Assessment of Structural Behaviour of Jetty under Marine Loads and It's Design for Berthing of Vessels

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Abstract— This report consists of application of various marine loads as per Indian standard codes on jetty structure and observing the behaviour of the structure under given loads and load combinations. The structure is also modelled and designed for all the seismic zones in India and the change, behaviour and Sensitivity of structure to different loads is discussed in the report.

Keywords: Dead load, Berthing of Vessels, Marine Loads, jetty structure

I. Introduction

Waterways play an important role in the transportation of goods and people across the world and are thus crucial to the development of a country's industry, trade and economy. In this report a jetty is considered for berthing of vessels with three rows of piles in transverse direction with 6m C/c distance apart and longitudinal piles with 4m C/c distance apart up to desired length of jetty. Various loads coming on to the jetty are calculated as per Indian standard codes and designed have been carried out for corresponding load combinations.

II. Loads on Structure

A. *Dead load:*

Dead load coming on the structure are mainly self-weight of all components of structure, any other permanent loads that can be considered in dead load. For calculation of dead loads IS 875 (part1) -1987 is adopted.

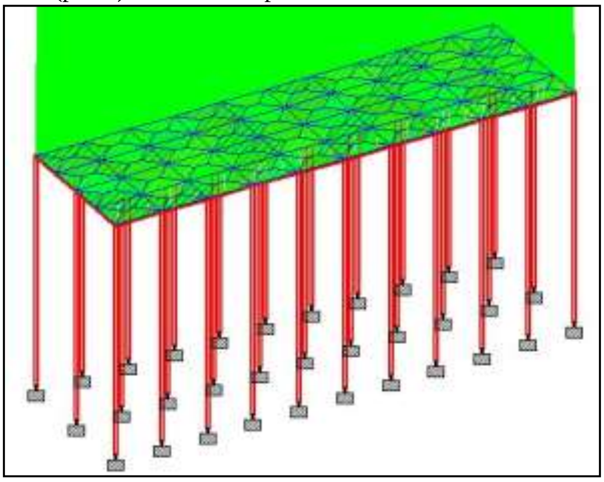

Fig. 1 : Dead load application in model

B. *Live load:*

Live load on structure depends on the type of the usage of the platform like for passenger movement , Cargos unloading and loading , type of the vehicle movement on the platform like type of crane , number of cranes, crane operating weight, any other surcharge weights. IS 875(part2) and IRC 6: 2014 is adopted.

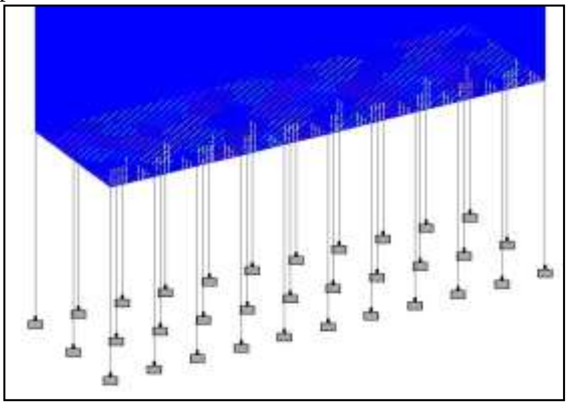

Fig. 2: Live load application in model

C. *Wind force:*

Calculation of basic wind speed was carried out as per IS 875(part3)-2015.

Design wind speed

$$V_z = V_b * K1 * K2 * K3 * K4$$

$$P_z = 0.6 * V_z^2$$

Vb = basic wind speed
Vz = Design wind speed at height z
K1 = Probability factor (risk coefficient), (Clause 6.3.1)
K2 = Terrain roughness and height factor, (Clause 6.3.2)
K3 = Topography factor, (Clause 6.3.3)
K4 = Importance factor for cyclonic region, (Clause 6.3.4)

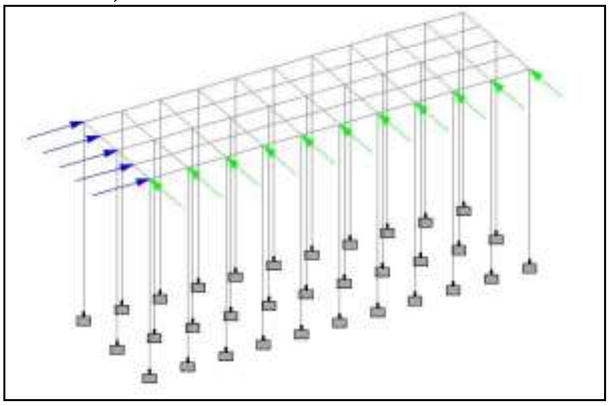

Fig. 3: Wind load applied model along X direction

D. *Seismic force:*

IS 1893-2002 is used for Seismic force calculation. 100 percent of dead load and 50 percent of live load is considered in seismic weight calculations.

$$A_h = \frac{Z.I.S_a}{2.R.g}$$

Z= Zone Factor.
I= Importance Factor.
$\frac{Sa}{g}$ = Average response acceleration coefficient.
R= Response reduction factor.
Vb = Ah .W
W=Seismic weight of the structure.
Vb= Base Shear.

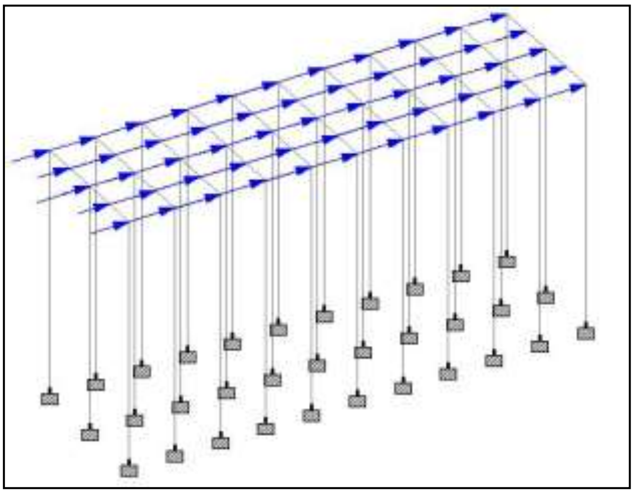

Fig. 4: Seismic load applied model along x+ direction

E. Wave Force and current force:

The seabed generally don't have an influence on the wave field in deep water. When waves encounter an island, headland or obstacles during their propagation, they diffract through these obstructions and such phenomenon should be account for in the wave analysis.

For the deep water waves, the most important processes in the development of the wave field are usually energy growth from wind, deep water waves propagation and eventual decay of wave energy.

Pressure due to current forces will be applied to the area of the vessel below the water line when fully loaded. It is approximately equal to $W.V^2 / 2.g$ per square meter of area, where v is the velocity in m/s and w is the unit weight of water in tonnes/m3. The generally ship is berthed parallel to the current With the strong currents and where berth alignment materially deviates from the direction of current, the likely force should calculated by any recognized method and taken into account. For the calculation of the velocity along the depth of pile at each of the specified location.

$$P = \frac{k.w.v^2}{2g}$$

Where,
P= Pressure force
w=unit wt. of water in tonnes/m3
g=acceleration due to gravity
k= for circular c/s=0.70
v=current velocity

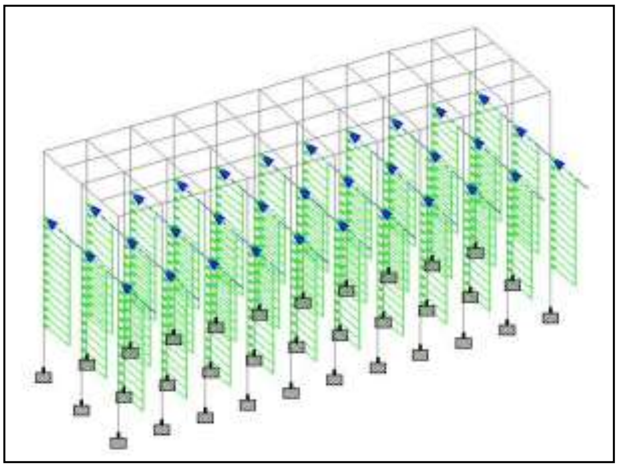

Fig 5: Current force and wave force application in model

F. Earth Pressure:

Earth Pressure force is applicable only if the berth has a retaining wall at the landside and it retains the earth. Thus the active earth pressure can be defined as, if the wall moves sufficiently away from the backfill by translatory motion or by rotation about the base or by their combination, lateral pressure of the backfill is reduced and is termed as Active earth pressure.
Soil Data soil
γ_{soil} = Unit wt. of soil (KN/m3),
Surcharge Load= q (KN/m2),
ϕ= Internal Friction Angle,

$$Ka = \text{Coeff. Of active earth pressure} = \frac{1 + \sin\phi}{1 - \sin\phi}$$

Lateral earth pressure due to soil (P1) => $P1 = Ka .\gamma .H$
Lateral Pressure due to Surcharge (P2) => $P2 = Ka \times q$

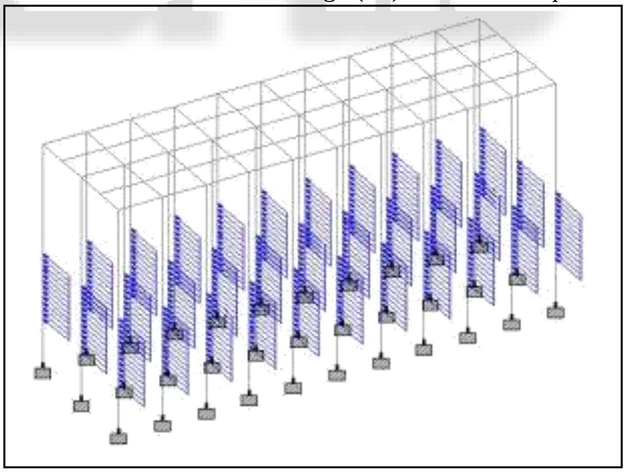

Fig. 6: Earth pressure application in model

G. 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 fendering system. The reaction force for which the berth is to be designed can be obtained and deflection-reaction diagrams of the fendering system chosen as required. 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 below:

$$E = \frac{Wd \cdot V2 \times Cm \times Ce \times Cs}{2g}$$

Where,
V= Vessel moving with velocity
Wd = Displacement tonnage (DT) of the vessel in Tonnes.
g = Acceleration due to gravity in (m/sec2)
Cm = Mass Coefficient
Ce = Eccentricity Coefficient
Cs = Softness Coefficient

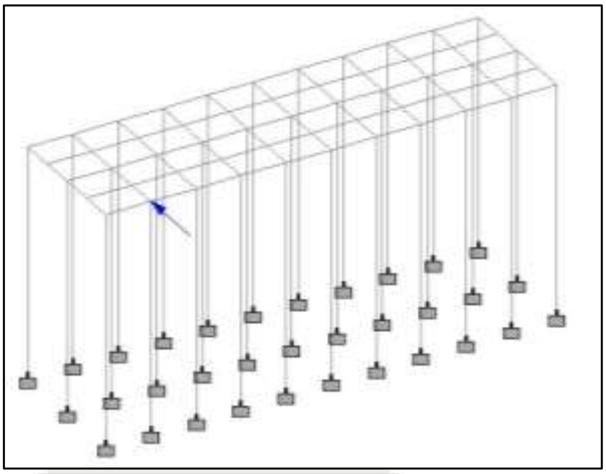

Fig. 7: Berthing force application in model

H. *Mooring Force:*

The mooring loads are the lateral loads that caused by the mooring lines when they pull the ship into the dock 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 = C w .Aw .P
F = Force due to wind in kg
Cw = Shape Factor =1.3 to 1.6
Aw = Windage Area in m2
P = Wind pressure in kg/m2 to be taken in procedure with IS 875-1987

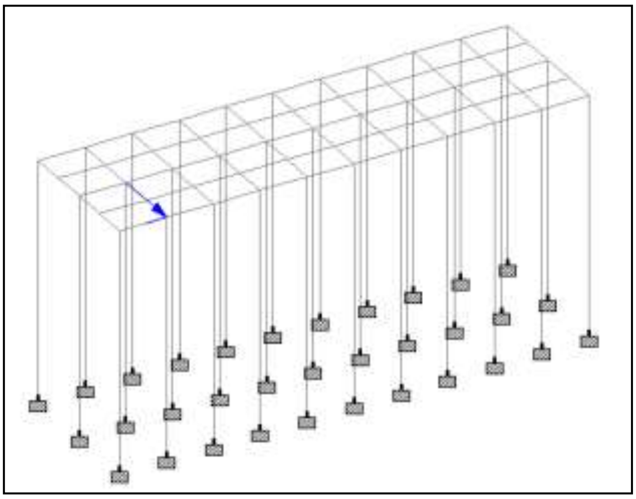

Fig. 8: Mooring force application in model

I. *Temperature Stress:*

Temperature stresses are generally makes very big impact on Jetty structure mostly along the length of the structure. Temperature change cause additional strain to structural element. For unconstrained structural element temperature change cause zero stress, but for constrained structural element that temperature change causes stress. For this reason expansion joints are provided so that the joint is free to expand.

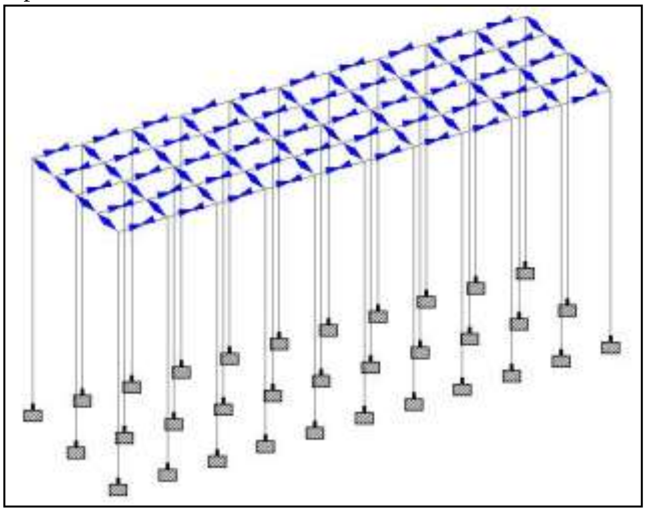

Fig. 9: Temperature force application in model

III. MATERIAL PROPERTY

A. *Concrete Properties:*

Young's Modulus (E)	=	31622.77 MPa
Poissons'Ratio	=	0.17
Density	=	25kN/m3
Thermal expansion	=	10^{-5} /c
Critical Damping	=	0.05

B. *Steel Properties:*

Young's Modulus (E)	=	205000 MPa
Poissons'Ratio	=	0.3
Density	=	76.8195 kN/m3
Thermal expansion	=	$1.2*10^{-5}$ /c
Critical Damping	=	0.03

IV. DESIGN

A. *Design of pile:*

Diameter of pile: 1200mm
Clear cover: 70mm
Grade of concrete: M40
Grade of steel: Fe 415

B. *Design of Main beam:*

Diameter of pile: 1200x1800mm
Clear cover: 50mm
Grade of concrete: M40
Grade of steel: Fe 415

C. *Design of Secondary beam:*

Diameter of pile: 600x1200mm
Clear cover: 50mm
Grade of concrete: M40
Grade of steel: Fe 415

D. *Design of slab:*

Thickness of slab: 400mm

Clear cover: 25mm
Grade of concrete: M40
Grade of steel: Fe 415

V. CONCLUSION

Marine structures design depends the nature of bed rock and depth of embedment of pile into the bed and other various factors play key role in designing the structure. Berthing force calculation is very much depends on type of fender and the material type which is used.

In seismic Zone II and zone III Berthing force or mooring force is governing the design. Where as in Zone IV and Zone V seismic force is governing the design. The construction methodology, analysis and design of jetty for berthing of vessels has explained.

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