Civil Engineering

Railway, Airport, Dock, Harbour & Tunnelling Engineering

Comprehensive Theory

with Solved Examples and Practice Questions

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Contents

Railway, Airport, Dock, Harbour & Tunnelling Engineering

Section-A: Railway Engineering

Chapter 12

Tunnelling 163

■■■■

Section - A

CHAPTER 01

Railway Track

1.1 Introduction

- Railway track is a combination of rails, fitted on sleepers and resting on ballast and subgrade.
- Essential function of railway track is to support and guide the vehicles that run over it.
- The conventional railway track consists of two rails located at fixed distance apart. The pressure exerted over by the rails is in turn transmitted to the formation with the help of sleepers and ballast.
- Railway track is also known as permanent way.
- The name permanent way is given to distinguish the final layout of the track from temporary tracks. Temporary tracks are laid for conveyance of earth and materials during construction works.
- In a permanent way, rails are joined in series by fish plates and bolts and then they are fixed to sleepers by different types of fastenings.

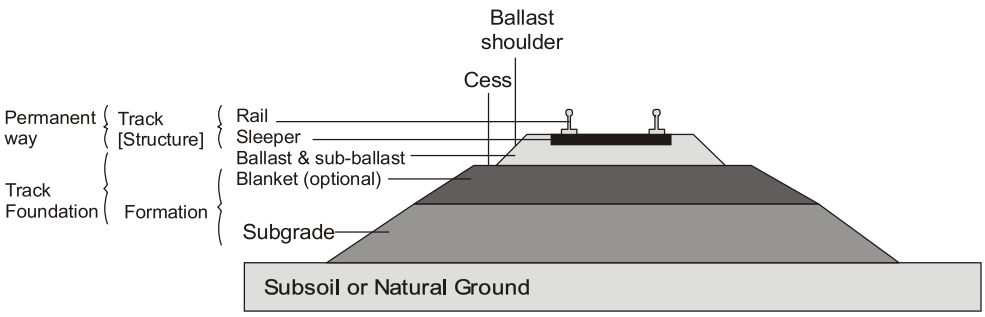


***Fig. 1.1** Typical cross-section of a permanent way on embankment*

- The sleepers properly spaced, resting on ballast, are suitably packed and fixed with ballast.
- This layer of ballast rests on the prepared subgrade called the formation.

1.2 Requirements of an Ideal Permanent Way

Following are the basic requirements of an ideal permanent way

(i) The gauge should be uniform and correct.

(ii) Both the rails should be at the same level in a straight track.

(iii) On curves, proper superelevation should be provided to the outer rail.

(iv) Track should have enough lateral strength.

(v) Track must have certain amount of elasticity.
(vi) Radii and superelevation, provided on curves, should be properly designed.
(vii) All joints, points and crossings should be properly designed.
(viii) Drainage system should be perfect.
(ix) It should have adequate provision of easy renewals and repairs.
(x) The components of track i.e., rail, fittings, sleepers, ballast must fully satisfy requirement for which they are provided.

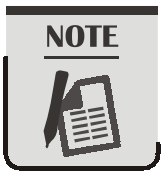
1.3 Gauge of Railway Track

The gauge of a railway track is the clear distance between the running or gauge faces of the two rails.

NOTE: These running faces are the inner faces of the rails in India.

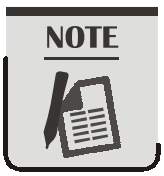
We have three types of gauges:
(i) Broad Gauge (BG) → 1676 mm (5 ft. 6 inches)
(ii) Metre Gauge (MG) → 1000 mm (3 ft. 3.375 inches)
(iii) Narrow Gauge (NG) → 762 mm (2 ft. 6 inch) 610 mm (2 ft.)

A larger gauge has the advantage of greater traffic capacity, speed and safety.
However, it requires flatter gradients and curves.



(i) 610 mm is for feeder track gauge.
(ii) Small lengths of standard gauge (1435 mm) are used in India for individual projects and short line lengths.
For example: Delhi Metro Rail Corporation.

Factors responsible for selection of gauge:
(i) Cost of construction
(ii) Volume and nature of traffic
(iii) Development of under developed area
(iv) Physical features of the country
(v) Speed of vehicle movement



(i) On important section in India, Broad Gauge is preferred.
(ii) Gauge should be uniform throughout as far as possible in a country.
(iii) Because transshipping passengers and goods from vehicles of one gauge to another is a cumbersome task.

1.4 Load Transfer on a Railway Track

- All the components of a P-way are required to transfer the rolling load to the subgrade while maintaining the proper position.
- Rail acts as girders to transmit wheel load to sleeper.
- Sleeper holds the rail in correct alignment and transmit the load to ballast.
- Ballast distributes load over formation known as subgrade and finally to natural soil on ground.

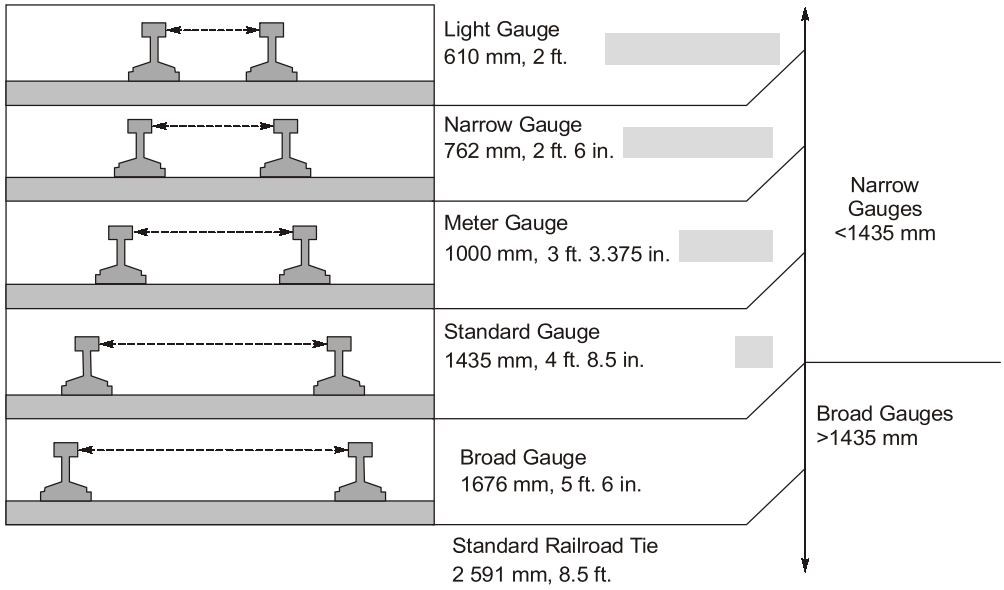
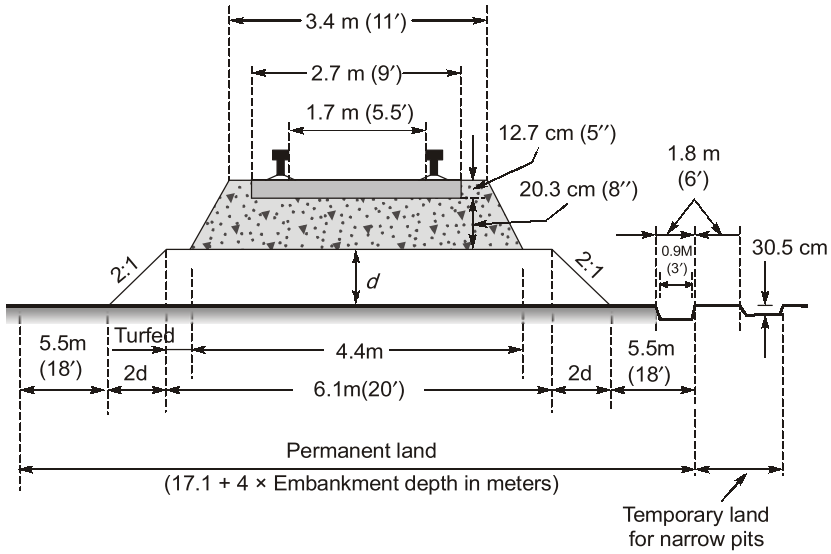


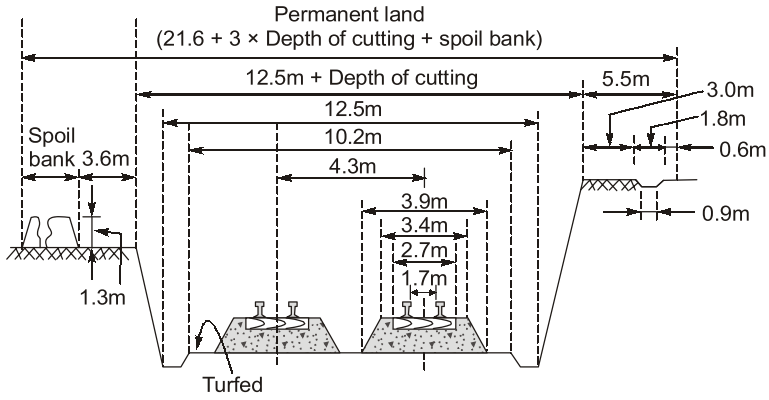
Fig. 1.2

1.5 Railway Track Cross-section

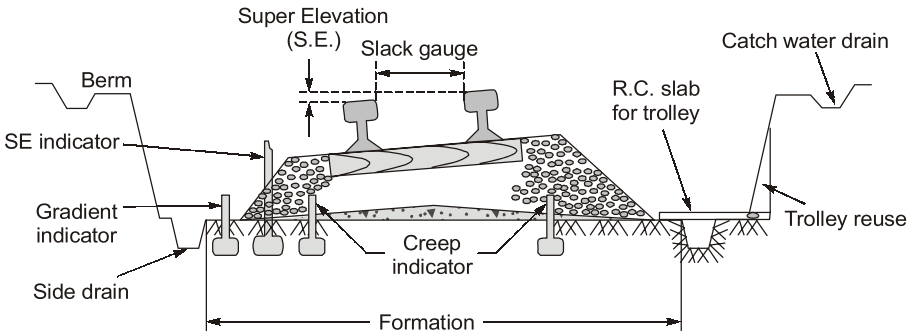
The typical cross-section of a railway track have been shown in the figure given below:



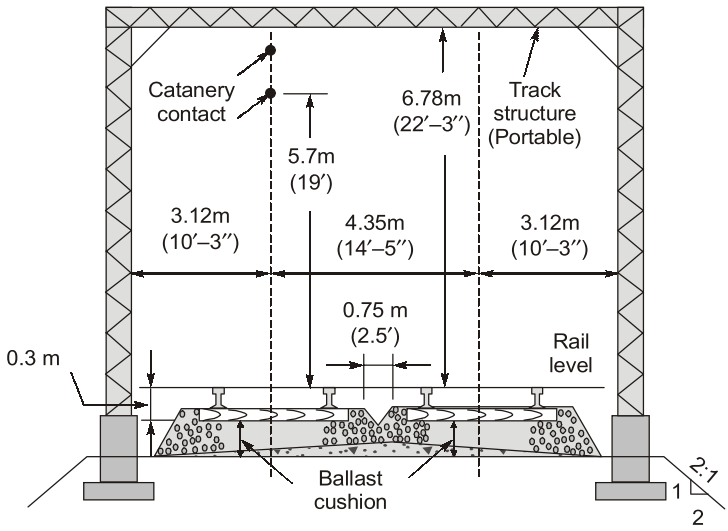
The cross-section of a B.G. Track in Embankment (On straight track)



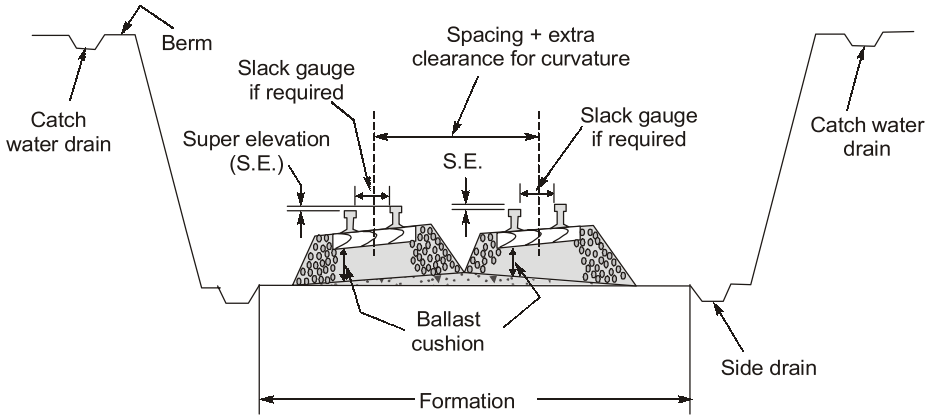
The cross-section of a B.G. Track in cutting for double line (On straight track)



The cross-section of a B.G. track for a single Line (curved track)



The cross-section of a B.G. Track for double line with electric-traction



The cross-section of a B.G. Track for double line in Cutting (On Curved Track)

Fig. 1.3

1.6 Coning of Wheels and Canting of Rails

1.6.1 Coning of Wheels

(i) The tread or rim of railway vehicles are not made flat but are sloped and this sloping surface along the circumference forms part of a cone (with a slope of about 1 in 20). This is known as coning of wheels.

(ii) On straight and level track, the wheel remains central and circumference of treads of both wheels are equal.

(iii) On the level track as the axle moves towards one rail, the diameter of wheel tread over the rail increase while it decreases over the other rail. This prevents the further movement of axle retreat back to original position with equal diameters and equal pressure on both rails.

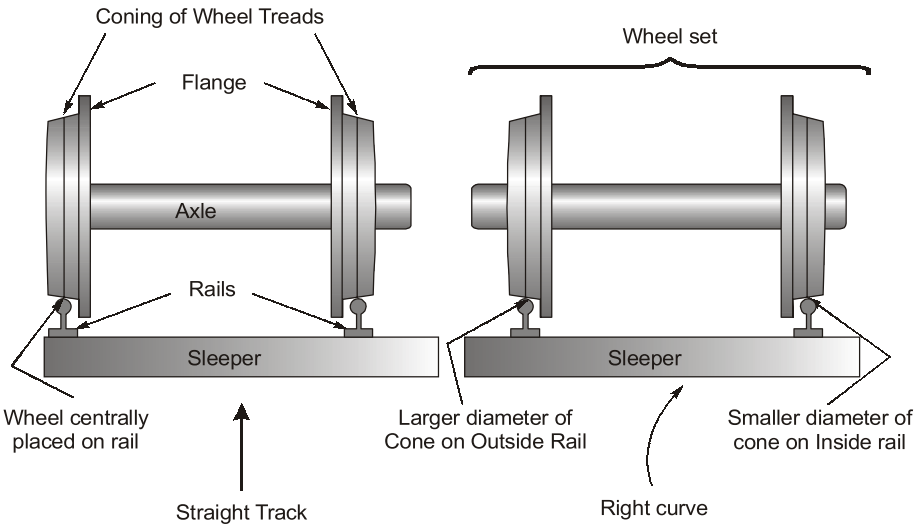


Fig. 1.4

(iv) On curved track, outer wheel has to travel greater length than the inner wheel.
Vehicle on a curve has the tendency to move sideways towards the outer rail, so the circumference of the tread on the outer rail towards inner edge of the wheel becomes greater than that on the inner rail. This helps outer rail to cover a greater distance than the inner rail.

(v) Conicity of wheel = angle between wheel tread and horizontal axis of axle.

1.6.2 Advantages of Coning of Wheel

- It helps vehicle to negotiate curves smoothly.
- To keep the train just in central position in a level track.
- To provide for possibility of lateral movement of axle with its wheels.
- To prevent wheels from slipping to some extent.
- It reduces wear and tear of the wheel flanges.

1.6.3 Disadvantages of Coning of Wheel

- The pressure of the horizontal component of the force near the inner edge of the rail has a tendency to wear the rail quickly.
- The horizontal component of the force tends to turn the rail outwards and hence the gauge is widened sometimes.
- If no base plates are provided, sleepers under the outer edge of the rail may get damaged.

1.6.4 Canting of Rails

- In order to minimize the disadvantages due to coning of wheels, canting of rails is done which means that rails are not laid flat but are tilted inwards.
- This reduces wear on the rail as well as on the tread of the wheel.
- The slope of the base plate is 1 in 20 which is also the slope of the wheel flange.
- Tilting of rails can be achieved by
  (i) Adzing of sleepers
  (ii) Use of canted base plate

1.6.5 Adzing of Sleepers

- A groove (having angle of 1 in 20) is being cut on the top of the sleepers. The rail is being seated into this groove in such a manner that it remains fixed in this location.
- This sort of angle making in sleepers so as to seat the rail is known as adzing of sleepers.

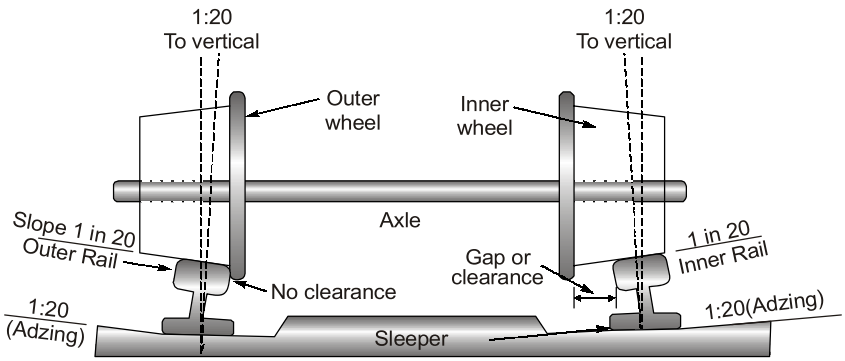


Fig. 1.5

Summary

- Railway track is a combination of rails fitted on sleepers and resting on ballast and subgrade.
- Gauge of a railway track is the distance between the inner faces of the two rails.
- Dimension of broad gauge, metre gauge and narrow gauge are 1676 mm, 1000 mm, 762 mm (also 610 mm) respectively.
- 610 mm narrow gauge is for feeder track gauge.
- Standard gauges are 1435 mm length.
- Coning of wheels is a method of levelling the wheels to avoid depreciation to the wheels and rim caused by friction between rims and inner faces of the rail top.
- Canting of rails is done in order to minimize the disadvantages due to coning of wheels.
- Tilting of rails can be achieved by either adzing of sleepers or the use of canted base plate.
- Adzing of sleepers is a sort of groove making in sleepers so as to seat the rail.

Objective Brain Teasers

Q.1 Which of the following factors govern the choice of the gauge?
(i) volume and nature of traffic
(ii) speed of train
(iii) physical features of the country
(a) only (i) (b) both (i) and (ii)
(c) both (ii) and (iii) (d) (i), (ii) and (iii)

Q.2 For developing thinly populated areas, the correct choice of gauge is
(a) Broad Gauge (b) Metre Gauge
(c) Narrow Gauge (d) any of the above

Q.3 The formation width for a single line metre gauge track in embankment as adopted on Indian Railways is
(a) 4.27 m (b) 4.88 m
(c) 5.49 m (d) 6.10 m

Q.4 The side slope of embankments for a railway track is generally taken as
(a) 1 : 1 (b) 1.5 : 1
(c) 2 : 1 (d) 1 : 2

Q.5 The formation width for a double line Broad Gauge track in cutting (excluding drains) as adopted on Indian Railways is
(a) 6.10 m (b) 8.84 m
(c) 10.21 m (d) 10.82 m

Q.6 The tread of wheels is provided an outward slope of
(a) 1 in 10 (b) 1 in 15
(c) 1 in 20 (d) 1 in 25

Q.7 Wheels of rolling stock are provided flanges on
(a) outer side (b) inner side
(c) both sides (d) neither side

Q.8 Coning of wheels is provided
(a) to check lateral movement of wheels
(b) to avoid damage to inner faces of rails
(c) to avoid discomfort to passengers
(d) All the above

Q.9 For providing the required tilt of rails, adzing of wooden sleepers, is done for
(a) bull headed rails
(b) double headed rails
(c) flat footed rails
(d) any type of rails

Q.10 Check rails are provided on inner side of inner rails if sharpness of a B.G. curve, is more than
(a) 3^{o} (b) 5^{o}
(c) 6^{o} (d) 8^{o}

Q.11 The rail section which is not used on Indian Broad Gauge tracks, is
(a) 35 R (b) 40 R
(c) 45 R (d) 55 R

Q.12 The rail section which is not used on Indian metre gauge tracks, is

(a) 25 R (b) 30 R
(c) 35 R (d) 40 R

Q.13 In India the rails are manufactured by

(a) open hearth process
(b) duplex process
(c) both (a) and (b)
(d) neither (a) nor (b)

Q.14 In Indian railways, the ratio of axle load and weight of rail, is

(a) 312 (b) 412
(c) 512 (d) 600

Q.15 Match **List-I** (Railway zone) with **List-II** (Headquarters) and select the correct answer by using codes given below the lists:

List-I	List-II
A. N.E.R.	1. Calcutta
B. E.R	2. Gorakhpur
C. S.C.R	3. Maligaon (Guwahati)
D. N.E.F.R	4. Secunderabad

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	3	2	1	4
(d)	4	3	2	1

Answers

1. (d)	2. (c)	3. (b)	4. (c)	5. (c)
6. (c)	7. (b)	8. (d)	9. (c)	10. (d)
11. (b)	12. (d)	13. (c)	14. (c)	15. (b)

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Section - B

CHAPTER 1

Airport

1.1 Airport

- It is area regularly used for landing and take off of aircraft.
- It is also provided with facilities like shelter, repair of aircraft and for passengers and cargo.

Classification of Airport

A. According United State Federal Aviation Administration (FAA)

Primary Airport: These have more than 10,000 boardings each years.

Non-Primary Airports: Which handle less than 10,000 passengers each year.

B. According International Civil Aviation Organization (ICAO)

1. Based on runway length
   - The classification is done using code number 1 to 4.
   - Where code 1 has least basic runway length (< 800 m) and code 4 has longest runway length (≥ 1800 m)
2. Based on wing span and outer main gear wheel span
   - This classification is done using code letter A to E
   - Here A has least wing and outer main gear wheel spans while E has highest wing and outer main gear wheel spans.

1.2 Aircraft Components

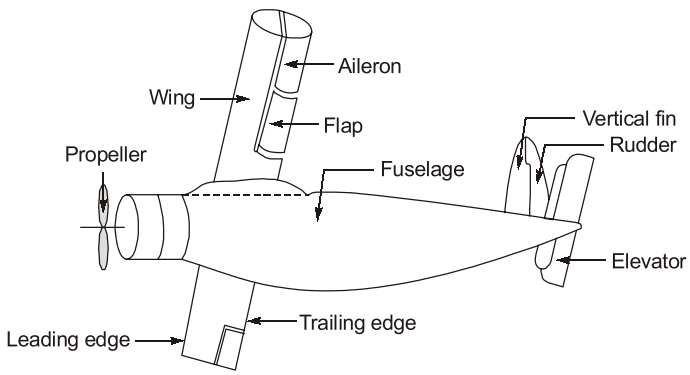


Fig. 1.1 Major Components of an Aeroplane

1. **Wings:** Wings support the aircraft in the flight when the engine has given it the necessary forward speed.

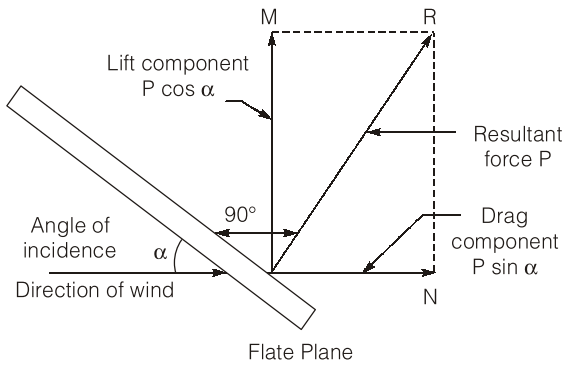


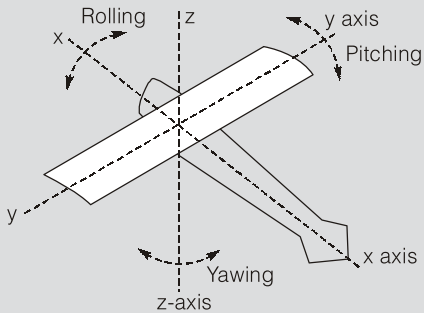
Fig. 1.2

Note: As the angle of incidence increase, the drag component also increases and the lift component reduces.

2. **Three principal controls:**
   There are three axes about which an aircraft may move to control these movements, the airplane is provided with three principal controls.
   (a) Elevator: Controls the pitching movement.
   (b) Rudder: Used for turning or yawing movement.
   (c) Aileron: Used to control the rolling moment.
3. **Fuselage:** It forms main body of aircraft and provides for power plant, fuel, cockpit, passengers, cargo etc.
4. **Flaps:** Used for increasing lift on aerofoils.

NOTE

- The movement of aircraft about the X-axis is called lateral or rolling movement.
- The movement about y and z axes are called pitching and yawing movements respectively.



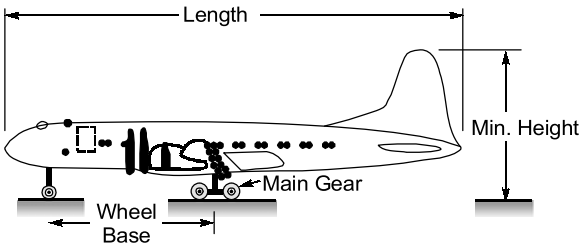
1.3 Aircraft-Characteristics

The aircraft characteristics needed to be studies are:

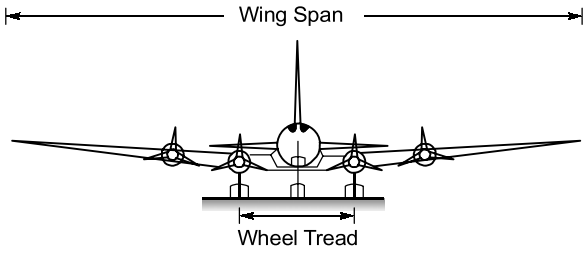
1. Type of propulsion
2. Size of aircraft
3. Minimum turning radius
4. Minimum circling radius
5. Speed of aircraft
6. Capacity of aircraft
7. Aircraft weight and wheel configuration
8. Jet blast
9. Fuel spillage
10. Noise

1. **Type of Propulsion:** Propeller generally consists of two or more blades which are driven round in circular path reflecting air backwards with an acceleration and thus imparting forward thrust (lift) to the aeroplane, this is called propulsion.
   Size of aircraft, its circling radius, speed and weight carrying characteristics etc. depend upon the type of propulsion.

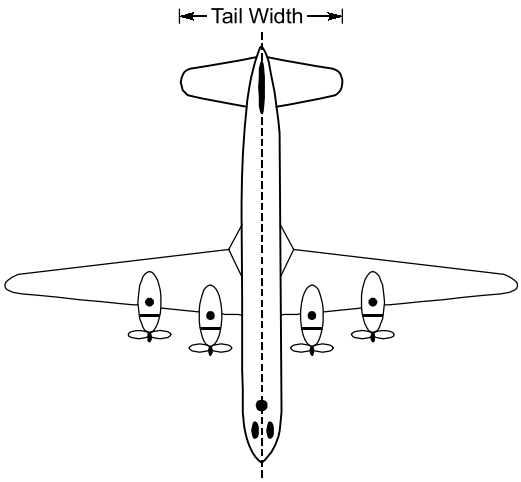
2. **Size of Aircraft**: Size of Aircraft Involves following dimensions
   1. Wing span
   2. Fuselage length
   3. Height
   4. Distance between main gears, i.e. gear tread
   5. Wheel base and
   6. Tail width
   - The wing span decides the width of taxiway, size of aprons, hangars etc.
   - The length of aircraft decides the widening of taxiways on curves, sizes of aprons and hangars etc.
   - The height of aircraft is known as empennage height decides the height of hanger gate.
   - The gear trade and the wheel base affect the minimum turning radius of the aircraft.
3. **Minimum Turning Radius:**
   - It is very essential to decide the radius of taxiways, to establish path of the movement of aircraft.
   - The distance of the farthest wing tip from the centre of rotation represents the minimum turning radius.
   - Theoretically, the maximum angle of rotation is 90° which corresponds absolute minimum turning radius which produces excessive tire wear.
4. **Minimum Circling Radius:** It is minimum radius with which the aircraft can take turn in space.
5. **Speed:** Cruishing speed/Ground Speed – Aircraft speed with respect to ground when aircraft is flying at its maximum speed. Air speed – Aircraft speed relative to wind.
6. **Aircraft Capacity:** Capacity of aircraft is described in terms of number of passengers, cargo and fuel that can be accommodated in the aircraft.
7. **Weight of Aircraft:** It influences the length of runway, thickness of runway, taxiway, apron and hanger.



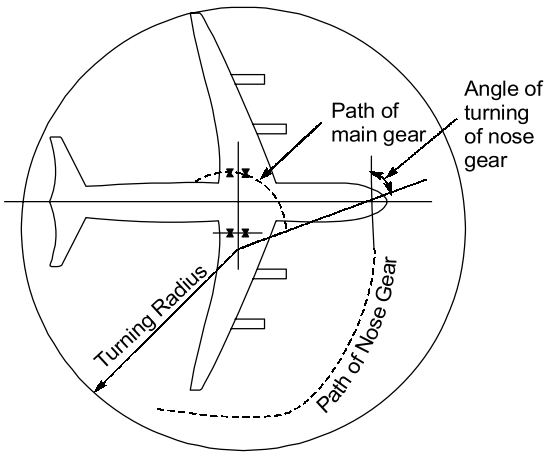
(a) Side view



(b) Front view



(c) Plan



(d) Turning Radius of Aircraft

Fig. 1.3

Weight Components:

- Empty operating weight is a constant weight of aircraft.
- Zero fuel weight is the sum of empty operating weight and the maximum payload.
- Maximum take off weight is sum of empty operating weight and flexible combination of payloads and fuel.
- Maximum landing weight < Maximum take off weight (because fuel is burned during flight).
- Maximum ramp weight is slightly higher than the maximum take off weight (because some fuel is used in taxing etc).

8. **Jet Blast:** The flexible bituminous pavements are affected by the jet blast, therefore, it is desirable to provide cement concrete pavement at least at the touch down portion to resist the effect of blast in comparison to the bituminous pavements.
9. **Fuel Spillage:** The flexible bituminous pavements are affected by the fuel spillage and therefore constant supervision of the area by the airport authorities is essential.
10. **Noise:** The correct assessment of noise patterns is essential to the optimal layout of the runways.

Summary

- Classification of airport is done according to Federal Aviation Administration (FAA) and International Civil Aviation Organisation (ICAO).
- Fuselage is main body part of aircraft including passengers chamber, Pilot's cabin and tail of aircraft.
- The wing span decides the width of taxiway, size of hangers and aprons.

Objective Brain Teasers

Q.1 Cruishing speed of an aircraft is 650 kmph. If there is head wind of 50 kmph, than air speed and ground speed of aircraft respectively.
(a) 700 kmph and 700 kmph
(b) 650 kmph and 700 kmph
(c) 650 kmph and 650 kmph
(d) 700 kmph and 650 kmph

Q.2 Which of the following statement(s) is/are correct
(a) the speed of aircraft relative to the ground, is called cruising speed
(b) the speed of aircraft relative to wind, is called air speed
(c) when wind is blowing the direction of the flight, air speed is less than cruising speed
(d) all above

Q.3 Zero fuel weight of an aircraft is
(a) equal to empty operating weight
(b) equal to maximum operating weight
(c) equal to sum of empty operating weight and maximum pay load
(d) less than empty operating weight

Q.4 Maximum ramp weight of an aircraft is
(a) equal to maximum take off weight
(b) more than maximum take off weight
(c) less than maximum take off weight
(d) equal to maximum landing weight

Q.5 Maximum landing weight of an aircraft is
(a) equal to maximum take off weight
(b) more than maximum take off weight
(c) less than maximum take off weight
(d) equal to zero fuel weight

Q.6 **Statements (I):** The actual payload particularly in passenger aircraft, is normally less than the maximum structural payload even when the aircraft is completely full.

Statement (II): There are limitations in the use of space when passengers are carried in an aircraft.

(a) Both I and II are true and Ii is correct explanation of A
(b) Both I and II are true but II is not a correct explanation of A
(c) I is true but II is false
(d) I is false but II is true

Q.7 Pick up the component not applicable to aeroplanes

(a) wings (b) engines
(c) air screw (d) None of these

Q.8 The fuselage includes

(a) passengers chamber
(b) pilot's cabin
(c) tail of aircraft
(d) All of the above

Q.9 Wing loading of an aircraft is

(a) load of the wings

(b) $\frac{\text{gross total weight of the aircraft}}{\text{load of wings}}$

(c) $\frac{\text{gross total weight of the aircraft}}{\text{wings area}}$

(d) $\frac{\text{gross total weight of the aircraft}}{\text{total available HP of engines}}$

Answers

1. (d)	2. (d)	3. (c)	4. (b)	5. (c)
6. (a)	7. (d)	8. (d)	9. (c)	