this is not true in the case of railways because the wheels are provided with flanges so the direction of movement of the vehicle to another track are control automatically by the wheel flanges rather than the driver. The problem of diversion of train from one track to another

is solved by special arrangement known as point and crossing.



Important term used in point and crossing.

1. facing direction:

If some one stand at the end of switch and looks toward the crossing then the direction is called facing direction.

2. Trailing direction:-

If some one stand at the crossing and look towards switches then the direction is called trailing direction.

3. Right hand and left hand turnout:-

If a train from main track is diverted to the right of the main route in the facing direction then this diversion is known as right hand turn out. If the train from main track is diverted to the left of the main route in the facing direction then the diversion is known as left hand turn out.

Crossing:-

Crossing is a device which provide two flange ways through which the wheels of the flanges may move when two rail intersect.

Each other at an angle the flanged wheel of the train jump over the gap from through to nose of the crossing and to check the wheel flanges from striking the nose the opposite wheel flanges are guided by use of check rail inside the running rail.

Requirement and characteristic of a good crossing.

- The assembly of a crossing has to be rigid to stand against seismic vibration.
- The wheel on parts of the wing rail opposite the nose and also on nose it self must be protected.
- The crossing body should be as rigid as possible and as long as possible.
- The nose of crossing should have some thickness from practical consideration.

Types of crossing

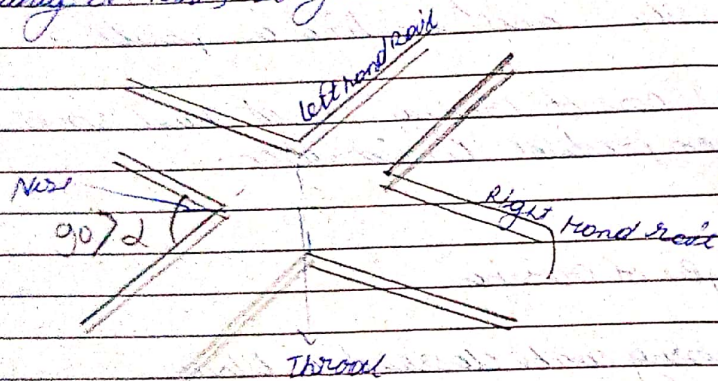
Crossing can be classified as below

1. on the bases of shape of crossing.
 - i) Acute angle crossing
 - ii) obtuse angle crossing
 - iii) Square crossing
2. on the bases of assembly of crossing
 - i) Spring or movable crossing
 - ii) Ramped crossing

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(i) Acute Angle Crossing

This type of crossing is widely used. Its crossing is obtained when a left hand rail of one track crosses a right hand rail of another track at the angle of intersection or approaching rail is acute angle it is termed as acute angle crossing. It consist mainly of left, wing rail and check rail.



(ii) Obuse angle crossing:-

This crossing is obtained when left hand rail of one track crosses right hand rail of other track on viceversa at an obtuse angle. In diamond crossing or pair of special crossing is used which is called obuse crossing. In case of obuse angle crossing the wing rail donot carry the tubular as in case of acute angle crossing rather it is a

check angle

(iii) Square crossing

when two straight track cross each other at right angle they give rise to square crossing. this type of crossing must be avoided in main line because there is heavy wear due to dynamic loads.

Important term use in crossing:-

1. Theoretical and actual rise of crossing

The point rail is never made to a well defined sharpest point as it would break off under the dynamic action of moving traffic so blunt nose is provided for the point rail. The thickness of blunt nose is usually equal to the thickness of web of the rail. The thickness of blunt nose varies from 0.6 cm to 1.9 cm. The sharp imaginary point where the two gauge faces in case of acute angle crossing or the gauge face of sloping angle crossing would meet is known as theoretical nose of crossing. all the calculation are made from "TNC"

Switch

A switch consists of a stock rail and a tongue rail a set of switches on point consist of a left hand switch and right hand switch. switches are tapered rail both with the pillar end known as bell fixed to the main track and other end known as heel too movable by means of which the flanged wheel of the train are diverted from one road to another.

Types of Switches

There are two types of switches

1. Stub switch

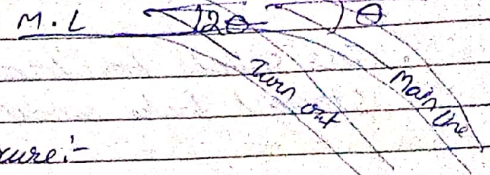
In this type of switch no separate tongue rail is provided and some portion of track is moved side to side. It is an old form of the switch and has got many disadvantages. This type is no more in use.

2. Split switch

In this type of switch a tongue rail is combine with the stock rail.

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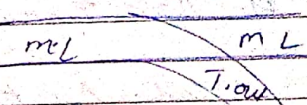
Types of Track Junction



1. Turn out of similar flexure:-

A turn out of similar flexure keeps running in the same direction as the main line curve even after branching off from it. The degree of turn out curve is generally lighter than that of the main line curve.

2. Turn out of contrary flexure



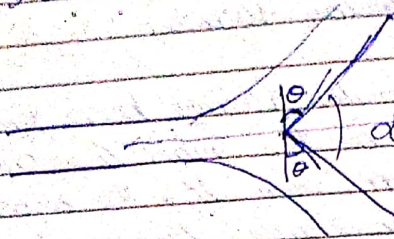
A turn out of contrary flexure moves in the opposite direction of the main line.

3. Symmetrical split or equivalent turn out:-

When a turn out is taken off from a curved track it is termed as split. When a straight track is split up in two different sections with equal radii it is known as symmetrical split. The salient features of this track junction are:

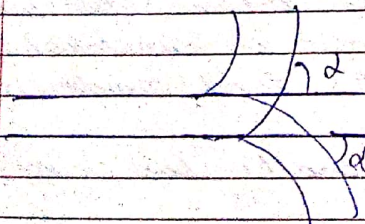
- The radii of main track and the lead curve are equal.
- The turnout is symmetrical about the center line.
- In such cases the number of crossings 1:6 is generally used.
- This provides the facility for turning of train in both left and right direction on the main curve.

- It is suitable for location where turn out from a straight track would take too much space.

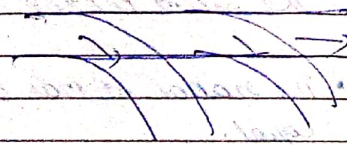


4. Three Throw Switch

When the turn out from a curved track turns away in the opposite direction they are set to be Contrary three throw switch. If the turn out and the main track turn in the same direction the curve is set to be Similler three throw switch. When two turn out take off from same point of a main straight track it is called three throw arrangement.



Three throw switch



Similler three throw switch.

The Simlar feature of three throw switch are

- It consist mainly of two switches, concrete fill blocks for both the turning side of the switch, and two stock rails, three crossing and check rail.
- It is suitable for main lines with heavy traffic because use of double switches may lead to derailment.
- This may be used in congested area where space is not enough and heavy traffic is not prevailing. Such as goods yard, entrance to locomotive yards.
- In case of three throw of contrary flexure the road of turn out are same but the similler flexure the road are different.

5. Diamond Crossing

When straight tracks or curved track of same or different gauge cross each other at an angle less than 90° a diamond shape is formed so this crossing is called diamond crossing. The Simlar feature of this crossing are - it consist of two acute angle crossing and two obtuse angle crossing.

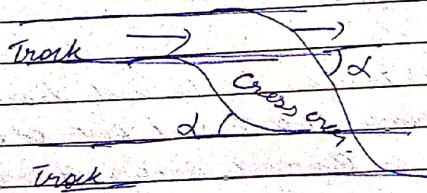
- The length of the gap between two noses of an obtuse crossing increases as a acute angle of the

crossing decreases.

- diamond crossing should be avoided as far as possible on curves as there is restriction of speed.

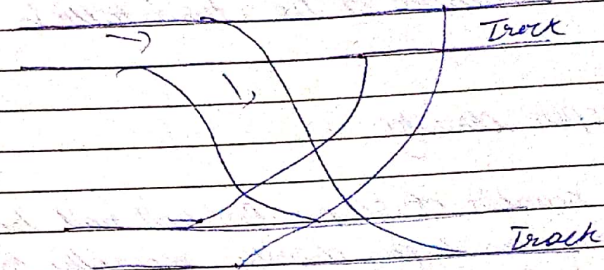
6. Cross overs :-

When two adjacent parallel or diverging track which may be straight or curved are connected by two sets of turn out with or without a straight length between them the connecting line is known as cross over. ~~straight length~~
The important feature of this are 'items' of two pairs of switches, two cut angle crosser with buffer to curve with or without straight length between them.



7. Sisson crossover on double crossover

It is a combination of one crossover over the other cross over in the opposite direction to enable the train to change the track from either direction along the main track.



8. Gathering line on leader track

When a number of track are branched off from the straight track in continuation of a turn out it is called as gathering line on leader track.



• Triangle Turn Out

The triangles are required for changing the direction of single turn table are also used to change to direction of engine but they are very costly. So if enough area is available and railway section are not very important than the installation of the turn table is not justified.

ii. Sleeper density

The number of sleeper per unit rail length is known as sleeper density. Generally one sleeper is used for every one meter length of rail at it is specified as an "N+X" "M+X" where M or N is the length of rail in meter and X is a mathematical number which varies according to the following factors.

- Axle load and speed of train.
- Type and section of rail.
- Type and strength of sleeper.
- Depth of ballast and cushion.
- Nature of formation.

On Indian railway on big track is adopted as M+7 or M+14 for big track.

Q. determine the sleeper density for a b.g rail when the length of rail is 700m.

Sol:

$$\text{Sleeper density} = M+7$$

$$\text{Total length of rail} = 700\text{m}$$

$$\text{D.G. length of rail} = 12.8 \text{ or } 13\text{m}$$

$$\text{No. of Rail} = \frac{700}{12.8}$$

$$= 54.68 \text{ or } 53.84$$

$$\Rightarrow 54.68 \text{ or } 53.84$$

$$\underline{55 \text{ No.}} \text{ or } 54 \text{ No.}$$

$$\text{Sleeper density} = M+7$$

$$= 12.8/13 + 7$$

$$= 19.8 = 20$$

$$\text{Total sleeper density}$$

$$= 20 \times 54/55$$

$$= 1080 \text{ No.}$$

Q Determine the sleeper density $M+6$ for a track when the length of rail is 640m

Sol: Sleeper density of $= M+6$
 length of rail = 640m
 B.G = length of rail = 12.8m

$$\text{No. of Rail} = \frac{640}{12.8} = 50$$

$$\begin{aligned} \text{Sleeper density} &= M+6 \\ &= 12.8 + 6 \\ &= 18.8 \\ &= 19 \end{aligned}$$

$$\begin{aligned} \text{Total sleeper density} \\ &= 19 \times 50 \\ &= 950 \text{ No of sleeper} \end{aligned}$$

Q Using a sleeper density of $M+5$ find out the No. of sleepers required for construction of 1280m track

Sol: Sleeper density $= M+5$
 length of rail = 1280m
 we will consider B.G = 12.8m

$$\text{No of Rail} = \frac{1280}{12.8} = 100$$

$$\text{Sleeper density} = M+5$$

$$\begin{aligned} &= 12.8 + 5 \\ &= 17.8 \\ &= 18 \end{aligned}$$

$$\begin{aligned} \text{Total sleeper density} &= 18 \times 100 \\ &= 1800 \text{ No of sleeper} \end{aligned}$$

Q Find out the expression for sleeper density for a track if 19 sleepers are used under a rail length

Sol: No of sleepers = 19, B.G = 12.8

$$\begin{aligned} 19 &= M+x \\ 19 &= 12.8 + x \\ 19 - 12.8 &= x \\ 6.2 &= x \\ 6.2 &= x \end{aligned}$$

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Station and yard

A railway station is selected place on a railway line where train halt for one or more of the following purposes:-

1. for exchange of passengers, goods.
2. for control of train movement.
3. to enable the trains on a single line track to cross from opposite direction.
4. to enable the following express train to overtake.
5. for taking diesel, coal and water for locomotives.
6. for detaching engines and running staff.
7. In emergency in case of obstruction of track due to rain or accidents.

Sites selection for railway station

1. Acquisition of land
2. Proximity to town or village
3. Nature of land area.
4. Approach roads to station sight.
5. Station sight alignment.
6. Sight drainage.
7. Type of station and yard.
8. Station amenities.
9. Road of authority.

requirement of railway station

1. Public requirement:-

- Booking office for ticket.
- Goods and passenger platforms with overhead shade.
- Proper arrangement for drinking water.
- Suitable lighting and ventilation.
- Waiting room and retiring room.
- Sanitary arrangement.
- Other facility like public telephone, refreshment room, telegraph office, inquiry office.
- Microphone to announce arrival and departure time of train.
- Provision of big display board for schedule to train and change if any.
- Guides from railway department to help interstate passenger.

2. Traffic staff and police requirement (staff room, retiring room, quarter for railway staff)

3. Train requirement (Signal and signal, movement of train, Number of platform and siding)

4. Requirement of locomotive (Supply of fuel and water to locomotive, arrangement for cleaning, examining, inspecting and maintaining of locomotive).

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Requirement for development of Railway (easy and comfortable approach road, installation of deck, availability of coolers and facility like cinema, escalators, restaurant and underground passage leading to important places of city)

1. operational classification

(i) Block station:-

Block station which are sort of compartment into which the railway line is divided are established so as to safety space the train being over the block station are made at the end of the block section and are equipped with signals. A block station is a place on the railway line at which permission to approach and authority to proceed are granted.

(a) "A" class station:- It is a station where the line has to be cleared upto and adequate distance beyond the home signal for giving permission to approach to a train. It includes home signal, starter signal, warning signal.

• "B" class station:- B class station is one where the line has to be cleared upto an adequate signal or outer signal before giving permission to train.

• "C" class station:- C class station is only a block hut where no passenger are book. It is used as a means to split a long block section so that the interval between successive train is reduced. It is minimum signal requirement.

(ii) Non-Block station :-

These are also called "D" class of flag station. These are situated between two consecutive block stations. They do not define the boundary of any block station.

2. Functional classification :-

(i) Non-Junction or way side station

This station consists of an arrangement for crossing and on up and down train on the overtaking. The slower train by the fast moving train it may be of single line, double line or triple line.

(ii) Junction station

A junction station is one where a branch line joins a main line and at such Junction special arrangements are made for the following.

- To facilitate the interchange of traffic between the main and branch line.
- To enable the engine to be rebased at Junction for servicing.

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(iii) Terminal station or Terminal

The station at which the railway line or one of its branches terminate is known as terminal station or are Lodi, Howrah, Bombay etc.

Platform

A raised level surface from where either passengers board and alight from trains or loading and unloading of goods is done is known as platform. Platforms are generally of two types.

1. Passenger platform :-

This platform is meant for passengers who are using the railway. The following are essential of the passenger platform.

- The platform should be covered for a minimum distance of 60 m of their length.
- A minimum width of 3.65 m of platform should be paved.
- The ends of the raised platform should be in form of beam with a minimum slope of 1:6.
- Adequate arrangement of lighting on platform should be made for efficient and safe running of train at night.

- adequate drinking water should be provided.

2. Goods

Two platforms are used for loading and unloading of goods the following are essential of a goods platform.

- Goods platform are generally higher with high wagon floor. This facility is provided for handling of goods.

- Goods should be provided and at the same time weighing arrangement should be provided on platform.

- Proper drainage facility should be provided.

- The facility for direct access from the goods platform to goods siding is provided.

Yards

A yard is defined as a system of tracks laid usually on a level within definite limits for receiving, storing, sorting, making of new train etc. The various movement on a system of track are governed by rules, regulation and signals.

Types of yards

1. Passenger bogie yard:-

The main function of passenger bogie yard is to provide facility for the safe movement of passenger and vehicles for the use of passenger. This yard is of specific importance at terminal station or junction where extra passenger bogie are accommodated and ~~storing~~, cleaning or storing is done.

2. Goods yards:-

The main function of goods yard is to provide facility for receiving, loading and unloading, delivery of goods and the movement of goods vehicle all the station except flat station are provided with goods yards loading and unloading is done on goods platform where as storing is done in goods shed. Separate goods siding are also provided for storing and delivery of goods.

3. Marshalling yards:-

marshalling yards is said to be a machine to receive, retrain and dispatch train enroute. In other words a marshalling yard is one where train and other loads are received, sorted and

and train are formed.

i. Locomotive yard:-

They are the yards in which locomotives are housed and where all the facility for cooling, watering, repairing, oiling, cleaning etc. are provided for ensuring good stability of locomotives.

ii. equipment in station yard:-

Necessity of equipment:-

- equipment for the convenience of passenger in a passenger yard for this purpose public telephone, microphone, overbridges or subways are provided on busy station.
- equipment for good service in a goods yard for this purpose cranes, weight bridge, loading gauges and loading ramps are provided.
- equipment for the locomotive in locomotive yard for this purpose engine shake, ash pit, ash pan, exhumation pit, dropper, water column, fan table etc. are provided.

- equipment for the safety of locomotive movement for this purpose section block, derailling switch, buffer stop, sand lamp, level junction and signal may be provided.

- other equipment of railway such as refrigerator to supply cold water in hot weather, shed and wind protection arrangement, good water supply.

#

2. Mobile cranes

This is the most useful type of crane which is mounted on a vehicle and can be used anywhere in the yard.

3. Portery Cranes:-

- This consist of two parallel beam & supported at one vertical post hoisting machine is installed on a platform which travel on a parallel beam.

Weigh Bridge

These are provided in goods yard to get the weight of loaded wagen. The weigh bridge are level platform with roll wheels are connected with the track the level platform are supported to beam and return beam are loaded in a pit under the track, the loaded wagen is brought on to the platform and it is assured that the beam rest on knife edge rollers attached to the frame.

water columns

water columns are provided for feeding the water to steam locomotive they are provided at intermediate station by the side of main line track at distance not less than 48 km. They may also be installed on the ash pits. At important station two or more water columns can be provided they are also provided in locomotive yard.

Turn table

A turn table is used for changing the direction of locomotive. The use of turn table is made at important station where available space is limited. A turn table is a circular installation where a triangle. The turn table is consist of a track on a platform which is then is supported on a pair of girders.

The girders are properly braced and are supported on a central pivot. The central pivot is installed on a turn table.

Switch blocks

It is common practice to separate all the siding and shunting lines from running lines the separation of siding is provided by providing construction known as switch block. A switch block is a curved

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2# warner signal

A Semaphore signal at the entrance to station is combine with a warner signal. A warner signal is similar to semaphore signal in shape except "V" notch at free end. The warner signal is placed on the same post of the semaphore signal at 1.8 to 2.1m below the semaphore signal. The warner signal is painted yellow and exhibit a yellow colour instid of red colour.

#3 Shunting signal (Disc signal)

This signal are used for shunting operation in station yard and therefore they are called shunting signal. They are of circular disc shape with a red band on a white background. The disc can rotate in a vertical plane by pulling the lever by hands. Two holes are

provide one for the red lamp and other for green lamp when the red band on the disc is in horizontal position on it shows red light at night it indicate stop when the red band is inclined on shows green light at night it indicate provide.

4# Colour light signal:-

With the introduction of electricity in railway and increased traffic requirement Semaphore signal and warner signal are being replaced by light intensity beam colour light signal both during day and night they may be either 2 aspect (green, red), 3 aspect (green, yellow, red) and 4 aspect (green, yellow, red, yellow). 3 aspect signal are generally used all over the world.

Locational signal

1. reception signal:-

The signal which control the reception of train into a station are called reception signal. The reception signal are of 2 type the outer and home signal.

The outer signal is the first stop signal at a station where it is provided that is this is the first stop signal which indicate the entry of train from block to station yard. It should be provide at an adequate ^{distance}. This adequate distance depend on the basis of maximum allowable speed in India which is 0.54 km for BG track 0.40 km for MG track.

Home signal is called as home signal because of its location at the door of the station the home signal indicate which line is to be used. It is one of the important function of interlocking to ensure that the road is properly set before the signal arm is taken to off position.

2. Departure Signal

The Signal which control the departure of train from the station are known as departure signal. This are mainly of two types starter signal and advanced starter signal.

Starter signal mark the limit upto which train stopping at the station come to a stand or halt. The starter is the last stop signal at a station if advance starter is not provided then in such cases it has to be place outside all connection of the line to which it refers unless permitted by approved instruction. Thus starter signal control the movement of train when they depart from the station beside the starter signal for each of the station line from which train start a advance starter may also be provided beyond the limit the advance starter become the last stop signal.

Control of movement of train

One of the basic objective of signalling is to control the movement of train with a view to ensure safety by preventing accident to achieve this goal a particular system of working should be adopted. In view of 3 important aspect safety, speed and traffic density of operation the absolute block system is generally used on the Indian railways. Various system that used on one or more on the other railway for the control of movement of train are the following.

1. Absolute block system one space interval system.

This system of working is most widely used in India and about 90% of train are controlled by this system. In this system the entire track is divided into section called block section separated by block station that is station provided with block instrument in pairs at each station. This instrument are used to show whether the section ahead is clear or reserve. All block section are linked in series for operation of block instrument and telephonic for verbal exchange of information.

2. Automatic block system also called automatic signaling

This system is an improvement of absolute block

System and avoid possibility of accident due to human being. In this particular system the signal are operated by the train themselves and therefore the train can follow each other between the two station. The section between the two station is divided into number of block one block is about 5 km to 7 km in length. An electric current is conveyed through the electric circuit track when a train enter a particular block the electric current put the signal at danger position for the particular block until the train has gone nearly two block ahead. In America further advancement is automatic signaling in which they use electric fitting with wheel break of the locomotive.

3. Centralized traffic control System (CTC)

Centralized traffic control mean the centralization of operation of all the point and signal at the various station on a section of the railway at one signal box and concentrating the control over all the points and signal indication into the hand of signal official. This is the latest system developed to control the movement of train in which point and signal are operated from a central control room. This system was first introduced in USA and has only been introduced on north east railway in India.

Interlocking

Interlocking is defined as technique which through mechanical or electrical devices or agency by which it can be ensure that before a signal is taken to off position for the road which the signal control is properly set and held at the same time all the signal and point the operation of which may lead to conflicting movement.

Necessity and function of Interlocking

In Signalling operation it is absolutely necessary that only that signal should be lowered for which road it is meant and the road has been correctly set in advance. Interlocking is a device which help in the proper and safe working of signal. Interlocking makes necessary performing following function.

- It must be impossible to take off a signal for approaching train unless the road to which the train is travelling is properly locked.
- It must be impossible to take off position at one end the same time for fixed signal.
- It must be impossible for loose wagon to interfere with the road for which point are set and signal has been taken to off position.

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$\theta = 1720^\circ$

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Super elevation :-

To counteract the effect of centrifugal force the level of outer road is raised above the inner road by certain amount to introduce the centripetal force. This raised elevation of outer road above the inner road at horizontal curve is called Super elevation.

- ① If a 8° curve track diverges from a main curve of 5° in a opposite direction in the lay out of a big yard calculate the super elevation and the speed on the branch line if the maximum speed permitted on mainline is 45 km/h

Ques. equil. cont. required for 45 km/h speed by equation

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

G = Gauge distance

$$B.G. = 1.676$$

$$M.G. = 1$$

$$N.G. = 0.76$$

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$$e = \frac{1.67 \times 45^2}{127 \times 1720}$$

$$= \frac{1.67 \times 1720}{5}$$

$$e = 7.74\%$$

for track gauge the cont. distance for main line is 7.6 cm. So the cont. for main track =

$$7.74 - 7.6 = 0.14 \text{ cm}$$

There is no cont. to be provided on direct track as the - 0.14% is negative cont. for 10 km/h. 7.6 cm, 0.6 = 5.1 cm, 0.6 = 3.8 cm

With cont. of 7.6 cm which is permissible to provide the cont. will be for curve - 7.6 - 0.14 = 7.46

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

$$R = \frac{1720}{8}$$

$$= 7.72 = \frac{1.67 \times V^2}{127 \times 1720 \times 8} = 34.74 \text{ km/h}$$

Q A curve of 5° diverges from 3° main line curve in reversed direction to the lay out of B.G track. If the speed on branch line is restricted to 35 km/h , determine the restricted speed of main line.

Sol:-

$$B.G \Rightarrow 1.676 \text{ m}$$

$$\text{super } C = \frac{G V^2}{1.27 R}$$

$$\text{Branch } V = 35 \text{ km/h}$$

$$R = \frac{1720}{5} \\ \Rightarrow 344$$

$$e = \frac{1.676 \times (35)^2}{1.27 \times 344} \Rightarrow 4.69 \text{ cm}$$

So the -ve cant equal to equilibrium cant -
cant deficiency (cant deficiency for B.G track permitted is equal to 7.6 cm)

$$7.6 - 4.69 = 2.91 \text{ cm}$$

-ve Cant equal to maximum permissible super elevation on the main line equal to 2.91 cm .

Theoretical super elevation which can be provided on main line will be -

$$= 7.6 + 2.91$$

$$\Rightarrow 10.51 \text{ cm}$$

$$e = \frac{G V^2}{1.27 R}$$

$$, R = \frac{1720}{3} = 573.33$$

$$10.51 = \frac{1.676 \times V^2}{1.27 \times 573.33} \Rightarrow 67.57 \text{ km/h}$$

N-D

Q A 4° main line curve has a 6° branch line curve at the same point in lay out of a broad gauge yard if the maximum speed on main line is 70 km/h then calculate ~~the~~ -ve super elevation and maximum speed on branch line

Sol:- $B.G = 1.676 \text{ m}$

$$V = 70 \text{ km/h}$$

Q A curve of 5° diverges from 3° main line curve in reversed direction to be lay out of B.G. yards. If the speed of branch line is restricted to 35 km/h , determine the restricted speed of main line.

Sol:

$$B.G. \Rightarrow 1.676 \text{ m}$$

$$\text{super } C = \frac{Gv^2}{1.27R}$$

$$\text{Branch } v = 35 \text{ km/h}$$

$$R = \frac{1720}{5} \\ \Rightarrow 344$$

$$e = \frac{1.676 \times (35)^2}{1.27 \times 344} \Rightarrow 4.69 \text{ cm}$$

So the -ve cant equal to equilibrium cant -
cant deficiency (cant deficiency for B.G track permitted is equal to 7.6 cm)

$$7.6 - 4.69 = 2.91 \text{ cm}$$

-ve cant equal to maximum permissible super elevation on the main line equal to 2.91 cm .

theoretical super elevation which can be provided on main line will be

$$\Rightarrow 7.6 + 2.91 \\ \Rightarrow 10.51 \text{ cm}$$

$$e = \frac{Gv^2}{1.27R}, R = \frac{1720}{3} = 573.33$$

$$10.51 = \frac{1.676 \times v^2}{1.27 \times 573.33} \Rightarrow 67.57 \text{ km/h}$$

N-D
Q

A 4° main line curve has a 6° Branch line curve at the same point is lay out of a broad gauge yard if the maximum speed on main line is 70 km/h then calculate the -ve super elevation and maximum speed on branch line

Sol: $B.G. = 1.676 \text{ m}$

$$v = 70 \text{ km/h}$$

$$R = \frac{1720}{4} = 430$$

$$e = \frac{1.676 \times (70)^2}{1.27 \times 430} = 15.03$$

from B.G the cant deficiency for main line equal to 7.6. So the cant for main track equal to

$$15.03 - 7.6 = 7.43 \text{ cm}$$

There fore the cant to be provided for branch track equal to - 7.43.

With cant deficiency of 7.6 cm the speed of the train will be for a cant of

$$7.6 - 7.43 = 0.17 = e$$

$$0.17 = \frac{1.676 \times v^2}{1.27 \times 286.66} \quad R = \frac{1720}{6} = 286.66$$

$$v = 6.07 \text{ km}$$

③ A 3' main line curve has a 5' branch line curve at the same point in lay out of broad gauge yard. If max speed on main line is 60 km/h then calculate -ve super elevation and max speed on branch line.

$$\Rightarrow B.G = 1.676$$

$$v = 60 \text{ km/h}$$

$$R = \frac{1720}{3} = 573.33$$

$$e = \frac{G v^2}{1.27 \times R} \Rightarrow \frac{1.676 \times (60)^2}{1.27 \times 573.33}$$

$$\Rightarrow 8.28$$

from B.G the cant deficiency from main line equal to 7.6. So the cant for main track equals to $8.28 - 7.6 = 0.68$

There fore the cant to be provided for branch track equal to - 0.68

With cant deficiency of 7.6 the speed of the train will be for cant of

$$7.6 - 0.68 = 6.92 \text{ cm}$$

$$R = \frac{1720}{5} = 344$$

$$6.92 = \frac{1.676 \times V^2}{1.27 \times 344}$$

$$V = 42.47 \text{ km}$$

- ③ A 4° main line curve has a 6° Branch line curve at the same point in layout of a BG yard. If max speed on Branch line is 45 km/h then calculate - v, superelevation and max speed of branch line.

Soln

$$BG = 1.676$$

$$V = 45 \text{ km}$$

$$R = \frac{1720}{4} = 430$$

$$e = \frac{1.676 \times (45)^2}{1.27 \times 430} = 6.21$$

for the cant deficiency for main line equal to 7.6 so that cant of main track equal to

$$6.21 - 7.6 = -1.39$$

There for cant to be provided for branch track equal to 1.39

With cant deficiency of 7.6 on the speed of the train will be from a cant of

$$7.6 + 1.39 = 8.99 = e$$

$$R = \frac{1720}{e} = 286.66$$

$$8.99 = \frac{1.676 \times V^2}{1.27 \times 286.66}$$

$$V = 44.19 \text{ km}$$

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UNIT-5

Bridge engineering

Bridge

A Bridge is a civil engineering structure designed to span a physical obstacle such as river, valley or road to provide a continuous pathway for the movement of vehical, pedestrian, trains etc. It is a structure to carry load and transfer super imposed load safely from the super structure to the foundation. A bridge must be structurally sound and satisfy criteria such as strength, stability, stiffness and durability. Indian standard and International design standard like IRC in India is used for designing bridges. In designing ~~for~~ bridges ~~like~~ factors like dead load, live load, impact forces, thermal expansion and environment condition are taken in account.

Bridge Component :-

1. Super structure, 2. Sub structure, 3. foundation.

1. Super structure :- This is the portion above the support that directly carry the traffic load. No different part of Super structure are as follows.

(i) Deck :- The roadway or surface on which vehical or pedestrian travel is called as Deck.

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Requirement of road drainage system

A proper road drainage system is essential for maintaining road durability, preventing damage and the safety of road users. It involves systematic removal of surface water and sub surface water from road and adjacent area.

(i) Efficient surface drainage.

It is design to remove rainwater and prevent water logging. proper cross slope and cambers are design. side drain along the road shoulder for water collection is made. concrete culverts and basins at regular interval are made. proper alignment and gradient to ensure smooth smooth water flow is design.

(ii) Effective sub surface drainage.

To prevent weakening of Road foundation due to ground water in filtration. drainage layer under the pavement is provided to prevent capillary rise of water. longitudinal drains and pipe are installed to drain off the water.

(iii) adequate capacity and gradient.

To handle peak water flow without overflowing on

drainage drains should be designed based on the intensity and duration of rainfall in the area. Self-cleaning velocity should be maintained. A sharper gradient can cause erosion so lining with stone or concrete is needed.

(ii) Infiltration in natural

To avoid disturbing a natural water flow and prevent flooding, road drainage should be connected to natural stream or river at appropriate location.

It should be conducted before constructing road in sensitive areas.

(v) Maintain and accessibility:

To maintain long term functionality and ease of repairs, regular inspection and clearing of drains is done and if more durable material is made.

Types of road drainage system.

A road drainage system is essential for maintaining road stability, preventing water damage, etc.

road drainage system can be broadly classified into following ways: 5

1) Surface drainage system:

The surface drainage system is designed to remove rain water and run off from the road surface quickly to prevent water logging, skidding, hazards and pavement damages.

Component:-

- side drain (longitudinal drain):

This are open or covered drains running parallel to the road. Typically constructed using concrete or stone to allow high water flow. They collect and guide surface runoff.

- catch basin or inlet:

Small opening located at the edge of the road. It is generally used in urban areas.

- gutters and kerb drain:

used in city roads particularly in areas with high traffic.

• Comber

The road surface is designed with a slight slope to facilitate quick drainage toward the sides.

(ii) Subsurface drainage system:-

Subsurface drainage is used to control ground water level and prevent moisture from weakening the road foundation excess water in the sub soil can cause pavement failure, pothole and road slide.

Component

- Perforated pipes installed below the road surface to collect and carry away ground water. It is commonly used in areas with high water table.

- A network of small perforated pipes are installed below the pavement to drain excess moisture.

- Weep holes are provided as small opening in retaining wall, bridge and culverts that allow trapped water to escape.

- French drain are provided with gravel bed

ditches with perforated pipes designed to redirect water away from the road.

(iii) Cross drainage system:-

Cross drainage system allows water from natural streams, rivers and other sources to flow across the road without causing damage. Type of cross drainage structure.

• Culverts :-

Small passage way constructed below road to allow water to pass through it they may be pipe culvert, box culvert, & slab bed culvert.

• Bridge :-

Large structure that is constructed over rivers, lakes and canals. Its design is based on water flow capacity and structural load requirement.

• Cause ways :-

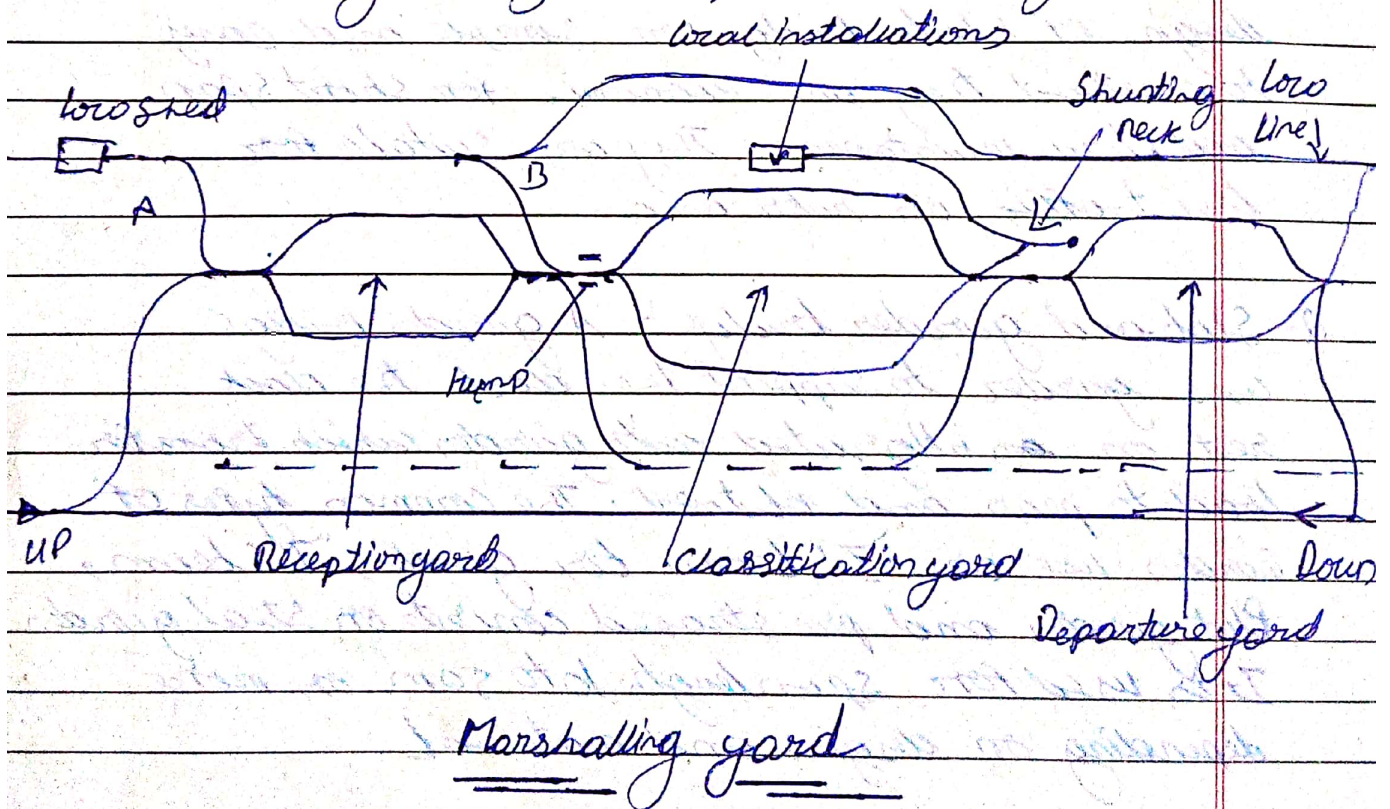
Low level crossing constructed over water bodies to flow over the road during flood and low water area. Not economical.

Types of RCC bridge :-

1. Slab bridge - A slab bridge is a type of bridge that uses a solid concrete slab as its main structural element to support load across a short span. Slab bridges are typically constructed using reinforced or prestressed concrete. Slab bridges are suitable for short spans, usually up to 10 to 15m. They are simply supported or continuous slab bridges. They are used for small roadways, pedestrian crossing, river road and over small stream or canals. The design of slab bridge are simple and easy to construct. They are economical for short span and low maintenance. They are suitable for low traffic or rural area.

2. Slab and girder bridge - A girder bridge uses girder to support the deck. The deck rest on an integrated with girder which transfer load to pier and abutment. The common types of girder use are 'I' beam, box girder, 'T' beam. Flat girder and pre stressed concrete or steel girder. It is used for span length 10 to 50m or more depending on design and material.

3. Pre stress concrete bridge:- A prestress concrete bridge is a type of bridge where concrete elements are pre loaded with internal stresses using high strength cables before applying external load. This help the structure from better resist tension and cracking. High strength tendons are tensioned and curved to compress the concrete. This compression counter act the tensile forces from live loads, improving performance and durability. They are long span with less material. They have higher load carrying capacity. They are low in maintenance and durable. They are used in highway and railway bridges overpasses and flyovers.



Imp

Q Difference between bridge and culvert.

As Bridge	Culvert
1. A bridge is a passage of transportation over a large body of water or physical obstruction.	A culvert is a structure generally a tunnel that allows water to pass under a road way or railway.
2. The basic component of bridge are Superstructure, Substructure and foundation.	The component of a culvert are simpler and include concrete boxes, pipes, dock and supporting parts.
3. Bridge are constructed at a height more than 20 ft.	Culvert are built at less than 20 ft ⁴ above the obstruction.
4. A Bridge Span varies from 6 meter to 120 m.	The length of culvert is typically not more than 6m.
5. Piers and abutment are the supporting structure of a bridge.	Culvert are usually embedded in the soil which gives the major portion of the culvert.
6. The construction of strong and deep foundation is very important in building a bridge.	No deep foundation is required.

7. A bridge is usually a linear and straight passage

culvert are totally enclosed structure. That can be semi circular, rectangular, elliptical or pear shape.

8. Construction of bridge generally required a lot of time and manpower.

Culvert are simpler in structure and design so it can be constructed with less time and laborer.

9. A bridge is built over a body of water that is large and has variable flow

A culvert is constructed when water need to be coming through tunnel or channel under a road way.

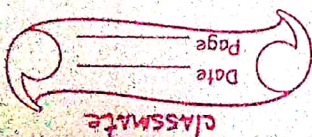
10. bridge can with stand heavy and speedy vehical

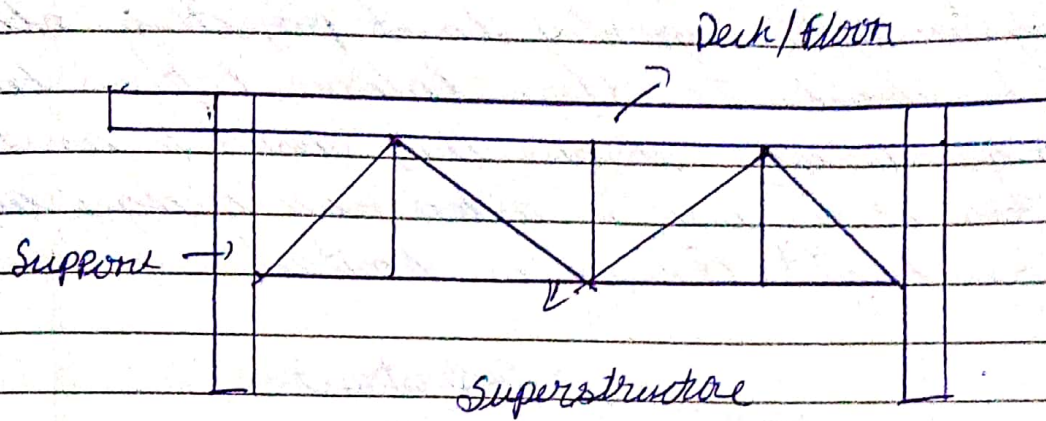
Some culvert like box culvert have sharp corner that are unsuitable for high velocity vehical

Int

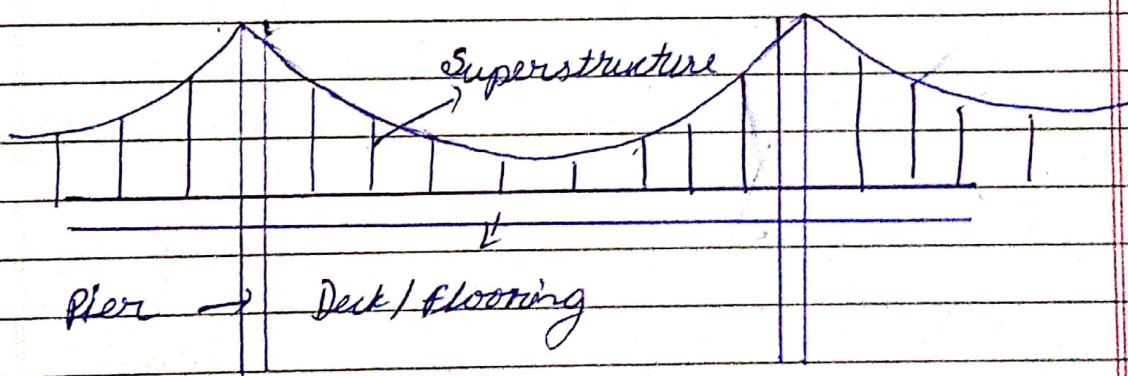
11. Explain deck bridge, Through, semi Through with diagram.

Deck bridge: A bridge in which deck is placed on top of the main load bearing structural element like trusses or girder. The deck is supported by the top chords and top flange of the structure. System it is easier in maintenance of the ~~and~~ super structure it may require total pier or support for longer span they are typically used in fly over express way and over passes.



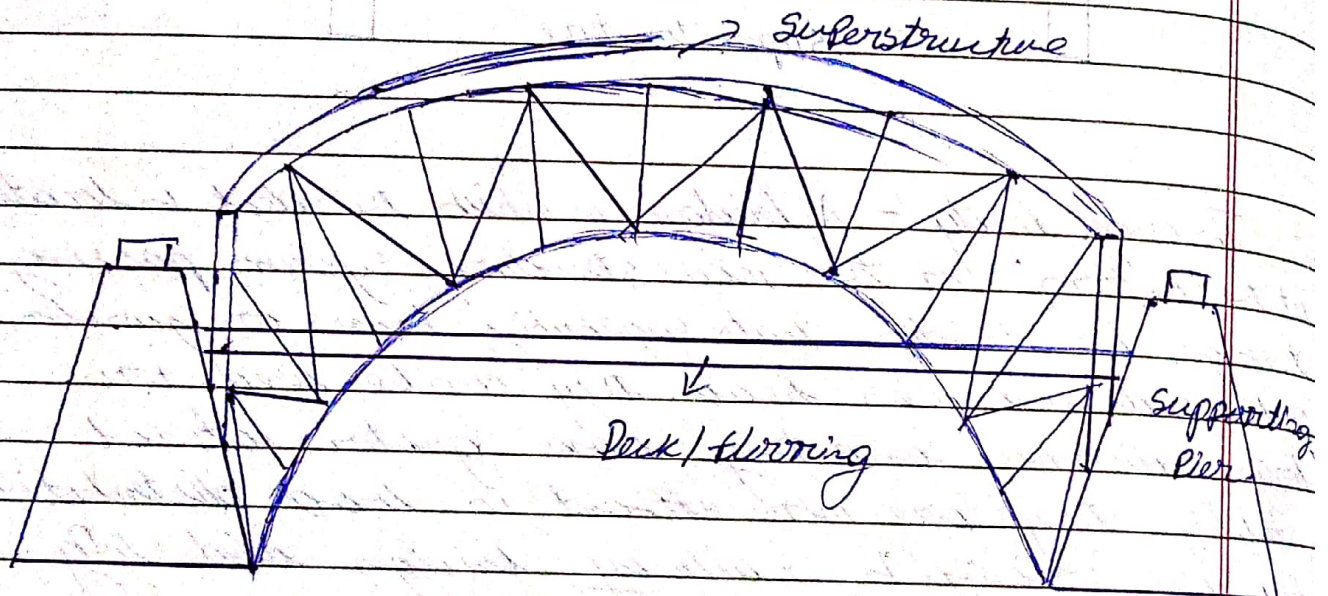


Through bridge - A bridge in which the deck is located at the bottom of the main structural system passing through the structure with supporting truss or girder on both side and over head truss can be used for longer distance and they have greater lateral stability they are more efficient in load distribution they are used in railway bridges and long span highway bridges over river or valleys.



Semi Through or half Through bridge:-

A bridge the deck is placed at the mid height of the structural system with supporting element projecting above and below the deck. It offers balance between both and through bridge. Despite it is easier to construct and maintain it is used in urban rail bridges and road where height clearance is limited.



Imp 2024

Q Derive an expression for economical span of the bridge.

Ans The factors affecting economic span are material cost, labour availability and slight site condition the span of bridge for which the total cost of the bridge is minimum is called economic span of bridge.

Let the ratio of cost of one span be "S"

Cost of one pier "P" then

$$R = \frac{S}{P} \text{ --- (eqn)} \quad \therefore S = RP$$

Then, Considered the overall cost of bridge be

$$C = nS + (n-1)P$$

where n = number of spans

$n-1$ = number of piers

We know

$$S = RP$$

Then

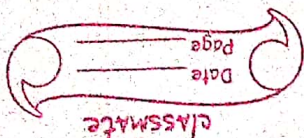
$$C = n(RP) + (n-1)P$$

for minimum value of C we will differentiate w.r.t n

$$\frac{dC}{dn} = 0$$

$$C = nRP + (n-1)P$$

$$\frac{dC}{dn} = \frac{d}{dn} (nRP) + (n-1)P$$



$$\frac{dc}{dn} = \frac{d}{dn} n(RP) + \frac{d}{dn} (n-1)P$$

$$\frac{dc}{dn} = RP \frac{dn}{dn} + \frac{d}{dn} (n-1)P$$

$$\frac{dc}{dn} = RP(1) + 1(P) = 0$$

$$RP - P = 0$$

$$RP = P$$

$$[R = 1]$$

from eq. 1:

$$R = S/P$$

$$1 = S/P$$

$$[S = P]$$

Procedure of bridge construction.

The steps of bridge construction are as follows.

Step 1: site selection and investigation.

Selection of suitable site considering accessibility, soil type and water flow then we conduct topographical survey, hydrological survey and soil investigation.

Step 2: Planning and design.

We decide the type of bridge based on span length, uses and environmental condition. The structural design of all component is done using relevant code and standard we get approval from concerned authority.

Step 3: Site preparation.

Clear the site by removing vegetation, structure and debris. provide diversion for traffic and construct temporary structure.

Step 4: Foundation construction.

marking and excavation for foundation is done as per design. the construction of foundation may be pile, shallow or well foundation. Then proper concreting and curing is done.

Step 5: construction of substructure.

Construction of piers and abutment are done. installation of bearing to support the superstructure is done then the check for alignment and stability is done.

Step 6: construction of superstructure.

Erect girders on beam using cranes on launching. rebar placed then concrete reinforcement for each slab pour and cure of concrete to complete the deck.