**Nile Higher Institute**
**For Engineering & Technology**
**Dept. Civil Engineering**

# Harbor Project

Prepared by: -

| | |
|---|---|
| 180091 | Yousef Elsayed Fathi Shoaib |
| 190037 | Maged Mahmoud Mohamed |
| 190051 | Omar Hamada Mohamed |
| 190080 | Amin Khalil Eltahry |

Under supervision of:

**Assoc-prof :Mohamed Tarek Shamaa**

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# Abstract

The Al-Arish Port, situated in northeastern Egypt, is a strategically significant maritime gateway to the Mediterranean Sea. This port is crucial for trade and economic development, serving as a pivotal transportation hub that fosters regional integration.

This project underscores the importance of Al-Arish Port by examining its various components and their contributions to its overall functionality. The primary goal is to design and optimize the port's key elements, focusing on efficiency, capacity, and sustainability.

We outline the project's objectives, which include upgrading the port's infrastructure, refining the terminal's layout and design, and enhancing logistics and operational procedures. Additionally, the project emphasizes the integration of advanced technologies, such as intelligent systems for cargo handling, security, and communication.

Environmental considerations are also central to the design process, aiming to reduce the port's ecological footprint and ensure sustainable practices. This involves exploring renewable energy options, implementing effective waste management strategies, and adopting environmentally friendly practices.

The project will entail comprehensive research, data analysis, and collaboration with key stakeholders, including port authorities, industry experts, and local communities. The expected outcomes will support the long-term development and growth of the Al-Arish Port, increasing trade volumes, attracting investments, and boosting economic prosperity in the region.

In summary, this project aims to design and optimize the Al-Arish Port's components, with a focus on enhancing efficiency, capacity, and sustainability. By addressing critical aspects of infrastructure, technology, and environmental impact, the project will significantly contribute to the port's development, promoting economic growth and regional integration in Egypt and its surrounding areas.

# Chapter (1)
# Project Definition

# Project Definition

## 1.1 Introduction

With the rapid development of the Egyptian eastern north coast, the need for a modern and well-equipped harbor has become apparent. The existing port of El-Arish is inadequate for the projected growth in the area, as it is primarily designed to handle small general cargo ships and fishing berths. Consequently, investigations have been carried out to identify a suitable location for a new port.

Our project focuses on several key aspects. Firstly, we conducted an investigation into the environmental conditions along the El-Arish coast. This involved estimating the prevailing wind direction and analyzing wave refraction, which influences the alignment of the approach channel, breakwater, and berth orientation and arrangement.

Secondly, we studied the current direction, which flows from west to east parallel to the shoreline, and its impact on sediment transport. This information is crucial in the planning of the new port to address potential sedimentation issues.

Moreover, we examined the recommended location for the new port based on wave refraction diagrams from the NNW and North directions. The topographic conditions, including the shape of the shoreline and seabed contours, were considered to minimize the amount of dredging and earthworks required during the construction of the harbor.

The project also involved a comprehensive study of foundation and geological conditions, which influenced the design of berthing structures and the selection of the breakwater type. Taking into account the seabed slope, shoreline shape, and limited land availability, we determined that an offshore port design would be most suitable. This design requires filling the near-shore area to construct the berthing structures.

Detailed drawings were created to establish the general layout of the new port, considering environmental conditions, economic planning, water area, and land area requirements. The arrangement of berths was suggested based on cargo type, ship size, future expansion needs, dredging minimization, and providing sufficient water area for ship movement. Efforts were made to minimize the length of the breakwater while ensuring safe navigation and reducing wave forces acting on the ships.

Furthermore, we designed the artificial protection of the port using a main breakwater and secondary breakwater. The selection of a rubble mound breakwater type was based on its advantages in construction, stability, efficient dissipation of wave energy, and ease of maintenance. Detailed drawings were prepared to illustrate cross sections and longitudinal sections of the main breakwater.

The foundation conditions, including soil characteristics, bearing capacity, and methods of ground improvement, were thoroughly studied. Vessel size and various factors affecting design, such as vessel impact force, wind load, depth of quay wall, and live load related to cargo type and handling systems, influenced the selection of suitable berthing structures.

For each of the four berth types, we conducted analysis and design, adhering to principles that ensure ductile behavior, rapid energy dissipation, structural strength, and stability. The selected structures included counterfort retaining walls for the fishing basin, block-type quay walls for general cargo berths, cellular sheet pile walls for container berths, and slipways for maintenance and repair of fishing and service units.

In conclusion, this project encompasses the investigation of environmental conditions, site selection, layout planning, and design of key components for a new port at El-Arish. The detailed studies, analyses, and design proposals provided valuable insights for the development of a modern, efficient, and sustainable harbor, capable of accommodating the projected growth in the region.

## 1.2 Study Objectives

- Collecting wind data at the proposed sites and drawing wind roses to determine prevailing wind direction.
- Determine range of tide in the proposed sites.
- Collecting bathymetry data at the proposed sites.
- Construct and draw wave refraction diagram to determine harbor site.
- Calculate the minimum number of berths required for the harbor.
- Planning of harbor to determine the location and alignment of elements such as entrance, approach channel, turning basin, breakwaters, wharves, jetties, and docks etc. to ensure easy maneuverability and additional navigation facilities.
- Design approach channel, turning basin, breakwaters, and different kinds of berths.

## 1.3 Design Constraints

The primary constrains faced during our research work are classified into these categories:

### 1.3.1 Economic

The Egyptian code of water resources and irrigation works, volume seven, and the British standard code of practice for Maritime structures are applied in this project.

a) Availability of cheap land & construction material.

b) Traffic potentiality of harbor.
c) Calculate the minimum number of berths required for the harbor.
d) Determine the layout, the depth, and the width of approach channel.
e) Good and quick repair facilities to avoid delay.
f) Sufficient quay space and facilities for transporting, loading and unloading cargo.
g) Storage sheds for cargo.
h) Design breakwaters, and different kinds of berths.

### 1.3.2 Environmental

Prime Minister's decision No. 338 of 1995 Issuing the executive regulations of the Environmental Law Promulgated by Law No. 4 of 1994 and its modification.

a) Water wave motion and bathymetry affect the selection of harbor site.
b) Terminals for coal, cement, clinker, fertilizers, iron ore, salt, and soda ash should be opposite to the direction of prevailing wind in harbor.
c) Terminals of oil, LPG, LNG should be close to the entrance of harbor.
d) The wastewater treatment station of harbor should be opposite to the direction of prevailing wind in harbor.

### 1.3.3 Sustainability

The natural metrological phenomenon should be studied at site with respect to frequency of storms, rainfall, range of tides, maximum and minimum temperatures, direction and intensity of winds, humidity, direction, and velocity of currents etc. It is common to use two or three environments including the 100-yr wave with associated wind and current, and the 100-yr wind with associated wave and current.

### 1.3.4 Ethical

The Egyptian Code of Ethics for the Practice of the Engineering Profession.

### 1.3.5 Health and Safety

Safety and health in the new Egyptian labor law, No.211 to No. 244.

### 1.3.6 Social and Political

The development of the Al-Arish Port has significant social implications, including economic growth, job creation, skill development, and cultural exchange. Politically, the port promotes regional integration, national security, foreign relations, and infrastructure development.

# Chapter (2)
# Wind Rose

## 2.1 Introduction

**A wind rose is a graphical tool that represents wind patterns and frequencies at a specific location over a set period. It is particularly valuable in port planning and design for understanding prevailing wind directions and intensities. This discussion highlights the significance of wind roses in port contexts and their various implications.**

**Navigation and Ship Maneuverability: Wind patterns significantly affect vessel navigation and maneuverability within ports. By analyzing wind roses, port authorities can identify prevailing wind directions and design port layouts, including approach channels, turning basins, and berths, to minimize the impact of wind on ship handling. This ensures safe navigation and efficient operations within the port.**

**Berth Alignment and Layout: Wind roses help determine the optimal alignment and layout of berths. Understanding prevailing wind directions allows port planners to position berths to reduce wind forces acting on vessels during berthing and mooring. This is crucial for preventing accidents, minimizing vessel damage, and ensuring the safety of personnel and infrastructure.**

**Port Infrastructure Design: Wind roses are essential in designing port infrastructure such as breakwaters, quay walls, and other protective structures. By analyzing wind patterns, engineers can determine the necessary dimensions, orientation, and structural strength required for these elements to effectively withstand wind-induced forces like wave action and wind-driven vessel impacts, ensuring long-term stability and durability of the port's infrastructure.**

**Environmental Conditions: Wind roses provide valuable information about the local wind climate, essential for assessing the potential dispersion of air pollutants, such as dust, particulate matter, and emissions from port activities. Understanding wind patterns helps develop strategies to minimize the impact of these pollutants on the surrounding environment and neighboring communities.**

**Energy Generation: Wind roses are useful for identifying potential wind energy generation within the port area. By analyzing wind speeds and directions, renewable energy developers can determine the feasibility and efficiency of installing wind turbines or other wind energy systems within the port premises. This allows ports to explore sustainable energy options and reduce their carbon footprint.**

**In summary, wind roses provide critical information for port planning, design, and operations. They guide decisions regarding navigation, berth alignment, infrastructure design, environmental considerations, and renewable energy generation. Understanding wind patterns is essential for ensuring safe and efficient port operations, minimizing environmental impacts, and fostering sustainability.**

| ***ARISH WIND DATA (2024)*** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Surface Wind*** | | | | | | | | | | | | |
| **wind speed (knots)** | **Percentage Frequency of Wind Blowing from the Following Direction** | | | | | | | | | | | |
| | 345 14 | 15 44 | 45 74 | 75 104 | 105 134 | 135 164 | 165 194 | 195 224 | 225 254 | 255 284 | 285 314 | 315 344 |
| **1.0-10.0** | 12.21% | 6.72 % | 3.95 % | 2.45 % | 3.41 % | 2.27 % | 1.46 % | 2.66 % | 1.56 % | 2.43 % | 6.99% | 15.60 % |
| **11.0-27.0** | 4.93% | 1.95 % | 0.61 % | 0.59 % | 0.23 % | 0.23 % | 0.59 % | 2.67 % | 3.42 % | 2.78 % | 8.65% | 11.20 % |
| **28.0-47.0** | 0.00% | 0.00 % | 0.00 % | 0.00 % | 0.00 % | 0.00 % | 0.08 % | 0.27 % | 0.09 % | 0.00 % | 0.00% | 0.00% |
| ∑sum | 17.13% | 8.67 % | 4.55 % | 3.04 % | 3.65 % | 2.50 % | 2.13 % | 5.59 % | 5.08 % | 5.22 % | 15.64 % | 26.80 % |

## 2.2.Wind rose calculations

***Total No. hours of year = 365*24=8760 hrs**

***No. hours of recorded wind = 8586 hrs**

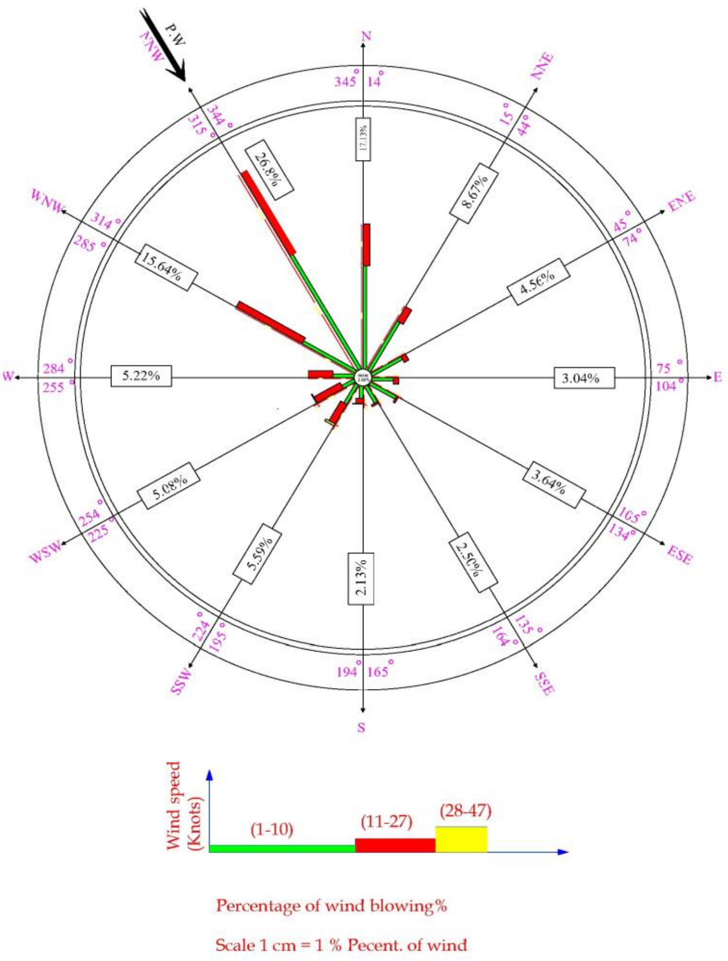
*** No. hours of unrecorded wind = 16 hrs**

***No. hours of calm wind = 141 hrs**

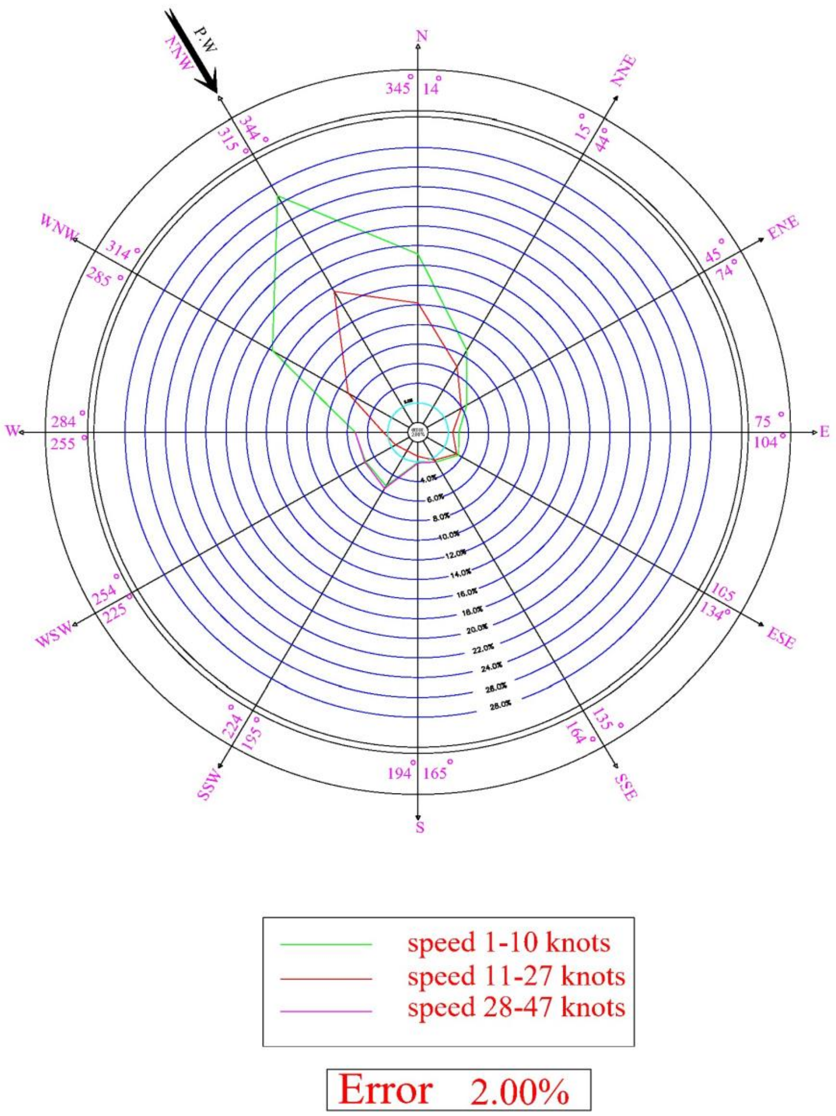
***No. hours of variable wind = 17 hrs**

***Error = (8760-**8586)*100/8760 = 1.99 ≈ 2.0 %

## For bar method:



# For contour method:



# Chapter (3)
# Wave Refraction

## 3.1 Introduction

Wave refraction is a phenomenon that occurs when waves approach a coastline, and their direction changes due to the varying depth of water. This process is governed by the principles of wave propagation and the interaction between waves and the underwater topography.

When waves approach a coastline at an angle, they encounter areas of varying water depths. As waves reach shallower water, their speed decreases while their wavelength shortens. This causes the waves to bend or refract, aligning more parallel to the coastline. The bending occurs because the part of the wave crest in shallower water slows down compared to the part in deeper water.

Wave refraction has several important implications, particularly in the context of port design and coastal engineering:

1. Approach Channel Alignment: Understanding wave refraction is crucial for determining the alignment of the approach channel leading to the port. By considering wave refraction, port planners can design the channel to align with the prevailing wave direction, reducing the impact of wave forces on vessels during navigation.
2. Breakwater Alignment: Wave refraction also affects the alignment of breakwaters, which are protective structures constructed to attenuate wave energy and create calm waters within the port. By analyzing wave refraction patterns, engineers can optimize the positioning and alignment of breakwaters to provide effective protection from waves approaching the port.
3. Berth Orientation and Layout: The knowledge of wave refraction helps in determining the orientation and layout of berths within the port. By considering the direction of refracted waves, port planners can position berths in a manner that minimizes wave forces acting on moored vessels, ensuring safer and more efficient operations.
4. Sediment Transport: Wave refraction affects the movement of sediments along the coastline. As waves refract and change direction, they can cause sediment deposition or erosion in specific areas. Understanding these patterns is crucial for managing sediment transport and ensuring the long-term stability of the port and nearby coastal areas.

5. Coastal Erosion and Protection: Wave refraction plays a role in coastal erosion and shoreline stability. By studying wave refraction patterns, coastal engineers can identify areas prone to erosion and develop appropriate measures, such as beach nourishment or the construction of protective structures, to mitigate the effects of wave action and preserve the coastline.

In conclusion, wave refraction is a significant factor in port design and coastal engineering. Understanding the bending of waves as they encounter varying water depths helps optimize the alignment of approach channels, breakwaters, and berths within the port. It also aids in managing sediment transport, mitigating coastal erosion, and ensuring the safety and stability of port infrastructure.

## 3.2. Wave refraction calculations

**For N.N.W direction:**

**F= 350 Km** **Td = 20 years**

**Ho = 6.00m** **T = 7.00sec**

**Lo= 1.56* $to^2$=1.56*$7^2$=76.44 m**

**Lo / 2 = 76.44/2 = 38.22 m**

**The beginning of transition zone at contour line of sea bed = (-38.22)**

**Lo / 25 = 76.44/25 = 3.06m**

***The beginning of shallow zone at contour line of sea bed = (-3.06)***

| d | d/Lo | Tanh(2πd/L) | c1/c2 | R |
|---|---|---|---|---|
| 38.22 | 0.50 | 0.9964 | - | - |
| 35.00 | 0.46 | 0.9939 | 1.002515 | 3.0075 |
| 25.00 | 0.33 | 0.9712 | 1.023373 | 3.0701 |
| 17.50 | 0.23 | 0.91528 | 1.061096 | 3.1833 |
| 12.50 | 0.16 | 0.8349 | 1.096275 | 3.2888 |
| 8.50 | 0.11 | 0.7337 | 1.137931 | 3.4138 |
| 6.00 | 0.08 | 0.6493 | 1.129986 | 3.3900 |
| 4.00 | 0.05 | 0.531 | 1.222787 | 3.6684 |
| 3.06 | 0.04 | 0.4802 | 1.105789 | 3.3174 |

**For North wind during seasonal storms:**

***F= 350 Km*** ***Td = 20 years***

***Ho = 2.50m*** ***to = 6.00sec***

***Lo= 1.56* to$^2$=1.56*6$^2$=56.16 m***

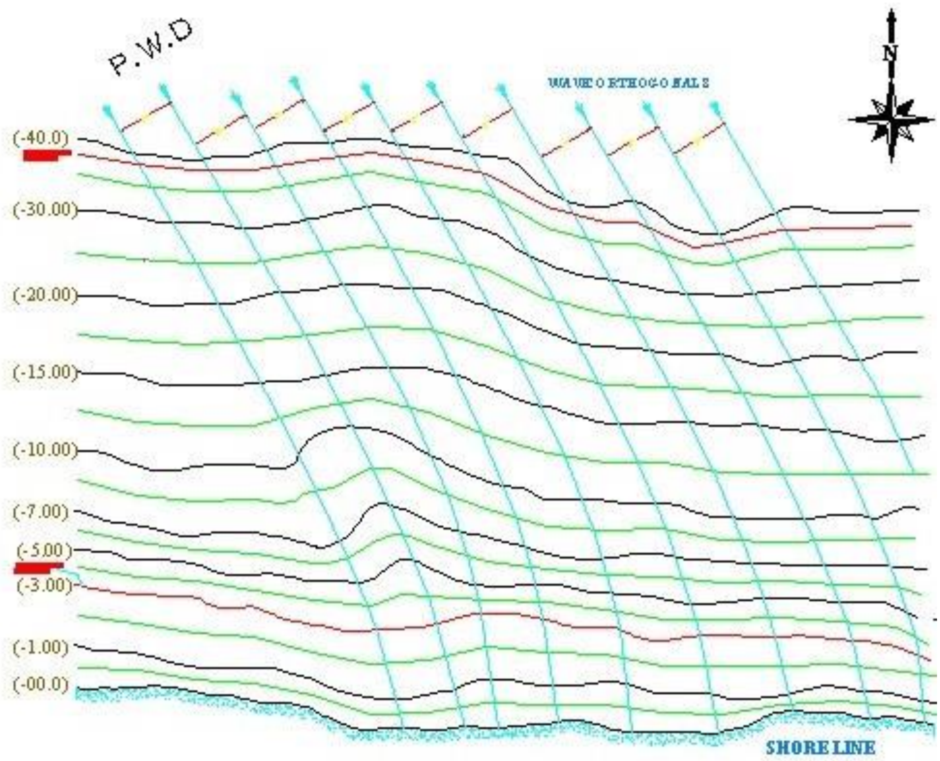
***Lo / 2 = 56.16/2 = 28.08m***

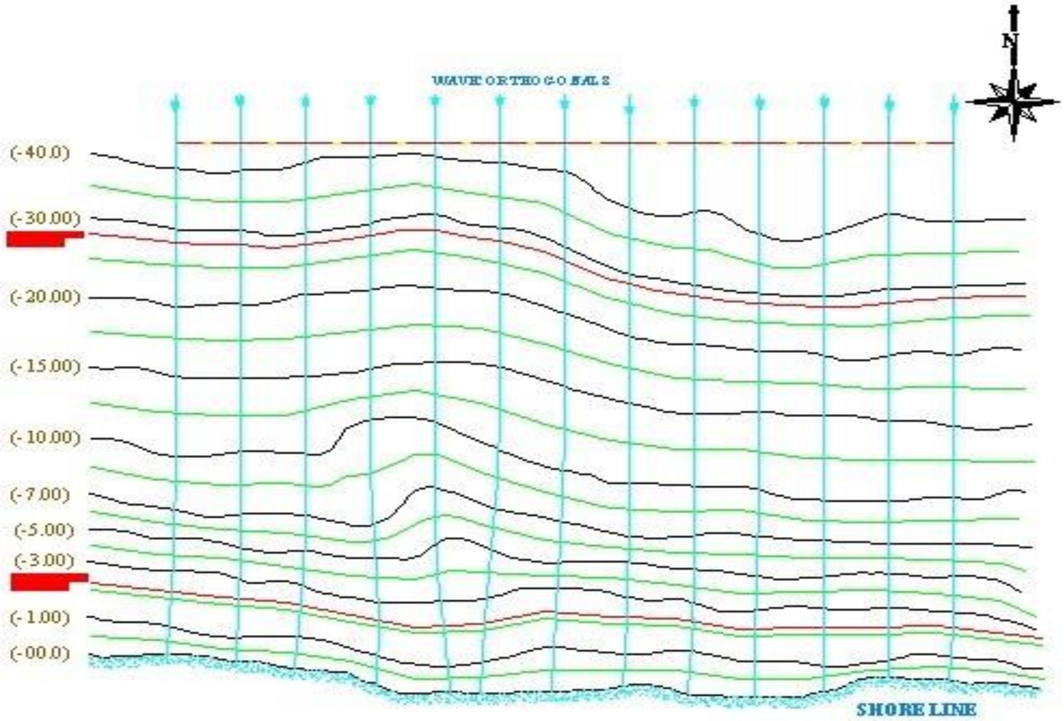
***The beginning of transition zone at contour line of sea bed = (-28.00)***

***Lo / 25 = 76.44/25 = 2.25m***

***The beginning of shallow zone at contour line of sea bed = (-2.25)***

| d | d/Lo | Tanh(2πd/L) | c1/c2 | R |
|---|---|---|---|---|
| 28.08 | 0.50 | 0.9964 | | |
| 25.00 | 0.45 | 0.9933 | 1.003121 | 3.009 |
| 17.50 | 0.31 | 0.96448 | 1.029881 | 3.090 |
| 12.50 | 0.22 | 0.90632 | 1.064172 | 3.193 |
| 8.50 | 0.15 | 0.81755 | 1.108581 | 3.326 |
| 6.00 | 0.11 | 0.7337 | 1.114284 | 3.343 |
| 4.00 | 0.07 | 0.6144 | 1.194173 | 3.583 |
| 2.25 | 0.04 | 0.4802 | 1.279467 | 3.838 |




N
WAVE ORTHOGONALS
(-40.0)
(-30.00)
(-20.00)
(-15.00)
(-10.00)
(-7.00)
(-5.00)
(-3.00)
(-1.00)
(-00.0)
SHORE LINE

# Chapter (4)

# Planning of Ports

## 4.1. Introduction

Planning of ports involves the systematic process of designing, developing, and managing port facilities to ensure efficient and safe maritime operations. It encompasses various aspects, including site selection, layout design, infrastructure development, and operational considerations. Here, we discuss key elements involved in the planning of ports:

1. Site Selection: Choosing the appropriate location for a port is a critical first step in the planning process. Factors such as natural harbor conditions, navigational access, water depth, proximity to transportation networks, and future expansion possibilities are considered. The site selection process involves conducting feasibility studies, assessing environmental impacts, and evaluating economic and social benefits.
2. Port Layout Design: The layout design involves determining the arrangement and configuration of various port components, such as berths, quays, storage areas, container yards, and support facilities. Considerations include optimizing vessel traffic flow, minimizing conflicts between different types of cargo and vessels, providing adequate space for storage and handling operations, and ensuring efficient intermodal connectivity.
3. Infrastructure Development: Port planning includes the design and construction of infrastructure elements essential for port operations. This includes constructing berths, quay walls, breakwaters, navigational channels, access roads, rail connections, and utilities. Infrastructure development must adhere to engineering standards, environmental regulations, and safety requirements.
4. Navigation and Channel Design: Planning considers navigational requirements, including the design of safe and efficient access channels, turning basins, and harbor entrances. Factors such as water depth, tidal range, wave conditions, and vessel sizes are taken into account to ensure navigational safety and minimize the risk of accidents or grounding.
5. Environmental Considerations: Port planning incorporates environmental assessments and mitigation measures to minimize negative impacts on the surrounding ecosystem. This includes evaluating the potential effects on water quality, marine life, coastal erosion, and air pollution. Implementing sustainable practices, such as

reducing emissions, managing waste, and preserving natural habitats, is an essential part of modern port planning.

6. Operational Efficiency: Planning considers the optimization of port operations to enhance efficiency and productivity. This includes analyzing cargo flows, storage requirements, handling equipment, and workflow processes. Factors such as minimizing vessel turnaround time, optimizing berth allocation, and implementing advanced technologies for cargo handling and tracking are essential for maximizing operational efficiency.
7. Safety and Security: Port planning incorporates measures to ensure the safety and security of port facilities, personnel, and cargo. This includes designing secure perimeters, implementing surveillance systems, establishing emergency response plans, and complying with international security standards. Port planning also considers potential risks, such as natural disasters, and incorporates resilience measures into the design and operation of port infrastructure.
8. Stakeholder Engagement: Effective port planning involves engaging various stakeholders, including government agencies, port authorities, shipping companies, labor unions, local communities, and environmental groups. Stakeholder consultations and collaboration help address concerns, ensure transparency, and foster support for the port development project.

In summary, the planning of ports involves a comprehensive and multidisciplinary approach to design, develop, and manage port facilities. It considers site selection, layout design, infrastructure development, operational efficiency, safety, environmental sustainability, and stakeholder engagement. Effective port planning is crucial for creating economically viable, environmentally sustainable, and socially beneficial port facilities.

## 4.2. Calculations

**Part (1)Number of berths:-**

( I ) **Approximate Method :**

**No. Of Berths (N) = $A_n$ / ( D*H*R )**

**Where :**

**$A_n$ : Annual Amount Of Cargo. (ton/yr)**

**R : Rate Of Handling. (ton/hr)**

**D : No. Of Working Days In Year. (day/yr)**

**H : No. Of Working Hours In Day. (hr/day)**

**Assume H = 16 hours.**

***For General**

$N_1 = (3 * 10^6) / (300 * 16 * 600) = 1.042$

∴ **Take $N_1$ = 2 berth.**

***For Special Cargo:-**

$N_2 = (1.0 * 10^6) / (200 * 16 * 800) = 0.39$

∴ **Take $N_2$ = 1 berth.**

*** For Clinker& Cement :-**

$N_3 = (2.0 * 10^6) / (200 * 16 * 1500) = 0.42$

∴ **Take $N_3$ = 1 berth.**

*** For Container&R/R :-**

**R=20*30=600 (ton/hr)**

**$N_4 = (1.5 * 10^6) / (300 * 16 * 600) = 0.52$**

**∴ Take $N_4 = 1$ berth.**

*** <u>For Passengers</u>:- $N_5 = 2$ berth.**

| Type Of Cargo | No. Of Berths |
|---|---|
| For General cargo | 2 |
| Special Cargo | 1 |
| Clinker& Cement | 1 |
| Container | 1 |
| Passengers | 2 |

( Π )

**<u>Exact Method</u> :**

**Where:**

**n : No. Of Trials.**

**N: No. Of Berths.**

$$n = 2N + 2$$

$$P_n = N^n * e^{-N} / n!$$

**Where :**

d : Depth Of The Quay. (m)

L: Length Of The Quay. (m)

$W_{cost}$ = Ship Waiting Cost. ($/d)

$V_{cost}$ = Daily Cost Of Vacant Berth. ($/d)

For All Berths:

$W_{cost} / V_{cost} = 4/1$

► **Berth No. (1) [General cargo] :** N=2 , n= 2*2+2=6

∴ $L_{quay} = 180 + (15 : 20) = 200$ m

∴ $d_{quay}$ = Draft + Squat + H/2+1= 9 + 1.0= 10.0 m

∴ $P_n = N^{n} * e^{-N} / n!$

| n | n! | PN | 1BERTH | | 2 BERTH | | 3 BERTH | | 4 BERTH | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | W | V | W | V | W | V | W |
| 0.0 | 1.0 | 0.135 | 0.135 | 0.000 | 0.270 | 0.000 | 0.405 | 0.000 | 0.540 | 0.000 |
| 1.000 | 1.0 | 0.271 | 0.000 | 0.000 | 0.271 | 0.000 | 0.542 | 0.000 | 0.813 | 0.000 |
| 2.000 | 2.0 | 0.271 | 0.000 | 0.271 | 0.000 | 0.000 | 0.271 | 0.000 | 0.542 | 0.000 |
| 3.000 | 6.0 | 0.180 | 0.000 | 0.360 | 0.000 | 0.180 | 0.000 | 0.000 | 0.180 | 0.000 |
| 4.000 | 24.0 | 0.090 | 0.000 | 0.270 | 0.000 | 0.180 | 0.000 | 0.090 | 0.000 | 0.000 |
| 5.000 | 120.0 | 0.036 | 0.000 | 0.144 | 0.000 | 0.108 | 0.000 | 0.072 | 0.000 | 0.036 |
| 6.000 | 720.0 | 0.012 | 0.000 | 0.060 | 0.000 | 0.048 | 0.000 | 0.036 | 0.000 | 0.024 |
| ∑SUM | | | 0.135 | 1.105 | 0.541 | 0.516 | 1.218 | 0.198 | 2.075 | 0.060 |
| Cost=∑V+4∑W | | | 4.555 | | 2.605 | | 2.010 | | 2.315 | |

∴ **We Use [ 3 Berths ].**

► **<u>Berth No. (2) [Special Cargo]:-</u> N=1, n= 2*1+1=4**

**∴ $L_{quay}$ = 160 + (15 : 20) = 180 m**

**∴ $d_{quay}$ = Draft + Squat + H/2+1= 8 + 1.0= 9.0 m**

| n | n! | PN | 1BERTH | | 2 BERTH | | 3 BERTH | | 4 BERTH | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | W | V | W | V | W | V | W |
| 0.0 | 1.0 | 0.368 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 | 1.472 | 0.000 |
| 1.000 | 1.0 | 0.368 | 0.000 | 0.000 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 |
| 2.000 | 2.0 | 0.184 | 0.000 | 0.184 | 0.000 | 0.000 | 0.184 | 0.000 | 0.368 | 0.000 |
| 3.000 | 6.0 | 0.061 | 0.000 | 0.122 | 0.000 | 0.061 | 0.000 | 0.000 | 0.061 | 0.000 |
| 4.000 | 24.0 | 0.015 | 0.000 | 0.045 | 0.000 | 0.030 | 0.000 | 0.015 | 0.000 | 0.000 |
| ∑SUM | | | 0.368 | 0.351 | 1.104 | 0.091 | 2.024 | 0.015 | 3.005 | 0.000 |
| Cost=∑V+4∑W | | | 1.772 | | 1.468 | | 2.084 | | 3.005 | |

∴ **We Use [ 2 Berths ].**

► **<u>Berth No. (3) [Clinker& Cement ] :-</u> N=1, n= 2*1+1=4**

**∴ $L_{quay}$ = 160 + (15 : 20) = 180 m**

**∴ $d_{quay}$ = Draft + Squat + H/2+1= 8 + 1.0= 9.0 m**

| n | n! | PN | 1BERTH | | 2 BERTH | | 3 BERTH | | 4 BERTH | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | W | V | W | V | W | V | W |
| 0.0 | 1.0 | 0.368 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 | 1.472 | 0.000 |
| 1.000 | 1.0 | 0.368 | 0.000 | 0.000 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 |
| 2.000 | 2.0 | 0.184 | 0.000 | 0.184 | 0.000 | 0.000 | 0.184 | 0.000 | 0.368 | 0.000 |
| 3.000 | 6.0 | 0.061 | 0.000 | 0.122 | 0.000 | 0.061 | 0.000 | 0.000 | 0.061 | 0.000 |
| 4.000 | 24.0 | 0.015 | 0.000 | 0.045 | 0.000 | 0.030 | 0.000 | 0.015 | 0.000 | 0.000 |
| ∑SUM | | | 0.368 | 0.351 | 1.104 | 0.091 | 2.024 | 0.015 | 3.005 | 0.000 |
| Cost=∑V+4∑W | | | 1.772 | | 1.468 | | 2.084 | | 3.005 | |

∴ **We Will Use [ 2 Berths ].**

► **<u>Berth No. (4) [ Container]</u> :-**

∴ $L_{quay}$ = 270 + (15 : 20) = 290 m

∴ $d_{quay}$ = Draft + Squat + H/2+1= 12 + 1.5 + 2.5/2 + 1= 15.75 m

| n | n! | PN | 1BERTH | | 2 BERTH | | 3 BERTH | | 4 BERTH | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | V | W | V | W | V | W | V | W |
| 0.0 | 1.0 | 0.368 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 | 1.472 | 0.000 |
| 1.000 | 1.0 | 0.368 | 0.000 | 0.000 | 0.368 | 0.000 | 0.736 | 0.000 | 1.104 | 0.000 |
| 2.000 | 2.0 | 0.184 | 0.000 | 0.184 | 0.000 | 0.000 | 0.184 | 0.000 | 0.368 | 0.000 |
| 3.000 | 6.0 | 0.061 | 0.000 | 0.122 | 0.000 | 0.061 | 0.000 | 0.000 | 0.061 | 0.000 |
| 4.000 | 24.0 | 0.015 | 0.000 | 0.045 | 0.000 | 0.030 | 0.000 | 0.015 | 0.000 | 0.000 |
| ∑SUM | | | 0.368 | 0.351 | 1.104 | 0.091 | 2.024 | 0.015 | 3.005 | 0.000 |
| Cost=∑V+4∑W | | | 1.772 | | 1.468 | | 2.084 | | 3.005 | |

| Type Of Cargo | No. Of Berths |
|---|---|
| For General cargo | 3 |
| Special Cargo | 2 |
| Clinker& Cement | 2 |
| Container | 2 |
| Passengers | 2 |

**Part (2) *DESIGN OF APPROACH CHANNEL*:-**

**DATA:**

**Design ship: 270*32*12**

**Draft= 12m , Lmax = 270m , B= 32m**

**Assume: TR= 1.17 , S.L = 1.0 m S.Q =1.5 m**

**Pitch =1.00m , clearance =1.00m**

(1) WIDTH :

***** FOR one lane*****

**w= 4.8 bmax**

**= 4.8*32=153.6m**

**for one lane take B=155m**

***** For two lane*****

**W=8.1bmax=8.1*32=259.2m**

**For two lane take B=260m**

(2) side slope :

**For fine sand slope (1:5)**

(3) water depth :

**L.L.W.L =(0.00)**

**D=d+H/2+T.R/2+SQ+P.L+SL.+ clearance**

**D=12+(2.5/2)+(1.17/2)+1.0+1.50+1.0+1.0= (18.00)**

(4)turning basin :

**D=2Lmax**

**= (2-3)*270**

**=540 m**

**D=d+T.R/2+SQ+P.L+SL.+ clearance**

**D=12+(1.17/2)+1.0+1.50+1.0+1.0= (17.00)**

(5) GAP :

**G=W+50=155+50=205m**

**G=Lmax=270**

**Use Gap=270m**

**Part (3) *Master Plan* :--**

(1) **for general cargo**

► **use transit shed**

**assume sf=1.25 mechanical handling (hs)=4.0m**

**$A=2.25*D.W.T.*s_f / h_s =2.25*16000*1.25/4=11250\ m^2$**

**B=11250/160=70 m**

**(LXB)= (160X70) m**

(2) **for special cargo**

►use **transit shed**

**$A=2.25*D.W.T.*s_f / h_s =2.25*18000*1.25/4=12656.25\ m^2$**

**B=12656.25/180=70.31 m**

**(LXB)= (180X70) m**

(3) **for Clinker& Cement**

► use silos for cement

**for one silos take D=10m h=30m**

**v= ΠD2/4 *h= Π(10)2/4 * 30 =2355m2**

**Total volume =16000**

**No of silos = 16000/2355=6.79=8 silo**

(4) **for container**

► min area for one berth =24 f**ed**

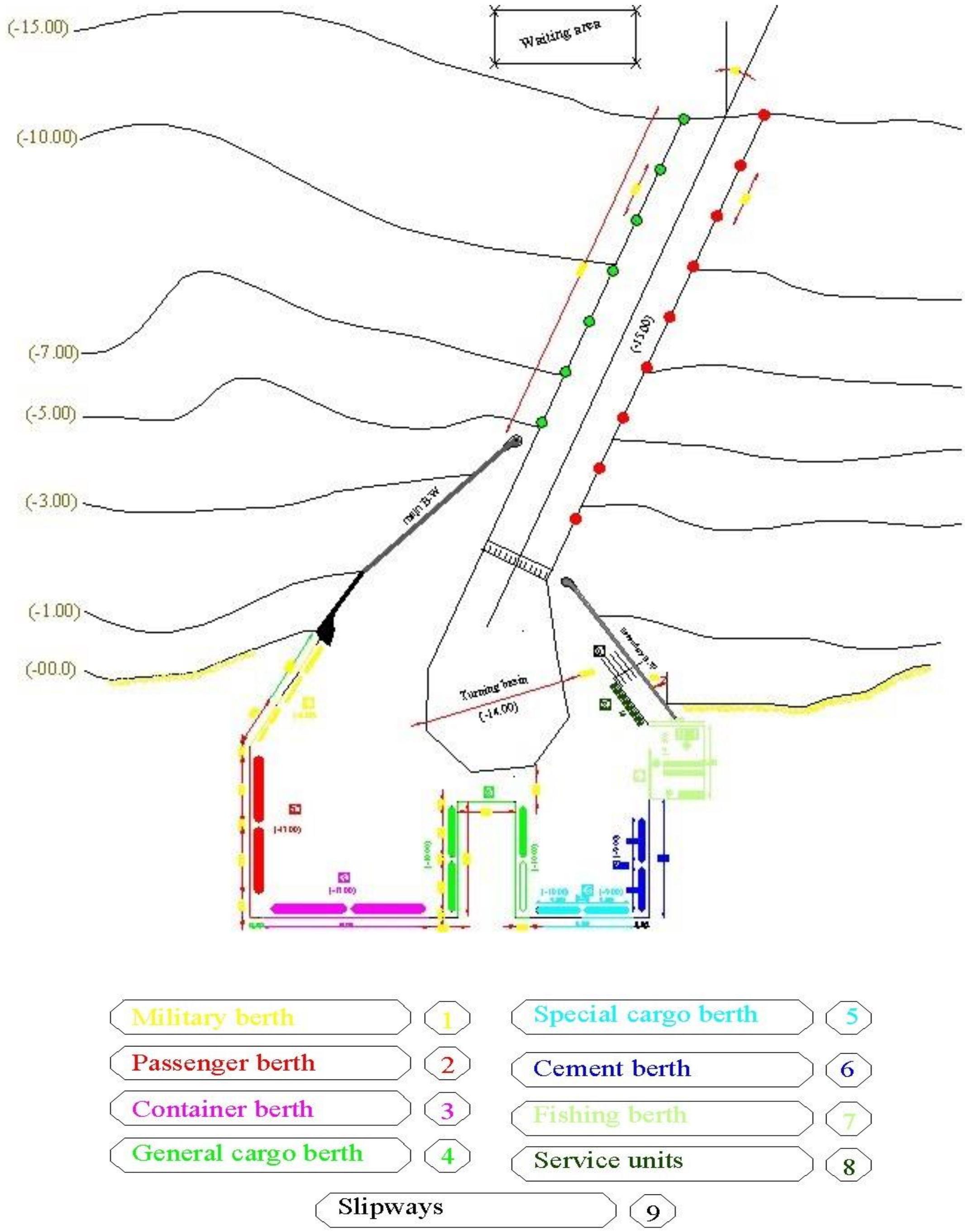
**A= 24*4200=100800 m2**

**L=270m**

**B= 100800/270=373.33m**

**(L*B)=(270*375) m**

# General layout




MASTER PLAN
(-00.0)
Turning basin
(-14.00)
W.A
W.A
W.A
W.A
Workshop

# Chapter (5)
# Breakwaters

## 5.1. Introduction

Breakwaters play a crucial role in the design and functionality of ports by providing protection against wave action and creating calm waters within the harbor area. These structures are typically constructed parallel or at an angle to the coastline and are designed to dissipate wave energy, reduce sedimentation, and enhance navigational safety. Here are some key aspects to consider when discussing breakwaters in ports:

1. Wave Energy Dissipation: One of the primary functions of breakwaters is to dissipate the energy carried by waves approaching the port. By providing a barrier, breakwaters reduce the wave height and the intensity of wave-induced forces within the harbor, creating a sheltered area for vessels to dock and maneuver safely. This protection is particularly important during storm events when wave energy is higher.
2. Types of Breakwaters: Different types of breakwaters can be employed based on the specific coastal and environmental conditions. Some common types include rubble mound breakwaters, vertical or composite breakwaters, and floating breakwaters. The selection of the most suitable type depends on factors such as wave climate, water depth, seabed conditions, construction materials, and project budget.
3. Design Considerations: Breakwater design involves careful consideration of several factors, including wave conditions, water depths, sediment transport patterns, and shoreline stability. Engineers must determine the appropriate dimensions, alignment, and orientation of the breakwater structure to ensure effective wave energy dissipation while minimizing impacts on sediment movement and adjacent coastlines.
4. Material Selection: The choice of materials for constructing breakwaters is critical for their structural integrity and durability. Common materials include concrete armor units, natural rock or stone, or specially designed geotextile containers filled with sand or gravel. The selection depends on factors such as wave climate, available resources, construction methods, and maintenance requirements.
5. Environmental Impacts: Breakwaters can have both positive and negative environmental impacts. While they provide protection to the harbor, they can alter sediment transport patterns, impact marine habitats, and affect coastal erosion and accretion processes.

Environmental assessments and mitigation measures are essential to minimize adverse effects and preserve the ecological balance.

6. Maintenance and Monitoring: Breakwaters require regular maintenance to ensure their continued effectiveness. This may involve periodic inspections, repairs, and replenishment of armor materials. Monitoring wave climate, sediment movement, and the stability of the breakwater structure is crucial to identify any potential issues and address them promptly.
7. Integration with Port Infrastructure: Breakwaters must be designed and integrated into the overall port infrastructure plan. Considerations include aligning breakwaters with approach channels, positioning them to provide protection to berths and quay walls, and ensuring compatibility with other port facilities and operational requirements.

In summary, breakwaters are essential components of port infrastructure, providing protection against wave energy and creating a safe environment for vessels. Their design, construction, and maintenance involve careful consideration of wave conditions, materials, environmental impacts, and integration with other port facilities. Well-designed breakwaters contribute to the efficient and safe functioning of ports, enhancing navigation, and protecting coastal areas.

## 5.2. Calculations

**Break water calculations**

***Design of rubble mound break water***

- ***For section at head (1-1)***
  - **head section at water depth =4.5m**
  - **ho=6.0 m**
  - **t=10 sec**
  - **from refraction bo=4cm b1=4.13**
  - **kr =(b0/b)^0.5=(4/4.13)^0.5=0.984**
  - **L=1.56T2=1.56(10)2=156 m**
  - **d/L=4.5/156=0.0288**
  - **H at sec(1-1) = d *0.78 =4.5*0.78=3.51**
    - **d =4.5m >1.25 H non breaking wave**

**- Weight of Stone :**

*(1)* ***Armor layer*** **:**

$$W=\gamma_r H^3/K_D(S_r-1)^3 \cot\alpha$$

► ***By using natural stone*:**

$\gamma_r=2.2 t/m^3$ , $H=3.51$ m , $\cot\alpha=2.0$ , $S_r=\gamma_r/\gamma_w=2.2/1.025=2.146$

**assume use armour unit quarry stone - rough angular-N=2 placement (random) – non bracking wave- cot α =2.0 from above : Kd= 2.8**

$W=2.2*3.51^3/\{2.8*(2.146-1)^3*2\}=11.29>10$ **(use artificial stone)**

*(2)* ***For filter layer :***

**Wf=WA/4: WA/10 =2.82 t: 1.128 t**

*(3)* ***For core layer:***

**WC=WA/400: WA/1000 =28.22 kg: 11.29kg**

► **By using artificial stone:**

**Use dolose, N=2.0, placement (random), cot α =2.0**

**KD=16.5,** $\gamma_r = 2.4\ t/m^3$

**W=2.4*3.51^3/{16.5*(2.4/1.025-1)^3*2}=1.30 t**

**- Thikness of Layer**

$t=nK_\blacktriangle(V)^{1/3}$ , $V=W/\gamma_r$

*(1)* ***Armer layer :***

**Armour units dolose n =2.0 placement (random)**

K▲=1.3

$t_A=2*1.3*(1.30/2.4)^{0.333}=1.87$ **m**

***(2 )For filter layer:***

**Quarry stone (rough) N =2.0 placement (random)**

$t_F=2*1.15*(1.974/2.2)^{1/3}=2.2$ **m**

**- LEVELS**

► Construction from the land

**CORE LEVEL = 0+2.00=2.00m**

**CREST LEVEL = water level+ (Hwave/2)+tidal range+run up**

**= 0.00+ (3.51/2)+1.17+1.25*3.51=(7.30)**

**Filter LEVEL=2.00+2.20=4.20**

**Armor LEVEL=4.20+1.87=6.07**

***- For section at trunk (2-2)***

- **trunk section at water depth =3.0m**
- **ho=6.0m**
- **t=10sec**
- **from refraction bo=4cm b1=4.15**
- **kr =(b0/b)^0.5=(4/4.15)^0.5=0.982**
- **L=1.56T2=1.56(7.5)2=87.75**
- **d/L=3/156=0.019**
- **H at sec(2-2) = d*0.78=3*.78=2.34 m**
- **d =3m >1.25 H non breaking wave**

**- weight of stone :**

*(1) __armer layer__* :

$$W=\gamma_r H^3/K_D(S_r-1)^3\cot\alpha$$

**► By using natural stone:**

**$\gamma_r$=2.2t/m$^3$ , H=2.34m , cot$\alpha$=2.0 , $S_r = \gamma_r / \gamma_w$=2.2/1.025=2.146**
**assume use armour unit quarry stone - rough angular-N=2 placement (random) – non breaking wave- cot $\alpha$ =2.0**
**from above : Kd=2.8**

**W=2.2*2.34$^3$/{2.8*(2.146-1)$^3$*2}= 3.34 t <10**

*(2) __Filter layer__ :*

**Wf=WA/4 : WA/10 =0.835 t :0.334 t**

*(3) __Core layer :__*

**Wc=WA/400 :WA/1000 =8.35kg :3.34 kg**

**- Thikness of Layer:**

$$T=nK_\blacktriangle(V)^{1/3}, \quad V=W/\gamma_r$$

*(1) __armer layer__* :

**Armour units Quarry stone (rough) N =2.0 , placement (random) ,**

K▲=1.15

**$t_A$=2*1.15*(3.34/2.2)$^{1/3}$=2.6 m**

(2) ***Filter layer :***

**Quarry stone (rough) N =2.0 , placement (random)**

**$t_F$=2*1.15*(0.58/2.2)$^{1/3}$=1.50 m**

**- LEVELS :**

► Construction from the land

**CORE LEVEL = 0+2.00=2.00m**

**CREST LEVEL = water level+ (Hwave/2)+tidal range+run up**

**= 0.00+ (2.34/2)+1.17+1.25*2.34=(5.30)**

**FILTER LEVEL=2.0+1.5=3.50 m**

**ARMOUR LEVEL=3.5+2.6=6.10m**

***For section at trunk (3-3)***

- **trunk section at water depth =2.0m**
- **ho=6.0m**
- **t=10 sec**
- **H at sec(3-3) = d*0.78**
  **=2.0*0.78=1.56m**

**d =2m >1.25 H non breaking wave**

**weight of stone**

**for (1) armer layer**

$$W=\gamma_r H^3/K_D(S_r-1)^3 \cot\alpha$$

**By using natural stone:**

**$\gamma_r$=2.2t/m$^3$ , H=1.56m , cotα=2.0 , $S_{r=}$ $\gamma_r$ / $\gamma_w$=2.2/1.025=2.146**

**assume use armour unit quarry stone -**
**rough angular-N=2 - placement (random) – non bracking wave-**

**cot** $\alpha$ **=2.0**

**from above : Kd=2.8**

$W=2.2*1.56^3/\{2.8*(2.146-1)^3*2\}=1.0t<10$

(2) ***For filter layer:***

**Wf=WA/4 : WA/10 =0.25 t : 0.1 t**

*(3)* ***For core layer :***

**Wc=WA/400 :WA/1000 =2.5 kg :1.0kg**

***<u>THICKNESS OF LAYER :</u>***

$t=nK_{\blacktriangle}(V)^{1/3}$ $V=W/\gamma_r$

**FOR ARMOUR LAYER :**

**Armour units Quarry stone (rough)**

n =2.0 placement (random) K▲=1.15

$TA=2*1.15*(1.0/2.2)^{1/3}=1.78m$

**FOR FILTER LAYER :**

**Quarry stone (rough) N =2.0 placement (random)**

K▲=1.15

$t_F=2*1.15*(0.175/2.2)^{1/3}=1.0\ m$

***** LEVELS :***

**Construction from the land**

**CORE LEVEL = 0+2.00=2.00m**

**CREST LEVEL = water level+ (Hwave/2)+tidal range+run up**

**= 0.00+ (1.56/2)+1.17+1.25*1.56=(3.90)**

**FILTER LEVEL=2.0+1=3.0 m**

**ARMOUR LEVEL=3.0+1.78=4.78m**

# Chapter (6)

# Design of Berths

## 6.1. Introduction

Berths in ports are designated areas where vessels can moor or dock to load, unload, and carry out various operations related to cargo handling, passenger embarkation/disembarkation, and vessel maintenance. Berths are essential components of port infrastructure and play a crucial role in facilitating maritime trade and transportation. Here are some key points to consider when discussing berths in ports:

1. Functionality: Berths serve as designated spaces where vessels can safely approach and be secured for various activities. They provide access to the shore for cargo transfer, fueling, repairs, and other port operations. Different types of berths cater to specific functions, such as container berths for handling containerized cargo, bulk berths for bulk commodities like coal or grain, and passenger berths for embarking/disembarking passengers.
2. Design and Layout: Berths are designed to accommodate different types and sizes of vessels. The layout of berths within a port is carefully planned to optimize the utilization of available space and ensure efficient vessel handling. Factors such as water depth, tidal range, wave conditions, and navigational requirements are considered during the design process.
3. Quay Walls: The quay wall, also known as the wharf or dock, forms the waterfront edge of a berth. It is a reinforced structure designed to withstand vessel impact, wave forces, and the weight of cargo being loaded or unloaded. Quay walls are typically constructed using materials like concrete or steel and can be equipped with fenders and bollards to facilitate vessel mooring.
4. Fenders: Fenders are installed along the quay walls to absorb the impact energy generated when a vessel berths. They protect both the vessel and the quay structure from damage by providing a cushioning effect. Fenders are made from rubber, foam, or other resilient materials and are designed based on the expected vessel sizes and berthing forces.
5. Mooring and Bollards: Bollards are strong posts or pillars installed along the quay wall to which vessels can be securely tied using ropes or mooring lines. They provide the necessary strength and stability to hold vessels in place during berthing and while cargo operations are being carried out. The number, spacing, and capacity of bollards

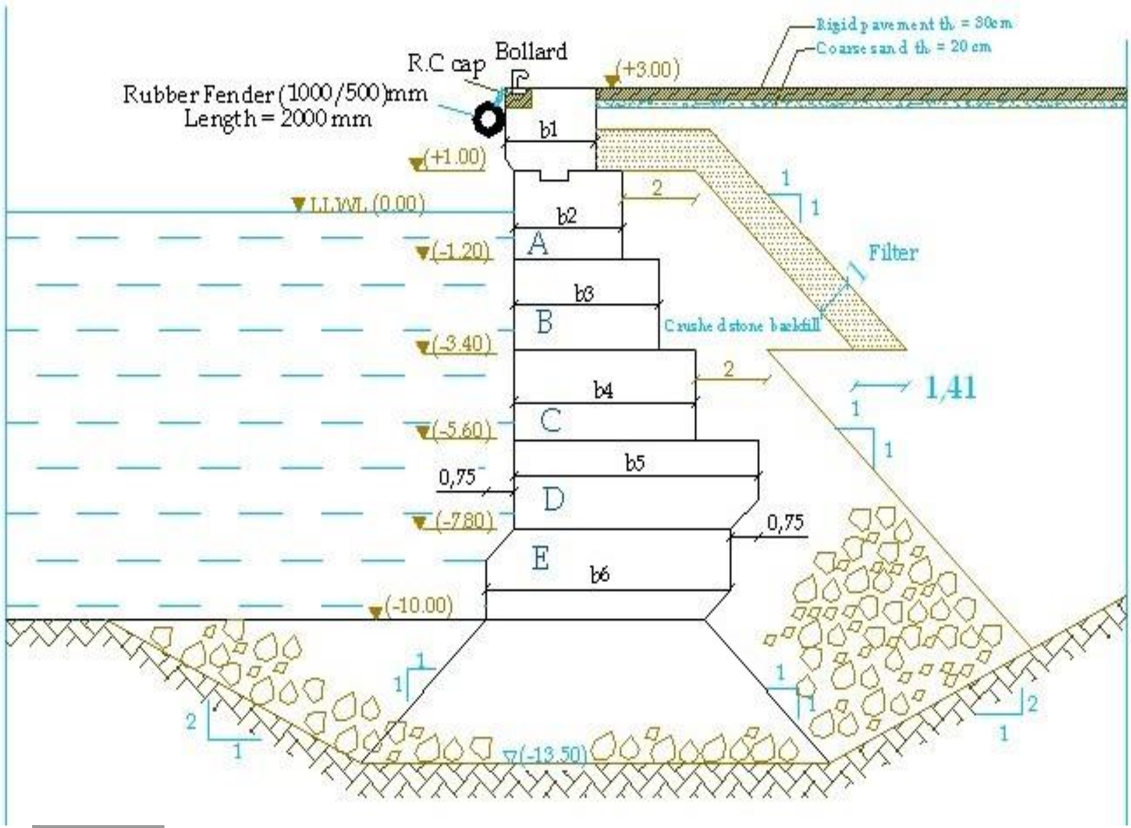
depend on the size and weight of the vessels expected to berth at the specific location.

6. Ancillary Facilities: Berths are often equipped with various ancillary facilities to support cargo handling operations. These may include container gantry cranes, mobile cranes, conveyor systems, storage yards, refrigeration facilities, and other specialized equipment specific to the cargo being handled. Passenger berths may include facilities such as terminal buildings, gangways, customs, and immigration areas, and other amenities for passenger comfort and convenience.
7. Expansion and Flexibility: Port planning takes into account the need for future expansion of berths to accommodate increasing vessel sizes and cargo volumes. Flexibility in berth design allows for adjustments or modifications as per evolving industry requirements, ensuring the port can adapt to changing trends and technologies.

In conclusion, berths in ports serve as essential docking and operational spaces for vessels engaged in cargo handling or passenger services. Their design and layout are crucial for efficient and safe vessel operations. Properly designed and equipped berths contribute to the smooth flow of trade, facilitate port activities, and support economic growth through maritime transport.

## 6.1. Calculations

# Block type for general cargo




## DATA

* **Surcharge Loads** = **3 t/m**

* **Tention On Bollard ( Pw ) = 180*9*9 .0065*90*90 ) = 85.3 ton**

**Let using 4 bolord**

**T = 85.3 /4 N= 21.5 ton .**

**T /m` =21.5 /20 = 1 T /m`**

* **Depth Of Water** = **9+ 1.0 = 10.0 m**

* **Tidal Range ( T.R. ) = 1.17 m**

* ▼ Crest =**3.00m.∴**

**Total Depth Of Berth = 10.0 + 3 = 13.00 m ∴**

* for active earth pressure at Φ =40

∴ **$K_a$ = ( 1 – Sin 40° ) / ( 1 + Sin 40° ) = 0.22**

**e = γ * h * $K_a$ ∴**

**$e_1$ = 1.8*2*2.2= 0.80 t/m²**

**$e_2$ = 1.8* 3*.22 = 1.2 t/m²**

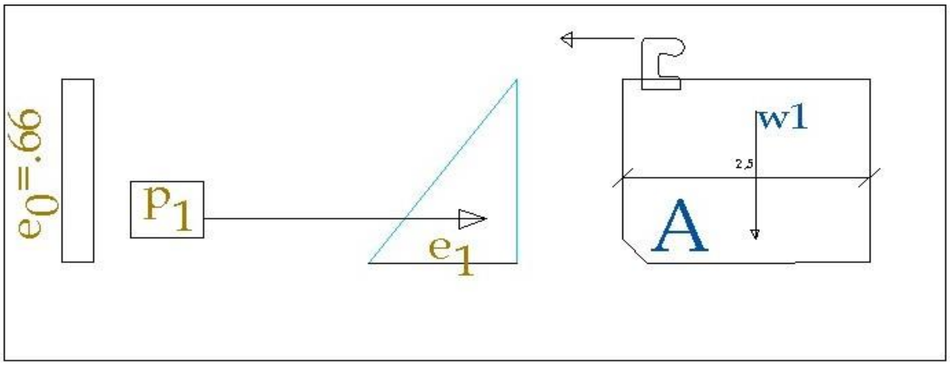
**$e_3$ = 1.5+ 1.1*1.2*.22 =1.5 t/m²**

$e_4$ = 1.5+1.1*1.2*.22 =2.01 t/m$^2$
$e_5$ = 2.01 +1.1*1.2*.22 =2.54 t/m$^2$
$e_6$ = 2.54 + 1.1*1.2*.22 = 3.07t/m$^2$
$e_7$ = 3.07+1.1*1.2*.22= 3.6 t/m$^2$
$e_u$ = 3.00 *0.22 = .66 t/m\

$P_1$ = ½ * .8* 2.00 = 0.8t/m\ ∴
$P_2$ = 0.8 *1 = 0.8 t/m\
$P_3$ = ½ * 1 * ( 1.2 -.8 ) = 02 t/m
$P_4$ = 2.2 *1.20 = 2.64 t/m\
$P_5$ = ½ * 2.2 *(1.5-1.2 ) = 0.33 t/m\
$P_6$ = 2.2 * 1.5 = 3.4t/m\
$P_7$ = ½ * 0.22 *(2.01-1.5 ) = 0.56t/m\
$P_8$ = 2.0 * 2.01 = 4.42 t/m\
$P_9$ = ½ * 2.2 * (2.54 -2.01 ) =0.58t/m\
$P_{10}$ = 2.20 *2.54 = 5.6t/m\
$P_{11}$ = ½ * 2.2 * (3.07-2.4 ) =.583 t/m\
$P_{12}$ = 2.2 * 3.07 =6.14 t/m\
$P_{13}$ = ½ * 2.2 * (3.6 -3.07 ) =.583 t/m
$P_u$ = 3 *.22 =.66 t/m\

# Design Of Block

## Design Of 1st Block




*** Determination of block wdth :-**

$M_o$ = .8 *(2/3 ) +.66*2*1 +1*(.4+2 ) = 6.65 t.m
$M_S$= (b1 *2.2*2 ) *(.5 b1 -.25 ) = 2.2 b1$^2$ -1.1b1
$M_S / M_o$ =1.50. (so,,,,,,, b1 =2.50 m )

* Check Of Sliding :-

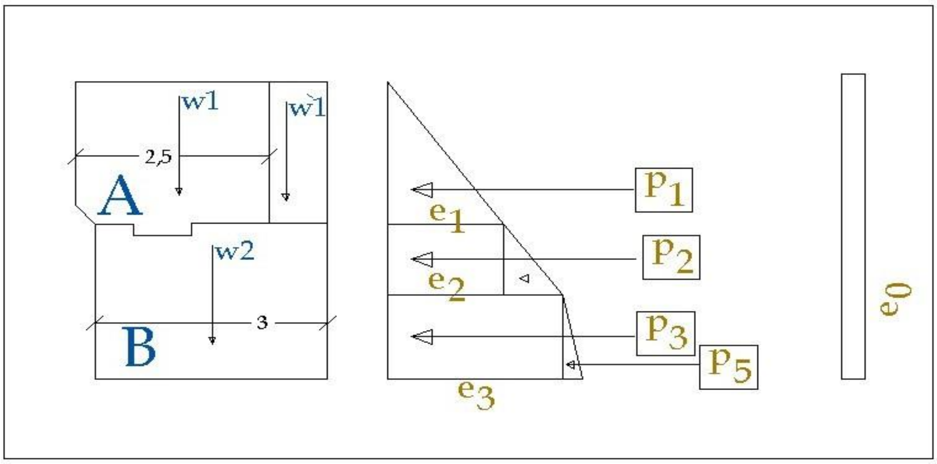
* Stability Force (w) 2.2*2.5 *2= 11t

* Sliding Force = $P_1$ + $P_2$ + $P_3$ + $P_4$ + $P_5$ + $P_{u1}$ + $P_{u2}$ + T
= 4.3 ton

∴ F.O.S. = Stability Force / Sliding Force =11/4.3 =1.76>1.5 (O.K. Safe)

To increase factor of safety against sliding use key

## Design Of 2nd Block




* Sliding :-

* Stability Force (W2=2.5*2.2*2 +1*(b282.2) +1.2*b2*1.2 2*1.8 *(b2-2.25)
=2.9+7.24b 2
* Sliding Force(H) = .5*1.2*3+.66*3 +1+.5*1.2(1.2+1.5)
= 6.4ton

∴ F.O.S. = Stability Force / Sliding Force =.5*W2/6.4
.5*(2.9+7.2b2) /6.4 =1.5

∴( b2 =3 m )

* Check Of Overturning :-

* $M_o$ =1.8*2.2+1.4*.6+.9*(1.2/3) +1*(.4+4.2) =.66*4.4(4.2/2) = 15.61 t.m.

* $M_s$ = (6.6+4.322 ) *1.5 +11*1+.5*1.8*2 =29.18 t.m m.t.

∴ F.O.S. = $M_s$ / $M_s$. = 29.18/15.61 = 1.87 > 1.50

∴ O.K. Safe.

## * Check Of Stresses :-

X = [ ( Stability Moment – Overturning Moment ) / ∑W ]
= [ ( 29.18 – 15.61 ) / 24.6]
= .55 m

e = b/2 - X
= 3/ 2 - .55 = .95 m

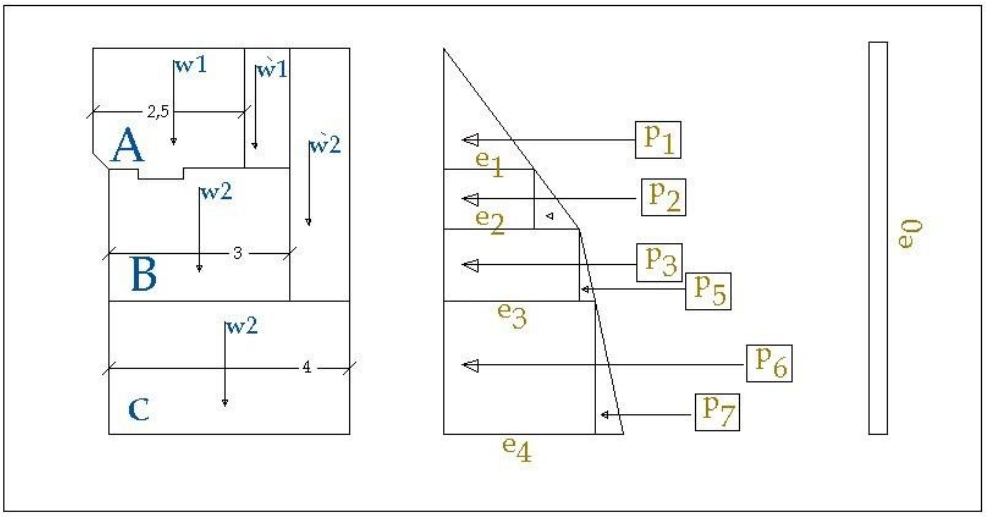
$f^1{}_2$ = - N/A [ 1 ± 6e / b ]

$f_1$ = - 24.6/ (3.0*1.0) [ 1 + 6 * 0.95 / 3.0 ] = -23.8 (comp)t/m$^2$

، $f_2$ = - 24.6/ (3.0*1.0) [ 1 - 6 * 0.95 / 3.0 ] =+ 7.3 t/m$^2$ (tens) <10 t/m$^2$

∴ O.K. Safe.

# Design Of 3rd Block :




## * Sliding :-

* Stability Force (W3) =11+6.6+4.32++1.8+(b-(3))*(1.2*1.1+3*1.8)+b3*1.2*2.2=(3.56+9.36b2).
* Sliding Force(H) = 1.8+1+5.44+4.224 =12.46 t
= 12.64ton

∴ F.O.S. = Stability Force / Sliding Force =.5*W2/12.64

∴( b3=4 m )

## * Check Of Overturning :-

* $M_o$ =1.8*4.4 +1*6.8 +4.22*.5*6.4 +4.08*.5*3.4 +1.36*3.4 /3 =36.7 t.m
* $M_s$ = 11*1+(6.6+4.32)*1.5 +4*2.2*1.2*2 +6.6*3.5 +1.8*2.5 =76.1 t.m

∴ F.O.S. = $M_s$ / $M_s$. = 76.1/36.7 = 2.07> 1.50

∴ O.k .safe

## * Check Of stresses :-

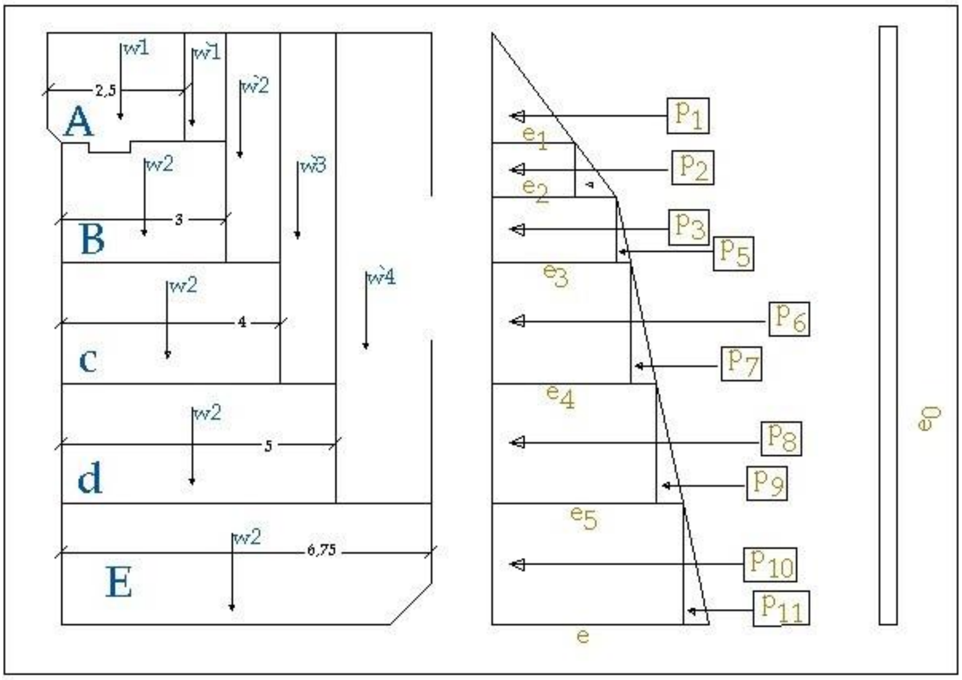
W =41 t

E =2-.96 =1.04 m

$f_1$ = -23.8 (comp)t/m$^2$    $f_2$ =+ 5.7t/m$^2$ (tens) <10 t/

∴ O.K. Safe

# Design Of 4th Block :




*

## Sliding :-

*** Stability Force (W3) = 11+6.6+4.32+10.56+1.8+6.6+b4*2.2*1.2+(b4-4)*(3.4*1.1+1.8*3) =4.32+11.789b4**

*** Sliding Force(H) = 1.8+1+10.47+.66*8.6**

**= 18.95ton**

**∴ F.O.S. = Stability Force / Sliding Force =.5*W2/18.95**

**∴( b4=4.5m )**

## * Check Of Overturning :-

*** $M_o$ = 1.8*6.6+1*8.6+5.67*4.3**

**= 44.86 m.t.**

*** $M_s$ = 76.1+6.6*3.5+4.57*4.25**

**= 122.25 m.t.**

**∴ F.O.S. =. $M_s$ / $M_o$. = 122.25/ 44.86 = 2.73 > 1.50**

**∴ O.K. Safe.**

## * Check Of stresses :-

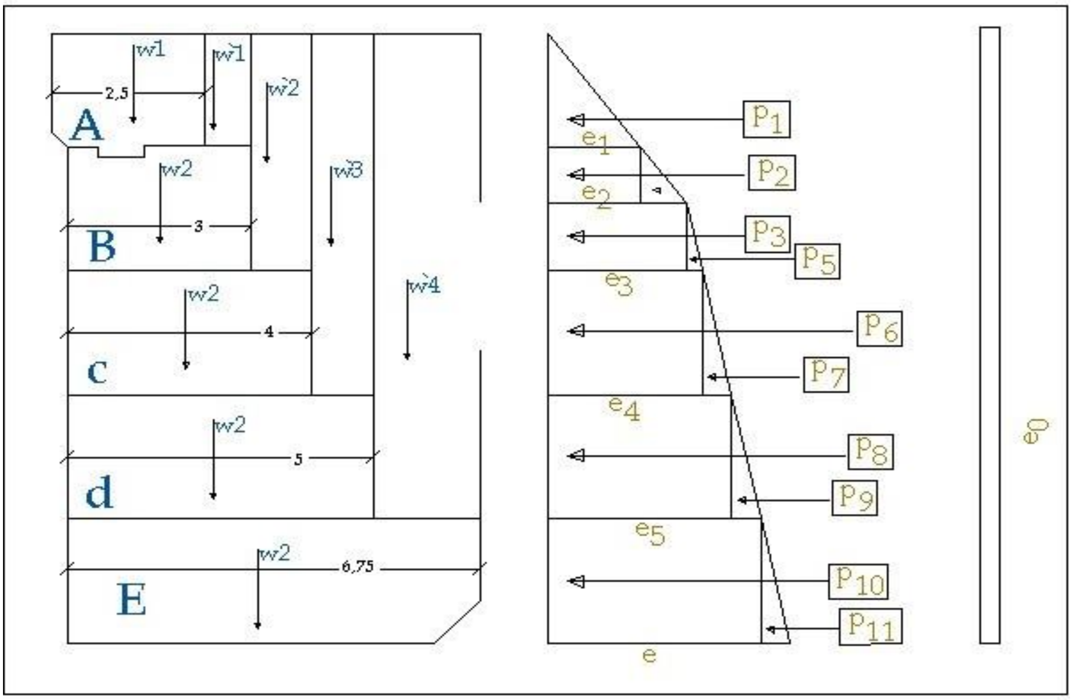
**W =41 t**

**e=2-.96 =1.04 m**

**$f_1$ = -28.1(comp)t/m$^2$ $f_2$ =+ 2.54t/m$^2$ $< 10$ t/m$^2$**

**O.K. Safe**

# Design Of 5th Block :




## * Sliding :-

* Stability Force (W3) = 5.31+ 14.2b5
* Sliding Force(H) = 1.8+.66*10.8+16.38
= 26.31ton

∴ F.O.S. = Stability Force / Sliding Force =.5*W2/26.31 ∴( b5=5m )

## * Check Of Overturning :-

* $M_o$ = 120.28m.t.
* $M_s$= 219.98m.t.

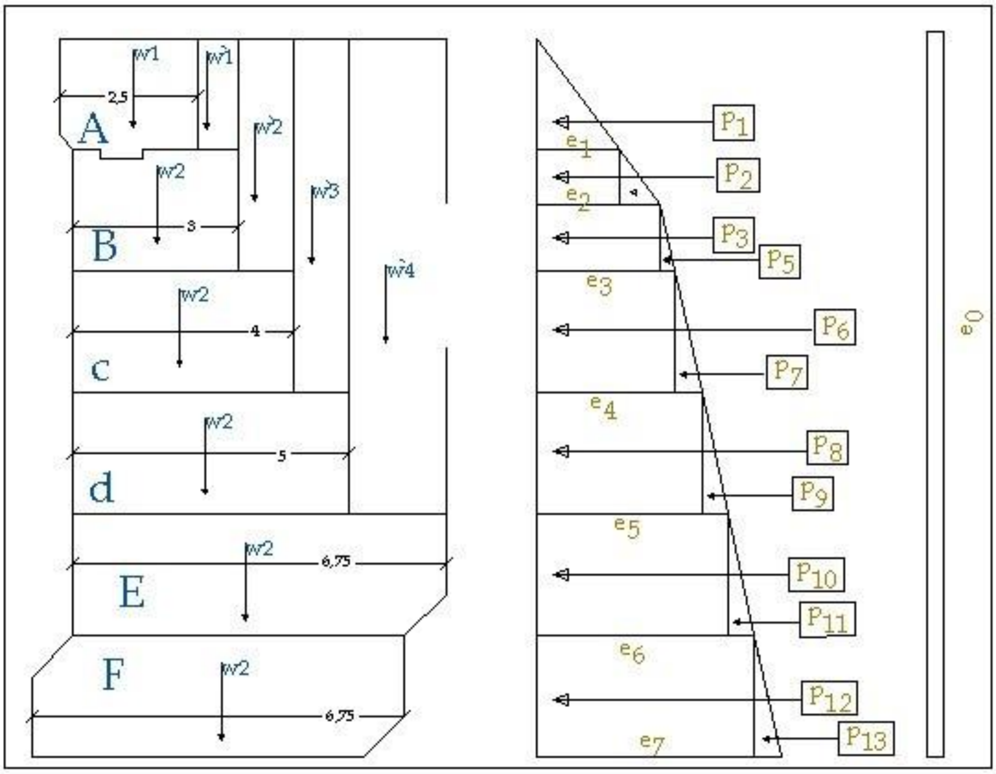
∴ F.O.S. =. $M_s$ / $M_o$. =219.98/120.28 = 1.82 > 1.50

∴ O.K. Safe.

## * Check Of stresses :-

W =41 t
e =2-.96 =1.04
F1 =-28.1(comp)t/m$^2$ F2 =+ 2.54t/m$^2$
O.K

# Design Of 6th Block :




## * Sliding :-

* Stability Force (W3) = 17.01+16.62b6
* Sliding Force(H) = 1.8+1+10.47+.66*8.6
= 18.95ton

∴ F.O.S. = Stability Force / Sliding Force =.5*W2/18.95

∴( b6=7.5m )

## * Check Of Overturning :-

* $M_o$ = 188.97 m.t.
* $M_s$ = 538.53 m.t.

∴ F.O.S. =. $M_s$ / $M_o$. = 538.53 / 188.97= 2.84 > 1.50

∴ O.K. Safe.

## * Check Of stresses :-

**W =131.17 t**

**e =1.08 m**

**$f_1$ = -32.6(comp)t/m$^2$**  **$f_2$ =- 2.37 t/m$^2$**

**∴ f > q**

**∴ unSafe.**

**Where :**

**q = Safe bearing Capacity Of Soil**

**so we need to change dimension of blocks (5) & (6)as shown :**

**$M_x'$ =124.6-131.17=26.23t.m**

**e1= 26.23/131.17 =.2**

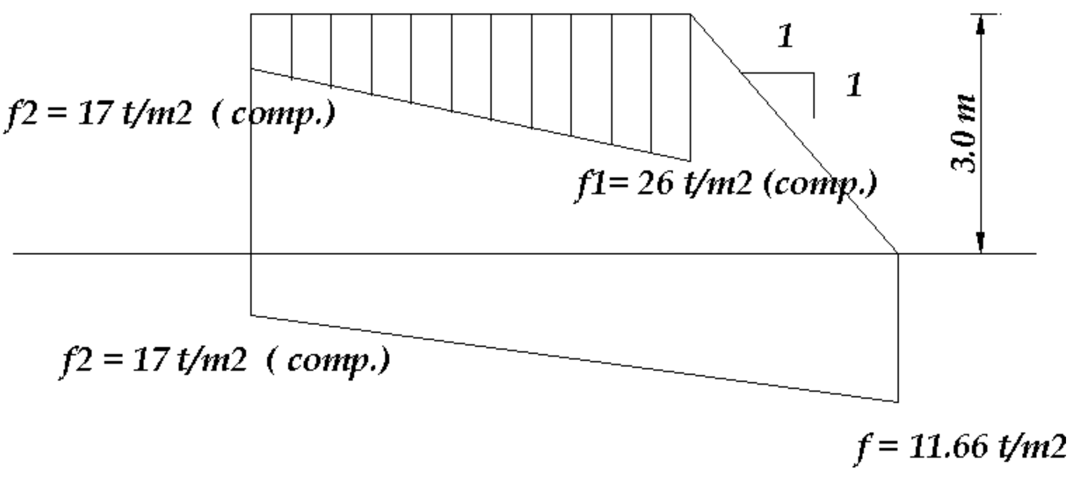
**$f_1$ = -26(comp)t/m$^2$**  **$f_2$ =- 17 t/m$^2$**

**check shear at section (V-V):**

**w=12.9t**  **q=1.5*(12.9/2.2) =8.8t/m$^2$**

**Ckeck stresses on soil :**

*bearing capacity = 15 t/m2*




**(16+17)*6/2=(f+17)*9/2**  **f=11.66 t/m$^2$**

**$F_{max}$=11.66+3*1.1=14.9 <15 safe**

**If using d =3.50m**

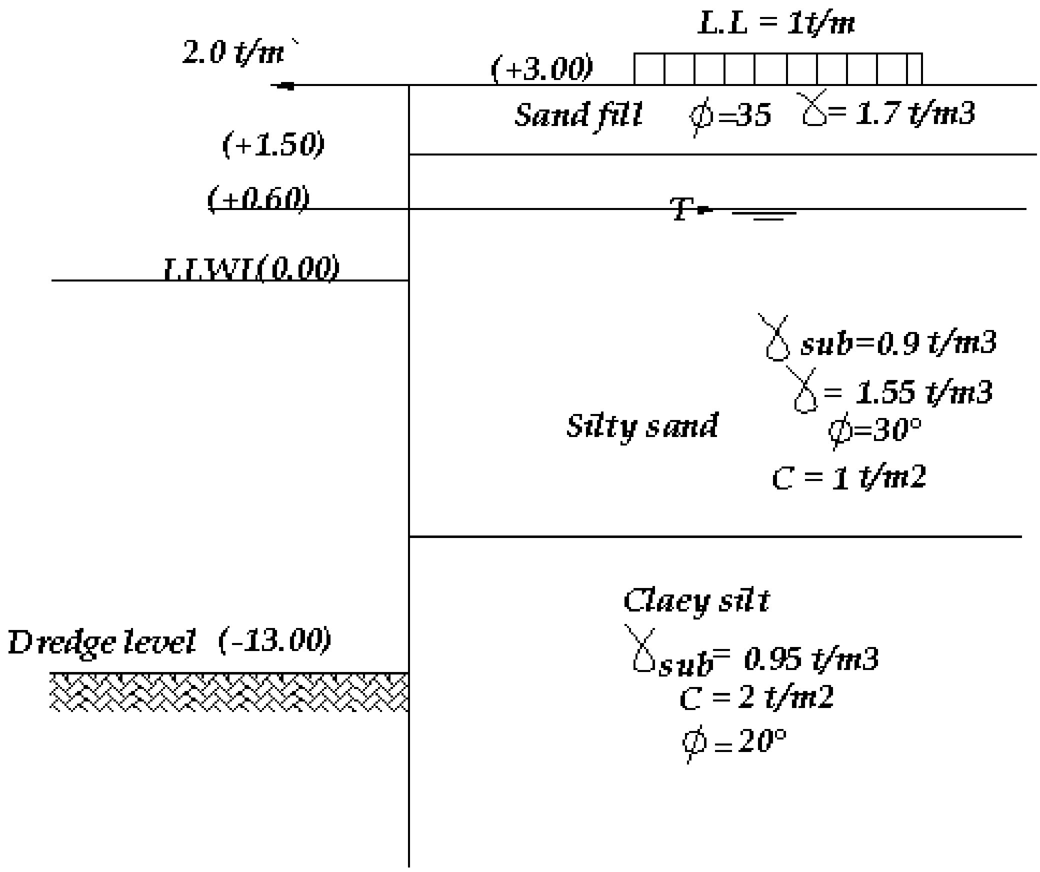
## * determination of blocks lenghths:-

*** Width of largest block =6.75 m**
**Height =2.2 m**
**Wench capacity =150t**
**150 =6.75 * 2.2*2.20*L**
**$L_{max}$=6.20 m**
**Total length of the quay =620 m**
**The quay consists of 31 celles (20m width each )**
**Details of Block type wall shown in the drawings.**

# Design of anchored steel sheet pile quay wall for passenger berth

**Data:**
**Tension on bollard:**
**Assume used 4bollard**
**T=158/4=39.5t**
t/m\`=39.5/20=1.97≈2.0t/m\`

**Soil profile:**
**We will used sand fill from level (+3.00)to(+1.50)**




**Assume penetration depth =7.0m**

* for active earth pressure at $\Phi = 35^\circ$

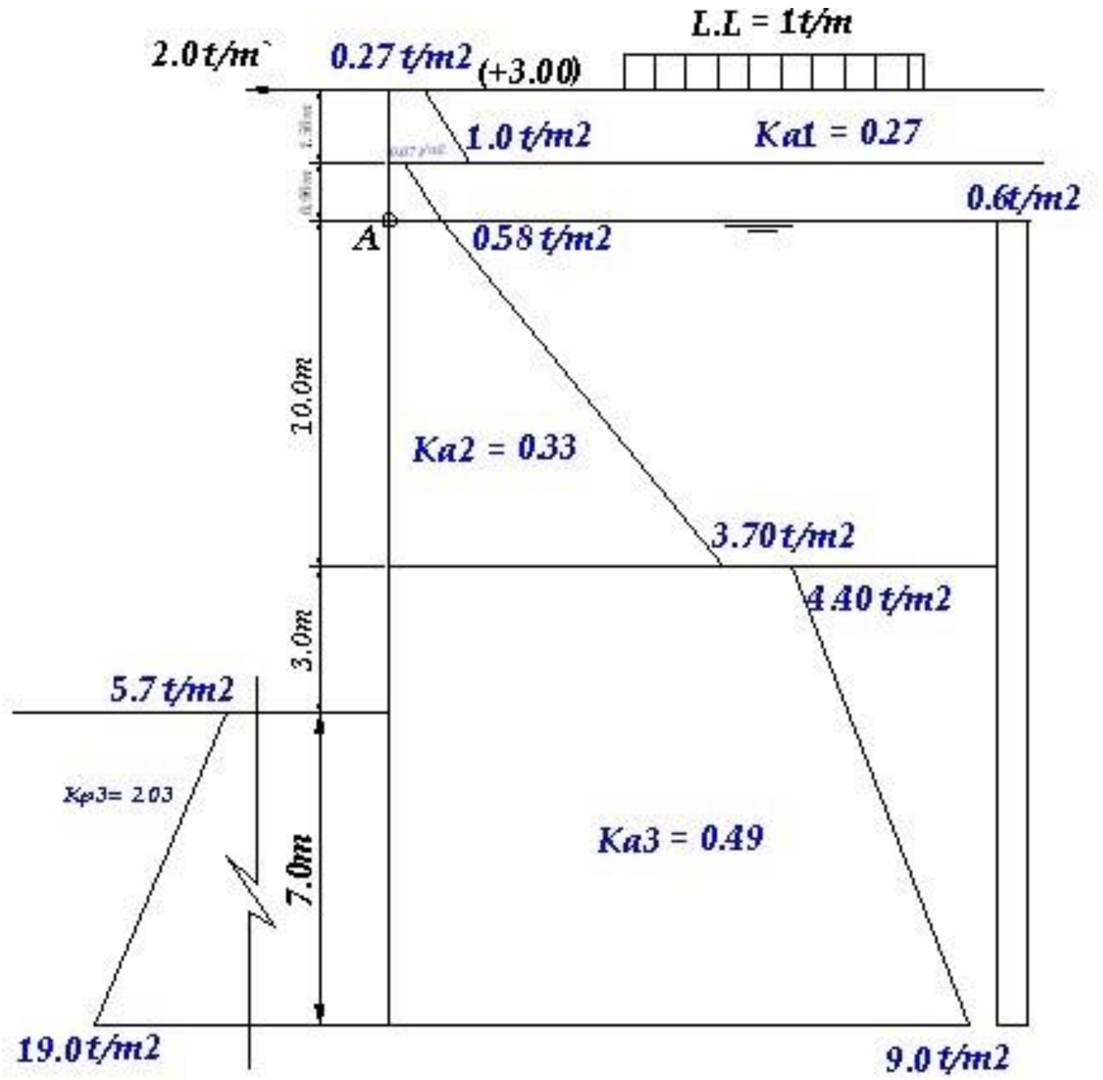
∴ $K_a = (1 - \sin 35^\circ) / (1 + \sin 35^\circ) = 0.27$

* for active earth pressure at $\Phi = 30^\circ$

∴ $K_a = (1 - \sin 30^\circ) / (1 + \sin 30^\circ) = 0.33$

* for active earth pressure at $\Phi = 20^\circ$

∴ $K_a = (1 - \sin 20^\circ) / (1 + \sin 20^\circ) = 0.49$




$e_{a1}$ =1.0*0.27=0.27t/m$^2$
$e_{a2}$ =1.8*1.5*0.27+0.27=1.0t/m$^2$
$e_{a3}$ =1.8*1.5*0.33+0.33-2*1*(0.33)$^{0.5}$=0.07t/m$^2$
$e_{a4}$ =(1.8*1.5+1.55*0.9)*.0.33+0.33-2*1.0*(.33)$^{0.5}$=0.53t/m$^2$
$e_{a5}$ =(1.8*1.5+0.9*10.6+1.55*0.9)*0.33+0.33-2*1*(0.33)$^{0.}$5=3.70t/m$^2$
$e_{a6}$ =13.64*0.49+1.0*0.49-2*2*(0.49)$^{0.5}$ =4.40t/m$^2$
$e_{a7}$ =(13.64+0.95*10)*0.49+0.49-2*2*(0.49)$^{0.5}$ =9.0t/m$^2$
$e_{p8}$ =2*2*(2.03)$^{0.5}$ =5.66t/m$^2$
$e_{p9}$ =5.66+0.95*7.0*2.0=19.0t/m$^2$

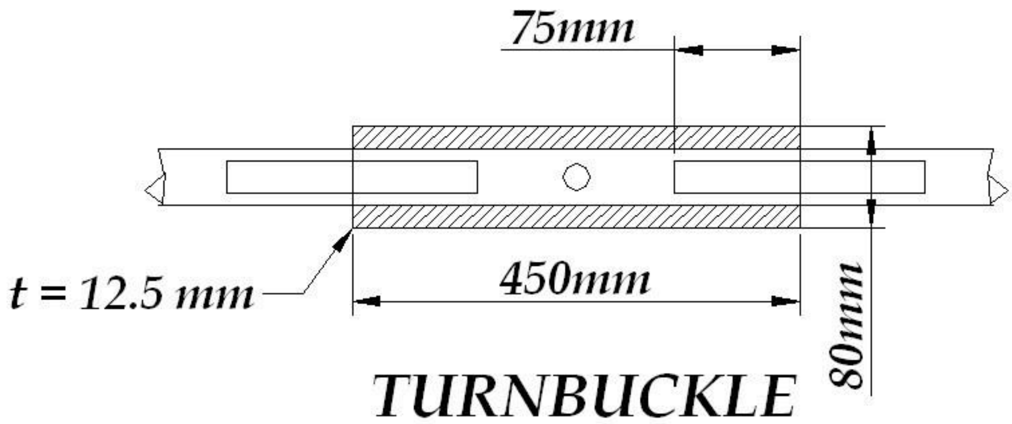
| FORCE | ARM |
| --- | --- |
| E1=0.27*1.5=0.405T | 1.65 |
| E2=0.73*0.5*1.5=0.55T | 1.4 |
| E3=0.07*0.9=0.06T | 0.45 |
| E4=0.46*0.5*0.9=0.207T | 0.3 |
| E5=10.6*0.53=5.62T | 5.3 |
| E6=3.17*0.5*10.6=16.8T | 7.07 |
| E7=4.4*10=44T | 15.6 |
| E8=4.6*0.5*10=23T | 17.27 |
| E9=0.6*20.6=12.36T | 10.3 |
| E10=5.66*7.0=39.62T | 17.1 |
| E11=0.5*13.34*7.0=46.7 | 18.3 |

**M@A:**
**Ma=1365.8m.t**
**Mp=1532.12m.t** **Mp>Ma**
**The penetration depth safe**
∑h=0.0 T=19.0t/m`

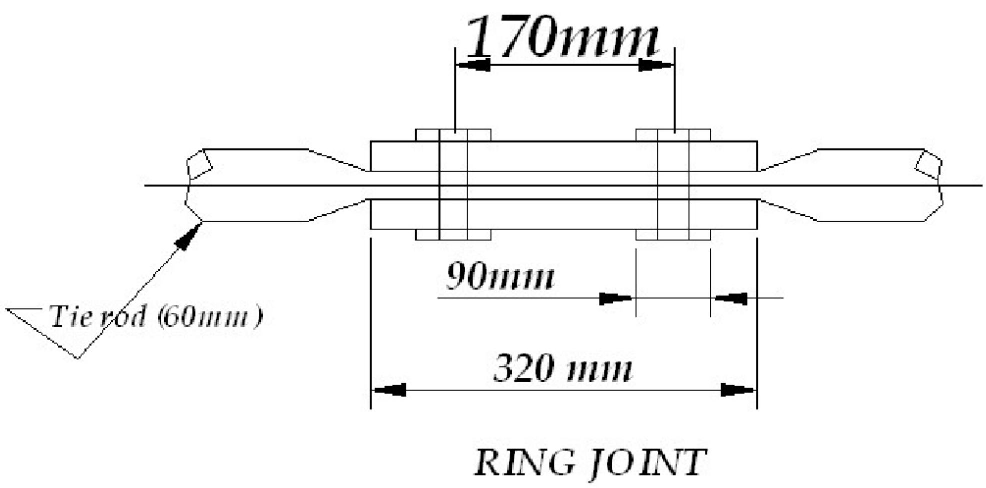
**Point of zero shear at depth from tie location h=4.5m**
**Mmax=0405*6.15+0.55*5.9+0.06*4.95+0.207*4.8+2.385*2.25+3*1.5=18 m.t**
**Require section modules:**
**Z=18*10$^5$/1600=112.5cm$^3$**
**Used larceny type beam (spacing between ties =2.0)**
**Mmax=tl$^2$/10=19*2$^2$/10=7.60m.t**
**Z=7.6*10$^5$/1600=775cm$^2$**

**Choose 2 channel No300**
**Design of rod :**
**Ftie = T*L=2*19.0=38T**
**A=38*1000/1500=25.3CM$^2$**
**Used tie rod 60mm**

**Dimension of (TURNBUCKLE)location at mid span of length**

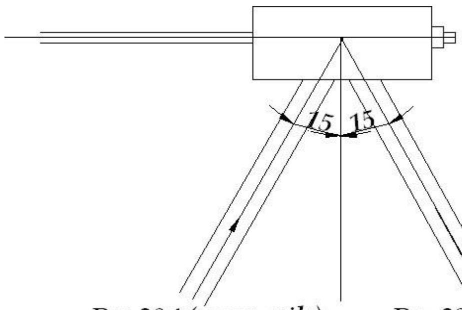



**Design of ring joints:**



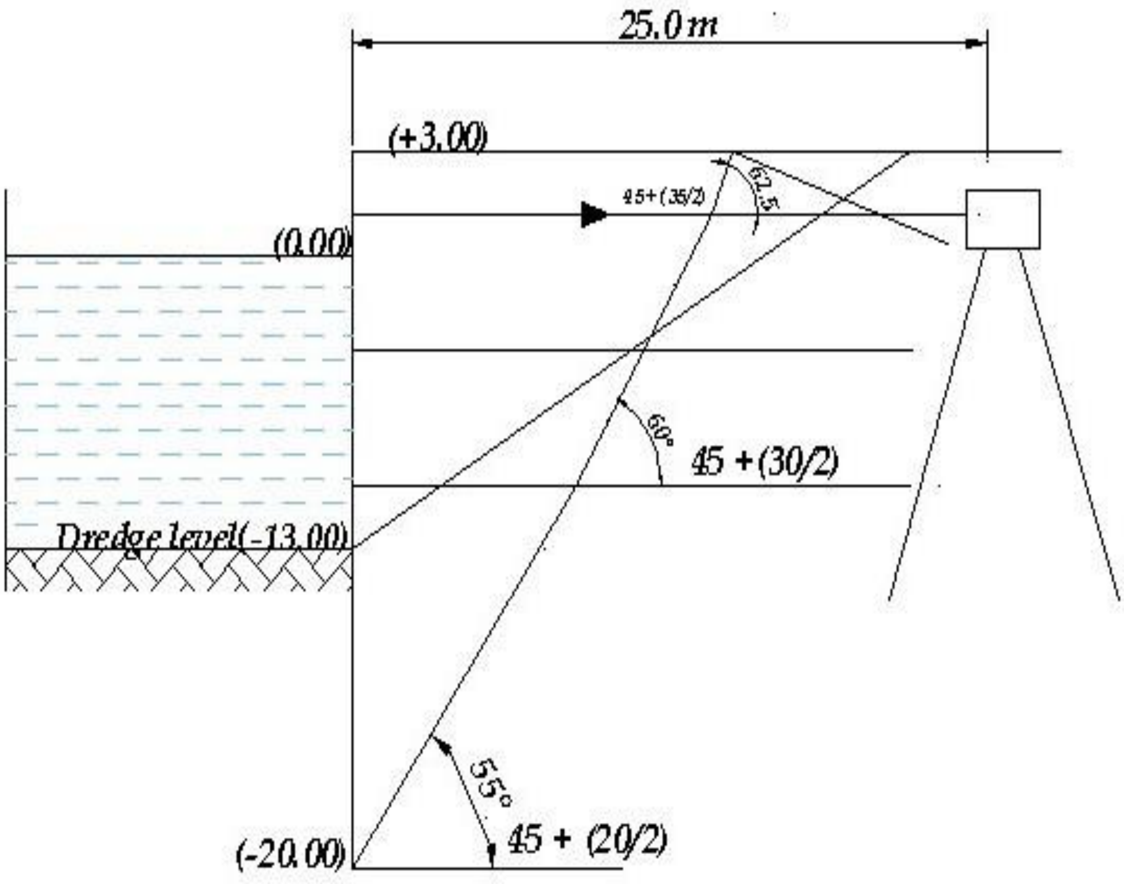
## design of anchorage system:

**Using rakked piles:**




**Force on the tie =19.0t**
**19=2*sin15*p**
**P=38.0t**
**Estimation of pile bearing capacity for layer (silty sand)**
**Friction : Pv(average)=13.0t/m$^2$**
**Kt=0.67 for driven pile**
**Tan Ø=0.41**
**Cu=10KN/m$^2$**
**Fs=1*10+0.67*130*0.41=45.7 KN/m$^2$**
**Qs=45.7*3.14*0.5*10=717.85KN**
**For layer (2)clay silt**
**Pv`=18t/m$^2$**
**Tan Ø=0.26 Kt=0.5**
**Fs=43.4 KN/m$^2$**
**Qs=136.35 KN/m$^2$**
**Qs(all)=853.85/2=426.9KN=42.6t**
**Pile length =12.0m (driven) D=50cm**

## Anchorage position



# DESIGN OF COUNTER FORT RETAINING WALL FOR FISHING&SERVICES BERTH

**DATA:**

**Size of units = 40*7*3.7**

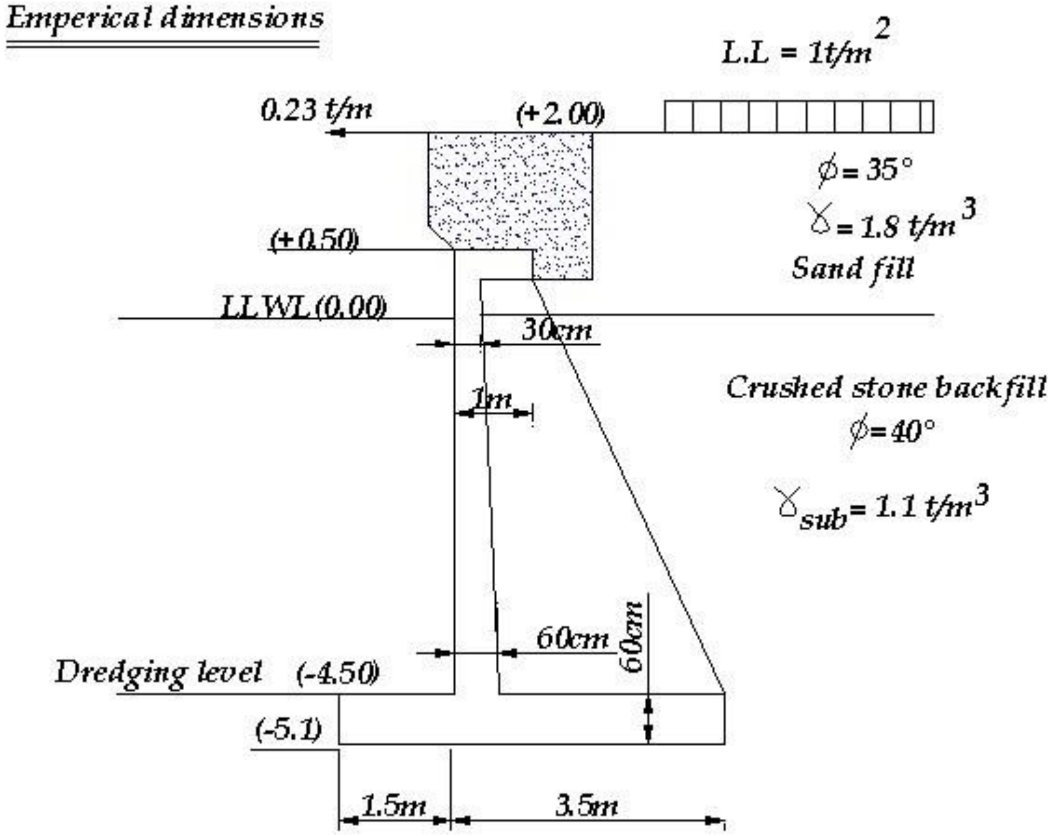
**Pw = 1.5*A*.0065*$v^2$ A=3.7*40=148$m^2$**

**V=90km/hr**

**Pw= 10.7t Pw=10.7/40=0.267t/m**

**H=0.267*cos30=0.23t/m**

**Uniform live load =1.0t/m**



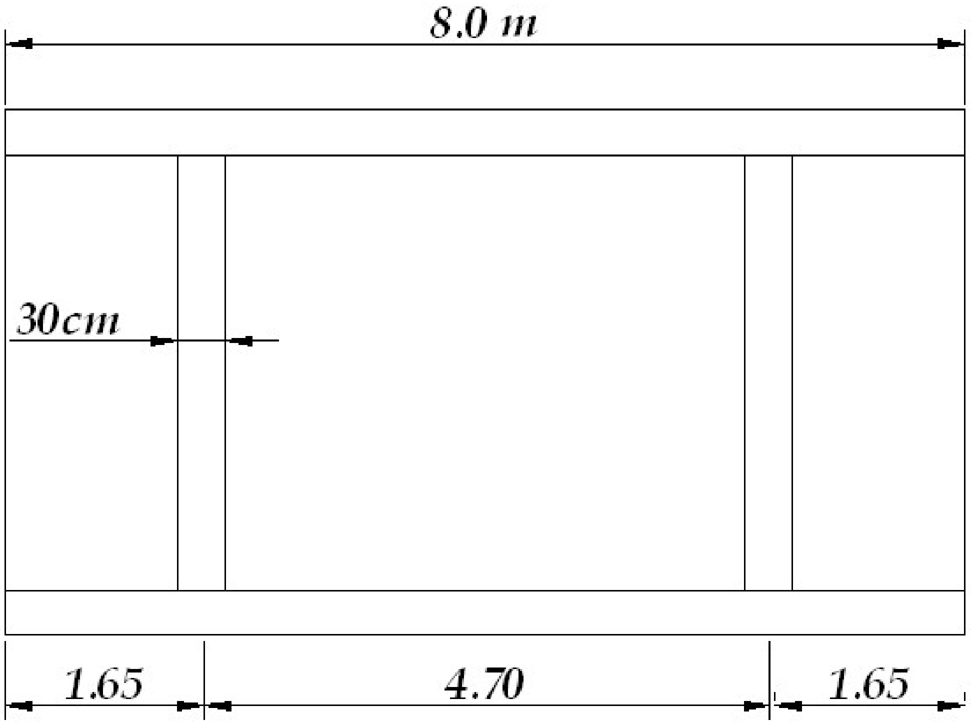
## Determination of precast part dimension :

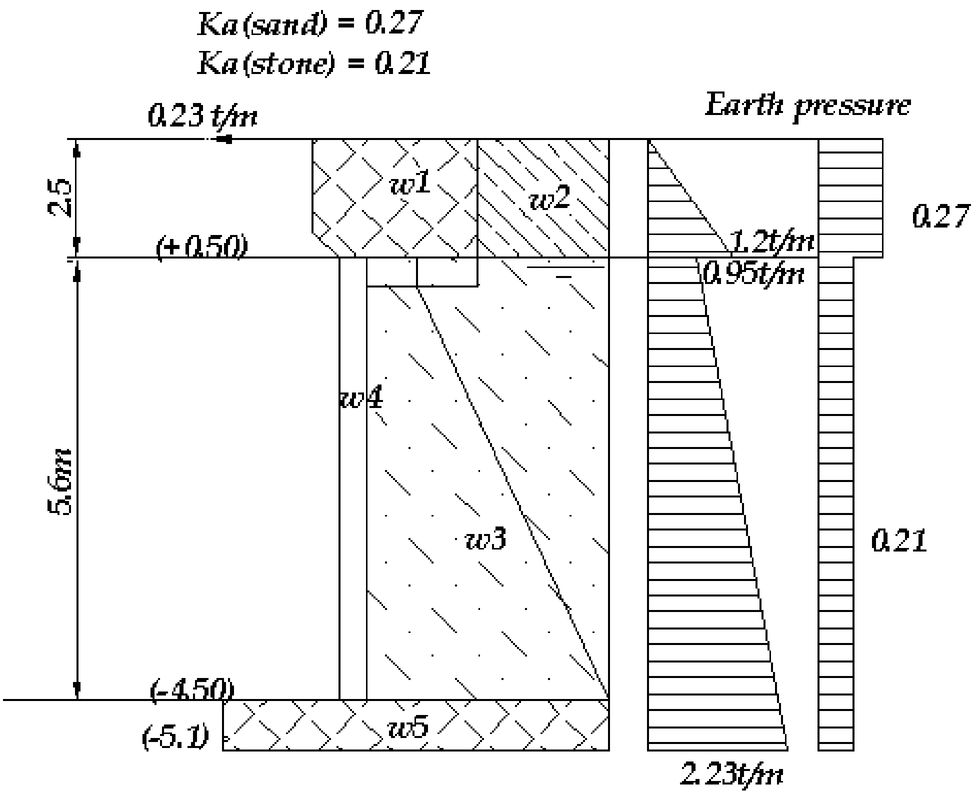
**Wench capacity =100t**

**W/m= 2.5*(0.6*5+0.45*5+0.7*.3)+(n/L)*0.5*(.7+2.9)*0.3*2.5=10.84+1.35**

**W=10.84L+1.35*n assume n=2**

**L=8.00m**






Width of cap :

**Ms=(2.2*2.5*b)(0.5b-0.25)**

**Mo=0.23*2.5+(0.5*1.2*2.5*2.5/3)**

**$2.75b^2$-1.375b-4=0.0**

**b =1.5m**

**Check stability of the wall:**

| Force | ARM |
|---|---|
| W1=2.5*2.5*1.5=8.25T | 2.25 |
| W2=1.8*2*2.5=9T | 3 |
| W3=1.1*5.0*2.9=3.85T | 3.85 |
| W4=1.5*5.0*0.45=3.40T | 1.7 |
| W5=1.5*5.0*0.6=4.5T | 2.5 |
| ∑W=41.10T | |

| Force | ARM |
|---|---|
| E1=0.5*1.2*2.5=1.5T | 6.43 |
| E2=0.27*2.5=0.675T | 6.85 |
| E3=0.21*5.6=1.18T | 2.8 |
| E4=0.95*5.6=5.32T | 2.8 |
| E5=1.28*0.5*5.6=3.58T | 1.86 |
| E6=0.23T | 8.1 |
| ∑E=12.5T | |

**Check sliding :**

**F.S = 0.4*41.1/12.5 = 1.3>1.25(safe)**

**Check overturning :**

**F.S= MS/MO=124/41.27= 3.0>1.5 (safe)**

**Check stresses :**

**Mnet = 124-41.27=82.73m.t '**

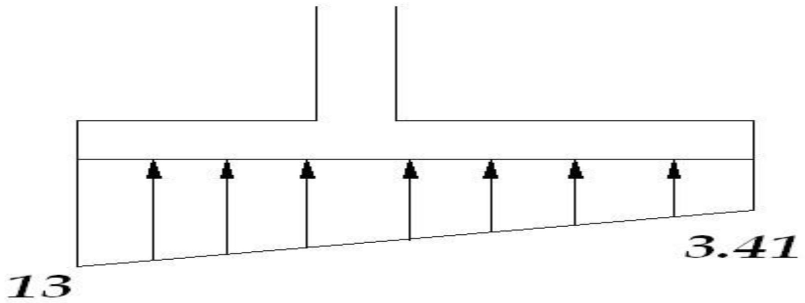
**X=(82.73/41.1)=2.01m**

**E=2.2-2.01=0.487m<(b/6) safe**

**F=-41.1/5.0(1±(6*0.487/5))**

**F1=-13.0 t/m$^2$**

**F2=-3.41 t/m$^2$**



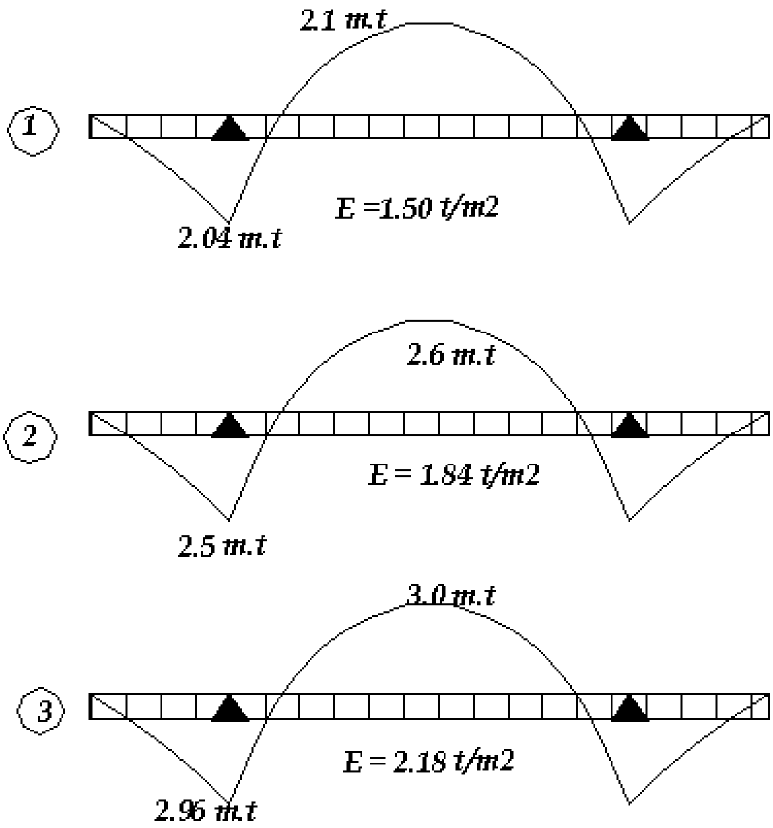

**Design of structure members of wall**

**Stem section**

**E@1.5m = 0.95+0.21+0.34 =1.5t/m$^2$**

**E@3.0m= 1.84 t/m$^2$**

**E@6.0m= 2.18 t/m$^2$**




**Design of section** :

**Check crack :**

**for M=3.0m.t** $t = 6M/bt^2 = 6*3*10^7/1000*600^2 = 0.5 < 1.93 N/mm^2$

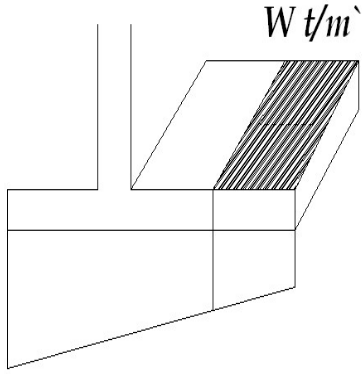
$As1 = M/K_2*d = 2.1*10^5/1100*30 = 6.36 cm^2$

$As1 = M/K_2*d = 2.5*10^5/1100*30 = 7.57 cm^2$

$As1 = M/K_2*d = 3.0*10^5/1100*30 = 8.96 cm^2$

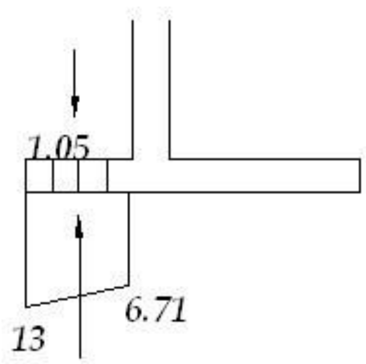
**Use 5Ø16/m`**

**Design of heel section**




**W=5*1.1+2.5*1.8+0.6*1.5+1.0=11.90t/m`**
**Pnet=11.90-3.41=8.51t/m`**
**M+ve=8.51*$1.65^2$/2=11.57m.t**
**M+ve=8.51*$4.70^2$/2=11.9m.t**
**D=$(11.9*10^5/300)^{0.5}$=62.98cm**
**65=k1$(11.9*10^5/100)^{0.5}$ k1=0.59 k2= 1100**
**As = 16.65$cm^2$ use 6 Ø 20 /m`**

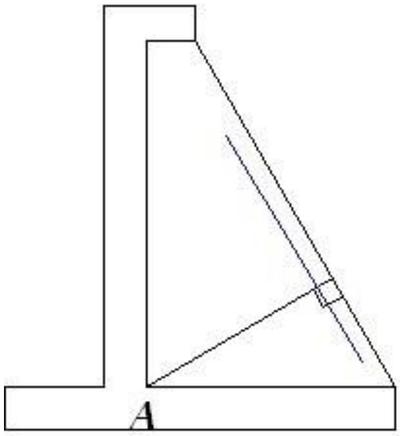
**Design of toe:**




**W net = (0.5*19.71)-(1.05)=8.82t/m`**
**d=$(12*10^5/300)^{0.5}$=63.24**
**T=70cm**
**As= $(12*10^5)$/(65*1100)=16.78$cm^2$**
**Use 6Ø20/m`**

**Design of counterfort :**

**Take moment @A**




**Ma=42.27m.t/m`**

**Ma=41.27*(4.7/2+1.65)=165.08m.t**

**r 1=2.7m**

**d1=15cm**

**Ta=165.08/(2.7-0.15)=64.7t**

**As=64.7/1.2=53.9cm$^2$ used As = 8Ø25**

**Horizontal steel:**

**Eh=2.18*4=8.72t**

**As=8.72/1.2=7.26cm$^2$**

**Used 6Ø12/m` each side**

**Vertical steel :**

**V=8.32*4=33.28t**

**As= (33.28/1.2)=27.7cm$^2$**

**Used 6Ø18/m` each side**

# Design of cellular type wall for container berth

## DATA

* Surcharge Loads = 6 t/m`
* Tention On Bollard ( Pw ) = $270*12*0.0065*90^2$ = 170.7ton

Let using 4 bolord

T = 85.3 /4 N= 42.64 ton .

T /m` =42.64/20=2.5 T /m`

* Depth Of Water = 12+ 1.0 = 10.0 m
* Tidal Range ( T.R. ) = 1.17 m

▼ Crest =3.00m∴

Total Depth Of Berth = 10.0 + 3 = 13.00 m

* for active earth pressure at $\Phi = 35^\circ$

∴ $K_a$ = $( 1 - \sin 35^\circ ) / ( 1 + \sin 35^\circ )$ = 0.27

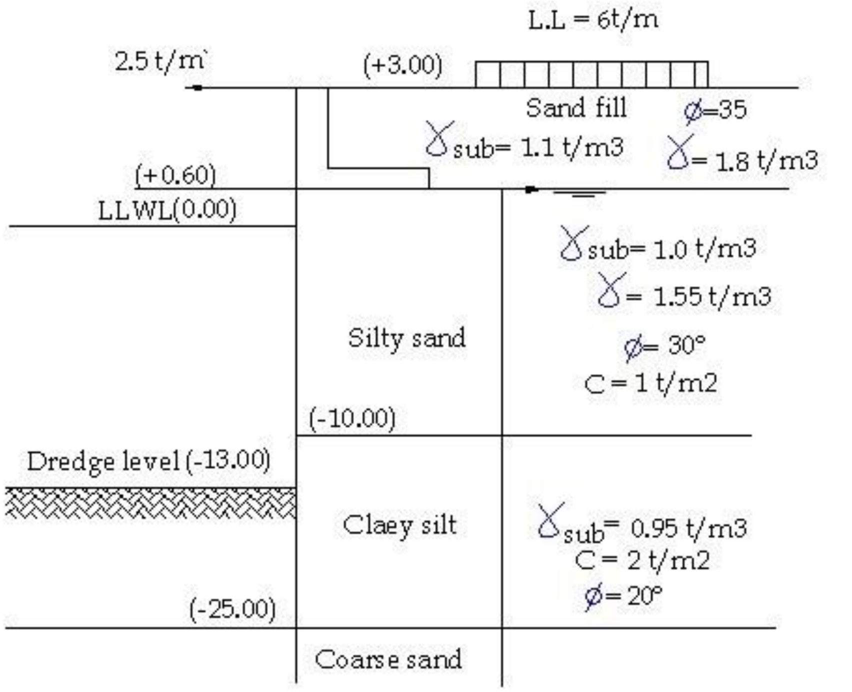
* for active earth pressure at $\Phi = 30^\circ$

∴ $K_a$ = $( 1 - \sin 30^\circ ) / ( 1 + \sin 30^\circ )$ = 0.33

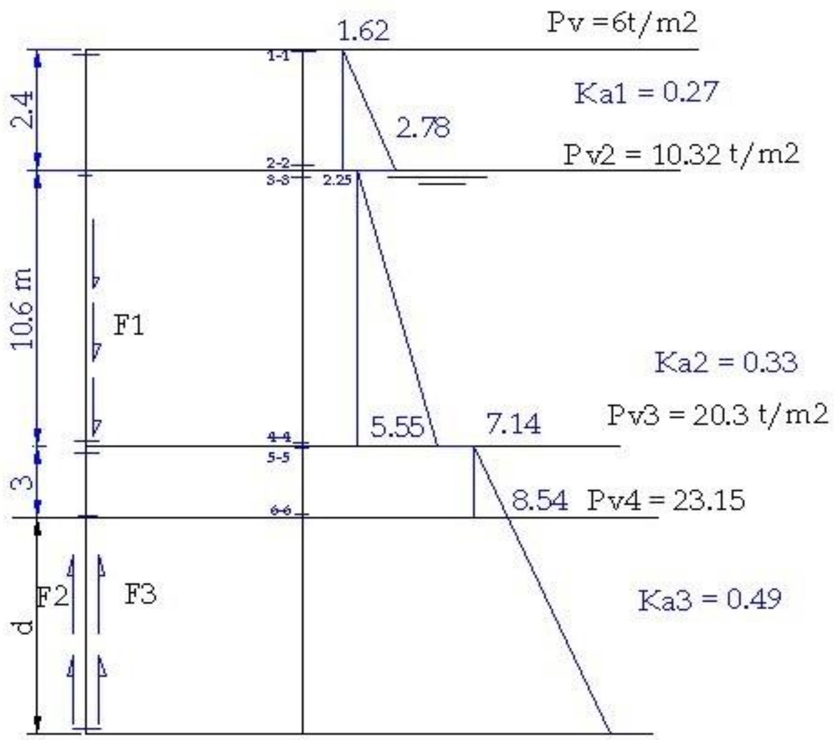
* for active earth pressure at $\Phi = 20^\circ$

∴ $K_a$ = $( 1 - \sin 20^\circ ) / ( 1 + \sin 20^\circ )$ = 0.49

# SOIL PROFILE




PENETRATION DEPTH:



$e_a = \sum \gamma H k_a + q k_a - 2c(k_a)^{1/2}$

$e_{a1} = 6*0.27 = 1.62/m^2$

$e_{a2} = 6*0.27+1.80*2.4*0.27 = 2.786 t/m^2$

$e_{a3} = 6*0.33+1.80*2.4*0.33-2*1*(0.33)^{1/2} = 2.25 t/m^2$

$e_{a4} = 6*0.33+(1.80*2.4+1*10.6)*0.33-2*1*(0.33)^{1/2} = 5.55 t/m^2$

$e_{a5} = 6*0.49+(1.80*2.4+1*10.6)*0.49-2*1*(0.49)^{1/2} = 7.14 t/m^2$

$e_{a5} = 6*0.49+(1.80*2.4+1*10.6+0.95*3)*0.49-2*1*(0.49)^{1/2} = 8.54 t/m^2$

E1=2.25*10.6=23.85t
E2=.5*10.6*3.3=17.50t
E3=7.14*3=21.4t
E4=.5*1.4*3=2.1t
$\sum$E=64.85t
Sin(2*30/3)=0.34
F1=64.85*0.34=22.05t/m`
F2=(2/3)*C*D =F3
F2+F3>F1
(4/3)*2.0*d=22.05
Get d=8.00m

The cells will penetrate the coarse sand layer (having adequate bearing capacity than clay silt )

Assume R=16.0m B= 1.92R=30.72m

CHECK SLIDING :

Active earth pressure :

E1= 1.62*2.4=3.88t

E2=0.5*1.16*2.4=1.35t

E3=2.25*10.6=23.85t

E4=0.5*3.3*10.6=17.5t

E5=7.14*11.5=82.11t

E6=8.36*0.5*11.5=48t

E9=0.6*(10.6+3+8)=13.0t

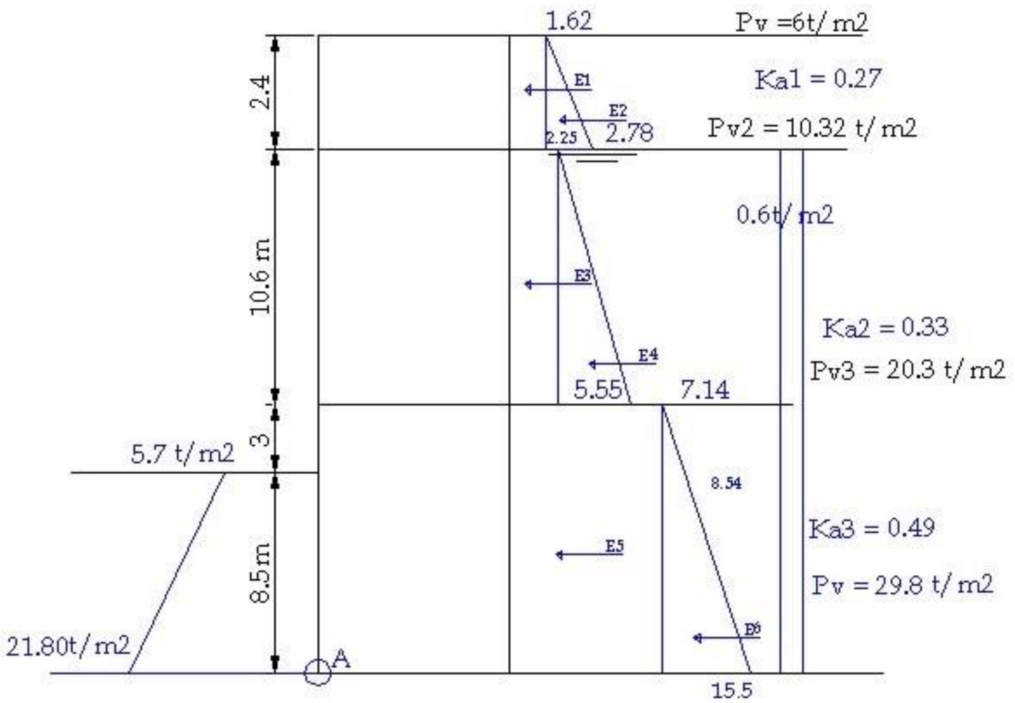
∑Ea=189.70t

Passive earth pressure :

E1=5.7*8.5=48.45t

E2=21.8*0.5*8.5=92.65t

∑Ep=141.1t




F=(1.8*2.4+0.9*10.60+0.95*11.5)*30.72*Tan20 =245t

F.S= ($E_P$+F)/$E_A$=3.0>1.50 (Safe)

<u>Check overturning:</u>

Mo@A=1258 m.t
Pf = (tan(2/3)*30)*75.5+(2/3)*2*2*8=76.3m.t
Ms=Pf*B=76.3*1.92*16=2343.7m.t
F.S=1.86>1.25 (SAFE)

DETERMINATION OF SHEET PILE SECTION:
Eat (0.75Hs)=5.55t/m2
Tmax=γ*0.75*Hc*ka*L=88.8
t=Tmax/qall(steel)
t=(88.8/1.6)/100=0.55cm=5.5mm
take f.s =1.50

t=10+2=12mm

CHECK OF ROLLING:
Mr=2*f*B
F=∑E*tan(2Ø/3)+c*h
F=48.6*tan20+2*24=65.68
Mr=2*65.68*30.72=4036t
F.O.S=Mr/Mo=4036/1258=3.2

<u>DESIGN SUMMARY:</u>
Using drum type wall:
R=16m
L=r=16m
B=30.72m
Penetration depth =8.0m

# Chapter (7)
# Slipway

## 7.1. Introduction

A slipway, also known as a marine railway or boat ramp, is a structure specifically designed for the launching and hauling out of boats and ships. Slipways play a vital role in maritime operations, particularly in areas where there is a need for vessel maintenance, repair, or construction. Here are some key points to consider when discussing slipways:

1. Functionality: Slipways are designed to provide a gradual and controlled slope into the water, allowing boats and ships to be launched or hauled out of the water. They enable easy access to vessels for maintenance, repair, inspection, painting, or other work that requires the vessel to be out of the water. Slipways are especially useful for smaller craft and recreational boats, as well as for the construction or repair of larger vessels.
2. Slipway Design: Slipways typically consist of a reinforced concrete or metal ramp leading from the shore into the water. The slope and dimensions of the slipway are carefully designed to accommodate the size and weight of the vessels using the facility. The angle of the slipway, known as the "inclination," allows for a controlled descent or ascent of vessels. Slipways may also include additional structures such as rails, cradles, or trailers to support and guide vessels during the launching or hauling out process.
3. Launching and Hauling Out: The slipway enables vessels to be launched into the water or hauled out onto dry land. Launching involves sliding the vessel down the slipway and into the water, usually with the assistance of gravity or a launching mechanism. Hauling out is the process of pulling a vessel up the slipway and onto land for maintenance or repair work. This is typically achieved using winches, cables, or hydraulic systems.
4. Slipway Maintenance and Safety: Slipways require regular maintenance to ensure their structural integrity and safe operation. This includes inspections, repairs, and upkeep of the launching surfaces, rails, supports, and associated equipment. Safety measures such as non-slip surfaces, fendering systems, and proper signage are essential to prevent accidents and protect workers during vessel launching and hauling out operations.
5. Slipways in Shipbuilding and Repair Yards: Slipways are commonly found in shipbuilding and repair yards where vessels are constructed or undergo major maintenance and overhaul. These facilities often

have multiple slipways of varying sizes and capacities to accommodate different types of vessels. Slipways may also be equipped with cranes, workshops, and other facilities to support the construction and repair processes.

6. Recreational Slipways: Slipways are also utilized in recreational boating areas to provide access for small boats and personal watercraft. These slipways may be located in marinas, yacht clubs, or public boat ramps, allowing boat owners to easily launch and retrieve their vessels for recreational use.
7. Environmental Considerations: Slipways need to be designed and operated with environmental considerations in mind. Measures such as proper stormwater management, sediment control, and pollution prevention are important to minimize the impact on water quality and marine ecosystems.

In summary, slipways are specialized structures used for launching and hauling out boats and ships. They facilitate vessel maintenance, repair, and construction activities. Slipways are designed to ensure safe and controlled access to the water, and their maintenance and operation are essential to ensure their continued functionality and safety.

## 7.2. Calculations

### Design of slipway for fishing unit

Ship dimension: 40*7.0*3.7

Width =2Bship +2*5=24m

Length =L1+L2+L3

L1=Lship+5.0=45.0m

L2=d*slope

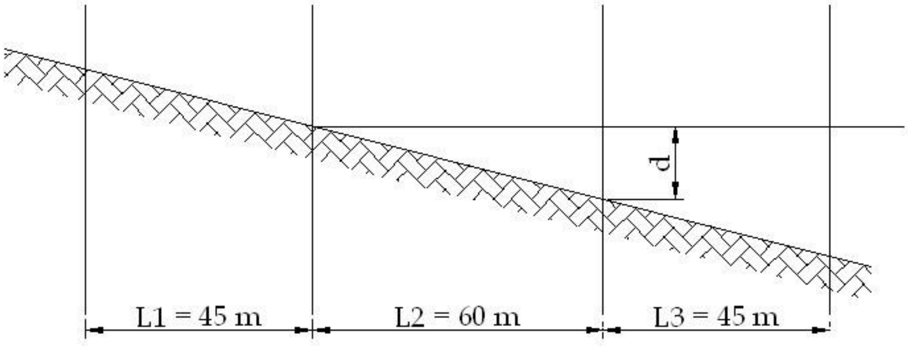
d =draft+tidal range +cradle height(0.75-1.0m)

d=3.70+1.17*1.0=6.0m

L2=6*10=60.0m (slope1:10)

L3=L1=45.0m

Total length=45+60+45=150m




## Loads:

W=L*B*d*C*1.025

W=40*7*3.5*0.65*1.025=690.0T

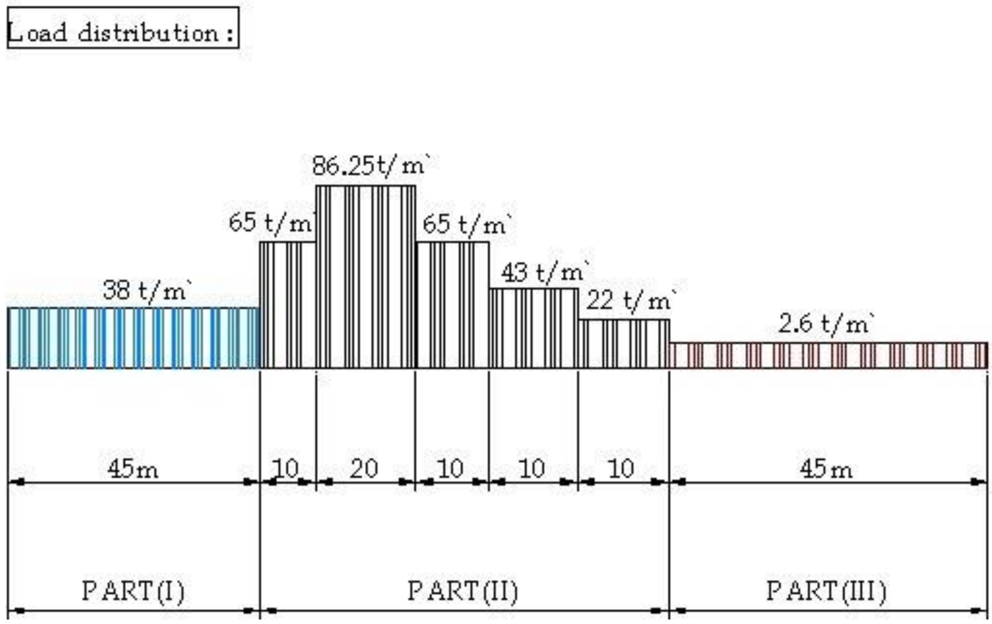
C=bulk coefficient

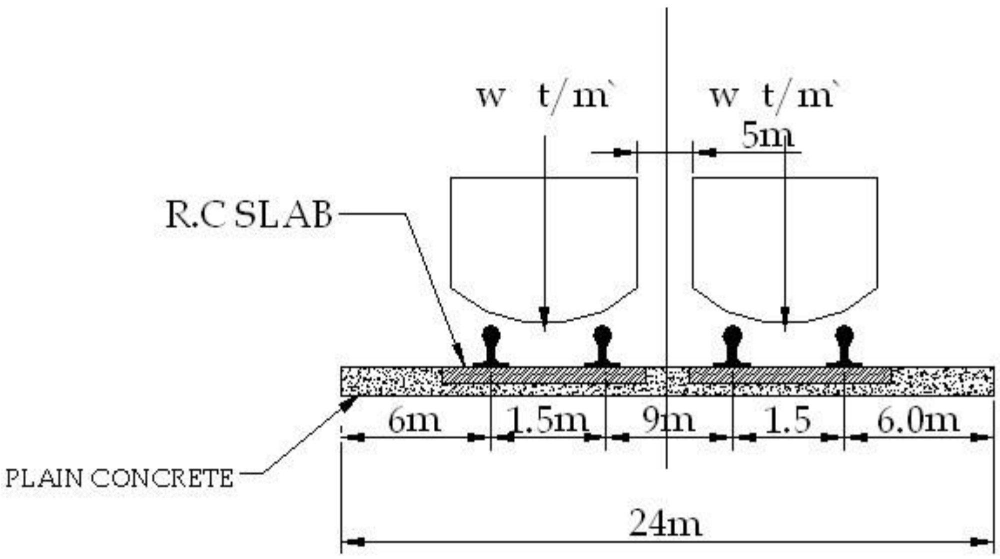
W>500T take W=W/8=86.25t

W`=(weight of cradle/length of cradle)=(0.1Wship/(2/3)Lship

=0.1*690/((2/3)*40)=2.6t/m`

W``=(Wt of ship +cradle/cradle length)*1.33=38t/m`


Load distribution :
86.25t/m`
65 t/m`
65 t/m`
43 t/m`
22 t/m`
38 t/m`
2.6 t/m`
45m
10
20
10
10
10
45m
PART(I)
PART(II)
PART(III)


w t/m`
w t/m`
5m
R.C SLAB
PLAIN CONCRETE
6m
1.5m
9m
1.5
6.0m
24m

## Design of R.C slaps:

**Part (2)**

**1-for 86.25t/m`**

**W=86.25/4.5=19.2t/m`<qall (crushed stone)**

**M-ve =21.6m.t**

**Design according to crack control:**

**Fcu=250kg/cm2**

**Fs=1400 kg/cm2**

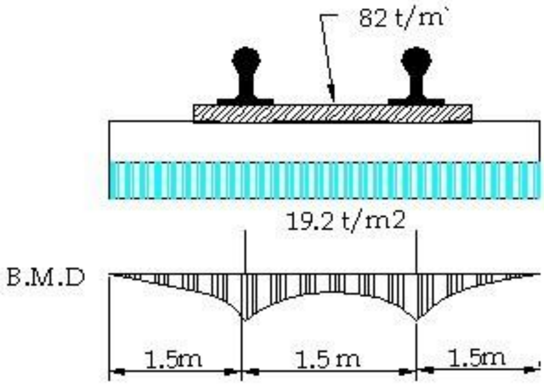
$$t = \sqrt{\frac{M}{300}} = 85 \text{ cm}$$

d = 80 cm

$$d = k1\sqrt{\frac{M}{100}}$$

k1 = 0.55
k2 = 1100
As = 23.82 cm2 / m`
Check As min = 0.4% Ac
= 0.4 % ( 85 x100) = 34 cm2/ m`

Use 10 Ø 22 t/m`



(2) w = 65 t/m`

w` = 14.5 t/m2

M-ve =16.3 m.t t = 75 cm

d = 65 cm

As = 30 cm2/m` 8 ∅ 22 /m`

(3) w = 43 tm`

w` = 43/4.5 m = 9.56 t/m2

M-ve = 10.76 t.m t = 60 cm

d= 55 cm As = 7∅ 22 /m`

(4) w = 22 t/m`

W` = 22/4.5 = 4.89 t/m2

M-ve = 5.5 m.t t = 45 cm

d = 40 cm

As = 12.5cm2/m` As = 5 ∅ 20 /m`

PART ( I ) :

w = 38 t/m`

W` = 38 /4.5 = 8.5 t/m2

M = 9.6 m.t t = 60 cm

As = 16 .0 cm2/m` As= 6 ∅ 20 /m`

PART (III)

w = 2.6 t/m`

W`= 0.55 t/m2 t = 20 cm

M = 0.62 t.m As = 8∅12 /m`

# Design of slipway

Ship dimension: 40*7.0*3.7

Width =2Bship +2*5=24m

Length =L1+L2+L3

L1=Lship+5.0=45.0m

L2=d*slope

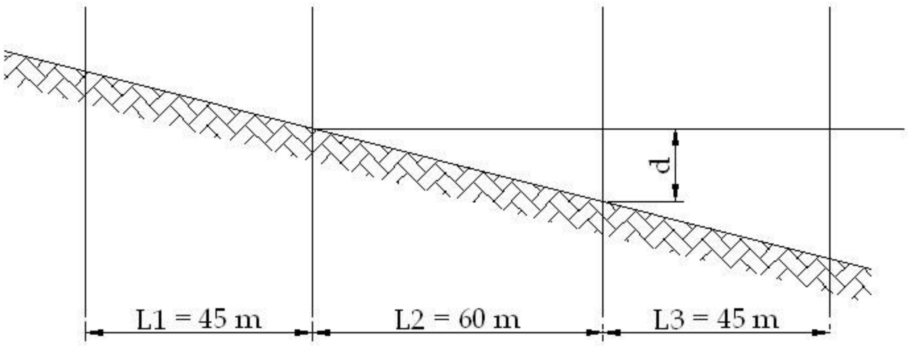
d =draft+tidal range +cradle height(0.75-1.0m)

d=3.70+1.17*1.0=6.0m

L2=6*10=60.0m (slope1:10)

L3=L1=45.0m

Total length=45+60+45=150m




Loads:

W=L*B*d*C*1.025

W=40*7*3.5*0.65*1.025=653.0T

C=bulk coefficient

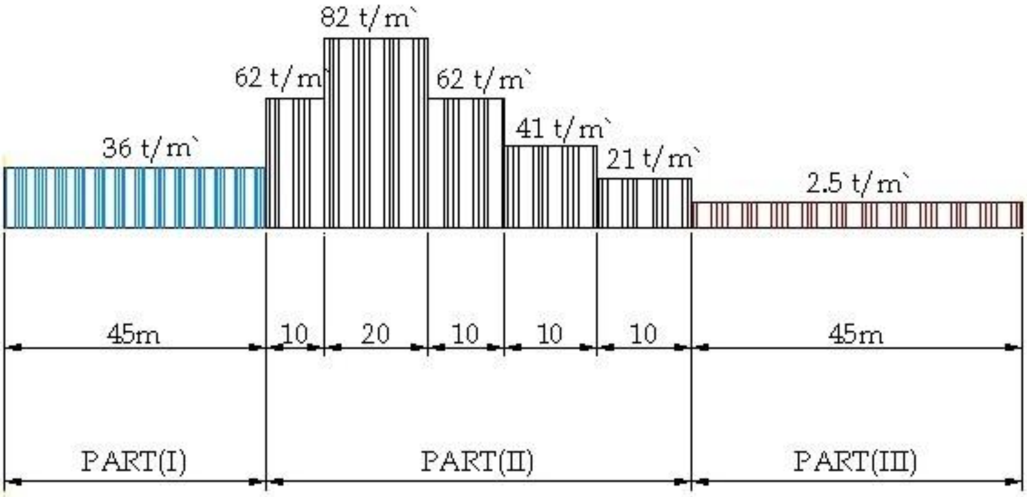
W>500T take W=W/8=82t

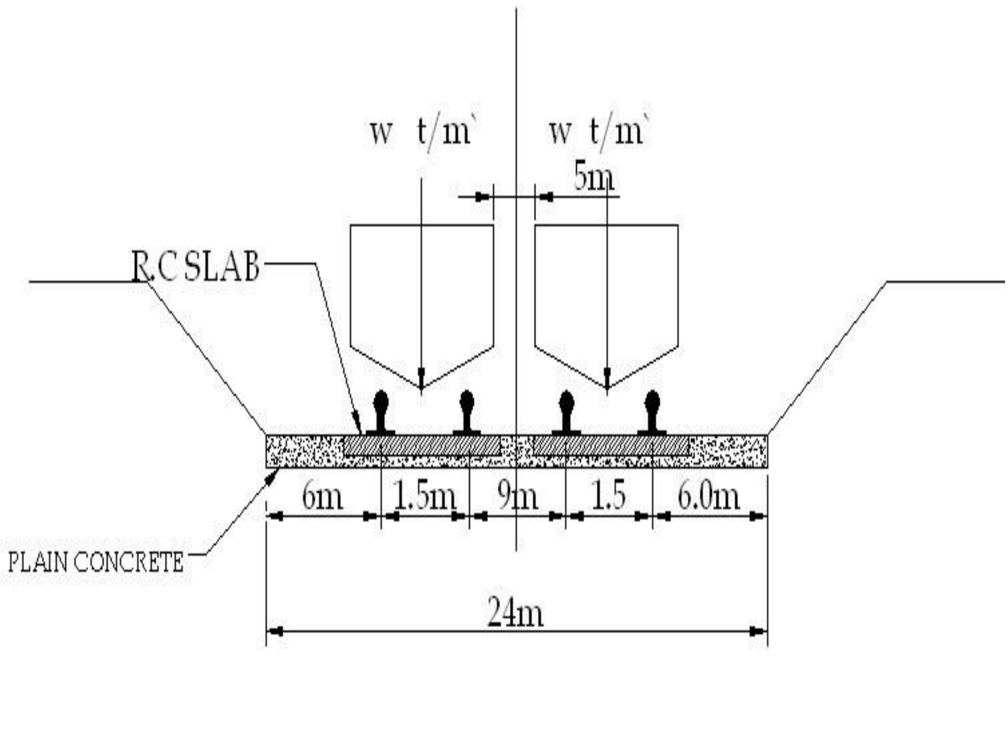
W`=(weight of cradle/length of cradle)=(0.1Wship/(2/3)Lship

=0.1*653/((2/3)*40)=2.5t/m`

W``=(Wt of ship +cradle/cradle length)*1.33=36t/m`

Load distribution :



Design of R.C slaps:

Part (II)

1-for 82t/m`

W=82/4.5=18.2t/m`<qall (crushed stone)

M-ve =20.47m.t

Design according to crack control:

Fcu=250kg/cm2

Fs=1400 kg/cm2

$$t = \sqrt{\frac{M}{300}} = 85 \text{ cm}$$

$$\boxed{d = 80 \text{ cm}}$$

$$d = k1\sqrt{\frac{M}{100}}$$

k1 = 0.55

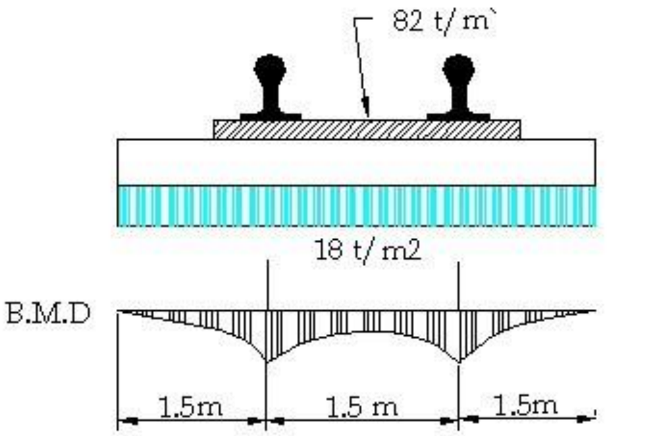
k2 = 1100

As = 23.82 cm2 / m`

Check As min = 0.4% Ac

= 0.4 % ( 85 x100) = 34 cm2/ m`

Use 10 Ø 22 t/ m`



d = 60 cm
As = 24 cm2/m\`

t = 70 cm
7 Ø 22 /m\`

③ w = 41 tm\`
w\` = 41/4.5 m = 9.11 t/m2
M-ve = 10.24 t.m

d- 55 cm

t = 60 cm
As = 7 Ø 22 /m\`

④ w = 21 t/m\`
W\` = 21/4.5 = 4.66 t/m2
M-ve = 5.24 m.t

d = 35 cm
As = 16 cm2/m\`

t = 40 cm
As = 6 Ø 19 /m\`

PART ( I ) :
w = 36 t/m\`
W\` = 36 /4.5 = 8 t/m2
M = 9 m.t

As = 16 .36 cm2/m\`

t = 55 cm
As= 6 Ø 19 /m\`

PART (III)
w = 2.5 t/m\`
W\`= 0.55 t/m2
M = 0.62 t.m

t = 20 cm
As = 7 Ø 13 /m\`

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5. The Egyptian code of water resources and irrigation works volume seven, 2003.
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7. US Army corps of engineers, Shore protection Manual, 1984.


## STANDARDS


- The Egyptian code of water resources and irrigation works volume seven, 2003.
- The British standard code of practice for Maritime structures, 1988-1991.
- US Army corps of engineers, Shore protection Manual, 1984.

# Appendix