Analysis of Mooring Dolphin In Vishakapatnam Port

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Abstract- *This project is conducted for a period of 44 days to have the knowledge of "Mooring Dolphin" and its analysis and various mooring accessories at Visakhapatnam port trust in course of our project. In this project we acquired knowledge of various aspects of mooring dolphin and its accessories such as bollards, fenders and various forces acting on the mooring dolphin have been recorded.*

Dolphins are usually installed to provide a fixed structure when it would be impractical to extend the shore to provide a dry-access facility, for example, when the number of ships is greater than can be accommodated by the length of the berth/pier. Mooring dolphins are used only for securing vessels. They're commonly built near piers to control the traffic of berthing vessels.

Keywords- Mooring Dolphin, bollards, fenders, berthing vessels.

I. INTRODUCTION

Visakhapatnam port trust is an organization in India. VPT, through its excellent port services rendered in exporting and importing goods and its expensive railway networks has brought worldwide recognition to it. It plays a major role in increasing the foreign trade and development. It stands as one of the major ports of India for the past six years .It is the only port which has been certified by ISO-9001:2OOO for its quality management OHSAS-18001 for the occupation health and safety of the port employee. It is located on the east coast of India on the shores of Bay of Bengal at the mid way between Kolkata and Chennai. (880 Km from Kolkata and 780 km from Chennai)

A chain of hills provides safe anchorage to ships surrounding the port like Dolphin nose, a Rose hill on the northern side. Dolphin nose protects the port from cyclones. The port was emerged as a multi commodity mega size port handling traffic of 46 million tons and has emerged as a leading major port in the country for these years i.e., 2000-2001, 2001-2002 and 2002-2003 in succession. It consists of inner harbour with18 berths and mooring berth and outer harbour with 7 berths and oil mooring berth.

II. HISTORY OF V.P.T

The Visakhapatnam Port is located almost midway between Kolkata and Chennai, at a latitude 17˚41'N and longitude 83˚18'E on the east coast of India, in the state of Andhra Pradesh on the shores of Bay of Bengal. It is one of the pre-independence ports of the country. The need for a port in this part of the country was emphasized as early as in 1858 in a report of a British Survey Party. Mr. E. S. Thomas, while submitting the proposals for creation of the port in 1872 described it as the most natural and most easily formed port on the east coast of India. It was only in 1914 that the proposal for construction of a harbour at Visakhapatnam was initiated by the then Bengal Nagpur Railway and in 1922 a proposal of Col. H. Cartwright Reid of British Admiralty for the construction of a harbour at the mouth of river Meghadrigedda was adopted.

Other important information about the V.P.T:

- The length of the conveyor through which iron ore/ pellets are Loaded to the vessels at ore berths is 4.8 Km.
- The length of railway network as on date is about 200.00 Km and Road network is about 63 Km.
- The port connectivity road (NHAI) with 12.47 Km, which includes4.00 Km long flyover.
- Sports and arts: It has sports and cultural complex at the heart of The city near NH 5, which includes outdoor stadium, AC indoor Stadium and AC auditorium is spread over about 25 acres of land.
- It has a dry dock facility and finishing harbour has a spill way Complex for repairs of small vessels and fishing trawlers Respectively.
- It has 10 MLD Sewage Treatment Plant constructed during the Year 1996 with which sewage water coming from city area will be Treated and utilized for dust suppression on the roads and dusty Cargo stockyards through Lorries and Mechanical Dust Suppression System (MDSS) respectively.

III. MARINE STRUCTURES IN PORT

Berth

A berth is a location in a port or harbour used specifically for Mooring vessels.

Quay Wall

A stretch of paved bank, or solid artificial landing place parallel to the navigable waterway, for use in loading and unloading vessels.

Jetty

A structure jutting out from the shore at which vessels are berthed either at the head of the structure or alongside.

Groyne

A groyne (groin in the United States) is a rigid hydraulic structure built from an ocean shore (in coastal engineering) or from a bank (in rivers) that interrupts water flow and limits the movement of sediment.

Breakwater

These are structures constructed on coasts as part of coastal defence or to protect an anchorage from the effects of weather and long shore drift offshore breakwaters, also called bulkheads, reduce the intensity of wave action in inshore waters and thereby reduce coastal erosion or provide safe harborage.

IV. MOORING DOLPHIN & ITS ACCESSORIES

Mooring Dolphin

A dolphin with a head upon a cluster of piles, which may be either vertical or combination of vertical and rakers, used for offshore mooring of vessels.

A **Dolphin** is a man-made marine structure that extends above the water level and is not connected to shore. Dolphins are usually installed to provide a fixed structure when it would be impractical to extend the shore to provide a dry access facility.

Bollard:

Bollard is fixed to the quay at cope level; these are employed for securing a vessel in position with rope moorings. These also provide a means of checking vessels entering or leaving the dock. These may be of concrete, cast iron or steel of different sizes and shapes.

V. FENDER AND ITS TYPES

Fender

A type of resilient buffer system provided at a berthing faceto protect the structure and the ship from damage due to force of impact of berthing vessel.

Timber Fenders:

They are low in strength and are subject to rotting and marine borer attack. Moreover, they have low energy absorption capacity and the berthing reaction depends on the point of contact. The contact pressure between fender and vessels are high.

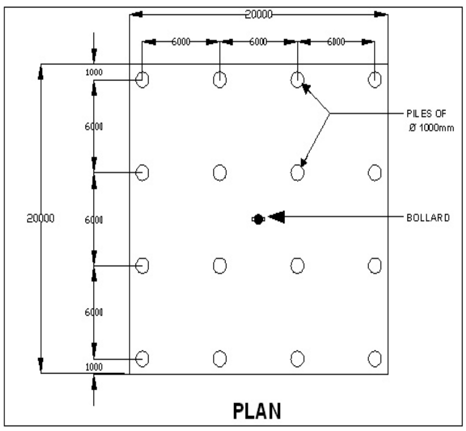
Plastic Fenders

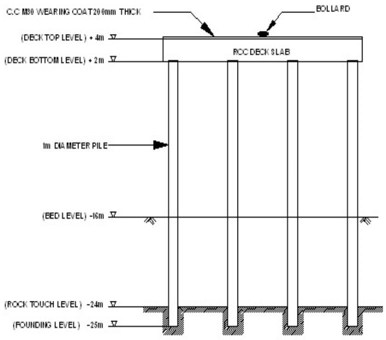
Their strength is similar to that of timber fenders but they have relatively high abrasive resistance. They are resistant to chemical and biological attack. Their energy absorption capacities are moderate and the berthing reactions are also dependent on the point of contact. The reaction is lower when compared with timber fenders for a given energy absorption. They are considered to be environmental friendly because they are manufactured from recycled material.

Rubber Fenders:

They possess high abrasive resistance and are also resistant to most biological and chemical attacks. They have moderate to high energy absorption capacity and the energy absorption performance is independent of the point of contact. Like plastic fenders, they are also environmentally friendly products.

VI. ANALYSIS OF MOORING DOLPHIN





SECTION

Technical Data:

6.1.1 VERTICAL LOADS

a) Dead loads
b) Live loads-3t/m^2 [Based on IS 4651]

6.1.2 HORIZONTAL LOADS

a) Berthing Forces
b) Bollard pull-100t
c) Wave Breaking Force (Not considered due to academicpointof view)
d) Seismic Forces (Not considered due to academic point of view)

6.1.3 DESIGN DREDGE DEPTH = -16m

6.1.4 LEVELS (OR) ELEVATIONS

Top Level of Slab= +4.00m
Thickness of wearing coat [c.c. M30] = 0.20m
∴ Top level of Mooring Dolphin = +4.20m
Bottom level of deck slab = +2.00

6.1.5 BOLLARD PULL = 100t

6.1.6 COMPUTATIONS OF LOADS

A. DEAD LOAD
Wearing coat = 20*20*0.2*2.5= 200t
Deck Slab = 20*20*2*2.5 = 2000t
Piles = 16*27.05* [(22/7)/4]*1^2 = 340.05528t
B. LIVE LOAD
L.L = 3.0t/m(Based on IS 4651)

6.2 Axial Loads on Each Pile

D.L for Type1 pile i.e., (extreme corner piles) 4no's
4m*4m panel = 101.602t
D.L for Type2 pile i.e., (next to extreme corner pile) 8no's
4m*6m panel = 132t
D.L for Type3 pile i.e., (middle pile) 4no's
6m*6m panel = 198t
L.L for type1 piles i.e., (extreme corner piles) 4no's
4m*4m panel = 48t (3.0t/m^2)
L.L for Type2 piles i.e., (next to extreme corner piles) 8no's
4m*6m panel = 72t
L.L for Type3 piles i.e., (middle piles) 4no's
6m*6m panel = 108t

6.3 Length of Piles

Length of piles for all piles are equal.

6.4 Deflection Stiffness of Piles

$K = [12*E_c*I*\Delta]/ L^3$

E_c = modulus of elasticity of concrete
= $5000\sqrt{f_{ck}}$

Where f_{ck} = characteristic compressive strength of concrete i.e., f_{ck} = 30 N/mm^2 (since M30)

∴ $E_c = 5000\sqrt{30} = 2.74*10^4$ N/mm^2 = $2.74*10^5$ kg/cm^2

$I = [\pi/64]*D^4 = \left[\frac{\pi}{64}\right]*100^4 = 4.910703*10^6 cm^4$

Δ = 1cm
L = length
∴ Stiffness of pile
$K_A = [12*2.74*10^5*4.910703*10^6*1]/(2705)^3$
= 815.78065 kg/cm
= 0.815t/cm

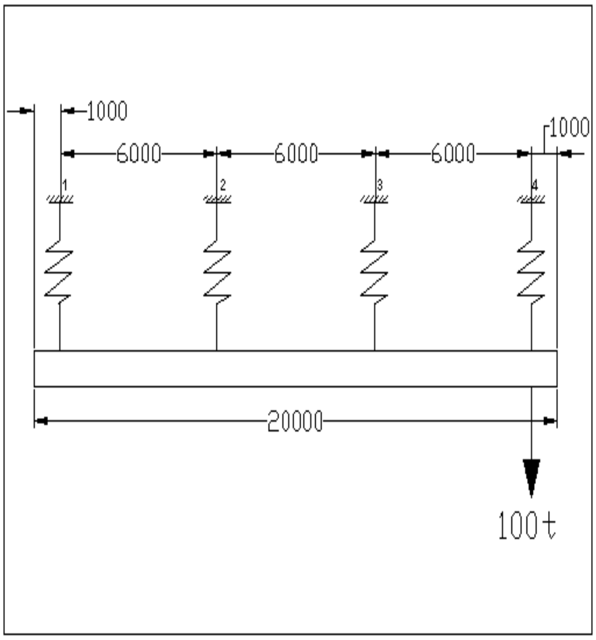
Total stiffness of four pile bent = 4* 0.815 = 3.260t/cm

6.5 LATERAL FORCE DUE TO MOORING PULL

Considering a total bollard pull of 100t on the structure using a
Single bollard of its full capacity

Force per 4piles bent @ 6m c/c = 1*100t*(6/18.00)
= 33.33299t
Force on each row piles = 33.33299*(0.815/3.260) = 8.33324t

Considering force due to eccentric mooring pull
(force on bollard at end of pile bent)



Considering force and moment equilibrium

- Force equilibrium

Δ_f /x * 3.260[x+(x-6)+(x-12)+(x-18)] = 100t

Δ_f * 3.260 (4x-36) = 100x

Δ_f = (100x)/[3.260(4x-36)] = (100x) / [3.260*4(x-9)]

= 7.67x/(x-) ---
---1

- Moment equilibrium

3.260* Δ_m /x [x^2+(x-6) + $(x-12)^2$+$(x-18)^2$] = 100x

3.260* Δ_m [x^2+x^2+36-12x+x^2+144-24x+x^2+324-36x] = 100t

3.260 Δ_m [$4x^2$-72x+504] = $100x^2$

Δ_m = ($100x^2$) / 3.260[4(x^2-18x+126)]

Δ_m = ($7.67x^2$) / [x^2-18x+126] -------------------------2

To find 'x' we can equate Δ_f ,Δ_m equations

(7.67x) / (x-9) = ($7.67x^2$)/ (x^2-18x+126)

x/(x-9) = (x^2)/(x^2-18x+126)

x^3 -18x^2+126x = x^3-9x^2

9x^2-126x=0

$$\frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$$\frac{-(-126)\pm\sqrt{(-126)^2-0}}{2\times 9}\ \frac{126+126}{18} = \frac{252}{18} = 14\text{m}$$

Hence point of rotation (x) = 14m

∴ Deflection corresponding to (x) = 14m

$\Rightarrow \Delta_f$ = 21.48 cm

Δ_m= 21.48 cm

∴ Max deflection at the end = 21.48 cm

Determination of depth of fixity of pile

(IS: 2911, part−1/sec.2)

T = $\sqrt[5]{\frac{EI}{k_1}}$ for sandy soils

Where,

E= young's modulus of elasticity

= 5000 $\sqrt{f_{ck}}$ = 5000 $\sqrt{30}$ = 27386.128 N/mm^2

= 2.74×$10^5\ KN/cm^2$

I= Moment of inertia of pile

= $\frac{\pi}{64} D^4$

= $\frac{\pi\times 100^4}{64}$ = 4.908738521$\times 10^6 cm^4$

k_1= modulus of sub-grade reaction of soil for medium sand, submerged condition

= 0.525 kg/cm^2

T= $\sqrt[5]{\frac{2.74\times 10^5\times 4.910714\times 10^6}{0.525}}$

T = 303.212 cm = 3.031m

L_1= Length from dredged depth to the point of horizontal load i.ecentre of deck slab

= $\frac{19}{303}$ = 6.2667

From fig 2 of IS 2911

(Fixed head pile) $\frac{L_f}{T}$ = 1.85

∴ L_f= length of fixity = 1.85×3.03 = 5.6055

Considering length of fixity of piles 6D = 6m

6.6 LENGTH OF PILES

Since all piles are uniform length

∴ Length of pile = 16+6+4

= 25m

- Forces in piles due to mooring pull

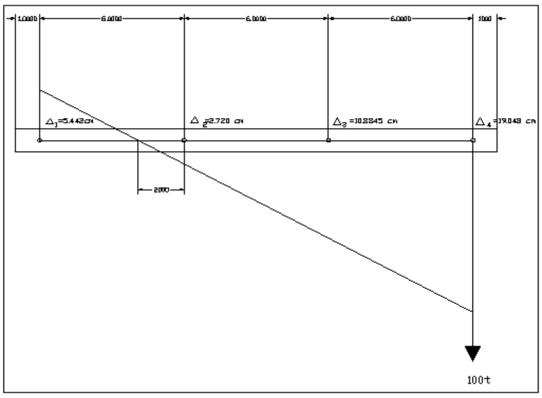
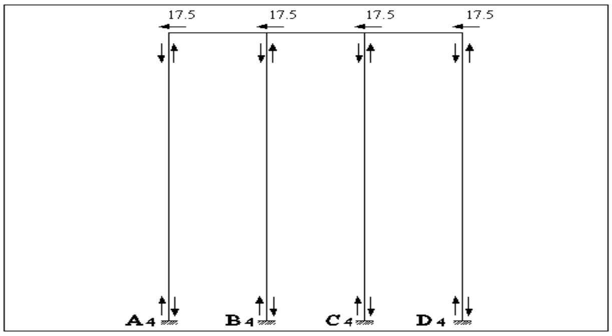


TABLE: 5

Pile No	Deflection stiffness (t/cm)	Deflection (cm)	Force in piles (t)
A_1	0.918	-5.442	-5.00
A_2	0.918	2.721	2.50
A_3	0.918	10.884	10.00
A_4	0.918	19.048	17.5
B_1	0.918	-5.442	-5.00
B_2	0.918	2.721	2.50
B_3	0.918	10.884	10.00
B_4	0.918	19.048	17.5
C_1	0.918	-5.442	-5.00
C_2	0.918	2.721	2.50
C_3	0.918	10.884	10.00
C_4	0.918	19.048	17.5
D_1	0.918	-5.442	-5.00
D_2	0.918	2.721	2.50
D_3	0.918	10.884	10.00
D_4	0.918	19.048	17.5

6.7 VERTICAL LOAD ON PILES DUE TO LATERAL FORCES

Considering max lateral forces from mooring pull acting on the pile bent.



6.8 MOORING PULL

$M_{A_4} = 17.5 \times \frac{25}{2} = 218.75\ t_m = M_{B_4} = M_{C_4} = M_{D_4}$

(∵ The max. lateral forces, piles lengths are equal piles A_4, B_4, C_4, D_4)

6.9 SHEAR FORCE

Span $A_4 - B_4 = \dfrac{218.75 + \frac{218.75}{2}}{6.0} = 54.6875t$

Span $B_4 - C_4 = \dfrac{\frac{218.75}{2} + \frac{218.75}{2}}{6.0} = 36.458t$

Span $C_4 - D_4 = \dfrac{\frac{218.75}{2} + 218.75}{6.0} = 54.6875t$

6.10MOORING PULL:

{*Net vertical forces*[*reactions*]}

At A_4 = +54.6875 (↓) compression

B_4 = -54.6875+36.458

= -18.229 (↑) Tension

C_4 = -36.458+54.6875

= 18.229 (↓) compression

D_4= -54.6875 (↑) Tension

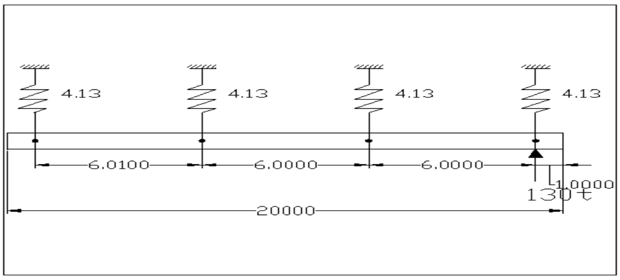
6.11 FORCES IN PILES DUE TO BERTHING FORCES

(Refer IS 4651 (part-3) clause No 5.2)

Berthing force = 100t

As the end berthing will produce max force in pile bents considering

B.F = 100t, acting at end fender location, i.e at last pile bent.



6.11.1 Calculating force in piles by force and moment equilibrium:

- Force equilibrium

4.13 $\times \frac{\Delta_f}{x}\{x+(x-0)+(x-12)+(x-18)\}$ = 130t

4.13 $\times \Delta_f\,(4x-36) = 130x$

$$\Delta_f = \frac{130x}{4.13[4(x-9)]}$$

$\Delta_f = \frac{7.8626x}{x-9}$ --------------------------1

- Moment equilibrium

4.13347 $\times \frac{\Delta_m}{x}$ $[x^2+(x-6)^2+(x-12)^2+(x-18)^2] = 130x$

4.13347 $\times \Delta_m[4x^2-72x+504] = 130x^2$

$\Delta_m = \frac{130x^2}{4.13347[4(x^2-18x+126)]}$

$\Delta_m = \frac{7.8626x^2}{x^2-18x+126}$ -----------------------------2

To find $'x'$ we can equate Δ_f , Δ_m equations

$\frac{7.8626x}{x-9} = \frac{7.8626x^2}{x^2-18x+126}$

$x^3-18x^2+126x = x^3-9x^2$

$9x^2-126x = 0$

$$\frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

where , $a=9$

$b=-126$

$c=0$

$= \frac{-(-126)\pm\sqrt{(-126)^2-4\times9\times0}}{2\times9}$

$= \frac{126+126}{18} = \frac{252}{18}$ = 14m

Hence point of rotation (x) = 14m from point of application of load

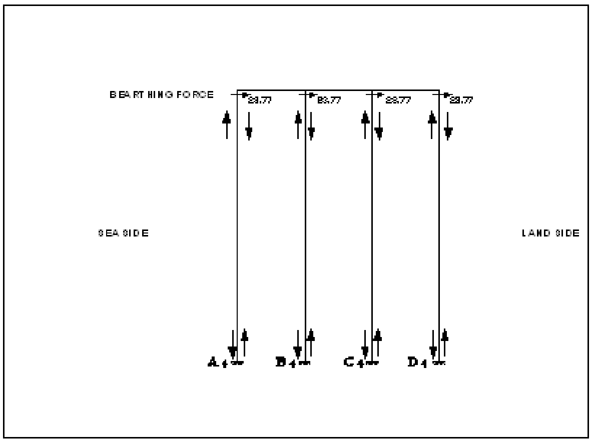
∴Deflection :

$\Delta_m \Rightarrow \Delta_f = \frac{7.8626\times14}{14-9}$

= 22.015 cm

TABLE: 6

Pile No	Deflection stiffness of piles (t/m)	Deflection (cm)	Force (t)
A_1	1.033	-6.29	-6.50
A_2	1.033	3.14	3.25
A_3	1.033	12.58	13.00
A_4	1.033	23.01	23.77
B_1	1.033	-6.29	-6.50
B_2	1.033	3.14	3.25
B_3	1.033	12.58	13.00
B_4	1.033	23.01	23.77
C_1	1.033	-6.29	-6.50
C_2	1.033	3.14	3.25
C_3	1.033	12.58	13.00
C_4	1.033	23.01	23.77
D_1	1.033	-6.29	-6.50
D_2	1.033	3.14	3.25
D_3	1.033	12.58	13.00
D_4	1.033	23.01	23.77



6.12 MOMENTS

$M_{A_4} = 23.77 \times \frac{25}{2} = 297.125 = M_{B_4} = M_{C_4} = M_{D_4}$

(Since the max lateral forces, piles lengths are equal for the piles A_4, B_4, C_4, D_4)

6.13 SHEAR FORCE

Span $A_4 - B_4 = \frac{297.125+\frac{297.125}{2}}{6.0}$ = 74.281t

Span $B_4 - C_4 = \frac{\frac{297.125}{2}+\frac{297.125}{2}}{6.0}$ = 49.54t

Span $C_4 - D_4 = \frac{\frac{297.125}{2}+297.125}{6.0}$ = 74.281t

- Reaction (Net vertical forces)

A_4 = -74.281 (↑) Tension

B_4 = +74.281(↓) − 49.52(↑) = +24.761(↓) compression

C_4 = +49.52(↓)−74.281(↑) = −24.761(↑) Tension

D_4 = +74.281(↓) compression

TABLE: 7

S.No	Forces	Pileunder compression with L.L			Pileunder Tension without L.L	
		Vertical load (t)	Transverse force	Longitudinal force	Vertical load	Transverse load
1	Dead load	198	–	–	198	
2	Live load	108	–	–	–	
3	Vertical load coming from lateral forces	+54.68	17.50	–	−54.68	17.50

VII. CONCLUSION

So finally, we got awareness on

1. Mooring dolphin and its analysis
2. Mooring accessories
3. Fenders& types of fenders
4. Major aspects of port.

REFERENCES

[1] Visakhapatnam Port Trust Civil Engg. Manual.

[2] IS: 4651 – 1974, “Code of practice for planning of Ports and Harbour”.

[3] IS: 2911 – 1981, “Code of practice for design and construction of Port and Harbour Structures.

[4] IS: 7314 – 1974,” Glossary of terms relating to port and harbour Engineering.