COMPARATIVE STUDY OF IN-SITU LONG PILE FROM BI-DIRECTIONAL STATIC LOAD TEST: A CASE STUDY AT VISHAKHAPATNAM

[1]Rahemanali Parabadiya, [2]Prof.Indrajit N Patel, [3]Er.Snehal Patel
[1]M.Tech. Student, [2]Professor,[3] Principal Engineer
[1]Structural Engineering Department,
[1]B.V.M Engineering College, V.V. Nagar, Anand, Gujarat, India

ABSTRACT: Bi-directional static loading test adopting load cells is widely used around the world at present, with increase in diameter and length of deep foundations. Some new load cells, test procedure, and construction technology were adopted based on the applications to different deep foundations. The paper presents the results of the bi-directional static load testing of a 1200mm diameter bored pile was designed for a load of 450 tons using a single level of S-cell. The length of the pile is 56.225m. The bi-directional static load testing method has proved advantageous over the conventional pile load testing methods in many aspects. This case was analyzed using finite element program PLAXIS 2D. The self-weight of the upper pile segment was taken into acccount. The equivalent top-load curve is used to illustrate as if the pile loaded from the pile head such as conventional head-down test. Comparison are presented between the results obtained when analyzed in PLAXIS and when field test is done.

KEYWORDS: Bi-directional load test, Cast in situ pile, Super cell, Ultimate bearing capacity

1. INTRODUCTION

The improvements to hardware and the materials utilized in the development of deep foundation, have made it possible to build a lot higher limit formations than were up to this point thought believable. S-Cell test the base obstruction and shaft opposition which must be changed over to equal top-load curve. Soil examination there is discovered three varied layer of soil under ground. The identical top-load curve of the bi-directional test results by considering pile supply pressure just as the pile conversation when the pile is connected at the top, instead of from the base. In numerous pieces of the world the greatest load that capacity be connected top-down applying vertical loads or kentledge is constrained in contrast with administration loads requested. Brilliant testing programs and the obtaining of amazing information are an essential for any real piling development works. The distinction in unit skin erosion between pile so f different diameter, even where the construction process may be the same in every otheraspect, can be large. These troubles are of incredible significance when the fashioner considers testing loads of a decreased distance across rather than full size heap testing. Acceptance this methodology may quick a hazardous extrapolation of the careful unit skin rubbing from littler model test loads to bigger measurement loads utilized underway. Even with the fact that the typical purposes behind this methodology are identified with cost when the required burdens are high for top-down loading, this isn't the situation with bi-directional test.

1.1 OBJECTIVES

- Plot graphs for load-settlement theoretical and practical of BDSLT
- Compare changes in parameters for different soil.
- To measure the pressure in the load cell, the displacements of the upper/lower parts of the piles shaft.
- To measure the total bearing capacity of the pile.

1.2 WORKING PRINCIPAL

When load is applied with top-down testing at the pile head via a reaction system, an equal force, P is applied downward to the pile and upward to the reaction system. All of the load measured at the pile head is applied to the pile, mobilising skin friction and the end bearing, P=F+Q. As shown in fig.1

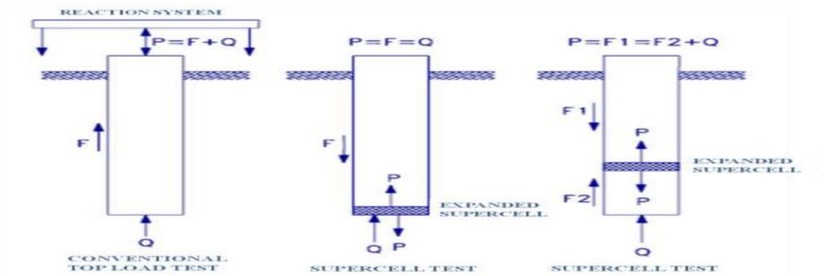


Fig.1 Test Method Comparison

With a S-cell placed at the toe of the pile, the load is applied directly to the end bearing. The skin friction is used to mobilise the base resistance and vice versa. Therefore, the skin friction and the base resistance mobilised are equal until one or the other reaches ultimate capacity or the S-cell system exceeds its capacity, P=F=Q. Where the skin friction (F1+F2) is expected to be higher than the base resistance, the S-cell can be placed at some balance point along the pile shaft where P=F1=F2+Q. The pile element above the S-cell uses the friction and end bearing below as a reaction Refer Fig. 1

2. SUBSURFACE SOIL CONDITION

Subsurfsce profile generally consists of recent fill overlying marine deposits (sand and clay) underlain by completely weathered rock and bedrock.filling consisting mostly of sandy clay/silty sand with gravels and boulders was encountered at the surfsce in borehole thickness of this layer was 6m to 8m.based on SPT test consistencies of cohesive soils(clay) typically between soft to very stiff,generally improving with the depth.completely weathered bed rock was encountered at 6m and 19 m below river bed in the marine borehole.spt test conducted in this layer encountered refusals (N>50),core recovery values varied between 0% and 10%.the bed rock was highly weathered to sound.core recovery values ranged between 10 and 96 %,while rock quality designation ranged between 0 and 79 % typically improving with depth. the borehole was terminated in the hard bedrock at 42 m to 60m.

3. BI-DIRECTIONAL STATIC LOAD TEST METHOD

The bi-directional static load test is conducted on bored pile with 1200 mm diameter and 56.225 m effective length. The proposed design load is 450 tons and the test load is 1125 tons. The test was executed using single level S-Cell, hence the pile will be divided into 2 segments. The hydraulic jack assembly consist of 600 tons in upward and downward direction. Hence, the total load capacity is 1200 tons. Figure shows the schematic of the pile load test installation. The drilling process of bored pile was under instruction and supervision of fthe engineer and the bottom elevation as also cleaned. Hydraulic jack assembly inside the cage used L-shaped bars and diagonal bars to directly weld to the cage. Concrete casting is done by using appropriate size tremie pipe with sufficient length to extend until the pile toe. The loading is done in 1 cycle and the load is increased at intervals of 10 % and the reading is maintained for 30 minutes while the 100% loading is maintained for 180 minutes. Meanwhile, for unloading condition, thre reading is taken for 15 minutes. The pile head movements were obtained directly using displacement tranducers which were installed on the reference beam with telltale rods attached to the pile head. Five (5) displacement tranducers were used to measure the movements of bottom pile, upper pile and pile top displacement.

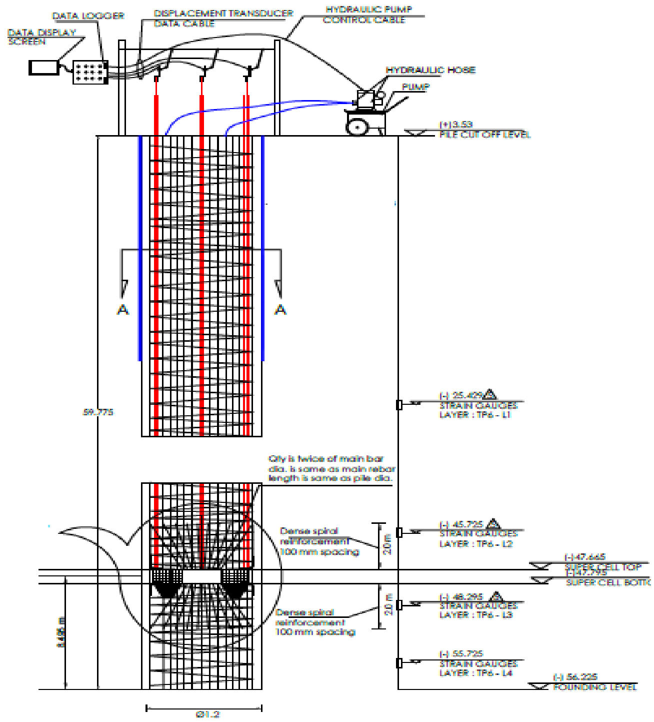


Fig.2 Schematic of pile load test installation

4. RESULT OF BI-DIRECTIONAL STATIC PILE LOAD TEST

Load testing initiated by applying hydraulic pressure to the hydraulic jacks using a water-driven hydraulic pump. A high-pressure Bourdon gauge as well as well-calibrated pressure transducer were used to control the pressure. The displacement transducers which supported by the reference frame were used to measure relative movement at the designated telltale locations. It should be noted that the result has not reflected the actual loading condition as the top cell which applies upward pressure is actually weighed by the buoyant weight of upper pile segment so it needs to be corrected by a reduction in pile buoyant weight. The bi-directional load test results have already corrected and is shown in Figure 3.

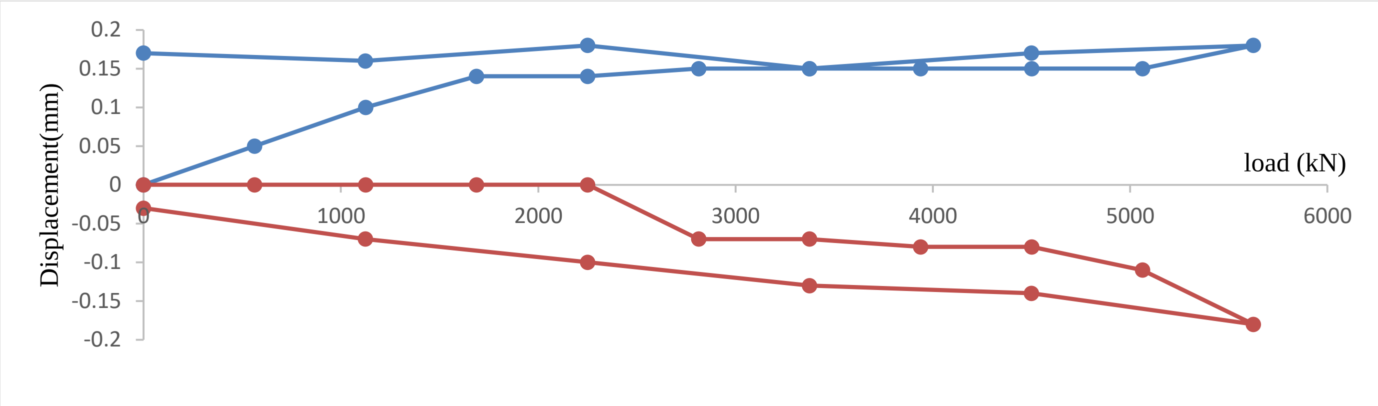


Fig.3 Results of Bi-directional Static Load Test

During cycle 1, the maximum pile top movement was 0.0 mm and maximum cell top movement was 0.18 mm and The maximum cell bottom movement was 0.18 mm which equivalent to the effective bi-directional load of 562.5 tons (250 % design load). In order to obtain the bearing capacity, the curve needs to be converted to equivalent top load curve Using research paper **[6]**

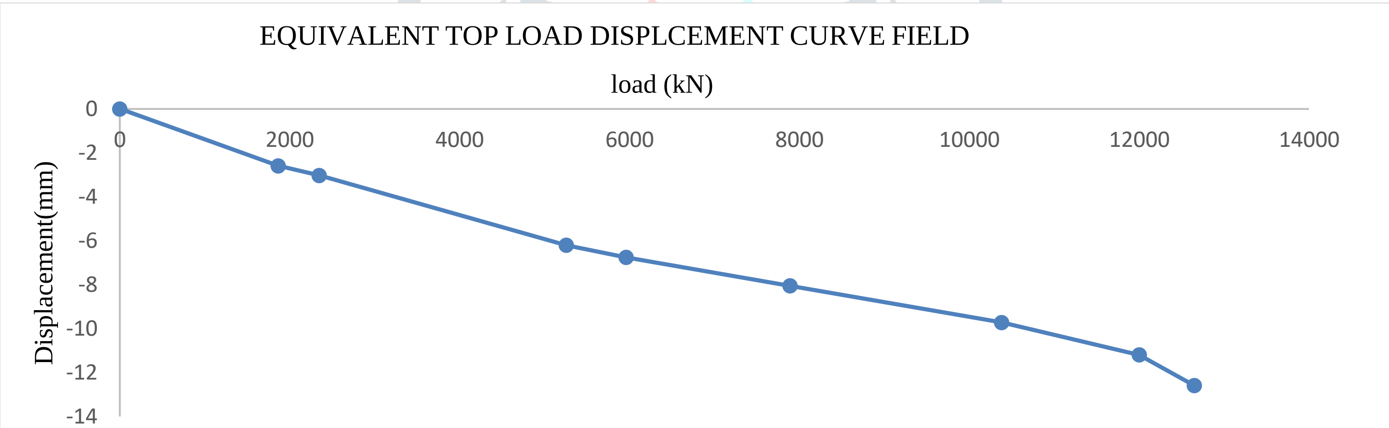


Fig.4 Computed Load Settlement Curve

5. MODELLING FOR SIMULATIONS OF PILE TEST

Geometry dimension of 60m x 60m. The soil is modelled as Mohr-Coulomb material with 15-nodes elements and classified into 4 layers. The soil stratification is modelled based on the average N-SPT. The pile is modelled as linear-elastic material with radius of 0.6m. To simulate the loading test, a same amount of distributed load is applied on top and bottom of S-Cell plate position. When the S-Cell began to work, the material between the plates is filled with elastic material with a very low elasticity modulus in order to minimize the interaction between upper and bottom segment. To improve the accuracy of the calculation, thethe stiffness and interface value to calibrate the load-displacement curve from numerical analysis with the field S-Cell test result.

Table 1: Material Parameters

Name of soil	Thickness of layer (meter)	ϒunsat [kN/m^3]	ϒsat [kN/m^3]	µ	Es [kN/m^2]	C [kN/m^2]	Ø [O°]
1. Silty Sand	20.28	17.2	19.6	0.35	9300	0	34
2.Stiff clay	6.41	16.2	19.9	0.3	15000	20	0
3.Extremely Wheathered Rock	22.07	21.3	21.7	0.25	250000	0	40
4. Moderately wheathered rock	11.24	25.4	25.4	0.2	300000	300	32

6. ANALYSIS RESULTS

The calculation was conducted with 10-phases analysis namely:

1. The drilling and casting of bored pile
2. Apply load of 5625 kN on top and bottom plates of S-Cell

3-10. Stage loading is applied with increment of 10% load until 100%

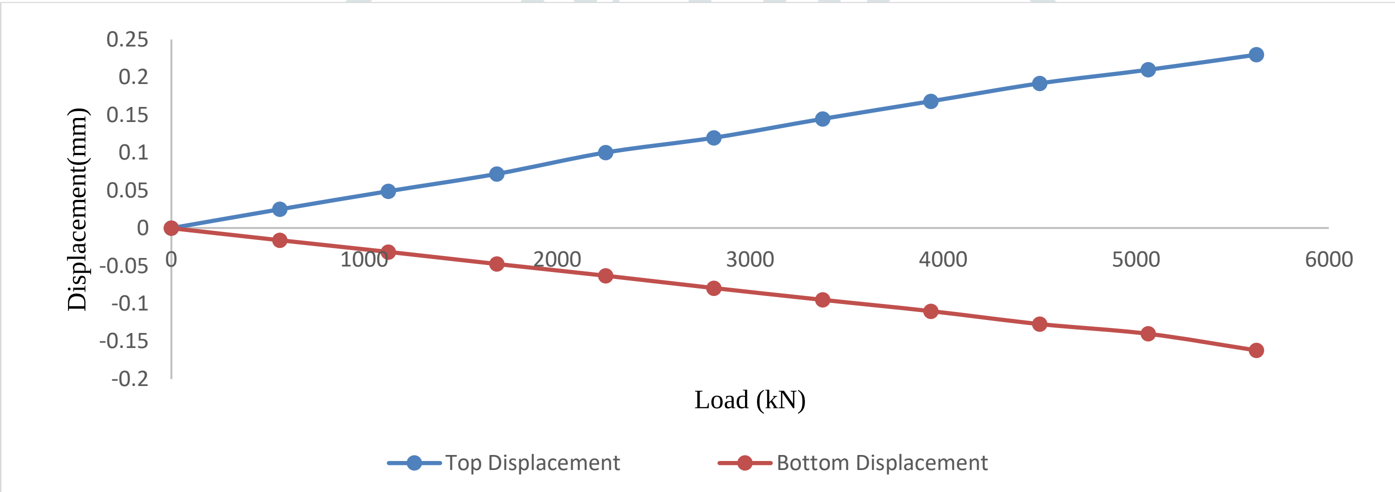


Fig.5 Load-Displacement Curve of S-Cell Test (PLAXIS)

The load-displacement curve of S-Cell from PLAXIS calculation is also compared with the curve from field testing and the result is quite similar. In order to obtain the bearing capacity, the curve needs to be converted to equivalent top load curve

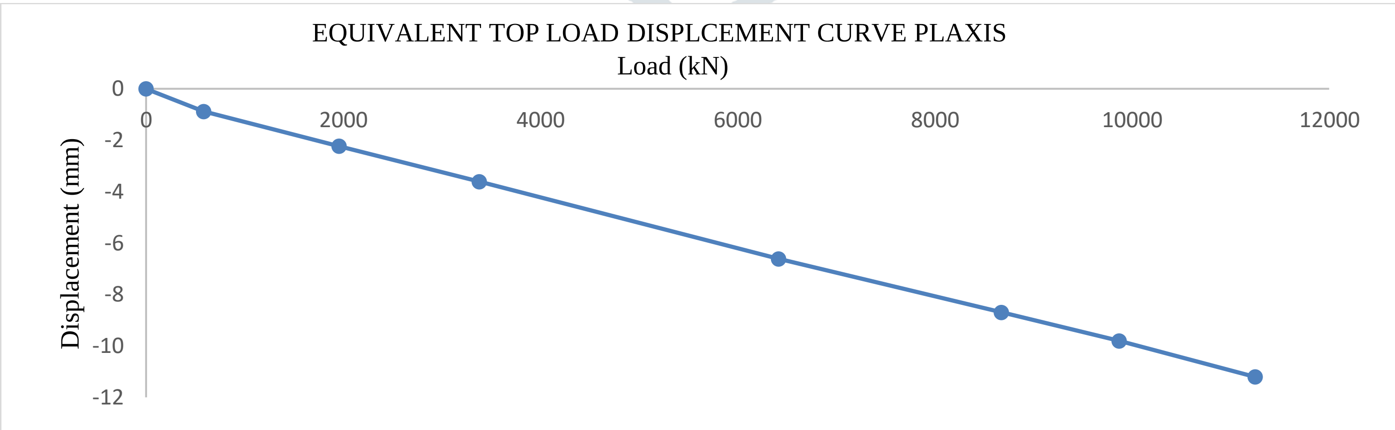


Fig.6 Equivalent Top-Load Curve of S-Cell Test (PLAXIS)

The load-displacement curve of S-Cell from PLAXIS calculation is also compared with the curve from field testing and the result is quite similar. In order to obtain the bearing capacity, the curve needs to be converted to equivalent top load curve.

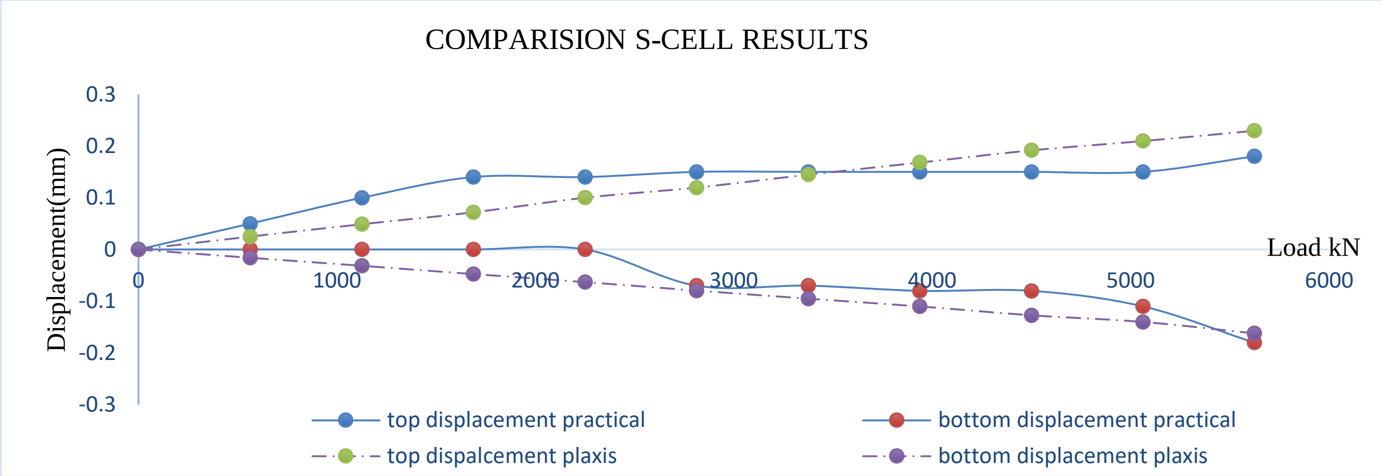


Fig.7 Comparison of S-Cell load-displacement curves between PLAXIS and field test

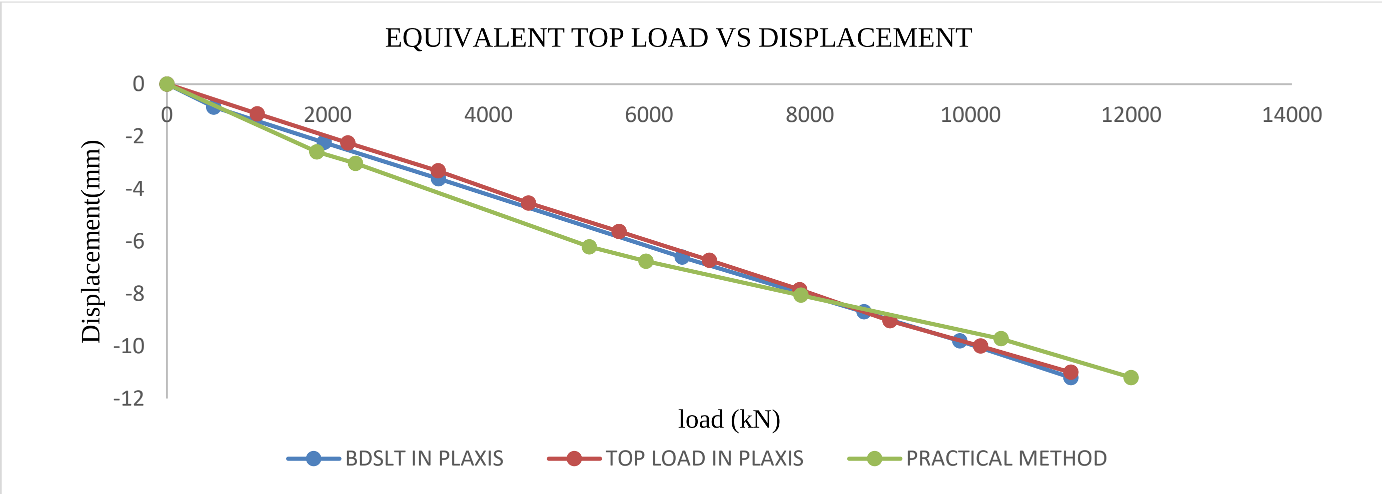


Fig.8 Comparison of Equivalent Top-Load Curves

7. RESULTS

A displacement of 10.51 mm was obtained during the test on the test pile 01 at a test load of 11250 kN on site while in Plaxis 2d software when modelled, a displacement of 11.20mm. Here it was observed % Error of = (11.20-10.51) *100/11.2 = 6.16%. A displacement of 4.61 mm was obtained during the test on the test pile 01 at a design load of 4500kN on site while in Plaxis 2d software when modelled, a displacement of 4. 71mm.Here it was observed that there was a % Error of = (4.71-4.61) *100/4.71 = 2.12%. The test pile was applied till the load of 11250 kN on site and was found that the test pile did not failed. Hence it was showed that using Load Cell the capacity of the pile is increased. The Ultimate capacity of the pile would the same as maximum capacity of the load cell. The Maximum capacity of the load cell is 5750kN.The displacement of the top pile increases as the modulus of elasticity of the soil is increased, while the displacement of the bottom pile is reduced as the modulus of elasticity of soil in increased. The result obtained in Plaxis 2d when the load was applied by the conventional method is similar to the result obtained when load applied is bi-directionally.

8. CONCLUSION

The ultimate bearing capacity of the test pile 01= 14.5MN. The percentage error of the displacement of pile practically and when modelled in Plaxis 2d software is 6.16 % and 2.57 %. This change is observed due to the calibration of the instruments that are used for the Bi-directional static load test, i.e. pressure gauge, displacement transducer. The maximum ultimate capacity is not reached in Plaxis 2D as there is no option available in the software to do the analysis by providing holding time period of the load. The change in the ultimate bearing capacity of both the test piles is observed due to the change in soil layer at the bottom from highly weathered rock to moderately weathered rock. The patented technology used for the bi-directional static load test is very cost effective and less time consuming method. The analysis of strain gauge data shows that the load is getting distributed throughout uniformly in long pile.

9. ACKNOWLEDGEMENTS

Permission by Supercell bharat$^{@}$ to present the analysis of the case data is gratefully acknowledged. Completion of this research work was possible with support of Supercell bharat$^{@}$ people. we would like to express my sincere gratitude to all of them.We want to begin by thanking, Mr.Snehal patel for providing valuable suggestion, time, guidance regarding various important aspects, inspiration and help throughout our Research work.

10. REFERENCES

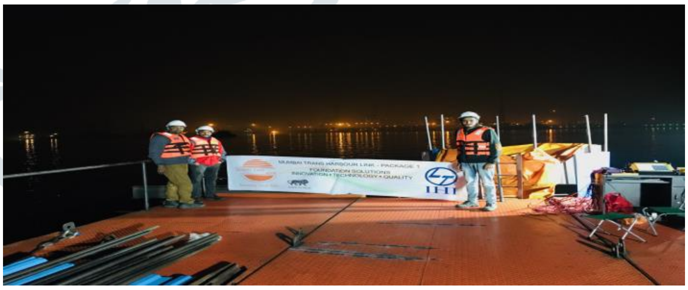
1) ASTM D1143. "Standard test methods for deep foundations under static axial compressive load“ American Society for Testing and Materials,Annual book of standards.
2) ASTM D8169: -Standard Test Methods for Deep Foundations Under Bi-Directional Load test
3) Berisavljevi, filipovi and stanisavljevi, “Experimental analysis of bi-directional pile static load test” European Conference on Geotechnical Engineering (2018)
4) Fellenius, Bengt H., (2006), Basics of foundation design. Electronic Edition.wwwFellenius.net. 275 p.
5) Howard P. Thomas, jon sinnreich michael and max buehler, “load test of a large bored pile for the golden ears bridge” ,ASCE(2012)
6) HoyoungSeon, RozbehB.Moghaddam, “Assessment of methods for construction of an equivalent top loading curve from O-cell test data” science direct (2016)
7) IRC:78-2014, “Standard specifications and code of practice for road bridges”, Indian roads congress december 2013
8) IS 2911:2010. “design and construction of pile foundations — code of practice. part 1 concrete piles”.
9) Jong-Sub Lee and Yung-Ho Park , “Equivalent pile load–head settlement curve using a bi-directional pile load test” Computers and Geotechnics 35 124–133 science direct (2008)
10) Nguyen minh hai and bengt H. Fellenius , “O-cell tests on two 70-m long bored piles in vietnam” ASCE(2014)
11) Raymond J. Castelli1, “osterberg load cell test results on base grouted bored piles in bangladesh” ASCE(2016)
12) Testing A. Zh. Zhussupbekov,r. E. Lukpanov and A. R. Omarov , “bi-directional static load” ASCE (2016)

11.ANNEXURE

Site visit photos different location at navi mumbai (MTHL Project). At Vishakhapatnam taking Photographs are also not permitted because it’s a Project of Indian Navy.

Installation time

Testing setup



During testing