MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)

Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

Estd. 2000

IQAC

L-01

LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture:SIGNIFICANCE OF ROAD, RAIL, AIR AND WATER TRANSPORTS

Introduction :

- The combination of rails, fitted on sleepers and resting on ballast and subgrade is permanent way or railway track.
- The temporary tracks are also laid for conveyance of earth and materials during construction works.
- The rails are joined in series by fish plates and bolts and then they are fixed to sleepers by different types of fastening.
- Rails act as girder to transmit the wheel load.
- Capacity of the railway track is the hourly capacity of the track to handle the train safely.

- **Prerequisite knowledge for Complete learning of Topic:**

- Role of railways in transportation.
- Permanent ways – components and its functions.
- Rails and its types.

Detailed content of the Lecture:

ROLE OF RAILWAYS IN TRANSPORTATION:

- Transportation is regarded as an index of economic, social and commercial progress of a country.
- Transport is mainly economical for persons and things to move from one place to another.
- Land, water and air have been used by the mankind for developing the transport mode – Railway, Highway and Airways etc.,

CLASSIFICATION FROM SURFACE POINT OF VIEW:

1. Land transport – Highway, Railway, Cableways, and Ropeways.
2. Water transport – Canal ways, River ways, Ocean ways, Lake ways.
3. Air transport – Airways.

CLASSIFICATION – COMMUNICATION:

1. Human porter.
2. 4. Animal Transport
3. Road transport
4. 5. Rail Transport.
5. Air Transport.
6. Water Transport.

CLASSIFICATION – FREEDOM TO MOVE:

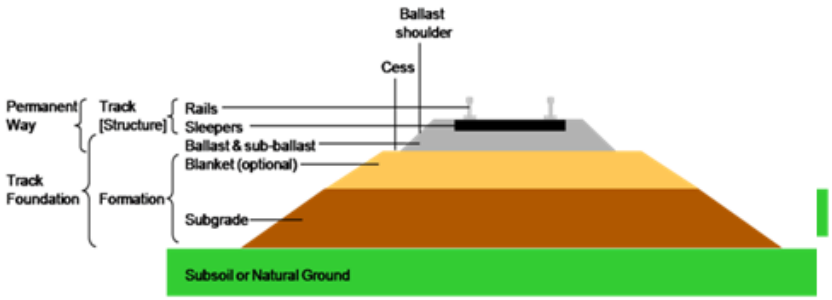
1. One Degree of freedom.
2. Two Degree of freedom.
3. Three Degree of freedom.

PERMANENT WAYS – COMPONENTS AND FUNCTIONS:

- A system of rails fitted on sleepers, which rest on ballast and everything supported by a sub grade is known as the permanent way.
- It consists of two rails running parallel at a specified distance, depending upon gauges of the track.
- Rails are fastened to sleepers. In turn sleepers are embedded in a layer of ballast of specified thickness over the formation.

COMPONENT PARTS OF A PERMANENT WAY:

- Rails.
- Sleepers.
- Ballast.
- Formation or sub grade.



RAILS:

FUNCTIONS OF RAILS:

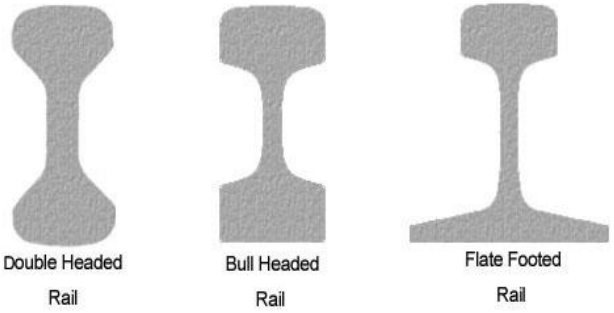
Rails are unsymmetrical I section, made up of a steel laid along the two parallel lines over sleepers. Rails are joined longitudinally by fishplates or by welding.

1. Acts as girders and transmit load to al large area of formation through sleepers and ballast.
2. Provide continuous and leveled surface.
3. Provide smooth surface with lesser friction
4. Provide lateral guidance to wheels
5. Bear stresses developed due to vertical loads, thermal and braking effects.

CLASSIFICATION OF RAILS:

Rails can be classified into the following categories:

- Double Headed Rail
- Bull Headed Rail
- Flat Footed Rail

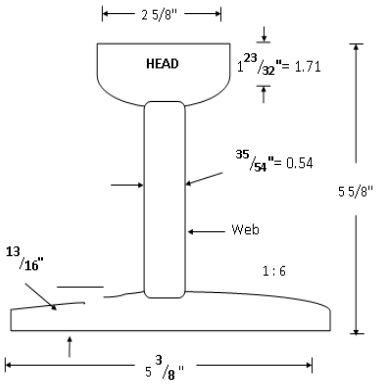


FLAT FOOTED RAIL:

- It is in inverted T-shaped rail i.e.,
- The foot is spread out to form a base having greater stability.
- It was developed by Charles Vignoles in 1836.
- This form of rail became so much popular that about 90% of railway tracks in the world are laid with this form of rails.

It consist of three parts,

- The Head.
- The Web.
- The Foot.



ADVANTAGES OF FLAT FOOTED RAILS:

- They don't need any chair and can be directly spiked into the sleepers which affects economy to great extent
- Cheaper than bull headed rail
- Requires less fastenings
- Give better stability to the track
- Give longer life to the track and reduced maintenance cost.

Video Content / Details of website for further learning (if any):

file:///C:/Documents%20and%20Settings/mecdivyat/My%20Documents/Downloads/Railway%20Engineering.pdf
http://www.engineeringarticles.org/what-is-rails-definition-types-of-rails/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.26)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 3.1)

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L-02

LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture: COORDINATION OF ALL MODES TO ACHIEVE SUSTAINABILITY

Introduction :

- Sub grade is the native material underneath a constructed road.
- Sub grades are commonly compacted before the construction of a road, pavement or railway track, and are sometimes stabilized by the addition of asphalt, lime, Portland or other modifiers.
- The load-bearing strength of sub grade is measured by California Bearing Ratio (CBR) test, falling weight deflect meter back calculation sand other methods.

Prerequisite knowledge for Complete learning of Topic:

- Sub grade.
- Embankments & cutting.
- Typical Cross section of sub grade.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

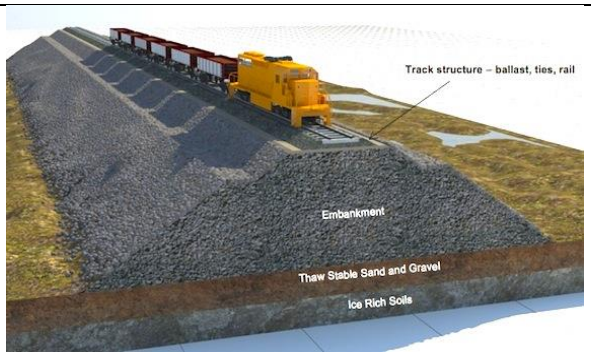
SUBGRADE:

- Subgrade is naturally occurring soil.
- It is prepared to support components of a railway track-ballast, sleepers and rails.
- This prepared surface is also termed as formation. Formation Could be in Embankments, Levels Or cutting.

REQUIREMENTS:

- Uniform transmission of load over a larger area.
- Effective draining off water entering from top.

- No variation in volume and moisture under adverse load and weather condition.



EMBANKMENTS:

- It is raised bank of earth or other materials above natural ground. It is constructed when railway have to be carried in low ground or valley. Stability of embankments depends upon
  - Stability of soil over which embankment is laid.
  - Stability of side slope.
  - Adoption of suitable standards for slopes in accordance with standards.

CUTTING:

- When a railway track is constructed by excavation of raised ground or hill cut, the track is said to be in cutting.

SLOPES OF CUTTING AND EMBANKMENT:

a. Embankment – 2 : 1
b. Cutting – $1^{1/2}$: 1
c. Slope of ballast - $1^{/2}$: 1

PATTERN OF FAILURE OF EMBANKMENT:

a. Slope failure.
b. Base failure.
c. Toe failure.

REMEDIES FOR THE ABOVE SAID FAILURE ARE:

a. Reduce the height of embankment.
b. Provide a flatter slope.
c. Provide an extra weight of soil beyond toe.

TYPICAL CROSS SECTIONS

SINGLE LINE B.G TRACK(EMBANKMENT)

DOUBLE LINE B.G TRACK(EMBANKMENT)

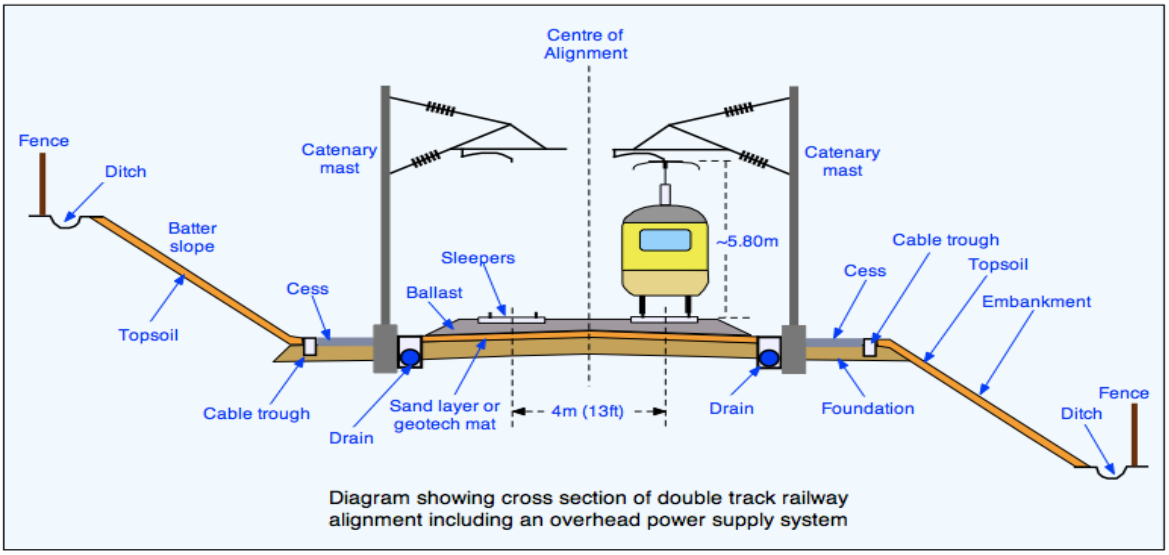
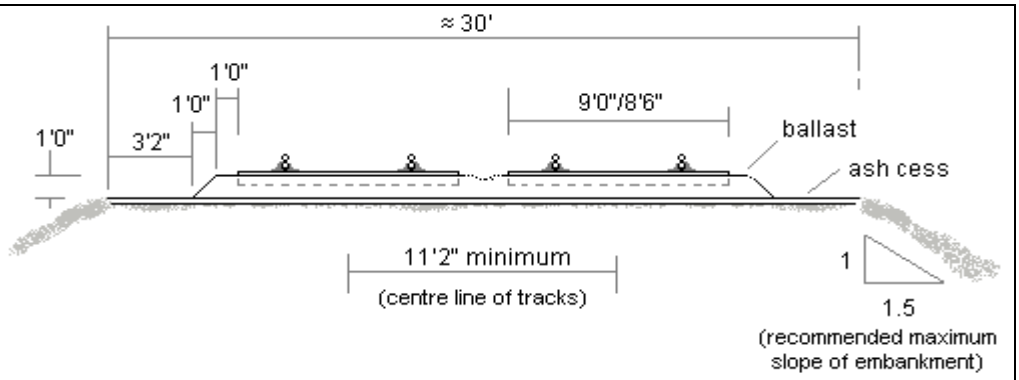


Diagram showing cross section of double track railway alignment including an overhead power supply system

CROSS SECTION OF DOUBLE LINE B.G TRACK



Video Content / Details of website for further learning (if any):
https://www.arema.org/publications/pgre/Practical_Guide/PGChapter4.pdf

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.36)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 12.1)

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L - 03

LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

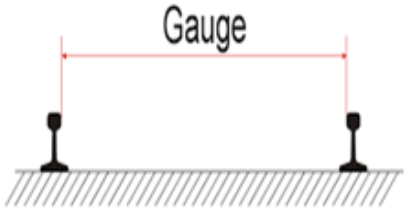
Date of Lecture:

Topic of Lecture: Elements Of Permanent Way ,Coning Of Wheels, creep in rails
Introduction : • Rails on the track can be considered for the purpose of carrying axle load. • A rail bears the stresses developing due to heavy vertical loads, lateral and braking forces and thermal stresses. • Gauge is the clear distance between the inner faces. • It is used in particular country should be uniform throughout as for as possible.
Prerequisite knowledge for Complete learning of Topic: • Concept of gauges. • Creep in rails. • Kinks of rails. • Coning of wheels.

Detailed content of the Lecture

CONCEPT OF GAUGES

1. Gauge of a railway track is the clear distance between inner or running faces of two track rails.
2. It is defined as outer to outer distance of pairs of rails.
3. In coning of wheel the tread or rim of wheels of railway vehicles is made in the shape of a cone with the slope of about 1 in 20.
4. On straight track, portions of wheels running on track have same diameter.
5. While on curved path, the outer wheel has to cover larger distance than the inner wheel. Thus the portions of wheels running on track have different diameters which help in smooth running of wheels.
6. Standard gauge (or) Broad gauge – 1.676 m.
7. Metre Gauge – 1m.
8. Narrow gauge – 0.762.
9. Light gauge – 06096.
10. The selection of gauges is depends upon the factors such as



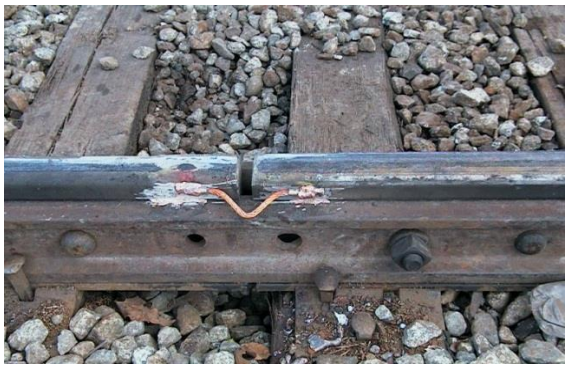
- Cost of construction of tracks.
- Traffic volume.
- Types of terrain
- Speed of train.

IMPACTS OF GAUGES ON SPEED:

1. The speed of a train is a function of diameter of wheel.
2. The diameter of the wheel is limited by gauge. Therefore speed of train is proportional to gauge.
3. The diameter of the wheel is about 0.75 times the gauge.

LENGTH OF RAILS:

- It is more economic and gives greater strength.
- The standard rail length of 13m for B.G and 12m for M.G. joints are the weakest points in railway tracks.
- The welding of rails into 3 rails, 5 rails and 10 rails was started.
- It is welded by pressure or melting together when hot.



CREEP IN RAILS:

- The longitudinal movement of rails with respect to sleepers in a track. It is measured at an interval of two months. Creep in excess of 150mm should not be permitted.

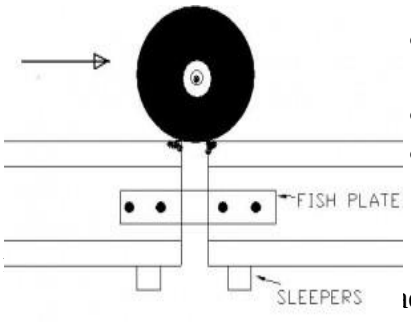
Causes of creep:

i. Closing of successive expansion spaces at rail joints in the direction of creep and opening out of joints at the point from where the creep starts.

ii. Marks on flanges and webs of rails made by spike heads by scraping or scratching as the rails slide.

Effects of Creep:

- Sleepers move out of position which leads to the change in gauge and



alignment of the track.

- Rail joints are opened out of their limit in some case and stresses are set up in fish plates and bolts which lead to the breakage of the bolts.
- Pints and crossings get disturbed.
- Maintenance and replacement of tracks becomes difficult.

KINKS OF RAILS :

When ends of adjoining rails move slightly out of position Kinks

ıcking at joints.

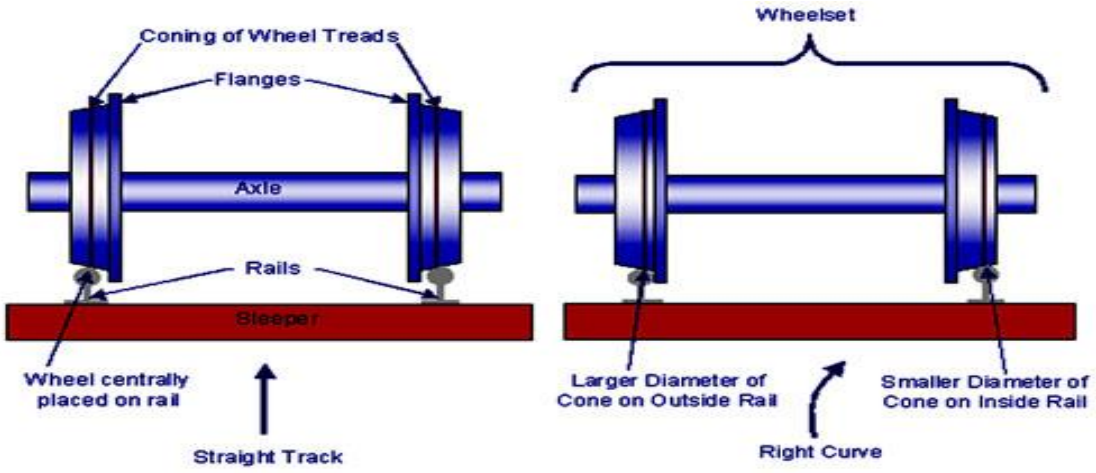
2. Defects in gauges and alignment and Uneven wear of rails head.

Effects of Kinks:

- Unpleasant jerk when vehicle pass over them.
- Defects in gauge, alignment and camber.
- Presents kinks of rails.

CONING OF WHEEL:

- In coning of wheel the tread or rim of wheels of railway vehicles is made in the shape of a cone with the slope of about 1 in 20.
- It maintains vehicle in the central position w.r.t. the track. On straight track, portions of wheels running on track have same diameter.
- While on curved path, the outer wheel has to cover larger distance than the inner wheel. Thus the portions of wheels running on track have different diameters which help in smooth running of wheels.



ADVANTAGES OF CONING OF WHEEL:

- Smooth riding
- Help vehicle to negotiate curves smoothly
- Reduces wear and tear of wheel flanges

DISADVANTAGES OF CONING OF WHEEL:

a. The pressure on the horizontal component of force near the inner edge of outer rail has a tendency to wear the rail quickly
b. The horizontal component has to turn the rail outwards and hence the gauge may be widened
c. If no base plates are provided sleepers under the outer edge of the rail may be damaged.

Video Content / Details of website for further learning (if any):

http://www.preservearticles.com/2012020422668/complete-information-on-railway-gauges.html. https://www.youtube.com/watch?v=5uxsFglz2ig
Important Books/Journals for further learning including the page nos.: ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.30) ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 8.2)

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L-04

LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture: RAILS, SLEEPERS, BALLAST, RAIL FIXTURES AND FASTENINGS

Introduction :

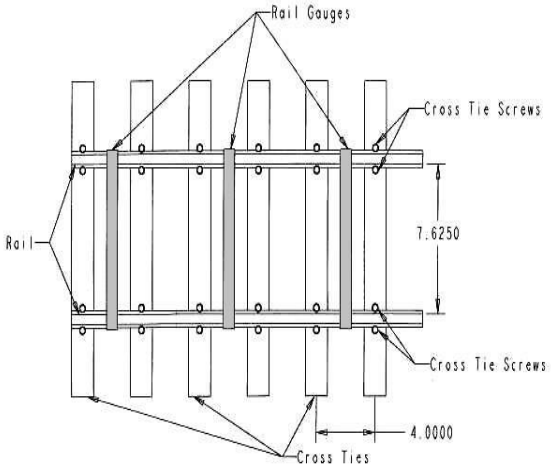
- The members which are laid transverse to the rails, to support the rails and to transfer the loads from rails to the ballast are the sleepers.
- These provide an elastic medium between the rails and ballast and absorb the vibration caused due to moving trains.
- The broken stone placed below and around the sleepers, to transmit wheel load from sleepers to formation and also to provide proper drainage.

Prerequisite knowledge for Complete learning of Topic:

- Sleepers.
- Ballast and its types.
- Rail fittings and fixtures and its types.

Detailed content of the Lecture:

Figure 6: Track Panel with Rail Gauges and Cross Tie Screws Applied.



RAILWAY SLEEPERS:

Sleepers are members that are laid transverse to the rails on which the rails are supported and fixed to transfer the loads from rails to the ballast and ground below.

FUNCTIONS OF SLEEPERS:

- Hold the rail to correct gauge
- Absorb blows and vibrations of moving loads
- Support the rail at proper level in straight track and proper super elevation on curves
- Transfer load to wider area of ballast or girders in case of bridges.

CLASSIFICATION OF SLEEPERS:

Depending on the material used for their manufacture, the sleepers can be divided into the following categories

- Wooden Sleepers
- Steel Sleepers

- Cast iron Sleepers
- Concrete Sleepers.

MERITS AND DEMERITS OF CONCRETE SLEEPER OVER OTHER :

MERITS

a. Service life is about 50-60years.
b. Manufacturing and maintenance cost is cheaper.
c. Track circuiting is easy.
d. No damage by white ants or corrosion.
e. Track elasticity is very high.
f. More suitable for high speed routes.
g. Resist movement better due to heaviness.

DEMERITS:

- Get damaged during manual handling.
- Mechanical maintenance alone is possible.
- Crack easily under heavy loads with stiff ballast.
- Only elastic fastening is possible.
- Spacing 29% greater than wooden sleepers.
-

SLEEPER DENSITY:

Sleepers density is indicated by (n+x)

Where, n – Length of rail in metres.

x – Number of sleepers required in excess of n.

Density of sleepers depends upon,

- Methods of providing rail joints.
- Speeds of trains.
- Maximum axle load expected on track.

The packing space in India varies from 30.5 cm to 35.5 cm except at joints.

RCC AND PRE-STRESSED CONCRETE SLEEPERS:

- RCC sleepers contains two block of RCC.
- A metal tie bar in the form of an inverted T section joins blocks.
- Pre – tensioned – Steel is tensioned before placing concrete.
- Post – tensioned – Steel is tensioned after concrete has hardened.

BALLAST:

Ballast is the granular material packed under and around the sleepers to transfer loads from sleepers to ballast. It helps in providing elasticity to the track.

FUNCTIONS OF BALLAST:

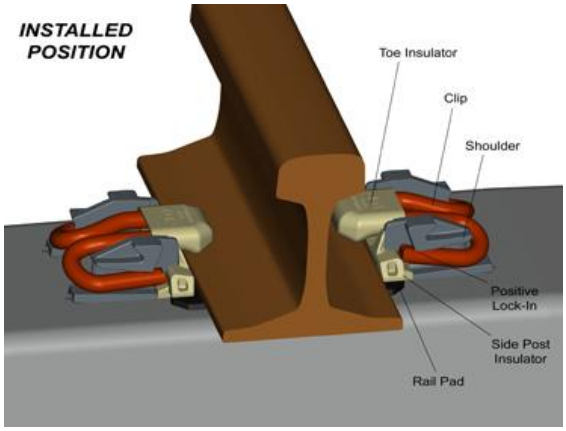
- It provides a hard and level bed for the sleepers.
- It holds the sleepers in proper position during the passage of moving trains.
- It provides to some extent an elastic bed for the track.
- It transmits and distributes the moving load of the trains from the sleepers to the formation uniformly.
- It protects the formation surface from direct exposure to sun, rain and frost.
- It provides a proper drainage to the track, keeping the sleepers in dry condition.
- It obstructs the growth of vegetation at the track formation.
- It provides proper super elevation to the outer rail on curves.

- It provides an easy means for correcting the unevenness of the track.

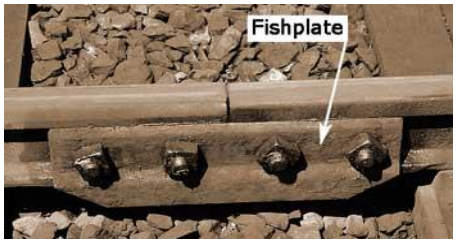
TYPES OF BALLAST:

- Broken stones
- Gravels
- Sand
- Moorum
- Cinder (or ash)
- Brick bats
- Kankar.
- Ballast earth.

RAIL FASTENINGS (OR) TRACK FITTINGS:



- Track fittings and Rail fastenings are used to keep the rails in the proper position and to set the points and crossings properly.
- They link the rails endwise and fix the rails either on chairs fixed to sleepers or directly on to the sleepers.
- The important fittings commonly used in a permanent way are the following.



1. **Fish plates:** Used to maintain the continuity of the rails and to allow for any expansion and contraction of the rail caused by temperature.

2. **Spikes:** For holding the rails to the wooden sleepers.
   i) Dog spikes.
   ii) Screw spikes.
   iii) Round spikes.
   iv) Standard spikes.
   v) Elastic spikes.
3. **Bolts.**
   Dog or hook bolt.
   i) Fish bolt.
   ii) Rag bolt.
   iii) Fang nut and bolt.
4. **Chairs**.
   i) Cast steel chairs.
   ii) Mild steel chairs.
5. **Blocks.**
   i) Heel blocks.
   ii) Distance blocks.
   iii) Crossing blocks.
6. **Keys.**
   i)Wooden key.
   ii)Morgan key.
   iii)Cotter and tie bars.
7. **Plates.**
   i) Bearing plates.
   ii)Saddle plates.

Video Content / Details of website for further learning (if any):
http://www.chandraindustrialworks.co.in/railway-track-fittings.html
http://www.trackcomponent.com/railway-track-fittings.html
http://civilblog.org/2015/06/04/what-is-ballast-why-is-it-placed-in-railway-track-beds/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.35)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 9.1& 10.1)

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L-05

LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture: Track Stress, defects in rails

Introduction :

- The primary consideration in the design of geometric cross sections for highways, runways, and taxiways is drainage. Details vary depending on the type of facility and agency.
- Turnouts in horizontal curves are usually viewed as “undesirable” to “prohibited”.
- Geometric details through the switch and frog are discussed– including short tangents for proper fit and gage – and proportioning stock rail bends and heel joint spreads for the respective curvatures.
- Minimum Horizontal Curve Radius based on the limit Value of Super elevation and limit value of lateral acceleration.
- Horizontal and vertical curves used in transportation systems are the critical sections on the alignment

Prerequisite knowledge for Complete learning of Topic:

- Horizontal Curves.
- Vertical curves.
- Stress

Detailed content of the Lecture:

Track Stress:

- **Lateral forces**
- The lateral force applied to the rail head produces a lateral deflection and twist in the rail. Lateral force causes the rail to bend horizontally and the resultant torque causes a huge twist in the rail as well as the bending of the head and foot of the rail. Lateral deflection of the rail is resisted by the friction between the rail and the sleeper, the resistance offered by the rubber pad and fastenings, as well as the ballast coming in contact with the rail
- **Longitudinal force**
- Due to the tractive effort of the locomotive and its braking force, longitudinal stresses are developed in the rail. Temperature variations, particularly in welded rails, result in thermal forces, which also lead to the development of stresses

DEFECTS IN RAILS:

(a) Metallurgy and age of rails

(i) High nitrogen content of the rails

(ii) Effect of oscillation at the time of rolling and straightening of rails.

(b) Physical and environment conditions of track

(i) Steep gradients

(ii) Yielding formation

(iii) Long tunnels

(iv) Electrified sections

(c) Train operations

(i) High speeds and high axle loads

(ii) Starting locations of trains

(iii) Locations where brakes are applied to stop the train

(d) Atmospheric effects

(i) High moisture content in the air particularly in coastal areas

(ii) Presence of sand

HORIZONTAL CURVES:

- These are provided whenever there is change in the direction of the alignment of the track.
- They are usually circular with parabolic transition curves at either end.

Horizontal curves are classified as under:

(1) Simple curves
(2) Compound curves
(3) Reverse curves
(4) Transition curves.

SIMPLE CURVES:

- The horizontal curve which consists of a single are of a circle, is called a simple curve of simple circular curve.
- Simple circular curves are designated either by their degree of radius.
- They are inserted between two straights or between two transition curves.

COMPOUND CURVES:

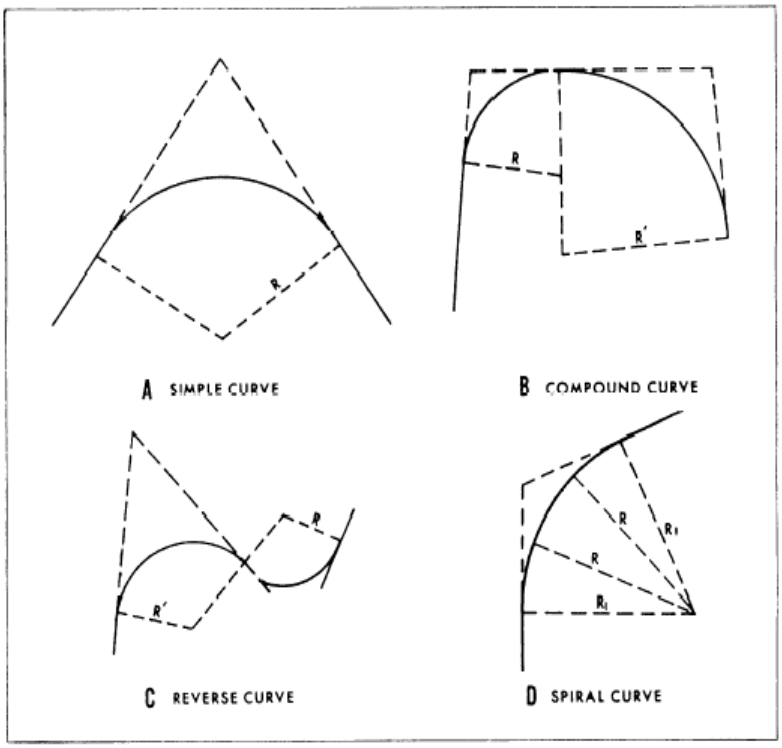
- The horizontal curve which consists of two or more arcs of different circles with different radii, having different centers on the same side of the common tangent and bending in the same direction, is called a compound curve.

REVERSE CURVES:

- The horizontal curve, which consists of two arcs of different circles of same or different radii, bending in opposite directions with a common tangent at the junction, is called a reverse curve.

TRANSITION CURVES:

- The horizontal curve of varying radii introduced between a straight and a circular curve, is called a transition curve. A transition curves is also known as curve of easement.
- The radius of a transition curve varies from the infinity at its beginning to a definite minimum value at the junction of the circular curve.



VERTICAL CURVES:

- These are provided whenever there is change in the gradient i.e., either a rising gradient changes to a falling gradient or vice versa or a rising gradient or falling gradient is increased or decreased.
- They are usually parabolic curves.

MAXIMUM DEGREE OF CURVATURE FOR DIFFERENT GAUGES:

B.G = 10^0.
M.G = 16^0.
N.G = 40^0.

SAFE SPEED ON CURVE:

a. The speed which is not prone for overturning and derailment.

b. Factors influencing speed:

i. Gauge of the track.
ii. Radius of curvature.
iii. Value of super elevation and
iv. Provision or otherwise of transition curves.

Video Content / Details of website for further learning (if any):

http://www.mhhe.com/engcs/civil/banks/graphics/chap4.pdf

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.42)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 15.25)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I -RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture: Route alignment surveys, conventional and modern methods, Geometric design of railways – Gradient

Introduction :

- Constructed line refers to the tangent of the angle of that surface to the horizontal.
- It is a special case of the gradient in calculus where zero indicates gravitational level.
- The grades or slopes of existing physical features such as canyons and hillsides, stream and river banks and beds are often described.
- Grades are typically specified for new constructions (such as roads, landscape grading, roof pitches, railroads, aqueducts, and pedestrian or bicycle circulation routes).

Prerequisite knowledge for Complete learning of Topic:

- Geometric Design of Railway Track.
- Gradients.
- Grade compensation.

Detailed content of the Lecture:

GEOMETRIC DESIGN OF TRACK:

Geometric design of the track to study will be confined to the following elements of a railway track.

1. Gradients and grade compensation
2. Speed of train
3. Radius or degree of the curve
4. Cant or super elevation
5. Curves
6. Widening of gauge on curves.

GRADIENT:

- It is the departure of a track from the level.
- This are of two types

i) Rising gradient – Track rises in the direction of movement.
ii) Falling gradients – Tracks fall in the direction of movement.'

Various Types of the Gradients:

(1) Ruling gradients
(2) Momentum gradients
(3) Pusher gradients
(4) Gradients in station yards.

RULING GRADIENT:

The ruling gradient on a section may be defined as the gradient which determines the maximum load that the engine can haul (or) force on the section. It is the maximum gradient allowed on the track section.

In plain terrain 1 in 150 to 1 in 200
In hilly regions 1 in 100 to 1 in 150

MOMENTUM GRADIENT:

Those gradients on a section which though more severe than this ruling gradient do not determine the maximum load of the train but on account of their favorable position on track the train before approaching them (i.e., such gradients) acquires sufficient momentum to negotiate them, are known as momentum gradients.

- **Example:**
- In valleys, a falling gradient is usually followed by a rising gradient.
- This rising gradient is called as momentum gradient and in such case a steeper grade than the ruling grade can be adopted.

PUSHER OR HELPER GRADIENT:

- The important effect of a ruling grade is its limit on locomotive capacity.
- But this types of gradient to used the train on the basis of load of the engine can carry on the remaining portion of track and arrange for an assisting engine (or pusher engine or banking engine) known as Pusher or helper gradient.
-

GRADIENTS IN STATION YARDS:

a. To prevent the movement of standing vehicles on the track due to the effect of gravity combined with a strong wind and or gentle push.

b. The minimum gradient is required to be provided for drainage On Indian railways, for all the gauges the maximum gradient permitted in station yards in 1 in 400.Minimum gradient of 1 in 1000 is recommended from drainage point of view.

GRADE COMPENSATION:

- Whenever a train is pulled along a curve, an additional attractive force is required.
- The ruling gradient is the maximum gradient on a particular section of the track.
- If a curve lines on a ruling gradient, the total resistance due to the gradient and curvature will exceed the ruling gradient.
- In order to avoid the total resistance beyond the permissible ruling gradient, the gradients are reduced on curves. This reduction in gradient is known as grade compensation on the curves.

The curve resistances are generally expressed as a percentage per degree of a curve.

B.G. track ….. 0.04% per degree
M.G. track ….. 0.03 5 per degree
N.G track …..0.02% per degree.

WORKED OUT EXAMPLES:

1. A B.G railway tracks is designed for a ruling gradients of 1 in 180 on a curve of 3^o. what should be the compensated gradients in the alignment?

Data Given:

Actual ruling gradients = 1 in 180
Degree of curve = 3^o.
Gauge = B.G

Solution :

Grade compensation for B.G = 0.04% / Degree of curve.
= 0.04 x 3 = 0.12%
Actual ruling gradients = 1/180 x 100 – 0.12
= 0.435%
= (1/0.435 x 100) = 229.9
= 1 in 230

Video Content / Details of website for further learning (if any):
http://www.mhhe.com/engcs/civil/banks/graphics/chap4.pdf

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.39)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 15.1)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture:

SOIL SUITABILITY ANALYSIS- SUPER ELEVATION.

Introduction :

- Super elevation is inclined roadway cross section that employs the weight of a vehicle in the generation of the necessary centripetal force for curve negotiation.
- Minimum curve radius can be derived to take into account the limit value of super elevation.
- If present or necessary, super elevation is less objectionable and possibly helpful where both routes are curved in the same direction, but may be troublesome where routes are curved in opposite directions.

Prerequisite knowledge for Complete learning of Topic:

- Cant.
- Cant deficiency.
- Factors influencing super elevation.
- Equilibrium super elevation and speed.
- Worked examples.

Detailed content of the Lecture:

SUPER ELEVATION:

- When a vehicle negotiates a curve, it is subjected to a constant radial acceleration which produces centrifugal force acting horizontally at the centre of gravity of the vehicle, radially away from the centre of the curve.
- In order to counteract this force, the outer rail of the track is raised slightly higher than the inner rail. The difference in elevation between the outer rail and inner rail is called super elevation or cant.

SUPER ELEVATION OR CANT:

- When a train moves round a curve it is subjected to a centrifugal force acting horizontally at the centre of gravity of each vehicle radically away from the centre of the curve. This increases the weight on the outer rail
- To counteract the effect of centrifugal force, the level of the outer rail is raised above the inner rail by a certain amount to introduce the centripetal force. This raised elevation of outer rail above the inner rail at a horizontal cure is called "super elevation".
- The term **"cant"** is frequently used as a synonym for super elevation but truly speaking cant should be used to represent the angle of a transverse slope.

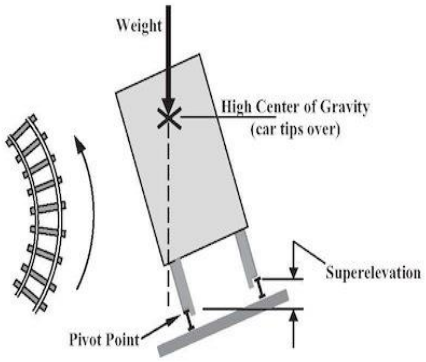


FIGURE 7.3. A car will tip over toward the inner rail, even at zero mph, if the superelevation and/or center of gravity are raised enough.

- The object of providing the super elevation is to make the force of reaction equal at both the rails and perpendicular to the track and thus equalize the weight on either rail. Super elevation is denoted by **"e"**.
-

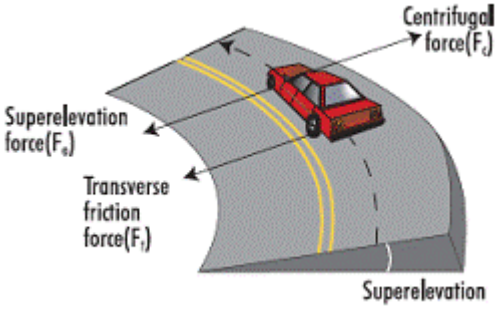
CANT DEFICIENCY:

- The equilibrium cant is provided on the basis of equilibrium speed (or average speed or weighted average speed) of different trains. But this equilibrium cant or super elevation falls short of that required for the high speed trains. This shortage of cant is called "cant deficiency".

This cant deficiency is limited due to two reasons:

(i) Higher cant deficiency gives rise to higher discomfort to passengers.

(ii) Higher cant deficiency means higher would be the balanced. Centrifugal forces and hence extra pressure and lateral forces on outer rails. This will require strong track and fastenings for stability.



FACTORS INFLUENCING SUPER ELEVATION:

a) Radius of curvature.
b) Frictional resistance between wheels and rails.
c) Body of vehicle.
d) Velocity of the train.
e) Gauges of the track.
f)

EQULIBRIUM SUPER ELEVATION:

The cant is in equilibrium when the cant provided exactly balance the centrifugal force.
Equilibrium super elevation (e) = $GV^2/127R$.

EQULIBRIUM SPEED:

Equilibrium speed is average speed under average condition on level tracks,

a) When maximum permissible speed (V max) of BG/MG section is more than 50 km/h.
   Equilibrium speed = ¾ V max subject to a minimum speed of 50 km/h.
b) When V max = 50 km/h
   Equilibrium speed = V max.
c) Weighted average is calculated for a particular speed.

WORKED EXAMPLES:

1. On a B.G track of 4^0 curves, equilibrium cant is provided for speeds of 60 km/hr. calculate.
   i. Value of equilibrium cant.
   ii. Maximum speed allowing maximum deficiency.

Given Data:

Degree of curve = 4^0.
Nominal gauge (B.G) = 1750 mm.
Speed of train = 60 km/hr.

Solution:

a. R = 1750 / D = 1750 / 4 = 437.5 m.
Equilibrium cant (e) = $GV^2/127R$ = 1750 x 60^2/127x437.5
= 113.39 mm = 115 mm.

b. Maximum allowable cant deficiency in B.G = 75 mm.
Theoretical cant after allowing cant deficiency = 115 + 75 = 190 mm.
190 = 1750xV^2/127x437.5
V = 77.67 km/hr.

Video Content / Details of website for further learning (if any):
https://www.fig.net/resources/proceedings/fig_proceedings/fig2012/ppt/ts06g/TS06G_kilinc_baybura_5563_ppt.pdf
http://www.mhhe.com/engcs/civil/banks/graphics/chap4.pdf

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.50)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 15.20)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture:

WIDENING OF GAUGES ON CURVES

Introduction :

- In passing over curved track, the car wheels bind hard against the outside rail at the curve.
- The reason for this is that the difference between the gauge of the track and the gauge of the wheels is taken up by the wheel base, which forms a chord to the curve of the track, instead of being parallel to the rails, as is the case on a straight line. To lessen this friction.

Prerequisite knowledge for Complete learning of Topic:

- Widening of Gauges on Curves.
- Transition curve.

Detailed content of the Lecture:

WIDENING OF GAUGES ON CURVES:

NEED FOR WIDENING.

- Wheel base is the distance between adjacent axes of a vehicle.
- The wheelbase of the vehicle is very rigid. Due to this rigidity when the outer wheel of the front axle strikes against outer rail, outer wheel of real axes bears a gap with rail.

Curves of less than 8 chains radius are fitted with a check rail.

The widening d = $\mathbf{13(B+L)^2/R}$

d = Extra width of gauge (m)

B = Rigid wheel base (m)

L = Lap of flange (m)

D = Diameter of wheel (m)

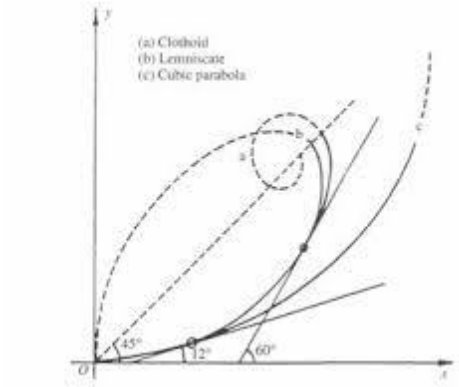
a. If the radius of curvature is more than 350m – upto + 15 mm.
b. If radius of curvature is less than 350 m – upto + 20mm.

EFFECTS OF THE WIDENING:

- A critical effect of widening is that outer wheels have to transverse longer distance than inner wheels.
- This is made possible due to coining of wheels. When a train vehicle moves in a curve, outer wheels almost touch the side of the head of the outer rails without any gap.

TRANSITION CURVES:

- It is a curve which passes from one condition to another in terms of radius of curvature.
- It is introduced from a straight to circular curve, to provide a smooth and harmonious merger. Radius of transition curve is infinite at straight curve.
    a. **Types of transition curves:**
        i. Spiral
        ii. Lemniscates
        iii. Cubic parabola



WORKED EXAMPLES:

1. If the wheel base of a vehicle moving on a B.G track is 6 m, the diameter of wheel is 1.5m and the depth of flanges below the top of rail is 3.17 cm. determine the extra width required to be provided on gauge, if the radius of the curve is 160m.

Given Data:

h = 3.17 cm.
D = 1.5 m = 150 cm.
B = 6 m.
R = 160 m.

Solution:

$\mathbf{L = 0.02 (h^2 + D \times h)^{1/2}}$
$= \mathbf{0}.02 (3.17^2 + 150 \times 3.17)^{1/2}.$
= 0.44 m
$= 13 (6 + 0.44)^2/160$
= 3.38 cm.

2. Calculate the shift and offset at every 15 m of a transition curve. The transition curve of 90 m long is to be

used to join the ends of a 4^0 circular curve within the straight and circular curve.

Solution:

R = 1720/4 = 430 m.

$S = L^2/24R = 90 \times 90/24 \times 430 = 0.817$ m.

Offset at 30 m = $(30^3/6 \times 90 \times 430) \times 100 = 11.65$ cm.

Where c = 1 / 6 RL

Offset at 60 m = $(60^3/6 \times 90 \times 430) \times 100 = 9.31$ cm.

Offset at 90 m = $(90^3/6 \times 90 \times 430) \times 100 = 314$ cm.

Video Content / Details of website for further learning (if any):

http://www.catskillarchive.com/rrextra/tkwk09.Html

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 1.60)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 15.38)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **I - RAILWAY PLANNING**

Date of Lecture:

Topic of Lecture:

POINT AND CROSSINGS

Introduction :

- Point and crossings are arrangement used in permanent way to guide the vehicle for directional change.
- The point and crossing are the vital components of track asset.
- Turnouts in horizontal curves are merely conventional 'straight' turnouts, with curve geometry modified.
- Turnouts utilize standard 'off-the-shelf' components – no special track work such as curved switches or frogs or exotic Other Track Material is needed.

Prerequisite knowledge for Complete learning of Topic:

1. Point & Crossings.
2. Various points and crossings.
3. Turnouts.
4. Component parts of crossing.
5. Track Junction.

Detailed content of the Lecture:

POINT & CROSSINGS:

- The Point & Crossings are used in the railway tracks to guide the trains for directional changes.
- This Point & Crossings is comprised of three prime components, namely Point, Lead and Crossing element. One point is basically consists of single pair of tongue rails and stock rails with various necessary fittings.

- While crossing is kind of device available in the form of V-piece. Both the points and crossing are primary components of track asset. These assure diversion of traffic from one track to another track. These are also used to give earliness to faster trains in the same direction.

Turnout: The term denotes points and crossing with the lead rails.

Tongue rail: It is tapered movable rail, connected at its thickest end to running rail.

Stock rail: It is the running rail, against which a tongue rail functions**.**

Switch: A pair of tongue with stock rail with necessary connections and fittings**.**

Points: A pair of tongue rail with their stock rails is termed as points.

Crossing: A crossing is a instrument which is installed at the junction where two rails cross to ensure the wheel flange of trains to pass from one track to the another.

Heel of switch: It is an imaginary point on the gauge line midway between the end of lead rail and the tongue rail in case of loose heel switches In case of fixed heel switches; it is a point on the gauge line of tongue rail opposite the centre of heel block.

Lead: The track portion between heels of switch to the beginning of crossing assembly is called lead.

TURNOUTS:

Points of switches:

A switch consists of a stock rail of a tongue rail. A set of switches or points consists of a left-hand switch and a right hand switch.

The various components parts of the switches are as below:

1. A Pair of stock rails.
2. A pair of tongue rails.
3. Heel block (or) distance block.

4. Stretcher bars.
5. Switch tie plate or gauge tie plate.

Types of switches:

1. Stub switch
2. Split switch
   (a) On the basis of fixation at heel:
      (i) Loose heel type
      (ii) Fixed heel type (or) spring type or flexible type.
      (b) (1) under cut switches
      (2) Over riding switches
      (3) Straight cut switches.

Crossings:

- A crossing or a frog is a device which provides two flange ways through which the wheels of the flanges may more when two rails intersect each other at an angle.
- The flanged wheels of the train jump over the gap from "throat" to "nose" of crossing and to check the wheel flanges from striking the nose the opposite wheel flanges are guided by use of check rails inside the running rails.

Component parts of crossing:

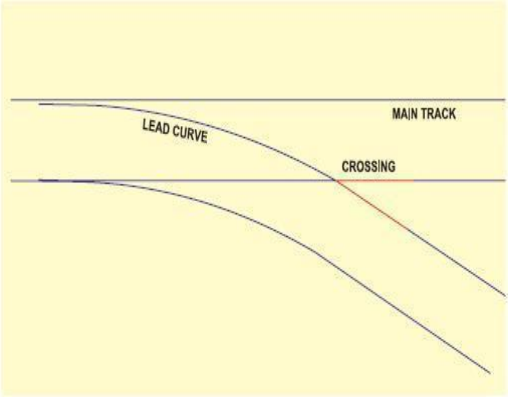
(i) A crossing or vee piece
(ii) Point and splice rails
(iii) Wing rails
(iv) Check rails.
(v) Chairs at crossing at toe and at heel
(vi) At throat, at nose, at heel.

Types of crossing:

(A) On the basis of shape of crossing.
   1) Acute angle crossing or V crossing or Frog
   2) Obtuse angle crossing or Diamond crossing
   3) Square crossing.
(B) On the basis of Assembly of crossing:
   1) Spring (or) movable wing crossing.
   2) Ramped crossing.

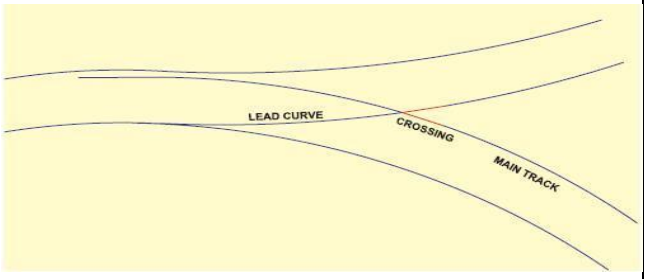
TRACK JUNCTION:

Track junctions are formed by combination of points and crossing. Depending upon the requirements, there can be large number of tracks junction. Commonly used one is turnouts, crossover, similar and contrary flexure turnouts.



1. **Turnouts from a straight track**: The curvature begins from a point on the straight main track ahead of the toe of the switch and ends at theoretical nose of crossing.
2. **Turnout of similar flexure**: It is the one that takes off towards the same direction as that of the main curved tracks. The degree of the turnout curve is higher or lower than of the main curve.
3. **Symmetrical split**: When a straight track splits in two directions with equal radii, it is known as symmetrical split.

4. **Turnout of contrary flexure:** It is the one that takes off towards the direction opposite to that in which the main curved turns.
5. **Three throw switch:** A three throw switch is one in which two turnouts take off from the same point of a main line track. This arrangement is used in congested goods and locomotive yards, where there are heavy limitation of space.



6. **Double turnouts:** The turnout is staggered and taken off from the main line at two different places. This eliminates defects of a three throw switch as heels of two switches are kept at a certain distance from each other.
7. **Cross ov er:** In this arrangement two parallel tracks are connected by a cross over.
8. **Diamond crossing:** It is provided when two straight or curved tracks cross each other at an angle between 90^{o}.
9. **Scissors cross over:** the objective of this cross over is to transfer vehicles from one track to another and vice versa. Whenever there is space limitation for provisions of two separate cross over this type is used. It has four pair of switches, six actual angle crossing, five obtuse angle crossing and check rails.

Video Content / Details of website for further learning (if any):
http://www.nmohanlal.com/pointsandcrossing.html
http://www.railwaytrackmaterial.com/railway-track-cross-section.html

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.2)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 16.2)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

EARTHWORK, STABILIZATIONS OF TRACK ON POOR SOIL

Introduction :

- The Works created through the moving or processing of parts of the earth's surface involving quantities of soil or unformed rock.
- The earth may be moved to another location and formed into a desired shape for a purpose.

Prerequisite knowledge for Complete learning of Topic:

- Earthwork and consolidation.
- Soil stabilizations and its methods.

Detailed content of the Lecture:

EARTHWORK AND CONSOILDATION:

- The earth consists of providing formations along the ground surface, in cuttings, up the embankments over bridges or through tunnels.
- On this formation or prepared surface the railway line is laid.
- The construction of formation requires the earth work (movement of earth).
- The height of the embankment above highest water level in the area should be at least 60cm.
- In India, the light earth work is carried out manually in the cross section direction which reduces the amount of lead by manual labour.
- The cost of earth work for formation varies with the following three factors.
    1. The type of soil used.
    2. Hauling distance or lead
    3. Lift required.
- Consolidation is usually done by the addition of admixtures and finally compacting the embankment by vibratory or impact method.

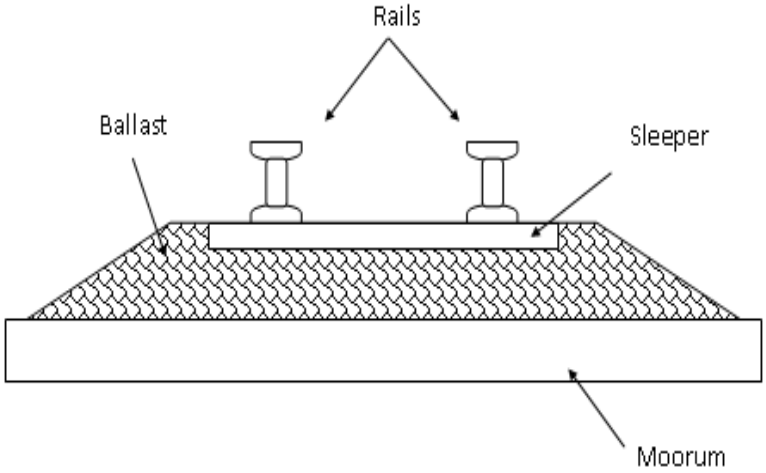
- After completion of embankment, small earthen walls usually 15cm high are built along and across the edges of formation at an interval of 3 to 4.5 m.
- The rain water is collected within the small earth walls which further help in consolidation.

STABILIZATIONS OF TRACK ON POOR SOIL:

- Sometimes it becomes unavoidable to lay tracks on a very poor (or undesirable) soil.
- In such cases it becomes necessary to improve and strengthen the nature of soil by some suitable methods.
- Under such circumstances, the following methods are used.

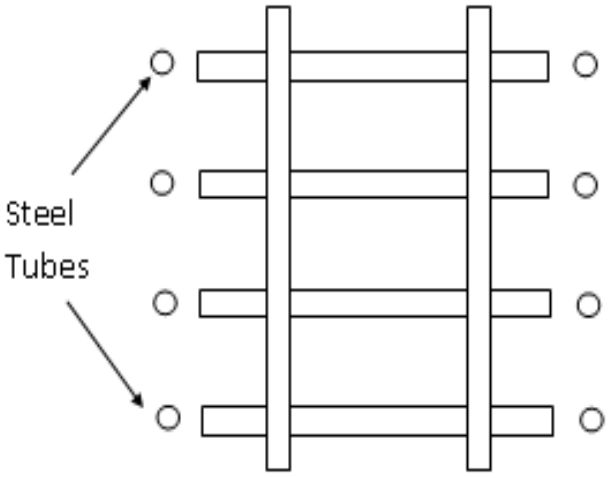
1. Layer of Moorum.
2. Cement Grouting.
3. Sand Piles.
4. Use of Chemicals.

- **LAYER OF MOORUM:**
  - **a.** This method is widely used and is adopted if a poor quality soil comes across a track such as black cotton soil which is a fine black loomy soil.
  - **b.** This soil has the tendency of expanding (or swelling) when moist and of caking and cracking heavily when dry.
  - **c.** Tracks laid on formation of maintain. In rainy season, the soil fills up ballast interest less, the track in the worst places gets sodden and spongy track is reduced.
  - **d.** In hot weather, the cracks are formed and the ballast is lost in filling up these cracks.



CEMENT GROUTING:

- In this method, steel tubes of 1 1/4 " in diameter and 5ft long are driven into the formation at every alternate sleeper and near their ends.
- The tubes are driven into the foundation at an angle such that the end of tube is nearly under the rail.
- The cement grout is forced under a pressure of 100 psi through these tubes. The proportion of cement grout depends on the type and condition of formation.



- The concert grout spreads through the poor soil and consolidates it. The steel tubes are then gradually taken out.

- **SAND PILES:**
  - This method of strengthening the track laid on poor is most widely used in development countries like America. In this method, a vertical bore about 12" diameter is made in the ground by driving a wooden pile.
  - The wooden pile is then withdrawn and the space is filled with sand and is well rammed.
  - It is also arranged that cross sectional area of the sand piles is about 20% of the formation area.
  - Thus, the top section of the formation is covered with sand which makes the track stable on poor soil.
- Use of Chemicals:
  - In this method, chemicals are used in place of cement grout to consolidate the soil. For example, silicate of

soda followed by calcium chloride is effective for sandy soils containing less than 25% of silt and clay.
Video Content / Details of website for further learning (if any): **http://www.engineeringarticles.org/soil-stabilization-and-railway-track/**
Important Books/Journals for further learning including the page nos.: ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.5) ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 22)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

TUNNELING METHODS

Introduction :

- 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.
- A tunnel may be for foot or vehicular road traffic, for rail traffic, or for a canal.

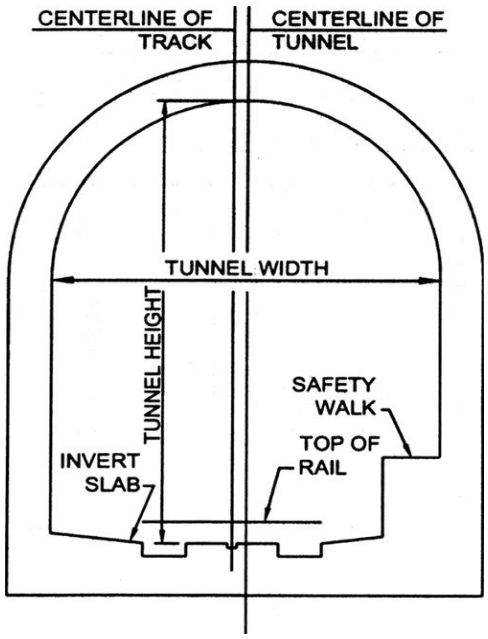
Prerequisite knowledge for Complete learning of Topic:

- Necessity of tunnels.
- Size and shape of railway tunnels.
- Methods of tunnels construction.
- Methods of tunnel construction in rocks.
- Methods of tunnel construction in soft ground.

Detailed content of the Lecture:

NECESSITY OF TUNNELS:

- are lesser as compared to a bridge or a heavy open cut. To avoid a long detention around a mountain or a spur, the use of tunnel in such cases reduces the length of the railway line and may be economical.
- The cost of excavation for providing an open cut in a mountain is excessive and maintenance costs are also high. It is therefore better to use a tunnel.
- The costs of maintenance of a tunnel



SIZE AND SHAPE OF RAILWAY TUNNELS:

- The size of the railway tunnels depends upon whether it has to carry a single line or a double railway line.
- The shape of the sectional profile of a tunnel should be such that the lining is able to resist the pressures exerted by the unsupported walls of the tunnels excavation.
- The lateral and vertical pressure depends upon the character of the materials.

METHODS OF TUNNELS CONSTRUCTION:

Tunneling methods in rocks differ from that of soft ground tunnel construction in the following aspects,

- The operation of tunneling in rock is costly.
- Greater care is required in accurately carrying out the work in rocks, as even slight deviation will involve huge loss of money.
- In rocks, for drilling and blasting it requires established of a power plant to operate machinery and excavating tools.

SHAFT:

The most common shaft construction methods, from simplest to complex, are

- Trench boxes and speed slide rails.
- Soldier piles and wood lagging.
- Liner plates.
- Precast segments.
- Conventional excavation with rock dowels and shotcrete.
- Sheet piles.
- Drilled shaft.

PILOT TUNNELS:

- The horizontal approach to the centre line of the tunnel is shorter than deep vertical shaft; a system of pilot tunnel is used to obtain additional faces for attack.

METHODS OF TUNNELS CONSTRUCTION IN ROCKS:

- Full face method.
- Heading and bench method.
- Drift method.

METHODS OF TUNNELS CONSTRUCTION IN SOFT GROUND:

- Size of tunnel.
- Types of ground.
- Available equipments, machinery and tools.
- Methods of excavation.

Video Content / Details of website for further learning (if any):

http://www.bms.co.in/explain-the-various-modes-of-transportation/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING"
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 27)

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LECTURE HANDOUTS

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Course Name with Code : 19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING

Course Teacher : Dr.R.SHANMUGAM

Unit : II - RAILWAY CONSTRUCTION AND MAINTENANCE

Date of Lecture:

Topic of Lecture:

TRACK DRAINAGE

Introduction :

- It has often been said that the most important topic in track design and performance is drainage.
- Drainage is nevertheless still one of the most neglected subjects in substructure design and maintenance.
- One is that the principles of drainage are not adequately understood. Another is that the economic impact of neglecting drainage has not been quantified, and hence drainage has a diminished priority. Another reason is that drainage action, unlike surfacing, can be deferred.

Prerequisite knowledge for Complete learning of Topic:

- Drainage system.
- Surface drainage.
- Sub surface drainage.
- Cross drainage.

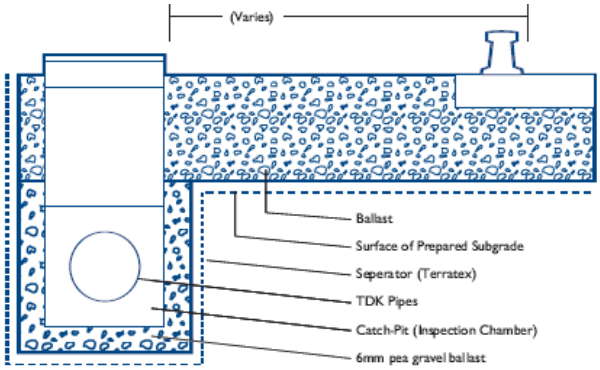
Detailed content of the Lecture:

PURPOSE, SCOPE AND APPLICATION:

- This Standard establishes the design requirements for track drainage systems to be installed on the Rail Corp network.
- It covers drainage of the track formation, supporting embankments and cuttings.
- This standard does not cover drainage from platforms, buildings, over bridges, footbridges, airspace developments, and external developments, and access roads, roads outside the rail corridor, Council drains or properties adjacent to the rail corridor.
- This standard does not include culvert design or selection

NEED FOR DRAINAGE:

- During rain or irrigation, the fields become wet.
- The water infiltrates into the soil and is stored in its pores.
- When all the pores are filled with water, the soil is said to be saturated and no more water can be absorbed; when rain or irrigation continues, pools may form on the soil surface



Section through BRR formation incorporating drainage detail.

DIFFERENT TYPES OF DRAINAGE:

1. Surface drainage.
2. Subsurface drainage

- Drainage can be either natural or artificial.
- Many areas have some natural drainage; this means that excess water flows from the farmers' fields to swamps or to lakes and rivers.
- Natural drainage, however, is often inadequate and artificial or man-made drainage is required.

SURFACE DRAINAGE:

- Surface drainage is the removal of excess water from the surface of the land.
- This is normally accomplished by shallow ditches, also called open drains. The shallow ditches discharge into larger and deeper collector drains.
- In order to facilitate the flow of excess water toward the drains, the field is given an artificial slope by means of land grading.

SUBSURFACE DRAINAGE:

- Changes in moisture content of sub grade or formation in embankment or cutting are caused mainly due to fluctuations in movement of capillary water, seepage water from adjacent area, ground water table and percolation of rain water.

1. **DRAINAGE OF CAPILLARY WATER:**

- The best method of preventing the capillary rise is to provide pervious layer in the embankment.
- The rise can also be prevented by providing a blanket or inverted filter of pervious material below the ballast.

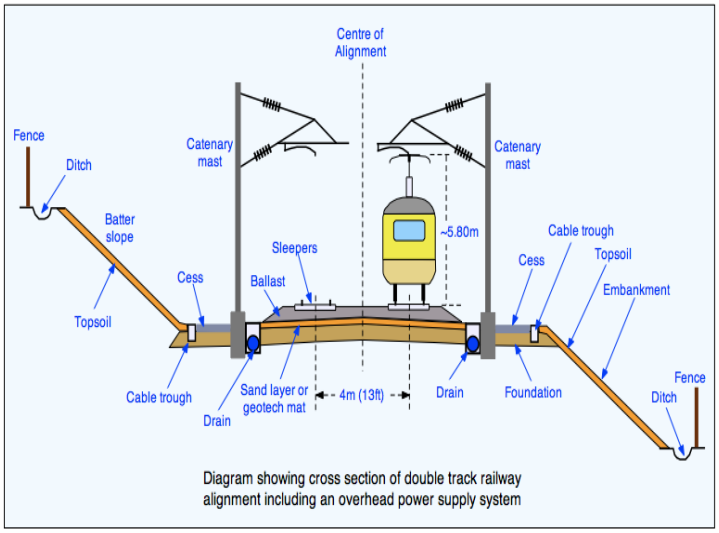


Diagram showing cross section of double track railway alignment including an overhead power supply system

TRACK DRAINAGE PROBLEMS:

1. Wet earth clogs the ballast.
2. Ballast sinks into the wet earth.
    - Use of pervious cess.
    - Use of perforated pipes and trench drains.
    - Use of inverted filter blanket.

- Cement grouting.
- Combination of pervious cess and inverted filter.\use of sand piles.
- Use of couterfort drains.
- Use of capillary break.

Video Content / Details of website for further learning (if any):
http://www.fao.org/docrep/r4082e/r4082e07.htm.

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.27)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 23.5)

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : 19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING

Course Teacher : Dr.R.SHANMUGAM

Unit : II - RAILWAY CONSTRUCTION AND MAINTENANCE

Date of Lecture:

Topic of Lecture:

VENTILATION FOR TUNNELS

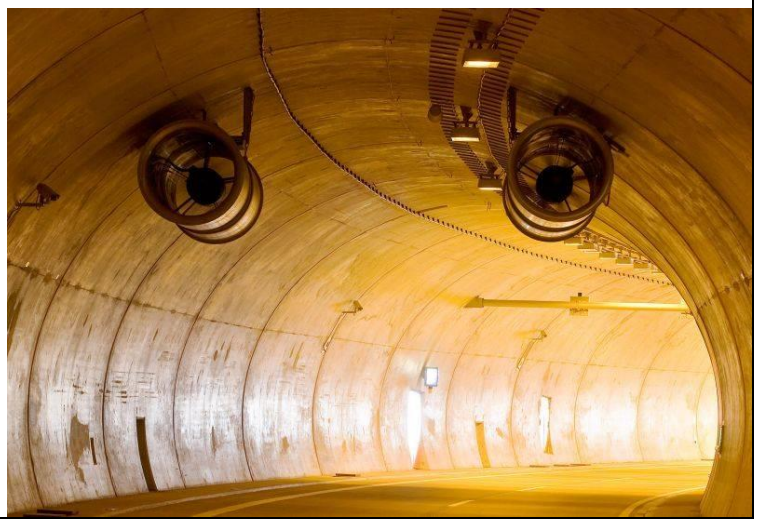
Introduction :

- Ventilation is a key element of electro-mechanical equipment and is crucial to the safety of tunnel operation.
- Due to increasing safety requirements, the ever-increasing length of tunnels and environmental protection issues, more and more demands are being made on tunnel ventilation systems today.

Prerequisite knowledge for Complete learning of Topic:

- Ventilation.
- Tunnel system.

Detailed content of the Lecture:



VENTILATION:

- The ventilation system greatly influences important parameters of the overall tunnel design.
- The earlier the aerodynamic concept and emergency response to fire are taken into account, the greater the efficiency and cost effectiveness with which these requirements can be harmonized with those of construction design, safety engineering and all other electro-

mechanical equipment.

- The company has successfully designed and supported the implementation of extremely complex ventilation systems all over the world and has played a leading role in the field of ventilation technology in the
- The most efficient ventilation system relies upon a combination of blower and exhaust fan.
- Immediately after blasting, exhaust system is used for 15 to 30 min to draw smoke and dust.
- For rest of the working time, fans are reversed for blowing in fresh air.
- The reversal operation can be done by valve arrangement.

SIMULATION OF TUNNEL VENTILATION:

- The software simulates the ventilation of complex road and rail tunnels, taking gravity and temperature effects into account.
- As a consequence, it is possible, for example, to investigate air flow in branch systems, the impact of the closure of a damper and the effect of the start-up of a fan.
- In the field of construction and installation ventilation, NUMSTA is a valuable tool to assess the interaction between air conditioning and
- It can also be used to simulate the aerodynamics of trains and road vehicles travelling at very high speeds through tunnel systems of almost any degree of complexity.
- For the construction of tunnels, it is mainly a matter of establishing what effect the pressure waves generated by vehicles have on adjacent surfaces in the entire tunnel system

ALTERNATES OF JET FAN LOCATION IN RAIWAY TUNNELS:

- The location of the jet fans at the roofing in the railway tunnels is impeded by the smaller cross-sectional area of the tunnel (34 – 55 m2) as well as the presence of the overhead trolley line in case of electrically driven engines.
- Thereby, only jet fans with the diameter below 900 mm can be located directly in the tunnel.
- In railway tunnels where electric propulsion engines are used the safety design margin limits the number of fans that can be installed in the section down to two fans fixed to the tunnel side walls.
- In railway tunnels that use diesel engines the safety design margin allows installation of up to four fans both at the roofing and on the side walls.
- The limited capacity of the traffic sections of the tunnels to locate the required number of jet fans needed to maintain the specified ventilation modes has resulted in attempts to find other design solutions.

SELECTION OF VENTILATION PATTERN FOR TUNNEL TO ENHANCE ITS OPERATIONAL SAFETY:

- The tunnel length is 3020 m with the cross sectional area of 44.5m2.
- The offset elevation is 530 m, while the elevation of Mt. Lysaya is 976 m.
- The respective elevations of the Southern and Northern Portals are 267.03 m and 283.94 m.
- Tunnel is characterized with bio-corrosion of engineering structures that lead to destruction of the concrete lining and malfunction of the signaling and communication systems, which impairs the safety of railway traffic.
-

ASSESSMENT OF EFFICIENCY OF NATURAL AIR FLOW CONTROL IN BAIKALSKY TUNNEL

WITH JET FANS:

- The peak elevation of the ridge reaches 1080 m.
- The Baikal tunnel is 6700 m in length with the cross sectional area of 34 m2 and the difference in portal elevation of 84 m.
- The tunnel was designed for unit-directional reverse movement of trains.
- To achieve this outside air is heated in winter time with fan heaters installed in ventilation structures at the tunnel portal

Video Content / Details of website for further learning (if any):

http://lampx.tugraz.at/~tunnel2014/history/Tunnel_2012_CD/PDF/17_Gendler.pdf/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING"
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : 19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING

Course Teacher : Dr.R.SHANMUGAM

Unit : II - RAILWAY CONSTRUCTION AND MAINTENANCE

Date of Lecture:

Topic of Lecture:

CALCULATION OF MATERIALS REQUIRED FOR TRACK LAYING

Introduction :

- Lay, repair, and maintain track for standard or narrow-gauge railroad equipment used in regular railroad service or in plant yards, quarries, sand and gravel pits, and mines.
- Includes ballast cleaning machine operators and railroad bed tamping machine operators.

Prerequisite knowledge for Complete learning of Topic:

- Railway track laying.
- Maintenance equipments operator.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

- Repair or adjust track switches, using wrenches and replacement parts.
- Cut rails to specified lengths, using rail saws.
- Patrol assigned track sections so that damaged or broken track can be located and reported.
- Clean tracks or clear ice or snow from tracks or switch boxes.
- Operate track-wrench machines to tighten or loosen bolts at joints that hold ends of rails together.
- Raise rails, using hydraulic jacks, to allow for tie removal and replacement.
- Clean or make minor repairs to machines or equipment.
- Dress and reshape worn or damaged railroad switch points or frogs, using portable power grinders.

MATERIALS USED IN TRACK LAYING:

- Modern running tracks are made out of synthetic rubber-like material.
- Some older tracks are made out of some combination of asphalt and rubber, but overall any running

track should be softer and springier than the material used in paved walkways.

- The exact materials vary depending on the vendor.
- For competition-level tracks, the surface is usually much harder and is designed for maximum energy return.
- This will lead to slightly faster performances, and almost inevitably any modern world records are set on such surfaces.
- For training, it is better for athletes to use a slightly softer track surface that absorbs some shock, leading to slower times but allowing the athlete to run on the surface for much longer without potentially causing injury.

MORDEN CONSTRUCTION IN RAILWAYS:

- The main contractor for the project, has already set up management camps along the proposed railway line between Nairobi and Mombasa to embark on the multibillion Kenyan shilling project.
- The construction of the SGR is one of the six critical thematic areas of the full year 2014/15 budget in order to further fortify the platform for accelerated inclusive growth.
- During the country's budgetary address, the government allocated 22.9 billion Kenyan shillings in the 2014/15 Budget to fund its portion of the Standard Gauge Railway project which is scheduled for completion and commissioning in 2017.
- The construction of the modern railway line is anticipated to contribute 1.5 per cent to the country's Gross Domestic Product (GDP).
- "Going forward we will see a higher GDP growth of 6.5 per cent in 2015 and 7 per cent by 2017 as a result of the SGR," Kenya's Cabinet Secretary of the National Treasury, Henry Rotich said during a press briefing in December.

SPEED TRENDS:

- The trains in developed countries are running with speed upto 200 – 210 Kmph.
- In japan the train run at speed upto 210 kmph.
- The maximum speed attained on trunk routes is 130 kmph.

MODERNIZATION OF TRACK:

- The speed at conventional track may be raised safely up to 250kmph, but not beyond that for achieving super high speeds.
- Moreover the conventional points and crossings will be replaced by movable type of crossing and a foam rubber packing or cushion may be provided below the sleepers.

HIGH POWERED LOCOMOTIVES:

- To meet with transport demand of the industries.
- Russia aims at introducing 4000 HP, locomotives known to be standard type at its railways.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.50)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 20)

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LECTURE HANDOUTS

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VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

Construction and maintenance of tracks –Modern methods of construction & maintenance

Introduction :

- Maintenance is the general day-to-day upkeep of the railway such as looking after tracks, signals and power supplies.
- Engineering work is larger scale projects such as track replacement.

Prerequisite knowledge for Complete learning of Topic:

- Maintenance of Tracks.
- Types of maintenance.
- Requirements.

Detailed content of the Lecture:

MAINTENANCE OF RAILWAY TRACK:

- The maintenance of railway track can be carried out either manually or by use of mechanical appliances or by a combination of i.e.., machines and labour.

The maintenance of track can be divided into two parts:

- Daily maintenance.
- Periodic maintenance.

Daily maintenance:

- Daily maintenance is carried out by the full time staff maintained through the year.
- The railway track is divided in suitable section of 5 to 6 km length.

Periodic maintenance:

- Periodic maintenance is carried out after an interval of two to three years.

- During periodic maintenance, the gauge, levels, alignment, points and crossing etc…

Site selection for railway stations:

- Acquisition of land.
- Proximity to town or village.
- Nature of land area.
- Approach roads to station site.
- Site drainage.
- Station amenities
- Type of station and yard.
- Station site alignment.

REQUIREMENTS OF A RAILWAYS STATION:

1) Public
2) Traffic staff and police.
3) Trains
4) Locomotives.
5) Development of railways.

FUNCTIONAL CLASSIFICATION: Based on their functions, stations are classified as below:

1) None – junction or wayside stations
2) Junction stations
3) Terminal stations.

Platforms: A raised level surface, from where either passengers board and alight from trains or loading and unloading of goods is done is known as a "platform".

Two types of platforms are provided at the stations.

1) Passenger platforms and
2) Goods platforms.

MODERN MATERIALS AND METHODS OF TRACK CONSTRUCTION AND MAINTENANCE:

1. Rail track restructing and maintenance.
2. Modern methods of construction and maintenance.

- Track laying machine.
- Ballast cleaning machine.\tamping machine.
- Catenary inspection and maintenance car.
- Strategies for track maintenance.
- Geotextiles.
- Non ballast track.
- Track recording.

Video Content / Details of website for further learning (if any):
http://www.engineeringarticles.org/soil-stabilization-and-railway-track/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.60)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 25)

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LECTURE HANDOUTS

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Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

RAILWAY STATIONS AND YARDS

Introduction :

- An area having a network of railway tracks and sidings for storage and maintenance of cars and engines.
- A railway yard in which trains are assembled and goods are loaded.
- Railroad yards have many tracks in parallel for keeping rolling stock stored off the mainline, so that they do not obstruct the flow of traffic.

Prerequisite knowledge for Complete learning of Topic:

- Stations and yards.
- Classification.
- Site selection for railway station and yards.

Detailed content of the Lecture:

STATIONS:

A station is defined as any place on a railway line where traffic is booked and dealt with and it is also the place where an authority is given to the trains to proceed further.

PURPOSE OF A RAILWAY STATION:

- For exchange of passengers and goods.
- For control of train movements

- To enable the trains on a single line track to cross from opposite directions.
- To enable the following express trains to overtake
- For taking diesel or coal and water for locomotives
- For detaching engines and running staff
- For detaching or attaching of compartments and wagons
- For sorting of bogies to form new trains, housing of locomotive in loco sheds.
- In emergencies in ease of dislocation of track due to rains, accidents etc...

RAILWAY YARDS:

- A yard is system of tracks for receiving, storing, sorting, making up and dispatch of passenger and goods trains.
- Normally movements of trains on yards are not governing by a time table.
- However movements are controlled by signals and have prescribed rules and regulation.

CLASSIFICATIONS OF STATIONS BASED ON OPERATIONAL CHARACTERISTICS:

a) Halt station – coaching yard.
b) Flag station – goods yard.
c) Crossing station – marshaling yards.
d) Junctions – locomotine yards.
e) Terminals – sick line yards.

CLASSIFICATIONS BASED ON MINIMUM SIGNAL REQUIREMENTS:

a) **'A' class station:** line has to be clear up to an adequate distance beyond home signal for giving permission to approaching train.
b) **'B' class station:** line has to be clear up to an adequate distance beyond outer signal for giving permission to approaching train.
c) **'C' class station:** It is only a block hut, where no passangers are booked.
d) **'D' class station:** These are flag station and are situated between any two consecutive block stations.

LAYOUT OF DIFFERENT TYPES OF STATION:

a) **HALT STATION:** The rail level platform with name boards at either ends.
   - Sometimes a small waiting shed, which may also serve as booking office is also provided.
b) **FLAT STATION:** It stands next to halt station.
   - It consists of waiting hall, booking office, platform with benches and drinking water facilities.
c) **CROSSING STATION:** It has in addition to basic facilities arrangement and equipment to control movement of trains.
   - This enables trains from either direction to pass independently.
d) **DOUBLE LINE STATION:** This separate up and down line is different to certain extent.
e) **JUNCTION STATION:** Two or more lines from different directions meet are termed as railway junctions.
   - The meeting may be between main lines and branch lines or between main lines.
f) **TERMINAL STATION:** A railway line or one of its branches terminates is known as terminal station.
   - This requires higher order facilities such as servicing, repairing, siding, changing of carriages and such other allied facilities.

FUNCTIONS OF DIFFERENT TYPES OF YARDS:

1. Coaching yards.
2. Goods yards.
3. Marshaling yards.
4. Locomotive yards.

5. Sick line yards.

FUNCTIONS OF MARSHALLING YARDS:

- Reception.
- Sorting.
- Departure yard.

TYPES OF MARSHALLING YARDS:

- Flat yards.
- Gravitational yards.
- Hump yards.

Video Content / Details of website for further learning (if any):

http://www.ustudy.in/node/1484.

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.64)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING" – (Pg.No – 18)

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LECTURE HANDOUTS

CIVIL

VI/III

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Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

PASSENGER AMENITIES - URBAN RAIL

Introduction :

- Indian Railways are one of the biggest transporters of passenger traffic in the world. Indian Railways run nearly 7500 passenger trains daily carrying on an average 12 million passengers per day.
- With the quickening pace of modernization, the Railway traveller today expects much more from the system than he did in the past in the form of amenities.

Prerequisite knowledge for Complete learning of Topic:

- Passenger Amenities.
- Highlights.
- Organisational set up.
- Scope of review.
- Sample size.

Detailed content of the Lecture:

PASSENGER AMENITIES:

- The provision of passenger amenities is, therefore, one of the important objectives of the Indian Railways both as a business ethic and a social obligation.
- The Indian Railways have issued a Citizens' Charter on Passenger services in which, it has been pledged to ensure adequate passenger amenities in trains and at Railway stations.

- One of the thrust areas in the VIII Plan was to provide basic passenger amenities at all stations on a priority basis.

Consequent to the recommendations of the Standing Committee of Parliament on Railways, the whole gamut of passenger amenities at stations was reviewed and Railway Board decided (May 1995):

1. To provide/ augment the existing facilities in a planned manner, by drawing up a Perspective Plan for the provision of passenger amenities and,
2. importance and volume of traffic handled at each station.

Board to the instructions issued in 1995:

- The amenities were classified as 'Minimum Essential Amenities', 'Recommended amenities' and 'Desirable amenities.
- Stations were categorised in 6 categories (categories A, B, C, D, E and F) depending upon the earnings. The yard sticks/ extent to which the amenities were to be provided was linked to the category of station.
- The categorisation was to be reviewed every five year. The next review is due in 2001, based on the earnings for the year 2000-2001.

ORGANISATIONAL SET UP:

- A separate Directorate functions in the Railway Board for monitoring passenger amenities provided and maintained by the Zonal Railways.
- The responsibility for monitoring of passenger amenities at the Zonal Headquarters rests with the Chief Commercial Manager (G) who is assisted by the Chief Engineer (P & D) and Deputy Chief Engineer (Planning).
- At the Divisional level, the Divisional Railway Manager (DRM) holds the overall charge.

SCOPE OF REVIEW:

The review attempts to examine

1. Whether the passenger amenities provided by the Railways were in accordance with the norms prescribed by the Railway Board.
2. Whether the facilities provided were maintained properly and actually utilised for the purpose. The review covers a period of five years from 1996-97 to 2000-2001.

SAMPLE SIZE:

At the macro level a general review of the passenger amenities available on stations was carried out. In addition the test-check as follows was carried out:

a. Maintenance of Passenger Amenities - 50 per cent of the Divisions on each Zonal Railway.
b. Halt Stations - Two Divisions on each Zonal Railway.
c. Model Stations - 50 per cent of the model stations on each Zonal Railway as notified by the Railway Board on 4th June 1999.

PROVISION OF MINIMUM ESSENTIAL AMENITIES:

- A commitment was made to the Estimates Committee that all deficiencies in respect of basic amenities, as per norms, would be eliminated by 1990-91.
- A review of extent of amenities provided so far revealed that out of 9 Zonal Railways, on 8 Zonal Railways more than 30 per cent of stations are having deficiencies in the following 'Minimum Essential Amenities':

- Booking Counter.
- Drinking water.
- Waiting Hall/ shed.
- Urinals.
- Latrines.
- Platform Shelters/ Shady trees .
- Seating arrangements.
- Fans.

Video Content / Details of website for further learning (if any):
http://saiindia.gov.in/english/home/Our_Products/audit_report/Government_ Wise/union_audit/recent_reports/union_performance/2002/Railway/2002_book2/chapter2.htm.

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.71)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING".

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **II - RAILWAY CONSTRUCTION AND MAINTENANCE**

Date of Lecture:

Topic of Lecture:

Infrastructure for Metro, Mono and underground railways.

Introduction :

- India has amongst the largest railway network in the world.
- Every city, town, village has a rail connection. Through railways very large volumes of goods can be transported economically over long distances to remote places in the country.
- Railways help to transport raw materials from extractive industries which are located at considerable distances. Besides this railways also transport massive amount of steel, automobiles, war equipment, across the country.

Prerequisite knowledge for Complete learning of Topic:

- Road transport.
- Water transport.
- Inland water transport.
- Mass rapid transit system.
- Rapid transit system.

Detailed content of the Lecture:

ROAD TRANSPORT:

- Road transport forms an essential part of any transport activity, whether rail, sea or air.
- It is essential as a supplementary and complementary mode of transport to complete movement by other modes of transport. Eg. From one terminal i.e. the railway station the goods have to be carried to the destination by road.
- In comparison to railroads, motor carriers have relatively small fixed investments in terminal facilities and

operate on publicly maintained highways.

In short Road transport offers certain **advantages** like

- Door to door service to customers which neither rail nor neither sea nor air transport can offer.

- On per unit basis, the cost of making a road is 1/6`h that of laying a railway line.
- Capital investment in case of railways is much less then railways designed to carry equivalent quantum of traffic.
- Road transport provides employment to many people.

WATER TRANSPORT:

- One of the oldest modes of transportation is water. In terms of time factor, they may be slow. But, they Water transport could be of inland can carry more shipment, at reduced cost over longer distance. Water transport could be of inland type or oceanic transport.

INLAND WATER TRANSPORT:

- In our country Inland water transport through rivers and canals is quite popular because of the low cost and bulk transport. But here, the inland water transport system heavily depends upon the rain and in many places on the tides.
- In our country Inland water transport through rivers and canals is quite popular because of the low cost and bulk transport. But here, the inland water transport system heavily depends upon the rain and in many places on the tides.

MASS RAPID TRANSIT SYSTEM:

- It is the backbone of any city transport system.
- Growth of personal modes of transport is not desirable in terms of pollution, fuel consumption and road space occupancy per person.
- Energy saving and environmental protection calls for restriction on personalized modes and promotion of public transport.

RAPID TRANSIT SYSTEM:

ADVANTAGES:

- Non polluting and environmental friendly system.
- High carrying capacity.
- Requires less space to carry same number of passengers.
- Fast, reliable, safe and comfortable.

Video Content / Details of website for further learning (if any):

http://www.bms.co.in/explain-the-various-modes-of-transportation/

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 2.80)
- ✓ S.C.Saxena & S.C.Arora "A TEXT BOOK OF RAILWAY ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Airport characteristics, airport classification.

Introduction :

- Airport is a location where facilities for landing and takeoff operations for aircraft are made available.
- They have elements such as runways, taxiways and buildings with passengers facilities, aprons, hangers, visual aids and air traffic controls.

Prerequisite knowledge for Complete learning of Topic:

- Airport characteristics.
- Airport classifications.
- Terminal airport.
- Intermediate landing ports.

Detailed content of the Lecture:

AIRPORT 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.
- It is the fastest mode of transport.
- Its velocity is faster than that of sound.
- It is capable of navigating continuously over mountains and ocean without any break in journey.
- It is also capable of accessing even remote locations such as forests, island and snowed mountains that are in accessible by other modes.
- However it has serious limitations by way of lesser carrying capacity and prohibitive costs.

AIRPORT CLASSIFICATIONS:

- 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 length; in the reference field length the stop way and the clear way are included as well.
- 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 classifications:

1. Terminal airport terminal facilities and filling stations):
    - ✓ Defence.
    - ✓ Commercial.
        - ✓ Ownership – Public, Joint, Private Venture.
        - ✓ Size – Larger, Medium and Smaller.
        - ✓ Area of operation – Domestic and international.
    - ✓ ICAO classifications – Airport reference code.
        - ✓ Letter code.
        - ✓ Number code.
2. Intermediate landing ports.

AIRPORT TERMINOLOGY:

1. **Aerodrome:** It is intended to be used for arrival and departure of aircraft.
2. **Air Field:** It is a field where aircraft can take off and land specifically, it is the landing field of an airport usually a military field.
3. **Airport:** A place where aircraft can take off. Usually they are equipped with hangers, facilities for refueling and accommodation for passengers.
4. **Aircraft:** Any machine supported for flight in the air by buoyancy or by the dynamic action of air on its surfaces, especially powered airplanes, gliders, and helicopters.
5. **Apron:** It is the area of an airport where aircraft are parked, unloaded or loaded, refueled, or boarded. The use of the apron is covered by regulations, such as lighting on vehicles; it is typically more accessible to users than the runway or taxiway.
6. **Run way:** A defined rectangular area prepared for landing and takeoff of aircraft and over which aircraft runs on ground.
7. **Airport and runway elevations:** Elevation of each threshold, elevation of runway end and significance high and low intermediate points along the runway and the highest elevation of the touchdown zone of a precision approach runway shall be given to the nearest metre.
8. **Airport reference temperature:** Airport reference temperature is monthly mean of daily maximum temperatures for the hottest month of a year. The temperature should be averaged over a period of years.
9. **Strength of pavements:** The bearing strength of a pavement should be greater than 5700 kg.
10. **Runway strip:** The area includes the runway and stop way.
    Purpose of the runway strip:
    - ✓ Reduce the risk of damage to aircraft on runways.
    - ✓ Protects aircrafts during takeoff or landing operation.

Video Content / Details of website for further learning (if any):
http://www.skycolors.com/paper_the-airport.htm.

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.2)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Airport Planning

Introduction :

- The site selection report should contain information on potential environmental impacts such as acres impacts to farmland, wetlands, historic properties, properties, and forest lands as well as necessary relocations.
- The site selection report must contain sufficient information to make an informed decision concerning the relative development costs of each of the proposed sites.

Prerequisite knowledge for Complete learning of Topic:

- Socio economic characteristics of catchment area.
- Site selection for airport.
- Factors influencing size of an airport.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

AIRPORT PLANNING:

SOCIO – ECONOMIC CHARACTERISTICS OF CATCHMENT AREA:

i. Assessment of traffic potential:

- Assessment of traffic potential for a proposed airport in terms of passenger and cargos is a crucial element in establishing the need for an airport.
- The first step in assessment of traffic potential is to delineate catchment area of the proposed airport in the national network of airport.
- After demarcation of imaginary influence area, socio economic characteristics of the population are studied.

ii. Population:

- Total population.

- Rate of growth of population.
- Estimation of future population.

iii. Economic characteristics:

- Pattern of employment – Industries, Business, Government, Private, others.
- Income group – Composition of families under high income group and middle income groups.
- Average per capita income of persons in income groups of HIG and MIG.
- Pattern of expenditure – Proportion of expenditure for different items and more particularly for travel.

iv. Travel characteristics:

- Frequency of air travel.
- Modal choice.

✓ Socio economic characteristics of the region are compared with that of other comparable regions, where airports are already in existence.

✓ From the comparative analysis, annual passenger volume and expected cargo volume are assessed.

SITE SELECTION FOR AIRPORT:

- ✓ Site selection is a critical element in airport planning.
- ✓ Efficiency, safety and capacity of airport to a greater extent depend on suitability of sites.
- ✓ The site analyses for alternate site are under taken and the best among them is chosen.
- ✓ Parameters for site selection include physical and economic characteristics of site and on site and off site facilities available.

FACTORS INFLUENCING SIZE OF AN AIRPORT:

- ➢ Type of an airport i.e., domestic or international or defence.
- ➢ Size of an airport depends upon whether it is an international or domestic one.
- ➢ Traffic potential of an airport region.
- ➢ Aircraft characteristics such as aircraft capacity, aircraft speed, minimum circling radius, minimum turning radius, noise level and takeoff and landing distance.
- ➢ Site characteristics such as topography and land availability.

AIRPORT PLANNING INVOLVES THE PREPARATION OF FOLLOWING PLANS:

- Topographical plan.
- Layout plan.
- Design of runway, taxiway and building.
- Vehicular circulation and parking area plan.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.6)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Objectives, Components, Airfield Layout Characteristics

Introduction :

- 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.
- 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.

Prerequisite knowledge for Complete learning of Topic:

- Airport planning.
- Objectives.
- Components.
- Layout characteristics.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

AIRPORT PLANNING:

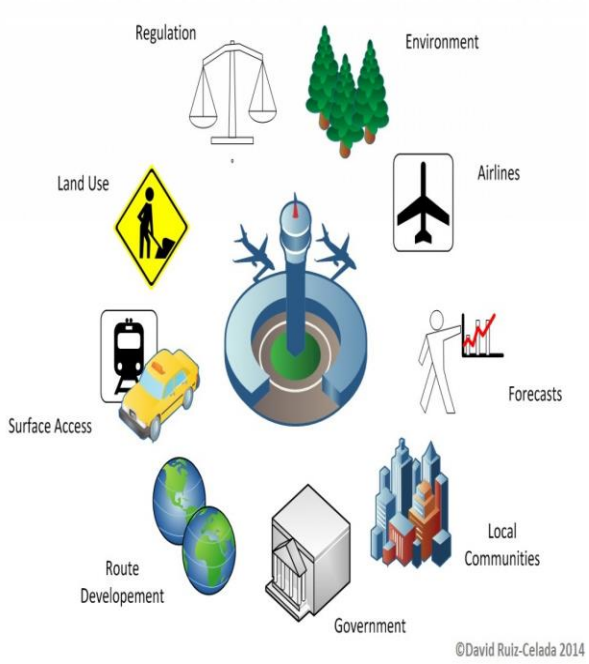
INTRODUCTION:

- It refers to preparation of a scheme beforehand for development of airport.
- Requirements of an airport are to ensure safe and speedy transport of air travel passengers.
- It has to facilities reception and departure of aircraft with least possible delays.

OBJECTIVES:

- 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.
- Justify the need for an airport.
- Formulate a layout plan for the airport and design of runways, taxiways and airport buildings.
- Prepare cost estimation.
- Propose institutional arrangement.

- Optimize the economic performance, the revenues generated, the construction costs and the functionality
- Integrate a flexibility that allows development of the airport that is adapted to its needs and to its future growth
- Guarantee the most efficient functioning for the airport in question



COMPONENTS OF AIRPORT PLANNING:

1. Assessment of traffic potential.
2. Site selection.
3. Design and drawing of airport components.
4. Cost estimation.
5. Evaluation of economic viability, engineering feasibility and environmental impact.
6. Financial resources.
7. Institutional arrangement.

AIRFIELD LAYOUT CHARACTERISTICS:

- Landing, takeoff and taxing – Independent operations.
- Shortest taxiway.
- Safe runway length.
- Safe approaches.
- Excellent control tower visibility.
- Adequate loading apron space.
- Comprehensive terminal building facilities.
- Land area for future expansion.
- Cost effective construction, maintenance and operation.

TYPES OF AIRPORT PLANNING:

- National System Planning.
- State Airport System Planning.
- Metropolitan Airport System Planning.
- Airport Master Planning.

Video Content / Details of website for further learning (if any):
http://www.faa.gov/airports/central/aip/sponsor_guide/media/0500.pdf

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.5)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Primary functions, Planning Concept, Principles of Passenger Flow , criteria for airport site selection and ICAO stipulations.

Introduction :

- Site selection is a very crucial stage in airport planning.
- A few alternate sites identifies in the designated are evolved against set criteria and the best among them is chosen.
- Cost of construction, cost of maintenance, efficiency and safety of airports depends upon sites.

Prerequisite knowledge for Complete learning of Topic:

- Airport site selection.
- Regional plan.
- Airport use.
- Proximity to other airport.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

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.

1. ICAO Stipulation:

- A region is a larger area consisting of cities, towns and villages.
- It gives a bird's eye view of all natural and manmade features.
- The ICAO has stipulated a minimum distance of separation between airports.
- This helps to narrow down location of proposed airport at macro level.

2. Significance of regional plan in airport planning:

- Under instrument landing system, aircrafts are brought to ground with the help of radio beam facilities.
- The operator of an aircraft manipulates control instruments as directed by radio beams.
- If two airports are close by operations of electronic instruments and movement of aircrafts may interfere.
- The minimum separation as per ICAO standards is required.

3. Minimum spacing as per FAA:

- Smaller airports under visibility flight rules(VFR) condition – 3 Km.
- Bigger airport under VFR condition – 6 Km.
- Airports operating piston engine aircrafts - 25 Km.
- Airports operating jet engine aircrafts – 160 Km.

The proposed site should satisfy standard for separation 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.
- Therefore the airport site selected should be such that it provides natural protection to the area from air roads.
- This consideration is of prime importance for the airfields to be located in combat zones. If the site provides thick bushes.

PROXIMITY TO OTHER AIRPORT:

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

GROUND ACCESSIBILITY:

- The site should be so selected that it is readily accessible to the users. The airline passenger is more concerned with his door to door time rather than the actual time in air travel.

• The time to reach the airport is therefore an important consideration especially for short haul operations.
Video Content / Details of website for further learning (if any): http://royal-civil.blogspot.in/2008/08/how-to-select-site-for-airport.html http://www.aboutcivil.org/factors-affecting-site-selection-for%20different-structures.html
Important Books/Journals for further learning including the page nos.: ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.10) ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture: Airport site selection

Introduction :

- Site selection is a very crucial stage in airport planning.
- A few alternate sites identifies in the designated are evolved against set criteria and the best among them is chosen.
- Cost of construction, cost of maintenance, efficiency and safety of airports depends upon sites.

Prerequisite knowledge for Complete learning of Topic:

- Topography.
- Obstruction.
- Visibility.
- Wind.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

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.
- It refers to natural features such as ground contours, water bodies, hillocks, forests, bushes,

trees and manmade features such as pattern of land use, intensity and height of buildings.

- An elevated site is considered ideal for an airport than to a plain or low lying site.

Advantages of elevated sites:

a. Less obstruction in approach and turning zones.
b. Natural drainage.
c. Uniform wind intensity.
d. Better visibility.

- Tall buildings in the proximity of a site and land uses, which generate wastes and consequently attract bird are objectionable.
- The site which is better from topographical point of view should be preferred.

OBSTRUCTIONS:

- When aircraft is landing or taking off it loses or gains altitude very slowly as compared to the forward speed.
- Long clearance areas are provided on either side of runway known as approach areas over which the aircraft can safely gain or lose altitude.

VISIBILITY:

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

WIND:

- Runway is so oriented that landing and takeoff is done by heading into the wind should be collected over a minimum period of about five years.
- Orientation of runway and efficiency of airports greatly depends upon the direction, duration and intensity of prevailing wind, frost, fog and temperature.
- Air transport is highly susceptible to meteorological factors.
- Therefore any proposed site should be carefully evaluated against wind, frost and fog.

NOISE NUISANCE:

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

GRADING, DRAINAGE AND SOIL CHARACTERISTICS:

- Grading and drainage play an important role in the construction and maintenance of airport

which in turn influences the site selection.

- The original ground profile of a site together with any grading operations determines the shape of an airport area and the general pattern of the drainage system.
- The possibility of floods at the valley sites should be investigated. Sites with high water tables which may require costly subsoil drainage should be avoided.

FUTURE DEVELOPMENT:

- Considering that the air traffic volume will continue to increase in future more member of runways may have to be provided for an increased traffic.

SHAPE AND DIMENSION OF A SITE:

- Shape of an airport depends upon the type and class of an airport, prevailing wind direction and configuration of runway.
- The shape of the site should preferably conform to regular geometrics such as rectangular, square and trapezoidal.
- Sites with odd dimensions may not be suitable

Video Content / Details of website for further learning (if any):

http://royal-civil.blogspot.in/2008/08/how-to-select-site-for-airport.html

http://www.aboutcivil.org/factors-affecting-site-selection-for%20different-structures.html

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.10)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

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VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Typical airport layouts.

Introduction :

- 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.

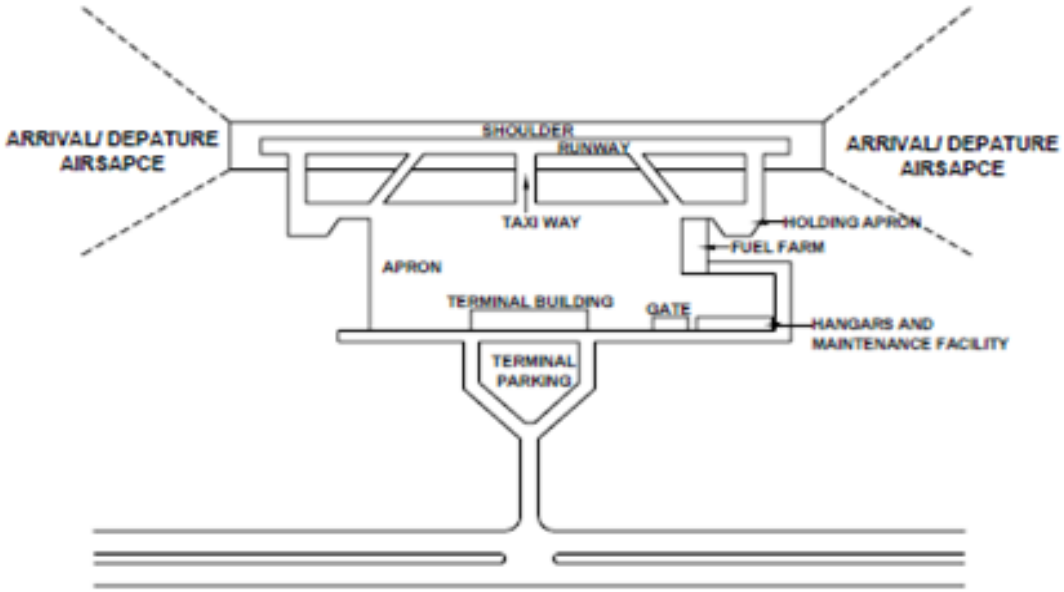
Prerequisite knowledge for Complete learning of Topic:

- Airport layout.
- Requirements of well-planned airport.
- Airport capacity.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

TYPICAL AIRPORT LAYOUT:

- Runway is the principal elements of an airport.
- The components of airport should have good correlation with runway.
- Integration of all elements makes efficient and effective airport.



REQUIREMENTS OF WELL PLANNED AIRPORT:

a. Optimal route from the apron to the runway, through the taxiway.
b. Control tower with a command over entire airfield.
c. Optimal service to air passengers.
d. Cost effective construction and maintenance.
e. Scope for future expansion.

- 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.
- 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.
- 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 - 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.

Inner portion of the approach surface drawing - Drawings containing the plan and profile view of the inner portion of the approach surface to the runway and a tabular listing of all surface penetrations. The drawing also may depict other approach surfaces, including the threshold-siting surface, those surfaces

associated with United States Standards for Instrument Procedures (TERPS), or those required by the local FAA office or state agency. The extent of the approach surface and the number of airspace obstructions shown may restrict each sheet to only one runway end or approach.

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.

Video Content / Details of website for further learning (if any):
http://www.southsuburbanairport.com/MasterPlan/MP-airportlayoutplan.htm

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING".
- ✓ S.C.Rangwala " AIRPORT ENGINEERING".

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Case studies of Airport Layouts

Introduction :

- 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.

Prerequisite knowledge for Complete learning of Topic:

- Conceptual layout pattern.
- Airport capacity.
- Layout of Indian airport.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

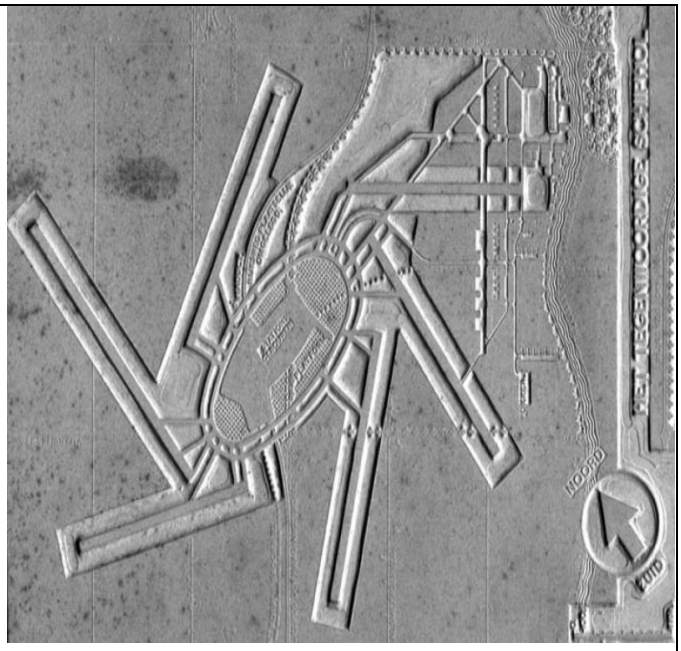
CONCEPTUAL LAYOUT PATTERN:

- Pattern of airport layout is determined to a greater extent by configuration of runways.
- A runway is the principal element in an airport.
- Secondary elements such as apron, taxiway and terminal building are positioned based on the orientation of runway.

AIRPORT CAPACITY:

- This refers to the ability of the airport to offer services for landing/takeoff operations in a given time.

- The capacity of an airport is expressed in terms of number landing or taking off in the said airport.
- Capacity of the airport is depends on the following factors.,
  a. Runway configuration.
  b. Sky line of surrounding developments.
  c. Loading apron space.
  d. Types of instrument – landing systems.

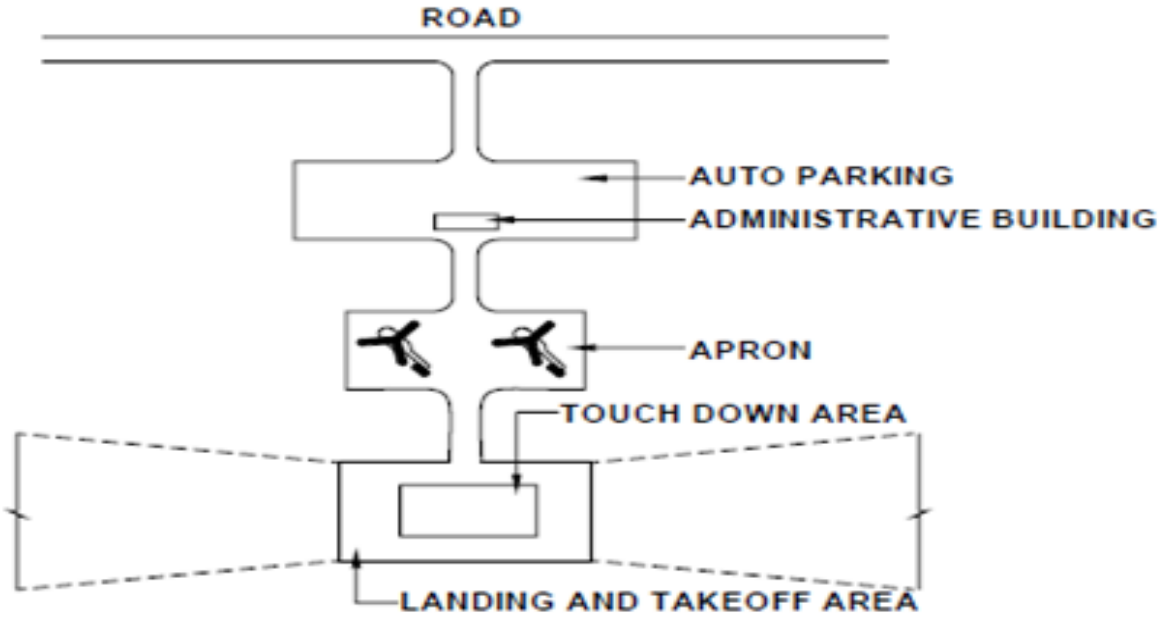


LAYOUTS OF INDIAN AIRPORT:

- Chennai airport handled around 120 landings a day.
- The breakup was 95 on St. Thomas mount end of the main runway and 25 on pallavaram side based on wind conditions.
- With the installation of ILS on pallavaram end, 48 landing could the handled.

HELIPORTS:

- It is prepared ground used for landing and takeoff of helicopters.
- It may have all facilities similar to that of airports but to a smaller scale.
- Landing area may range between 0.50 to 0.75 hectares.
- Chief characteristics of a helicopter are the capacity to hover around in air.



Typical Layout of a Heliport

Video Content / Details of website for further learning (if any):
http://www.southsuburbanairport.com/MasterPlan/MP-airportlayoutplan.htm

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING".
- ✓ S.C.Rangwala " AIRPORT ENGINEERING".

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Parking.

Introduction :

- One of the drawbacks of present air transport system is that the time saved in air travel is lost in surface travel.
- To optimize the surface travel within an airport, an efficient parking and circulation area have to plan.

Prerequisite knowledge for Complete learning of Topic:

- Parking.
- Categories of parking.
- Size of apron.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

PARKING:

- Parking may be defined as leaving of a car or other personal vehicle in a particular place for certain time.
- Air travel has become more popular among upper middle class and higher income group population.
- The socio economic status of air passengers are very high when compared with those who travel by railways, highway or waterways.
- The federal aviation agency (FAA) has stipulated certain guidelines to assess motor vehicles parking.
- According to FAA for each peak hour air passenger 1.5 to 2 cars are assumed as peak hour parking demand.

PARKING LOCATION:

- Location of parking area should be within a short distance from entrance of airport building.
- The minimize walking distance by passengers and visitors.
- This is particularly important because air passengers carry voluminous baggages.
- Parking spaces shall be located on a same lot.
- Parking shall not be located within the set back area of an airport building.
- In Indian context car parking bays are 2.5 m x 2.5 m.

CATEGORIES:

1. Short term
2. Long term.
3. Remote.

SHORT TERM:

- This parking facility are very nearer to the terminal building and a certain rent is charged for their use.
- The baggage trollies are available for carrying the suitcases.
- The short term parker usually park for 3 hours or less and nearly account for about 80 per cent of the parkers at an airport.
- They account for only 15 to 20 per cent of the accumulation of vehicles in the parking facility.

LONG TERM:

- This parking is slightly away from the main terminal complex and the rents are usually discounted for long term users.

REMOTE:

- The remote parking is usually quite distant from the main terminal complex and provisions are usually made to carry baggage between these areas and the main terminal complex.
- The rents are most economical.

SIZE OF APRON:

The three factors affect the size of an apron,

- Gate position.
- Number of gates.
- Systems of aircraft parking.

Gate position: used to denote an aircraft parking space adjacent to a terminal building and used by a single aircraft for the loading and unloading of the passengers and cargo.

The size of gate depends on the following two factors,

- Size of aircraft.
- Type of parking.

TYPES OF AIRCRAFT PARKING:

1. Nose in parking.
2. Angled nose in parking.
3. Nose out parking.
4. Angled nose out parking.
5. Parallel parking.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING".
- ✓ S.C.Rangwala " AIRPORT ENGINEERING".

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **III - AIRPORT PLANNING**

Date of Lecture:

Topic of Lecture:

Circulation area.

Introduction :

- 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.

Prerequisite knowledge for Complete learning of Topic:

- Circulation area.
- Access.
- Drive way standard.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

CIRCULATION AREA:

a) ACCESS:

- An important consideration in planning parking lot is it should be easily accessible.
- Time is a critical factor for air passengers.
- Therefore the planning for parking lot shall ensure least possible delay during entry and exit.
- Significance of this layout is adequate space for unparking vehicles to turn around.

b) DRIVEWAY STANDARDS:

- One way driveway for parking spaces shall have a minimum width of 3.75m.
- Two way driveways shall have a minimum width of 6.25m.

- Driveways or turn around aisles shall not be dead ended.
- Parking lots must be located close to arrival and departure halls.

c) MAXIMUM AISLE LENGTH:

- Maximum length of aisle should not exceed 100m, without a break in circulation.
- This will enable a parker to easily find parking space when a lot is approaching to capacity.
- Limitation on maximum length also discourages speeding of vehicles.
- An aisle width should be sufficient to allow a driver to couple parking and unparking manoeuvres in a single, convenient, smooth turn.

d) EMPLOYEES PARKING:

- It is desirable to segregate employees parking from that of passengers.
- Employees parking are normally long term parking.
- Modular width of employees parking can be narrower.

e) PARKING LOTS:

- Surface parking lots are provided very close to airport building.
- In case sufficient spaces are not available, multi storeyed car parking is provided.
- Based on size and shape of parking lots, the best parking angle is decided.
- Common patterns of parking adopted are:
    1. Parallel parking.
    2. 30^o angular parking.
    3. 45^o angular parking.
    4. 60^o angular parking.
    5. Right angle parking.
- Vehicles parked parallel to kerb is parallel parking.
- If vehicles are parked making angles with a kerb such type of parking is termed as angular parking.
- An operation of parking and unparking is difficult in parallel parking.
- Parking with 60 degree is practicable while 45 degree parking yield best result.
- Right angled parking is adopted only under exceptional condition.
- At airport parking for 3 hours or less is termed as short term parking.

APRON:

- It is a paved area for parking of aircraft for embarkation and de embarkation of passengers, loading and unloading of cargo and serving of aircrafts without interference to surface traffic aircrafts.
- The size of aprons depends upon.,
    1. Types of airports.
    2. Numbers and types of aircrafts using airports.
    3. Basic parking configurations of aircrafts.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING".
- ✓ S.C.Rangwala " AIRPORT ENGINEERING".

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Runway design.

Introduction :

- The runway orientation is the result of compromises between the airport usability and additional factors, such as available land, existing obstructions, topographic difficulties, flight path interference, noise pollution and other environmental impacts.
- The runway orientation is the aircraft operating direction related to true north. The runway configuration is the length, width, number and layout of runways.
- The runway orientation and configuration must be suitable for the size and shape of available land, satisfying the capacity requirement, safely avoiding existing obstructions, and minimizing environmental impacts to residential areas.

Prerequisite knowledge for Complete learning of Topic:

- Introduction.
- Elements of geometric design of runways.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

INTRODUCTION:

- Runway design is planning for a pattern and arrangement of runways.
- Components of runways design are runway orientation and wind coverage.
- Orientation is the position or direction of a runway.
- Coverage is the percentage of time in a year, during which a runway could be put into use.
- Runway is designed by drawing wind rose diagram.
- Wind rose diagram is one in which the direction, duration and intensity of wind at a selected airport site is represented to scale.
- Since the diagram resembles petals of a rose, it is named as wind rose diagram.

ELEMENTS OF GEOMETRIC DESIGN OF RUNWAYS:

- Runway length.
- Runway width.
- Width and length of safety area.
- Transverse gradients.
- Longitudinal and effective gradients.
- Rate of change of longitudinal gradients.
- Sight distance.

ORIENTATION OF RUNWAY:

- Orientation is positioning of runway.
- It is a runway usually along prevailing wind direction.
- This facilitates landing and takeoff operation in 'head wind'.
- Landing and takeoff operation take place in direction opposite to the prevailing wind. When landing operations take place against wind direction, the head wind provides a braking effect to aircraft and they come to a stop in a smaller length of runway.
- Similarly when aircraft takeoff the head wind provides greater lift on wings of aircraft and enables it to rise above the ground with in a shorter length of runway.
- Therefore a runway is oriented in head winds.
- Wind data in terms of direction, duration and intensity for the selected site is collected for 5 to 10 years. These factors impact orientation of runways.
- The orientation of a runway depends upon the direction of the wind and to some extent on the area available for development
- The direction of the runway controls the layout of the other airport facilities such as passenger terminals, taxiways, apron configuration, circulation roads and parking facilities.
- If there is cross wind available on any of the airport, which is mostly as per the FAA standard it says that for 95% of the time period, the aircraft should be able to take off or they should be able to land, without taking an effect of the allowable crosswinds into consideration.
- Another thing related to cross wind is the ICAO recommendation which has a maximum allowable cross wind component as defined for the different field lengths, reference field lengths and on the basis of that, like if the value of the reference field length is 1500 meters or over, that is more than that, then in that case, the maximum cross wind component can be 37 kilometers per hour, whereas if it is between 1200 metres and 1499 metres, then this is taken as 24 kilometers per hour and if it is less than 1200 metres, it is taken as 19 kilometers per hour.

Video Content / Details of website for further learning (if any):
http://www.skycolors.com/paper_the-airport.htm.

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.2)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Runway Length

Introduction :

- The number and orientation of the runway play an important role in the overall arrangement of various components of an airport.
- The length of runway based on the following assumed conditions is known as runway length.

Prerequisite knowledge for Complete learning of Topic:

- Runway length.
- Actual runway length.
- Problems in actual runway length.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

BASIC RUNWAY LENGTH:

Basic runway length is the length of a runway under following ideal conditions of an airport.

- Altitude of an airport is at sea level.
- Airport has standard temperature (15^0 c).
- Runway has no longitudinal gradient.
- Wind does not blow on the runway.
- Airport is loaded to its full capacity.
- Wind does not blow en route to destination.

- En route temperature is standard.

Basic runway length is determined based on an aircraft performance. Normally, the following cases are considered.

1. Normal landing.
2. Normal takes off case.
3. Engine failure case.

ACTUAL RUNWAY LENGTH:

(i) **Correction for elevation:** Temperature and gradients.

- ✓ Ideal condition for an airport is not possible in real world situation.
- ✓ In most of cases elevation of airport may not be at mean sea level and they may not have standard atmospheric condition.
- ✓ Correction may be required for actual sites of airports of any change in elevation, temperature and gradients.

(ii) **Correction for elevation:**

- ✓ Air density reduces with increase in elevation.
- ✓ The turn reduces lift on wings of aircrafts.
- ✓ Consequently longer runway is required.
- ✓ Therefore ICAO has recommended that basic runway length has to be increased by 7% for every 300 m rise in elevation above mean sea level.

(iii) **Correction for temperature:**

- ✓ Airport reference temperature is the sum of monthly mean average daily temperature for the hottest month of a year (Ta) and the monthly mean of maximum daily temperature (Tm) for same month of the year.

Reference temperature = (Ta) + ((Tm – Ta)/3).

(iv) Check for total correction for elevation plus temperature:

- ✓ ICAO has recommended that if total correction for elevation plus temperature exceeds 35% of the basic runway length.

(v) Correction for gradient:

- ✓ Steeper gradients requires longer runway. Therefore a runway length needs to be increased, in case of longitudinal gradients.
- ✓ As per F.A.A recommendations the runway has to be increased at a rate of 20% for every one percent of effective gradients.

(vi) Effective gradients:

- ✓ Effective gradients may be defined as the maximum difference in elevation between the highest and the lowest points of runway per unit length of runway.

Examples:

Monthly mean of average daily temperature for the hottest month of year at an airport site is 40^0 c. monthly mean of maximum daily temperature for the same month of the year is 50^0c. Calculate the airport reference temperature if the site is at mean sea level with a level ground. Determine the actual runway length is be provided.

Solution:

Mean of maximum daily temperature (Tm) = 50^0c.

Mean of average daily temperature (Ta) = 40^0c.

Airport reference temperature = Ta + (Tm – Ta) / 3.

= 43.33^0c.

Standard atmospheric temperature at mean sea level = 15^0c.

Rise in temperature = 43.33 – 15 = 28.33.

Correction = one percent per 1^0c rise of temperature.

Assume basic runway length as L meters.

Required correction = L/100 x 28.33 = 0.2833 L meters.

Corrected length = L + 0.2833 L = 1.2833 L meters.

The runway is at mean sea level. Therefore actual length of runway = 1.2833 times the basic runway length.

Video Content / Details of website for further learning (if any):

Nil

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.30)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Geometric design of runway.

Introduction :

- ICAO gives various geometric standards for the airport design.
- Most of its member nations provide international air services.
- In order to have uniformity in the landing facilities at the airport located in different countries, it is desirable to follow the common design standards as recommended by ICAO

Prerequisite knowledge for Complete learning of Topic:

- Length.
- Longitudinal and effective gradients.
- Rate of change of longitudinal gradients.
- Safety area.
- Sight distance.
- Transverse gradients.
- Width.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

LENGTH:

- The basic runway length will depends on the category in which the airport falls as per ICAO classification.
- The actual runway length is obtained by making adjustments for elevation, gradients and temperature with the basic runway length.

LONGITUDINAL AND EFFECTIVE GRADIENTS:

- The longitudinal gradients of runway increase the required runway length and also affects the airport performance in a number of ways.

RATE OF CHANGE OF LONGITUDINAL GRADIENTS:

- The sudden or abrupt change of the longitudinal gradients is undesirable because it may restrict the height distance and may cause premature lift off of the aircraft during the take off operation.

- For jet and supersonic aircraft having high lift off speed, the premature lift off may also affects the performance of iar crafts and can also develop the structural defects in the aircrafts.
- The change in gradients should be made smoothly by the vertical curves and as per ICAO, the rate of change of gradients is limited to a maximum per 30 m length of the vertical curves.

  For A and B types……0.10 per cent.

  For C type…….0.20 per cent.

  For D and E types……..0.40 per cent.
- The vertical curves are not generally required, if the change in slope is not more than 0.40 per cent.
- The distance between two successive points of the gradient intersections should not be less than the absolute numerical value of the change in slope.

SAFETY AREA:

- The runway safety area is an area which is cleared, drained and graded.
- It includes the structural pavements shoulders on either side of runway and the additional width.
- The length of safety area should extend 60m beyond the runway on its either end.
- The total length of the safety area will be equal to the length of runway plus 120m.
- If stop way is provided, the landing strip should extend a distance of 60m beyond the stop way.

SIGHT DISTANCE:

- There is generally no sight distance restriction as the longitudinal gradients for the runway are quite gentle.
- But there are chance for the collision of aircraft at the points where two runways or a runway and taxi way intersects each other.

TRANSVERSE GRADIENTS:

- It is provided for quick disposal of the surface water.
- The accommodation of water on the runway may produce hazardous situation for the aircrafts using such runways.

WIDTH:

- The runway width varies from 45 m to 18 m depending upon the types of aircraft and airport.
- The midway of runway is governed by the following two main consideration.

  (i) **Air traffic :**It is observed that the distribution of the air traffic is such that the central portion of about 12m on either side of the centre line of the runway is subjected to the maximum loading and it then goes on decreasing towards the edges. Thus, the central 24m width of runway pavements takes more concentrated air traffic load.

  (ii) **Outermost edges of air crafts:** The outer most part of machine of the largest aircrafts likely to use the airport should not extend beyond the pavement. The shoulders are made of loose soil or stabilizing the osil or by turfing them. The distance between the outer engine of a large jet transport and the longitudinal axis of the aircraft is about 13.5m

Video Content / Details of website for further learning (if any):

Nil

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.30)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

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VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Configuration and pavement design of runway.

Introduction :

- Configurations of runway refer to shape or arrangement of runway.
- Runway may be grouped as inter dependent or independent units.
- Basic methodology for the design of a runway pavement is the same as that for highway pavements design.
- Runway pavements are designed as per IRC specification with appropriate design wheel loads.

Prerequisite knowledge for Complete learning of Topic:

- Runway configuration.
- Runway pavement design.
- Runway drainage.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

RUNWAY CONFIGURATION:

(i) Pattern of runway configuration:

- Configurations of runway refer to shape or arrangement of runway.
- Runway may be grouped as inter dependent or independent units.
- They may be parallel or intersecting.
- The pattern of runway in any airport depends upon volume of traffic in an airport.

(ii) **Recommendation for international airport:**

- Basic pattern of runway normally adopted are:
  - (i) Single runway.
  - (ii) Parallel runway.
  - (iii) Intersecting runway.
  - (iv) Non intersecting runway.
- Minimum distance between parallel runway:

(i) Non intersecting parallel runway for simultaneous are
- 210m where the heigher code number is 3 or 4.
- 150m where the heigher code number is 2.
- 120m where the heigher code number is 1.

(ii) Parallel instrument runway for simultaneous are:
- 1035m for independent parallel approaches.
- 915m for dependent parallel approaches.
- 760m for independent parallel departure.
- 760m for segregated parallel operation.

(iii) For segregated parallel operation:
- May be decreased by 30m for each 150m so that the arrival runway is staggered towards arriving aircrafts, subject to a minimum of 300m.
- Should be increased by 30m for each 150m so that arrival runway is staggered away from arriving aircrafts.

RUNWAY PAVEMENTS DESIGN:

(i) **Runway and highway pavement characteristics:**
- ✓ Requirements of runway pavement are different from that of highways.
- ✓ Besides heavy dynamic wheel loading of aircraft, runway have to weather special problems such as fuel spillage, heat and blast of engine exhaust, high type pressure and small contact area.
- ✓ Effects of fuel spillage, heat and blast loosen pavement particles and this is hazardous to aircrafts.
- ✓ This phenomena leads to sudden changes in longitudinal grade and in pavement undulation.
- ✓ The repetitive load in narrow band along Centre line of taxiway cause rutting.

(ii) **Runway pavement design:**
- ✓ Basic methodology for the design of a runway pavement is the same as that for highway pavements design.
- ✓ Runway pavements are designed as per IRC specification with appropriate design wheel loads.

RUNWAY DRAINAGE:

It has certain unique characteristics. Drain pipes should be stronger enough to with stand heavy and dynamic wheel load of aircraft.

Crushing of pipes may be hazardous to aircraft.
- ✓ Heavy concentrated and dynamic wheel load.
- ✓ Wider runway when compared with highway pavements.
- ✓ Absence of side drains.

Video Content / Details of website for further learning (if any): Nil

Important Books/Journals for further learning including the page nos.:
- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.42)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Elements of Taxiway design.

Introduction :

A taxiway is a path for aircraft at an airport connecting runways with aprons, hangars, terminals and other facilities. They mostly have a hard surface such as asphalt or concrete, although smaller general aviationairports sometimes use gravel or grass.

Prerequisite knowledge for Complete learning of Topic:

- Geometric design of taxiway.
- Private taxiway.
- Width taxiway.
- Private taxiway.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

GEOMETRIC DESIGN OF TAXIWAY:

- Taxiways should be provided to permit the safe and expeditious surface movement of aircraft.
- Sufficient entrance and exit taxiways for a runway should be provided to expedite the movement of aeroplanes to and from the runway and provision of rapid exit taxiways considered when traffic volumes are high.
- To reduce the risk of runway incursions, the number of taxiway entrances having direct access to a runway should be kept to the minimum required for efficient runway use.

Private taxiways:

- Taxiways which are privately owned and are used exclusively to serve private interests should connect to an apron or taxiway which is part of the airport taxiway network. They should not connect directly to a runway.

Width of taxiways:

- A straight portion of a taxiway should have a width of not less than that given by the following tabulation:
- 15 m if the taxiway is intended to be used by aeroplanes with a wheel base less than 18 m.
- 18 m if the taxiway is intended to be used by aeroplanes with a wheel base equal to or greater than 18 m.

Taxiway Curve:

- Changes in direction of taxiways should be as few and small as possible. The radii of the curves should be compatible with the manoeuvring capability and normal taxiing speeds of the aeroplanes for which the taxiway is intended.
- The design of the curve should be such that, when the cockpit of the aeroplane remains over the taxiway centre line markings, the clearance distance between the outer main wheels of the aeroplane and the edge of the taxiway should not be less than those specified

Junctions and intersections

- To facilitate the movement of aeroplanes, fillets should be provided at junctions and intersections of taxiways with runways, aprons and other taxiways.
- The design of the fillets should ensure that the minimum wheel clearances specified in 3.4.1.3 are maintained when aeroplanes are manoeuvring through the junctions or intersections.

Taxiway minimum separation distances:

- The separation distance between the centre line of a taxiway and the centre line of a runway, the centre line of a parallel taxiway or an object should not be less than the appropriate dimension.
- It may be permissible to operate with lower separation distances at an existing aerodrome if an aeronautical study indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of aeroplanes.

Slopes on Taxiways:

Longitudinal slopes: The longitudinal slope of a taxiway should not exceed:

- 1.5 per cent where the code letter is C, D or E; and
- 3 per cent where the code letter is A or B.

Sight distance:

Where a change in slope on a taxiway cannot be avoided, the change should be such that, from any point:

- 3 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 300 m from that point, where the code letter is C, D or E;
- 2 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 200 m from that point, where the code letter is B; and

- 1.5 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 150 m from that point, where the code letter is A.

Transverse slopes:

The transverse slopes of a taxiway should be sufficient to prevent the accumulation of water on the surface of the taxiway but should not exceed:

- 1.5per cent where the code letter is C, D or E; and
- 2 per cent where the code letter is A or B.

Video Content / Details of website for further learning (if any):
https://www.tc.gc.ca/eng/civilaviation/publications/tp312-chapter3-3-4-4671.htm

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING" – (Pg.No – 3.50)
- ✓ S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Airport Zone.

Introduction :

An international zone is a type of extraterritoriality governed by international law, or similar treaty between two or more nations. They can be found within international airports and can contain duty-free shopping.

In areas of conflict there may be international zones called green zones that form protective enclaves to keep diplomats safe. Countries in conflict may also have international zones separating each other.

Prerequisite knowledge for Complete learning of Topic:

- Airport zone.
- Airport terminals.
- Airport designs.
- Ground transportation.
- Semi circular terminals.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

AIRPORT ZONE:

- International zone around the Republican Palace in central Baghdad in a crook of the Tigris River. This area was and still is the heavily fortified headquarters for the coalition and Iraqi Reconstruction Ministries. The official name started as the "Green Zone" but was later changed to the "International Zone" in June 2004 with the return of sovereignty to the Iraqi people.

AIRPORT TERMINAL:

- An airport terminal is a building at an airport where passengers transfer between ground transportation and the facilities that allow them to board and disembark from aircraft.
- Smaller airports have one terminal while larger airports have several terminals and/or concourses. At small airports, the single terminal building typically serves all of the functions of a terminal and a concourse.
- Some larger airports have one terminal that is connected to multiple concourses via walkways, sky-bridges, or underground tunnels (such as Denver International Airport). Some larger

airports have more than one terminal, each with one or more concourses (such as New York's John F. Kennedy International Airport). Still other larger airports have multiple terminals each of which incorporate the functions of a concourse (such as Dallas/Fort Worth International Airport).

DESIGNS:

- Due to the rapid rise in popularity of passenger flight, many early terminals were built in the 1930s–1940s and reflected the popular art deco style architecture of the time. One such surviving example from 1940 is the Houston Municipal Airport Terminal.
- Early airport terminals opened directly onto the tarmac: passengers would walk or take a bus to their aircraft. This design is still common among smaller airports, and even many larger airports have "bus gates" to accommodate aircraft beyond the main terminal.

PIER:

- A pier design uses a small, narrow building with aircraft parked on both sides. One end connects to a ticketing and baggage claim area. Piers offer high aircraft capacity and simplicity of design, but often result in a long distance from the check-in counter to the gate.

COMMON-USE FACILITY

- A common-use facility or terminal design disallows airlines to have its own proprietary check-in counters, gates and IT systems. Rather, check-in counters and gates can be flexibly reassigned as needed.

GROUND TRANSPORTATION:

- Many small and mid-size airports have a single two or three-lane one-way loop road which is used by local private vehicles and buses to drop off and pick up passengers.
- An international airport may have two grade-separated one-way loop roads, one for departures and one for arrivals. It may have a direct rail connection by regional rail, light rail, or subway to the downtown or central business district of the closest major city.
- The largest airports may have direct connections to the closestfreeway. Airport Transportation for there will be car rental agencies and taxi companies operating around the terminals. The Hong Kong International Airport has ferry piers on the airside to connect with ferry piers across the border.

SEMICIRCULAR TERMINALS:

- Some airports use a semicircular terminal, with aircraft parked on one side and cars on the other.
- This design results in long walks for connecting passengers, but greatly reduces travel times between check-in and the aircraft.
- Airports designed around this model include Charles de Gaulle Airport (terminal 2), Chhatrapati Shivaji International Airport, Mumbai (terminal 2), Dallas/Fort Worth International Airport, Seoul's Incheon International Airport, Jakarta's Soekarno-Hatta International Airport, Toronto Pearson Airport, Kansas City Airport and Sapporo's New Chitose Airport.

Video Content / Details of website for further learning (if any):

https://en.wikipedia.org/wiki/Airport_terminal

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING"
  S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Passenger Facilities and services.

Introduction :

Passenger is our primary focus. Here are some of the facilities and services available at disposal at the Cochin International Airport. We welcome you to utilize these facilities and services available at the airport while you are here and wish you a happy journey.

Prerequisite knowledge for Complete learning of Topic:

- Airport Facilitites.
- Arriving passengers facilities.
- Accommodation.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

HIGHLIGHTS:

- 4.78 lakhs sq. ft centrally air conditioned International Terminal with ample car parking facility
- 1.0 lakhs sq. ft centrally air conditioned Domestic Terminal with ample carparking facility
- TR / Book Stalls: Wide variety of reading materials besides travel requisites are available
- Tobacconist: Provides a wide array of cigarettes, cigars and chewing tobacco
- X-ray machines have been provided by CIAL for screening the registered baggage of passengers

FACILITIES FOR ARRIVING PASSENGERS:

- Free porterage service for convenience of old, infants, handicapped and unaccompanied ladies / minors
- The terminal is provided with modern illuminated signage for adequate guidance / direction in and around the terminal
- Drinking water facilities, public convenience for ladies and gents separately

- Public telephone facility with STD / ISD facility
- Free passenger baggage trolleys
- Tourist Information Counter
- Counter to check missed belongings.

ACCOMMODATION:

- International Airport offers excellent & comfortable accommodation to its bonafide passengers through its 14 well furnished guest rooms (suites, deluxe, standard & sharing rooms) within the airport. CIAL guest rooms have been designed and maintained by CIAL and are available to passengers on request over telephone or at the exclusive hospitality counters in the International and Domestic arrival terminals.
- The rooms are subject to availability at the time of booking.

SHOPPING:

- International Airport is always a pleasure. With a wide variety of world-class products, specialty and gift items, traditional handicraft items and curios unique to Kerala, passengers have the privilege of browsing through our stores at their own pace or could also rush in for some 'last minute'shopping.
- The duty free shop at the airport is owned and managed by Cochin International Airport Limited.
- The products on showcase include: the finest spirits, wines and beer, travel and fashion accessories, cosmetic and perfumes, confectionery, electronic items and everything else in between.
- The shopping arcade at the airport offers traditional Kerala items, travel accessories and a range of other handy products for travellers.
- The book shop is well stocked with a wide variety of reading materials besides travel requisites.

Delhi International Airport provides special rooms for babies and small children. Parents may avail these rooms to take care of any special needs for their kids such as changing of diapers and other need that their child / children may require.

Video Content / Details of website for further learning (if any):

Nil

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING"
  .S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – AIRPORT DESIGN**

Date of Lecture:

Topic of Lecture:

Runway and taxiway marking and lighting.

Introduction :

- The most important rule to remember is that any sign that has white letters on red is mandatory. Usually they mark points that must not be passed without permission from air traffic control.
- Taxiways should have centre line markings and runway holding position markings whenever they intersect a runway.

Prerequisite knowledge for Complete learning of Topic:

- Taxiway Lighting and Markings.
- Taxiway Edge Markings.
- Airport Signs.

Detailed content of the Lecture: (Diagram/ Description/Algorithm/Procedure for solving problems/ Derivation component with supporting content if any)

TAXIWAY LIGHTING AND MARKINGS:

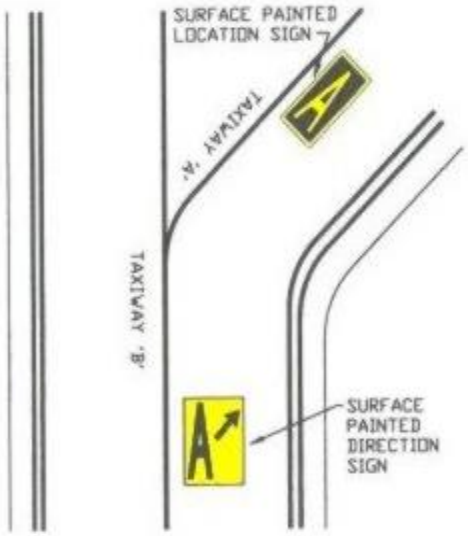
- Taxiways should have centreline markings and runway holding position markings whenever they intersect a runway.
- Taxiway edge markings are present whenever there is a need to separate the taxiway from a pavement that is not intended for aircraft use or to delineate the edge of the taxiway.
- Taxiways may also have shoulder markings and holding position markings for Instrument Landing System/Microwave Landing System (ILS/MLS) critical areas, and taxiway/taxiway intersection markings.
- The taxiway centreline is a single continuous yellow line, 6 inches (15 cm) to 12 inches (30 cm) in width. This provides a visual cue to permit taxiing along a designated path. Ideally the aircraft should be kept centred over this line during taxi to ensure wing-tip clearance.

TAXIWAY EDGE MARKINGS:

- Taxiway edge markings are used to define the edge of the taxiway. They are primarily used when the taxiway edge does not correspond with the edge of the pavement. There are two types of markings depending upon whether the aircraft is suppose to cross the taxiway edge:

1. **Continuous Markings**. These consist of a continuous double yellow line, with each line being at least 6 inches (15 cm) in width spaced 6 inches (15 cm) apart. They are used to define the taxiway edge from the shoulder or some other abutting paved surface not intended for use by aircraft.
2. **Dashed Markings.** These markings are used when there is an operational need to define the edge of a taxiway or taxi-lane on a paved surface where the adjoining pavement to the taxiway edge is intended for use by aircraft. e.g., an apron. Dashed taxiway edge markings consist of a broken double yellow line, with each line being at least 6 inches (15 cm) in width, spaced 6 inches (15 cm) apart (edge to edge). These lines are 15 feet (4.5 m) in length with 25 foot (7.5 m) gaps. (See FIG 2-3-9.)

- **Taxi Shoulder Markings.**
  - Taxiways, holding bays, and aprons are sometimes provided with paved shoulders to prevent blast and water erosion.
  - Although shoulders may have the appearance of full strength pavement they are not intended for use by aircraft, and may be unable to support an aircraft. Usually the taxiway edge marking will define this area.
  - Where conditions exist such as islands or taxiway curves that may cause confusion as to which side of the edge stripe is for use by aircraft, taxiway shoulder markings may be used to indicate the pavement is unusable.
- **Surface Painted Taxiway Direction Signs.**
  - Surface painted taxiway direction signs have a yellow background with a black inscription, and are provided when it is not possible to provide taxiway direction signs at intersections, or when necessary to supplement such signs.
  - These markings are located adjacent to the centreline with signs indicating turns to the left being on the left side of the taxiway centreline and signs indicating turns to the right being on the right side of the centreline.



Surface Painted Taxiway Direction Signs

Surface Painted Location Signs.

- Surface painted location signs have a black background with a yellow inscription. When necessary, these markings are used to supplement location signs located along side 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 centreline.

Runway Holding Position Markings. For runways these markings indicate where an aircraft is supposed to stop.

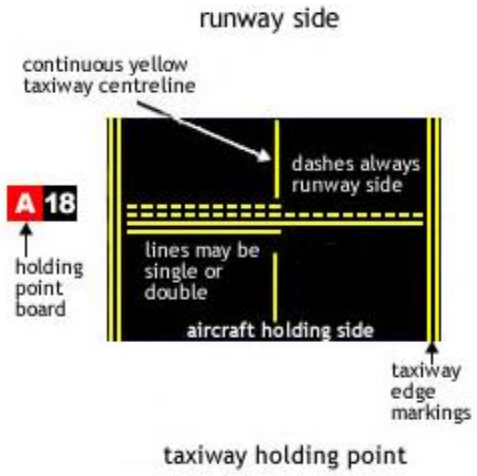
- They consist of four yellow lines two solid, and two dashed, spaced six or twelve inches apart and

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. These markings identify the locations on a taxiway where an aircraft is supposed to stop when it does not have clearance to proceed onto the runway.

- When instructed by ATC "Hold short of (runway "xx")" the pilot should stop so no part of the aircraft extends beyond the holding position marking.
- When approaching the holding position marking, a pilot should not cross the marking without ATC clearance at a controlled airport or without making sure of adequate separation from other aircraft at uncontrolled airports.
- An aircraft exiting a runway is not clear of the runway until all parts of the aircraft have crossed the applicable holding position marking.



taxiway holding point

AIRPORT SIGNS:

- There are six types of signs installed on airfields: mandatory instruction signs, location signs, direction signs, destination signs, information signs, and runway distance remaining signs.

Mandatory Instruction Signs:

These signs have a red background with a white inscription and are used to denote:

1. An entrance to a runway or critical area and;

2. Areas where an aircraft is prohibited from entering.

Video Content / Details of website for further learning (if any):

http://www.pilotfriend.com/training/flight_training/communication/taxiway_markings.htm

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "RAILWAYS, AIRPORTS AND HARBOUR ENGINEERING"
  S.C.Rangwala " AIRPORT ENGINEERING"

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:
Definitions of Harbours

Introduction :

- ✓ Ocean Water transportation is adopted for trade and commerce.
- ✓ It is estimated that about 75 per cent of international trade is carried out by shipping.
- ✓ The development of navy force is intended for national defense.
- ✓ Ocean water transportation has an limitation and it possesses high flexibility.

Prerequisite knowledge for Complete learning of Topic:

Water transportation
Artificial harbours

Detailed content of the Lecture:

Water transportation:

The water transportation can further be subdivided into two categories:

(i) Inland transportation and

(ii) Ocean transportation.

Inland Water transportation

Inland Water transportation is either in the form of river transportation or canal transportation.

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.

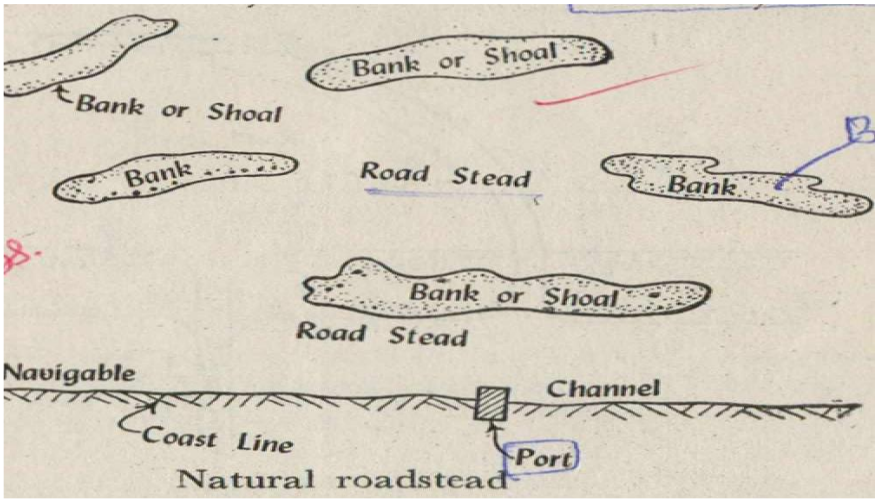
Harbours are broadly classified as:

- ✓ Natural harbours
- ✓ Semi-natural harbours
- ✓ Artificial harbours.

- ✓ Natural harbours:
- ✓ Natural formations affording safe discharge facilities for ships on sea coasts, in the form of creeks and basins, are called natural harbours.
- ✓ 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.
- ✓ The size and draft of present day vessels have necessitated the works improvement for natural harbours.
- ✓ 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:
- ✓ This type of harbour is protected on sides by headlands protection and it requires man-made protection only at the entrance.
- ✓ Vishakhapatnam is a semi-natural harbour.

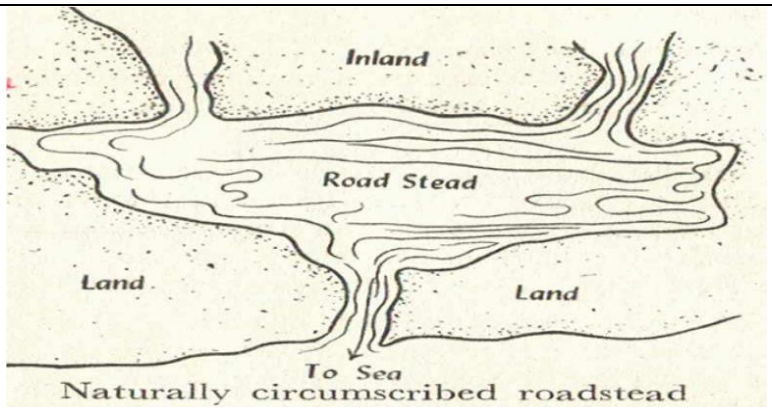
Artificial harbours:

- ✓ 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.
- ✓ Madras is an artificial harbour.
- ✓ 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:

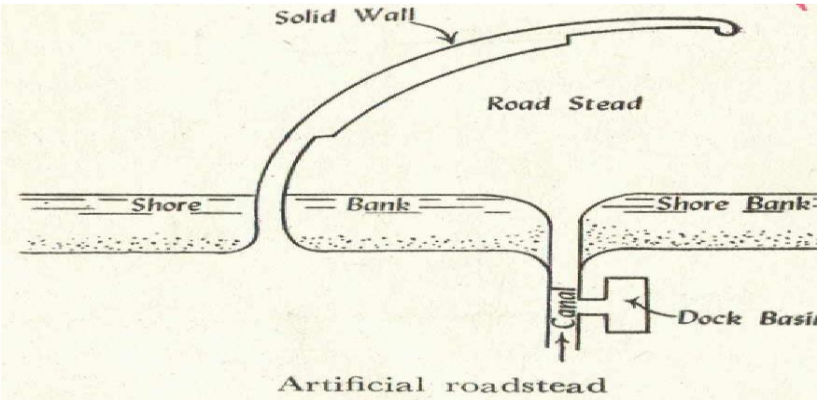
- ✓ A deep navigable channel with a protective natural bank or shoal to seaward is a good example of a natural roadstead as shown in fig..
- ✓ A confined area naturally enclosed by islands as in a creek if available is known as circumscribed natural roadstead.



Naturally circumscribed 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

- ✓ 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.
- ✓ Another method is to create a confined basin of small area having a narrow entrance and exit for ships.
- ✓ Such roadsteads with smaller inner enclosures and wharf and with loading and unloading facilities are commonly provided for fishing vessels.

Video Content / Details of website for further learning (if any):
http://nptel.ac.in

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "Railways, Airports and Harbour Engineering" -
- ✓ S.C.Saxena & S.C.Arora "A Text Book of Railway Engineering" -

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:
Planning and Design of Harbors Requirements

Introduction :

- ✓ The entrance is generally placed of the sea, with a passage to the interior of the harbour so arranged as to minimize the effect of rough seas.
- ✓ Thus; the size is determined by:
- ✓ Accommodation required.
- ✓ Convenience for maneuvering and navigation.
- ✓ Adaptability to natural features.

Prerequisite knowledge for Complete learning of Topic:

- **Requirements of commercial harbor**
- **Site selection**
- **Shape of the harbour**

Detailed content of the Lecture:

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

- ✓ Harbours of refuge including naval bases
- ✓ Commercial harbours, connected with ports
- ✓ 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

Requirements of commercial harbour:

- ✓ Spacious accommodation for the mercantile marine.

- ✓ Ample quay space and facilities for transporting; loading and Unloading cargo.
- ✓ Storage sheds for cargo.
- ✓ Good and quick repair facilities to avoid delay.
- ✓ More sheltered conditions as loading and unloading could be done with advantage in calmer waters.
- ✓ Accessibility and size of harbours
- ✓ Accessibility depends on the location of the harbours.
- ✓ The harbour entrance should be designed and located for quick easy
- ✓ negotiation by ships, overtaken by storms.
- ✓ At the same time, it should be narrow enough not to expose the harbour to the effects of the stormy sea.
- ✓ Maximum dimensions upto 180 have been adopted

Site selection:

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

- ✓ Availability of cheap land and construction materials
- ✓ Transport and communication facilities
- ✓ Natural protection from winds and waves
- ✓ Industrial development of the locality
- ✓ Sea-bed subsoil and foundation conditions
- ✓ Traffic potentiality of harbour
- ✓ Availability of electrical energy and fresh water
- ✓ Favorable marine conditions
- ✓ Defence and strategic aspects

Shape of the harbour:

The following principles should be kept in mind:

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

Video Content / Details of website for further learning (if any):
http://nptel.ac.in

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "Railways, Airports and Harbour Engineering" -
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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:
Classification, Location and Design Principles

Introduction :

- ✓ It is necessary to carry out a thorough survey of the neighbourhood including the foreshore and the depths of water in the vicinity
- ✓ 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
- ✓ The nature of the harbour, whether sheltered or not, should be studied.
- ✓ The existence of sea insect undermine the foundations should be noted.

Prerequisite knowledge for Complete learning of Topic:

- **Harbour planning**
- **Classification of ports**
- **Port design**

Detailed content of the Lecture:

Harbour planning:

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

- ✓ The problem of silting or erosion of coastline should be carefully studied.
- ✓ 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:

- ✓ 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.
- ✓ 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;

- ✓ Canal ports

- ✓ River ports and
- ✓ 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, transshipment 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:

- ✓ The entrance channel should be such that the ships can come in and go out easily.
- ✓ The ships should be able to turn in the basin itself.
- ✓ The alignment of quays should be such that the ships can come along side easily even when there is an on-shore wind.
- ✓ The width behind the quay should be sufficient to deal with the goods.
- ✓ There should be enough provision for railway tracks to take care for loading and unloading of cargo.

Requirements of a good port

- ✓ 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.
- ✓ It should get good tonnage i .e. charge per tonne of cargo handled by it.
- ✓ It should have good communication with the rest of country.
- ✓ It should be populous
- ✓ It should be advance in culture, trade and industry.
- ✓ It should be a place of defence and for resisting the sea-borne invasion
- ✓ It should command valuable and extensive trade.
- ✓ It should be capable of easy, smooth and economic development.
- ✓ It should afford shelter to all ships and at all seasons of the years

It should provide the maximum facilities to all the visiting ships including the servicing of ships.

Video Content / Details of website for further learning (if any):
http://nptel.ac.in

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "Railways, Airports and Harbour Engineering" -
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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:
Coastal Structures: Piers, Break waters

Introduction :

- ✓ Some of the natural and meteorological phenomena which primarily affect the location and design of the harbour.
- ✓ Coastal currents and evidences of sitting, including littoral drift or coast erosion.
- ✓ Tides and tidal range.
- ✓ Wind, wave and their combined effect on harbour structures.

Prerequisite knowledge for Complete learning of Topic:

- **Tides**
- **Waves and wind**
- **Breakwaters**

Detailed content of the Lecture:

TIDES AND WAVES:

Tides:

- ✓ Tides on the coast-line are caused by the sun and moon.
- ✓ The effect of tides is to artificially raise and lower the mean sea level during certain stated periods.

This apparent variation of mean sea level is known as the tidal range. Spring tides and Neap tides:

- ✓ 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.
- ✓ 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:

- ✓ The ‘sea wave’ is by far the most powerful force acting on harbour barriers and against which the

engineer has to contend.

- ✓ The wave has the impulse of a huge battering ram and equipped with the point of a pick axe and chisel edge".
- ✓ It is the most in compressible natural phenomena.
- ✓ 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:

- ✓ Character of coastal currents
- ✓ Cost and availability of materials of construction
- ✓ Directions and force of prevailing winds
- ✓ Nature of the bottom or foundation
- ✓ Probable maximum height, force and intensity of waves.

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

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

Detrimental forces acting on breakwaters:

Hydrostatic force:

- ✓ 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:

- ✓ The intensity of external forces, especially wind and wave action, is enormous.
- ✓ The power of wind produces vibrations in the masonry structure and weakens the different courses of masonry.
- ✓ 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.

Solvent action of sea water:

- ✓ This quality of sea water causes damage to the materials of construction Sea insects:
- ✓ The concentrated action of sea insects results in the undermining of the hardest and the soundest building material and it is for this reason that the marine structures are made specially bulky and strong.

Video Content / Details of website for further learning (if any): **http://nptel.ac.in**
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LECTURE HANDOUTS

CIVIL **th Code : 16CEE19- RAILWAYS, AIRPORT AND HARBO** **VI/III**
ENGINEERING

Course Teacher : Dr.R.SHANMUGAM

Unit : IV – HARBOUR ENGINEERING

Date of Lecture:

Topic of Lecture:

WHARVES

Introduction :

- ✓ 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.
- ✓ These platform locations should give sufficient depth of water for the ship to float.
- ✓ Such platforms are, called wharves.
- ✓ They are built out into or on to. the water

Prerequisite knowledge for Complete learning of Topic:

- ***Classification of breakwaters***
- **Wharves**
- **Piers**

Detailed content of the Lecture:

Classification of breakwaters:

- ✓ Breakwaters are classified mainly into three types:.
- ✓ Heap or mound breakwater
- ✓ Mound with superstructure
- ✓ 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.
- ✓ The quantity of rubble depends upon the depth, rise of tides and waves and exposure.
- ✓ On exposed sites, the waves gradually drag down the mound, giving it a flat slope on the sea face.

- ✓ As far as possible, such flattening has to he protected.
- ✓ The disturbing action of the waves is the most between the high and low water levels.
- ✓ Consequently, all protective methods are adopted above the low water level.
- ✓ Protection is also very necessary to the top of the mound and outer or exposed face.

WHARVES

- ✓ Thus, a wharf affords a working platform alongside the ship in continuity of the shore.
- ✓ 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.
- ✓ 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.
- ✓ 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.
- ✓ The former type is adopted at places where depth of water is sufficient for the ships to berth, say 10 m to 12 m
- ✓ The latter type is adopted at places where depth of water near the shore is not enough for the ships to enter safely.
- ✓ 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.
- ✓ Wharf should act as a unit when there is an impact from any vessel.
- ✓ 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.
- ✓ Such a construction will result in a smooth entry of vessels into the slips

PIERS

- ✓ The structures which are built perpendicular or oblique to the shore of a river or sea are known as piers.
- ✓ 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.
- ✓ 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.
- ✓ The dimensions of a pier should be worked out very carefully.
- ✓ Its length should be sufficient to accommodate the longest ship likely to take its advantage.
- ✓ 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.
- ✓ It can be stated that the pier should be of sufficient width to allow easy unloading of cargo without any undue delay.

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LECTURE HANDOUTS

CIVIL

VI/III

Course Name with Code : **19CEE27- RAILWAYS, AIRPORT AND HARBOUR ENGINEERING**

Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:

Wharves, Jetties, Quays, Spring Fenders

Introduction :

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

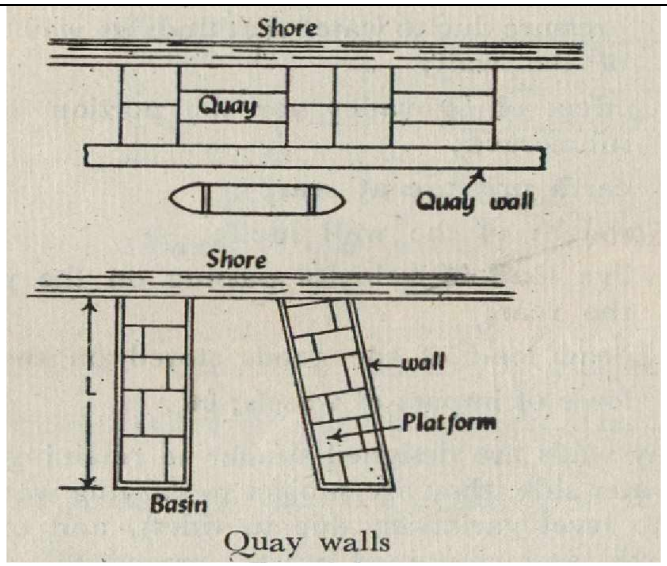
Prerequisite knowledge for Complete learning of Topic:

- **Quays**
- **Design of quay walls**
- **Jetties**
- **Fender**

Detailed content of the Lecture:

QUAYS

✓ 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 and protect the embankment or filling:
Factors affecting the design are as follows

- ✓ Character of foundation;
- ✓ Pressure due to water that finds its way to the real of the wall;
- ✓ Effect of buoyancy for the portion of the wall submerged;
- ✓ Earth pressure at rear;
- ✓ Weight of the wall itself;
- ✓ live load of vehicles passing on the platform at the rear;
  dead load of the goods stored on the platform;
- ✓ force of impact of vessels; etc.
- ✓ Quay wails are designed similar to retaining walls;
- ✓ But on the water side, they are subject to varying water pressure (owing to level variations due to tides), and on the land side, earth and contained water pressures, with proper allowances for surcharge.

JETTIES:

- ✓ 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.
- ✓ In rivers, the jetties divert the current away from the river bank and thus, the scouring action is prevented.
- ✓ As the current is diverted to deep waters, the navigation is also controlled.
- ✓ 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.
- ✓ Thus, they extend from the shore to the deep sea to receive the ships.
- ✓ 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.
- ✓ Jetties are exposed to severe wave action and their structural design is similar to that of breakwater.
- ✓ 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.
- ✓ The impact caused by the berthing ships will depend on the skill of the berthing officer, local condition of currents, wind, etc.
- ✓ The berthing velocity depends upon the condition of approach, wind, etc. and it decreases with the increase in the size of the ships

FENDER:

- ✓ The cushion which is provided on the face of jetty for ships to come in contact isknown as fender.
- ✓ It is provided for various forms and is made of different materials.
- ✓ 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.
- ✓ 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.

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Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:

Inland Water Transport

Introduction :

- ✓ In its simplest form, the fender system adopted for small vessels consists of rubbing strips of timber, coir padding or used rubber tyres
- ✓ It is also convenient to use pneumatic inflated tyres, either by suspending them or installing them at right angles to jetty face.

Prerequisite knowledge for Complete learning of Topic:

- **Quays**
- **Design of quay walls**
- **Jetties**
- **Fender**

Detailed content of the Lecture:

Rubbing strips:

- ✓ _ The inflated big-size tyres are useful to transfer cargo between mother ship and daughter ships.
- ✓ _ The pneumatic rubber fenders are very useful for transferring cargo from ship to ship of big sizes.

Timber grill:

- ✓ This system consists merely of vertical and horizontal timber members fixed to the face piles.
- ✓ This is a simple form of fender and to make it more effective, energy fender piles may 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 tendering:

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

NAVIGATIONAL AIDS

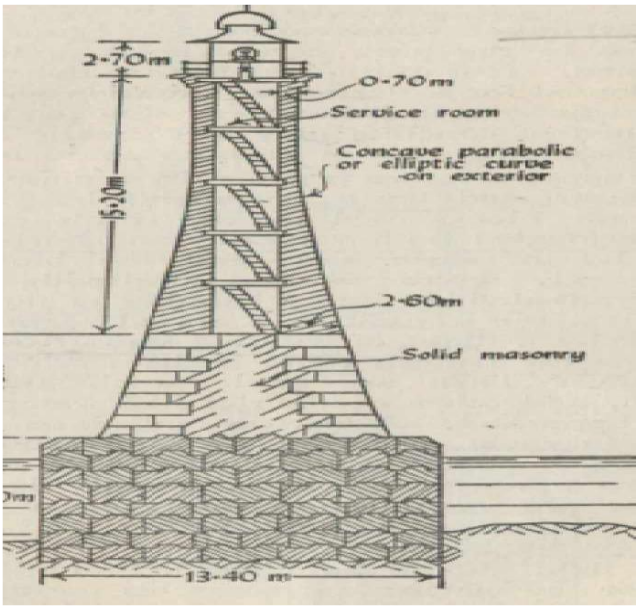
Necessity for signals:

The mariner and his ship have to be guided by proper signals during navigation, especially,
(1) to avoid dangerous zones like hidden rocky outcrop and sand bars,
(2) to follow proper approaches and
(3) to locate ports.

Fixed and floating light stations:

- ✓ The light stations when they are built on land are called fixed as in the case of permanent lighthouse structures.
- ✓ 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.
- ✓ Alternately, where there are difficulties in establishing proper foundations; floating light rations in the form of a light vessel may be adopted.
- ✓ Buoys of standard shapes also belong to the 'floating type and are generally used to demarcate boundaries of approach channels in harbour basins.

Lighthouse:



- ✓ It is a lofty structure popularly built of masonry or reinforced concrete in the shape of a tall tower on a high pedestal.
- ✓ The tower is divided into convenient number of floors, the topmost floor containing powerful lighting equipment and its operating machinery.
- ✓ The lower floors are used, as stores and living rooms necessary for the maintenance and working of the light station.
- ✓ The main parts of a typical lighthouse tower
- ✓ Lighthouses may be located on shore or on islands away from the mainland as in the case of warning light stations.
- ✓ In the former case, the lighthouse may be easily connected with the nearest village or township by proper communications, while in the later situation it is located far habited area.

In either case as a matter of convenience and urgency, all the requirements for the efficient and unfailing maintenance and working of the lighthouse, like stores and staff quarters are provided in the lighthouse shaft.

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Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:

Wave action on Coastal Structures and Coastal Protection Works

Introduction :

- ✓ It is quite evident that the type of foundation to be adopted for a particular situation will depend on the characteristics of soil of that area.
- ✓ On good rock or hard soil, a thick bed of concrete may serve while on submarine or marshy locations, piles or caissons could be used.
- ✓ The superstructure is generally a masonry or an R.C.C tower constructed on a prominent basement.

Prerequisite knowledge for Complete learning of Topic:

- **Lighthouse construction**
- **Requirements of a signal**
- **Types of signals**

Detailed content of the Lecture:

Lighthouse construction:

- ✓ concrete blocks used in the construction of the basement are joggled both vertically and horizontally
- ✓ To secure and bind the blocks together and resist strongly forces tending to dislodge or move them.
- ✓ The tower is divided into a number of floors and the light is housed at the summit in a glazed room.
- ✓ The floors are accessible by a flight of winding stairs from bottom to top.
- ✓ Just below the lantern room is the service room and other rooms lower down are used for oil and general stores, personnel, and other accessories like water storage and fire fighting apparatus.
- ✓ A narrow gallery is provided outside the lantern room protected by pipe railing.
- ✓ The dimensions and geometrical shapes shown in the figure are adopted in modern practice and more recent lighthouse like the Eddystone are examples of this type of construction.
- ✓ The light should be identified and its distance ascertained, for the mariner to locate his position.
- ✓ These lights are made 'fixed' or flashing for easy identification by the navigator and are classified accordingly to their illuminating power.
- ✓ The height of the tower above sea level determines the geographical range and the intensity or power of the light the luminous range.
- ✓ These two are important factors, deciding the range of visibility.
- ✓ The illumination is both refracted through powerful lenses and prisms and reflected or flashed by highly polished hyperbolic concave mirrors fig.shows the details of the light apparatus.

- ✓ Fixed lights are likely to be confused with the private lights of the neighbourhood and hence, it is desirable to avoid fixed lights as far as possible.
- ✓ Signals:
- ✓ The approach channel of a modern port should be clearly defined odemarcated by the provision of suitable signals.

Thus, signals will be required at the following places:

- ✓ Light ships have to be provided at important changes in the direction of theroute of ships.
- ✓ Lighted beacons are to be fixed on river banks
- ✓ Buoys are required at entrance channels to ports

Requirements of a signal

- ✓ It should be conspicuously visible, from a long distance.
- ✓ It should not vary in character and should be positively recognizable.
- ✓ It should be simple for identification.

Types of signals:

The signals are broadly divided into the following three categories':

1. Light signals
2. Fog signals
3. Audible signals.

The first classification of light signals is very important. Fog signals and audible signals are occasionally used.

Light signals

These signals are subdivided into three types:

(1) Light ships
(2) Beacons
(3) Buoys.

Light ships:

Small ships displacing about 500 tonnes are used for this purpose.

The lantern is carried on an open steel tower approximately 9 m to 12 m above the water level and erected amidships.

The light apparatus consists of four pairs of mirror reflectors placed around the light and made to revolve at a suitable speed emitting ,a predetermined number of flashes.

The ship is with service personnel and is securely anchored or moored.

light ships are more stable and the lights in them more steady which is an important factor for a mariner.

The hulls of light ships are built of steel and they are generally painted with red colour.

The name of the station is painted in white colours on both sides of light ship.

The superstructures are also provided with white colours.

The storm warning signals are also installed on the light ships.

When the light ships are being overhauled, red colour relief light ships with the word 'Relief' on the sides are used.

Video Content / Details of website for further learning (if any):http://nptel.ac.in

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LECTURE HANDOUTS

CIVIL

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Course Teacher : **Dr.R.SHANMUGAM**

Unit : **IV – HARBOUR ENGINEERING**

Date of Lecture:

Topic of Lecture:

Environmental concern of Port Operations

Introduction :

- Any prominent object, natural or artificially constructed, easily indentifiable and capable of being used as a means to indicate and guide in navigation is generally designated as a beacon.
- Lofty topographical feature like hill summit, building or structure like a church steeple, or factory chimney, could all be made use of as beacons.
- Alternately, a beacon could be built in the form of an open tapering frame work, with a wide stable base and gradually narrowed top, terminating in a distinctive figure, like a triangle or circle

Prerequisite knowledge for Complete learning of Topic:

- **Beacons**
- **Fog signals**:
- **Audible signals**

Detailed content of the Lecture:

Beacons:

The distinctive geometrical figure is suitably painted so as to cause prominence. Buoys:

Buoys are floating structures of small size employed for demarcation like entrances, approach channel used for indicating direction changes in means of alignment.

Beacons are thus of the navigation.

Beacons are navigation or as immense help in boundaries and so on.

They are moored to sinkers, or heavy anchors, with the help of heavy chains, whose length are two to three times the depth of water and which are 70 to 90 mm in diameter.

They are useful in indicating approach channel widths, two rows of buoys being usedone along each boundary.

These buoys are denominated ‘Star board-hand’ or ‘port-hand’ buoys according to their positions being to

the left or right of the navigator respectively as he approaches the harbour.

Buoys are of different designs and patterns. They are designed not only to support their own weight, but also the weight of cables or chains by which they are moored.

The surface of buoy structure near water line should be protected by the provision of stout wooden fendering so that it is not seriously damaged in case of an impact.

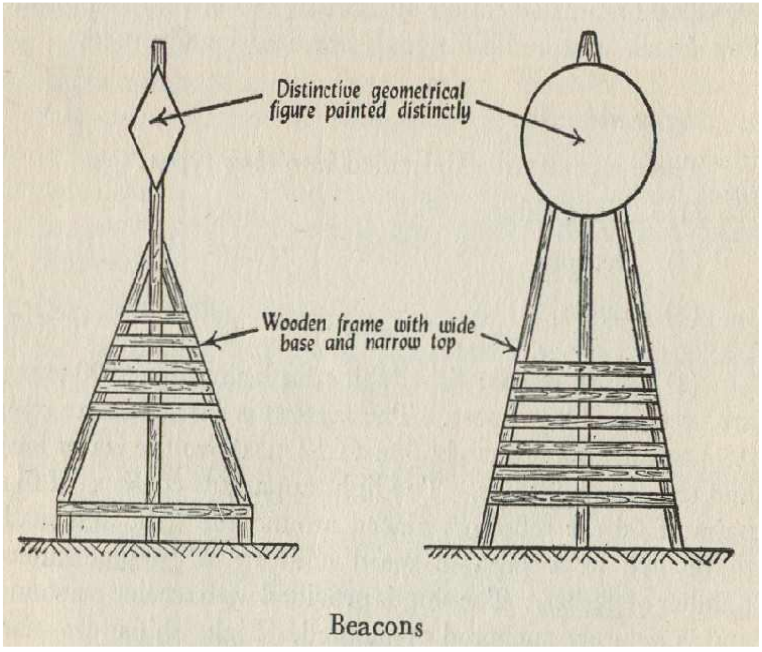
Thus, buoys are floating signals and they are usually prepared of steel and iron plates of minimum thickness 6 nun.

Buoys are hollow structures and they are constructed in two watertight sections so that in case one of them is leaky, at least the other one may prevent it from sinking.

The maxi mum distance between consecutive buoys is about 16Q0 m in estuaries and in narrow channels, it is about 150 m to 300 m.

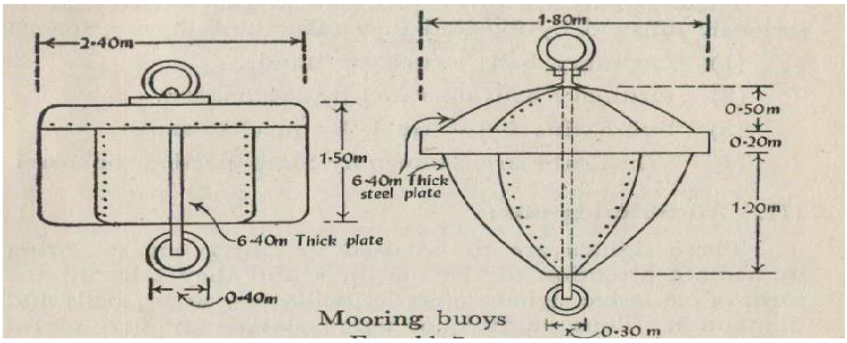
The diameter of a buoy varies from 1 80 m to 3 m.

In tidal places, the depth of water is liable to fluctuation and hence, in such cases, the buoys are not steady and they do not give correct guidance regarding alignment



Beacons

- ✓ The presence of buoys also indicates the proximity of places with shallow depth of water.
- ✓ Buoys are also classified according to their size, shape, colour, weight, purpose, etc.
- ✓ Brief descriptions of buoyage system, mooring buoys and wreck buoys are given below.
- ✓ Mooring buoys:



Mooring buoys

- ✓ In harbour interiors, buoys are pro vided in fixed positions to which ships could be moored during their stay in the harbour without using anchors.

These buoys are called mooring buoys. Some common types of mooring buoys in use in India are Wreck buoys:

- ✓ These arc of peculiar shape and are used to locate wrecks in harbour exteriors or open seas.
- ✓ They are also used for sea cable crossing locations

Fog signals:

These signals are to be provided at places likely to be seriously affected by fog and they take the following forms:

- ✓ Ordinary bells struck by hand.
- ✓ Ordinary bells operated by mechanism.
- ✓ Submarine bells struck by mechanism.
- ✓ Whistles or sirens blown by compressed air or steam.

Audible signals:

- ✓ These signals are to be used in emergency to bring immediate attention of the mariners and they take up the form of explosive signals, electric oscillators, sirens, bells and diaphones.
- ✓ Thus, audible or sound signals are very useful during heavy mists or fogs. It should also be noted that sound transmitted through the air gives sometimes the misleading idea about the direction of sound.
- ✓ Hence, resort is made to submarine sound signals in such a way that they can be heard from a great distance with easy identification of the direction.

Video Content / Details of website for further learning (if any):
http://nptel.ac.in

Important Books/Journals for further learning including the page nos.:

- ✓ K.P.Subramanian "Railways, Airports and Harbour Engineering" -
- ✓ S.C.Saxena & S.C.Arora "A Text Book of Railway Engineering" -

Course Teacher

Verified by HOD