Analysis and Design of Passenger Berthing Structure

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Abstract - *Analysis and design of berthing structures seems to be a new subject to common structural engineers, but they are the important structures contributing to the development of trade in our nation. This design project is focusing on analysis and design of 2nd passenger berth at Beypore port, Kozhikode. It's an open piled bored cast-in-situ structure and lying in the seismic zone III. The berth is to be designed for a vessel having capacity of 5000DWT. The structure is subjected to various forces and combinations such as, High tide, Earthquake, High winds, heavy live loads as per IS: 4651-1983. A model was generated using STAAD-Pro software and analysis was conducted with appropriate loads acting on the structure. It was observed that seismic force was nominal since Beypore being located in seismic zone III. This research is an attempt to understand the concept of design and analysis of berthing structures under different conditions of loading.*

***Key Words*: Berth, Load, Wind, Tide, Earthquake**

1. INTRODUCTION

This Shipping service is the life line of the people of Lakshadweep as they serve as the primary means for transportation of men and material in the mainland-island sector as well as in the inter-island sector. As a result of geographical isolation of these islands from main land, and from one island to one another, the people of these islands fully depend on the mainland for everything. In case of any disruption in the shipping services in the mainland-island sector, the people immediately experience shortage of supplies of all goods like Public distribution system items, petroleum products, other items required for their day-to-day living in these islands. In addition to this for medical treatment the residents of Lakshadweep totally depend on the mainland. Shipping service is a critical component for the socio-economic development of the people and the islands as a whole, as this acts as the main link with the mainland and from one island to another. To meet the above prime requirement of the people of these islands, the Lakshadweep Administration has been operating ships/vessel between Kochi, Beypore and Mangalore Ports in mainland and islands. All the Public distribution system items, Petroleum products and other items are being transported from Beypore and Mangalore ports to these islands. At present Union Territory of Lakshadweep Administration is operating 7 passenger vessels, 3 high speed vessels and 4 cargo barges between Beypore ports and Lakshadweep islands for passenger and cargo movements. However, the Lakshadweep Administration is not having any of its own passenger terminal/wharf for berthing of Lakshadweep vessels at Beypore and accordingly, the Administration has been utilizing the present available facility of Cargo Terminal/Wharf facility at Beypore for berthing the vessels. The passenger/cargo ships of Lakshadweep Administration have to wait for long hours for a wharf and the cargo ships sometimes have to wait for days together to get a wharf at Beypore which leads to lot of hardship and inconvenience to the local passengers and also timely loading and unloading of cargo bound for Lakshadweep are adversely affected. The Administration is further augmenting the shipping fleet as recommended in the 15 years Perspective Plan for shipping requirements in Lakshadweep and accordingly one 2000 LPG Cylinder Carrier ship named Elikalpani has already been commissioned in 2012 and one 150 MT Oil Barge put into service in 2014. Moreover there is also proposal to acquire 2 Nos. 800 MT Multipurpose Cargo Barges and which is expected to start service by the end of 2015 and one 1000 MT Oil Barge by the end of 2016. Hence with the expansion of the shipping fleet with the acquisition of above vessels it would be difficult for the Administration to find suitable berthing facilities at Beypore for timely berthing and transportation of cargo. Now only one berth is available at Beypore Port for berthing of UTL passenger as well as cargo vessels, which makes it very difficult to get timely berth especially for loading of cargo.

1.1 Beypore Port – A Case Study

The Existing Beypore Port is located on the south western coast of India (latitude 11˚08‟N & longitude 75˚51‟E), which is midway between the two major ports of Cochin and New Mangalore. It is situated at the mouth of Beypore/Chaliyar River which discharges to the Arabian Sea. Beypore was well known for its crafting of huge wooden boats called "Uru". Boats built here were used on the sea routes to Arab countries. The area was also well known for spices and was a major stop on the old "Silk Route" to Mesopotamia. Kozhikode, a busy district town in Kerala is commercially well known to be an important trade centre for textiles, steel and timber products, seafood processing and tiles manufactures. Beypore has some port facilities in terms of berthing wharves where small vessels (mostly barges) operate. The traffic from mainland operates to and from Lakshadweep Islands through Beypore port. The traffic from Lakshadweep forms approximately 50% of the total of traffic through Beypore Port. The location of the proposed dedicated berth for

Lakshadweep is at are 11° 9'48.96"N and 75 48'27.74"E. It will be constructed as a northern extension to the existing Port, east of the existing fishing harbour. The location is well connected by Road, Rail air and water. It is 10 km by road from Calicut Railway Station, 20 km from Kozhikode Airport. The Land for the proposed facility is owned by Government of Kerala and given on lease to Union Territory of Lakshadweep for a period of 30 years.

Fig -1: Beypore Port Location

2. DESIGN OBJECTIVE

To Analyze and design the passenger berthing structure as per the guidelines provided by the bureau of Indian Standards and followed by the bye laws of International Maritime Organization.

- The Objective of this project is to analyze a Passenger berth structure of size 200m x 20m
- To design all the components in the berthing structure as per the codal provisions.
- To analyze the structure using the STAAD. Pro.

2.1 Berthing Structure

The berthing structures are constructed for the berthing and mooring of vessels to enable loading and unloading of cargo and for embarking and disembarking of passengers, vehicles etc. The planning and design of berthing structures depend on various factors. A berthing structure is a capital intensive project, thereby; optimum use of both space and capital becomes imperative. This means that proper planning of the various units of the structure, for the present and an optimistic future demands, is necessary. Berthing structures world over suffer from congestion or inflexibility due to short comings in planning or due to wrong estimate of the traffic and or land requirement. Planning a berthing structure should satisfy certain basic objective,

2.2 Berthing structures vary widely in

- Configuration, layout, container handling technology user requirements and operating rationale.
- Berth requirements depending upon the type of shipping service, ship types and sizes to be served.
- Land access, rail, road service requirements

In particular planning of a berthing structure means establishing the number of berths, berth length, the area required for storing containers until they are discharged, area requirement for parking both terminal and highway trailers and the areas for administrative and maintenance operations. To arrive at an economic design of a berthing structure the structural engineer has to repeat the design for different alternatives for all loading conditions. To minimize his effort a computing tool has become necessary. The software developed can be used for the analysis and design of new berthing structures and can also be used for obtaining the design aspects while reconstructing an existing structure.

2.3 Components of Berthing Structure

- Beam
- Slab
- Pile
- Fenders
- Bollards

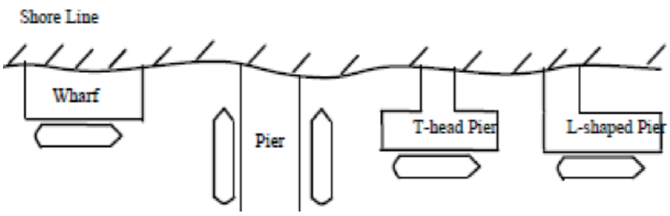

Fig -2: Types of Berthing Structures

3. PORT DESIGN

On the review of detailed feasibility report carried out by Consulting Engineering Services on the "Development of Beypore Port", it has recommended a passenger berth of size 200 x 20 m on the eastern side of the existing old wharf to cater the demand of Lakshadweep. The passenger berth shall be constructed as an extension in the same alignment as the existing wharf. Open type berth structure is proposed for the site which involves construction of piled berth of size 200x 20m. The foundation for the berth structure is bored cast in situ pile at a depth of 30 as specified by the geotechnical study recommendation. Above these piles, pile cap beams and secondary beams are aligned in both directions with the RCC deck slab through these beams. The 200 m berth will be constructed in 4 bays having construction joints separating them. The width of the berth is designed to be sufficient enough for the movement of a double lane vehicle of cargo and smooth operation of a cargo handling crane.

3.1 Design Methodology

The design methodology adopted for the project are focused into reinforced concrete design and general design approach of the structure based on the Codal Provisions of IS 4651-1 (1974) Code of Practice for planning and design of ports and harbours.

3.2 Selection and Requirements of Berth

- After having decided about the location of the berthing structure, the type of the structure to be constructed needs to be examine.
- The factors controlling the selection of the type of structure are the flow conditions and based on the soil properties
- Berthing structures can be classified as wharfs and piers
- The number of berth required in the terminal largely depends on the traffic to be handled in terms of number of ships to be serviced and their arriving pattern,
- The length of berth to be provided depends upon the function of the terminal and the size and the types of ships that are likely to call at the port
- Berthing area should be based on the length and breadth of the largest size of the ships using the berths

3.3 General Methodology Adopted

The general methodology adopted for this project is based on the review of the existing data available and the collection of secondary resources for the project from the various government agencies with reference to special case studies of berthing structures design project. Whereas the data and resources are reviewed in order to finalize the requirements and the type of berth structure proposed to design in which all the structural elements are designed based on the bureau of Indian standards codal provisions.

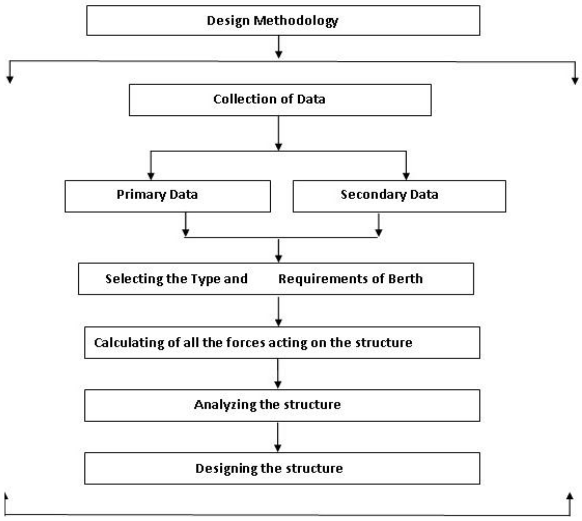

Fig -3: General Methodology

3.4 Calculating of all the forces acting on the structure

All the possible loads on the berthing structure were calculated as per IS 4651 (1974) - 3 Code of Practice for planning and design of ports and harbours Loading Conditions

3.5 Manual Design

The structural reinforced design methods there are two types i.e. working stress method, limit state method

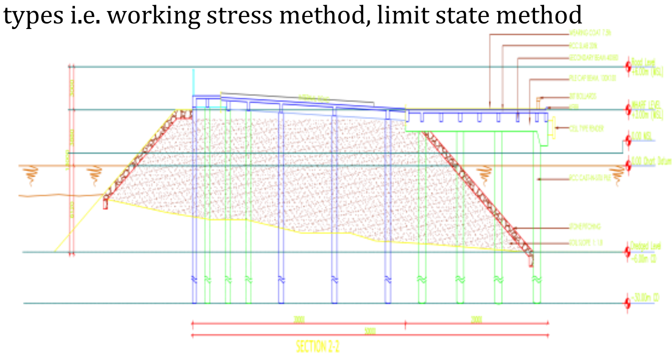

Fig -4: Cross Section view of the Berth

3.6 Designing the structure

The design of the slabs, beams and piles are design as per IS 456:2000, SP: 16 and IS 2911 (1). Suitable forms have been developed to design and draw the required reinforcement in the structural members.

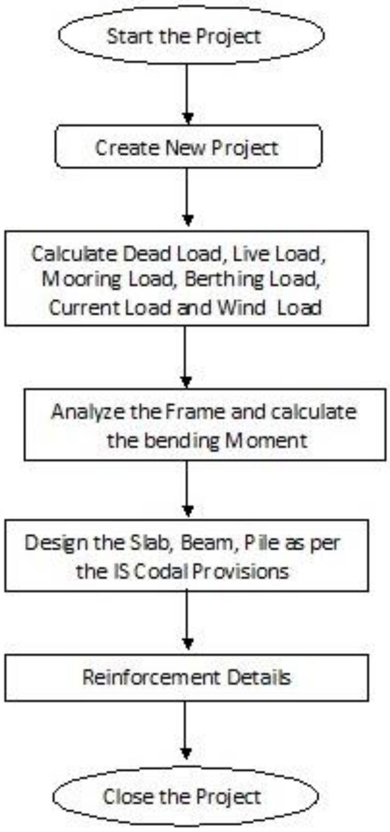

Fig -5: Design & Analysis of the Structure

3.7 Working Stress Design

There are uncertainties in load, material and theoretical models. Two different methods are available to take into account the uncertainties, namely the working stress design method and the limit state design method. The working stress method can be expressed as:

$$S^* < S/SF$$

Where,

S = Nominal stress capacity
SF =Safety Factor
S* = Design stress
Stress: Nominal or Shear

The disadvantages of working stress method are not consistency reliable.

3.8 Limit State Method

Limit state design is a design method in which the performance of a structure is checked against various limiting conditions at appropriate load levels. The limiting conditions to be checked in structural steel design are ultimate limit state and serviceability limit state. Ultimate limit states are those states concerning safety, for example load carrying capacity, overturning, sliding, and fracture due to fatigue or other cause. Serviceability limit state are those state in which the behavior of the structure under normal operating conditions is unsatisfactory, and these include excessive deflection, excessive vibration, and excessive permanent deformation.

4. ANALYSIS OF THE STRUCTURE

4.1 Load Calculations,

4.1.1 Dead Load [IS 875-1987 Part I]

All dead loads of and on structures relating to docks and harbor should be assessed and included in the design. Dead loads consist of the weight of all components of the structure as well as the weight of all permanent attachments. The DL of a port related marine structure constitutes a relative small percentage of the total load acting on the structure.

Slab Weight = 0.2×25 =5KN/m^2

Transverse beam = 1.10×1.80×25 = 50KN/m

Longitudinal beam = 1.10×0.6×25= 16.5KN/m

Pile = ((pi×2^2)/4) ×25 = 78.5KN/m

4.1.2 Live Load [IS 4651(Part III)-1974]

Surcharges due to stored and stacked material, such as general cargo, bulk cargo, containers and loads from vehicular traffic of all kinds, including trucks, trailers, railway, cranes, containers handling equipment and construction plant constitute vertical1ive loads. Vertical LL consists of the weight of all movable equipments on the structure. The function of berth related to Truck loading B (Passenger Berth) so we are adopted 10KN/m^2

Table -1: The function of berth related to Truck loading

S. No	Functioning of Berth	Truck Loading	Uniform Vertical LL(T/m^2)
1	Passenger Berth	B	1.0
2	Bulk unloading & loading berths	A	1.0 to 1.5
3	Container berths	A or AA or 70R	3 to 5
4	Cargo berth	A or AA or 70 R	2.5 to 3.5
5	Heavy Cargo berth	A or AA or 70 R	5 or 6
6	Small boat berth	B	0.5
7	Fishing berth	B	1.0

4.1.3 Berthing Load [IS 4651(Part III) – 1974]

Berthing Energy, when an approaching vessel strikes a berth a horizontal force acts on the berth. The magnitude of this force Depends on the kinetic energy that can be absorbed by the rendering system. The reaction force for which the berth is to be designed can be obtained and Deflection-reaction diagrams of the fendering system chosen. These diagrams are obtainable from fender manufacturers the kinetic energy, E, imparted to a fendering system, by a vessel moving with velocity V m/s is given by:

$$E = \left(\frac{W_D V^2}{2g}\right)(Cm)\ (Ce)\ (Cs)$$

Where,

WD = Displacement Tonnage (DT) of the vessel (5000DWT)

V = Velocity of Vessel in m/s, Normal to the Berth (0.10m/s)

g = Acceleration due to Gravity in m/s^2 (9.81 m/s^2)

cm = mass coefficient (Refer Table-2) =0.51m/s

ce = eccentricity coefficient = 1.6m/s

cs = soft coefficient = 0.95m/s

E = 19.75kN.m

1 unit of berth (33 meters)

4.1.4 Mooring Load [IS 4651 (Part III) -1974]

The mooring loads are the lateral loads caused by the mooring lines when they pull the ship into or along the dock or hold it against the forces of wind or current. The maximum mooring loads are due to the wind forces on exposed area on the broad side of the ship in light condition

F = Cw Aw P

Where,

F = force due to wind in Kg

C_w = shape factor = 1.3 to 1.6

A_w = wind age area in m^2

P = wind age pressure in m^2 to be taken in accordance with IS: 875-1964

The wind age area (A_w) can be estimated as follows:

A_w= 1.175L_p (D_M-D_L)

Where,

L_p= length between perpendicular in meter

D_M = mould depth in m, and

D_L =average light draft in m.

Actual this is the actual procedure but port engineers suggested that bollard pull = 900kN is adopted (Design load). Generally mooring load act in various angle of forces so we have to resolve on the mooring point while designing the berth. And spacing taken as bollard to bollard is 15m c/c, if suppose we fixed 7 bollards then the load on each bollard is

900/7 = F = 128kN

Resolving of forces on mooring points are as follows,

Horizontal component = F Cos θ = 90kN

Vertical component = F Sinθ = 90kN

Generally angle is taken as 450 here if necessary need to calculate at different angles as per maximum ship moment observations.

4.1.5 Current load [IS 4651(Part III)-1974]

Forces due to Current - Pressure due to current will be applied to the area of the vessel below the water line when fully load

$$F = \frac{WV^2}{2g}$$

Where,

Unit weight of water (w) = 1.025 tones/m^3

Velocity of current (v) = 0.26m/s

Acceleration due to gravity (g) = 9.81m/s^2

F= 0.035kN/m^2

For 1 unit of berth F = 0.035X33X21.65 =25kN

25kN for 12 piles for each pile F = 2.02 kN

Load distribution is converted as uniform on pile

F=2.02/21.6=0.096 kN/m

4.1.6 Earth Pressure [IS 4651(Part III)-1974]

P_a= Kγh

Where,

K = coefficient of earth pressure

h = height of the structure = 30m

γ = unit weight of soil=18kN/m^3

ϕ = angle of internal friction of the soil =30°

$K = (\frac{1-\sin\emptyset}{1+\sin\emptyset})$

$P_a = (\frac{1-\sin 30°}{1+\sin 30°})$ x 18 x 30 = 19.98KN/m^2

=19.98 x 3 x 33(for 1 unit of berth)

= 1978/12 (on each pile)

= 164.8/3 (level)

Converted as uniform load =54.945 kN/m

Table -2: Level wise earth pressure on piles

Level (m)	Pressure (kN/m)	On each pile (kN/m)
0-3	17.4	47.85
3-4.5	28.7	78.92
4.5-7.5	19.14	52.6
7.5-9	9.57	26.31

4.1.7 Hydrostatic Pressure [IS 4651(Part III)-1974]

In the case of waterfront structures with backfill, the pressure caused by difference in water level at the fill side and waterside has to be taken into account in design.

$$P = \gamma h$$

Where,

γ = unit weight of water =10kN/m^3

H = water head on structure=18m

P =10 x 18 = 180kN/m^2

= 180 x 1.57

= 270kN/m on each pile

4.1.8 Wind Load [IS 875-Part (III) - 1987]

Wind contributes primarily to the lateral loading on a pier. It blows from many directions and can change without notice. The wind impinging upon a surface increases the pressure on that surface and results in a force loading.

Wind speed (V_z) = $V_b \times k_1 \times k_2 \times k_3$

Where,

V_b = basic wind speed

k_1 = probability factor (Risk coefficient) =0.92

k_2 = terrain, height and structure size factor =1.05

k_3 = topography factor = 1

V_z = (50) (0.92)(1.05)(1) = 48.3m/sec

Design wind pressure p = 0.6(v_z)^2

P = 1400N/m = 1.4 kN/ m^2

The design wind pressure is resolved as nodal loads = 1.4× 33×1 = 46.2/12 = 3.85 kN

4.1.9 Seismic load [IS 1893 - Part (1)]

Design seismic base shear $V_B = A_h W$

$$A_h = \left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)\left(\frac{I}{R}\right)$$

Where,

A_h = horizontal seismic coefficient

W = seismic weight of structure

Z = zone factor = 0.16

I = importance factor = 1.5

R = response reduction factor = 5

$\left(\frac{S_a}{g}\right)$ = 2.50 (hard rock)

$$A_h = \left(\frac{0.16}{2}\right)\left(\frac{2.5}{9.81}\right)\left(\frac{1.5}{0.5}\right) = 0.006$$

W= seismic weight of the structure=55318.5kN

VB=.006X55318.5

V_B= 4500.5kN

The approximate fundamental natural frequency period of vibration = $(\frac{0.09h}{\sqrt{d}})$ (T_s in sec)

h= height of the structure in meter

d= base dim. of the structure at plinth level in m

$$T_s = (\frac{0.09*20}{\sqrt{33}}) = 0.31 \text{ sec}$$

4.1.10 Basic Load Combinations

- D.L+1.5L.L + 1(Earth Pressure) + 1 (Hydrostatic Pressure) + 1.5 (Berthing Load) + 1.5 (Mooring Load)
- 1.2D.L+1.2L.L+1E.P+1.2H.P
- 1.2D.L+1.2L.L+1E.P+1H.P+1.5 (Wind Load)
- 1.2D.L+1.2L.L+E.P+1H.P+1.5 (Seismic Load)

5. DESIGN OF THE STRUCTURE

5.1 Slab Design

a. Data:

L_x = 5.24m; L_y = 5.24m

f_{ck} = 40 N/mm²

f_y = 415 N/mm²

$\frac{\text{Ly}}{\text{Lx}} < 2$ *Two way slab*

$\frac{5.24}{5.24} = 1 < 2$

b. Depth of the slab:

Over all depth is taken as D=300mm

Effective cover d'=D – d=300-217

Effective cover d'=83mm

Clear cover=75mm

c. Loads:

Self-weight of the slab = 0.300 x 25 =7.5kN/m²

Service Load = 10kN/m²

Total Load = 22.5kN/m²

Design Ultimate Load = 1.5 x 22.5 =

= 33.75KN/m²

d. Ultimate Design moments and shear force:

$M_u = \frac{wl^2}{8} = \frac{(33.75X(5.24X10^3)^2)}{2}$=115.83 kNm

$V_u = \frac{wl}{2} = \frac{(33.75X5.24X10^3)}{2}$=88.425kN

e. Design of reinforcement:

$\frac{Mu}{bd^2} = \frac{115.83X10^6}{1000X217^2}$=2.459

Refer Table 2 SP-16 and read out the percentage of steel corresponding to

Fe = 415N/mm²,

f_{ck} = 40N/mm²

Percentage of steel required p_t =0.738%

$A_{st} = \frac{0.74}{100}$X1000X217 = 16058mm²

Provide 1605.8 mm² Area of steel.

Diameter of the bar is 16mm is taken

Area of the bar = $\frac{\pi}{4}d^2$ = 200mm²

Required spacing between bars = 130mm

Number of bars required per meter =

$$\frac{\text{Ast}}{\text{area of the bar}} = \frac{1605.8}{200} = 8\text{No's}$$

f. Check for shear stress:

$\tau_v = \frac{Vu}{bd} = \frac{88.425X1000}{1000X217} = 0.407N/mm^2$

$Pt = \frac{100Ast}{bd} = \frac{100X1605.8}{1000X217} = 0.74N/mm^2$

Refer Table 19 of IS 456 and readout.

K=1

τ_c=0.6N/mm²

K τ_c=1x0.6=0.6N/mm²

K $\tau_c > \tau_v$

Hence the shear stress is within the safe permissible limits

g. Check for deflection control:

$(\frac{L}{d\prime})max = (\frac{5.24X10^3}{83}) = 63$

$(\frac{L}{d})\ actual = (\frac{5.24X10^3}{217}) = 24.15$

$(\frac{L}{d\prime})\ max > (\frac{L}{d})actual$

Hence deflection control is satisfied, Reinforcement in edge strips

A_{st} min=0.12% of effective depth

$=\frac{0.12}{100}$ x 1000 x 217

= 261mm²

Provide 12 mm diameter bars at 70 mm

5.2 Longitudinal beam design

Grade of concrete	= M_{40}
Grade of steel	= Fe_{415}
Cover	= 75 mm
Spacing between bars	= 200 mm
Longitudinal reinforcement	= 20 mm dia bars used

Shear reinforcement in x-direction with 12 mm diameter at 160 mm c/c

Shear reinforcement in y-direction with 12 mm diameter bar at 160 mm c/c

Size of beam = 1500 x 300mm

Area of top reinforcement = 6196.7mm²

Area of bottom reinforcement = 10427.3mm^2

Skin reinforcement is provided 24 bars with 20 mm diameter with spacing 50 mm

Number of bars used in top = 20 No's

Number of bars used in bottom = 20 No's

5.3 Transverse beam design

Grade of concrete = M_{40}

Grade of steel = Fe_{415}

Cover = 83 mm

Spacing between bars = 300 mm

Longitudinal reinforcement = 20 mm diameter bars

Shear reinforcement in x- direction with 12 mm diameter at 300 mm c/c

Shear reinforcement in y-direction with 12mm diameter bar at 300mm c/c

Size of beam = 400 X 800 mm

Area of top reinforcement = 4565.3 mm^2

Area of bottom reinforcement = 10055mm^2

Skin reinforcement is provided 15 bars with 20mm diameter 50mm spacing

Number of bars used in top = 15 No's

Number of bars used in bottom = 15 No's

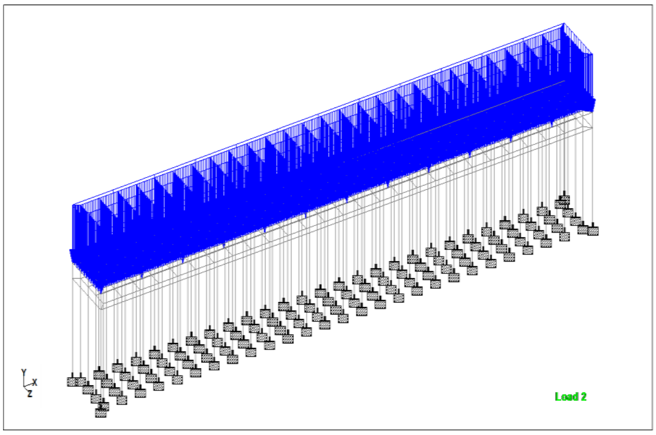

Fig -7: Live Load

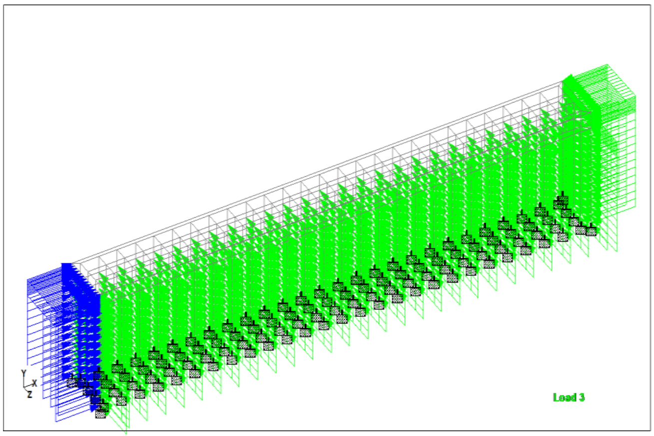

Fig -8: Wind Load

5.4 STAAD. Pro Analysis

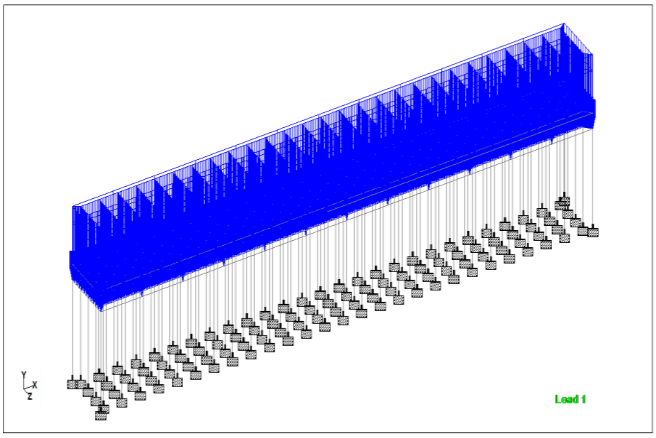

Fig -6: Dead Load

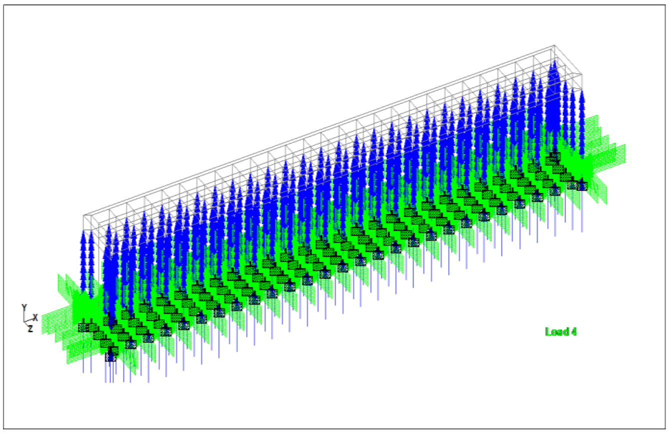

Fig -9: Earthquake Load

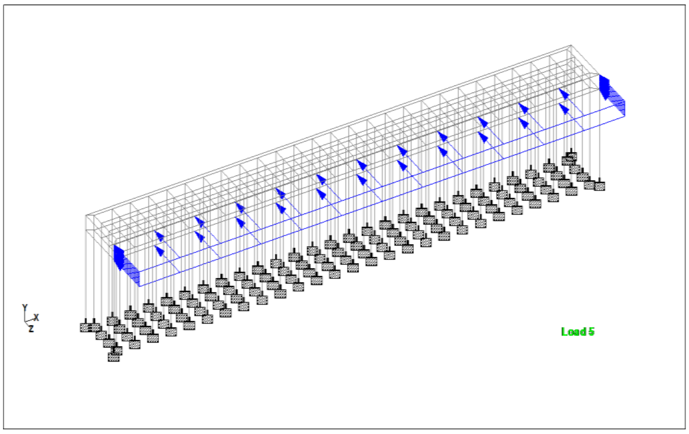

Fig -10: Berthing Load

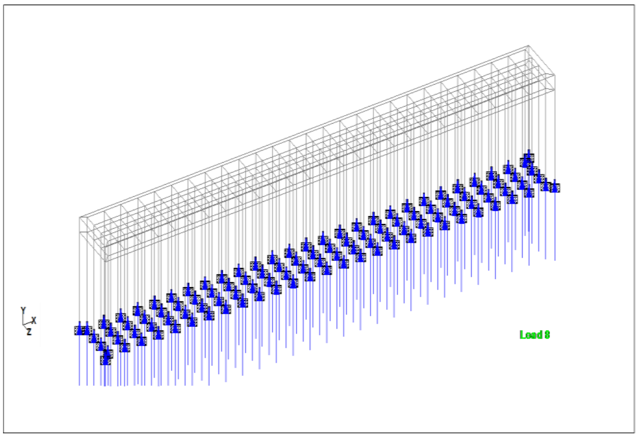

Fig -13: Earth Pressure Load

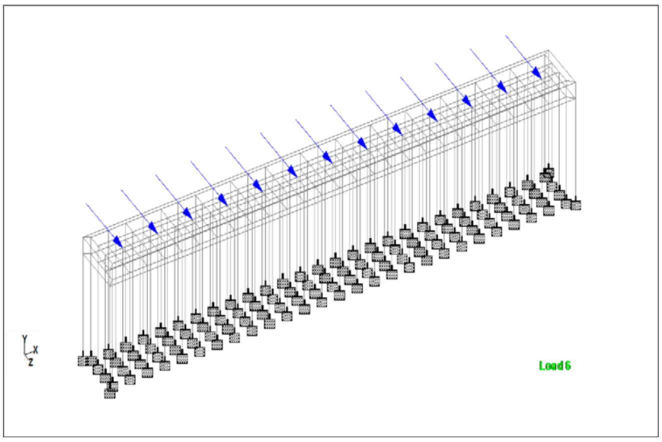

Fig -11: Mooring Load

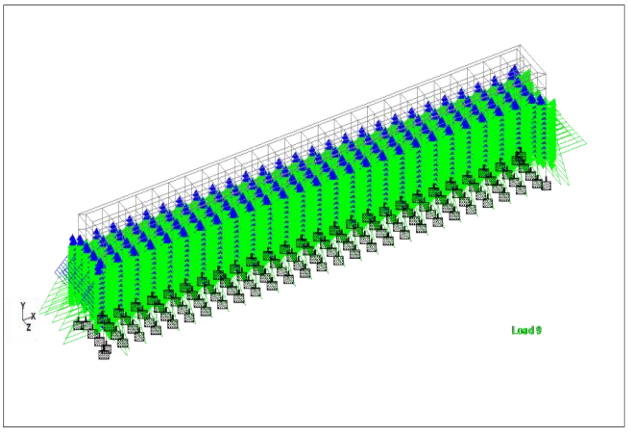

Fig -14: Water Pressure Loads

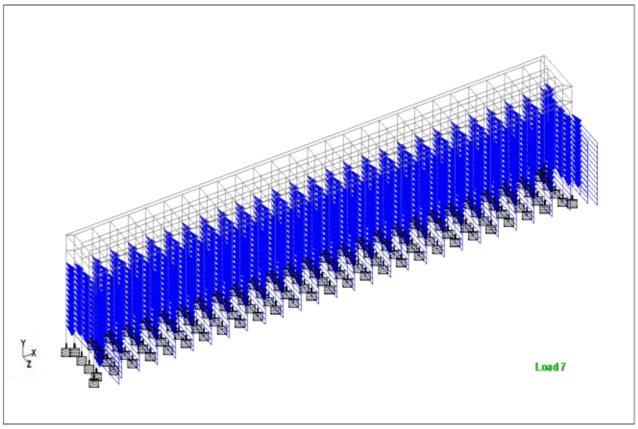

Fig -12: Current Load

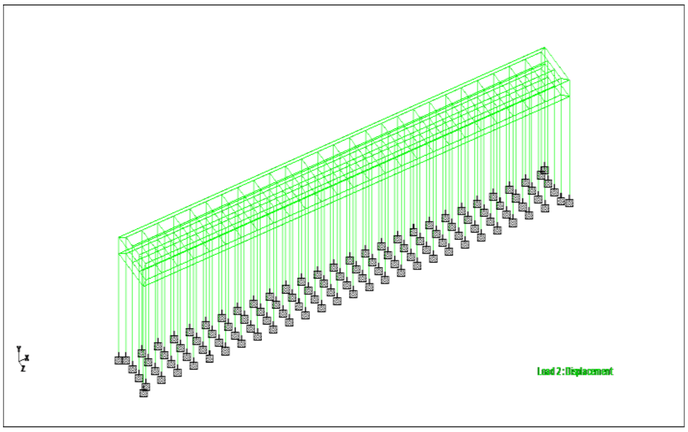

Fig -15: Displacement

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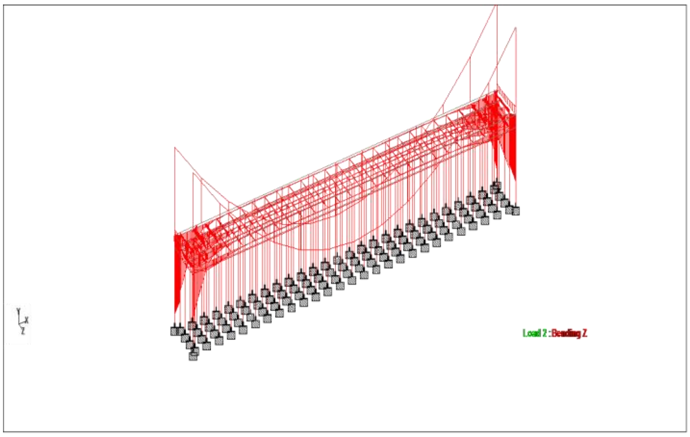

Fig -16: Bending Moments

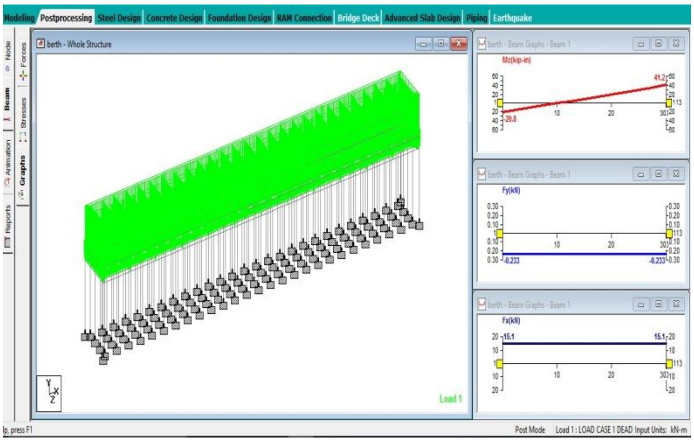

Fig -17: Load Analysis

6. CONCLUSION

The Analysis and Design of Passenger Berthing Structure has been Completed Successfully. The Structural elements are designed manually by using limit state design and the whole Berthing structure has been analyzed by using STAAD Pro Software. The Design of Slab, Beam has been done as per limit state design. The beam having the maximum positive and maximum negative bending moment is taken from the manual analysis report and it is designed using limit state method of design. The compression and tension reinforcement is calculated and the shear reinforcement is provided. Thus the structural elements in the berthing structure are designed and reinforcement details are calculated successfully.

REFERENCES

[1] Considerations||, Second Revision, Bureau of Indian Standards, New Delhi.

[2] Dayaratnam P and Design of Reinforced Concrete Structures New Delhi oxford and Ibh publishing co 2010

[3] Design of Structures||, Fourth Revision, Bureau of Indian Standards, New Delhi.

[4] Dr Khalid Mahmood Limit state design of reinforced concrete 2009

[5] Earthquake) For Buildings and Structures Part 3 Wind Loads||, Second Revision, Bureau of Indian Standards, New Delhi.

[6] IS 14238:1995, ―Code of Practice for Inland vessels – Selection of rubber Fenders for berthing structures code of practice||, second Revision, Bureau of Indian Standards, New Delhi.

[7] IS 456: 2000, ―Code of Practice for Plain And Reinforced Concrete Code Of Practice||, Ninth Revision, Bureau of Indian Standards, New Delhi.

[8] IS 4651 (Part IV): 1989, ―Code of Practice for General Design

[9] IS: 1893-1984, ―Code of Practice Criteria For Earthquake Resistant

[10] IS: 4851 (Part III) – 1974, ―Code Of Practice For Planning and Design of Ports and Harbours ―, First Revision, Bureau of Indian Standards, New Delhi

[11] IS: 875 (Part 1) – 1987, ―Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures Part 1 Dead Loads — Unit

[12] IS: 875 (Part 3) – 1987,|| Code of Practice for Design Loads (Other Than

[13] IS: 875 (Part 5) – 1997, ―Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures Part 5 Special Loads and Combinations||, Second Revision, Bureau of Indian Standards, New Delhi.

[14] Kavitha.P.E, Dr..Narayanan.K.P, Dr. Sudheer.C.B., ―Software Development for the Analysis and Design of Ship Berthing Structures||, ACEEE Int. J. On Transportation and Urban Development, 2011, Vol.1, No. 1.

[15] N. Krishna Raju, Design of Reinforced Concrete Structures, 2010

[16] PC. Varghese, Design of Reinforced Concrete Structures in Limit State Method of Design. As per IS 456:2000, second edition 2009.

[17] Punmia BC Reinforced Concrete Structures Volume I Delhi Standard publishers distributors, 2010

[18] Ramamurthi. S Design and Testing of Reinforced Structures Delhi Dhanpat Rai & Sons, 2011

[19] S.N. Sinha Reinforced Concrete structures, sixth edition

[20] WAPCOS, (2009) Detailed Report on Development of Fishery Harbor at Madhwad

[21] Weights of Building Materials And Stored Material||, Second Revision, Bureau of Indian Standards, New Delhi