UNIT-I

RAILWAY PLANNING

Significance of transport:

Transport plays a significant role in the overall economic development. Transportation results into growth of infrastructure, industrialization and massive production.

Advancement in the transport sector has resulted into comfort and convenience. Well-functioning transportation systems form the basis for economic prosperity and social well being of societies.

1. Industrial growth:

Transportation and the Industrial development are interrelated. Without improved modes of transportation it would have been harder for the industrial producers to produce and then sell their goods to the wider markets.

Transportation facilitates movement of raw material and other requirement from the place of supply to the place of production. Efficient transport is indispensable to the economic development of the nation.

2. Creates employment:

Transport also contributes to economic development through job creation. It creates both direct and indirect employment opportunities. In India, a sizeable portion of the country's working population is directly or indirectly employed in the transport sector.

It also facilitates movement of labors and thereby encourages employment resulting into industrial development and thereby economic development.

3. Creates place utility:

Transportation enables movement of commodities from the producer to the final consumer whenever and wherever they are demanded. It creates place utility. Transportation plays an essential role in the agricultural sector.

Agricultural requirements are made available to the farmer at a short span of time. It is an integral part t of commerce. It gives place and time utility to goods by removing them from the place of production to the places where they are to be consumed.

4. Bring countries closer:

No country in the world is self-sufficient. They have to depend on one another to fulfil their requirements. Transportation has brought the countries closer. It not only caters to the need of mobility but also provides comfort and convenience.

Travelling is a part of our daily lives. People travel for business purpose, education purpose I and vacation purpose etc. The transport system is doing a great job by easing the pain of covering vast distance of land thereby bringing the countries closer.

5. Serve several purposes:

Transportation provides access to natural resources and promotes trade, allowing a nation to accumulate wealth and power. Transportation also allows the movement of soldiers, equipment, and supplies during war.

Hence transportation is vital to a nation's economy as it serve several purposes. It includes the manufacture and distribution of vehicles, the production and distribution of fuel, and the provision of transportation services.

6. Stability in prices:

Goods can be transported to places where there is scarcity and the prices are high from places where there is surplus and the prices are low. Such transfer of goods from the place of surplus to the place of scarcity enables to stabilise the prices of the commodity. Thus stability of prices restricts the local producers to charge prices at their own will. This discourages monopoly and encourages competition.

7. Specialization and division of labour:

Transport increases the mobility of labour and capital, widens the market that leads to specialization and division of labour, which helps in stabilizing prices. Specialization provides employment to a very large number of persons.

It is only due to transport that modern industrial system and large-scale industries are in a position to develop. Without efficient transport it would not have been possible to procure raw material, gather large number of workers and distribute the finished goods.

8. Use of Economic resources:

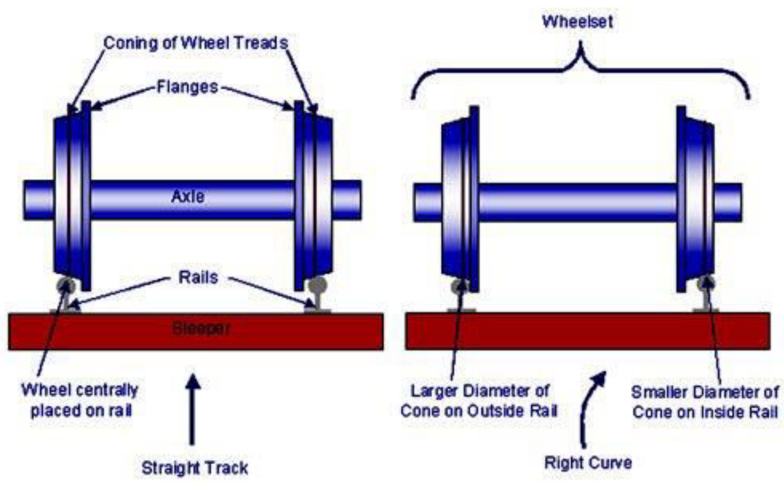
Transportation enables society to enjoy advantages of specializations of resources, and the benefits of labour by making it possible for products to be brought great distance, thus avoiding the necessity for local production for all conceivable commodities of need.

Each economic region can thus concentrate upon the goods and services for which it is best adapted either through natural resources endowment or through historical development. It, thus, leads to a better economic use of available resources.

9. Standard of living:

Transportation raises the standard of living, making possible improved housing, clothing, food and recreation.

Coning of Wheel



The rim or flanges of the wheels are never made flat but they are in the shape of a cone with a slope of about 1 to 20. This is known as coning of wheels. The coning of wheels is manly done to maintain the vehicle in the central position with respect to the track. When the vehicle is moving on leveled track then the flanges of wheels have equal circumference

But when the vehicle is moving along a curved path then in this case the outer wheel has to cover a greater distance then that of inner wheel. Also as the vehicle has a tendency to move sideways towards the outer rail, the circumferences of the flanges of the inner wheel and this will help the outer wheel to cover a longer distance than the inner wheel. In this ways smooth riding is produced by means of coning of wheels.

Coning Wheels Disadvantages

Coning wheels has the following disadvantages:

1. In order to minimize the above below disadvantages the tilting of rails is done. i.e. the rails are not laid flat but tilted inwards by using inclined base plates sloped at 1 in 20 which is also the slope of coned surface of wheels.
2. The pressure of the horizontal component near the inner edge of the rail has a tendency to wear the rail quickly.
3. The horizontal components tend to turn the rail outwardly and hence the gauge is widened sometimes.
4. If no base plates are provided, sleepers under the outer edge of the rails are damaged.
5. In order to minimize the above mentioned disadvantages the tilting of rails is done. i.e. the rails are not laid flat but tilted inwards by using inclined base plates sloped at 1 in 20 which is also the slope of coned surface of wheels.

Advantages of Tilting of Rails

1. It maintains the gauge properly.
2. The wear at the head of rail is uniform.
3. It increases the life of sleepers and the rails.

Track stresses

1. Wheel load
2. Dynamic action of wheel load

3. Hammer blow
4. Horizontal Thrust
5. Horizontal thrust due to nosing action
6. Thermal stresses

Creep in rails

Creep in rail is defined as the longitudinal movement of the rails in the track in the direction of motion of locomotives. Creep is common to all railways and its value varies from almost nothing to about 6 inches or 16cm. Major causes of creep are.

1. Creep may be developed due to forces that come into operation when the train is starting or stopping by application of brakes. Increase of starting the wheels pushes the rail backward and hence the direction of creep is in backward direction.
2. Creep is also developed due to wave motions. When the wheels of the vehicles strikes the crests, creep is developed.
3. When brakes are applied then the wheels of the vehicles push the rails in forward direction and hence the creep is in forward direction.
4. Another reason creep develops because of unequal expansion and contraction owing to change in temperature.

Points, Switches and crossings

All railways require points or ‘turnouts’ to be able to divert trains from one track to another and crossings or ‘diamonds’ to allow trains to cross other tracks at an angle. This applies to all railways from the most complicated reversible layouts at terminal stations to simple single track tramways with passing loops. Any assembly of points and crossings is called a layout. Some layouts occur frequently and have acquired their own names. The most common is the ‘crossover’ which is simply two sets of points laid crossing to crossing in adjoining track enabling trains to change track in one direction. If two crossovers are superimposed, thus enabling movements from either track in either direction, the layout is known as a ‘scissors crossover’ for obvious reasons. In this layout there are four sets of points and one central diamond. Points or turnouts and diamonds are themselves composed of elements known as crossings and switches.

Surveys and route allignment

1. Reconnaissance Survey

A reconnaissance survey is the first engineering survey which is carried out in territory which has not been previously surveyed for the purpose of laying a new railway line. The main objects of reconnaissance survey are as follows:

- To obtain a general knowledge of the whole territory and
- To obtain information regarding the salient feature of the territory.

Importance of Reconnaissance Survey

By reconnaissance survey, a number of possible alternative routes between two points can be worked out. This information becomes useful at a later stage in the selection of best possible route between two points. The successful conduct of the reconnaissance survey entirely depends on the personal qualities and abilities of engineers such as training and experience, capacity of observation and interpretation of the features of the territory etc.

2. Preliminary Survey

The object of preliminary survey is,

- To conduct the survey work along the alternative routes (found out by reconnaissance survey) with the help of theodolite and leveling instruments
- To determine the greater accuracy the cost of railway line along these alternative routes involving cost of removing obstruction, construction of bridges etc
- To decide the most economical and efficient route

3. Location Survey

It is the final survey used to locate the centre line of the railway line the main object of this survey is to carry out the detaile3d survey along the route which has been fixed as the most economical route from the data of preliminary survey.

Importance of Location Survey

The location survey established the center line of actual track to be laid and hence as soon as the location survey is completed, the construction work is started.

Elements of permanent way

Following are the components of a permanent way.

1. Subgrade
2. Ballast
3. Sleepers
4. Rails
5. Fixture and Fastening

In a permanent way, rails are joined either by welding or by using fish plates and are fixed with sleepers by using different types of fastenings. Sleepers are properly placed and packed with ballast. Ballast is placed on the prepared subgrade called formation.

REQUIREMENTS OF AN IDEAL PERMANENT WAY

Following are the basic requirements of a permanent way:

1. The guage should be uniform and correct.
2. Both the rails should be at the same level in a straight track.
3. On curves proper superelevation should be provided to the outer rail.
4. The permanent way should be properly designed so that the load of the train is uniformly distributed over the two rails.

5. The track should have enough lateral strength.
6. The radii and superelevation, provided on curves, should be properly designed.
7. The track must have certain amount of elasticity.
8. All joints, points and crossings should be properly designed.
9. Drainage system of permanent way should be perfect.
10. All the components of permanent way should satisfy the design requirements.
11. It should have adequate provision for easy renewals and repairs.

DESIGN AND RATING – BROAD GAUGE

1.1 GENERAL

a) The aim of the track alignment design shall be to allow trains to maintain the maximum speed for the traffic operating. This is generally best achieved by minimizing the grade and curvature of the track.

b) Except as provided for elsewhere in this part, the parameters given in Table 2.1 shall be adopted:

Table 2.1: Maximum values of track parameters

	PARAMETER	**MAXIMUM ALLOWABLE**
1	Actual cant:	
	- where rails are continuously welded and curves are properly transitioned (except at platforms)	130mm
	- where rails are not continuously welded or curves are not properly transitioned (except at platforms)	90mm
	- at platforms and road crossings	50mm
	- on diverging route of conventional/tangent turnouts	Nil

2	Actual negative cant (only applies to divergent routes over contraflexure turnouts at speeds up to 25km/h)	20mm
3	Cant gradient	1:400
4	Cant deficiency [see sub-clause 2.4.3(c) and clause 2.4.5]; - where rails are continuously welded and curves are properly transitioned (except at platforms) .... - where rails are not continuously welded or curves are not properly transitioned (except at platforms) .... - at platforms and road crossings .... - on diverging route of conventional/tangent turnouts .... - horizontal bend	 100mm 70mm 40mm 100mm 40mm
5	Cant excess (negative deficiency)	80mm
6	Rate of change of cant deficiency, excess cant or actual cant [see paragraph 2.4.4(e)(2)]: - plain track - on diverging route of conventional/tangential turnouts	 39mm/sec 39mm/sec
7	Horizontal bend angle	1º 50'
8	Horizontal curve radius	See note [1]
9	Vertical curve radius (see clause 2.10.3)	
10	Grade (compensated)	1 in 45
11	Nominal spacing of vehicle bogies	17.5

Note [1]: There is no maximum allowable radius, however the minimum allowable radius on main lines = 200 m.

1.2 TRACK GAUGE

a) Gauge shall be measured, in mm, between the inside face of the rails, 16 mm below the top surface.

b) The nominal track gauge of PTSOM's rail tracks shall be 1 600 mm and all formulae in this part are for this gauge (commonly referred to as broad gauge).

c) On PTSOM, the gauge shall not be increased on curves of radius equal to or greater than 200 m.

1.3 TANGENT TRACK

Tangent track shall be laid and measured between the tangent points of curves, points and crossings or the ends of the line. In general, tangent track shall be laid and maintained level across the rails. Exceptions to this rule occur at the approach to un-transitioned curves, where half the cant is applied on the tangent track and the other half on the curve.

1.4 HORIZONTAL CURVES

1.4.1 Radius

The radius of all curves shall be expressed in metres.

1.4.2 Minimum radius

a) The minimum radius of curve for existing running lines shall be 200 m or 800 m for all new work.

a) The minimum radius of curve to be used alongside a passenger platform shall be 800 m for all new work.

c) The minimum radius of curve to be used on sidings shall be 140 m.

d) No concave curves to be allowed through platforms

1.4.3 Definitions:

a) The actual cant is that which is applied to the curve in practice.

b) The equilibrium cant is the theoretical cant at which the resultant of the centrifugal force and the vertical force due to the mass of the vehicle is perpendicular to the top plane across the track at the maximum vehicle design speed.

c) The cant deficiency is the amount by which the actual cant would have to be increased to equal the equilibrium cant. Except as provided for in clause 2.6.2, cant deficiency shall not exceed 80% of the actual cant.

equilibrium cant = actual cant + cant deficiency

d) Negative cant is where the inside rail on a curve is higher than the outside rail, and is to be avoided where possible, but may occur on a contraflexure turnout where the whole turnout is canted to favour the main running line and thus puts a negative cant on the other leg of the turnout. The maximum negative cant shall be 20 mm with a maximum speed of 25 km/h. Above 25 km/h, no negative cant is to be used. The cant on the main running line may have to be reduced in order to keep the negative cant within these limits.

1.4.4 Cant and speed - an explanation

a) When a rail passenger vehicle enters a curve, centrifugal force acts on the vehicle and any passengers inside. This force is proportional to the square of the speed of the vehicle and inversely proportional to the radius of the curve. At moderate levels of operation centrifugal force has no effect on safety, but can affect the comfort of passengers. To counter the effects of centrifugal force on passengers, cant is applied to the curve by lowering the inside rail and raising the outside rail by equal amounts.

b) For a train traveling at a different speed than that used to calculate the cant, there shall be an "excess cant" if the train is traveling too slow or a "cant deficiency" if the train is traveling too fast.

c) Overseas tests reveal that risk of derailment is increased if the "excess cant" appreciably exceeds one tenth of the gauge, i.e.160 mm on PTSOM. By considering a near stationary train on a curve (for example, at a "stop" signal), this effectively sets an upper limit for the (total) cant i.e. the original deliberately applied (nominal) cant plus any further cant accidentally applied because of track settlement should not exceed 160 mm. As a result, well-maintained track may safely take a higher nominal cant than poorly maintained track.

d) Note: The prime reason for canting curved track is for passenger comfort, not safety. Excessive cant may jeopardize safety; lack of cant will not, (except near the speed at which capsizing may occur, but cant would only have a marginal effect at such an excessive speed).

e) Tests also show that for passenger comfort:

   1) cant deficiency should not exceed 100 mm (but see Table 2.1);

   2) rate of change of cant or cant deficiency should not exceed 39 mm/sec. However where space is restricted a rate of up to 60 mm/sec may be used in accordance with sub-clause 2.6.2(a) (Transitions of restricted length);

1.4.5 Maximum allowable actual cant and cant deficiency

Except as provided for in sub-clause 2.6.2(a), the maximum allowable actual cants and cant deficiencies are as shown in Table 2.1 (lines 1 and 4):

1.4.6 Cant / speed relationship

a) The vehicle design speed shall be the maximum speed that trains shall not normally exceed.

b) The maximum allowable vehicle design speed for any curve shall be determined by the formula in Figure 2.1. Where "V" exceeds the maximum allowable line speed, the line speed shall be used and cants recalculated accordingly.

Figure 2.1: Determination of speed

$$V = 0.276\sqrt{E_q.R}$$

where:

V = Maximum allowable vehicle speed for curve in km/h

E_q = Equilibrium cant in mm = $E_a + E_d$

E_a = Actual cant in mm

E_d = Cant deficiency in mm

R = Radius of the curve in metres

c) The cant that may be applied to a curve shall be determined by the formulae in Figure 2.2:

Figure 2.2: Determination of cant

1) The equilibrium cant is calculated as follows:

$$E_q = 13.1 \times \frac{V^2}{R}$$

where

E_q = Equilibrium cant in mm

V = Vehicle design speed in km/h

R = Radius of curve in metres

2) The actual cant is calculated as 55% of the equilibrium cant.

3) If this exceeds the value shown in Clause 2.4.5 for the location, then determine the maximum allowable equilibrium cant and then calculate the maximum allowable vehicle design speed as in paragraph 2.4.6(b).

1.5 BENDS

1.5.1 Occurrence of bends

Bends occur where two tangent tracks meet at near 180 degrees without an intermediate curve. Mostly they occur at the toe of straight switches but can occur on the running line due to historical inaccuracies when the line was originally laid out. Except at the toe of conventional points, horizontal bends should be avoided where possible

1.5.2 Allowable maximum speed through a bend

The allowable maximum speed through a bend shall be as shown in Figure 2.3:

Figure 2.3: Maximum allowable speed through a bend

$$V = 2.09 \times \sqrt{\frac{Ed \times B}{A}}$$

where: V = Maximum allowable vehicle design speed in km/h

E_d = allowable cant deficiency in mm

B = bogie centres of rolling stock in metres

A = angle between two tangent tracks in degrees

On PTSOM it may be assumed that E_d = 40mm and B = 17.5m, thus:

maximum allowable speed = 55 ÷ $\sqrt{A}$

EXAMPLE: For a straight 6.09 m switch (angle = 1.28°), max. allowable speed = 45 km/h. Note, however the speed through the turnout may be dependent on its radius.

1.6 TRANSITIONS

1.6.1 Standard transitions

a) All standard curve transitions shall be of cubic parabola form.

b) The centre line of the track on the true curve shall be moved towards the centre of the curve by the "shift" to facilitate the construction of the transition.

c) The rate of change of actual cant or cant deficiency shall be limited to 39 mm/sec. and the cant gradient to not steeper than 1 in 400. Thus, the lengths of transitions shall be as shown in Figure 2.4.

Figure 2.4: Lengths of transitions

The length of transition on any curve shall be the highest value of the results of the following three calculations:

1) $L = 0.0072.E_a.V$

2) $L = 0.0072.E_d.V$

3) $L = 0.4.\ E_a$

where L = Transition length in metres

E_a = Actual cant in mm

E_d = Cant deficiency in mm

V = Maximum allowable vehicle design speed in km/h

If the theoretical transition length is less than 20 m, or the shift is less than 10 mm [see clause (b)] no transition shall need to be applied.

1.6.2 Transitions of restricted length

In certain circumstances it may not be possible to apply the standard transition lengths as calculated from clause 2.6.1(c). If so the alternative solutions, in descending order, may be:

a) Adopt a greater rate of change of cant than that specified in clause 2.6.1(c). Under no circumstances shall this value exceed 60 mm / sec. [see paragraph 2.4.4(e)(2)] and by adopting it, the formulae in figure 2.4 are modified as follows:

1) $L = 0.0046.E_a.V$

2) $L = 0.0046. E_d.V$

3) $L = 0.4. E_a$

b) Adopt a higher cant deficiency than that specified in clauses 2.4.5 and 2.4.6 up to, but not exceeding, the actual cant.

c) Adopt a shorter transition than calculated but commence canting the track before the commencement of the transition and increase the cant in accordance with paragraphs 2.6.1(c) or 2.6.2(b) until the full cant is applied. The distance over which the cant is increasing shall be symmetrical with the distance over which the track is transitioned.

1.6.3 Curves without transitions and "virtual" transitions

If it is not possible to apply any transition at all, the following action shall be considered. Between when the first bogie of a bogie vehicle enters a curve and the second bogie enters the curve, the vehicle gradually takes up circular motion. This is the "virtual transition" and is equal in length to the bogie centres. On PTSOM, the virtual transition is 17.5 m long. By considering the transition as 17.5 m long (symmetrical about the tangent point) the alternatives shown in clauses (a) or (b) may be used.

a) If the curve is canted without a transition, the cant shall be applied from zero at the beginning of the virtual transition and increased in accordance with the maximum rate of change of cant or cant deficiency or cant gradient until the maximum cant is reached at the end of the virtual transition. As the maximum vehicle design speed will be attained if the actual cant equals the cant deficiency, the calculation of the cant and speed shall be as in Figure 2.5.

Figure 2.5: Curve canted but not transitioned

$V = 0.276\sqrt{E_q.R}$ (see Figure 2.2)

But if $E_q = E_a + E_d = 2 \times E_a$; then $V = 0.276\sqrt{2.Ea.R}$

From the transition formula L (= 17.5 m) = $0.0072.E_d.V$

Therefore equating V from the two formulae:

$0.276\sqrt{2.Ea.R} = 17.5 \div 0.0072.E_d$

$E_a = E_d = [268.7 \div \sqrt[3]{R}]$

EXAMPLE: If R = 200 m, $E_a = E_d = [268.75 \div \sqrt[3]{200}] = 46.0$ mm

Then $V = 0.276\sqrt{E_q.R} = 37.5$ km/h

b) If the curve is un-canted and without transition, the maximum allowable vehicle design speed shall be determined using the maximum allowable cant deficiency for the curve. (The maximum cant deficiency is specified in Table 2.1). The cant deficiency is assumed to build up over the virtual transition and shall need to be checked to ensure that it does not exceed the allowable cant gradient. The calculation of the cant and speed shall be as in Figure 2.6.

Figure 2.6: Curve uncanted and not transitioned

$V = 0.276\sqrt{E_q.R}$ (see Figure 2.2)

From the transition formula L (= 17.5 m) = $0.0072.E_d.V$

Therefore equating V from the two formulae:

$0.276\sqrt{E_q.R} = 17.5 \div 0.0072.E_d$

In this case $E_q = E_d$ therefore $E_d = [426.5 \div \sqrt[3]{R}]$

EXAMPLE: If R = 200 m; $E_d = [426.5 \div \sqrt[3]{200}] = 72.9$ mm

Then $V = 0.276\sqrt{E_q.R} = 33$ km/h]

1.6.4 Compound curves

In compound curves, transitions between different radii of the compound curve shall use the same criteria as for a simple curve with the following variations:

a) Calculations involving cant shall use the difference in cant between the two radii.

b) Calculations involving cant deficiency shall use the difference in cant deficiency for the two radii.

c) The cant and speed shall be determined for each curve individually.

d) The length of transition between the two curves shall be derived from the formulae in Figure 2.4, modified as follows:

1) $L = 0.0072.(E_{a1} - E_{a2}).V$

2) $L = 0.0072.(E_{d1} - E_{d2}).V$

3) $L = 0.4.(E_{a1} - E_{a2})$

1.6.5 Reverse curves

In reverse curves, transitions between different radii of the reverse curve shall use the same criteria as for a simple curve with the following variations:

a) Calculations involving cant shall use the sum of the cants for the two radii.

b) Calculations involving cant deficiency shall use the sum of the cant deficiencies for the two radii.

c) The cant and speed shall be determined for each curve individually.

d) The length of transition between the two curves shall be derived from the formulae in Figure 2.4, modified as follows:

1) $L = 0.0072.(E_{a1} - E_{a2}).V$

2) $L = 0.0072.(E_{d1} - E_{d2}).V$

3) $L = 0.4.(E_{a1} - E_{a2})$

1.7 LENGTHS OF STRAIGHTS AND CURVES

For all new work:

a) Between similar flexure curves a transition should be provided.

b) Between contraflexure curves a straight of minimum length should be provided equal to the longest bogie centres of rolling stock in use (17.5 m). However, the minimum length of straight may be reduced at crossovers.

c) Circular and transition curves should have a minimum length of 20 m.

d) The cant gradient should be not less than 20 m long including between curves in a compound curve.

1.8 GEOMETRIC DESIGN DOCUMENTATION

The design details pertaining to the current design should be maintained and should include:

a) Survey co-ordinates and datums if available;

b) Location details (bench marks, tangent spiral, spiral curve, vertical curves, changes in grade);

c) Curvature;

d) Length of curves

e) Gradient;

f) Cant and cant deficiency;

g) Maximum allowable speed;

h) Transition length;

i) Cant gradient.

Unit-2

Railway Construction & Maintenance

Earthwork

Before taking up of actual execution of work, detailed drawings need to be prepared for the entire length of the project to give alignment, formation levels, formation width at ground level, cross sections of catch water drains & side drains, cross section & levels of subgrade, blanket levels, etc. to facilitate smooth execution at site. Execution of work has to be carried out in systematic manner so as to construct formations of satisfactory quality which would give trouble free service. The activities and adoption of good practices involved in execution of earthwork are covered under following headings:-

a) Preliminary works

b) General aspects

c) Compaction of earth work

d) Placement of Back-Fills on Bridge Approaches and Similar Locations

e) Drainage Arrangement in Bank/Cutting

f) Erosion control of slopes on banks & cuttings

Stabilization of track on poor soil:

Poor soil consisting predominantly of clay, having low shear strength, poor permeability and high swelling index are very often encountered on alignment over the Indian Railways. Formation constructed through such soil exhibit maintenance problem and, in several cases, result into a more severe formation failure. The paper discusses present guidelines on soil survey and the measures required to be taken for construction of formation under such conditions.

In the coastal areas, the rail tracks are constructed onembankments overlying soft and compressible formationsoils. The passage of heavy haul trains with considerable imposed train loads over these deposits causes excessive track settlement and significant reduction in the load bearing capacity of the track. This requires an investigation into the effects of various track parameters including track substructure thickness and stiffness, shoulder width and track modulus on the overall track performance.

IMPORTANCE OF TRACK DRAINAGE

Drainage of track is the most important factor for the proper maintenance of track. Water softens the formation unless it is drained away as soon as it falls on the track. Soft formation has less bearing capacity and is liable to settle under load, seriously affecting the track parameters as well as retentivity of packing. Interpenetration of soil and ballast takes place in a soft formation causing loss of ballast into the formation on the one hand and mud pumping and clogging of ballast on the other. Loss of ballast on account of poor drainage can be quite substantial. Ballast pockets inside the embankement collect water and further soften the soil of the bank. Clogging of ballast affects drainage of water on to the formation to be led in to the side drains. It also affects the elasticity of the track which means more wear and tear of track components and vechile undergear, resulting in rail fracture, spring breakages and premature renewal of track and vehicle components.

GOOD DRAINAGE OF TRACK

It can be ensured by

- Maintenance of clean ballast which will drain the water quickly on to the formation.
- Maintenance oc proper slope of formation so that the water brought on to the formation flows out of the track easily and quickly.
- Proper drainage arrangements so that water does not stand near the track and flows away from the track readily.
- Drainage of track on embankments takes place as long as the cess level is maintained and the ballast is clean. However in cuttings and in yards where free and quick flow of water away from track is not possible, a well planned drainage system must be provided.

- While doing track renewals/doublings/gauge conversions, drainage arrangements required as per this circular must be planned as part of the relaying estimate and completed along with the track work.
- Growth of vegetation in track indicates clogging of ballast and lack of adequate track drainage. Such stretches should be overhauled or deep screened.
- About 25 to 50 mm below the rail foot shall be kept clear of any ballast, earth or cinder on all lines inside and outside the yards to enable surface flow, avoid corrosion and prevent failure of track circuits.
- The Permanent Way staff shall keep all side drains and catch water drains clear as part of annual maintenance not only on run through lines but also on non running lines in yards. They should ensure that the outfall of these drains and the waterways of all bridges and culverts are kept free from obstruction. The spoils from cleaning drains or cuttings shall not be deposited at a place from where it is likely to be washed back into the drains.
- The muck arising in the course of deep screening and overhauling shall be dumped on to the side slopes or used to make up cess in the case of track in embankments. In the case of track in cuttings, the muck should be removed and dumped in such a location that it will not be washed into the drains nor will it in any other way interfere with the drainage of the station yard.

Drainage in mid section

- Side drains along the track shall be provided in cuttings and zero fill locations, where the cess level is not above the ground level.
- All drains must be given adequate grade to enable free flow of the collected water.
- On Group `A' routes essentially and on other routes preferably side drains shall be lined except where the drains are cut in rocky strata.
- To take the full flow of side drains adequate opening should be provided under level

crossing, trolley refuges and OHE masts where these exist in cuttings.

- Wherever necessary, catch water drains shall be provided in cuttings. Their size may be kept according to the volume of the water catered for.
- Surplus ballast in the shoulder retards drainage and encourages vegetation growth. All such ballast shall be taken out of track and stacked in small heaps alongside.

DRAINAGE IN STATION YARDS.

- Ballast section in station yards must be the same as on main line
- Every station yard shall have network of cross and longitudinal drains, whether earthen or masonry, such that the storm water is led away in the least possible time.
- Arrangements for surface drainage at carriage watering points and washing hydrants shall be efficiently maintained. The water must be adequately trapped and led away in a pipe or line drain.
- The yards must be kept clear of all of all loose materials, heaps of earth or cinder which will interface with drainage.
- Every yard must have a Master Plan For Drainage.
- The drainage plan shall show reduced levels of rails at suitable intervals from which the cess levels can be derived and levels of outfalls, drain crossings and other obligatory points determined.

PLANNING OF YARD DRAINAGE

- Surface drains shall generally be open for ease of cleaning and inspection. While designing drains in yards, velocity range of 0.5 1.0 m/sec. for kutcha drains and 1.0 2.0m/sec. for pucca drains may be adopted.
- Longitudinal drains between two tracks should be saucer shaped. However, drains with vertical sides may be provided wherever saucer drains are not practicable.

- In the case of large size drains and in some in some particular situation in yards, drains covers may have to be provided.
- Normally, the drain top shall not be above the cess level for effective drainage of ballast bed. However, if a drain with higher top level has to be provided to retain ballast, weep holes shall be provided at the assumed cess levels and the drain designed so as not to flow above bottom level weep holes. Weep holes generally gets choked. A preferable alternative is to provide 1 cm. Wide vertical weep slits at about one metre intervals, right from the top level of the drain down upto the cess level of the drain down upto the level.
- Wherever outfall is available at either end of a yard, longitudinal drain shall be provided with slope in opposite direction from the middle of the yard. This will ensure minimum size and depth of the drains.
- Formation with in 3.5 metres of track center line shall be maintained at least 200 mm below the sleeper bottom for run through lines and 150 mm for the other lines.

DRAINAGE OF PLATFORMS

- All end platforms shall normally be slopped away from the track.
- All drains from platform shelters, tea stalls, toilets, water taps or other sullage generation points shall be in pipes and normally discharged on the non track side of the end platform. If necessary longitudinal covered drains may be provided on the platform.
- In the case of island platform s, all drains shall discharge on the less important track and not towards the run through line. Wherever situation exists to the contrary, the drainage shall be modified to conform.
- Whenever a cross drain discharges towards a track, it should be in a pipe discharging directly in to the drain between the track.
- All drains emanating from the platform must be provided with suitable grating, well fixed in position so that any material likely to clog the drain is retained on the grating.

DRAINAGE IN BC SOIL CUTTINGS

Old IRW&WM Indian Railways Way and Works Manual says “In BC soil cuttings the catch water drains are to be provided sufficiently away from the track,since after getting soaked in water BC soil completely looses its strength and will breach in to the track/side drains blocking the side drains.For this reason extra land shall be acquired”

Alternately we shall go for RCC drains,as catch water drains in BC soils to avoid the above problem.

Ventilation of railway tunnels

Planning of aerodynamics and the related climate and ventilation requires interfacing with engineering disciplines such as civil design, technical equipment and railway technology. Aerodynamics, climate and ventilation of tunneling projects are important in projects characterized by the following:

1. high-speed rail tunnels
2. very long tunnels
3. steep tunnels
4. deep tunnels
5. high-performance underground or metro systems
6. high overburden resulting in high heat ingress from the ground
7. tunnels exposed to extreme climate conditions (wind at portals, outside temperatures)

Railway station

It is the selected place on a railway line, where trains halt for one or more of the following purposes”

1. For exchange of passengers
2. For exchange of goods
3. For control of train movements

4. For crossing
5. For overtaking
6. For detaching engines and staff
7. For taking diesel or coal and water for locomotives

Passenger amenities

1. A booking office for tickets
2. Goods and passenger platforms
3. Drinking water
4. lighting and ventilation
5. Waiting rooms and retiring rooms
6. Sanitary arrangements and bath rooms
7. Refrigerators for cold drinking water
8. City map or guide map
9. Display boards

Station yards

A system of tracks laid usually on a level within defined limits, for receiving, storing, making up new trains, dispatch of vehicles and for other purposes over which movements are not authorised by a time table. Following are the type of station yards.

1. Passenger bogie Yards
2. Goods yards
3. Marshalling Yards
4. Locomotive Yards

1.Passenger bogie yards-- Provides facilities for the safe movement of passengers and vehicles for the use of passengers

2. Goods yards-- Provides facilities for receiving, loading and un loading, delivery of goods and the movement of goods vehicles

3. Marshalling Yards-- Is one where trains and other loads are received, sorted out and new trains are formed and dispatched onwards to their destinations

Functions:

1. Reception
2. Sorting
3. Departure

Siding for marshelling yard:

1. Reception siding
2. Sorting siding
3. Departure siding

Urban Rail:

Urban rail transit is an all-encompassing term for various types of local rail systems providing passenger service within and around urban or suburban areas. The set of urban rail systems can be roughly subdivided into the following categories, which sometimes overlap because some systems or lines have aspects of each.

Monorail:

A monorail is a railway in which the track consists of a single rail, as opposed to the traditional track with two parallel rails.

Tunneling methods

A tunnel is an underground or underwater passageway, dug through the surrounding soil/earth/rock and enclosed except for entrance and exit, commonly at each end. A pipeline is not a tunnel, though some recent tunnels have used immersed tube construction techniques rather than traditional tunnel boring methods.

The different method of tunnelling are,

Full face method- excavated in 3 phase and suitable in firm oil.

Top heading and benching method- suitable were stability of soil is less.

Drift method- drift is made at the center of the tunnel and the excavation is carried broadly.

Full face method- suitabe in firm ground and adopted in rocks also.
A tunnel is relatively long and narrow; the length is often much greater than twice the diameter,malthough similar shorter excavations can be constructed such as cross passages between tunnels.

Equipment used for construction of tunnels:

1. Boring machines- to drill the face of the tunnel.
2. Drilling and blasting
3. Hydraulic jacks
4. Mucking machine- used to dispose tunnel excavated mud.

Construction maintenance of track

Every Mate and Key man shall see that his length of line is kept safe for the passage of trains. Kilometer ages (Mileages) needing urgent attention shall be picked up without waiting for orders from the Permanent Way Inspector.

REGULAR TRACK MAINTENANCE:

THROUGH PACKING:

Through packing shall consist of the following operations in sequence, not more of the track on any one day being opened out than can be efficiently repacked before closing the work: -

A) Opening of the road.

B) Examination of rails, sleepers and fastenings.

C) Squaring of sleepers.

D) Slewing of track to correct alignment.

E) Gauging. F) Packing of sleepers.

G) Repacking of joint sleepers.

H) Boxing of ballast section and tidying.

POINTS AND CROSSINGS:

Maintenance:

i) At all points and crossings the gauge shall be exact, the clearances correct as prescribed in the Schedule of Dimensions, the switches and crossings in good condition and alignment the sleepers well packed and the chairs and fastenings and all other fittings properly secured. At the toe of the switch the gauge will however, be slightly slack between stock rails.

ii) The condition of wear, top as well as side, in stock and switch rails and in crossings should be carefully examined. Bent tongue rails should be straightened where possible; badly or damaged stock and tongue rails and crossings should be replaced by serviceable ones. Burred stock rails likely to obstruct the lock bars should be replaced if necessary.

iii) Stock and tongue rails should be replaced as complete sets as far as possible.

MAINTENANCE OF LEVEL-CROSSINGS:

1. Each level-crossing must be opened out and the condition of sleepers, rail and fastenings inspected at least once a year or more frequently as warranted by conditions. In all cases where earth is normally in contact with rails (running or guard) and fastenings, these shall be thoroughly cleaned with wire brush and a coat or coal-tar applied.

2. When replacing sleepers at level-crossings, treated or coal-tarred sleepers should be used.

3. The Key man during his daily beat should pay requisite attention to the general condition of such level-crossings and keep the flange ways clean and free from obstruction.

Repacking of joint sleepers:

The joint and 'shoulder' sleepers should be repacked before boxing is done and the cross levels at joints checked. The rail-joints being the weakest portion, firmness of its support is essential.

UNIT-3

AIRPORT PLANNING

Airport's Characteristics

An airport consists of a movement area and a manoeuvring area. The movement area consists of parking spaces (gates, ramps) and manoeuvring area; the manoeuvring area consists of taxi ways and runways. Regarding the runway is worth to mention that its longitudinal slope must not be above 1% for runways code number 3 and 4, and not above 2% for a runway that is code number 1 or 2, while the transversal slope must not be above 1.5% for a runway that is code letter C, D, E, F and not above 2% for runways code letter A or B. Moreover, regarding runways, is worth to say that there are instrument runways and non instrument runways; the instrument runways are divided in precision runways and non precision runways; moreover, depending on the ILS system (Instrument Landing System) available, a precision runway can be of one of the following categories: 1, 2, 3A, 3B, 3C.

Runways and stop ways are positioned within so called runway strips, which have the purpose to reduce the damage to the aircraft in case this one would run out of the runway. The stop way is a bidimensional area of the same width of the runway, placed at both extremities of the runway in order to make available a longer distance for stopping to aircraft which fail to take off. The clear way is a threedimensional zone, clear of obstacles, placed at runway's extremity, above the stopway, in order to ease the take off. The clearway's width must not be under 75 meters from the runway's center line.

Regarding the so called declared distances of a runway, we have the LDA (Landing Distance Available) same as TORA (Take Off Run Available) which are distances of the runway without the stop way and the clear way, TODA (Take Off Distance Available) which is the distance of the runway plus the clearway, and the ASDA (Accelerate Stop Distance Available) which consists of runway's distance plus the stopway.

The distance of the hold short from the center line of the runway varies in accordance with the type of runway: for non instrument runways code number one the holding position is placed at 30 meters, for runways code number two is situated at 40 meters while for runways code number three and four the hold short is placed at 75 meters; for non precision instrument runways code number one and two the hold short is at 40 meters, while for those which are code number three and four is at 75 meters; for precision runways of the first category code number 1 and 2 the holding position is at 60 meters while for runways code number 3 and 4 is at 90 meters; for precision runways of the second category and of the third category the holding position is situated at 90 meters.

Airports Classification

The classification of the airports is based on the characteristics of the "critical aircraft". The critical aircraft is the airplane with the highest requirements that can use the airport. In accordance with its own characteristics to each airport is assigned a code number and a code letter. The code number refers to the airplane reference field lenght; in the reference field lenght the stop way and the clear way are included aswell. The code letter refers to the critical airplane's wing span and the distance that it's between the external extremities of the wheels of its main landing gear. An aerodrome's reference code may be 1A, 2B, 3C, 4D, 4E, 4F.

Airport Planning

General

Airport planning is a systematic process used to establish guidelines for the efficient development of airports that is consistent with local, state and national goals. A key objective of airport planning is to assure the effective use of airport resources in order to satisfy aviation demand in a financially feasible manner. Airport planning may be as broad based as the national system plan or more centrally focused as an airport master plan for a specific airport. The primary types of airport planning may basically be

classified as follows:

(1) National System Planning (NPIAS)

(2) State Airport System Planning (SASP)

(3) Metropolitan Airport System Planning

(4) Airport Master Planning

National Plan of Integrated Airport Systems (NPIAS)

Before the FAA can consider an airport eligible to receive Federal funds, the airport must be included in the National Plan of Integrated Airport Systems (NPIAS). The NPIAS is a Federal Aviation Administration (FAA) document that provides short (1-5 year) and long (6-10 year) cost estimates of AIP eligible projects associated with establishing a system of airports adequate to meet the needs of the National Airspace System (NAS). Section 47103 of Title 49 United States Code (USC) establishes the FAA requirement to maintain the NPIAS.

The NPIAS provides an inventory of airport development for the FAA's Airport Capital Improvement Plan (ACIP). The FAA formulates the ACIP based on the airport development needs identified by the NPIAS. The ACIP is essentially a subset of the NPIAS, highlighting airport needs over a 3-year funding cycle.

FAA Policy:

FAA Order 5090.3C, Field Formulation of the National Plan of Integrated Airport Systems (NPIAS) establishes the criteria for inclusion into the NPIAS. The NPIAS includes airport development recommended by FAA-accepted airport master and system plans or as shown on FAA approved airport layout plans. It may also include airport development identified from FAA airport site visits and contained in airport owners' capital improvement programs.

Key Factors:

The FAA will evaluate an airport's inclusion into the NPIAS based upon:

- Whether an airport is considered a public-use airport
- The number of enplanements the airport has or is forecast to have
- The number of based aircraft located at the airport

- Whether an airport receives U.S. Mail service
- Whether there is a component of the U.S. Military, Reserves or National Guard permanently based on or adjacent to the airport
- Special justification that would consider the isolation of the community being served, whether the airport serves the need of an Indian tribe, supports recreation areas, or is needed to develop or protect important national resources

Master Plan

For the individual airport, owners rely more on the airport master plan for their airport. An airport master plan represents the

airport's blueprint for long-term development. A few of the goals of a master plan are:

- To provide a graphic representation of existing airport features, future airport development and anticipated land use.
- To establish a realistic schedule for implementation of the proposed development
- To identify an realistic financial plan to support the development
- To validate the plan technically and procedurally through investigation of concepts and alternatives on technical, economic and environmental grounds.
- To prepare and present a plan to the public that adequately addresses all relevant issues and satisfies local, state and federal regulations.
- To establish a framework for a continuous planning process.

Airport Layout Plans

The Airport Layout Plan (ALP) serves as a critical planning tool that depicts both existing facilities and planned development for an airport. Sponsors of airport development carried out at federally obligated airports must accomplish the improvement in accordance with an

FAA-approved ALP.

By definition, the ALP is a plan for a specific airport that shows:

- Boundaries and proposed additions to all areas owned or controlled by the sponsor for airport purposes.
- The location and nature of existing and proposed airport facilities and structures.
- The location on the airport of existing and proposed non-aviation areas and improvements thereon.

Environmental Assessment (EA)

As the proponent, the airport owner is responsible for identifying all environmental issues associated with the proposed development. The airport owner must also develop conceptual alternatives for consideration. The airport owner typically accomplishes this environmental review by preparing an environmental assessment (EA).

The FAA is responsible for independently analyzing and evaluating the environmental consequences identified in the sponsor's environmental assessment. After verifying the adequacy and sufficiency of the environmental assessment, the FAA will issue either a Finding of No Significant Impact (FONSI) or an Environmental Impact Statement (EIS). The FAA formally documents the determination by issuing a Record of Decision (ROD).

Airport site selection as per ICAO

Airport site selection .

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 defense. There fore 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 loose 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 take off 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 take off 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.

Typical Airport layout

Airport Layout Plan

The airport layout plan (ALP) is a set of drawings that shows the near-, intermediate-, and long-term facilities for an airport. The ALP is prepared in conformance with the Federal Aviation Administration's (FAA) Advisory Circular 150/5070-6B, "Airport Master Plans." Other information that is typically included are plan sheets that show runway details and data, approach and departure profiles, airspace protection surfaces, obstruction information, meteorological data, terminal area plans, land-use information and airport property maps.

Airport layout plans are prepared either as first time planning documents, formal revisions based on changes to the airport, or informal revisions based on minor improvements to the airport. Informal revisions, often referred to as pen-and-ink revisions (now accomplished electronically), can be made to individual sheets of the ALP drawing set, although the responsibility for review and approval must still be coordinated with the FAA. These and other requirements are discussed in FAA Order 5100.38, Airport Improvement Program Handbook.

Individual sheets that comprise the airport layout plan set will vary with each planning effort. The ALP preparer, airport sponsor, FAA and any other approving agency must determine which sheets are necessary during the project scoping activities. Many state aviation agencies also have specific ALP requirements. Some of the drawings that might be included in the airport layout plan drawing set are described below:

Cover sheet – A separate cover sheet, with approval signature blocks, airport location maps, and other pertinent information as required by the local FAA airports office.

Airport layout plan – A drawing depicting the existing and future airport facilities. The drawing should include required facility identifications, description labels, imaginary surfaces, runway protection zones, runway safety areas and basic airport and runway data tables. It may be necessary to include the data tables on a separate sheet.

Airport airspace drawing – 14 CFR Part 77, Objects Affecting Navigable Airspace, defines this as a drawing depicting obstacle identification surfaces for the full extent of all airport development. It also should depict airspace obstructions for the portions of the surfaces excluded from the inner portion of the approach surface drawing.

Terminal area drawing – This plan consists of one or more drawings that present a large-scale depiction of areas with significant terminal facility development. Such a drawing is typically an enlargement of a portion of the ALP. At a commercial service airport, the drawing would include the passenger terminal area, but it also might include general aviation facilities and cargo facilities.

Land-use drawing – On and off airport drawings that depict the land uses within and adjacent to the airport property boundary.

Airport property map sheet – A drawing depicting the airport property boundary, the various tracts of land that were acquired to develop the airport, and the method of acquisition.

Characteristics of catchment area

Although catchment area analysis can provide useful evidence regarding an airport's passenger base, and the potential and strength of constraints from its competitors, it is important to note the distinction between catchment area analysis and geographic market definition.

Catchment area analysis is a way of estimating the geographic area from which a large proportion of an airport's outbound passengers originate, or inbound passengers travel to, and their geographic distribution within this area. The size of catchment areas and overlaps between catchment areas of neighbouring airports could provide useful evidence of the potential for, and strength of, competition between these airports.

By contrast, geographic market definition analyses the area over which passengers would substitute to other airports in light of a small but significant non-transitory increase in price of 5 to 10% above the competitive price level at the original airport. Consequently, while catchment areas can provide useful evidence, they should not be taken as establishing which airports are within the same geographic market, for two main reasons:

Catchment areas illustrate overlaps between all airports in the regions being considered. However, the services offered at these airports may be differentiated in such a way that limits competition between them. Consequently there could be fewer airports in the same relevant market than indicated by the catchment area analysis.

Conversely, catchment areas might in some circumstances be smaller than the relevant geographic market, in particular where catchment areas are based on current airport usage patterns. Two neighbouring airports with similar services and prices might have relatively small catchment areas with little or no overlaps, but any increase in price or reduction in service quality might result in a significant shift of passengers from one airport to another, suggesting they might be in the same geographic market.

Catchment area analysis could therefore provide an initial indication of the patterns of substitution between the various neighbouring airports, but methodological differences between catchment area analysis and the definition of the relevant market framework mean that supplementary evidence would need to be considered when defining the relevant geographic market.

Parking and circulation area

Garage Parking

The garage is located approximately 40 yards directly across from the terminal. The entrance is located across from baggage claim level or on the upper level across from the terminal building. Clearance is 7 feet.

Long-Term Parking

Long-term surface parking lots are located on both sides of the parking garage.

Free shuttle service available to and from the terminal 24 hours a day at 10-20 minute intervals

Shuttle buses are handicap-lift equipped

Short-Term Parking

Short-term parking is available at meters in front of the building for up to two hours. Meters take quarters only. Change machines are located inside the building.

Valet Parking

Valet drop-off service is available at the center of the upper level. Pick up your vehicle on the lower level.

Overflow Parking

Overflow parking is available (only when all other lots are full) just to the north of the terminal and on satellite lots nearby. All long-term and satellite lots are served regularly by airport shuttles. Only open when all other lots are full

Handicapped Parking

Handicapped spaces are provided throughout the facility on both levels, including short-term metered and long-term lots. Shuttle buses to and from the long-term parking area are handicap-lift equipped.

UNIT-4

AIRPORT DESIGN

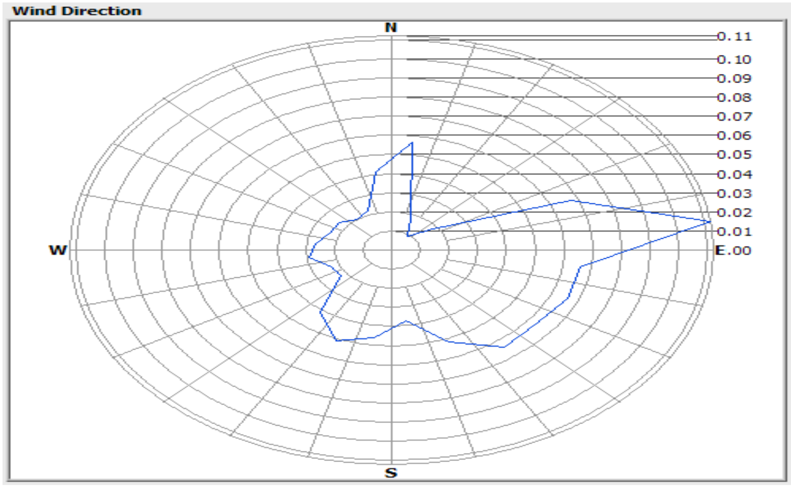
Runway orientation:

The orientation of the runway is an important consideration in airport planning and design

1. The goal of this exercise is to define the runway orientation that maximizes the possible use of the runway throughout the year accounting for a wide variety of wind conditions.
2. FAA and ICAO regulations establish rules about runway orientation and their expected coverage.
3. Ideally, all aircraft operations on a runway should be conducted against the wind.
4. Unfortunately, wind conditions vary from hour to hour thus requiring a careful examination of prevailing wind conditions at the airport site

Wind Rose Analysis

1. A clever way to portray all wind data in agraphical template and estimate the percent runway coverage
2. The wind rose is just a graphical way to add decompose vectors
3. The wind rose is populated with percentages derived from wind observations
4. You can build a wind rose with a piece of cardboard and a transparent template



Airport Lighting,Marking, and
Signage

Introduction

Visual aids assist the pilot on approach to an airport, as well as navigating around an airfield and are essential elements of airport infrastructure.

As such, these facilities require proper planning and precise design. These facilities may be divided into three categories: lighting,marking, and signage. Lighting is further categorized as either approach

lighting or surface lighting. Specific lighting systems described in this chapter include,

1. Approach lighting
2. Runway threshold lighting
3. Runway edge lighting
4. Runway centerline and touchdown zone lights
5. Runway approach slope indicators
6. Taxiway edge and centerline lighting

The proper placement of these systems is described in this chapter but no attempt has been made to describe in detail the hardware or its installation. Airfield marking and signage includes

1. Runway and taxiway pavement markings
2. Runway and taxiway guidance sign systems

Airfield lighting, marking, and signage facilities provide the following functions:

1. Ground to air visual information required during landing
2. The visual requirements for takeoff and landing
3. The visual guidance for taxiing

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The Requirements for Visual Aids

Since the earliest days of flying, pilots have used ground references for navigation when approaching an airport, just as officers on ships at sea have used landmarks on shore when approaching a harbor. Pilots need visual aids in good weather as well as in bad weather and during
the day as well as at night. In the daytime there is adequate light from the sun, so artificial lighting is not usually required but it is necessary to have adequate contrast in the field of view and to have a suitable pattern of brightness so that the important features of the airport can be identified and oriented with respect to the position of the aircraft in space. These requirements are almost automatically met during the day when the weather is clear.

The runway for conventional aircraft always appears as a long narrow strip with straight sides and is free of obstacles. It can therefore be easily identified from a distance or by flying over the field. Therefore, the perspective view of the runway and other identifying reference landmarks are used by pilots as visual aids for orientation when they are approaching the airport to land. Experience has demonstrated that the horizon, the runway edges, the runway threshold, and the centerline of the runway are the most important elements for pilots to see. In order to enhance the visual information during the day, the runway is painted with standard marking patterns. The key elements in these patterns are the threshold, the centerline, the edges, plus multiple parallel lines to increase the perspective and to define the plane of the surface.

During the day when visibility is poor and at night, the visual information is reduced by a significant amount over the clear weather daytime scene. It is therefore essential to provide visual aids which will be as meaningful to pilots as possible.

The Airport Beacon

Beacons are lighted to mark an airport. They are designed to produce a narrow horizontal and vertical beam of high-intensity light which is rotated about a vertical axis so as to produce approximately 12 flashes per minute for civil airports and 18 flashes per minute for military airports. The flashes with a clearly visible duration of at least 0.15 s are arranged in a white-green sequence for land airports and a whiteyellow sequence for landing areas on water. Military airports use a double white flash followed by a longer green or yellow flash to differentiate them from civil airfields. The beacons are mounted on top of the control tower or similar high structure in the immediate vicinity of the airport.

Obstruction Lighting

Obstructions are identified by fixed, flashing, or rotating red lights or beacons. All structures that constitute a hazard to aircraft in flight or during landing or takeoff are marked by obstruction lights having a horizontally uniform intensity duration and a vertical distribution design to give maximum range at the lower angles (1.5° to 8°) from which a colliding approach would most likely come.

The Aircraft Landing Operation

An aircraft approaching a runway in a landing operation may be visualized as a sequence of operations involving a transient body suspended in a three-dimensional grid that is approaching a fixed two-dimensional grid. While in the air, the aircraft can be considered as a point mass in a three-dimensional orthogonal coordinate system in which it may have translation along three coordinate directions and rotation about three axes. If the three coordinate axes are aligned horizontal, vertical, and parallel to the end of the runway, the directions of motion can be described as lateral, vertical, and forward. The rotations are normally called pitch, yaw, and roll, for the horizontal, vertical, and parallel axes, respectively. During a landing operation, pilots must control and coordinate all six degrees of freedom of the aircraft so as to bring the aircraft into coincidence with the desired approach or reference path to the touchdown point on the runway. In order to do this, pilots need translation information regarding the aircraft's alignment, height, and distance, rotation information regarding pitch, yaw, and roll, and information concerning the rate of descent and the rate of closure with the desired path.

Alignment Guidance

Pilots must know where their aircraft is with respect to lateral displacement from the centerline of the runway. Most runways are from 75 to 200 ft wide and from 3000 to 12,000 ft long. Thus any runway is a long narrow ribbon when first seen from several thousand feet above. The predominant alignment guidance comes from longitudinal lines that constitute the centerline and edges of the runway. All techniques, such as painting, lighting, or surface treatment that develop contrast and emphasize these linear elements are helpful in providing alignment information.

Height Information

The estimation of the height above ground from visual cues is one of the most difficult judgments for pilots. It is simply not possible to provide good height information from an approach lighting system. Consequently the best source of height information is the instrumentation in the aircraft. However, use of these instruments often requires the availability of precision ground or satellite based navigation technologies. Many airports have no such technologies, and at others only provide lateral approach guidance to certain runways. Consequently two types of ground-based visual aids defining the desired glide path have been developed. These are known as the visual approach slope indicator (VASI) and the precision approach path indicator (PAPI) which are discussed later in this chapter. Several parameters influence how much a pilot can see on the ground. One of these is the *cockpit cutoff angle*. This is the angle between the longitudinal axis of the fuselage and an inclined plane below which the view of the pilot is blocked by some part of the aircraft.

Approach Lighting

Approach lighting systems (ALS) are designed specifically to provide guidance for aircraft approaching a particular runway under nighttime or other low-visibility conditions.

While under nighttime conditions it may be possible to view approach lighting systems from several miles away, under other low-visibility conditions, such as fog, even the most intense ALS systems may only be visible from as little as 2500 ft from the runway threshold.

Threshold Lighting

During the final approach for landing, pilots must make a decision to complete the landing or"execute a missed approach." The identification of the threshold is a major factor in pilot decisions to land or not to land. For this reason, the region near the threshold is given special lighting consideration. The threshold is identified at large airports by a complete line of green lights extending across the entire width of the runway, and at small airports by four green lights on each side of the threshold. The lights on either side of the runway threshold may be elevated. Threshold lights in the direction of landing are green but in the opposite direction these lights are red to indicate the end of the runway.

Runway Lighting

After crossing the threshold, pilots must complete a touchdown and roll out on the runway. The runway visual aids for this phase of landing are be designed to give pilots information on alignment, lateral displacement, roll, and distance. The lights are arranged to form a visual pattern that pilots can easily interpret. At first, night landings were made by flood lighting the general area. Various types of lighting devices were used, including automobile headlights, arc lights, and search lights. Boundary lights were added to outline the field and to mark hazards such as ditches and fences. Gradually, preferred landing directions were developed, and special lights were used to indicate these directions. Floodlighting was then restricted to the preferred landing directions, and runway edge lights were added along the landing strips.

Runway Edge Lights

Runway edge lighting systems outline the edge of runways during nighttime and reduced visibility conditions. Runway edge lights are classified by intensity, high intensity (HIRL), medium intensity (MIRL), and low intensity (LIRL). LIRLs are typically installed on visual runways and at rural airports. MIRLs are typically installed on visual runways at larger airports

and on nonprecision instrument runways, HIRLs are installed on precision-instrument runways. Elevated runway lights are mounted on frangible fittings and project no more than 30 in above the surface on which they are installed. They are located along the edge of the runway not more than
10 ft from the edge of the full-strength pavement surface. The longitudinal spacing is not more than 200 ft. Runway edge lights are white, except that the last 2000 ft of an instrument runway in the direction of aircraft operations these lights are yellow to indicate a caution zone.

Runway Centerline and Touchdown Zone Lights

As an aircraft traverses over the approach lights, pilots are looking at relatively bright light sources on the extended runway centerline. Over the runway threshold, pilots continue to look along the centerline, but the principal source of guidance, namely, the runway edge lights, has moved far to each side in their peripheral vision. The result is that the central area appears excessively black, and pilots are virtually flying blind, except for the peripheral reference information, and any reflection of the runway pavement from the aircraft's landing lights. Attempts to eliminate this "black hole" by increasing the intensity of runway edge lights have proven ineffective. In order to reduce the black hole effect and provide adequate guidance during very poor visibility conditions, runway centerline and touchdown zone lights are typically installed in the pavement.

Runway and Taxiway Marking

In order to aid pilots in guiding the aircraft on runways and taxiways, pavements are marked with lines and numbers. These markings are of benefit primarily during the day and dusk. At night, lights are used to guide pilots in landing and maneuvering at the airport. White is used for all markings on runways and yellow is used on taxiways and aprons.

Runway Threshold Markings

Runway threshold markings identify to the pilot the beginning of the runway that is safe and available for landing. Runway threshold markings begin 20 ft from the runway threshold itself.

Runway threshold markings consist of two series of white stripes, each stripe 150 ft in length and

5.75 ft in width, separated about the centerline of the runway. On each side of the runway centerline, a number of threshold marking stripes are placed, For example, for a 100-ft runway, eight stripes are required, in two groups of four are placed about the centerline. Stripes within each set are separated by 5.75 ft. Each set of stripes is separated by 11.5 ft about the runway centerline.

Centerline Markings

Runway centerline markings are white, located on the centerline of the runway, and consist of a line of uniformly spaced stripes and gaps. The stripes are 120 ft long and the gaps are 80 ft long. Adjustments to the lengths of stripes and gaps, where necessary to accommodate runway length, are made near the runway midpoint. The minimum width of stripes is 12 in for visual runways, 18 in for nonprecision instrument runways, and 36 in for precision instrument runways. The purpose of the runway centerline markings is to indicate to the pilot the center of the runway and to provide alignment guidance on landing and takeoff.

Aiming Points

Aiming points are placed on runways of at least 4000 ft in length to provide enhanced visual guidance for landing aircraft. Aiming point markings consist of two bold stripes, 150 ft long, 30 ft wide, spaced 72 ft apart symmetrically about the runway centerline, and beginning 1020 ft from the threshold.

Touchdown Zone Markings

Runway touchdown zone markings are white and consist of groups of one, two, and three rectangular bars symmetrically arranged in pairs about the runway centerline. These markings begin 500 ft from the runway threshold. The bars are 75 ft long, 6 ft wide, with 5 ft spaces between the bars, and are longitudinally spaced at distances of 500 ft along the runway. The inner stripes are placed 36 ft on either side of the runway centerline. For runways less than 150 ft in width, the width and spacing of stripes may be proportionally reduced. Where touchdown zone markings are installed on both runway ends on shorter runways, those pairs of markings which would extend to
within 900 ft of the runway midpoint are eliminated.

Side Stripes

Runway side stripes consist of continuous white lines along each side of the runway to provide contrast with the surrounding terrain or to delineate the edges of the full strength pavement. The maximum distance between the outer edges of these markings is 200 ft and these markings have a minimum width of 3 ft for precision instrument runways and are at least as wide as the width of the centerline stripes on other runways.

Displaced Threshold Markings

At some airports it is desirable or necessary to "displace" the runway threshold on a permanent basis. A displaced threshold is one which has been moved a certain distance from the end of the runway. Most often this is necessary to clear obstructions in the flight path on landing. The displacement reduces the length of the runway available for landings, but takeoffs can use the entire length of the runway. T. These markings consist of arrows and arrow heads to identify the displaced threshold and a threshold bar to identify the beginning of the runway threshold itself. Displaced threshold arrows are 120 ft in length, separated longitudinally by 80 ft for the length of the displaced threshold. Arrow heads are 45 ft in length, placed 5 ft from the threshold bar. The threshold bar is 5 ft in width and extends the width of the runway at the threshold.

Blast Pad Markings

In order to prevent erosion of the soil, many airports provide a paved *blast pad* 150 to 200 ft in length adjacent to the runway end. Similarly, some airport runways have a *stopway* which is only designed to support aircraft during rare aborted takeoffs or landing overruns and is not designed as a full strength pavement. Since these paved areas are not designed to support aircraft and yet may have the appearance of being so designed, markings are required to indicate this.

Centerline and Edge Markings

The centerline of the taxiway is marked with a single continuous 6-in yellow line. On taxiway curves, the taxiway centerline marking continues from the straight portion of the taxiway at a constant distance from the outside edge of the curve. At taxiway intersections which are designed for aircraft to travel straight through the intersection, the centerline markings continue straight through the intersection. At the intersection of a taxiway with a runway end, the centerline stripe of the taxiway terminates at the edge of the runway. At the intersection between a taxiway and a runway, where the taxiway serves as an exit from the runway, the taxiway marking is usually extended on to the runway in the vicinity of the runway centerline marking. The taxiway centerline marking is extended parallel to the runway centerline marking a distance of 200 ft beyond the point of tangency. The taxiway curve radius should be large enough to provide a clearance to the taxiway edge and the runway edge of at least one-half the width of the taxiway. For a taxiway crossing a runway, the taxiway centerline marking may continue across the runway but it must be interrupted for the runway markings.

Taxiway Hold Markings

For taxiway intersections where there is an operational need to hold aircraft, a dashed yellow holding line is placed perpendicular to and across the centerline of both taxiways. When a taxiway intersects a runway or a taxiway enters an instrument landing system critical area, a holding line is placed across the taxiway. The holding line for a taxiway intersecting a runway consists of two solid lines of yellow stripes and two broken lines of yellow stripes placed perpendicular to the centerline of the taxiway and across the width of the taxiway. The solid lines are always placed on the side where the aircraft is to hold. The holding line for an instrument landing system critical area consists of two solid lines placed perpendicular to the taxiway centerline and across the width of the taxiway joined with three sets of two solid lines symmetrical about and parallel to the taxiway centerline.

Terminal facility requirements

– Ticketing/check-in

–Passenger screening

– Holdrooms

– Concessions

– Baggage claim

– Circulation

– Airline offices and operations areas

– Baggage handling

– Baggage screening system

– International facilities

—Federal Inspection Services

– Support areas

– Special requirements

– Building systems

• Functional relationships •

Flow sequences

– Passengers

– Visitors

– Employees

– Baggage

– Deliveries

– Waste removal

• Passenger movements

– People mover systems

– Passenger way finding and

-signage

Runway length:

Designers and planners for determining recommended runway lengths for new runways or extensions to existing runways at civil airports. The AC highlights the fact that the length of usable runway length made available by an airport may not be entirely suitable for all types of airplane operations. Key factors influencing the suitability of available runway length include:

1. airport elevation
2. temperature
3. wind velocity
4. airplane operating weights
5. flap settings
6. runway surface condition
7. runway gradient
8. presence of obstructions
9. locally imposed noise abatement restrictions
10. other locally imposed prohibitions

Determination of actual runway length Runway Specifications for design:

Basic Runway Length: 3000m Runway Width: 60m Stabilised shoulder: 7.5m Obstacle free zone: 77.5m either side of the centre line Effective Runway Gradient: 0.30% Determination of actual length of runway to be provided:

Correction for Elevation: The basic length has to be increased at the rate of 7% per 300m elevation above mean sea level. The proposed airport site is at an elevation of just 37m from mean seal level so the correction for elevation is not required.

Correction for Temperature: Airport reference temperature = [T1+ {(T2-T1/3)}] = 31.27 C T1= Mean of average daily temperature recorded during the year 2012-13 at Sriperumbudur = 25.3 C T2=Maximum of average daily temperature recorded during the year 2012-13 at Sriperumbudur = 43.2C

Standard atmospheric temperature at MSL = 15 C Rise in temperature = 31.27-15 = 16.27 C Applying correction at the rate of 1% for every 1 C, Correction for temperature = (0.001*3000)*16.27 = 48.81m Corrected length = 3048.81 There is no combined correction as the correction for elevation is not there

Correction for Gradient: Effective Runway gradient = (Difference in elevation along the proposed profile of runway/Basic Runway Length)*100 = 0.30% Applying correction for the effective gradient at the rate of 20% for each 1% effective gradient. Correction for gradient = (0.2*3048.81*0.30) = 182.93m

Actual length of Runway = 3048.81+182.93 = 3,230m (approx.)

Structural design of flexible airfield pavement:

The term structural design of pavements refers to the determination of the thickness of the pavement and its components.

Aircraft Considerations Load (95% main landing gear, 5% nose gear) Landing gear type and geometry

• Single gear aircraft

• Dual gear aircraft

• Dual tandem gear aircraft

• Wide body aircraft – B-747, B-767, DC-10, L-1011 Tire pressure: 75 to 200 psi (515 to 1,380 kPa)

Traffic volume

Principles of Rigid Airport Pavement Design

Based on Wester gaard analysis of edge loaded slabs (modified to simulate a jointed edge condition)

1. Determine k value for rigid pavement
2. Concrete flexural strength
3. Gross weight of design aircraft
4. Annual departures of design aircraft.

Concrete Flexural Strength

1. Design strength of 600 to 650 psi is recommended for most airfield applications
2. Strength at 28 days
3. 5% less than the test strength used for thickness design

Elements of taxiway design

Normal Centerline A single continuous yellow line, 15 centimetres (6 in) to 30 centimetres (12 in) in width.

Enhanced Centerline The enhanced taxiway center line marking consists of a parallel line of yellow dashes on either side of the taxiway centerline. Taxiway centerlines are enhanced for 150 feet (46 m) before a runway holding position marking. The enhanced taxiway centerline is standard[1] at all FAR Part 139 certified airports in the USA.

Taxiway Edge Markings Used to define the edge of the taxiway when the edge does not correspond with the edge of the pavement.

Continuous markings consist of a continuous double yellow line, with each line being at least 15 centimetres (6 in) in width, spaced 15 centimetres (6 in) apart. They divide the taxiway edge from the shoulder or some other abutting paved surface not intended for use by aircraft.

Dashed markings define the edge of a taxiway on a paved surface where the adjoining pavement to the taxiway edge is intended for use by aircraft, e.g. an apron. These markings consist of a broken double yellow line, with each line being at least 15 centimetres (6 in) in width, spaced 15 centimetres (6 in) apart (edge to edge). These lines are 15 feet (4.6 m) in length with 25 foot (7.6 m) gaps.

Taxi Shoulder Markings Taxiways, holding bays, and aprons are sometimes provided with paved shoulders to prevent blast and water erosion. Shoulders are not intended for use by aircraft, and may be unable to carry the aircraft load. Taxiway shoulder markings are yellow lines perpendicular to the taxiway edge, from taxiway edge to pavement edge, about 3 metres.

Surface Painted Taxiway Direction Signs Yellow background with a black inscription, provided when it is not possible to provide taxiway direction signs at intersections, or when necessary to supplement such signs. These markings are located on either side of the taxiway.

Surface Painted Location Signs Black background with a yellow inscription and yellow and black border. Where necessary, these markings supplement location signs located alongside the taxiway and assist the pilot in confirming the designation of the taxiway on which the aircraft is located. These markings are located on the right side of the centerline.

Geographic Position Markings These markings are located at points along low visibility taxi routes (when Runway visual range is below 1200 feet (370 m)). They are positioned to the left of the taxiway centerline in the direction of taxiing. Black inscription centered on pink circle with black inner and white outer ring. If the pavement is a light colour then the border is white with a black outer ring.

Runway Holding Position Markings These show where an aircraft should stop when approaching a runway from a taxiway. They consist of four yellow lines, two solid and two dashed, spaced six or twelve inches (15 or 30 cm) apart, and extending across the width of the taxiway or runway. The solid lines are always on the side where the aircraft is to hold. There are three locations where runway holding position markings are encountered: Runway holding position markings on taxiways; runway holding position markings on runways; taxiways located in runway approach areas.

Holding Position Markings for Instrument Landing System (ILS) These consist of two yellow solid lines spaced two feet (60 cm) apart connected by pairs of solid lines spaced ten feet (3 metres) apart extending across the width of the taxiway.

Holding Position Markings for Taxiway/Taxiway Intersections These consist of a single dashed line extending across the width of the taxiway.

Surface Painted Holding Position Signs Red background signs with a white inscription to supplement the signs located at the holding position.

The taxiways are given alphanumeric identification. These taxiway IDs are shown on black and yellow signboards along the taxiways.

Lights:

Taxiway Edge Lights: used to outline the edges of taxiways during periods of darkness or restricted visibility conditions. These fixtures are elevated and emit blue light.

Taxiway Centerline Lights: They are steady burning and emit green light located along the taxiway centerline

Clearance Bar Lights: Three in-pavement steady-burning yellow lights installed at holding positions on taxiways

Runway Guard Lights: Either a pair of elevated flashing yellow lights installed on either side of the taxiway, or a row of in-pavement yellow lights installed across the entire taxiway, at the runway holding position marking at taxiway/runway intersections.

Stop Bar Lights: A row of red, unidirectional, steady-burning in-pavement lights installed across the entire taxiway at the runway holding position, and elevated steady-burning red lights on each side used in low visibility conditions (below 1,200 ft RVR). A controlled stop bar is operated in conjunction with the taxiway centerline lead-on lights which extend from the stop bar toward the runway. Following the ATC clearance to proceed, the stop bar is turned off and the lead-on lights are turned on.

Taxiway edge lights are spaced 75 feet apart.

Signs:

Operational guidance sign

Location signs **–** yellow on black background. Identifies the runway or taxiway the aircraft is currently on or is entering.

Direction/Runway exit signs **–** black on yellow. Identifies the intersecting taxiways the aircraft is approaching, with an arrow indicating the direction to turn.

Stop Bar signs **–** white on blue background. The designation consists of the letter S followed by designation of the taxiway on which the Stop Bar is positioned. This sign is not standard.

many airports use conventional traffic signs such as stop and yield signs throughout the airport

Mandatory instruction sign:

Runway signs **–** White text on a red background. These signs identify a runway intersection ahead, e.g. runway 12-30 in the photo above.

Frequency change signs **–** Usually a stop sign and an instruction to change to another frequency. These signs are used at airports with different areas of ground control.

Holding position signs **–** A single solid yellow bar across a taxiway indicates a position where ground control may require a stop. If two solid yellow bars and two dashed yellow bars are encountered, this indicates a holding position for a runway intersection ahead.

Airport Zoning

APPROACH ZONE _

1. During landing, the glide path of an aircraft varies from a steep to fiat slope. But during take-off, the rate of climb of aircraft is limited by its wing loading and engine power. _
2. As such wide clearance areas, known as approach zones are required on either side of runway along the direction of landing and take-off of aircraft. _
3. Over this area, the aircraft can safety gain or loose altitude. _ The whole of this area has to be kept free of obstructions and as such zoning laws are implemented in this area. _
4. The plan of approach zone is the same as that of the approach surface. , The only difference between the two is that while approach surface is an imaginary surface, the approach area indicates the actual ground area.

Clear Zone _

The inner most portion of approach zone which is the most critical portion from obstruction view-point is known as clear zone. _

UNIT-5

HARBOUR ENGINEERING

Water transportation:

The water transportation can further be subdivided into two categories:

1. inland transportation and
2. Ocean transportation.

Inland Water transportation:

1. Inland Water transportation is either in the form of river transportation or canal transportation.
2. Ocean Water transportation is adopted for trade and commerce.
3. It is estimated that about 75 per cent of international trade is carried out by shipping.
4. The development of navy force is intended for national defense.
5. Ocean water transportation has an limitation and it possesses high flexibility.

Definitions

Harbours:

A harbour can be defined as a sheltered area of the sea in which vessels could be launched, built or taken for repair; or could seek refuge in time of storm; or provide for loading and unloading of cargo and passengers.

Harbours are broadly classified as:

1. Natural harbours
2. Semi-natural harbours
3. Artificial harbours.

Natural harbours:

1. Natural formations affording safe discharge facilities for ships on sea coasts, in the form of creeks and basins, are called natural harbours.

2. With the rapid development of navies engaged either in commerce or war, improved accommodation and facilities for repairs, storage of cargo and connected amenities had to be provided in natural harbours.

3. The size and draft of present day vessels have necessitated the works improvement for natural harbours.

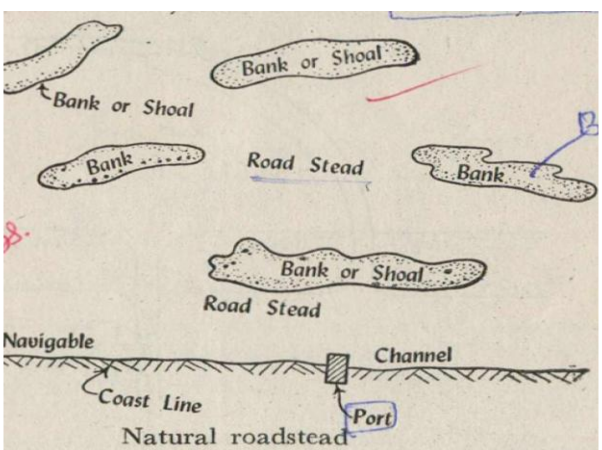
4. The factors such as local geographical features, growth of population, development of the area, etc. have made the natural harbours big and attractive. Bombay and Kandla are, examples of natural harbours

Semi-natural harbours:

1. This type of harbour is protected on sides by headlands protection and it requires man-made protection only at the entrance.

2. Vishakhapatnam is a semi-natural harbour.

Artificial harbours:



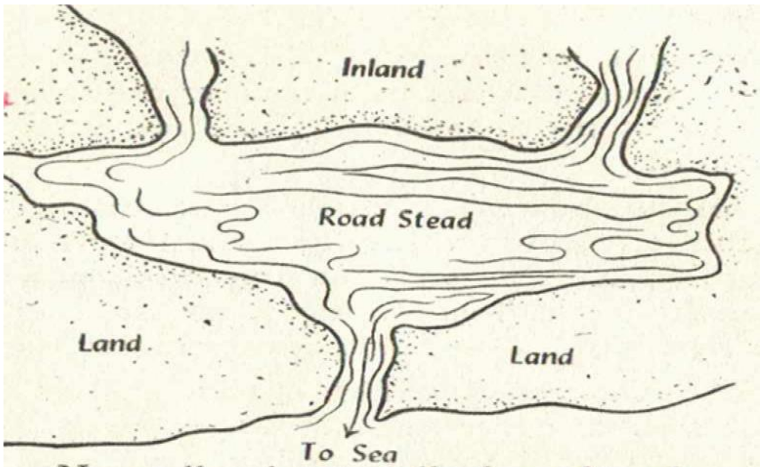
1. Where such natural facilities are not available, countries having a seaboard had to create or construct such shelters making use of engineering skill and methods, and such harbours are called artificial or man-made harbours.

2. Madras is an artificial harbour.

3. Thus, a naval vessel could obtain shelter during bad weather within a tract or area of water close to the shore, providing a good hold for anchoring, protected by natural or artificial harbour walls against the fury of storms

Natural roadsteads:

A deep navigable channel with a protective natural bank or shoal to seaward is a good example of a natural roadstead as shown in fig.

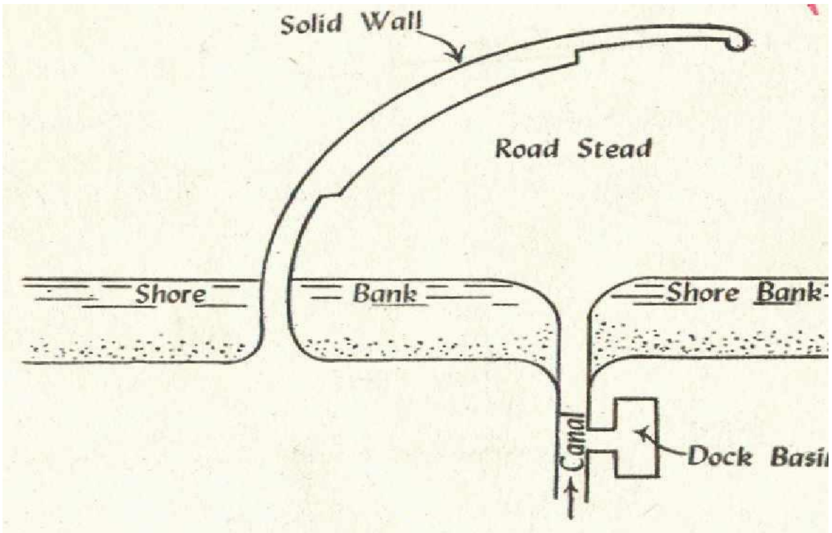


Naturally circumscribed roadstead

A confined area naturally enclosed by islands as in a creek if available is known as a circumscribed natural roadstead.

Artificial roadsteads:

These may be created suitably by constructing a breakwater or wall parallel to the coast or curvilinear from the coast



Artificial roadstead

1. As an alternative a circumscribed artificial roadstead could be formed by enclosing tract provided good anchorage, by projecting solid walls called jetties, from the shore.

2. Another method is to create a confined basin of small area having a narrow entrance and exit for ships.

3. Such roadsteads with smaller inner enclosures and wharf and with loading and unloading facilities are commonly provided for fishing vessels.

From their utility and situation, harbours are further classified into three major types:

1. Harbours of refuge including naval bases
2. Commercial harbours, connected with ports
3. Fishery harbours.

It is necessary to study the requirements of these types of harbours and provide for such requirements.

Requirements of harbour of refuge:

- Ready accessibility
- Safe and commodious anchorage
- Facilities for obtaining supplies and repairs

PLANNING AND DESIGN OF HARBOURS

Requirements of commercial harbour:

1. Spacious accommodation for the mercantile marine.
2. Ample quay space and facilities for transporting; loading and unloading cargo.
3. Storage sheds for cargo.
4. Good and quick repair facilities to avoid delay
5. More sheltered conditions as loading and unloading could be done with advantage in calmer waters.

Site selection:

The guiding factors which play a great role in choice of site for a harbour are as follows

1. Availability of cheap land and construction materials
2. Transport and communication facilities
3. Natural protection from winds and waves
4. Industrial development of the locality
5. Sea-bed subsoil and foundation conditions
6. Traffic potentiality of harbour
7. Availability of electrical energy and fresh water
8. Favorable marine conditions
9. Defence and strategic aspects

Shape of the harbour:

The following principles should be kept in mind:

1. In order to protect the harbour from the sea waves, one of the pier heads should project a little beyond the other.
2. Inside the pier heads, the width should widen very rapidly.
3. The general shape of the harbours should be obtained by a series of straight lengths and no re-entrant angle should be allowed

Harbour planning:

The important facts to be studied and scrutinized can be enumerated as follows:

1. It is necessary to carry out a thorough survey of the neighbourhood including the foreshore and the depths of water in the vicinity
2. The borings on land should also be made so as to know the probable subsurface conditions on land. It will be helpful in locating the harbour works correctly
3. The nature of the harbour, whether sheltered or not, should be studied.
4. The existence of sea insect undermine the foundations should be noted.
5. The problem of silting or erosion of coastline should be carefully studied.
6. The natural metrological phenomenoa should be studied at site especially with respect to frequency of storms, rainfall, range of tides, maximum and, minimum temperature and of winds, humidity, direction and velocity of currents, etc.

Ports:

1. The term port is used to indicate a harbour where terminal facilities, such a stores, landing of passengers and cargo, etc. are added to it.
2. Thus, a harbour consists of the waterways and channels as far as the pier head lines and a port includes everything on the landward side of those lines i.e. piers, slips, wharves, sheds, tracks, handling equipment, etc.

CLASSIFICATION OF PORTS

Depending upon the location, the ports can be classified as;

1. Canal ports
2. River ports and
3. Sea ports

- The term free port is used to indicate an isolated, enclosed and policed area for handling of cargo; etc. for the purpose of reshipping without the intervention of customs.
- It is furnished with the facilities for loading and unloading; for storing goods and reshipping them by land or water; and for supplying fuel.
- Free port thus indicates an area within which goods can be landed, stored, mixed, blended, repacked, manufactured and reshipped without payment of duties and without the intervention of custom department.
- Depending upon the commodities dealt with or their use, the ports can also be classified as grain ports, coaling ports, transhipment ports, ports of call, etc.
- Depending upon the size and location, the ports can also be grouped as major ports, intermediate ports and minor ports
- A major port is able to attract trade and it commands a really pivoted position for the extension of communications.

Port design:

The design of a port should be made while keeping in mind the following requirements:

1. The entrance channel should be such that the ships can come in and go out easily.
2. The ships should be able to turn in the basin itself.
3. The alignment of quays should be such that the ships can come along side easily even when there is an on-shore wind.
4. The width behind the quay should be sufficient to deal with the goods.

5. There should be enough provision for railway tracks to take care for loading and unloading of cargo.

Requirements of a good port

1. It should be centrally situated for the hinterland. For a port, the hinterland is that part of the country behind it which can be served with economy and efficiency by the port.
2. It should get good tonnage i .e. charge per tonne of cargo handled by it.
3. It should have good communication with the rest of country.
4. It should be populous
5. It should be advance in culture, trade and industry.
6. It should be a place of defence and for resisting the sea-borne invasion
7. It should command valuable and extensive trade.
8. It should be capable of easy, smooth and economic development.
9. It should afford shelter to all ships and at all seasons of the years
10. It should provide the maximum facilities to all the visiting ships including the servicing of ships.

TIDES:

Tides on the coast-line are caused by the sun and moon.

1. The effect of tides is to artificially raise and lower the mean sea level during certain stated periods.
2. This apparent variation of mean sea level is known as the tidal range.

Spring tides and Neap tides:

1. At new and full moon or rather a day or two after (or twice in each lunar month), the tides rise higher and fall lower than at other times and these are called Spring tides.
2. Also one or two days after the moon is in her quarter i.e. about seven days from new and full moons (twice in a lunar month), the tides rise and fall less than at other times and are then called neap tides.

Waves and wind:

1. The ‘sea wave’ is by far the most powerful force acting on harbour barriers and against which the engineer has to contend.
2. The wave has the impulse of a huge battering ram and equipped with the point of a pick axe and chisel edge”.
3. It is the most in compressible natural phenomena.
4. The formation of storm waves takes place in the open sea due to the action of wind.

Water waves are of two kinds:

- Waves of oscillation and
- Waves of translation;

- The former are stationary, while the latter possess forward motion.
- But all translatory waves originally start as waves of oscillation and, become translatory by further wind action.
- The harbour engineer’s main concern is the translatory wave.

Breakwaters:

- 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.

Alignment:

- A good alignment for a breakwater is to have straight converging arms so that the angle of inter section does not exceed 60 degrees.
- It is desirable to avoid straight parallel or diverging arms running out to sea.

Design of breakwaters:

Following information should he collected before the design of a breakwater:

1. Character of coastal currents
2. Cost and availability of materials of construction
3. Directions and force of prevailing winds
4. Nature of the bottom or foundation
5. Probable maximum height, force and intensity of waves. !

The three important rules to be observed in the design of a breakwater are as under:

1. The design should be based on the extreme phenomena of the wind and waves, and not on the mean or the average.
2. The height of the wave should he determined by Using the equation H = 034¥Fand the height of wall should be decided accordingly by making sufficient allowance for freeboard.
3. It should be seen that the material in the foundation is not subject to scour.

Detrimental forces acting on breakwaters:

Hydrostatic force:

1. This force reduces the apparent weight and hence, the marine structures suffer these losses to a great extent unless the foundations are absolutely impervious.

External forces:

1. The intensity of external forces, especially wind and wave action, is enormous.
2. The power of wind produces vibrations in the masonry structure and weakens the
3. different courses of masonry.
4. In a similar way, the wave when it recedes induces ‘suction action and it results in the erosion of the foundation unless it is made safe and secure.

Classification of breakwaters:

Breakwaters are classified mainly into three types:

1. Heap or mound breakwater
2. Mound with superstructure
3. Upright wall breakwater.

Heap or mound breakwater:

It is a heterogeneous assemblage of natural rubble, undressed stone blocks, rip rap, supplemented in many cases by artificial blocks of huge bulk and weight, the whole being deposited without any regard to bond or bedding.

This is the simplest type and is constructed by tipping or dumping of rubble stones into the sea till the heap or mound emerges out of the water, the mound being consolidated and its side slopes regulated by the action of the waves.

WHARVES:

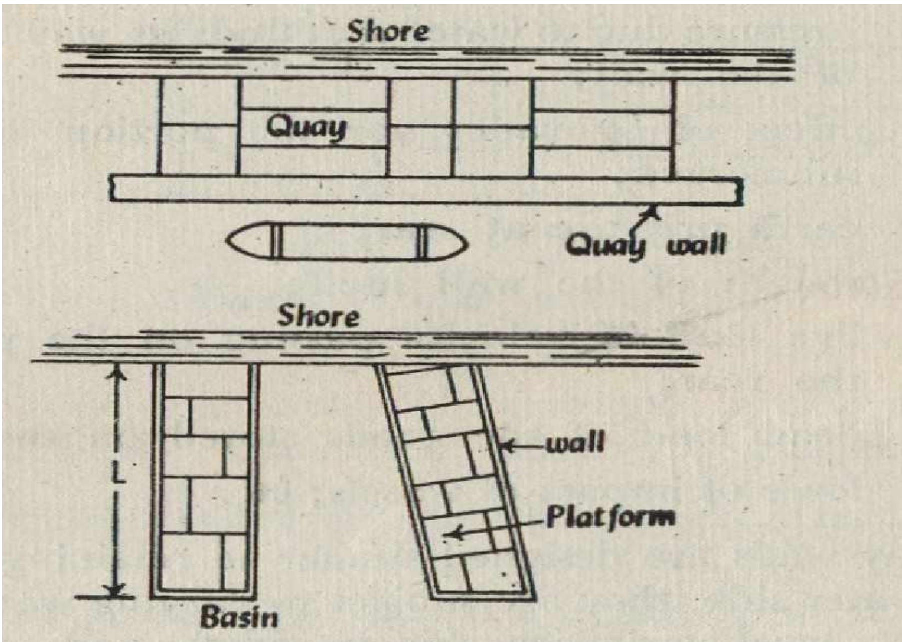
1. Platforms or landing places are necessary for ships to come, close enough to the shore, for purposes of embarkation, disembarkation, etc. at the same time.
2. These platform locations should give sufficient depth of water for the ship to float. Such platforms are, called wharves.
3. They are built out into or on to. the water
4. Thus, a wharf affords a working platform alongside the ship in continuity of the shore.
5. A wharf is quay but the term wharf is generally used for an open structure of piles or posts with bracings, jutting from the shore towards the sea.
6. A wharf may be a sheet pile wall or it may consist of a piled projection with or without artificial retention of soil some distance behind or it may be a gravity wall.
7. Wharves may either be parallel to the shore and abutting against it or they may project into the water either at right angles or oblique to the shore.
8. The former type is adopted at places where depth of water is sufficient for the ships to berth, say 10 m to 12 m

9. The latter type is adopted at places where depth of water near the shore is not enough for the ships to enter safely.
10. The level of wharf should be above the high water level. But at the same time, it should be economical to load the vessels when the water level is low.
11. Wharf should act as a unit when there is an impact from any vessel.
12. Hence, it should be properly braced and bolted. It is desirable to provide rounded corners for wharves which art likely to be used by large vessels.
13. Such a construction will result in a smooth entry of vessels into the slips

PIERS

1. The structures which are built perpendicular or oblique to the shore of a river or sea are known as piers.
2. In the sea the piers are constructed where the sea is not deep and the natural harbour is not convenient for allowing the ships to berth adjacent to the shore.
3. In many cases, the piers are constructed with piles, columns and braces leaving good space for the ocean current to flow without causing any obstruction.
4. The dimensions of a pier should be worked out very carefully.
5. Its length should be sufficient to accommodate the longest ship likely to take its advantage.
6. In other words, it should project beyond the bow or stern of the ship so as to protect its hull. Its width should be sufficient to satisfy its utility.
7. It can be stated that the pier should be of sufficient width to allow easy unloading of cargo without any undue delay.

QUAYS:



Quay walls

Wharves along and parallel to the' shore, are generally called quays and their protection walls are called quay walls

Design of quay walls:

They are built to retain(Similar to retaining walls) and protect the embankment or filling: Factors affecting the design are as follows

1. Character of foundation;
2. Pressure due to water that finds its way to the real of the wall;
3. Effect of buoyancy for the portion of the wall submerged;
4. Earth pressure at rear;
5. Weight of the wall itself;
6. live load of vehicles passing on the platform at the rear;
7. dead load of the goods stored on the platform;
8. force of impact of vessels; etc.

JETTIES:

1. These are the structures in the form of piled projections and they are built out from the shore to deep water and they may be constructed either for a navigable river or in the sea.
2. In rivers, the jetties divert the current away from the river bank and thus, the scouring action is prevented.
3. As the current is diverted to deep waters, the navigation is also controlled.
4. In the sea, the jetties are pr at places where harbour entrance is affected by littoral drift or the sea is shallow for a long distance.
5. Thus, they extend from the shore to the deep sea to receive the ships.
6. In a limiting sense, a jetty is defined as a narrow structure projecting from the,shore into water with berths on one or both sides and sometimes at the end also.
7. Jetties are exposed to severe wave action and their structural design is similar to that of breakwater.
8. However, the designed standards may be released to a certain extent due to the fact that the jetties are usually built normal to the most dangerous wave front.
9. The impact caused by the berthing ships will depend on the skill of the berthing officer, local condition of currents, wind, etc.
10. The berthing velocity depends upon the condition of approach, wind, etc. and it decreases with the increase in the size of the ships.

FENDER:

1. The cushion which is provided on the face of jetty for ships to come in contact is known as fender.
2. It is provided for various forms and is made of different materials.
3. The common material used as fender for jetties is the framework of timber pile driven into the sea bed at a short distance from the jetty and filling the space with coiled rope, springs, rubber, buffers, etc.
4. The fender system controls the relative motion between dock and ship caused by wind and waves. Hence, it also prevents the paint of ships being damaged.

5. For the purpose of classification, the fenders can be classified in the following four categories:

Rubbing strips:

In its simplest form, the fender system adopted for small vessels consists of rubbing strips of timber, coir padding or used rubber tyres

1. It is also convenient to use pneumatic inflated tyres, either by suspending them or installing them at right angles to jetty face.
2. The inflated big-size tyres are useful to transfer cargo between mother ship and daughter ships.
3. The pneumatic rubber fenders are very useful for transferring cargo from ship to ship of big sizes.

Timber grill:

1. This system consists merely of vertical and horizontal timber members fixed to the face piles.
2. This is a simple form of fender and to make it more effective, energy fender pilesmmay be driven along the jetty face with cushion or spring inserted between them.

Gravity-type fendering system:

As the ships grew in size, this s came into force and in its simplest form, it consists of a weighty fender which is raised up when there is an impact of the berthing ship and thus, the initial energy of shock, is absorbed.

Rubber Fendering:

1. Due to the development of rubber technology and with, further growth in ship size, rubber fendering is preferred at present.
2. The shapes of rubber fenders may be cylindrical, square, V-shape or cell type.

floating light stations:

1. The light stations when they are built on land are called fixed as in the case of permanent lighthouse structures.
2. Such structures are located either in the hinterland close to the shore or in the sea on submerged outcrops and exposed to the fury of the waves.
3. Alternately, where there are difficulties in establishing proper foundations; floating light stations in the form of a light vessel may be adopted.
4. Buoys of standard shapes also belong to the ‘floating type and are generally used to demarcate boundaries of approach channels in harbour basins.

Lighthouse:

1. It is a lofty structure popularly built of masonry or reinforced concrete in the shape of a tall tower on a high pedestal.
2. The tower is divided into convenient number of floors, the topmost floor containing powerful lighting equipment and its operating machinery.
3. The lower floors are used, as stores and living rooms necessary for the maintenance and working of the light station.
4. Lighthouses may be located on shore or on islands away from the mainland as in the case of warning light stations

Structural Methods for Coastal Shore Protection:

Seawalls - Seawalls are usually massive, vertical structures used to protect backshore areas from heavy wave action, and in lower wave energy environments, to separate land from water.

Bulkheads - These are vertical retaining walls to hold or prevent the soil from sliding seaward.

Revetments - Revetments are a cover or facing of erosion resistant material placed directly on an existing slope, embankment or dike to protect the area from waves and strong currents.

Dikes and Levees - Dikes are typically earth structures (dams) that keep elevated water levels from flooding interior lowlands.

Breakwaters - Breakwaters are generally shore-parallel structures that reduce the amount of wave energy reaching the protected area.

Groins - Groins are the oldest and most common shore-connected, beach stabilization structure.

Sills / Perched Beaches - Construction of a low retaining sill to trap sand results in what is known as a "perched beach," one that is elevated above its original level.

Jetties and Piers - Jetties are shore-normal stone structures commonly used for training navigation channels and stabilizing inlets. Pier structures are sometimes referred to as jetties.

Environmental impacts of port and harbour operations

Cargo operations

Discharges and emissions from cargo handling

During cargo handling operations in ports and harbours discharges and emissions can and do occur, often accidentally. Handling of dry bulk cargo including grain, coal, iron ore, china clay may cause the production of dust. Handling of liquid bulks may require discharge through pipelines, which provides the potential for leaks, emissions and spillages. Sources of atmospheric pollution can stem from cargo vapour emissions. Release of cargoes into the marine environment may have direct environmental effects, as in the case of the loss of toxic substances, or indirect effects, such as the loss of non-toxic organic-rich substances which may result in oxygen depletion on their breakdown.

Noise from ships and boats

Noise associated with shipping has the potential to cause disturbance to marine animals, including the marine mammals, fish and birds designated under the Habitats Directive. The main source of noise from vessels is generated by the engine, which may travel via the atmosphere or be transmitted through the structure of the craft. The volume of sound generated and transmitted into the air or water will depend on the size, design and location of the engine, and the craft's size and construction. There have been very few studies carried out to investigate the effects of noise pollution in UK coastal waters, particularly with regard to ship-generated noise on marine animals. The level of information that is available on underwater noise is generally inconclusive with regard to the effects on marine life.

Marine accidents

There is an inherent risk of marine accidents occurring where goods are transported by sea, just as there are risks associated with other forms of transport, although these risks are far less per tonne mile than occur with other forms. Such accidents may occur if a ship is unsuccessful in its attempt to avoid another vessel or obstruction. Harbour authorities make an important contribution to reducing the risk of such events by undertaking their responsibilities as conservancy authorities over various measures to provide for navigation safety. Furthermore, where response plans have been drawn up, an appropriate, co-ordinated approach to any incident will ensure that any potential damage to the environment is limited, particularly where hull ruptures and loss of cargo or fuel spillage occur. The potential impacts of such oil spills and discharges are discussed in the Waste Management Section.

Anchoring and mooring

Ports and harbours around the UK coast, and the estuary and bay habitats in which they lie provide shelter and safe anchorage for ships and boats. However, the anchoring of vessels may disturb or damage animals and plants on the seabed, either temporarily by increasing suspended sediments from the disturbance of the bottom or through direct contact with dragging anchors. The effects are of most concern in areas with sensitive or slow growing species, such as shellfish beds, soft corals, sea grasses and maerl. Disturbance from anchoring depends upon the frequency, magnitude and location of activity, type of sediments, and the sensitivity of benthic communities. Where the seabed sediments are soft and there are no sensitive communities or other underwater obstructions, damage caused by anchoring is likely to be minimal and any disturbance is generally temporary, although disturbance in low energy environments can be more than temporary. However, when anchoring over sensitive rocky communities the effects may be more damaging, for example on subtidal reef habitats. However, anchoring is often already restricted or discouraged in areas containing debris, wrecks and other obstructions, typical of uneven rocky bottom areas, which are referred to as foul ground on navigational charts. The impacts from mooring vessels depend on the type of mooring involved.