1.1 AIR TRANSPORT CHARACTERISTICS

Air transport has the following characteristics:

1. **Unbroken Journey:**

   Air transport provides unbroken journey over land and sea. It is the fastest and quickest means of transport.

2. **Rapidity:**

   Air transport had the highest speed among all the modes of transport.

3. **Expensive:**

   Air transport is the most expensive means of transport. There is huge investment in purchasing aero planes and constructing of aerodromes.

4. **Special Preparations:**

   Air transport requires special preparations like wheelers links, meteorological stations, flood lights, searchlights etc.

Fastest Mode of Transport:

Advantages:

1. **High Speed:**

   The supreme advantage of air transport is its high speed. It is the fastest mode of transport and thus it is the most suitable mean where time is an important factor.

2. **Comfortable and Quick Services:**

   It provides a regular, comfortable, efficient and quick service.

3. **No investment in Construction of Track:**

   It does not require huge capital investment in the construction and maintenance of surface track.

4. No physical barriers:

It follows the shortest and direct route as seas, mountains or forests do not come in the way of air transport.

5. Easy Access:

Air transport can be used to carry goods and people to the areas which are not accessible by other means of transport.

6. Emergency services:

It can operate even when all other means of transport cannot be operated due to the floods or other natural calamities. Thus, at that time, it is the only mode of transport which can be employed to do the relief work and provide the essential commodities of life.

7. Quick Clearance:

In air transport, custom formalities can be very quickly complied with and thus it avoids delay in obtaining clearance.

8. Most suitable for carrying Light goods of high value:

It is most suitable for carrying goods of perishable nature which require quick delivery and light goods of high value such as diamonds, bullion etc. over long distances.

9. National Defence:

Air transport plays a very important role in the defence of a country. Modern wars have been fought mainly by aeroplanes. It has upper hand in destroying the enemy in a very short period of time. It also supports over wings of defence of a country.

10. Space Exploration:

Ai r transport has helped the world in the exploration of space.

Disadvantages:

In spite of many advantages, air transport has the following limitations:

1. Very costly:

It is the costliest means of transport. The fares of air transport are so high that it is beyond the reach of the common man.

2. Small carrying capacity:

Its carrying capacity is very small and hence it is not suitable to carry cheap and bulky goods.

3. Uncertain and Unreliable:

Air transport is uncertain and unreliable as it is controlled to a great extent by weather conditions. Unfavourable weather such as fog, snow or heavy rain etc, may cause cancellation of scheduled flights and suspension of air service.

4. Breakdowns and Accidents:

The chances of breakdowns and accidents are high as compared to other modes of transport. Hence, it involves comparatively greater risk.

5. Large Investment:

It requires a large amount of capital investment in the construction and maintenance of aeroplanes. Further, very trained and skilled persons are required for operating air service.

6. Specialised Skill:

Air transport requires a specialised skill and high degree of training for its operation.

7. Unsuitable for cheap and bulky goods:

Air transport is unsuitable for carrying cheap, bulky and heavy goods because of its limited capacity and high cost.

8. Legal Restrictions:

There are many legal restrictions imposed by various countries in the interest of their own national unity and peace.

1.2 CLASSIFICATION OF AN AIRPORT

AIRPORT

An airport is a location where aircraft such as airplanes take off and land. It is a facility where passengers connect from ground transportation to air transportation. Aircraft may also be stored or maintained at an airport. An airport should have runway for takeoffs and landings, buildings such as hangars and terminal buildings.

AIRPORTS ARE CLASSIFIED INTO DIFFERENT TYPES

1) Based on Take-off & Landing.

2) Based on Aircraft approach speed.

3) Based on Function.

4) Based on Geometric Design.

5) Based on aircraft wheel characteristics.

BASED ON TAKE-OFF & LANDING

Aircraft can have different ways to take off and land. Conventional airplanes accelerate along the ground until sufficient lift is generated for takeoff, and reverse the process to land. Some airplanes can take off at low speed, this being a short takeoff.

a. Conventional Take-Off and Landing Airport (CTOL)
   - Runway Length > 1500 m
b. Reduced Take-Off and Landing Airport (RTOL)
   - Runway Length 1000 to 1500 m
c. Short Take-Off and Landing Airport (STOL)
   - Runway Length 500 to 1000 m
d. Vertical Take-Off and Landing Airport (VTOL)
   - Operational area 25 to 50 sq m.

BASED ON AIRCRAFT APPROACH SPEED.

An aircraft approach category is a grouping differentiating aircraft based on the speed at which the aircraft approaches a runway for a landing.

Approach Category A- < 91

Approach Category B - 91– 120

Approach Category C - 120 – 140

Approach Category D - 141 – 165

Approach Category E - >165

BASED ON FUNCTION.

a. **Civil Aviation**

It is one of two major categories of flying, representing all non-military aviation, both private and commercial.

• **Domestic**

A domestic airport is an airport that handles only flights within the same country. Domestic airports do not have customs and immigration facilities.

• **International**

An international airport is an airport with customs and border control facilities enabling passengers to travel between countries.

b. **Military Aviation**

Military aviation is the use of military aircraft and other flying machines for the purposes of conducting or enabling aerial warfare, including national airlift capacity to provide logistical supply to forces stationed in a theater or along a front.

ICAO Airspace 101

Current ICAO airspace designations where adopted in 1990, with the U.S. adopting the same classifications, though used differently in 1993. In case you didn't know, the U.S. had 20 different types of airspace designations prior to 1993. Basically under ICAO, there is controlled airspace and uncontrolled airspace.

Controlled Airspace

Controlled Airspace is defined as airspace of defined dimensions within which air traffic control service is provided to IFR flights and to VFR flights in accordance with the airspace classification. Under ICAO, controlled airspace is defined as:

Class A:

IFR flights only are permitted, all flights are provided with air traffic control service and are separated from each other.

Class B:

IFR and VFR flights are permitted, all flights are provided with air traffic control service and are separated from each other.

Class C:

IFR and VFR flights are permitted, all flights are provided with air traffic control service and IFR flights are separated from other IFR flights and from VFR flights. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights.

Class D:

IFR and VFR flights are permitted and all flights are provided with air traffic control service, IFR flights are separated from other IFR flights and receive traffic information in respect of VFR flights, VFR flights receive traffic information in respect of all other flights.

Class E:

IFR and VFR flights are permitted, IFR flights are provided with air traffic control service and are separated from other IFR flights. All flights receive traffic information as far as is practical. Class E shall not be used for control zones.

Uncontrolled Airspace

Generally under ICAO, uncontrolled airspace is as follows:

Class F:

IFR and VFR flights are permitted, all participating IFR flights receive an air traffic advisory service and all flights receive flight information service if requested.

Class G:

IFR and VFR flights are permitted and receive flight information service if requested.

1.3 ICAO

ICAO is funded and directed by 193 national governments to support their diplomacy and cooperation in air transport as signatory states to the Chicago Convention (1944).

Its core function is to maintain an administrative and expert bureaucracy (the ICAO Secretariat) supporting these diplomatic interactions, and to research new air transport policy and standardization innovations as directed and endorsed by governments through the ICAO Assembly, or by the ICAO Council which the assembly elects.

Industry and civil society groups, and other concerned regional and international organizations, also participate in the exploration and development of new standards at ICAO in their capacity as 'Invited Organizations'.

As new priorities are identified by these stakeholders, the ICAO secretariat convenes panels, task forces, conferences and seminars to explore their technical, political, socio-economic and other aspects. It then provides governments with the best results and advice possible as they collectively and diplomatically establish new international standards and recommended practices for civil aviation internationally.

Strategic Objectives

In its ongoing mission to support and enable a global air transport network that meets or surpasses the social and economic development and broader connectivity needs of global businesses and passengers, and acknowledging the clear need to anticipate and manage the projected doubling of global air transport capacity by 2030 without unnecessary adverse impacts on system safety, efficiency, convenience or environmental performance, ICAO has established five comprehensive Strategic Objectives:

Safety:

Enhance global civil aviation safety. This Strategic Objective is focused primarily on the State's regulatory oversight capabilities. The Global Aviation Safety Plan (GASP) outlines the key activities for the triennium.

Air Navigation Capacity and Efficiency:

Increase the capacity and improve the efficiency of the global civil aviation system. Although functionally and organizationally interdependent with Safety, this Strategic Objective is focused primarily on upgrading the air navigation and aerodrome infrastructure and developing new procedures to optimize aviation system performance. The Global Air Navigation Capacity and Efficiency Plan (Global Plan) outlines the key activities for the triennium.

Security & Facilitation:

Enhance global civil aviation security and facilitation. This Strategic Objective reflects the need for ICAO's leadership in aviation security, facilitation and related border security matters.

Economic Development of Air Transport:

Foster the development of a sound and economically-viable civil aviation system. This Strategic Objective reflects the need for ICAO's leadership in harmonizing the air transport framework focused on economic policies and supporting activities.

Environmental Protection:

Minimize the adverse environmental effects of civil aviation activities. This Strategic Objective fosters ICAO's leadership in all aviation-related environmental activities and is consistent with the ICAO and UN system environmental protection policies and practices.

ICAO Standards

The establishment and maintenance of international Standards and Recommended Practices (SARPs), as well as Procedures for Air Navigation (PANS), are fundamental tenets of the Convention on International Civil Aviation (Chicago Convention) and a core aspect of ICAO’s mission and role.

SARPs and PANS are critical to ICAO Member States and other stakeholders, given that they provide the fundamental basis for harmonized global aviation safety and efficiency in the air and on the ground, the worldwide standardization of functional and performance requirements of air navigation facilities and services, and the orderly development of air transport.

Today, ICAO manages over 12,000 SARPs across the 19 Annexes and five PANS to the Convention, many of which are constantly evolving in concert with latest developments and innovations.

The development of SARPs and PANS follows a structured, transparent and multi-staged process – often known as the ICAO "*amendment process*" or "*standards- making process*" – involving a number of technical and non-technical bodies which are either within the Organization or closely associated with ICAO.

Typically, it takes approximately two years for an initial proposal for a new or improved Standard, Recommended Practice or procedure to be formally adopted or approved for inclusion in an Annex or a PANS. Occasionally, this timescale can be expanded or compressed depending on the nature and priority of the proposal under consideration.

1.5 AIRPORT SITE SELECTION

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

The factors listed below are for the selection of a suitable site for a major airport installation:

1.Regional plan

2.Airport use

3.Proximity to other airport

4.Ground accessibility

5.Topography

6.Obstructions

7.Visibility

8.Wind

9.Noise nuisance

10.Grading , drainage and soil characteristics

11.Future development

12.Availability of utilities from town

13.Economic consideration

Regional plan:

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

Airport use:

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

Proximity to other airport:

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

Ground accessibility:

The site should be so selected that it is readily accessible to the users. The airline passenger is more concerned with his door to door time rather than the actual time in air travel. The time to reach the airport is therefore an important consideration especially for short haul operations.

Topography:

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

Obstructions:

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

Visibility:

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

Wind:

Runway is so oriented that landing and take off is done by heading into the wind should be collected over a minimum period of about five years.

Noise nuisance:

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

Grading, drainage and soil characteristics:

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

Future development:

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

1.6 AIRPORT LAYOUT

The presents and the prevailing ultimate airport layout is explained in detail in Airport Layout Drawing. The main components of the Airport plan drawing contain wind data formulation, Place of airfield services, the physical features of the airport and prevailing general aviation growth.

Airport Layout drawings also present the runway protection locations, airport boundary property, and income funding zones. The descriptive plan designed for computers provides a detailed information on the future and prevailing features about several structures of understanding that allows the user to analyze and study any section in the airport zone clearly. The plan can be used for the primary information and understand the design of the airport and it can also update easily in the future in accordance to the new growth of the airport and more elaborated conditions of prevailing airport conditions that are made by airport design surveys.

As eminent in the Circular 150/5070-6B recommended by FAA and Airport Master Plans, the ALP has five prime purposes:

1. To create a design for the airport development by portraying planned facility growth.
2. The instruction by the ALP through which the airport promoter can ensure that growth upholds safety requirements and airport design standards, and is fully reliable with airport and community land use plans.
3. It acts as a manuscript for public use that aids as aeronautical record necessities and as a place of community reference discussions on budget resource planning and land use proposals.
4. It serves to enable the airport sponsor and the FAA to plan for ability developments at the airport. It also allows the FAA to forestall financial and technical needs. It also allows the FAA to prevent the airspace needed for approach procedure improvements or facility.
5. It acts as an efficient tool for the airport supporter, particularly its maintenance staff and growth.

It acts as a major requirement for the airport sponsor to get financial support from the FAA

The airport layout plan is a comprehensive illustration of the scaled version of prevailing and planned airport features. It indicates the position of the port and relevant authorization and geometric info that is needed to show compliance with pertinent principles.

The Airport Layout Plan portrays the suggested place of the capacities which are estimated to provide accommodations for the 30-year requirement. The airport layout plan shows growth of needed capacities in stages, constant with estimate request. Summary of the plan aids as a guide to the methodical and balanced developments of the airport that is done progressively.

Major Role of the airport

The Airport that is designed in this literature is chosen to be general aviation airport that is used only for general purposes like transportation of cargos, military operations, corporate use, emergency purposes, and for medical and agricultural uses, etc. As suggested, the forthcoming part played by an airport is to endure this general purpose until the municipal decides to follow commercial roles. Using existing Federal aviation authority guidelines, the Airport suggested can be listed in the Wasatch Front Regional Council's apprise to the Metropolitan Airports System Plan (MASP) and National Plan of Integrated Airport Systems (NPIAS) as a general aviation facility, accepting group C aircraft.

An airport is mainly divided into two areas −

- Airside Area
- Landside Area

Airside Area

It is the area beyond landside area inside the airport. It includes runways, taxiways, and ramps.

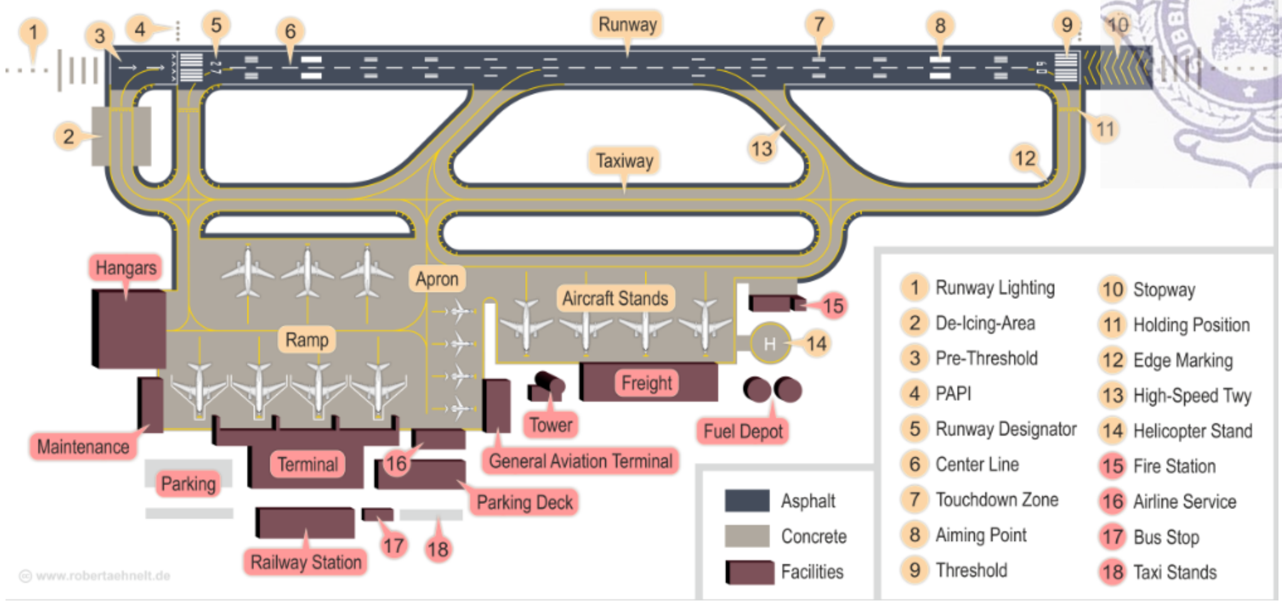
- **Runway** − An area where aircraft takes off and lands. It is made of soft grass, asphalt, or concrete. It has white markings, which help the pilot during take-off and landing. It also has lamps on the sides to guide the pilot during night. The vehicles other than the aircrafts are strictly prohibited to enter this area of the airport.
- **Ramp** − Also called Apron, this area is used for parking the aircrafts. It can be accessed for boarding and alighting the aircraft. The airline staff or ground duty staff can access this area.
- **Taxiway** − It is a path on the airport that connects the ramp to the runway.

Landside Area

It is the area in the airport terminal and the area towards city. It has access to the city roads and it contains parking area as well as public transport area.

- **Terminal** − It is a part of airport building that where travelers come to board their flight or arrive from a flight. There are security checking, baggage checking, amenities, and waiting areas at the terminal.
- **Car Parking** − This area is outside but adjacent to the terminal where vehicles can be parked on chargeable basis.

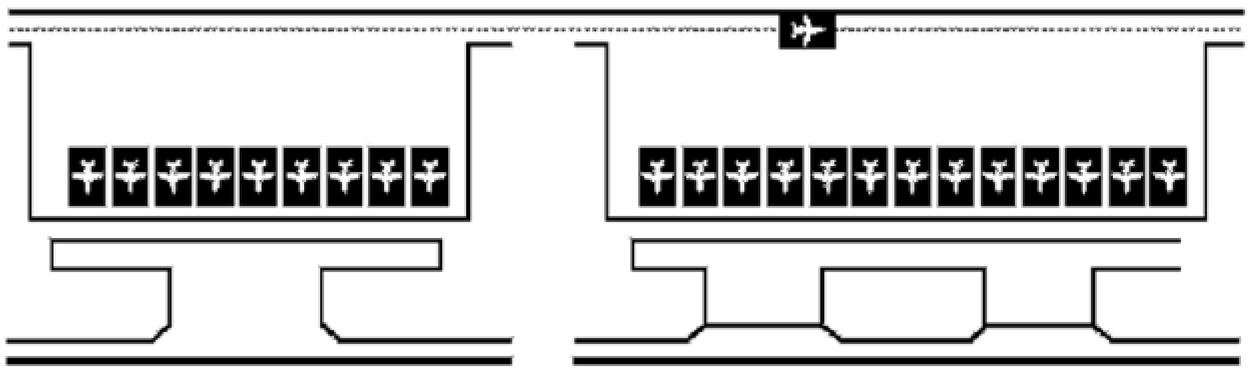
Most of the airports around the world are owned by local, regional, or national government bodies. According to the Aircraft Rules, 1937, the airports other than government airports are permitted to be owned by Indian citizens, or Indian companies or corporations registered and having their principal place of business as India. In India, some airports are owned by the state governments, private companies, or even individual citizens.


Runway
Taxiway
Hangars
Apron
Aircraft Stands
Ramp
Freight
Tower
Fuel Depot
Maintenance
Terminal
General Aviation Terminal
Parking
Parking Deck
Railway Station
Asphalt
Concrete
Facilities
1 Runway Lighting
2 De-Icing-Area
3 Pre-Threshold
4 PAPI
5 Runway Designator
6 Center Line
7 Touchdown Zone
8 Aiming Point
9 Threshold
10 Stopway
11 Holding Position
12 Edge Marking
13 High-Speed Twy
14 Helicopter Stand
15 Fire Station
16 Airline Service
17 Bus Stop
18 Taxi Stands
www.robertaehnelt.de

1.7 AIRCRAFT PARKING

Aircraft Parking Area, also known as airport apron, is the area of an airport where the aircrafts are parked, loaded, unloaded, refueled or boarded. It is a restricted area where access is controlled, there are 6 types of apron namely Simple, Linear, Curvilinear, Open, Pier and Satellite.

LINEAR



Advantages:

1. Offers ease of access and short walking distances for passengers from the transit area to the aircraft contact gates
2. Terminal can be expanded further by extending the current terminal linearly or developing another linear terminal with connectors

CURVILINEAR

Advantages:

1. Simple organisational principles
2. Allows future expansion of terminal
3. Allow more aircraft to park "nose-in" to the terminal building while maintaining short walking distances from the airport entrance to the aircraft gate

The apron and gate system

The apron and gates are the locations at which aircraft park to allow the loading and unloading of passengers and cargo, as well as for aircraft servicing and preflight preparation prior to entering the airfield and airspace.

The size of aircraft, particularly their lengths and wingspans, is perhaps the single greatest determinant of the area required fori ndividual gates and apron parking spaces. In fact, the grand size of airport terminals is a direct result of large numbers of gates designed to accommodate aircraft of wingspans reaching 200 feet in length.

The size of any given aircraft parking area is also determined byt he orientation in which the aircraft will park, known as the aircraft parking type. Aircraft may be positioned at various angles with respect to the terminal building, may be attached to loading bridges or Jet-ways, or may be freestanding and adjoined with airstairs for passenger boarding and deplaning. Some aircraft parking types require aircraft to be maneuvered either in or out of their parking spaces by the use of aircraft tugs, whereas other parking types allow the movement of aircraft in and out under their own power.

The five major aircraft parking types are nose-in parking, angled nose-in, angled nose-out, parallel parking, and remote parking. Most large jet aircraft at commercial service airports park nose-in to gates at the terminal and connect directly to the terminal building by loading bridges.

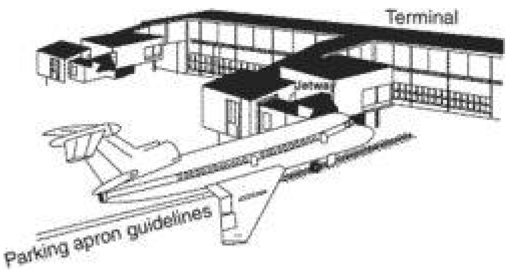
Aircraft are able to enter nose-in parking spaces under their own power, and tend to be pushed out by an aircraft tug and oriented so that they may move forward on the apron without coming into contact with any other structures. The primary advantage to nose-in parking is that it requires less physical space for aircraft than any other aircraft parking type. The majority of commercial service airports, particularly those with large volumes of jet aircraft operations, have primarily nose-in parking.

With nose-in parking, only the front-entry door on the aircraft isu sed for boarding, because the rear doors are typically too far from the terminal building to extend a loading bridge. This has some, but not ane ntirely significant, impact on the efficiency of passenger boarding and deplaning.

Angled nose-in parking brings aircraft as close to the terminal building as possible while maintaining enough maneuvering room so that aircraft may exit the parking space under its own power. Angled nose-inp arking is typically used by smaller aircraft, such as turboprops or small regional jets.

Parallel parking is said to be the easiest to achieve from an aircraft maneuvering standpoint, although each space tends to require the largest amount of physical space for a given size of aircraft. In this configuration, both front and aft doors of the aircraft on a given side may be used for passenger boarding by loading bridges.

Nose-in parking



Nose in parking.

A parking position near the terminal building as shown in the illustration. Normal ly, aircraft park in this position under their own power but they have to be towed back f or starting and taxiing out. Many operators, when authorized by their regulatory authorit y, can be "powered back" using the airplane power plant and reverse thrust.

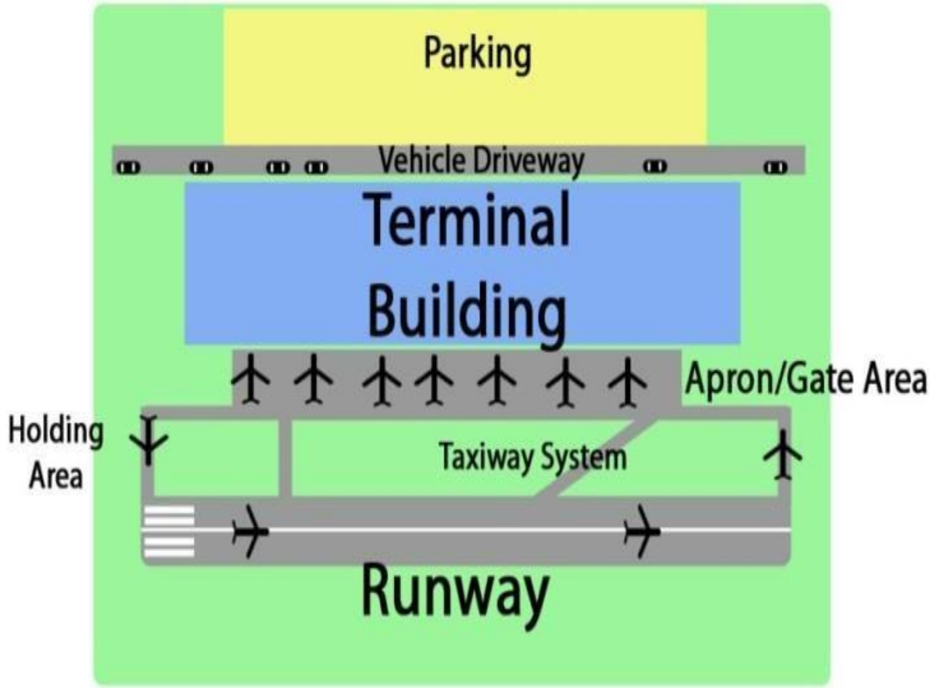
Angled nose-in brings aircraft as close to the terminal building as possible while maintaining enough maneuvering room so that aircraft may exit the **parking** space under its own power.

Angled nose-in parking is typically used by smaller aircraft, such as turboprops or small regional jets.

Aangled **nose-out** brings **aircraft** slightly farther from the terminal building than **nose**-in and angled **nose-** in **parking**, because the blast from jets or large propellers has the potential of causing damage to terminal buildings if too close to the facility.

2.1 COMPONENTS OF AN AIRPORT

COMPONENTS OF AIRPORT



The **main components of airport are**

1. Landing Area of Airport

It is the airport components used for landing and takeoff operations of an aircraft. Landing Area includes ***Runways*** and ***taxiways***.

Landing area is the component of airport used for landing and takeoff operations of an aircraft. Landing area includes,

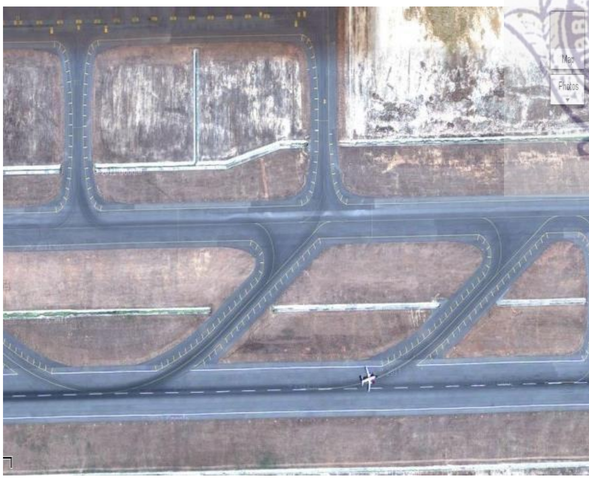
a. Runways
b. Taxiways

a. Runways

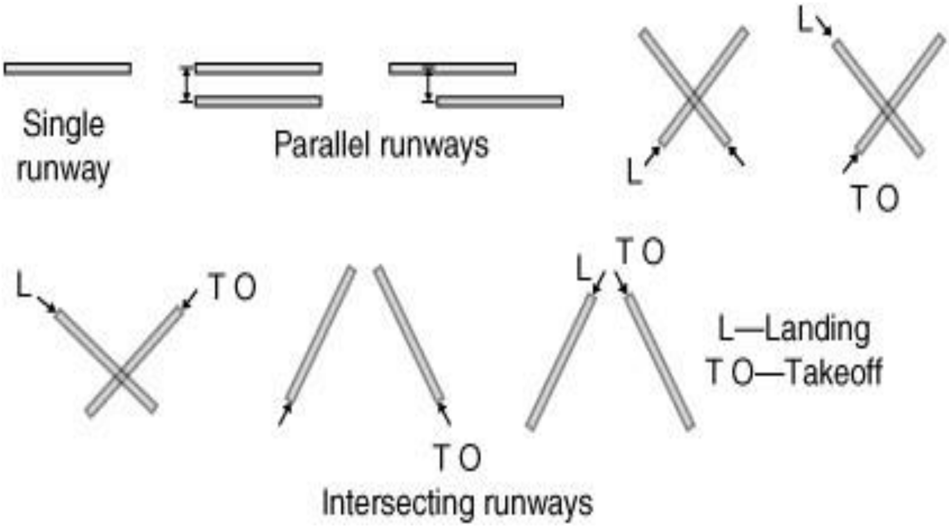
It is the most important part of an airport in the form of paved, long and narrow rectangular strip which actually used for landing and takeoff operations. It has turfed (grassy) shoulders on both sides. The width of runway and area of shoulders is called the landing strip. The runway is located in the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

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

Runway



Taxiway



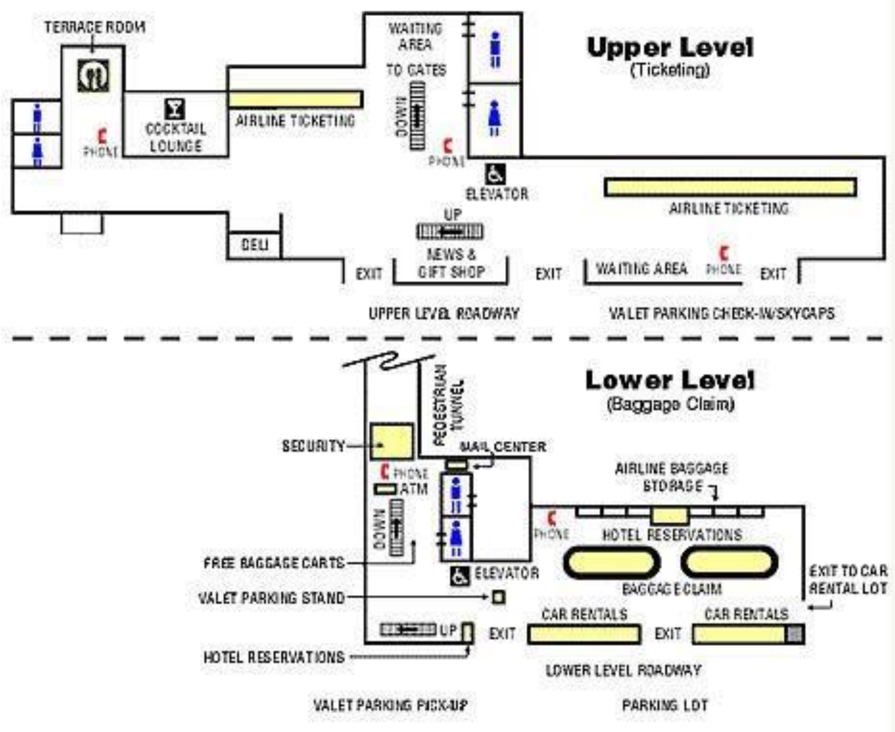
b. Taxiways

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

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

2. Terminal Area

The transition of passengers and goods from ground to air takes place in the terminal area. Various methods are used to accommodate and transfer the public and its goods arriving either by ground or by air. The degree of development in the terminal area depends up on volume of airport, operations, type of air traffic using airport, number of passengers and the airport employees to be served and the manner in which they are served and accommodated. Terminal area consists of the following parts ***Terminal building***, ***Apron***, ***Automobile Parking Area***, ***Hangers***.



Terminal building

2.2 GEOMETRIC DESIGN OF RUNWAY AND TAXIWAYS

ELEMENTS OF TAXIWAY DESIGN

Taxiway

A taxiway is a path for aircraft at an airport connecting runways with aprons hangars terminals and other facilities.

Geometric Design Standards

- Turning radius
- Sight distance
- Rate of change of longitudinal gradient
- Transverse gradient
- Longitudinal gradient
- Width of safety area
- Width of taxiway
- Length of taxiway

Length of Taxiway

The speed of an aircraft on a taxiway is also less than the runway.

Width of taxiway is lower than the runway width.

No specifications are recommended by any organisation. Width of taxiway

It should be as short as practicable.

Longitudinal Gradient

ICAO recommends that the longitudinal gradient should not exceed 1.5% for A and B types and 3% for C D and E types.

A width of 7.5 m of shoulders adjacent to the pavement edges should be paved with light strength material.

Width of safety area

This area includes taxiway pavement on either side that may be partially paved plus the area that is graded and drained.

Rate of change of longitudinal gradient

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

ICAO has recommended that the transverse gradient should not exceed 1.5% for A,B and C and C types and 2% for D and E types of airports.

Transverse Gradient

This is essential for quick drainage of water.

Sight distance

The radius of horizontal curve is obtained by : R=V^2/125f V =speed in kmph coefficient of friction f =.13

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

ICAO has recommended that the surface of taxiway must be visible from 3m height for a distance of 300m for A,B and C types and distance of 250 m be visible for 2.1m height for D and E types of airports.

TURNING RADIUS

Horonjeff equation

R=.388w^2/T/2-S

W=wheel base of taxiway in metre

T=width of taxiway pavement in metre

S=distance between midway point of main gears and the edge of the taxiway pavement in metre for super sonic planes it is taken as 180m and for sub sonic it is taken as 120m.

Taxiway design and geometrical design of taxiway

The speed of an aircraft on taxiway is much lower than its speed on a runway during the landing or take-off.} A taxiway is a path for aircraft at an airport connecting runways with aprons,hangars,terminals.

Factors controlling taxiway layout

Turning radius Sight

distance Transverse

gradient Longitudinal

gradient Width of

safety area Width of

taxiway Length of

taxiway Bypass

taxiway Holding

apron Separation

clearance Fillets

Exit taxiways

Factors controlling exit taxiway Aircraft

leaves runway quicker Intersection of

taxiway and runway avoid Taxiway-short

distance

No interfere taxiway

Fillets

Distance between two parallel taxiway

Icao-recommends radius of fillet should not less than width of taxiway

Provide at junction of two runways, taxiway.

Fillets(radius) separation clearance

Also called turnaround taxiway

No parallel taxiway is recommended because is not economic

Checking process if any defects – change aircraft

Wait for turn to take-off

Holding apron bypass taxiway(more traffic)

GEOMETRIC DESIGN OF RUNWAY

Length

Longitudinal and Effective gradient

Safety Area Sight

Distance Transverse

Gradient Width

Length of Runway

The Basic runway length is given by ICAO in accordance with the classification of airports.

The actual runway length is computed after applying corrections in length for: –

Elevation

Temperature, and

Gradient

Longitudinal and Effective gradient

The longitudinal gradient increases the runway length

Fuel consumption of aircraft increases on uphill slope climbing during takeoff.

Safety Area

It includes runway, shoulders on either side of runway, and additional length

The shoulders are generally unpaved

They are only used in case of emergency

They are generally turfed or made of stabilized soil

Shoulders provide a sense of openness and vastness to pilot

The length of safety area should extend by 60m on either side beyond runway ends

The total length of safety area is = Runway Length +120

Stopway

A stopway is an area beyond the runway to decelerating an aircraft in case of an aborted takeoff.

It must be at least as wide as the runway and must be capable of supporting an airplane without causing structural damage to it.

Clearway

A clearway is a defined area connected to the end of a runway

It increases the allowable airplane operating takeoff weight without increasing runway length.

Runway:

Design Criteria

It should be designed keeping in view the characteristics of critical aircraft.

The major design guidelines:

Length, width, and orientation (direction),

configuration (multiple runways),

Slope (Longitudinal and cross)

Pavement thickness of runways

Immediate airfield area surrounding the runways obstructions

Function of Taxiways

They connect runways with other areas, like terminal building, cargo, and parking areas. Taxiways gives access for aircraft to and from the runways

Types of taxiways

Parallel taxiway

Provided parallel to an adjacent runway, It facilitates aircrafts to reach the apron area from runway after landing and from apron area to runway for take-off.

Entrance taxiway

Located near the runway threshold. It facilitates entry of an aircraft to runway for take-off operation.

Exit taxiways

Located at various points along the runway to allow landing aircraft to efficiently exit the runway after landing.

Bypass taxiways

Provided to give way to aircraft, Located at areas of congestion at busy airports.

Taxiways:

Design Criteria

Provide each runway with a parallel taxiway

Design taxiways of optimum length

Provide bypass capability or multiple accesses to runway ends

Minimize crossing runways

Provide large curves and fillet radii for easier maneuvering of aircrafts.

Provide airport traffic control tower line-of-sight

3.1 RUNWAY ORIENTATION

Runway

"Rectangular area on an aerodrome used for landing and takeoff." Runway orientation is important in airport planning. Current practice is to layout a runway in the direction of prevailing wind.

Importance of runway layout

- Determination of runway is a critical task.
- It is very important for safe take offs and approaches.
- The width and sloping of runway also play a role in safe approaches.

Runway Numbers

- Runways are numbered according the magnetic compass direction.
- Consists of two numbers one at each end of runway.
- Preceding that number are eight stripes.

Runway Heading

- By 500 feet is the touchdown zone, identified by six stripes.
- Runway numbers are not given in degrees, rather in shorthand format.
- A runway with a marking of 14 is actually 140 degrees.
- For simplicity FAA rounds off the precise headings to nearest tens.

Runway Configuration

FAA includes over 20 runway layouts. Amongst them there are 4 basic runway patterns:

- Single Runway
- Parallel Runway
- Open-V Runway
- Intersecting Runway

Factors affecting runway orientation

- Wind
- Airspace Availability
- Environmental factors
- Obstructions to navigation
- Air traffic control visibility
- Wild life hazards
- Terrain and soil consideration

Wind rose analysis

An approach often used in determining the runway orientation. The method uses a wind rose template. A transparent runway template is placed and rotated around the center of wind rose. At each rotating angle, the percentage of allowable cross winds is measured

Runway Lighting

These lights are used to assist pilot in to identify the runway.

- Green Threshold Lights: Line the runway edge.
- Red Lights: Mark the end of runway.
- Blue Lights: Run alongside taxiways.

While runways have Yellow or White lights marking their edges

Runway Signs

Various kinds of runway signs are also used for facilitation. They differ according to their purpose and action.

3.2 WIND ROSE DIAGRAM

A **wind rose** is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location.

Historically, wind roses were predecessors of the compass rose (found on charts), as there was no differentiation between a cardinal direction and the wind which blew from such a direction.

Using a polar coordinate system of gridding, the frequency of winds over a time period is plotted by wind direction, with colour bands showing wind speed ranges.

The direction of the longest spoke shows the wind direction with the greatest frequency.

Before the development of the compass rose, a wind rose was included on maps in order to let the reader know which directions the 8 major winds (and sometimes 8 half-winds and 16 quarter-winds) blew within the plan view.

No differentiation was made between cardinal directions and the winds which blew from those directions. North was depicted with a fleur de lis, while east was shown as a Christian cross to indicate the direction of Jerusalem from Europe

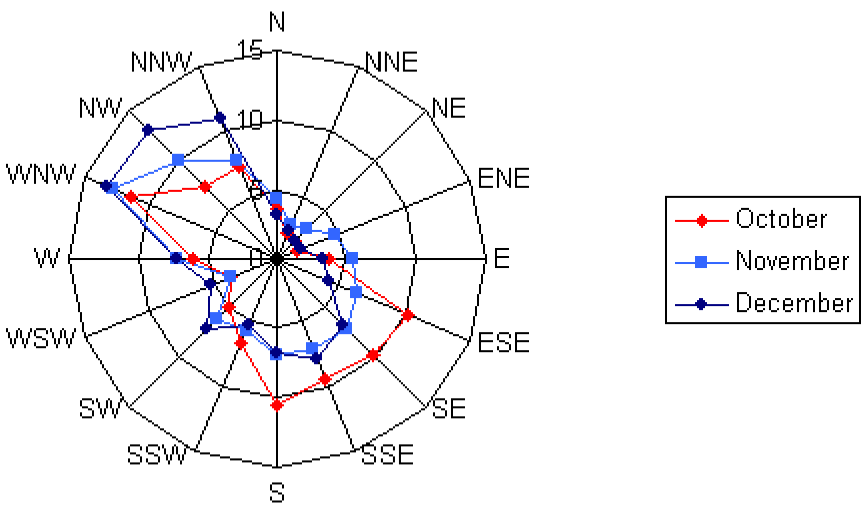
Presented in a circular format, the modern wind rose shows the frequency of winds blowing *from* particular directions over a specified period. The length of each "spoke" around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric circle represents a different frequency, emanating from zero at the center to increasing frequencies at the outer circles. A wind rose plot may contain additional information, in that each spoke is broken down into colour-coded bands that show wind speed ranges. Wind roses typically use 16 cardinal directions, such as north (N), NNE, NE, etc., although they may be subdivided into as many as 32 directions.

In terms of angle measurement in degrees, North corresponds to 0°/360°, East to 90°, South to 180° and West to 270°.

Compiling a wind rose is one of the preliminary steps taken in constructing airport runways, as aircraft can have a lower ground speed at both landing and takeoff when pointing against the wind.

Wind rose, map diagram that summarizes information about the wind at a particular location over a specified time period. A wind rose was also, before the use of magnetic compasses, a guide on mariners' charts to show the directions of the eight principal winds. The modern wind rose used by meteorologists gives the percentage of the time the wind blows from each direction during the observation period; it sometimes shows the strengths of these winds and the percentage of the time calm air or light winds are observed. This wind rose usually has eight radiating lines, whose lengths are proportional to wind frequency, and shows wind strength by the thickness of the lines or by feathers attached to them. The frequency of calm or nearly calm air is given as a number in the centre.

The earliest-known wind roses appeared on navigation charts used in the 13th century by Italian and Spanish sailors. The eight points were marked with the initials of the principal winds; sometimes the east point had a cross, and the north point had a fleur-de-lis. When the magnetic compass began to be used in navigation, the wind rose was combined with it and used as a compass card.



3.4 AIRPORT ZONING

Airport height **zoning** is also termed as hazard **zoning**. Height **zoning** is mainly used to protect the approaches to the **airport** from the obstruction of any object. Certain rules and regulars are made to the heights of structures on land surrounding the **airport**.

Land Use Compatibility Zones

It is critical to maintain safe operational environments both on airport property, as well as within communities surrounding local airports. As outlined in previous chapters, one of the primary factors in determining land use compatibility often relates to the proximity of a specific land use to an airport and more specifically the runways. Identification of zones that delineate specific geographic areas of interest is an important part of the land use planning process. It is necessary to define types of land uses that are not compatible, limited, or allowed within the designated geographic areas surrounding an airport. These land uses can then be incorporated into city or county comprehensive plans and/or airport zoning ordinances.

The land uses included in this document are not an inclusive list. They are intended to provide a general understanding of the types of land uses typically found in a community. If individual land use requests arise that are not included in the tables identified in this chapter, local communities should apply the general concepts outlined in this document to evaluate the requests for land use compatibility on a case-by-case basis. Some interpretation by individual municipalities may be necessary to fully address the needs within their community due to site specific needs. This chapter identifies recommended land use zoning districts and distinguishes compatible land use types within each zones district.

Basis for Land Use Zones

Two primary sources of information were used to develop recommended zones for land use compatibility within Iowa:

• Federal Aviation Administration (FAA) Advisory Circular (AC) 150- 5300-13, Change 11, Airport Design, specifically Runway Protection Zones (RPZs)

• Federal Aviation Regulation (FAR) Part 77, Objects Affecting Navigable Airspace, commonly know as the FAR Part 77 Surfaces RPZs and Part 77 Surfaces .

FAR Part 77 Surfaces and RPZs can be utilized to evaluate the concept of compatible land use and provide a multi-purpose tool with commonly recognized surfaces to address both height and land use concerns. Dimensional standards and descriptions of these surfaces are contained in the following section to define the basis for land use compatibility. Airport traffic patterns, while not used as a basis for the land use zoning districts, are important to understand as they relate to compatible land use within each zone.

Runway Protection Zones

RPZs are the areas at each end of the runway that have a critical need for protection from incompatible land uses. It is desirable to clear all objects from the RPZ, per the criteria noted in FAA AC 150/5300-13 Change 11, Airport Design, although some uses are permitted, provided they do not attract wildlife, are outside of the runway object free area (OFA), and do not interfere with navigational aids. Land uses specified in AC 150/5300-13 Change 11, Airport Design, which are prohibited from the RPZ areas include:

• Fuel storage facilities

• Residential structures (homes, condominiums, apartments, and manufactured housing parks)

• Places of public assembly (places of worship, schools, hospitals, office buildings, shopping centers, or other uses with similar concentrations of people)

If an airport does not own or control the entire RPZ where it has been determined to be impracticable to purchase the property, then the AC's RPZ land use standards should be consulted to determine the appropriate recommendation status for the portion not owned by the airport.

If residential structures are currently located within an RPZ, the airport should attempt to fully acquire the property. However, if this option is impractical, the airport sponsor should consider the acquisition of an avigation easement to provide control over the RPZ area. Obtaining easements which are restrictive enough to limit building opportunities, as well as height, are often just as costly to procure as purchasing the property outright.

The FAA evaluates height concerns for land uses within the following four surface areas used as a basis for compatibility.

Approach surface

The approach surface is longitudinally centered on the extended runway centerline and extends outward and upward from the end of the runway primary surface. The approach slope of a runway is a ratio of 20:1, 34:1, or 50:1, depending on the approach type. The length of the approach surface varies from 5,000 to 50,000 feet and also depends upon the approach type.

Transitional surface

The transitional surface extends outward and upward at right angles to the runway centerline and extends at a slope of seven feet horizontally for each one foot vertically (7:1) from the sides of the primary and approach surfaces. The transitional surfaces extend to the point at which they intercept the horizontal surface at a height of 150 feet above the established airport elevation.

Horizontal surface

The horizontal surface is a horizontal plane located 150 feet above the established airport elevation and encompasses an area from the transitional surface to the conical surface. The perimeter is constructed by generating arcs from the center of each end of the primary surface and connecting the adjacent arcs by lines tangent to those arcs. The radius of the arc is 5,000 feet for all utility or visual runways and 10,000 feet for all other runways.

Conical surface

The conical surface extends upward and outward from the periphery of the horizontal surface at a slope of 20 feet horizontally for every one foot vertically (20:1) for a horizontal distance of 4,000 feet.

Departure surface

In addition to the aforementioned surfaces, an additional surface to consider is the departure surface for runways with non-precision or precision runways instrument guidance. The departure surface is 1,000 feet to 10,000 feet depending on the type of instrument guidance and has a slope of 40 feet horizontally for every one foot vertically (40:1) for a distance of 6,466 feet. Objects, structures, or natural vegetation penetrating the departure surface may affect the departure procedures at an airport and therefore should be protected for each runway end.

3.5 PASSENGER FACILITIES AND SERVICES

BAGGAGE WRAPPING

Baggage wrapping service using state of the art technology is available in the city side as well as the check in area of International Terminals.

DUTY FREE

Duty free shops are located both in the arrival and departure of International Terminals.

SELF CHECK IN

Simply drop your check in baggage at the baggage drop counter of respective airlines on utilizing the self check-in facility available in the departure hall of domestic and international terminals. You can select seats and print your boarding pass using this facility.

WI-FI

Free wi-fi facility is available for 45 minutes for passengers at domestic and international terminal. To connect to free wi-fi service, passengers should provide their mobile numbers as login id's. Once connected, this service enables the passengers to access the net. This service requires a valid Indian mobile number and after the free time the same can be extended on payment.

OTHER SERVICES

Passenger can place a request to concerned airline for a wheelchair while booking tickets or can also contact the airline ticketing counter after reaching the airport for the same

At the Airport, AAI has provided,

Ramps for seamless movement of wheelchairs.

Braille symbols and auditory signals in the lifts for visually impaired.

Differently-abled friendly toilets.

Ambulift services on payment basis.

Free telephone facility is also available on the cityside of the both the Terminals with the contact numbers of airlines.

SMOKING LOUNGE

Smoking lounge facility is available at the Security Hold Area of both International & Domestic Terminals.

PRAYER ROOM

Prayer room is available in the Security Hold Area at International Terminal for the convenience of passengers.

INDIA POST

Both passengers & visitors can avail the facility of postal service at the Airport. Counter is conveniently located at Domestic Departure level. The postal services are available 10:00 hrs – 18:00 hrs from Monday to Saturday. The postal services remain unavailable on Sundays and Public Holidays.

INTER TERMINAL TRANSFERS

Free battery-operated vehicles and courtesy coaches offering shuttle service for the convenience of transit passengers between Domestic & International terminals.

LOST AND FOUND

As a policy and practise all agencies at the airport are expected to deposit any unclaimed goods under the Lost & found property to the Duty Terminal Manager both at Domestic & International Terminals. The Lost & Found item are deposited after duly recording the contents, description, date & time of deposition and the depositors signature. The Lost & Found items are deposited to warehouse after 24hrs and can be reclaimed by the passenger or by any person duly authorized by passenger on all working days between 0930 – 1800hrs.

CHILD CARE ROOM

Child care rooms are available at Domestic (5nos.) & International (2nos.) Terminals for providing essentials to the child/infant such as feeding, changing diapers etc.

FOREIGN EXCHANGE

Passengers and tourists can avail currency exchange services with 2 foreign exchange counters in Domestic Terminal and 5 counters in International Terminal.

ATM

Automatic Teller Machine (ATM) of various banks are conveniently located at Domestic & International Terminals to extend selected banking services for travel need.

CHECK IN COUNTER

124 Check in counters are operational in Domestic & International Departure Terminals. The check-in counters are divided in two wings as east & west wing containing 31 counters each and the information is available on Flight Information Display Monitors

AIRLINE TICKET COUNTER

Ticketing counters of various airlines are available at Departure level of Domestic Terminal. Two other non – airline ticketing counters are providing services at Arrival level of Domestic Terminal and Departure level of International Terminal. All these counters can be accessed through cityside.

LOUNGE FACILITY

Lounges at multiple locations in the Domestic & International Departures of Chennai Airport offers world class amenities including best of cuisines, plush seating, complimentary Wi-Fi, wide range of National, International & Regional dailies along with various magazines. Serving round the clock the lounges cater to Airline CIP customers as well as passengers availing access through Priority Pass, high-end credit cards and other loyalty cards.

3.6 RUNWAY AND TAXIWAY MARKING

Runways

Runways are defined rectangular surfaces, on an airport, prepared or suitable for the landing or takeoff of airplanes. The colors of markings on runways are white. A runway should be marked according to its usage. The three classifications of runways are

1. Visual Runways,
2. Nonprecision Instrument Runways, and
3. Precision Instrument Runways.

A Visual Runway does not have an existing or planned straight-in instrument approach procedure.

A Nonprecision Instrument Runway has an existing instrument approach procedure which uses navigational aids with only horizontal or lateral guidance to the airport or runway.

A Precision Instrument Runway has an existing instrument approach procedure using a precision instrument landing system, which provides both lateral and vertical guidance to a runway end.

Runway Centerline Markings

Centerline markings on runways identify the physical center of the runway and provides alignment guidance during landing and takeoff. The runway centerline markings are white and are located along the centerline of the runway between the runway designation markings. These markings consist of a line of uniformly spaced stripes and gaps. The stripes are 120 feet long and have gaps that are 80 feet in length. Any adjustments to the length and gaps of the stripes that may be needed because of runway length are to be made near the runway midpoint. The minimum width of each stripe is 12 inches for visual approach runways, 18 inches for non precision instrument runways, and 36 inches for precision instrument runways.

Runway Threshold Marking

A threshold marking identifies the beginning of the runway that is available and suitable for landing. The runway threshold markings consist of eight white longitudinal stripes of uniform dimension arranged evenly about the runway centerline. These markings start 20 feet from the runway threshold. The stripes must be 150 feet long, 5.75 feet wide, and spaced 5.75 feet apart except the center space which is 11.5 feet apart. The stripes extend sideways to within 10 feet from the edge of the runway or to a distance of 90 feet on either side of a runway centerline, whichever is the smaller lateral distance.

Runway Aiming Point Marking

An aiming point marking provides jet aircraft a visual aiming point for landing operations. The aiming points are white and the beginning of these markings are located 1,020 feet from the threshold. The aiming points consist of two rectangular markings, 150 feet in length, located on each side of the runway centerline. The width of each marking is 30 feet for a runway with a width of 150 feet or greater. The spacing between the inner sides of the markings is 72 feet for a runway width of 150 feet or greater. For runways that are less than 150 feet wide, the width of the markings and the space between the inner sides of the markings is decreased in proportion to the decrease in the width of the runway. Where there are touchdown zone markings, the space between the inner sides of the markings should be the same as that of the touchdown markings.

Runway Touchdown Zone Marking

The touchdown zone markings identify the touchdown zone for landings and are coded to provide distance information. These markings are white and consist of groups of one, two, and three rectangular bars evenly arranged in pairs along the runway centerline. For runways less than 150 feet in width, the markings and spaces are reduced proportionally, but the lengths remain the same. On runways having touchdown zone markings at both ends, the pairs of markings which extend to within 900 feet of the runway midpoint are eliminated. The fixed distance markings are a part of the touchdown zone markings but are used alone on non precision instrument runways and visual runways 4,000 feet in length or longer used by jet aircraft. Touchdown zone markings are required on runways with precision instrument approaches.

Runway Side Strip Marking

Runway side stripe markings provide a visual distinction between the runway and the surrounding terrain and also outline the runway width. Runway side stripes are white and consist of continuous stripes located along each side of the runway. The maximum distance between the outer edges of the stripes is 200 feet. The stripes have a minimum width of 36 inches for precision instrument runways and are at least equal to the width of the runway centerline stripes on other runways. The stripes extend to the end of displaced threshold areas which are used for takeoffs and rollouts. Side stripes are required on precision instrument runways.

Runway Threshold Bar

A threshold bar identifies the beginning of the runway that is available for landing when there is pavement aligned with the runway on the approach side of the threshold. A threshold bar is white and is located on the landing runway at the threshold. The threshold bar is 10 feet wide and extends across the width of the runway.

Demarcation Bar

A demarcation bar identifies a runway with a displaced threshold from a blast pad, stopway or taxiway that precedes the runway. The demarcation bar is yellow and is located on the blast pad, stopway or taxiway at the point where the runway intersects. The demarcation bar is 3 feet wide and extends across the width of the blast pad, stopway or taxiway.

Arrows and Arrowheads

Arrows are used to identify a displaced threshold area and are useful for centerline guidance for takeoffs and/or rollouts. Arrowheads are used in connection with a threshold bar to highlight the beginning of a runway where the use of chevrons is not appropriate. Arrows and arrowheads used in a displaced threshold area are white. Arrowheads used on taxiway prior to a runway threshold are yellow.

When a runway threshold is permanently displaced, the rows and arrowheads are located in the portion of the runway before the displaced threshold. Where the pavement area before a runway is used as a taxiway, arrowheads are located prior to the threshold bar. Please refer to the FAA Advisory Circular AC 150/5340-1J, "Standards for Airport Markings", for dimensions and spacing of arrows and arrowheads.

Chevrons

Chevrons are used to identify pavement areas unusable for landing, takeoff, and taxiing. Chevrons are yellow and are located on pavement areas that are aligned with and adjacent to the runway. Please refer to the FAA Advisory Circular AC 150/5340-1J, "Standards for Airport Markings", for dimensions and spacing of chevrons.

Markings For Blast Pads And Stopways

A runway blast pad is a surface near the ends of runways provided to reduce the erosive effect of jet blast and propeller wash. A runway stopway is a defined surface beyond the end of the runway that was designed to be suitable for supporting an aircraft, without damaging that aircraft, during an aborted takeoff. All markings on blast pads and stopways are painted yellow.

Taxiways

Taxiways are defined as the paths that are used for the taxiing of aircraft from one part of an airport to another. All taxiway markings are yellow. The different types of taxiway markings are as follows:

- Taxiway Centerline Marking
- Taxiway Edge Marking
- Holding Position Markings
- Markings for a Taxiway in Front of a Runway

Taxiway Centerline Marking

Taxiway centerlines are marked to provide a visual identification of the designated taxiing path. Taxiway centerlines are yellow and consist of a continuous stripe along the centerline of the designated taxiway. On a taxiway curve, the markings continue from the straight portion of the taxiway at a constant distance from the outside edge of the taxiway. A width of between 6 inches and 12 inches wide is acceptable provided the width selected is uniform for its entire length.

The centerline will be continuous in length except where it intersects a holding position marking or runway marking element. For taxiway intersections designed for the straight thorough method of taxiing, the centerline markings continue straight through the intersection. At taxiway intersections with a runway end, the taxiway centerline marking is terminated at the runway edge, (with the exception of the situation where there is a displaced threshold, in which case the taxiway centerline may be extended onto the runway displaced area). On taxiways used as an entrance or exit to a runway, the taxiway centerline marking curves onto the runway and extends parallel to the runway centerline marking for 200 feet past the point where the two markings become parallel. For taxiways crossing a runway, the taxiway centerline marking may continue across the runway but must be interrupted for the runway markings.

Taxiway Edge Marking

Taxiway edge markings are used to delineate the edge of the taxiway. They are used when the taxiway edge does not correspond with the edge of the pavement and where the full strength pavement of the taxiway is not readily visible. Taxiway edge markings are yellow and can either be continuous or dashed. Continuous taxiway edge markings are used to identify the taxiway from the shoulder or some other surface not intended to be used by aircraft.

Dashed taxiway edge markings are used when the aircraft would need to cross the lines, for example when a taxiway enters or crosses aprons.

Continuous taxiway edge markings consist of a continuous double yellow line, each being at least 6 inches in width and spaced 6 inches apart. Dashed taxiway edge markings consist of a broken double yellow line, each being at least 6 inches wide spaced at 6 inches apart from edge to edge. The lines are 15 feet in length with 25 foot gaps.

Runway Holding Position Markings

On Taxiways Holding position markings identify the location on a taxiway where an aircraft is supposed to stop while awaiting clearance to proceed onto the runway. Holding position markings should be located on all taxiways that intersect runways based upon the most critical aircraft using the runway. There are four types of holding position markings. These markings are outlined with black lines and black interim spaces if needed for improved visibility on light colored (such as Portland cement) pavement areas. They are as follows:

- Holding Position Markings for Taxiway/Runway Intersections
- Holding Position Markings for Runway/Runway Intersections
- Holding Position Markings for Taxiway/Taxiway Intersections
- Holding Position Markings for Instrument Landing System (ILS) Critical Areas

Holding Positions Markings For Taxiway/Runway Intersections

Holding position markings for taxiway/runway intersections are indicated with two solid lines followed by two broken lines. The solid lines are always on the side where the aircraft is to hold.

Holding Positions Markings For Runway/Runway Intersections

Holding position markings for runway/runway markings are identical to the holding position markings for taxiway/runway intersections (see Figure 13.1). The solid lines of these markings are also always on the side where the aircraft is to hold. However, these markings should only be installed on a runway where that portion of the runway is used as a taxiway or used for “land and hold short” operations.

Holding Positions Markings For Taxiway/Taxiway Intersections

Holding position markings for taxiway/taxiway intersections are indicated with a single line of dashes and spaces. These markings should only be installed at taxiway/taxiway intersections where there is an operational need to hold aircraft at this point, and are often not necessary.

Holding Positions Markings For ILS Critical Areas

The holding position markings for ILS critical areas are indicated with a set of two parallel lines spaced four feet apart, in between these two lines and perpendicular to them are sets of two parallel lines spaced one foot apart . Due to their appearance, these markings are commonly referred to as a “ladder” or “rail road tracks”.

The holding position markings for ILS critical areas identify the location on a taxiway where an aircraft is supposed to stop when it does not have clearance to enter these critical areas. These critical areas are used to protect the navigational aid signal or the airspace required for the approach procedure. These markings are installed at the perimeter of the ILS critical area and are perpendicular to the taxiway centerline. Where the distance between the taxiway/runway holding position and the holding position for an ILS critical area is 50 feet or less, one holding position may be established, provided it does not affect capacity. The local FAA airways facilities office will help designate the ILS critical areas for the airport operator.

4.1 DEFINITIONS OF BASIC TERMS

HARBOUR

Harbour is defined as a parking or storage space along the coastline, where boats, barges and ships can take shelter from bad weather or are kept for future. It is the area alongside the coast, which consists of a thick wall providing protection from the waves and currents to the ships, vessels, and cargo container loaders.

PORT

Port is defined as the place situated at the shore of the sea which connects land with the waterbody. They work as junction points for trading internationally, as in the exchange of modes of transport, goods, etc. These are located in harbours, alongside the coastlines.

SATELLITE PORT

A satellite port can either be one that is already existing or is created near a port that is reaching capacity. Satellite ports help overcome issues such as limited land availability and draft adequacy, which is depth of water to which a ship sinks according to its load.

WHARF

It denotes any structure of timber, masonry, cement, or other material built along or at an angle to the navigable waterway, with sufficient depth of water to accommodate vessels and receive and discharge cargo or passengers. The term can be substituted for quay when applied to great solid structures in large ports. The area between the quay wall (made of solid masonry) and the nearby warehouse or storage facility is ca1led the quay apron.

PIER

A pier is a construction work extending into the harbour with sufficient depth of water alongside to accommodate vessels, also used as a promenade or landing place for passengers.

JETTY

A jetty is a small pier, usually made of timbers for boats, yachts or fishing boats (fisherman jetty), but it also refers to large ships.

DOCK

A dock is an enclosed area of water used for loading, unloading, building or repairing ships. Such a dock may be created by building enclosing harbour walls into an existing natural water space, or by excavation within what would otherwise be dry land.

A wet dock or impounded dock is a variant in which the water is impounded either by dock gates or by a lock, thus allowing ships to remain afloat at low tide in places with high tidal ranges. The level of water in the dock is maintained despite the rising and falling of the tide. This makes transfer of cargo easier. It works like a lock which controls the water level and allows passage of ships.

A dry dock is another variant, also with dock gates, which can be emptied of water to allow investigation and maintenance of the underwater parts of ships.

A floating dry dock (sometimes just *floating dock*) is a submersible structure which lifts ships out of the water to allow dry docking where no land-based facilities are available.

WAVES

Due to the extreme raging force exerted on the surface of the water by the wind, waves are formed. Waves are usually seen in shallower areas of the ocean. Waves are created when many winds and water influences interact with each other.

TIDES

Due to the interaction of gravitational effects between the Earth, the moon, and the sun, tides are produced. In deep oceanic areas, tides are usually produced. Tides are created by rising and falling sea levels through the influence of gravity.

4.2 PLANNING AND DESIGN OF HARBOURS

The planning and design of harbor is an important engineering phenomenon with both major commercial and social implications. The literature suggests that various approaches for harbors design of harbors such as fishing, commercial and refugee harbors. The aim of this paper is to present a general guidance for the planning and design of harbors. There are a number of general requirements which has to be fulfilled while designing the harbors but also there are some specific requirements for each of them. Furthermore, the different types of foundations such as shallow water foundations, deep water foundations and pile foundations, as well as breakwaters such as permanent breakwaters and temporary breakwaters, and finally caissons are submitted for the design of harbors. The equations, formulae and specifications for the design of the essential components of harbors are also given.

Due to the incremental growth in the world population and the current trend of globalization, there is a significant interest for harbor development whether this includes constructing new harbors or existing ports that need to improve or grow their ability. A harbor is a position of security and solace, a little bay or other shielded piece of a zone of water, generally very much ensured against high waves and solid streams, and sufficiently profound to give dock to ships and other specialty. It is likewise a place where port facilities are given such as convenience for ships and cargo dealing facilities. Harbor construction activities include installing anchor piles, constructing jetty, mooring and berthing dolphins which are designed to safely moor vessels alongside offshore structures and quay wall renovation which might be required to reinforce existing quay walls to enable heavier materials and equipment to be handled. Harbors can be classified into three categories which are natural, semi-natural and artificial harbors

Major Types of Harbors Considering their benefit and situation, harbors are separated into three types as refugee harbors including naval bases, commercial harbors connected with ports and fishery harbors

Harbors of Refugee Including Naval Base

A harbor of refugee is a secured water region utilized exclusively as a sanctuary for ships in a tempest or a part of a commercial harbor with satisfactory space for a different dock zone that does not meddle with the commercial traffic.

Commercial Harbors Connected With Ports

A commercial harbor is one that has docking facilities comprising of piers, wharves, or dolphins at which ships berth while loading or unloading cargo. Huge numbers of extensive commercial harbors in urban communities are municipal, or government-controlled, harbors operated by port authorities.

Fishing Harbors

A fishing harbor contains multifunctional facilities that provide sufficient requirements for the capture of fish and its consumption. Large fishing vessels and huge number of fish creates a demand for well-bred maintenance and repair facilities not only for the vessels but also for the equipment as well.

Design Requirements for Harbors

Before designing a harbor, there are two major activities which have to be done. These activities are 'Collecting the necessary information' and 'Identifying the area required'.

Collection of the Necessary Information

To carry out the planning of a harbor, the first step is that the collection of necessary information of the existing properties of the suggested site. The following important facts should be investigated first:

- To perform a complete investigation of the neighborhood including the foreshore and depths of water in the vicinity
- To study the nature of the harbor (if it is refuge or not)
- To study the existence of sea insects which could give damage the foundation

- To study the problem of silting or erosion of coastline
- To ascertain the character of the ground borings and to take the soundings
- To identify the probable surface conditions on land and borings on land
- To study the natural metrological phenomenon at site with respect to frequency of storms, rainfall, range of tides, maximum and minimum temperatures, direction and intensity of winds, humidity and also direction and velocity of currents

Identify the Area Required

The area of the harbor depends upon the following factors:

- Size and number of ships to be accommodated in the harbor at a time
- Length and width needed for movement of ships to and from berths
- Type of cargo carried

General Requirements of a Harbor

Following are the requirements of a good harbor:

- The ship channels should have sufficient depth for the draft of the visiting vessels to the harbor
- The bottom of the harbor should provide secured anchorage to hold the ships against the force of strong winds
- The land masses or breakwater must be provided to protect against the destructive wave action
- The entrance of the harbor should be wide enough to provide the ready passage for shipping and at the same time it should be narrow enough to restrict the transmission of excessive amount of wave energy in time of storms.

Requirements of a Harbor of Refugee Including Naval Base

Following are the requirements of a harbor of refugee:

- Facilities which obtain repairs and supplies
- Safe and convenient anchorage against the sea
- Ready accessibility from the high seas
- Spacious accommodation as damaged ships will need immediate shelter and quick repairs
- Accommodation for naval vessels

Requirements of a Commercial Harbor

Following are the requirements of a commercial harbor :

- Storage sheds for cargo,
- Good and quick repair facilities to avoid any delay,
- Long and large quays to make loading and unloading of cargo and facilities for transporting easier and quicker,
- Sufficient accommodation for the commercial marine,
- Large accommodation for the commercial marine,
- Well and enough sheltered conditions for loading and unloading.

Requirements of a Fishing Harbor

Following are the requirements of a fishing harbor:

- The harbor should be continuously available for arrival and departure of fishing ships
- Loading and unloading facilities along with quick dispatch facilities for the perishable fish catch such as railway sidings and roads should be there,
- Freezing compartment stores with sufficient storing space for keeping the fish safe.

4.3 HARBOUR LAYOUT AND TERMINAL FACILITIES

Estimation of littoral drift and direction of net drift are needed for design of harbour projects. Different methods are used to study shoreline changes in the coastal area. Among them, mathematical modelling is considered as an effective technique. The current study addresses this issue through the use of mathematical models viz. spectral wave model to derive nearshore wave climate, Boussinesq wave model for evolving the harbour layout to provide adequate wave tranquillity in the harbour basin and one line model for prediction of shoreline changes in the adjacent shoreline of the project.

In the present study, the mathematical models were applied for design of a layout for fishing harbour, on the West Coast of India in Kerala State. Different alternatives of the harbour layout were tested in order to reduce siltation in the harbour and also to achieve the desired tranquillity in the harbour basin. In the first alternative, the southern breakwater was extended by 340 m. However it was observed that after two to three years, the shoreline will advance and the drift will start entering the harbour basin. Therefore, in the second alternative, the mouth of the harbour was further taken into deeper water to minimize the drift entering in the harbour. With this alternative the wave tranquility studies showed that the layout is adequate to provide desired tranquility in the harbour basin and the wave heights will remain within 0.3 m almost round the year. Thus, mathematical modelling technique was used to evolve a harbour layout that satisfies the tranquillity criteria and also ensures minimum siltation in the harbour basin.

Introduction

Fisheries sector is considered as one of the most important productive and developing sectors of the Kerala state. In order to promote fishing sector Kerala government is building fishing harbours across Kerala coast. One such fishing harbour with two breakwaters, north breakwater of 145 m length and south breakwater of 476 m length was constructed at Thottappally. The location is fully exposed to the high waves of upto 2.5 m height from Arabian Sea and also to the effects of littoral drift. Presently, major siltation in the harbour and subsequent advancement of the shoreline on southern side of south breakwater and erosion on northern side of north breakwater has been observed since the construction of the two breakwaters.

Central Water and Power Research Station (CWPRS) suggested modifications to the existing harbour layout to minimize the problem of siltation in the harbour and provide adequate wave tranquillity. This paper presents Mathematical model studies carried out to optimize the harbour layout to provide desired tranquillity in the harbour and also to reduce siltation in the harbour.

Methodology

The offshore wave data reported by India Meteorological Department as observed from ships plying in deep waters off Thottappally were transformed by MIKE 21 (SW) Spectral Wave model to get the near-shore wave climate at the fishing harbour in the absence of measured near-shore wave data. MIKE21- (BW) Boussinesq Wave was used for assessment of near-shore wave field and wave penetration in the fishing harbour. Estimation of littoral drift distribution and simulation of shoreline changes were carried out using LITPACK model. These mathematical models are developed by Danish Hydraulic Institute , Denmark **ite Conditions**

The fishing harbour is situated at 9°19'8.64"N latitude and 76°22'47.21"E longitude. The near-shore bathymetry at the site is having mild slope and the coastline orientation is 1550 N. Mean tidal level is 0.6 m. observed shoreline changes from October 2005 to February 2013 were considered for the study. The grain size (D50) varied from 0.22 mm to 0.09 mm.

Littoral drift between Fort Cochin and Anthakaranazhi is 7X106 m3 towards south as estimated by Pravin D Kunte (2001). Longshore sediment transport rates for the Kerala Coast were estimated by V. Sanil Kumar (2006). The annual net transport of 16,929 m3 towards north was estimated at Alleppey which is about 25 km towards North of Thottappally. The annual net transport of 383,784 m3 towards south was estimated at

Kollam which is about 50 km towards South of Thottappally. From shoreline changes occurring in the vicinity of the breakwaters and also the satellite imageries from Google, it is seen that net drift is towards north. The Offshore wave climate during the entire year indicates that the predominant wave directions in deep water are from SSW to West with the maximum wave heights of the order of 4.5 m. These deep water wave data were transformed by MIKE 21- SW model to get the nearshore wave climate in 8m depth at the fishing harbour.

Estimation of littoral drift distribution and simulation of shoreline changes

LITDRIFT module of LITPACK software was used to estimate annual littoral drift rates and its distribution on the profile normal to the shoreline. The LITDRIFT module simulates the cross-shore distribution of wave height, setup and longshore current for an arbitrary coastal profile. The longshore and cross-shore momentum balance equation is solved to give the cross-shore distribution of longshore current and setup. Wave decay due to breaking is modelled. LITDRIFT calculates the net/gross littoral transport over a specific design period. Important factors, such as linking of the water level and the beach profile to the incident sea state, are included. The bed profile near the harbour was used for drift computation. This profile covers a distance of 2.4 km extending up to about -8m depth contour (with respect to Chart Datum). The profile was descretized with grid size of 10 m. The model was calibrated for observed shoreline changes. The model was run for annual nearshore wave climate. Annual, northward and southward transport rates were computed. The northward drift is plotted as positive while southward drift is plotted as negative.

In order to assess the impact of the breakwaters on the coastline, LITLINE module of LITPACK software was used. The length of the shoreline considered for the studies is 1.2 km, extending about 500 m towards north of the breakwater and about 500 m towards south of the breakwater. It is divided into 236 grid points of grid size 5 m. The harbour layout proposed by Harbour Engineering Division (HED), Kerala, was considered for the shoreline evolution. The harbour layout consists of Northern breakwater of 250 m length and southern breakwater of 816 m (476+340) length. LITLINE is a one dimensional model. Therefore, projected lengths of the breakwaters were considered in the model setup. For the proposed layout, projected lengths of 250 m and 370 m of the Northern and Southern breakwater were considered respectively.

While the modified layout suggested by CWPRS, consists of southern breakwater of 896 m (476+420) and Northern breakwater of 436 m length. For the modified layout, projected lengths of 388 m and 460 m of the Northern and Southern breakwater were considered respectively. The model was run for 2, 4 and 6 years with the proposed breakwaters and modified breakwaters.

Marine Terminals

A terminal is a place where loading and unloading of people or goods takes place like for e.g. a bus terminal or a train terminal. In simple terms it can be said that marine terminals are stops or stations for ships and boats.

However, it has to be noted that a marine terminal is not a distinct station for the ships. Marine terminals just form a part of the port where goods and cargo can be loaded into a ship and unloaded in case a ship comes to the port. Marine terminals are very popular and form an important necessity when it comes to the cargo aspect of ships.

The port or harbour is a very busy place. There are not just passengers arriving but there are also people waiting to aboard a ship. In addition to so many people, there is also the hauling and offloading of cargo that needs to be done since cargo ships also form a major component in ports.

If proper care is not taken to load the cargo in the proper ship or offload the goods correctly in the right manner, then it could lead to a lot of loss. This loss would not only be in terms of finance but also in terms of important and necessary goods and commodities, to both the businessmen as well as the clients.

This is the main reason why marine terminals are kept separate from the rest of the port or harbour. This keeping aside of a separate area ensures that the loading and offloading process takes place continuously, and in the most perfect manner. It has to be noted that marine terminals are also known as docks (used for bigger ships) and wharfs (when ships of smaller sizes are hauled with cargo).

Another important presence in such marine terminals is of the people, who are responsible for the smooth functioning of the marine terminal. The professionals who help with the entire goods hauling and unloading process work round-the-clock and tirelessly to make sure that there are no errors whatsoever. They are alert and responsible professionals which make it easier for the companies and clients to trust such marine terminals with their goods and cargo.

Marine terminals are also an important necessity when it comes to oil rigs and oil drillings. In the deep oceanic and high sea areas where oil drilling and oil rigs form a crucial part, the crude oil containers are hauled and emptied in marine terminals that are located in the high seas. This ensures that a regular supply of crude oil and gas is maintained to the inshore areas as and when required. This continuous supply also helps to avoid any chances of oil spills and accidents in case any oil tanker collapses due to excess weight.

Business activities carried over sea-routes are a very old custom. But even as they were popular and necessary in the olden days, the amount of loss to the cargo was also huge because of lack of regulation. In today's times, with the benefits and assistance provided by marine terminals, the prospect of loss has been reduced drastically. For this reason alone, marine terminals and the people who work in such terminals deserve to be appreciated and admired greatly.

4.4 COASTAL STRUCTURES

The main and prime reason to construct coastal protection structures is to protect harbor and other infrastructures from sea wave effects such as erosion. Not only are they useful for changing current and sand movements but also to redirect rivers and streams.

Types of Coastal Protection Structures

There are various structures that considered or used as coastal protection structures for example groins, seawalls, bulkheads, breakwaters, and jetties.

1. Seawalls

This large coastal protection structures can be built using different types of construction materials such as rubble mound, granite masonry, or reinforced concrete. Seawalls are commonly built and run along shoreline to prevent coastal structures and areas from the detrimental influence of ocean wave actions and flooding which are driven by storms. There are various arrangements or configurations that might be employed includes curved face seawall, stepped face seawall, rubble mound seawall.

a. Curved face seawall

Curved face seawall is designed to withstand high wave action effects. Foundation materials loss, which might be caused by scouring waves and leaching from over topping water or storm drainage underneath the wall, is avoided by employing sheet pile cut off wall. Moreover, the toe of the curved face seawall is built from large stones to decrease scouring.

b. Stepped face seawall

Stepped face seawall is used to oppose or resist moderate wave actions. Reinforced concrete sheet piles with tongue and groove joints are employed to construction this type of seawall. The spaces which is created between piles is either filled with grout in order make sand proof cut off wall or install geotextile fiber at the back of the sheet pile to form sand tight barrier. Applying geotextile is beneficial because it allows seeping water through and consequently prevents accumulating hydrostatic pressure.

c. Rubble Mound Seawalls

Design and construction this type of seawall configuration might be easier and cheaper. It can resist substantially strong wave actions. Despite scouring of the front beach, quarry stone comprising the seawall could be readjusted and settled without causing structural failure.

2. **Bulkheads**

Bulkheads can be constructed by concrete, steel, or timber. There two major types which are gravity structures and anchored sheet pile walls. The bulkheads might not have exposed to sustainability strong wave actions and its main purpose is to retain earth but scouring at the base of the structure should be considered by the designer. Cellular sheet pile bulkheads are employed for situations where rock is close to the surface and enough penetration cannot be achieved for the anchored bulkhead type. Moreover, sheet pile should be sufficiently reinforced for bending moment, soil conditions, hydrostatic pressures and support points.

3. **Groins**

Groins are shore protection structures that decrease erosion effects to the shoreline by changing offshore current and wave patterns. Groins can be built by materials such as concrete, stone, steel, or timber and are categorized depend on length, height, and permeability. Furthermore, groins are commonly constructed vertically to the shoreline and it can either impermeable or permeable.

4. Jetties

Jetties are usually built of materials such as concrete, steel, stone, timber, and occasionally asphalt used as binder. This structure is constructed at river estuary or harbour entrance and extended into deeper water to oppose forming of sandbars and limit currents.

5. **Breakwaters**

There are three major types of breakwaters namely: offshore, shoreconnected, and rubble mound. Not only are they used to protect shore area, anchorage, harbor from wave actions but also to create secure environment for mooring, operating, and handling ships.

PIER

A **Pier** is a raised structure that rises above a body of water and usually juts out from its shore, typically supported by piles or pillars, and provides above-water access to offshore areas. Frequent pier uses include fishing, boat docking and access for both passengers and cargo, and oceanside recreation. Bridges, buildings, and walkways may all be supported by piers. Their open structure allows tides and currents to flow relatively unhindered, whereas the more solid foundations of a quay or the closely spaced piles of a wharf can act as a breakwater, and are consequently more liable to silting. Piers can range in size and complexity from a simple lightweight wooden structure to major structures extended over 1,600 m (5,200 ft). In American English, a pier may be synonymous with a dock.

Piers have been built for several purposes, and because these different purposes have distinct regional variances, the term *pier* tends to have different nuances of meaning in different parts of the world. Thus in North America and Australia, where many ports were, until recently, built on the multiple pier model, the term tends to imply a current or former cargo-handling facility. In contrast, in Europe, where ports more often use basins and river-side quays than piers, the term is principally associated with the image of a Victorian cast iron pleasure pier. However, the earliest piers predate the Victorian age.

TYPES OF PIER

Piers can be categorized into different groupings according to the principal purpose. However, there is considerable overlap between these categories. For example, pleasure piers often also allow for the docking of pleasure steamers and other similar craft, while working piers have often been converted to leisure use after being rendered obsolete by advanced developments in cargo-handling technology. Many piers are floating piers, to ensure that the piers raise and lower with the tide along with the boats tied to them. This prevents a situation where lines become overly taut or loose by rising or lowering tides. An overly taut or loose tie-line can damage boats by pulling them out of the water or allowing them so much leeway that they bang forcefully against the sides of the pier.

WORKING PIERS

Working piers were built for the handling of passengers and cargo onto and off ships or (as at Wigan Pier) canal boats. Working piers themselves fall into two different groups. Longer individual piers are often found at ports with large tidal ranges, with the pier stretching far enough off shore to reach deep water at low tide. Such piers provided an economical alternative to impounded docks where cargo volumes were low, or where specialist bulk cargo was handled, such as at coal piers. The other form of working pier, often called the finger pier, was built at ports with smaller tidal ranges. Here the principal advantage was to give a greater available quay length for ships to berth against compared to a linear littoral quayside, and such piers are usually much shorter. Typically each pier would carry a single transit shed the length of the pier, with ships berthing bow or stern in to the shore.

The advent of container shipping, with its need for large container handling spaces adjacent to the shipping berths, has made working piers obsolete for the handling of general cargo, although some still survive for the handling of passenger ships or bulk cargos. One example, is in use in Progreso, Yucatán, where a pier extends more than 4 miles into the Gulf of Mexico, making it the longest pier in the world. The Progreso Pier supplies much of the peninsula with transportation for the fishing and cargo industries and serves as a port for large cruise ships in the area. Many other working piers have been demolished, or remain derelict, but some have been recycled as pleasure piers. The best known example of this is Pier 39 in San Francisco.

At Southport and the Tweed River on the Gold Coast in Australia, there are piers that support equipment for a sand bypassing system that maintains the health of sandy beaches and navigation channels.

PLEASURE PIER

Pleasure piers were first built in Britain during the early 19th century. The earliest structures were Ryde Pier, built in 1813/4, Trinity Chain Pier near Leith, built in 1821, and Brighton Chain Pier, built in 1823. Only the oldest of these piers still remains. At that time the introduction of the railways for the first time permitted mass tourism to dedicated seaside resorts. The large tidal ranges at many such resorts meant that for much of the day, the sea was not visible from the shore. The pleasure pier was the resorts' answer, permitting holidaymakers to promenade over and alongside the sea at all times. The world's longest pleasure pier is at Southend-on-Sea, Essex, and extends 1.3 miles (2.1 km) into the Thames estuary. The longest pier on the West Coast of the US is the Santa Cruz Wharf, with a length of 2,745 feet (837 m).

Providing a walkway out to sea, pleasure piers often include amusements and theatres as part of their attractions. Such a pier may be unroofed, closed, or partly open and partly closed. Sometimes a pier has two decks. Galveston Island Historic Pleasure Pier in Galveston, Texas has a roller coaster, 15 rides, carnival games and souvenir shops.

Early pleasure piers were of wooden construction, with the first iron pleasure pier being Margate Jetty, opened in 1855. Margate pier was wrecked in storms in 1978 and never repaired. The longest iron pleasure pier still remaining is the one at Southend. First opened as a wooden pier in 1829, it was reconstructed in iron and completed in 1889. In a 2006 UK poll, the public voted the seaside pier onto the list of icons of England.

Fishing piers

Many piers are built for the purpose of providing boatless anglers access to fishing grounds that are otherwise inaccessible. Many "Free Piers" are available in larger harbors which differ from private piers. Free Piers are often primarily used for fishing.

BREAKWATERS

Breakwaters are structures constructed on coasts as part of coastal defense or to protect an anchorage from the effects of both weather and long shore drift.

- A structure protecting a shore area, harbor, anchorage or basin from wave disturbance.
- A barrier that breaks the force of waves, as before a harbor.

Breakwater types

There are several types of breakwaters, the different types can be divided into two categories. Rubble mound breakwaters which are made out of large heaps of loose elements, and monolithic breakwaters which have a cross section acting as one block, for instance a caisson.

The following breakwater types have been implemented: conventional rubble mound breakwater, caisson breakwater and the vertically composite breakwater. For each of these structures a class is defined with which a conceptual design can be made.

Conventional Rubble Mound

As mentioned in the introduction a rubble mound breakwater is made out of large heaps of loose elements, the armour layer of these types are made with either rock or concrete armour units such as Xbloc or XblocPlus. Both types of armour layer can be used to design a breakwater.

Design of breakwater with Rock as armour layer

Makes a conceptual design for a conventional rubble mound breakwater with rock as the armour layer, for one or several limit states. The following computations are performed:

- The armour layer is designed with the Van der Meer formulas for deep and shallow water (van der Meer, 1988; van Gent et al., 2003).
- The underlayer is designed by using the rules for the underlayer
- A filter layer is designed if one is needed, depends on **Dn50_core**
- The toe is designed with the toe stability formula of Van der Meer (1998).
- The crest freeboard is computed with the formula from EurOtop (2018)
- The required width of the scour protection with Sumer and Fredsoe (2000)
- If a **Soil** is specified, a slip circle analysis is performed

Composite (vertical)

The caisson type and vertical composite breakwater are included in one design class as they are basically the same structures. The main difference is the water depth immediately in front of the caisson. In this package the classification criteria from Eurotop (2018) is used, which classifies a vertical breakwater as vertical if dh>0.6dh>0.6, else the breakwater is classified as a vertically composite breakwater.

Design of (composite) vertical breakwater

Makes a conceptual design of a vertical or composite vertical breakwater, with a caisson on a rubble mound foundation. The following computations are performed:

- The necessary size of the armour layer of the foundation is designed with the modified Tanimoto formula (Takahashi, 2002).
- The required stone size for the core of the foundation
- The water depth in front of the caisson is computed based on the dimensions of the foundation and water depth
- The crest freeboard is computed with the formulae from EurOtop (2018), **vertical()** is used, which automatically classifies the breakwater so that the correct formula is used.
- The required width of the caisson is computed with the extended Goda formula (Takahasi, 2002).
- The required width of the scour protection with Sumer and Fredsoe (2000). Note that a scour protection is only added if the width of the foundation is not sufficient.
- If a Soil is specified the bearing capacity of the soil will also be checked with Brinch Hansen (1970).

Breakwaters

- Breakwaters are structures constructed on coasts as part of coastal defense or to protect an anchorage from the effects of both weather and long shore drift.
- A structure protecting a shore area, harbor, anchorage or basin from wave disturbance.
- A barrier that breaks the force of waves, as before a harbor.

- Breakwater are the structures constructed to enclose the harbours to protect them from the effect of wind generated waves by reflecting and dissipating their force or energy. Such a construction makes it possible to use the area thus enclosed as a safe anchorage for ships and to facilitate loading and unloading of water by means of wave breakers.

Need of Breakwater

- Breakwaters are built to provide shelter from waves to manipulate the littoral/sand transport conditions and thereby to trap some sand entrance inside the Anchorage Area
- A breakwater is a large pile of rocks built parallel to the shore. It is designed to block the waves and the surf. Some breakwaters are below the water's surface (a submerged breakwater).
- Breakwaters are usually built to provide calm waters for harbors and artificial marinas.
- Submerged breakwaters are built to reduce beach erosion. These may also be referred to as artificial "reefs."
- A breakwater can be offshore, underwater or connected to the land. As with groins and jetties, when the long shore current is interrupted, a breakwater will dramatically change the profile of the beach. Over time, sand will accumulate towards a breakwater. Down drift sand will erode.
- A breakwater can cause millions of dollars in beach erosion in the decades after it is built.

Types of Breakwaters

- Detached breakwater (breakwaters can completely isolated from the shore)
    - Head land breakwaters
    - Near shore breakwaters
- Attached breakwater (Breakwaters can be connected to the shore line)

Low crested structure

High crested structure

- Rubble mound structure
- Composite structure
- Using mass (caissons)
- Using a revetment slope (e.g with rock or concrete armor units)
- Emerged breakwaters
- Submerged breakwaters
- Floating breakwaters

DETACHED Breakwater

Breakwaters without any constructed connection to the shore. This type of system detached breakwaters are constructed away from the shoreline, usually a slight distance offshore .they are designed to promote beach deposition on their lee side appropriate in areas of large sediment transport

Head land breakwaters(HB)

A series of breakwaters constructed in an "Attached" fashion to the shoreline & angled in the direction of predominant waves - the shoreline behind the structures evolves into a natural "crenulate" or log spiral embayment.

Nearshore Breakwaters

Nearshore breakwaters are detached, generally shore-parallel structures that reduce the amount of wave energy reaching a protected area. They are similar to natural bars, reefs or nearshore islands that dissipate wave energy. The reduction in wave energy slows the littoral drift, produces sediment deposition and a shoreline bulge or salient feature in the sheltered area behind the breakwater. Some longshore sediment transport may continue along the coast behind the nearshore breakwater

Rubble mound breakwater

- Rubble mounds are frequently used structures.

- Rubble mound breakwater consists of armour layer, a filter layer & core.
- It is a structure, built up of core of quarry run rock overlain by one or two layers of large rocks. Armour stone or precast elements are used for outer armour layer to protect the structure against wave attack. Crown wall is constructed on top of mound to prevent or to reduce wave
- A breakwater constructed by a heterogeneous assemblage of natural rubble or undressed stone.
- When water depths are large RBW may be uneconomical in view of huge volume of rocks required.
- Built upto water depth of 50m.
- Not suitable when space is a problem. If the harbor side may have to be used for berthing of ships, the RBW with its sloping faces is no suitable for berthing.
- These type of breakwaters dissipate the incident wave energy by forcing them to break on a slope and thus do not produce appreciable reflection.

ADVANTAGES OF RMBW

- Use of natural material
- Reduces material cost
- Use of small construction equipment
- Less environmental impact
- Easy to construct
- Failure is mainly due to poor interlocking capacity between individual blocks
- Unavailability of large size natural rocks leads to artificial armour blocks.

Disadvantages of RMBW

- Needs a considerable amount of construction materials.

- Continuous maintenance is required.
- Sometimes there are difficulties in erection, as the rock weight increases with the increase of wave heights.
- Can't be used for ship berthing

VERTICAL BREAKWATER

- A breakwater formed by the construction in a regular and systematic manner of a vertical wall of masonry concrete blocks or mass concrete, with vertical and seaward face.
- Reflect the incident waves without dissipating much wave energy.
- Wave protection in port/channel
- Protection from siltation, currents
- Tsunami protection
- Berthing facilities
- Access/transport facility
- Normally it is constructed in locations where the depth of the sea is greater than twice the design wave height.

Vertical Wall Breakwaters - Types

Conventional type

The caisson is placed on a relatively thin stone bedding. Advantage of this type is the minimum use of natural rock (in case scarce) Wave walls are generally placed on shore connected caissons (reduce overtopping)

Vertical composite type

The caisson is placed on a high rubble foundation This type is economic in deep waters, but requires substantial volumes of (small size) rock fill for foundation

Horizontal composite type

The front slope of the caisson is covered by armour units This type is used in shallow water. The mound reduces wave reflection, wave impact and wave overtopping Repair of displaced vertical breakwaters Used when a (deep) quay is required at the inside of rubble mound breakwater

Block type

This type of breakwater needs to be placed on rock sea beds or on very strong soils due to very high foundation loads and sensitivity to differential settlements

Piled breakwater with concrete wall

Piled breakwaters consist of an inclined or vertical curtain wall mounted on pile work. The type is applicable in less severe wave climates on site with weak and soft subsoils with very thick layers. Manfredonia New Port (Italy)

Sloping top

The upper part of the front slope above still water level is given a slope to reduce wave forces and improve the direction of the wave forces on the sloping front.
Overtopping is larger than for a vertical wall with equal level.

Perforated front wall

The front wall is perforated by holes or slots with a wave chamber behind. Due to the dissipation of energy both the wave forces on the caisson and the wave reflection are reduced

Semi-circular caisson

Well suited for shallow water situations with intensive wave breaking Due to the dissipation of energy both the wave forces on the caisson and the wave reflection are reduced

Dual cylindrical caisson

Outer permeable and inner impermeable cylinder. Low reflection and low permeable Centre chamber and lower ring chamber fills with sand Combi-caisson

Disadvantages of vertical wall breakwaters

- Sea bottom has to be leveled and prepared for placements of large blocks or caissons.
- Foundations made of fine sand may cause erosion and settlement.
- Erosion may cause tilting or displacement of large monoliths.
- Difficult and expensive to repair.
- Building of caissons and launching or towing them into position require special land and water areas beside involvement of heavy construction equipments.
- Require form work, quality concrete, skilled labour, batching plants and floating crafts.

PARAMETERS FOR THE CONSTRUCTION OF A BREAKWATER

When a breakwater is to be built at a certain location, and the environmental impact of such a structure has already been evaluated and deemed environmentally feasible, the following parameters are required before construction can commence:

- a detailed hydrographic survey of the site;
- a geotechnical investigation of the sea bed;
- a wave height investigation or hindcasting;

- a material needs assessment; and
- the cross-sectional design of the structure.

Geotechnical investigation

A geotechnical investigation of the sea bed is required to determine the type of founding material and its extent. The results of this investigation will have a direct bearing on the type of cross-section of the breakwater. In addition, it is essential to determine what the coastline consists of, for example:

- soft or hard rock (like coral reefs or granite);
- sand (as found on beaches);
- clay (as in some mangrove areas); and
- soft to very soft clay, silt or mud (as found along some river banks, mangroves and other tidal areas).

Basic geotechnical investigations

Basic geotechnical investigations normally suffice for small or artisanal projects, especially when the project site is remote and access poor. A basic geotechnical investigation should be carried out or supervised by an experienced engineer or geologist familiar with the local soil conditions. The following activities may be carried out in a basic investigation using only portable equipment:

- retrieval of bottom sediments for laboratory analysis;
- measurement of bottom layer (loose sediment) thickness;
- approximate estimation of bearing capacity of the sea bed

The equipment required to carry out the above mentioned activities consists of :

A stable floating platform (a single canoe is not stable enough, but two canoes tied together to form a catamaran are excellent)

Diving equipment

A Van Veen bottom sampler (may be rented from a national or university laboratory)

A 20 mm diameter steel pricking rod and a water lance (a 20 mm diameter steel pipe connected to a gasoline-powered water pump).

Simply picking up samples from the sea bed with a scoop or bucket disturbs the sediment layers with the eventual loss of the finer material and is not a recommended method. The sediments thus collected should then be carefully placed in wide-necked glass jars and taken to a national or university laboratory for analysis. At least 10 kilograms of sediment are normally required by the laboratory for a proper analysis

Sometimes, a good hard bottom is overlain by a layer of loose or silty sand or mud. In most cases this layer has to be removed by dredging to expose the harder material underneath. To determine the thickness of this harder layer, a water lance is required. This consists of a length of steel tubing (the poker), sealed at the bottom end with a conical fitting and connected to a length of water hose at the top end. The water hose is connected to a small gasoline-powered water pump drawing seawater from over the side of the platform. The conical end has four 3 mm diameter holes drilled into it.

The diver simply pokes the steel tube into the sediment while water is pumped into it from above until the poker stops penetrating. The diver then measures the penetration. This method, also known as pricking, works very well in silty and muddy deposits up to 2 to 3 metres thick. It is not very effective in very coarse sand with large pebbles.

WHARF

A **wharf**, **quay** or **staith(e)** is a structure on the shore of a harbour or on the bank of a river or canal where ships may dock to load and unload cargo or passengers.[2][3] Such a structure includes one or more berths (mooring locations), and may also include piers, warehouses, or other facilities necessary for handling the ships. Wharves are often considered to be a series of docks at which boats are stationed.

A wharf commonly comprises a fixed platform, often on pilings. Commercial ports may have warehouses that serve as interim storage: where it is sufficient a single wharf with a single berth constructed along the land adjacent to the water is normally used; where there is a need for more capacity multiple wharves, or perhaps a single large wharf with multiple berths, will instead be constructed, sometimes projecting over the water. A pier, raised over the water rather than within it, is commonly used for cases where the weight or volume of cargos will be low.

Smaller and more modern wharves are sometimes built on flotation devices (pontoons) to keep them at the same level as the ship, even during changing tides.

In everyday parlance the term *quay* is common in the United Kingdom, Canada, Australia, and many other Commonwealth countries, and the Republic of Ireland, whereas the term *wharf* is more common in the United States. In some contexts *wharf* and *quay* may be used to mean pier, berth, or jetty.

In old ports such as London (which once had around 1700 wharves) many old wharves have been converted to residential or office use.

Certain early railways in England referred to goods loading points as "wharves". The term was carried over from marine usage. The person who was resident in charge of the wharf was referred to as a "wharfinger".

JETTIES

Jetties protect the shoreline of a body of water by acting as a barrier against erosion from currents, tides, and waves. **Jetties** can also be used to connect the land with deep water farther away from shore for the purposes of docking ships and unloading cargo. This type of **jetty** is called a pier.

For regulating rivers

Another form of jetties, wing dams are extended out, opposite one another, *from each bank of a river*, at intervals, to contract a wide channel, and by concentration of the current to produce a deepening.

For berthing at docks

Where docks are given sloping sides, openwork timber jetties are generally carried across the slope, at the ends of which vessels can lie in deep water or more solid structures are erected over the slope for supporting coal-tips. Pilework jetties are also constructed in the water outside the entrances to docks on each side, so as to form an enlarging trumpet-shaped channel between the entrance, lock or tidal basin and the approach channel, in order to guide vessels in entering or leaving the docks. Solid jetties, moreover, lined with quay walls, are sometimes carried out into a wide dock, at right angles to the line of quays at the side, to enlarge the accommodation; and they also serve, when extended on a large scale from the coast of a tideless sea under shelter of an outlying breakwater, to form the basins in which vessels lie when discharging and taking in cargoes in such a port as Marseille.

At entrances to jetty harbor

The approach channel to some ports situated on sandy coasts is guided and protected across the beach by parallel jetties. In some cases, these are made solid up to a little above low water of neap tides, on which open timber-work is erected, provided with a planked platform at the top raised above the highest tides. In other cases, they consist entirely of solid material without timber-work. The channel between the jetties was originally maintained by tidal scour from low-lying areas close to the coast, and subsequently by the current from sluicing basins; but it is now often considerably deepened by sand-pump dredging. It is protected to some extent by the solid portion of the jetties from the inroad of sand from the adjacent beach, and from the levelling action of the waves; while the upper open portion serves to indicate the channel and to guide the vessels. The bottom part of the older jetties, in such long-established jetty ports as Calais, Dunkirk and Ostend, was composed of clay or rubble stone, covered on the top by fascine-work or pitching, but the deepening of the jetty channel by dredging and the need that arose for its enlargement led to the reconstruction of the jetties at these ports. The nes jetties at Dunkirk were founded in the sandy beach, by the aid of compressed air, at a depth of 22.75 feet (6.93 m). below low water of spring tides; and their solid masonry portion, on a concrete foundation was raised 50 feet (15 m). above low water of neap tides.

At lagoon outlets

A small tidal rise spreading tidal water over a large expanse of lagoon or inland backwater causes the influx and efflux of the tide to maintain a deep channel through a narrows no longer confined by a bank on each side, becomes dispersed, and owing to the reduction of its scouring force, is no longer able at a moderate distance from the shore effectually to resist the action of tending to form a continuous beach in front of the outlet. Hence a bar is produced that diminishes the available depth in the approach channel. By carrying out a solid jetty over the bar, however on each side of the outlet, the tidal currents are concentrated in the channel across the bar, and lower it by scour.

Thus the available depth of the approach channels to Venice through the Malamocco and Lido outlets from the Venetian Lagoon have been deepened several feet (metres) over their bars by jetties of rubble, carried out across the foreshore into deep water on both sides of the channel. Other examples are provided by the long jetties extended into the sea in front of the entrance to Charleston harbour, formerly constructed of fascines weighed down with stone and logs, but subsequently of rubble stone, and by the two converging rubble jetties carried out from each shore of Dublin Bay for deepening the approach to Dublin harbour. Jetties have the adverse effect of endangering Surf Culture as a whole with their ability to destroy surf breaks.

At the outlet of tideless rivers

Jetties have been constructed on each side of the outlet river of some of the rivers flowing into the Baltic, with the objective of prolonging the scour of the river and protecting the channel from being shoaled by the littoral drift along the shore. The most interesting application of parallel jetties is in lowering the bar in front of one of the mouths of a deltaic river flowing into a tide — a virtual prolongation of its less sea, by extending the scour of the river out to the bar by banks. Jetties prolonging the Sulina branch of the Danube into the Black Sea, and the south pass of the Mississippi River into the Gulf of Mexico, formed of rubble stone and concrete blocks, and respectively, have enabled the discharge of these rivers to scour away the bars obstructing the access to them; and they have also carried the sediment-bearing waters sufficiently far out to come under the influence of littoral currents, which, by conveying away some of the sediment, postpone the eventual formation of a fresh bar farther out

At the mouth of tidal rivers

Where a river is narrow near its mouth, has a generally feeble discharge and a small tidal range, the sea is liable on an exposed coast to block up its outlet during severe storms. The river is thus forced to seek another exit at a weak spot of the beach, which along a low coast may be at some distance off; and this new outlet in its turn may be blocked up, so that the river from time to time shifts the position of its mouth. This inconvenient cycle of changes may be stopped by fixing the outlet of the river at a suitable site, by carrying a jetty on each side of this outlet across the beach, thereby concentrating its discharge in a definite channel and protecting the mouth from being blocked up by littoral drift. This system was long ago applied to the shifting outlet of the river Yare to the south of Yarmouth, and has also been successfully employed for fixing the wandering mouth of the Adur near Shoreham, and of the Adour flowing into the Bay of Biscay below Bayonne. When a new channel was cut across the Hook of Holland to provide a straighter and deeper outlet channel for the river Meuse, forming the approach channel to Rotterdam, low, broad, parallel jetties, composed of fascine mattresses weighted with stone, were carried across the foreshore into the sea on either side of the new mouth of the river, to protect the jetty channel from littoral drift, and cause the discharge of the river to maintain it out to deep water. The channel, also, beyond the outlet of the river Nervion into the Bay of Biscay has been regulated by jetties; and by extending the south-west jetty out for nearly 0.5 miles (0.80 km) with a curve concave towards the channel the outlet has not only been protected to some extent from the easterly drift, but the bar in front has been lowered by the scour produced by the discharge of the river following the concave bend of the southwest jetty. As the outer portion of this jetty was exposed to westerly storms from the Bay of Biscay before the outer harbour was constructed, it has been given the form and strength of a breakwater situated in shallow water.

QUAYS

The construction of quays falls broadly into two classifications: quays with a closed or solid construction, and quays with an open construction, where the deck is supported on piles. A key element inside a typical fishing harbour, however, is the draft, ranging from 1.5 metres to 6 metres may be required, depending on the type, size and number of resident fishing vessels. An artisanal fishing port hosting small fishing vessels having a loaded draft of no more than 1 metre would not normally require a draft of more than 1.5 metres at low tide unless large vessels visit the port during the peak fishing season.

Solid quays – minimum draft 1.5 metres

The earth-retaining structure, as the quay wall is known, consists of a number of layers of concrete-filled jute bags placed on a rubble foundation in a brickwall fashion. This structure does not require any major cranage and may be built with the sole assistance of one or two divers. The major advantage of this type of construction is that an uneven sea bed or large boulders can be included in the foundation. The jute bags should be filled with just enough concrete to form a pillow of uniform thickness. Overstuffed bags, item B, should not be incorporated into the wall. Prior to commencing such work, a temporary guide frame should be built as shown in the construction method for solid breakwaters. The frame can be in scaffold pipes, bamboo or other timber sections.

Granular material only (no silt, mud or clay) should be used as backfill and the top surface should be blinded or sealed with graded aggregate. The blinding should be compacted properly using a vibrating plate compactor. The front or toe of the quay should also be protected against scour by both propellers and tidal streams. This protection can consist of concrete-filled jute bags laid side by side over the screeded rubble. The concrete capping block should be cast in situ after the granular backfill has been placed. Each capping block should not be more than 5 metres long and should contain some reinforcement.

Solid quays – minimum draft 3 metres

Concrete blockwork quay built from concrete blocks placed by a crane on a screeded bed of stone rubble. This kind of earth-retaining structure is very common but requires the use of a suitable crane. The crane can either be the floating type or terrestrial. The concrete blocks are first cast in a yard and after 28 days have elapsed, they are lifted and placed on the sea bed. The blocks are placed to form pillars on the screeded rubble. The block pillars should be kept about 50 mm apart in such a way that each pillar may settle without rubbing against adjacent pillars. To achieve this, it is common to nail wooden spacers, 50 mm thick, to one side of the blocks prior to placing. Slings may either pass underneath the block or lift the block via hooks. The slings may be in wire rope or chain and the factor of safety in the lifting apparatus for safe working loads is 8. Some countries require a higher value to take the wear-and-tear of the slings into consideration.

Solid quays – minimum draft 6 metres and beyond

The cross-section may be adapted for a quay with a draft of 6 metres by increasing the size and width of the concrete blocks; however, the required size of the blocks would be so large as to require very large and heavy lifting equipment. A more economical solution in terms of the equipment required. The earth-retaining structure in this case is a special corrugated sheet of steel, known as a sheet pile, which interlocks with adjacent units to form a continuous wall. This wall is driven into the sea bed, sheet pile by sheet pile, and the top tied back to an anchor wall, which may consist of a slab of reinforced concrete or a length of the same bulkhead. A temporary timber or steel guide frame is generally erected to help drive the sheet piles vertical and in a straight line. The crane used to drive sheet piles must have a long jib to enable it to pick entire lengths of sheet pile for driving.

The crane may either be mounted on a barge, in which case the sheet piles are driven from the sea side of the bulkhead, or driven over a temporary reclamation and driven from the rear of the bulkhead. The temporary reclamation may then be used as backfill. Sheet piles are suitable for driving into clay, sand and silt deposits, as well as some types of coral. Sheet piles cannot be driven in most types of rock and in the presence of large boulders. Hammers for driving sheet piles may be of two types: impact hammers or high-frequency hammers. Impact hammers, as their name suggests, are hammers which impart an impact to the sheet pile. In the presence of soft deposits or clay, impact hammers do not pose any problem. In the presence of difficult ground, however, such as when sand contains large boulders, the impact from the hammer may damage or bend the sheet pile.

Open quays – minimum draft 1.5 metres

The deck of an open quay is supported on piles and the whole structure is open to full view. In view of this, an open structure is considered to be more delicate than a solid one and special fendering measures have to be incorporated in the design to prevent damage to the structure. Open quays may be constructed entirely in timber, concrete or steel, or a mixture of the three. Timber, however, may be attacked by insects. It illustrates how an artisanal open quay may be built using mainly locally available materials, such as timber or steel pipes. Given the small dimensions of the structure, a crane may not be needed if a light lattice tower or tripod and a piling winch are available to drive the piles. The figure also demonstrates the manner in which the pile heads should be prepared to receive the cross-beams. The timber used in such a structure should be the right kind of timber and treated against decay and attack by insects.

Open quays – minimum draft 3 metres and beyond

Conventional, deeper water open quays of the type traditionally found in larger fishing ports. The structures are typically subdivided into two categories: with and without tidal variation. Cross-section without tidal variation, where the impact load from a vessel is transmitted directly to the deck of the quay via a simple rubber fender. The open quay, in this case, is fronted by another structure, the rubbing fender pile, which has to absorb the impact from a vessel mooring at low tide without damaging the main quay piles immediately behind it. If the quay wall is solid (sheet piles), then timber or rubber strips are applied to the sheet pile for the vessels to rub against. Piled quays are particularly effective at absorbing wave energy due to the presence of the rubble slope underneath the deck. The rubble is normally similar to a breakwater grading, requiring core material (1–100 kilograms), armouring (200–1 000 kilograms) and toe berm (1 000–2 000 kilograms) to prevent scour damage. If the reclamation behind the piled structure is not sealed properly with a geotextile membrane, fines tend to leach out of the rubble, leading to uneven settlement of the apron.

The piles may either be in normally reinforced concrete, prestressed concrete, or steel. Whereas most concrete piles are solid, steel piles are usually hollow pipes. In most cases, if only small lengths of pile can be handled by the crane, piles can be jointed in situ to form longer lengths as required. Concrete piles are generally glued with special epoxy glues, whereas steel piles are commonly welded together via simple butt-joints. If hollow pipes are used, these may either be filled up with concrete and reinforcing steel (to prevent corrosion on the inside and add strength to the pile) or, if the pipe thickness is enough, left as open-ended piles.

FENDERS

These are the marine equipment's specially designed for the purpose of imparting safety to the port and vessels against collision with other vessels. These are special equipment designed to provide the cushion effect to ship, boats or other naval vessels when they experience collision against other vessels, wharves, piers and ports or berths. These are also referred as marine bumpers.

Marine fenders are a type of marine equipment that are used to prevent boats, ships and other naval vessels from colliding against each other or against docks, wharves and piers. In other words, marine fenders can be simply termed as a marine bumper.

Marine fenders are important marine equipment as they prevent loss to the body of a boat or a ship. The fender systems that are used in naval vessels have evolved continuously throughout the times and now are devised in such a way that the prevention process is almost faultless and foolproof.

Marine fenders, in today's times are employed in such a way that they are kept on the hull or the head of a boat or a ship in order to prevent casualty to the hull or the head of the naval vessel if there is any collision happening between boats. However, at the same time, marine fenders are also employed in piers, docks, wharves and other regular boat entrance and exit points on a permanent basis.

This permanent fixing of marine fenders help because, in case there is a heavy traffic of boats passing through from a particular dockyard, and there is an accident or a collision then the casualty to the boat and the dockyard will be both minimised to a great extent.

Fender systems have been devised in order to protect all vehicles from damage caused due to accidents. When it comes to marine fenders, the marine equipment is one of the best technological advancements to have occurred in contemporary times.

Even in the earlier centuries, fender systems were used to prevent loss to a naval vessel's torso but the concept and idea has evolved more in the modern times than in the past. Through successful innovations and initiations, there are a wide variety of marine fender systems available which act as excellent marine equipment.

There are various types of marine fenders which have emerged over the years and which provide excellent utility in the area of water transportation. The wide variety of marine fenders ensures that sufficient options are provided so as to enable a person or an authority to choose the best possible fender system or marine fender.

During its voyage, a vessel has to approach port for loading and unloading of crew and commodities and to other vessel for supplying and accepting certain commodities; in these cases there are definite chances of collision and during collision huge amount of energy is transferred which causes fatality to its crew and damage to vessel itself, port and commodities. Marine fenders prevent either the head or hull of a vessel to collide with any other water body. The certain features for which a port authority has to look after before buying the marine fenders are briefed as follows:

i) These marine bumpers should be made up of high performance materials which require no or little maintenance. **ii)** ii) These are to be designed in such a way that they can serve all the working demands for which these are deployed. **iii)** iii) These marine fenders should be capable of serving to all their commitments in all prevailing environmental conditions. **iv)** iv) The marine fenders should be durable i.e. they are so designed and developed so as to serve a longer period of time.

Categorizations Of Marine Fenders

Marine Fenders can be categorized in different types on the basis of location where these are fitted and material they are made up of.

On The Basis Of Material

The different sorts of marine bumpers available in the market as per the material they are made up of are as follows:

1. Rubber Fenders
2. Foam Fenders **3.** Composite Fenders

1.Rubber Fenders:

Rubber fenders are developed in wide range of variations to serve different applications. These fenders are developed complying with PIANC guiding principles. Rubber Fenders decrease the input reaction force and provide requisite angular guidance to the hull pressure. These are the fenders which have highest market demand. These fenders also have a positive impact on rubber industries round the globe. There noticed a great advancement and growth of rubber industry due to marine application of rubber in last ten years. There are many types of rubber fenders, manufactured by different shipping accessory companies, which are detailed as follows:

a) Super Cone Fenders: These are the latest sort of rubber fenders and generally referred as “Cone Fenders”. The conical body of the cone fenders keep them stabilised at even higher values of compression angles. They are highly efficient and provide optimum performance. They have better resistance to shear and overcompression. Their geometry plays a significant role in their stability. Today, rubber compounds find their widespread application in marine industry and extensively used for manufacturing of Cone Fenders.

b) SCK Cell Fenders: These fenders have simpler design which is the main reason for their popularity. These high performing fenders have great strength. These cell fenders are available in vast size range and capable of supporting large panels. These cell fenders are preferably found appropriate for systems which deal with hull at low level.

c) Arch Fenders: This type of marine equipment is used in order to provide aid and assistance to a type of marine fender known as the cylindrical fender. Since the maintenance aspect in arch fenders is absolutely zero, it is one of the best marine equipment and the best fender system. Arch fenders can be used for small and midranged ships and boats and provide excellent quality service to the same. These fenders are favoured when there is a need of rough marine fender system. These are most reliable fenders which serve their purpose victoriously even in severe most conditions. These allow easy installation. These are excellent in wear resistance and shear resistance. If these fenders are to be provided on corners of harbor these are called as Corner Arch Fenders.

d) Leg Fenders: These are the fenders which can be easily installed due to their modular design. A main advantage of these fenders is that they require less or no maintenance. Leg fenders are majorly opted at locations where the area on which fenders are to be mounted is limited.

e) Parallel motion Fenders: These can reduce the overall reaction to about 60% more as compared to conventional cone fenders. These are somewhat similar to leg fenders with difference that parallel motion fenders are vertical non tilting type fenders, but still capable of catering berth or vessel at 20° without energy dissipation.

f) Slide in Slide Out Fenders (or SISO Fenders): These fenders have frontal frame to which wear pads are fastened with the help of bolts. For maintenance purpose and in case of failure the complete assembly of fenders is not needed to be changed but the replacement made is conforming to only wear pads with sliding panel, which are to be replaced with newer ones. Sliding panels can be easily removed from guide rails and replaced with spare panels. So their maintenance is quite easier and can be quickly availed for services when go out of order.

g) **Cylindrical Fenders:** They are the most basic and common fender systems used in today's times. They can be used for all types of marine boats and ships and they are quite economical too when the aspect of fitting them up is taken into account. These are easy to install, widely used fenders with simpler design. They can serve to both large as well as small vessels. As per the requirement of cylindrical fenders, these are available in three size categories: Small Cylindrical Fenders, Intermediate Cylindrical Fenders and Large Cylindrical Fenders. These fenders are economical and have thick walls which can efficiently resist wear, abrasion and higher loads.

h) **Extruded Fenders:** These are the rubber fenders with simpler design and are directly fastened using bolt fasteners to the structure. These fenders are highly flexible and can fit any length and even curves.

i) **Composite Fenders (Rubbylene):** These are the fenders which are made up of composite rubber compounds and provide maximum resilience to the vessel. These fenders are made up with tough materials having lower coefficient of friction and maximum resistance to wear.

j) **Marine Fender Bars:** These fenders are made up of high performance tough bars which have highest impact resistance. These bars have wider flexibility of application. They can be installed at all sorts of locations.

k) **Pneumatic Fenders:** These are the ideal choice for inter ship dealings and port accessories. Their deployment is quick and robust. At the time of docking the pneumatic fenders minimize the risk of damage and safeguards both people and cargo. These fenders should comply with quality assurance guidelines of ISO issued in 2014. These are of five types namely: chain-tire net (CTN) pneumatic fenders;

Sling type fenders; low pressure pneumatic fenders; hydo-pneumatic fenders and. The CTN pneumatic fender has a network of tyres connected with chains in horizontal as well as vertical direction to protect the fender body. As the chains remains in water all the time so must be made up of corrosion resistant galvanized materials. These are simplest and cheaper type of marine fenders which increases the clearance between structure and the hull to a larger extent. Sling type pneumatic fenders are similar to chain type fenders with the only difference that fenders can be slung with even ropes made up of meshed wire strands than chains. Low pressure pneumatic fenders are the type of pneumatic fenders which deliver minimum pressure to the hull by absorbing kinetic energy to a maximum extent by providing maximum contact surface. Hydro-pneumatic Fenders: These are the pneumatic fenders which are made in compliance to the need of fender.

2)Form Fenders

The structure of these fenders is a dual-layered closed cell structure. The inner core of foam fenders is made up of polyethylene foam and reinforced polyurethane elastomer is used as covering to the core. The water penetration in these type of fenders is approximately nil. These can serve continuously throughout their life and even when damaged. There are different sorts of foam fenders:

a) Sea-Guard fenders: These can serve equally well in floated as well as suspended conditions. These fenders are available for both ship as well as harbor and have easy maintenance works. These fenders are mostly employed in ship-to-ship operation and cannot be destroyed or destructed. These fenders are unsinkable and deflation-free. Most of the foam fenders are manufactured on the guidelines of US navy stipulations.

b) Sea-cushion fenders: These are rough and tough fenders. These are floating fenders to be employed in roughest situation and the core used in their manufacturing is of superior grade then in sea-guard fenders. It has a network of chain tire with hard core which serves as a unsinkable and sea-cushion. These are most reliable and efficient sort of foam fenders used for LNG vessels which require least maintenance. They find their application in LNG ships because they cannot burst.

c) Donut Fenders: These are a special sort of marine fenders and moreover a type of berth fenders which are used as a guide or a turn structure. For the alignment of ships these fenders have tubular pile which can be rotated. These are made up of nylon filament reinforced in polyurethane skin. These are available in bright colours for improved visible access. As it is a sort of form fenders so require less maintenance.

3) Composite Fenders

These are the fenders which can be made up of any sort of composite materials. All sorts of Tug Fenders are considered in this category

Tug Fenders: These are only vessel fenders and installed on a tug vessel. These fenders are exposed to maximum wear and abrasion so these are made up of toughest materials which are capable of bearing greater degree of wear and abrasion, to which a ship is exposed due to water currents and other ship. So that the fenders can serve longer life with maximum efficiency. These can be cylindrical, tapered, key hole, M- and W-tug fenders on the basis of geometrical features. These all are ship fenders and somehow similar to one another with only difference in geometric design. All of these tug boat fenders are made up of extremely tough materials so as to resist wearing and shearing offered to the ship by other ship and the water current. All these fenders are heavy duty fenders and different design enable efficient working in different condition.

On The Basis Of Location They Are Fitted: On The Basis Of Location Of Fenders These Are Of Two Types Namely:

1.) Ship Fenders: These are the fenders which are installed to the ship so as to have increased clearance while having ship-to-ship dealing. Tug boat fenders fall in this category. These fenders should be made up of material stronger than that used in dock fenders because the ship fenders are exposed to more severe conditions than the dock fenders.

2.) Dock Fenders: Dock fenders are the sort of fenders which are installed at harbor and provide protection to ship and dock at the time of docking. Leg fenders and parallel flow fenders are the examples of such sorts of fenders.

All these fenders serve the primary purpose of absorbing high kinetic energy so that the shock experienced by the dock or the ship is minimized so as to cause no harm to the cargo and the crew.

W Fenders:

These type of marine fenders are used mainly to aid the larger ships and boats because they offer a high rate of resistance and thus better protection to the water-crafts in case of any accident occurring.

Other types of marine fenders are the I fender, Cell Fender, Cone Fender and the Pneumatic Fender which along with the other three marine fenders, help in providing a very viable and feasible solution to the problem of accidents and collisions of naval vessels.

Precautions While Working With Marine Fenders

- A certain degree of softness in fender is necessary for efficiently absorbing the kinetic energy and thrust, but it should be hard enough to bear the impact.
- Fenders should not burst while in operation.
- Proper repair works and maintenance should be carried out to ensure maximum safety.

DOLPHINS AND FLOATING LANDING STAGE

A kind of floating dolphin landing stage includes main hull, and the main hull bottom is provided with multiple drinking water bodies being parallel to each other, and drinking water is provided with ballast tank in vivo. It is connected in main hull front at least provided with the anchor chain that a pair are symmetrical arranged in anchor capstan, anchor capstan connection through the hawse-pipe on main hull with being located at the anchor of main hull bottom. The utility model has the advantages that, improve the utility of coastline of port and pier, particularly original old harbour is renovated, the solution for anchor of exempting to cast anchor can be provided for substantial amounts of harbour anchorage by using the arrangement form of multiple rows of row combination, bank electricity is inputted into this floating dolphin landing stage using very simple technique to realize come port berthing ship lay day " oil changes electricity ", positive booster action is played to build green harbour.

Floating dolphin landing stage

Technical field

This project is related to a kind of floating dolphin landing stage, and its structure type is simple, cheap, deep with enough drinking water The drinking water of degree and anchor chain exit point is more than the extreme draft for mooring waters ship.

Background technology

Existing port and pier have jetty type wharf, quay by horizontal layout form, dig into formula harbour, island-type pier With formula harbour in dike；This kind of

Wharf Construction investment is huge, and the construction period is long, and the big-and-middle-sized harbour in generally harbour and inland is adopted With；Most of inland rivers and the port and pier in reservoir waters are influenceed typically to use special landing stage by the seasonal water level swell that disappears Form, water level phase of rising that disappears wants frequent shifting berth, causes to be unable to the actual conditions of operation during its shifting berth, to normal production and operation order Impact, and the old anchoring in landing stage and the formation of mooring form can only moor a boat by waters center side, utility of coastline It is extremely low, and being exposed to the anchor chain and mooring cable of the water surface and being had the wet season more wound by a large amount of floating refuses, but can not be with very Convenient method cleaning, has uglified harbour water area environment, has a ship waters wide, there is large number of different types of anchor Ground, but be all the form of single secure anchoring up to now, and this anchoring approach wastes a large amount of water surface areas. Before setting sail Necessarily unmoor, build fixed anchorage and carry out the mode of anchorage ship and also there is no precedent. Due to being independent anchoring, ship is in anchoring Harbor generator is at least also used in period, substantial amounts of ship is generated electricity using subsidiary engine in anchorage causes substantial amounts of waste gas row again Put, severe contamination harbour environment.

With the fast development of economic society, China faces resource environment constraint, communications and transportation development and faces soil, water front The rigid constraint of resource scarcity will be further exacerbated by, and more urgent requirement is proposed to communications and transportation Green Development. Therefore, build If green harbour is the important measures for promoting transportation Green Development. Now, limited harbour coastline resource is non-renewable, Old terminal facilities, equipment and very low utilization rate hinders the fast development of port construction.

The content of the invention

The technical problems to be solved in the utility model is to provide a kind of floating dolphin landing stage to improve the bank of port and pier Line use ratio, particularly renovates to original old harbour, uses the arrangement form of multiple rows of multiple row chain of rings combination can be with The solution for anchor of exempting to cast anchor is provided for substantial amounts of harbour anchorage, bank electricity is inputted by ship by this floating using very simple technique Pier landing stage, which is realized, carrys out port berthing ship lay day " oil changes electricity ", and positive booster action is played to build green harbour.

In order to solve the above technical problems, the technical solution adopted in the utility model, which is a kind of floating dolphin landing stage, includes master Hull, the main hull bottom is provided with ballast tank in vivo provided with drinking water body, drinking water ;

In main hull front main ship is passed through at least provided with the anchor chain that a pair are symmetrical arranged in anchor capstan, anchor capstan connection Hawse-pipe on body is connected with being located at the anchor of main hull bottom.

Further, the hawse-pipe is penetrated from main hull front and passed from drinking water body bottom, the master in hawse-pipe exit Hull base plate is set and hawse-pipe central axis.

Further, four drinking water bodies set up separately at four angles of main hull bottom.

Further, main hull bottom is provided with a drinking water body, and drinking water body forms a Back Word along main hull bottom margin Type closed shape.

Further, main hull bottom symmetrical absorbs water provided with two and is not connected between bodies, two described drinking water bodies.

Further, the ballast tank of each drinking water body carries out ballast or off-load using portable pump.

Further, the drinking water of the drinking water body, which is more than, moors most gobbling for waters berthing this floating dolphin landing stage ship Water.

Further, bank electricity can be inputted this floating dolphin by the floating dolphin landing stage using very simple technique Landing stage, realizes and carrys out port berthing ship lay day " oil changes electricity ".

Advantages：

1. The floating dolphin landing stage after anchorage is appropriate, because of its anchor chain exit point（Hawse-pipe is exported）With enough depth, Using when the water-area navigation or berthing operation ship are heavily loaded

extreme draft deeply plus rich d -trans- allethrin as its draft. When carrying out ship berthing Without producing anchor chain touching carry out ship and hindered because its anchor chain exit point is relatively deep, forming peripheral direction all around can moor The floating dolphin of ship, economic and practical, operation technique is simple, construction cost is cheap, is efficiently to utilize non-renewable harbour bank Line resource provides a solution.

2. Floating dolphin landing stage only set anchor and anchor chain it is supporting come anchorage landing stage, exempt to set to bank base mooring hawser be set, it is excellent In conventional landing stage as fine as a spider's web cable lead around defect, can create whole in the waters collar of its berthing inward ship operation Clean, safe water environment.
3. With two this landing stages and any pierhead pontoon as dried food and nuts pierhead pontoon, wharf for bulk cargo landing stage, container The a chain of landing stage of pierhead pontoon, roll-on berth is combined, and applicability is extensive.
4. Can also constitute jointly pontoon bridge type harbour using a plurality of floating dolphin landing stage, this combining form be suitable for from The shallower water environment of bank and reach deeper water, deeper water is arranged in using this landing stage of supporting relatively deep drinking water, it is supporting compared with This light-draft landing stage, which to be arranged in, gone directly compared with shallow water area on the bank, supporting between this landing stage of pontoon bridge type harbour scope two of which Using landing stage connection is jumped, anchor arrangement need not be configured by jumping landing stage, and such combination can be utilized extends compared with shallow water area to profundal zone Carry out wharf.
5. This landing stage can as floating dock dolphin, the sinking at floating dock and lift what the special process of ship operation needed Maximum is heavy deep larger, general river ship dock >=3m, the drinking water of seagoing vessel floating dock is bigger, if made using itself mooring system Industry, cumbersome, labor

intensity are big, add and are frequently adjusted using highpower windlass, energy consumption is big；It is fixed using pile foundation

Harbour configuration guide pillar can solve above-mentioned problem, but pile foundation fixed quay is built by harbour addressing, all many conditions of fluctuation in stage Limitation and it is difficult, and invest huge, unsuitable popularity. This project only needs to configure two floating dolphin landing stages, A side of a ship shipboard only on this landing stage, which is set, to sink with floating dock and the attachment means of lift ship floating linkage can just solve to float The above-mentioned problem of dock, and economic, applicable, safety, energy-conservation.

6. Common pierhead pontoon general at this stage be using anchoring and mooring two ways is come fixed quay landing stage, its Middle anchoring form is because anchor chain exit point surfaces mostly and causes berthing ship from the initial and tail sections close to landing stage, wherein mooring Form be to guide mooring rope on the bank earth anchor facility from landing stage bollard, be substantially all exposed to landing stage and pull in shore the water of side On face, it is also as fine as a spider's web that What is more, and such landing stage offshore side is just unable to berthing ship completely. Form dock barge only Can be by the middle of the river（Or waters center）A side of a ship berthing carry out ship. Harbour utility of coastline is extremely low, the protrusion on floating dolphin landing stage Advantage can be achieved on four direction all around and harbour utility of coastline can be substantially increased with berthing ship, be precious The rational exploitation and utilization of expensive coastline resource, there is provided a solution for beautification harbour environment. Further use this practicality New any combination form, can easily be realized using the technique being simply connected with bank base very much the harbour itself and come Port berthing operation ship uses bank electricity, reaches the purpose of " oil changes electricity ", and a kind of solution is provided to create the green harbour of energy-saving and emissionreduction Certainly scheme.

4.5 INLAND WATER TRANSPORT

1. Navigable Inland Waterways

A stretch of water, not part of the sea, over which craft of a carrying capacity not less than 50 tonnes can navigate when normally loaded. This term covers both navigable rivers and lakes (natural water courses, whether or not they have been improved for navigation purposes) and canals (water ways constructed primarily for the purpose of navigation).The length of rivers and canals is measured in mid channel and length of lakes, as well as lagoons, is counted as the length between the most distant points between which the transport is performed. An inland waterway forming a common frontier between two countries is reported by both.

National Waterways means an Inland Waterway of India designated as a National Waterway by the Government.

2. Major Port vis a vis Non-Major Port

The words "major", "intermediate" and "minor", do not have a strict association with the traffic volumes served by these ports. As an example, Mundra Port, a newly developed minor port in the state of Gujarat registered a cargo traffic of around 28.8 million tonnes per annum during the financial year of 2008, which is higher than that of many major ports.

The classification of Indian ports into major, minor and intermediate has an administrative significance. Indian government has a federal structure, and according to its constitution, maritime transport falls under the "concurrent list", to be administered by both the Central and the State governments. While the Central Shipping Ministry administers the major ports, the minor and intermediate ports are administered by the relevant departments or ministries in the nine coastal states of West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat. Several of these 185 minor and intermediate ports are merely "notified", with little or no cargo handling actually taking place. These ports have been identified by the respective governments to be developed, in a phased manner, a good proportion of them involving Public-private partnership.

3. INLAND WATER TRANSPORT

The chief data source for this sector is Transport Research Wing of the Ministry of Road Transport and Highways.

As on 31st March, 2007 the total navigable length of waterways in the country was 13731.2 kilometre. Number of inland water vessels increased from 7434 in 200203 to 12906 in 2006-07, showing an impressive CAGR of 15% per annum.

Total number of accidents increased from 583 in 2005-06 to 687 in 2006-07. Number of persons killed increased from 742 in 2005-06 to 825 in 2006-07. This shows that suitable safety measures and technology upgradations need to be evolved in IWT to improve safety of passengers.

Central budgetary support for the sector increased from `89.9 crore in 2002-03 to `150 crore in 2006-07. However utilization of funds is showing a decreasing trend from 87% to 66% during the period. The total state plan outlay during the 10th plan was `192 crore compared to central plan outlay of `634 crore.

Cargo movement on inland waterways has shown an impressive increase from 9 million tonnes in 2002-03 to 35 million tonnes in 2006-07. Passenger movement during the period increased from 87 million to 107 million.

The maximum freight per tonne kilometer for cargo transport (for the reporting companies) was `3.41/- in 2005-06 and `2.10/- in 2006-07. This gives us a very broad idea of freight charges because freight charges may vary widely based on cargo type.

5.1 WAVE ACTION ON COASTAL STRUTURES

Waves are important for building up and breaking down shorelines. Waves transport sand onto and off of beaches, transport sand along beaches, carves structures along the shore. The largest waves form when the wind is very strong, blows steadily for a long time, and blows over a long distance.

The wind could be strong, but if it gusts for just a short time, large waves won't form. Wave energy does the work of erosion at the shore. Waves approach the shore at some angle so the inshore part of the wave reaches shallow water sooner than the part that is further out. The shallow part of the wave 'feels' the bottom first. This slows down the inshore part of the wave and makes the wave "bend." This bending is called **refraction**.

Wave refraction either concentrates wave energy or disperses it. In quiet water areas, such as bays, wave energy is dispersed, so sand is deposited. Areas that stick out into the water are eroded by the strong wave energy that concentrates its power on the wave-cut cliff.

A wave-cut platform is the level area formed by wave erosion as the waves undercut a cliff. An arch is produced when waves erode through a cliff. When a sea arch collapses, the isolated towers of rocks that remain are known as sea stacks.

1. Wave Deposition

Rivers carry sediments from the land to the sea. If wave action is high, a delta will not form. Waves will spread the sediments along the coastline to create a beach. Waves also erode sediments from cliffs and shorelines and transport them onto beaches. Beaches can be made of mineral grains, like quartz, rock fragments, and also pieces of shell or coral. Waves continually move sand along the shore and move sand from the beaches on shore to bars of sand offshore as the seasons change. In the summer, waves have lower energy so they bring sand up onto the beach. In the winter, higher energy waves bring the sand back offshore. Some features form by wave-deposited sand. These features include barrier islands and spits. A spit is sand connected to land and extending into the water. A spit may hook to form a **tombolo**. Shores that are relatively flat and gently sloping may be lined with long narrow barrier islands. Most barrier islands are a few kilometers wide and tens of kilometers long. In its natural state, a barrier island acts as the first line of defense against storms such as hurricanes. When barrier islands are urbanized, hurricanes damage houses and businesses rather than vegetated sandy areas in which sand can move. A large hurricane brings massive problems to the urbanized area.

2. PROTECTING SHORELINES

Intact shore areas protect inland areas from storms that come off the ocean. Where the natural landscape is altered or the amount of development make damage from a storm too costly to consider, people use several types of structures to attempt to slow down wave erosion. A groin is a long narrow pile of rocks built perpendicular to the shoreline to keep sand at that beach. A breakwater is a structure built in the water parallel to the shore in order to protect the shore from strong incoming waves. A seawall is also parallel to the shore, but it is built onshore. People do not always want to choose safe building practices, and instead choose to build a beach house right on the beach. Protecting development from wave erosion is difficult and expensive and it doesn’t always work. The northeastern coast of Japan was protected by anti-tsunami seawalls, yet waves from the 2011 tsunami that resulted from the Tohoku earthquake washed over the top of some seawalls and caused others to collapse. Japan is now planning to build even higher seawalls to prepare for any future (and inevitable) tsunami.

5.2 COASTAL PROTECTION STRUCTURES

The main and prime reason to construct coastal protection structures is to protect harbor and other infrastructures from sea wave effects such as erosion. Not only are they useful for changing current and sand movements but also to redirect rivers and streams.

Types of Coastal Protection Structures

There are various structures that considered or used as coastal protection structures for example groins, seawalls, bulkheads, break waters, and jetties.
Description and advantages of these structures will be discussed in this article.

1. Seawalls

This large coastal protection structures can be built using different types of construction materials such as rubble mound, granite masonry, or reinforced concrete. Seawalls are commonly built and run along shoreline to prevent coastal structures and areas from the detrimental influence of ocean wave actions and flooding which are driven by storms. There are various arrangements or configurations that might be employed includes curved face seawall, stepped face seawall, rubble mound seawall. These forms will be explained in the following sections:

a- **Curved face seawall**

Curved face seawall is designed to withstand high wave action effects. Foundation materials loss, which might be caused by scouring waves and/or leaching from over topping water or storm drainage underneath the wall, is avoided by employing sheet pile cut off wall. Moreover, the toe of the curved face seawall is built from large stones to decrease scouring.

b- **Stepped face seawall**

Stepped face seawall is used to oppose or resist moderate wave actions. Reinforced concrete sheet piles with tongue- and- groove joints are employed to construction this type of seawall. The spaces which is created between piles is either filled with grout in order make sand proof cut off wall or install geotextile fiber at the back of the sheet pile to form sand tight barrier. Applying geotextile is beneficial because it allows seeping water through and consequently prevents accumulating hydrostatic pressure.

c- **Rubble Mound Seawalls**

Design and construction this type of seawall configuration might be easier and cheaper. It can resist substantially strong wave actions. Despite scouring of the front beach, quarry stone comprising the seawall could be readjusted and settled without causing structural failure.

2. Bulkheads

Bulkheads can be constructed by concrete, steel, or timber. There two major types which are gravity structures and anchored sheet pile walls. The bulkheads might not have exposed to substantially strong wave actions and its main purpose is to retain earth but scouring at the base of the structure should be considered by the designer. Cellular sheet pile bulkheads are employed for situations where rock is close to the surface and enough penetration cannot be achieved for the anchored bulkhead type. Moreover, sheet pile should be sufficiently reinforced for bending moment, soil conditions, hydrostatic pressures, and support points.

3. Groins

Groins are shore protection structures that decrease erosion affects to the shoreline by changing offshore current and wave patterns. Groins can be built by materials such as concrete, stone, steel, or timber and are categorized depend on length, height, and permeability. Furthermore, groins are commonly constructed vertically to the shoreline and it can either impermeable or permeable.

4. Jetties

Jetties are usually built of materials such as concrete, steel, stone, timber, and occasionally asphalt used as binder. This structure is constructed at river estuary or harbor entrance and extended into deeper water to oppose forming of sandbars and limit currents.

5. Breakwaters

There are three major types of breakwaters namely: offshore, shoreconnected, and rubble mound. Not only are they used to protect shore area, anchorage, harbor from wave actions but also to create secure environment for mooring, operating, and handling ships.

6. RIP-RAP

Rip-rap is a single-layer shore protection structure, which protects the reclaimed land from erosion, wave, current, and tide actions, and leakage of material. It is usually constructed in a less dynamic environment with a shallow seabed. Rip-rap usually has a single stable slope of 1:3 to 1:7 and some graded stones are generally provided between the armor stones and the sand fill. Nowadays the thickness and layers of graded stones have been reduced and a geofabric layer is provided instead. The size of the armor stones is selected based on the expected force of the waves and currents.

7. RETAINING ROCK BUND

A retaining rock bund is usually provided where the seabed is deep and has more dynamic waves and currents. A more systematic layering of graded stones is required for a retaining rock bund. Larger armor stones are also required for protection against the greater dynamic forces expected in the open sea. Rocks used for shore protection works are generally granite or sandstone. Granite is preferred to sandstone. To control the quality of stones, some specifications are deemed necessary. Since a retaining rock bund is usually constructed for a deep seabed, sometimes several berms are required to stabilize the structure.

8. BREAKWATER

A breakwater is usually constructed to break the waves which are directed towards the reclamation. Such structures are long arms protruding from the reclaimed land to protect the land from strong waves and currents. The structure is usually constructed with armor stones. The whole structure has either a rock or sand core with a shell of armor stones depending upon the force of the waves and currents. The length of the shore protection is generally determined based on the hydraulic model.

9. HEADLAND

Headlands are an alternative for breaking the waves and currents. Headlands are normally constructed perpendicular to the wave direction. Such headlands are provided when beaches are required to be formed at the edge of the reclaimed land. When a headland is provided, tabular shaped beaches are naturally formed in the process of coastal action. When headlands are required, the shore protection structure is constructed only to a certain level, usually under water. Headlands are constructed at the crest of the lower bund and beaches with gentle slopes are formed behind the headlands.

10. VERTICAL WALL

Vertical walls are constructed when there is a constraint in area, such as a limited navigation channel or a deep seabed. When reclamation is carried out for a seaport and jetty, vertical walls are deemed necessary since sufficient draft is required for ship berthing. Several types of vertical walls are described in the following sections.

Cantilever, counterfort and gravity walls:

Cantilever walls are suitable for shallow seabed conditions. These walls are usually placed before the filling at the periphery area. For cantilever walls, sufficient weep holes are required in order to maintain the groundwater level behind the wall to be the same as the sea level in front. Insufficient weep holes would result in poor drainage from the groundwater flow and the wall will have to carry unnecessary additional water pressure. In order to improve the drainage, vertical drainage is usually provided behind the wall. Vertical drainage is formed with geotextile at the drainage core.

11. Sheet pile wall

A sheet pile wall is an alternative type of retaining wall generally used for deep and soft seabed conditions. For a soft seabed condition, sufficient penetration

depth is required for sheet pile installation. The sheet piles are usually supported by raker pipe piles at reasonable intervals. Raker piles give support from the passive side and these piles are usually strengthened again by toe pins.
On the active side the piles are usually pulled back by internal anchors. A typical design of a retaining wall, with raker piles, toe pin, and anchor.

Retaining walls constructed with sheet piles are necessary as protection from corrosion especially when the structure is constructed in a marine environment. Several coats of paint are necessary to protect them from the corrosive action. On top of the coating, catholic protection is usually applied to counteract the corrosion action.

12. Caisson

A caisson is an alternative vertical wall structure. This type of structure is usually used in reclamation for port and harbor construction. Caissons are either circular or square in shape. Inside the caisson are several sub-divided cells and these hollow cells are filled with granular material after the caisson is positioned at predetermined locations. Whenever the foundation is not sufficiently strong, either a sand key, a sand blanket, a rock key, or a rock blanket is provided below the caisson.

13. Box gabion

At some locations where the underlying formation is firm, simple box gabions are used in the retaining structure.

14. QUAY WALL

A quay wall is usually constructed for a port facility. This type of wall is either of masonry or a rock structure. A berthing facility can be constructed in front of a rock structure using pile foundation.

15. COMPOSITE RETAINING STRUCTURES

There are some retaining structures that are constructed with a combination of methods in order to strengthen the foundation or in order to achieve a stable retaining structure. Some retaining structures are constructed after the soft foundation soil has been improved. Some quay wall structures can be constructed with sand piles behind the wall, which can carry vertical and horizontal loads. There are several combinations of structures to form a wharf or berthing facility depending on the nature of the foundation soil.

5.3 COASTAL REGULATION ZONE:

Under the Environment Protection Act, 1986 a notification was issued in February, 1991, for regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF). As per the notification, the coastal land up to 500m from the High Tide Line (HTL) and a stage of 100m along banks of creeks, estuaries, backwater and rivers subject to tidal fluctuations, is called the Coastal Regulation Zone(CRZ). CRZ along the country has been placed in four categories. The above notification includes only the inter-tidal zone and land part of the coastal area and does not include the ocean part. The notification imposed restriction on the setting up and expansion of industries or processing plaits etc. in the said CRZ.

Classification of Coastal Regulation Zone:

For regulation of developmental activities, the coastal stretches within 500m of HTL on the landward side are classified into four categories, viz..

- Category I (CRZ-I)
- Category II (CRZ - II)
- Category III (CRZ-III)
- Category IV (CRZ-IV)

Category I (CRZ -I):

a) Areas that are ecologically sensitive and important, such as national parks/marine parks, sanctuaries, reserve forests, wild habitats, mangroves, corals/coral reefs, area close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such areas as may be declared by the authorities.

b) Areas between the Low Tide Line and High Tide Line

Regulations:

No new constructions shall be permitted within 500m of the HTL.

Category II (CRZ -II):

The area that have already been developed up to or the shoreline. For this purpose, ' Developed Area' is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.

Regulations:

a) Buildings shall be permitted neither on the seaward side of the existing road(or roads proposed in the approved Coastal Zone Plane of the area) nor on the seaward side of the existing and proposed road. Existing authorized structures shall be subject to the existing local Town and Country Planning regulations including the existing norms of FIS/FAR

b) Reconstruction of the authorized building to be permitted subject to the existing FSI/FAR norms and without change in the existing use.

c) The design and construction of buildings shall be consistent with the surrounding landscape and architectural style

Category III (CRZ -III):

Areas that are relatively undisturbed and those which do not belong to either Category I or II. These will include coastal zone in the areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.

Regulations:

a) The area up to 200m from the HTL is be earmarked as 'No Development Zone'. No construction shall be permitted in this zone except for repairs of existing authorized structures not exceeding existing FSI, existing plinth area and existing density. However, the following uses may be permissible in this zone-agriculture, horticulture, gardens, pastures, parks, play fields, forestry and salt manufacture from sea water.

b) Development of vacant plots between 200 and 500m of High Tide Line in designated areas of CRZ-III with prior approval of Ministry of Environment and forests permitted for construction of hotels/beach resorts for temporary occupation of tourists / visitors.

c) Construction/ reconstruction of dwelling units between 200m and 500m of the High Tidal Line permitted so long as it is within the ambit of traditional rights and customary uses such as existing fishing villages and gothans. Building permission for such Construction/reconstruction will be subject to the conditions that the total member of dwelling unit shall not be more than twice the number of existing units; total area covered on all floors shall not exceed 9 meters and construction shall not be more than 2 floors (ground floor plus one floor).

d) Reconstruction/alteration of an existing authorized building permitted subject to (1) to (3) above.

Category IV (CRZ-IV):

Coastal stretches in the Andaman and Nicobar Islands, Lakhadweep and small islands, except those designated as CRZ I, CRZ II and CRZ III.

Regulations

Andaman and Nicobar Islands:

1. No new construction of buildings shall be permitted within 200m of HTL.
2. The buildings between 200m and 500m from the HTL shall not more than 2 floors, the total area covered on all floors shall not be more than 50% of the plot size and total height of construction shall not exceed 9m.

3. The design and construction of buildings shall be consistent with the surrounding landscape and local architectural style.
4. Corals and sand from the beaches and coastal waters shall not be used for construction and purposes.
5. Dredging and underwater blasting in and around coral formations shall not be permitted
6. However, in some of the islands, coastal stretches may also be classified into categories of CRZ-I or II or III with the prior approval of the MoEF and in such designated structures.

Activities prohibited within the CRZ

The following activities are declared as prohibited within the CRZ

1. Setting up of new industries and expansion of existing industries, except those directly related to water front or directly needing foreshore facilities.
2. Manufacture or handling or disposal of hazardous substances.
3. Setting up and expansion of fish processing units including warehousing (excluding hatchery and natural fish drying in permitted areas)
4. Setting up and expansion of units/mechanism for disposal of waste and effluents into the water course.
5. Discharging of city untreated waters and effluents from industries, cities or towns and other human settlements.
6. Dumping of city or town waste for the purposes of land filling or otherwise; the existing practice, if any, shall be phased out within a reasonable time not exceeding three years from the date of notification.
7. Dumping of ash or any wastes form the date of notification.

8. Land reclamation, building or disturbing the natural course of sea water with similar observations, except those required for control of coastal erosion and maintenance or sandbars except tidal regulators, storm water recharge.
9. Mining of sand, rocks and other substrata materials not available outside CRZ areas.
10. Harvesting or drawl of groundwater and construction of transfer within 200m of HTL; in the 200m to 500m zone it shall be permitted only when done manually through ordinary wells for drinking, horticulture, agriculture and fisheries.
11. Construction activities in ecologically sensitive areas
12. Any construction between LTL and HTL except facilities for carrying treated effluents and waste discharges, oil, gas and similar pipelines and dressing or altering of sand dunes, hills natural features including landscape changes for beautification, recreational and other such purposes.