# Reliability And Probability of Failure on Berthing Structures For Handling Bulk Cargo

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***Abstract-*** *Berthing structure is a general term used to describe a marine structure for the mooring of vessels, for loading and unloading cargo, for embarking and disembarking passengers. Damage to port/harbor structure was primarily due to Stack and Crane load. Berthing structure mainly consists of Deck slab and Substructure. In this project, considered the entire superstructure is situated on Substructure consists of vertical piles, racker piles & Diaphragm wall to withstand loading conditions i.e., BGML, Crane load, Stack load, Concentrated load & IRC 70R loadings. In addition to these loads it can also resists mooring forces. The literature on the adequacy of the STAAD. Pro modeling of substructure to analyze their behavior under varying the Stack, Crane & Mooring forces is limited. . This project describes the effect of Stack, Crane and Mooring forces on bending moment of "T" Shaped Diaphragm wall and the axial forces of vertical & racker piles.*

***Keywords***- Berthing Load, Current Load, Earth Pressure, Hydrostatic Pressure, Mooring Load, Wind Load

## I. INTRODUCTION

India has one of the largest merchant shipping fleets among developing countries and is ranked 16th in the world in terms of gross tonnage. Over the years, cargo handling capacity of Major Ports has steadily increased. Due to this, many new ports are constructed over the past few years.

Generally, the transportation costs can be reduced by using larger vessels with, among other things, a larger draft; new ports will be constructed in more environmentally challenging conditions, so the loads working on the marine constructions and berthed vessels will be higher.

The currently applied approach for structural design has been used for decades but is based on vessel types from around 1980. It is therefore worthwhile to have a closer look at this approach for marine construction designs. When a vessel approaches a jetty, it is important to berth the vessel as gently as possible. Berthing structure is a general term used to describe a marine structure for the mooring of vessels, for loading and unloading cargo, for embarking and disembarking passengers. In U.S.A. a berthing structure is referred to as a pier, and wharf, and in European terminology, a jetty, and quay.

Berthing structures vary widely from port to port. The number of berths will depend upon the number of ships to use the port and the time it will take to discharge and take on cargo or passengers. The selection of the type of berth and the material used for its construction will depend upon a number of factors, such as: Availability of materials, Economy of construction, Size and weight of ships using the port, Method of construction.

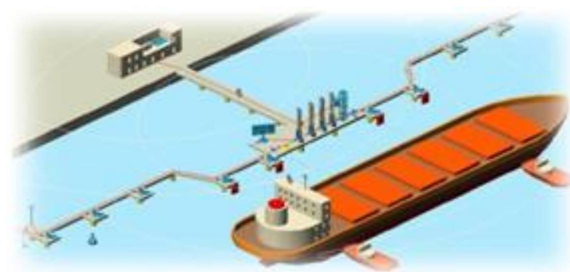

**Fig 1: Open Type of Berthing Structure**

## II. OBJECTIVE OF THE STUDY

The objectives of the present study are as follows:

1) The main objective of this paper is to study the effect of Crane, Stack & mooring forces on bending moment of "T" Shaped Diaphragm wall.
2) And also studied the effect of Crane, Stack & mooring forces on axial force of vertical & racker piles.

## III. METHODOLOGY

***Basic model specifications of Substructure***

The entire berth of 255 metres length is divided into 5 units each 51 metres long. Each unit consists of 17 Nos. "T" shaped diaphragm wall panels. The diaphragm wall is connected at the top through a cellular deck 2.8 m deep to a series of vertical piles (850 mm dia) and raker piles (700 mm dia). All the substructure elements are socketed in hard rock.

***Material Properties***

(a) The material used for analysis Reinforced concrete with M-30 grade concrete and Fe-415 grade reinforcing steel.

(b) The Stress-Strain relationship used is as per IS: 456:2000. The basic material properties used are as follows:

Modulus of Elasticity of steel, Es = 21,0000 MPa
Ultimate strain in bending, $\varepsilon_{cu}$ =0.0035
Characteristic strength of concrete, fck = 30 MPa
Yield stress for steel, fy = 415 MPa

***Modelling of Structure***

The soil is idealized as a classical Winkler foundation - beam on elastic springs. The soil passive resistance is considered to be offered by linear elastic springs.

Spring constants for the Sub - structure elements - retaining diaphragm wall and the anchor piles are calculated using the elastic moduli of the soil strata. (Ref Soil profile).

- The structure is considered as a plane frame - an assemblage of line elements within plane loading.
- The supports at the end of the retaining diaphragm wall are considered to be effectively restrained against translation in the Y - direction.
- The supports at the end of the anchor piles are considered to be effectively restrained against translation in the X and Y directions.
- Supports for the retaining diaphragm wall and anchor piles are taken to be at level -28.00 m.
- Each of the other joints (node) have three degrees of freedom (DOF'S).
- The joint between the deck and the retaining diaphragm wall and that between the deck and the anchor piles are considered to be very rigid.
- Mobilisation of the soil's passive resistance is effected through linear elastic soil springs. Structural analysis package, " STAAD.Pro" is used for the analysis

**Table 1: Spring Constants for Retaining "T" Shaped Diaphragm Wall**

| Spring No | Level (m) | Spring Value (MT/m) |
|---|---|---|
| 1 | -17.00 | 1247 |
| 2 | -18.00 | 2493 |
| 3 | -19.00 | 2493 |
| 4 | -20.00 | 2493 |
| 5 | -21.00 | 2493 |
| 6 | -22.00 | 2493 |
| 7 | -23.00 | 2493 |
| 8 | -24.00 | 11200 |
| 9 | -25.00 | 11200 |
| 10 | -26.00 | 11200 |
| 11 | -27.00 | 11200 |
| 12 | 28.00 | 9251 |

**Table 2: Spring Constants for Vertical Pile**

| Spring No | Level (m) | Spring Value (MT/m) |
|---|---|---|
| 13, 14 & 15 | | 0 |
| 16 | -3 | 68 |
| 17 | -4 | 330 |
| 18 | -5 | 330 |
| 19 | -6 | 330 |
| 20 | -7 | 330 |
| 21 | -8 | 330 |
| 22 | -9 | 330 |
| 23 | -10 | 330 |
| 24 | -11 | 330 |
| 25 | -12 | 330 |
| 26 | -13 | 330 |
| 27 | -14 | 330 |
| 28 | -15 | 330 |
| 29 | -16 | 330 |
| 30 | -17 | 502 |
| 31 | -18 | 2403 |
| 32 | -19 | 2403 |
| 33 | -20 | 2403 |
| 34 | -21 | 2403 |
| 35 | -22 | 2403 |
| 36 | -23 | 3101 |
| 37 | -24 | 10790 |
| 38 | -25 | 10790 |
| 39 | -26 | 10790 |
| 40 | -27 | 10790 |
| 41 | -28 | Very Large |

**Table 3: Spring Constants for Racker Pile**

| Spring No | Level (m) | Spring Value (MT/m) |
|---|---|---|
| 42, 43 & 44 | | 0 |
| 45 | -3 | 68 |
| 46 | -4 | 330 |
| 47 | -5 | 330 |
| 48 | -6 | 330 |
| 49 | -7 | 330 |
| 50 | -8 | 330 |
| 51 | -9 | 330 |
| 52 | -10 | 330 |
| 53 | -11 | 330 |
| 54 | -12 | 330 |
| 55 | -13 | 330 |
| 56 | -14 | 330 |
| 57 | -15 | 330 |
| 58 | -16 | 330 |
| 59 | -17 | 502 |
| 60 | -18 | 2403 |
| 61 | -19 | 2403 |
| 62 | -20 | 2403 |
| 63 | -21 | 2403 |
| 64 | -22 | 2403 |
| 65 | -23 | 3101 |
| 66 | -24 | 10790 |
| 67 | -25 | 10790 |
| 68 | -26 | 10790 |
| 69 | -27 | 10790 |
| 70 | -28 | Very Large |

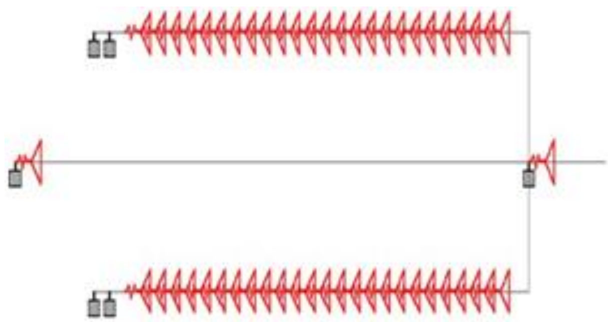

**Fig 1: Top View of Substructure**

**Fig 2: 3D View of Substructure**

***Loads consider on Substructure***

- Dead Load
- Earth pressure, lateral pressure due to surcharge
- Live loads: Electrical wharf crane
- BGML load
- Loaded crawler crane
- IRC 70R tracked and wheeled vehicle Stack load
- Bollard pull Seismic loading

***Load combination consider for Substructure***

- Wharf crane + one BGML (between wharf crane bogies) + UDL on the balance deck.
- Wharf crane + one BGML between wharf crane bogies + one BGML outside wharf crane bogies + UDL over the balance deck.
- Wharf cranes + one BGML between wharf crane bogies + crawler crane running perpendicular to the berth.
- Wharf crane + one BGML between wharf crane bogies + crawler crane running parallel to the berth.

## IV. RESULTS & DISCUSSIONS

**Table 4: Maximum Bending moment,Axial force values with varying Stack load**

| S. No | Variable Load | Intensity ofStack load (Tons/m$^2$) | Max positive B.M.of Diaphragm wall(Tons-m) | Max Negative B.M.of Diaphragm wall(Tons-m) | Axial forces | |
|---|---|---|---|---|---|---|
| | | | | | Racker pile (Tons) | Vertical pile (Tons) |
| 1 | Stack load | 6 | 2948.75 | 709.35 | 165.2 | 1254.42 |
| 2 | Stack load | 6.25 | 3071.61 | 738.90 | 165.82 | 1260.73 |
| 3 | Stack load | 6.5 | 3194.47 | 768.45 | 166.38 | 1267.04 |
| 4 | Stack load | 6.75 | 3317.33 | 798.00 | 167.08 | 1273.35 |
| 5 | Stack load | 7 | 3440.19 | 827.55 | 168.08 | 1290.8 |

**Table 5: Maximum Bending moment, Axial force values with varying Crane load**

| S. No | Variable Load | Intensity ofCrane load (Tons) | Max positive B.M.of Diaphragm wall (Tons-m) | Max Negative B.M.of Diaphragm wall(Tons-m) | Axial forces | |
|---|---|---|---|---|---|---|
| | | | | | Racker pile(Tons) | Vertical pile(Tons) |
| 1 | Crane load | 15 | 2192.25 | 551.835 | 121.725 | 913.50 |
| 2 | Crane load | 16 | 2338.41 | 588.624 | 129.84 | 974.40 |
| 3 | Crane load | 17 | 2484.57 | 625.413 | 137.96 | 1035.31 |
| 4 | Crane load | 18 | 2630.73 | 662.202 | 146.08 | 1096.22 |
| 5 | Crane load | 19 | 2776.89 | 698.991 | 154.20 | 1157.13 |

**Table 6: Maximum Bending moment, Axial force values with varying Mooring Force**

| S. No | Variable Load | Intensityof Mooring Force (Tons) | Max positive B.M.of Diaphragm wall (Tons-m) | Max Negative B.M.of Diaphragm wall (Tons-m) | Axial forces | |
|---|---|---|---|---|---|---|
| | | | | | Racker pile(Tons) | Vertical pile(Tons) |
| 1 | Mooring Force | 150 | 2976.11 | 787.4 | 175.93 | 1218.04 |
| 2 | Mooring Force | 180 | 2986.25 | 797.56 | 178.58 | 1232.89 |
| 3 | Mooring Force | 200 | 3002.13 | 813.75 | 182.73 | 1241.95 |
| 4 | Mooring Force | 220 | 3029.35 | 840.02 | 189.54 | 1247.74 |

## V. CONCLUSIONS

1) The percentage of increase in the bending moment of "T" shaped diaphragm wall with respect to Mooring force of 5%,15%, 25%, 35%were 0.35,0.54,0.89,1.05 respectively.
2) The percentage of increase in the Axial force of Racker pile with respect to Mooring force of 5%,15%, 25%, 35% were 1.60,2.45,3.87,4.50 respectively.
3) The percentage of increase in the Axial force of vertical pile with respect to crane load of 5%,15%, 25% 35% were 0.47,0.74,1.23,1.50 respectively.
4) The variation in Crane load &Mooring force plays a major role in influencing the bending moment of "T" shaped diaphragm wall when compared to Stack load.
5) The variation in Mooring force plays a major role in influencing the Axial force of vertical pile when compared to Stack load.

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