CBCS SCHEME

USN | | | | | | | | | | 17CV552

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Railways, Harbours, Tunneling and Airports

Time: 3 hrs. Max. Marks: 100

Note: *Answer any FIVE full questions, choosing ONE full question from each module.*

k pages. will be treated as malpractice.

Module-1

1 a. Discuss the factor which governs the choice of a gauge. **(06 Marks)**

b. What are the requirements of good ballast? Mention the different types of ballast used in permanent way. **(06 Marks)**

c. A 5° curve diverges from a 3° main curve in reverse direction in the layout of a B.G yard. If the speed on the branch lime is restricted to 35kmph. Determine the restricted speed on the main line cant deficiency for MG = 5.0cm **(08 Marks)**

1. a. **Choice of Gauge:** The choice of gauge is very limited, as each country has a fixed gauge and all new railway lines are constructed to adhere to the standard gauge. However, the following factors theoretically influence the choice of the gauge.

Cost Considerations: There is only a marginal increase in the cost of the track if a wider gauge is adopted. In this connection, the following points are important.

(a) There is a proportional increase in the cost of acquisition of land, earthwork, rails, sleepers, ballast, and other track items when constructing a wider gauge.

(b) The cost of building bridges, culverts, and tunnels increases only marginally due to a wider gauge.

(c) The cost of constructing station buildings, platforms, staff quarters, level crossings, signals, etc. associated with the railway network is more or less the same for all gauges.

(d) The cost of rolling stock is independent of the gauge of the track for carrying the same volume of traffic.

Traffic Considerations: The volume of traffic depends upon the size of wagons and the speed and hauling capacity of the train.

(a) As a wider gauge can carry larger wagons and coaches, it can theoretically carry more traffic.

(b) A wider gauge has a greater potential at higher speeds, because speed is a function of the diameter of the wheel, which in turn is limited by the width of the gauge.

(c) The type of traction and signalling equipment required are independent of the gauge.

Physical Features of the Country: It is possible to adopt steeper gradients and sharper curves for a narrow gauge as compared to a wider gauge.

Uniformity of Gauge: The existence of a uniform gauge in a country enables smooth, speedy, and efficient operation of trains. Therefore a single gauge should be adopted irrespective of the minor advantages of a wider gauge and the few limitations of a narrower gauge.

1. b. **Requirements of the good ballast**

• It should be able to withstand hard packing without disintegrating. In other words it should resist crushing under dynamic loads.

• It should not make the track dusty or muddy due powder under dynamic wheel loads but should be capable of being cleaned to provide good drainage.

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

• It should offer resistance to abrasion and weathering. Abrasion means wear due rubbing action of particles with each other and weathering means cracking and shattering of the material due to variation in temperature, moisture and freezing.

• It should retain its position laterally and longitudinally under all conditions of traffic, particularly on curves, where it should be able to prevent transverse displacement of sleepers.

• It should not produce any chemical action in rail and metal sleepers

• The size of stone ballast should be 5cm for wooden sleepers, 4cm for metal sleepers and 2.5cm for turnouts and crossovers.

• The materials should be easily workable by means of the implements in use.

• The ballast should be available in nearby quarries so that it reduces the cost of supply. It should also fulfil the requirements of quality, amount of traffic, life and maintenance cost.

1. c.

Given Data

V = 35kmph

Step 1: To find Equilibrium Super-Elevation

$$e = \frac{GV^2}{1.27R}$$

Where

V= 35 KMPH

G=1.676 for B.G Yard

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

Then We can get

$$e = \frac{1.676 * 35 * 35}{1.27} * \frac{5}{1720}$$

e = 4.71 cm

Step2:TofindthenegativeCan't

= equilibrium cant – can't deficiency
= (4.71 – 7.60) cm
= 2.89 cm

Note

Can't deficiency= 7.60 (for B.G Yards)

Step3:Tofindnegativecan't

Negative can't = maximum permissible Super-elevation on the main line
= 2.89 cm

Step 4: To find theoretical Super-elevation

Theoretical Super-elevation Provided on the main line
= 2.89+7.60 cm
=10.49 cm

Step 5: To find the Speed on the main line

$$e = \frac{1.676 * V^2}{1.27} * \frac{3}{1720}$$

$$10.49 = \frac{1.676 * V^2}{1.27} * \frac{3}{1720}$$

V^2 =4550 KMPH

V= 67.40 KMPH

OR

2 a. Explain i) coning of wheels ii) creep in rails. **(06 Marks)**

b. What is meant by wear of rails? How do you classify the wear? Discuss the various causes of wear. **(06 Marks)**

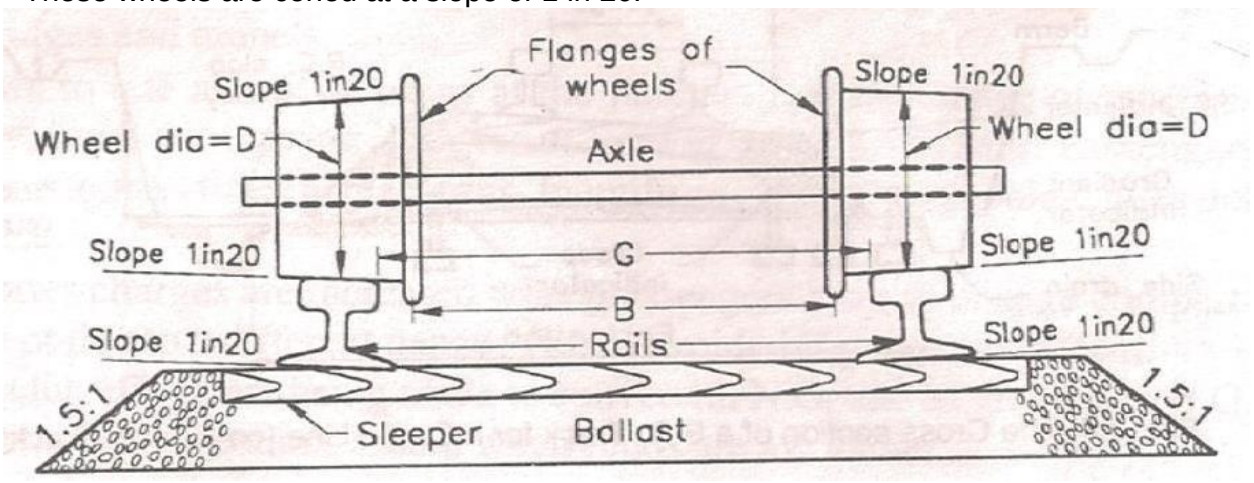
c. What would be the equilibrium cant on a MG curved track of 7° for an average speed of trains 50kmph? Also calculate the maximum permissible speed after allowing the maximum cant deficiency. **(08 Marks)**

2. a. **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 flanges and running edges of the rails, nearly equal to 1cm on either side.

• These wheels are coned at a slope of 1 in 20.



– To reduce the wear and tear of the wheel flanges and rails.

– To provide a possibility of lateral movement of the axle with its wheels.

– To prevent the wheels from slipping to some extent.

– It provides a smooth ride.

– It helps the train to negotiate a curve smoothly.

The advantages of coning of the wheels are

- To reduce the wear and tear of the wheel flanges and rails.
- To provide a possibility of lateral movement of the axle with its wheels.
- To prevent the wheels from slipping to some extent.

2. b.

• Wear is one of the prominent defects of rails.

• When the axle loads are abnormally heavy and the train moves with very fast speed then the concentrated stresses exceed the elastic limit resulting in metal flow, on the

Wear on rails

• Classification of wear – On the basis of location.

– On the basis of position of wear on rails.

• On the basis of location – On sharp curves

– On gradients

– On approaches to stations, where brakes are frequently applied.

– In tunnels

– Coastal areas(sea breeze)

– Weak foundations

– Wear on the top or head of rail
– Wear at the ends of rails
– Wear on the sides of the head.

gap or joint the ends are battered and at the curves the occurrence of skidding, slipping and striking of wheel flanges with rails results in wear and tear of rails.

• On the basis of position of wear

Wear on the top or head of rail: This type of wear occurs on straight i.e., tangent tracks and at curves.

On tangent tracks: the following are the factors which cause or encourage the wear on the top of rails on tangent lengths:

i. Due to flow of metal- this is because the heavy loads concentrated on small area produce the stresses which exceed the elastic limit and hence plastic flow of the metal takes place and burrs are formed which later get chipped of by moving wheel flanges

ii. Heavy axle load and its recurring impact cause the wear at the top of rails.

iii. Due to abrasion of rolling wheels, the rails generally get worn out at the top of rails.

iv. Due to constant brake application, which results in skidding and burning of the rail head? This finally results in excessive wear and abrasion.

v. Due to use of sand which is spread to produce friction in case of dampness in tunnels. The grinding action of sand particles with rails gives rise to wear.

vi. Due to fluctuations in gradients.

vi. Due to corrosion of rails by the action of sea breeze, this also gives rise to wear on top of rails. i. Due to slipping or skidding of wheels

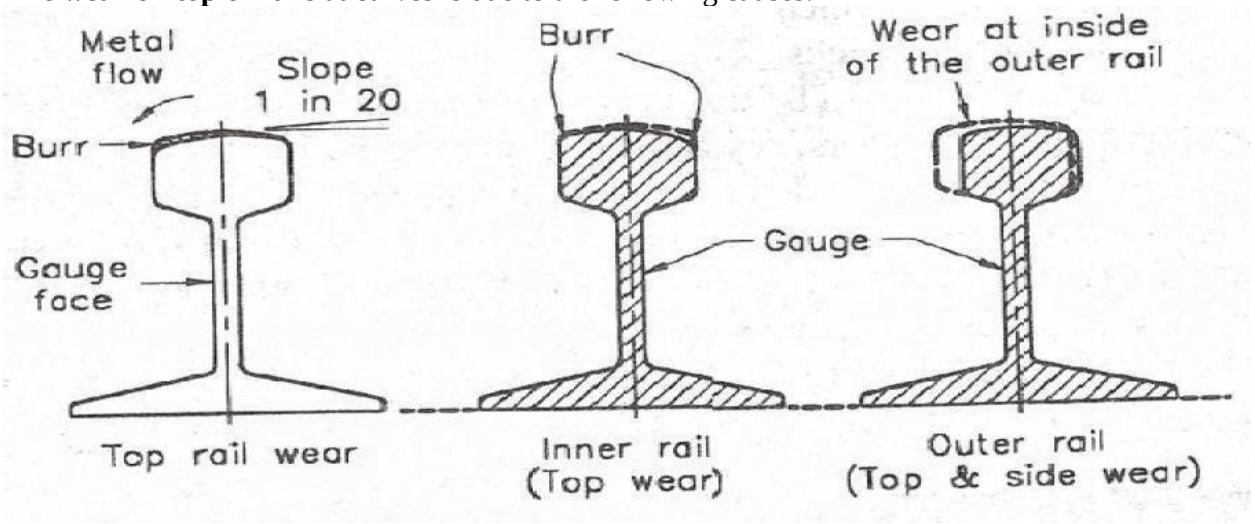
vii. Due to effect of centrifugal force and improper super elevation, load on one rail is greater than the other.

On curves: the wear on top of rails at curves is due to the following causes:

i. Due to slipping or skidding of wheels

ii. Due to effect of centrifugal force and improper super elevation, load on one rail is greater than the other.

The wear on top of rails at curves is due to the following causes:



Wear on the ends of the rails:

– This type of wear occurs, when a wheel jumps over the gap, giving blow to the end of the rail, as rough riding in the track, loosens the ballast under the joints and even disturbs the sleeper.

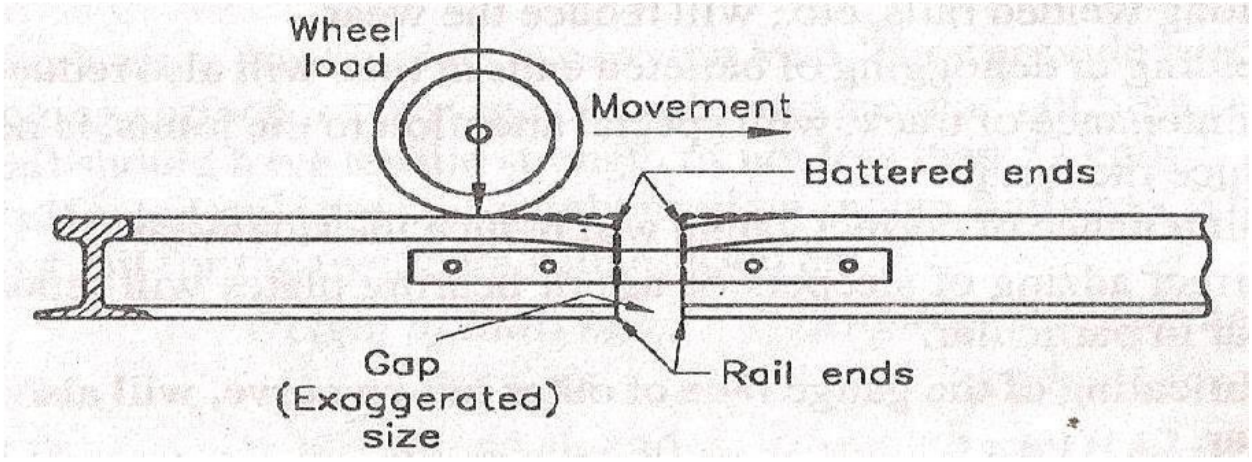
• This type of wear is occurs due to following factors: – Due to lose fish plates and fish bolts

– Due to heavy loads and large joint openings

– Difference in levels at joints

– Bad conditions of the vehicle springs

– Poor maintenance of the track



– This type of wear is only prominent when the rails are laid at curves.

– This wear is nature.

– This wear occurs due to following causes • At curves, there is greater thrust on inner rail, when trains run at lesser speed than equilibrium speed.

• Due to the rigidity of the wheel base.

• Slipping and skidding of wheel at curves.

Wear on sides of the rail head

more than first two types of wear and is most destructive in

• Allowable limits of wear**:** in India prescribed limit of wear is 5% of rail weight.

Module-2

3 a. List the modern surveying techniques that can be utilized for preliminary survey of railway line for different terrain. Explain any two techniques. **(10 Marks)**

b. Explain the modern methods of maintenance of railway track. **(10 Marks)**

3. a. Object of preliminary survey

- • To conduct the survey work along the alternative routes found out by reconnaissance survey and;
- • To determine with greater accuracy the cost of the railway line along these alternative routes.

Importance of preliminary survey

- • It decides the final route and recommends only one particular route in preference to other alternative routes
- • Thus, should be carried out with great precision as on it depends the alignment of the final route.

3. b. **Modern methods of maintenance**

The following are the main modern methods of track maintained:

• Mechanised Maintenance or Mechanical Tamping

• Measured Shovel Packing

• Directed Track Maintenance

Mechanised Maintenance

• It makes use of track machines namely tampers for day to day track maintenance

• This method is relatively more effective, economical, and efficient to cater the needs of high speed and heavier axle loads.

Methods of Mechanical Tamping

• Off -Track Tamping

• On- Track Tamping Off-Track Tamping

• Off-track tampers which are portable & can be taken off the track within a short period of time are used.

• They work in pairs from opposite sides of the sleepers diagonally under the rail seat to ensure maximum consolidation of the ballast.

• It requires no blocking of the traffic

Demerits

• Maintenance of tampers is difficult

• High standard of maintenance cannot be achieved

• Intensive supervision is needed

• Transportation of tampers with power unit is difficult Types of Off-Track Tampers

1. Self-contained Percussion type Vibratory type

2. Off-track tampers worked from a common power unit On- Track Tamping

OR

4	a.	What are the advantages and limitation of underground Railways?	**(08 Marks)**
	b.	Define Yards. Explain the types of Yards.	**(06 Marks)**
	c.	List the different surveys required to be conducted for track alignment. List the features to be considered during Reconnaissance survey.	**(06 Marks)**

4. a. **Underground Railways:** In such a system, the railway line is constructed below the ground level. The requisite construction work is done mostly by the 'cut and cover method'. The area is excavated in the shape of trenches and once the formation is ready, the track is laid, the necessary overhead structures are provided, and finally the trenches are covered and the ground is restored to its original state.

Advantages of Underground railway system:

The underground railway system solves the accommodation difficulty in large cities.

The excellent railway system facilitates the residents to live in the outskirts around the city and travel to work. Thus the emergence of towns helped to eliminate overcrowding in the city.

These new amenities helps to overcome communal differences among people.

Disadvantages of Underground railway system:

a. Growing Industrialization, increased migration, urbanization brought about excessive congestion in the city

b. To deal with the problem of commuting and linking suburbs with the city, underground railways were developed.

c. By 1880, in London the train service expanded carrying more than 40 million passengers, with newspapers reporting people's experiences in the train which were fully loaded with passengers.

d. Large number of houses were destroyed, people were displaced due to the construction of railways

e. Underground railways also caused serious health problems.

f. Compartments would be filled with passengers, with many of them smoking.

g. This causes pollution & suffocation in the compartments.

h. The atmosphere in the compartments were filled with dust, fumes, also generating so much of heat.

4. c. **Reconnaissance Survey:** It is the first engineering survey. It is a rough and visual identification about location and check map data to live location.

A reconnaissance survey can divided into two parts:

1. Traffic survey

2. Engineering survey

Traffic survey: This consists of collection of the information regarding the following:

• The general scenario of the location.

- Information of the local industries.
- The general information of agriculture, crop types and any mineral sources are there or not.
- The probable scenario of traffic to divert or used by new railway alignment.
- General study of existing transportation facilities and which mode is mostly used.
- Planning forecasting of economic and social growth of area that would be covered by this new railway line.
- Physical features of the country;
- The surface of the ground;

- Types of soil and its classification
- Streams and rivers, those which will cross the proposed railway line;
- Positions of valleys, mountains and rivers.
- Availability of materials and man power and transportation facilities of material for use during construction.

Engineering survey:

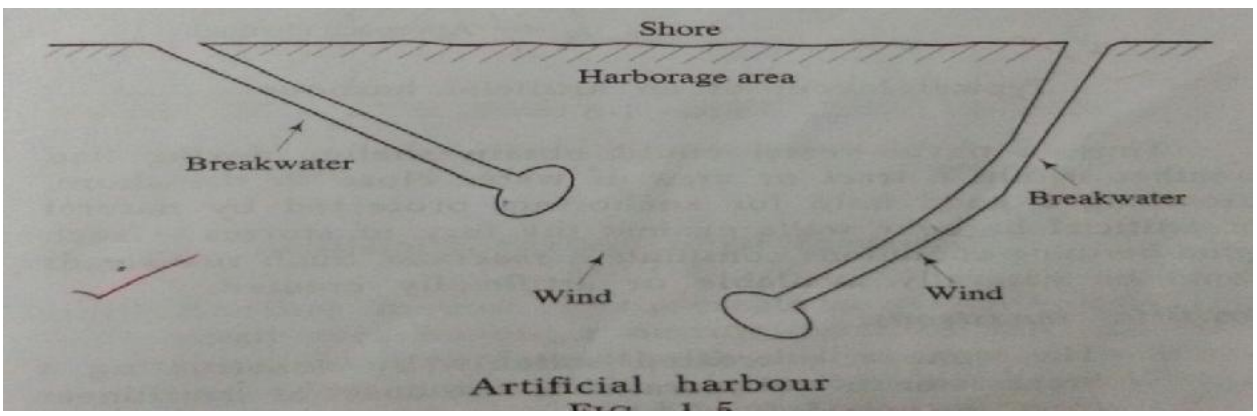
Physical features of the country;

- The surface of the ground;
- Types of soil and its classification
- Streams and rivers, those which will cross the proposed railway line;
- Positions of valleys, mountains and rivers.
- Availability of materials and man power and transportation facilities of material for use during construction.

Module-3

5	a.	Draw a neat sketch of artificial harbour. Explain the various components.	(08 Marks)
	b.	Define breakwater. Explain any one type of breakwater.	(06 Marks)
	c.	Draw a typical layout of harbour and explain.	(06 Marks)

5. a.



5. b. The protective barrier constructed to enclose harbours and to keep the harbour waters undisturbed by the effect of heavy and strong seas are called breakwaters

Types of Breakwaters

1. Vertical wall breakwater
2. Mound breakwater
3. Mound with super structure or Composite breakwater

Vertical wall breakwater:

The construction of vertical wall break is found advantageous under the following conditions.

- The depth of water is sufficiently large to prevent the breaking of waves. The depth of water should be twice the height of the greatest storm wave.
- Sea bed is resistant to erosion.
- Foundations are not subjected to uneven settlement.

If the sea bed is not resistant to erosion, in that case concrete block apron may be provided for protection. Also the load bearing characteristics of sea bed can be improved in various ways. If the top strata of the bed

contain materials like soft clay, silt or fine sand, then the best way is to remove these strata by trenching with a dredger.

Advantageous of vertical wall breakwater:

• They need comparatively less construction materials.

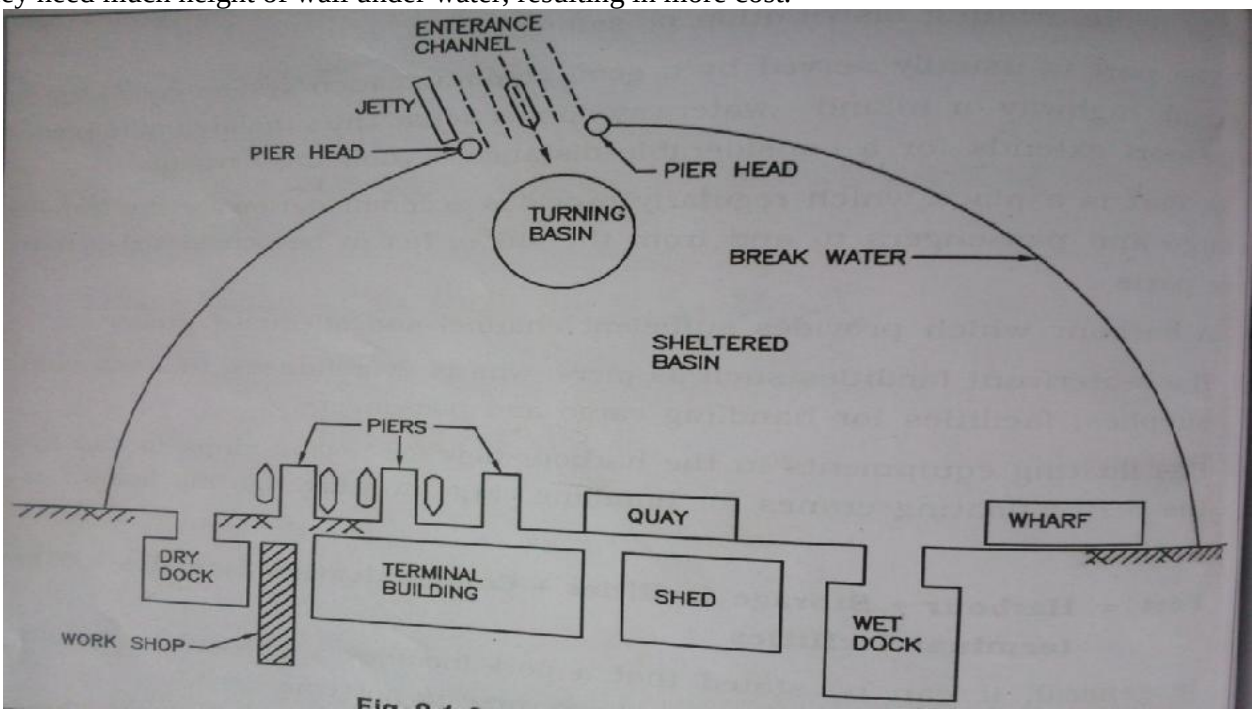
• They have no danger of unequal settlement as in the case of mound breakwater

Disadvantageous of vertical wall breakwater:

• They need special care and costly methods of construction.

• They need much height of wall under water, resulting in more cost.

5. c.



OR

6 a. Write short notes on :
i) Tunnel ventilation ii) Tunnel drainage (08 Marks)

b. Explain various shapes of Tunnels with neat sketches. (06 Marks)

c. Mention the objective of tunnel lining. List the materials used for tunnel lining. (06 Marks)

6. a. **Ventilation of Tunnels**

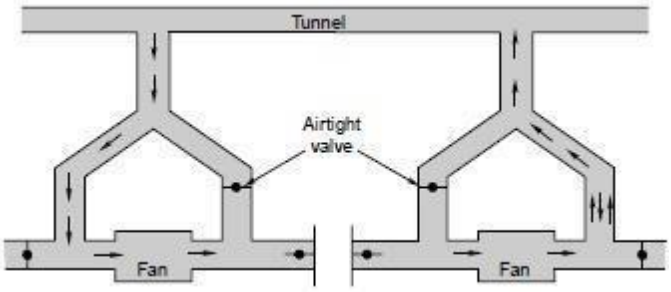
A tunnel should be properly ventilated during as well as after the construction for the reasons given below.

(a) To provide fresh air to the workers during construction.

(b) To remove the dust created by drilling, blasting, and other tunneling operations.

(c) To remove dynamite fumes and other objectionable gases produced by the use of dynamites and explosives.

The methods listed below are normally adopted for the ventilation of a tunnel.



Natural method of ventilation This is achieved by drilling a drift through the tunnel from portal to portal. In most cases natural ventilation is not sufficient and artificial ventilation is still required.

Mechanical ventilation by blow-in method In the blow-in method, fresh air is forced through a pipe or fabric duct by the means of a fan and supplied near the washing face (or the drilling face; the drilling operation requires the washing of bore holes too). This method has the advantage that a fresh air supply is guaranteed where it is required the most. The disadvantage is that the foul air and fumes have to travel a long distance before they can exit the tunnel and in the process it is possible that the incoming fresh air will absorb some dust and smoke particles.

Mechanical ventilation by exhaust method In the exhaust or blow-out method, foul air and fumes are pulled out through a pipe and is expelled by a fan. This sets up an air current that facilitates the entrance of fresh air into the tunnel. This method has the advantage that foul air is kept out of the washing face. The disadvantage, however, is that fresh air has to travel a long distance before it can reach the washing face during which period it may absorb some heat and moisture.

Combination of blow-in and blow-out methods By combining the blow-in and blow-out methods using a blower and an exhaust system, respectively, a tunnel can be provided with the best ventilation. After blasting the ground, the exhaust system is used to remove the smoke and dust. After some time, fresh air is blown in through the ducts and the rotation of the fans is reversed to reverse the flow of air.

6. b. **Size and shape of the tunnel**

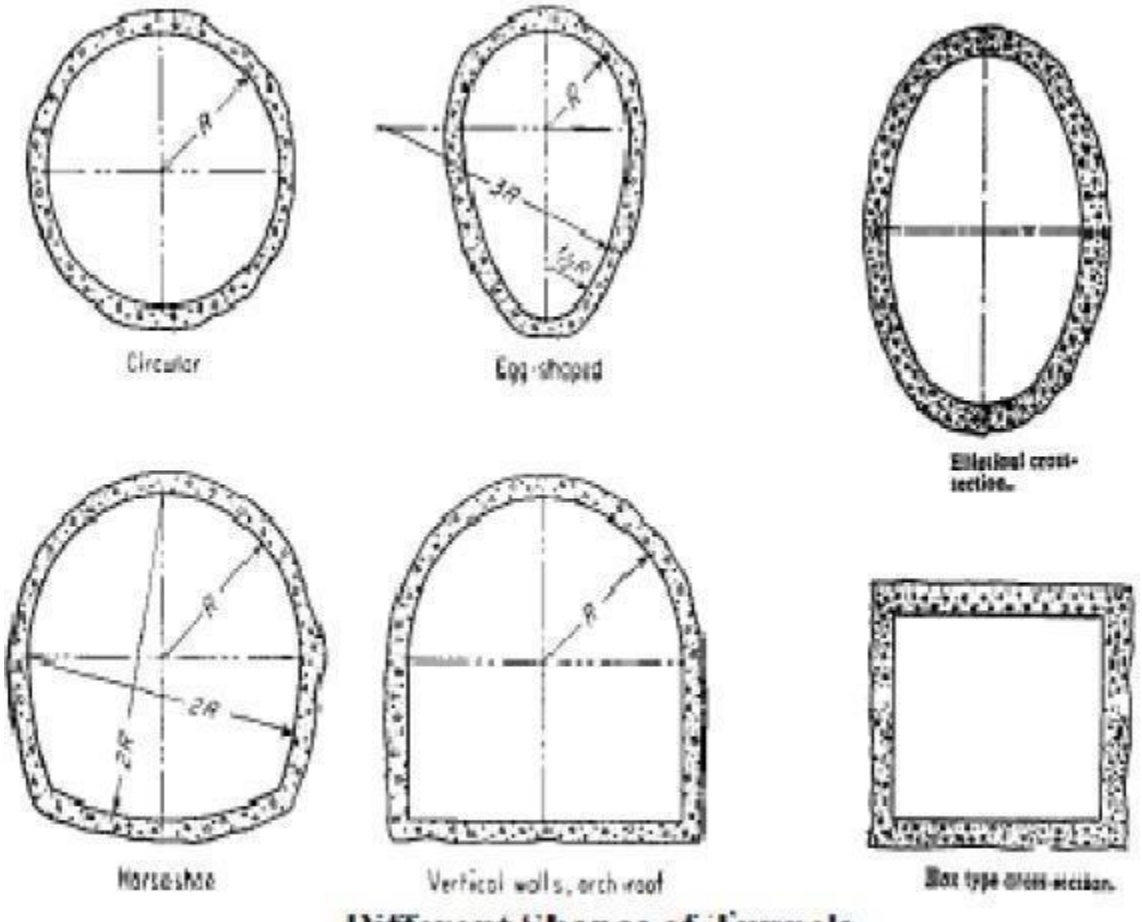
The shapes of tunnel linings are usually determined by their purpose, ground conditions, construction method and/or lining materials.

Rectangular shape Rectangular shaped tunnels are usually adopted by the cut and cover method. It is particular suitable for pedestrian and highway tunnels. On the other hand, multi- lane submerged highway tunnels are often in rectangular shape.

Elliptical shape / Egg shape Elliptical shape tunnels have the advantages for the transportation of sewer. The smaller cross section at the bottom maintains the flow at the required self cleaning velocity. However, due to the difficulty in construction, circular shape ones are more common.

Circular shape A circular shape tunnel has the greatest cross-sectional area to perimeter ratio. They are often associated with TBM or the shield tunnelling methods.

Horseshoe / segmental shape They are commonly used for rock tunnelling. It has the advantages of utilising the compressive strength of concrete in resisting the loading by means of arch action and the base is wide enough for traffic.



Different Shapes of Tunnels

6. c. **Lining of Tunnels**

Tunnels in loose rock and soft soils are liable to disintegrate and, therefore, a lining is provided to strengthen their sides and roofs so as to prevent them from collapsing. The objectives of a lining are as follows.

(a) Strengthening the sides and roofs to withstand pressure and prevent the tunnel from collapsing.

(b) Providing the correct shape and cross section to the tunnel.

(c) Checking the leakage of water from the sides and the top.

(d) Binding loose rock and providing stability to the tunnel.

(e) Reducing the maintenance cost of the tunnel.

Masonry:

Brick masonry: Brick masonry was the standard material for tunnel lining, but is now rapidly going out of use, except in the case of underground sewers, as bricks are more acid resisting and suitable to carry sewage. A great disadvantage in using brick lining is the difficulty in back packing the space between the tunnel roof and the extrodas of the arch which at best has to be hand packed and is imperfect.

Stone masonry: It has more or less the same disadvantages as brick lining and in addition is very heavy necessitating very strong centres. But is still used for lining the sides. Cement concrete has become the standard material for tunnel lining in both rock and soft soils. Its main advantage lies in its plasticity which allows it to be well packed between the form and the soil.

Timber: Is one of the oldest lining materials through of late, it is slowly yielding place to concrete. It is used both as a temporary support during construction and as a permanent support later.

Concrete lining: Concrete lining is done using proper form-work. The form should show the true outline of the finished tunnel section

Module-4

7 a. List the various elements of an airport and explain with a neat sketch. **(10 Marks)**

b. Explain the factors, which influence the site selection for airport. **(10 Marks)**

7. a. Therefore, the main components of airport are

1. Runway
2. Terminal Building
3. Apron
4. Taxiway
5. Aircraft Stand
6. Hanger
7. Control Tower
8. Parking

Runways: It is the most important part of an airport in the form of paved, long and narrow rectangular strip which actually used for landing and takeoff operations. It has turfed (grassy) shoulders on both sides. The width of runway and area of shoulders is called the landing strip. The runway is located in the centre of landing strip. The length of landing strip is somewhat larger than the runway strip in order to accommodate the stop way to stop the aircraft in case of abandoned takeoff.

The length and width of runway should be sufficient to accommodate the aircraft which is likely to be served by it. The length of runway should be sufficient to accelerate the aircraft to the point of takeoff and should be enough such that the aircraft clearing the threshold of runway by 15m should be brought to stop with in the 60% of available runway length. The length of runway depends on various meteorological and topographical conditions. Transverse gradients should not be less than 0.5% but should always be greater than 0.5%.

Terminal Buildings: Also known as airport terminal, these buildings are the spaces where passengers board or alight from flights. These buildings house all the necessary facilities for passengers to check-in their luggage, clear the customs and have lounges to wait before disembarking.

The terminals can house cafes, lounges and bars to serve as waiting areas for passengers. Ticket counters, luggage check-in or transfer, security checks and customs are the basics of all airport terminals.

Hangers: A hangar is a closed building structure to hold aircraft, spacecraft or tanks in protective storage. Most hangars are built of metal, but other materials such as wood and concrete are also used

Hangars are used for protection from the weather, direct sunlight, maintenance, repair, manufacture, assembly and storage of aircraft on airfields, aircraft carrier.

Aprons: Aircraft aprons are the areas where the aircraft park. Aprons are also sometimes called ramps. They vary in size, from areas that may hold five or ten small planes, to the very large areas that the major airports have.

Taxiway: Taxiway is the paved way rigid or flexible which connects runway with loading apron or service and maintenance hangers or with another runway. They are used for the movement of aircraft on the airfields for various purposes such as exit or landing, exit for takeoff etc. The speed of aircraft on taxiway is less than that during taking off or landing speed.

The taxiway should be laid on such a manner to provide the shortest possible path and to prevent the interference of landed aircraft taxying towards loading apron and the taxiing aircraft running towards the runway. The intersection of runway and taxiway should be given proper attention because during turning operation, this part comes under intense loading. If it is weaker then the aero plane may fell down from taxiway. Its longitudinal grade should not be greater than 3% while it s transverse gradient should not be less than 0.5%. It is also provided with a shoulder of 7.5m width paved with bituminous surfacing. The taxiway should be visible from a distance of 300m to a pilot at 3m height from the ground.

Aircraft Stand: A portion of an apron designated as a taxiway and intended to provide access to aircraft stands only.

7. b. **Criteria for airport site selection and ICAO stipulations**

The selection of a suitable site for an airport depends upon the class of airport under consideration. However if such factors as required for the selection of the largest facility are considered the development of the airport by stages will be made easier and economical. The factors listed below are for the selection of a suitable site for a major airport installation:

1. Regional plan
2. Airport use
3. Proximity to other airport
4. Ground accessibility
5. Topography

6. Obstructions
7. Visibility
8. Wind
9. Noise nuisance
10. grading, drainage and soil characteristics
11. Future development
12. Availability of utilities from town
13. Economic consideration

Regional plan: The site selected should fit well into the regional plan there by forming it an integral part of the national network of airport.

Airport use: the selection of site depends upon the use of an airport. Whether for civilian or for military operations. However during the emergency civilian airports are taken over by the defence. Therefore the airport site selected should be such that it provides natural protection to the area from air roads. This consideration is of prime importance for the airfields to be located in combat zones. If the site provides thick bushes.

Proximity to other airport: the site should be selected at a considerable distance from the existing airports so that the aircraft landing in one airport does not interfere with the movement of aircraft at other airport. The required separation between the airports mainly depends upon the volume of air traffic.

Ground accessibility: the site should be so selected that it is readily accessible to the users. The airline passenger is more concerned with his door to door time rather than the actual time

in air travel. The time to reach the airport is therefore an important consideration especially for short haul operations.

Topography: this includes natural features like ground contours trees streams etc. A raised ground a hill top is usually considered to be an ideal site for an airport.

Obstructions: when aircraft is landing or taking off it loses or gains altitude very slowly as compared to the forward speed. For this reason long clearance areas are provided on either side of runway known as approach areas over which the aircraft can safely gain or lose altitude.

Visibility: poor visibility lowers the traffic capacity of the airport. The site selected should therefore be free from visibility reducing conditions such as fog smoke and haze. Fog generally settles in the area where wind blows minimum in a valley.

Wind: runway is so oriented that landing and takeoff is done by heading into the wind should be collected over a minimum period of about five years.

Noise nuisance: the extent of noise nuisance depends upon the climb out path of aircraft type of engine propulsion and the gross weight of aircraft. The problem becomes more acute with jet engine aircrafts. Therefore the site should be so selected that the landing and takeoff paths of the aircrafts pass over the land which is free from residential or industrial developments.

Grading, drainage and soil characteristics: grading and drainage play an important role in the construction and maintenance of airport which in turn influences the site selection. The original ground profile of a site together with any grading operations determines the shape of an airport area and the general pattern of the drainage system. The possibility of floods at the valley sites should be investigated. Sites with high water tables which may require costly subsoil drainage should be avoided.

Future development: considering that the air traffic volume will continue to increase in future more member of runways may have to be provided for an increased traffic.

Module-5

9 a. Describe the elements of taxiway geometric design. **(10 Marks)**

b. Define windrose diagram, with a neat sketch, explain the method of locating the best orientation at runway. **(10 Marks)**

9. a. **Geometric design standards:**

• Length of taxiway
• Width of taxiway
• Width of safety area

• Longitudinal gradient
• Traverse gradient
• Rate of change of longitudinal gradient
• Sight distance
• Turning radius

Length of taxiway:

It should be as short as practicable. This will save the fuel consumption.

• No specifications are recommended by any organisation for limiting the length of taxiway.

Width of taxiway:

• The width of taxiway is much lower than the runway width.
• The speed of the aircraft on a taxiway is also lower than the speed on runway.
• The pilot can comfortably manoeuvre the aircraft over a smaller width of taxiway than on a runway.

Width of safety area:

• This area includes taxiway pavement shoulders on either side that may be partially paved plus the area that is graded and drained.
• This may extend up to a point where it intersects a parallel runway, taxiway and apron.
• Bitumen treated shoulders are normally used.
• The shoulders must be thick enough to support the airport petrol vehicles and the sweeping equipment.

Longitudinal gradient:

• If the gradient is steep, there will be greater fuel consumption.
• ICAO recommends that the longitudinal gradient should not exceed 1.5 percent for A and B types and 3 percent for other types of airports.

Transverse gradient:

• This is essential for quick drainage of surface water.
• ICAO recommends that for taxiway pavement like runway, the transverse gradient should not exceed a value of 1.5 percent for A, B and C types and 2 percent for D and E types of airports.
• ICAO does not specify any value for the transverse slope of taxiway shoulders.
• FAA recommends that it should be 5 percent for the first 3 m and 2 percent thereafter for all types of airports.

Rate of change of longitudinal gradient:

• ICAO recommends that rate of change of slope in longitudinal direction should not exceed 1 percent per 30 m length of vertical curve for A, B and C types and 1.2 percent for D and E types of airports.

Sight distance:

• ICAO recommends that the surface of a taxiway must be visible from 3 m height for a distance of 300 m for A, B and C types and distance of 250 m must be visible from

2.1 m height for D and E types of airports.

Turning radius:

Whenever there is a change in the direction of a taxiway, a horizontal curves is provided.

R = V2 / 125 f

Where, R – Radius, m
V – Speed, kmph
f – Coefficient of friction, 0.13

• • For airport serving subsonic jet transports, minimum value of radius of curvature is 120 m is suggested.

• • For airport serving supersonic jet transports, minimum value of radius of curvature is 180 m is suggested.

ICAO classification	Taxiway width	Maximum longitudinal gradient, %	Minimum transverse gradient, %	Maximum rate of change of longitudinal gradient per 30 m, %
A	22.5	1.5	1.5	1.0
B	22.5	1.5	1.5	1.0
C	15	3.0	1.5	1.0
D	9.9	3.0	2.0	1.2
E	7.5	3.0	2.0	1.2

10 a. Write note on airport classification.

10. a. **Based on take-off and landing:**

• Conventional Take-Off and Landing Airport (CTOL) Runway Length > 1500 m

• Reduced Take-Off and Landing Airport (RTOL) Runway Length 1000 to 1500 m

• Short Take-Off and Landing Airport (STOL) Runway Length 500 to 1000 m

• Vertical Take-Off and Landing Airport (VTOL) Operational area 25 to 50 sq m.

FAA Classification:

Based on Air Craft Approach speed: Approach Category	Approach Speed (knots)
A	< 91
B	91 – 120
C	120 – 140
D	141 – 165
E	>165

Based on Functions:

1. Civil Aviation: Domestic International
2. Military Aviation

ICAO Classification:

Based on Geometric Design: Airport Type	Basic Runway Length (m)	Width of Runway Pavement (m)	Maximum Longitudinal Grade (%)
Maximum		Minimum	

A	Over 2100	2100	45	1.5
B	2099	1500	45	1.5
C	1499	900	30	1.5
D	899	750	22.5	2.0
E	749	600	18	2.0

Based on Aircraft Wheel

Characteristics: Code No.	Single Isolated Wheel Load (kg)	Tyre Pressure (kg/cm2)
1	45000	8.5
2	34000	7.0
3	27000	7.0
4	20000	7.0
5	13000	6.0
6	7000	5.0
7	2000	2.5