INFLUENCE OF STACK, CRANE, AND MOORING FORCES ON SUBSTRUCTURE OF A BERTHING STRUCTURE

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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. Substructure is a part of a structure which helps in transferring the load of the superstructure and its own load on to the supporting soil. Forces and moments acting on the superstructure were transfer to the substructure elements In this paper, 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 subjected to 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 paper describes the influence of Stack, Crane and Mooring forces on bending moment of "T" Shaped Diaphragm wall and the axial forces of vertical & racker piles.

Key Words: *SubStructure, Stack Load, Crane Load and Mooring Load*

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1. INTRODUCTION

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 The selection of the type of berth and the material used for its construction will depend upon a number of factors, such as Local customs and practice: for example the massive quays are generally used in Europe, whereas, open and light structures are usually constructed in America.

Fig.1. Berthing Structure

1.1 Sub Structure

Berthing mainly consists of superstructure, substructure. In superstructure; the main cross head beam is situate. Substructure is a part of a structure which helps in transferring the load of the superstructure and its own load on to the supporting soil. Forces and moments acting on the superstructure and their transfer to the substructure elements 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.

LITERATURE REVIEW

Andrew T. Metzger et al (2003): This manuscript discusses how a state-of-the-art monitoring system was devised and implemented for the purpose of measuring vessel berthing parameters. The purpose of this study was to develop and implement a structural monitoring system that would allow collection of vessel berthing metrics of interest to the engineering community

K.Muthukkumaran et al. (2003) This paper gives the behavior of berthing structure in sloped ground under seismic load studied the effect of dredging on piles and diaphragm wall-supported berthing structures. .The lateral capacity of the pile when subjected to mooring force in sloping ground is increased by 70%when tie rods are provided and in horizontal ground, it is increased by 65%.

K. K. Phoon (2004): This paper presents an overview of the evolution in structural and geotechnical design practice over the past half a decade or so in relation to how uncertainties are dealt with. For the general reader who is encountering reliability-based design (RBD) for the first time, this would provide a valuable historical perspective of our present status and important outstanding issues that remain to be resolved

P. V. PREMALATHA (2006): This paper deals with the distribution of Lateral Load among the Piles of a Berthing Structure gives an experimental investigation has been carried out with a model scale single row instrumented piles of a berthing structure, with and without tie rod anchor.. In the present study, pile group is analyzed in the sloping ground of 1V:2H slope and horizontal ground

R.SUNDARAVADIVELU (2007) :This paper describes the berthing structures are subjected to large lateral forces due to berthing and mooring vessels. The lateral forces are to be resisted by the vertical pile, raker pile or diaphragm wall. A study has been conducted on the earthquake damaged structures of cargo berths No 1 to 5 at Kandla port, situated in Gujarat. The original design slope for the cargo berths was 1V:3H

OBJECTIVE OF THE STUDY:

The main objective of this thesis is to study the Influence of Stack ,Crane and Mooring forces on bending moment of “T” Shaped Diaphragm wall .

And also the Axial forces of vertical and Racker piles.

SCOPE OF THE WORK:

- STAAD.Pro was used to model the Substructure of a Berthing Structure.
- This thesis was restricted to study the influence of varying Stack, Crane and mooring forces on bending moment of ”T”Shaped diaphragm wall and also the axial forces of vertical and Racker piles.
- The other loads B.G.M.L, Concentrated load & IRC 70R loads were assumed constant throughout the study.
- Size of beams & diameters of piles were kept constant throughout the study.

METHODOLOGY

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 (T.D.W) panels,17 Nos . vertical piles and 19 racker piles. The diaphragm wall is connected at the top through a cellular deck 2.8 metres deep to a series of vertical piles (V.P) 850 mm dia and raker piles (R.P) 700 mm dia . All the substructure elements are socketed in hard rock.

2.1 Material Properties

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

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, ε_{cu} =0.0035

Characteristic strength of concrete, fck = 30 MPa

Yield stress for steel, fy = 415 MPa

2.2 Modeling 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 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,

(-17m) neglected due to soft marine clay. Structural analysis package, "STAAD.Pro" is used for the analysis.

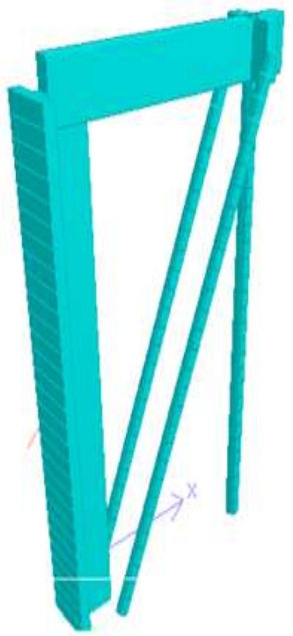

Fig2:A Model of Typical SubStructure In STAAD.Pro

2.3 Load combination consider for Substructure

Dead Load+ Live Load (Stack load+ Crane Load+ BGML +Concentrated load 20 T+IRC 70R+ +lateral pressure (EP+HP+MF))

3. RESULTS AND DISCUSSIONS

Analysis done for Substructure by using STAAD.Pro. Studied the Influence of varying Crane, Stack& Mooring forces on Bending moment of T" Shaped Diaphragm wall and the axial forces of vertical & racker piles.

3.1 Substructure with different loading conditions as follows:

The structure was analyzed for linear static analysis for the following Loads.
Stack load
Crane load
BGML load
IRC 70R load
Concentrated load
Mooring force of 90Tons
The results obtained are shown in Table No.2, 3 and 4 for variable stack, crane and mooring load

3.2 VARIABLE STACK LOAD

Table No.2. Details of Bending Moment of,"T" Shaped Diaphragm wall and the axial forces of vertical & racker piles for Stack load, keeping other loads constant.

Table.2

S. No	Stack Load (Tons/ m^2)	Max. positive B.M of T.D.W (Tons-m)	Max. Negt B.M of T.D.W (Tons-m)	Axial Force (R.P) (Tons)	Axial Force (V.P) (Tons)
1	5	2923.05	735.18	162.32	1218.0
2	5.25	2929.41	733.59	162.94	1224.3
3	5.5	2935.77	732.01	163.50	1230.
4	5.75	2942.13	730.42	164.20	1236.7
5	6	2948.75	709.35	165.2	1254.4

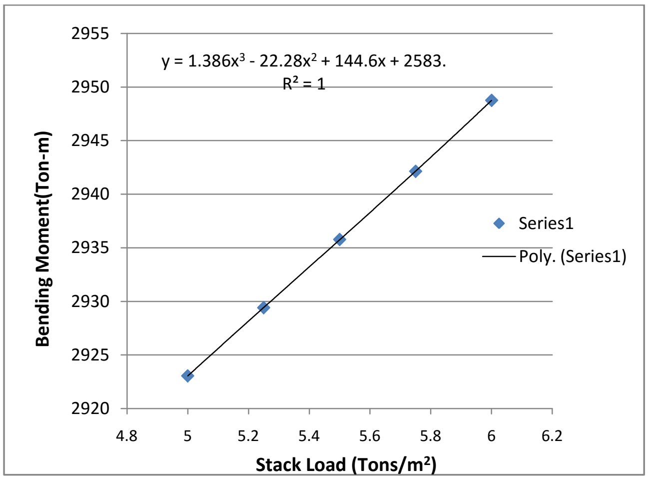

Fig 3. Stack Load v/s BM of T.D.W

Bending moment of T.D.W variation was in the polynomial of order 3 with respect to Stack load.

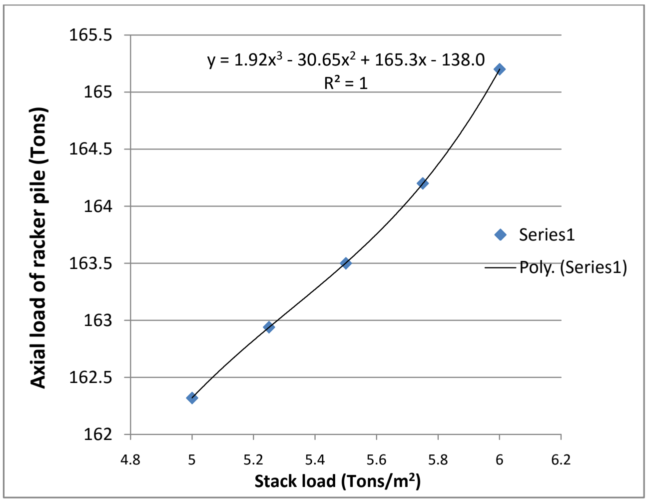

Fig 4. Stack Load v/s Axial force of (R.P)

Axial force of raker pile was in the polynomial of order 3 with respect to stack load.

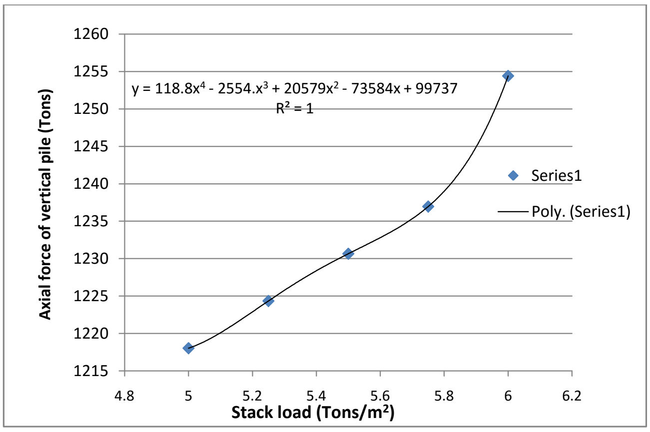

Fig 5. Stack Load) v/s Axial force of (V.P)

Axial force of vertical pile was in the polynomial of order 4 with respect to stack load.

3.3 VARIABLE CRANE LOAD

Table No3.Details of Bending Moment of,"T" Shaped Diaphragm wall and the axial forces of vertical & racker piles for Crane load, keeping other loads constant.

Table. 3

S. No	Crane Load (Tons)	Max. positive B.M of T.D.W (Tons-m)	Max. Negt B.M of T.D.W (Tons-m)	Axial Force (R.P) (Tons)	Axial Force (V.P) (Tons)
1	20	2923.05	735.18	162.32	1218.04
2	21	3000.29	736.15	164.11	1253.84
3	22	3077.54	737.11	165.89	1289.65
4	23	3154.79	738.08	167.68	1325.45
5	24	3232.03	739.05	169.47	1361.25

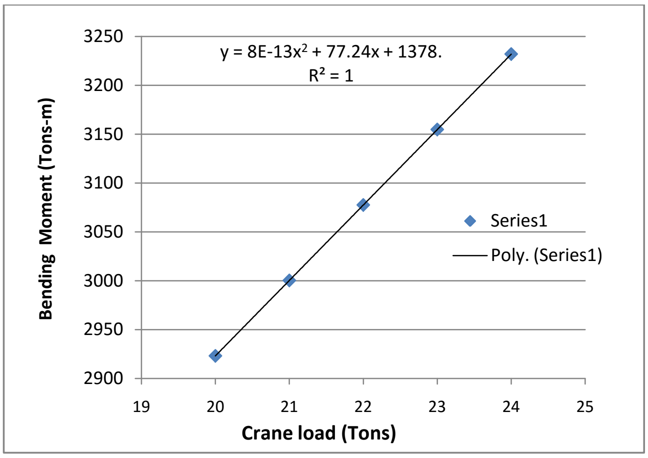

Fig 6. Crane Load v/s BM of T.D.W

Bending moment of T.D.W variation was in the polynomial of order 3 with respect to Crane Load

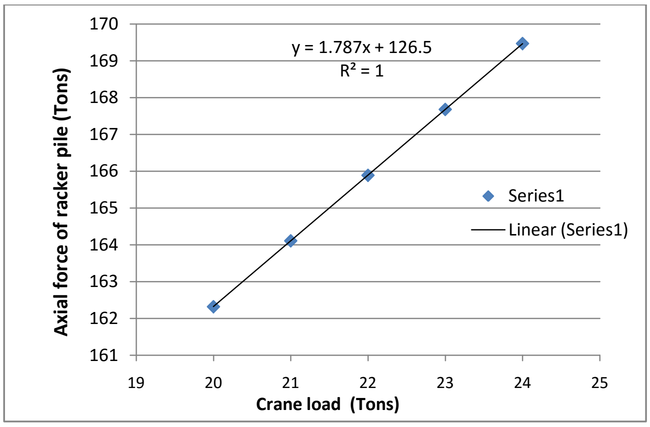

Fig 7. Crane Load V/S Axial Force Of (R.P)

Axial force of raker pile is linearly in order of 1 with respect to crane load.

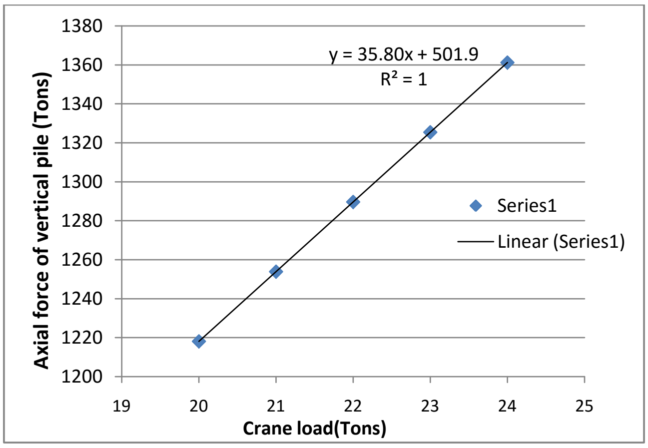

Fig 8. Crane Load v/s Axial force of (V.P)

Axial force of vertical pile linearly in order of 1 with respect to crane lo

4. VARIABLE MOORING LOAD

Table No4. Details of Bending Moment of "T" Shaped Diaphragm wall and the axial forces of vertical & racker piles for Mooring load, keeping other loads constant.

Table.4

S. No	Mooring Load (Tons)	Max. positive B.M of T.D.W (Tons-m)	Max. Negt B.M of T.D.W (Tons-m)	Axial Force (R.P) (Tons)	Axial Force (V.P) (Tons)
1	90	2923.05	735.15	162.32	1188.34
2	100	2933.39	745.37	164.97	1203.19
3	120	2949.58	761.32	169.12	1212.25
4	150	2976.11	787.4	175.93	1218.04

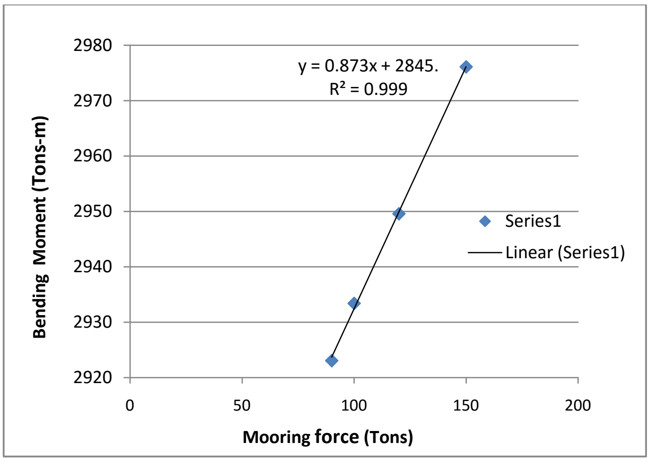

Fig 9. Mooring Load v/s BM of T.D.W

Bending moment of T.D.W variation was Linear with respect to Mooring Load of order 1

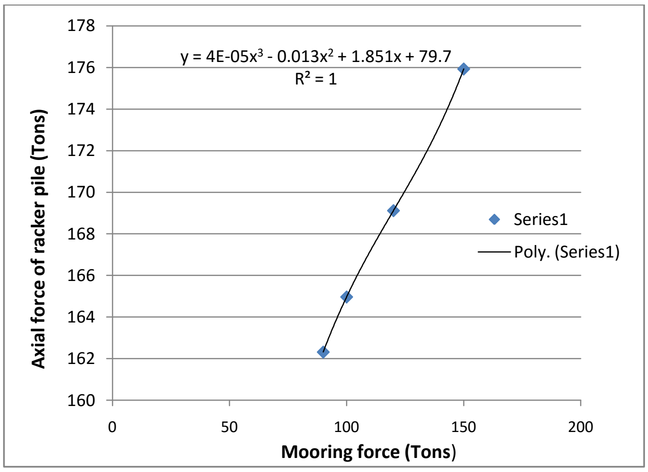

Fig 10. Mooring Load v/s Axial force of (R.P)

Axial force of raker pile was in the polynomial of order 4 with respect to Mooring Force.

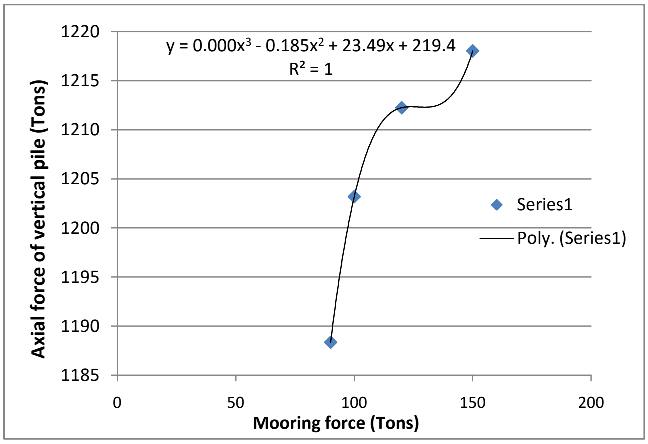

Fig 11. Mooring Load v/s Axial force of (V.P)

Axial force of vertical pile was in the polynomial of order 3 with respect to Mooring Force.

5. CONCLUSIONS

The following conclusions are obtained from the STADD.Pro analysis for variable stack , crane and mooring loads.

4.1. STACK LOAD

On increasing the stack load of 5%, 10%, 15%, 20% and 25% on 5T/m^2

a)The percentage of increase in the bending moment of T.D.W were 0.21,0.21,0.21,0.22,and 0.22 respectively.

c) The percentage of increase in the Axial force of racker pile were 0.38,0.34,0.42,0.6and 0.9respectively.

d) The percentage of increase in the Axial force of vertical pile were 0.51,0.51,0.51,1.39, and 1.39respectively.

4.2. CRANE LOAD

On increasing the Crane load 5%, 10%,15%, 20% and 25% on 20T

a)The percentage of increase in the bending moment of T.D.W were 2.57,2.51,2.44.2.38and 2.44respectively.

b)The percentage of increase in the Axial force of racker pile 1.09,1.07,1.06,1.05and1.04respectively.

c)The percentage of increase in the Axial force of vertical pile were 2.84,2.77.2.7.2.62, and 2.50respectively.

4.3. MOORING LOAD

On increasing 90T mooring load to 100T, 120T and 150T

a)The percentage of increase in the bending moment of T.D.W were 0.35,0.54,0.89 and 1.05respectively.

b) The percentage of increase in the Axial force of racker pile were 1.60,2.45,3.87 and 4.50respectively.

c)The percentage of increase in the Axial force of vertical pile were 0.47,0.74,1.23and 1..50respectively.

The variation in Crane load plays a major role in influencing the bending moment of "T" shaped diaphragm wall when compared to Stack load and mooring force.
The variation in Mooring force plays a major role in influencing the Axial force of racker pile when compared to Stack load and crane load.
The variation in crane load plays a major role in influencing the Axial force of vertical pile when compared to crane load and mooring force.

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