Some aspects of load tests on concrete piles

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Kentledge method of pile load tests for vertical compressions is commonly used. On working piles such tests sometimes can be avoided at the discretion of the designer to save construction time and costs. A case study of such vertical routine tests on working piles is presented.

For horizontal load tests, some shortcomings in selection test loads, criteria for evaluation of load capacity and anomalies in assessment of pile capacity using empirical formula and charts based on soil data are also discussed.

Load carrying capacity of piles is theoretically assessed based on soil exploration data using empirical formula [1]. The ultimate capacity of load bearing is determined by conducting Initial Load Test [2]. Further tests are carried out on working piles to determine any construction deficiency of variation in soil strata.

TESTS FOR VERTICAL COMPRESSION LOAD

This topic is regarding Pile Load Test for a Cable Stayed Road over Bridge Project in Barddhaman, West Bengal. The Road Over Bridge consists of a central pylon and supports at the two ends. All the supports are on pile foundations. The piles are 1500 mm dia 35 m long at pylon location. The maximum designed loads on the piles are:

Vertical compression load - 830 T

Horizontal load - 44 T

Pullout load - 100 T

The diameter and depth of the piles were assessed using soil properties obtained from the recommendation of sub-surface exploration reports. Structural design was carried out to sustain the design load under various loading conditions with safe limits of stresses in concrete and reinforcements.

Initial load tests

Initial load test was carried out to determine the geotechnical designed capacity and response of the pile to applied load in terms of settlement of ultimate load capacity. The test was done at the adjoining location with test load of 2.5 times the design load using 4 anchor piles as per tender recommendation. The minimum criterion of settlement was reached before the full test load is applied. The results of initial load tests were satisfactory.

Routine load tests with Kentledge

As per tender condition, routine load tests also shall have to be carried out for vertical compression. Six bore holes were installed in the project area and the variation in strata is minimal. Under the circumstances, the results of Routine Load Tests were not expected to vary significantly. The pile capacity is already established for the designed depth by initial test conducted in the vicinity and integrity tests have proven the soundness of the pile structure.

Routine Load Test for vertical compression was carried out for a pile under central pylon having the maximum design vertical load of 830 T. Accordingly, the test load shall be 1245 T and Kentledge load 1560 T. Platform for

Kentledge was of size 11.0m x 12.0m. Concrete blocks were used in 4 layers with offsets on four edges weighing 1000 T. The balance load was provided by placing steel plates over the top layer of concrete blocks. A photograph of Kentledge being erected is shown in Figure 1. The load test arrangements are shown in Figures 2 and 3.

The platform was supported on 6 adjoining working piles already cast. The weight of primary girder was 1.42 T and that of secondary girders consisting 52 numbers ISMB 500 was 5.42 T. 4 numbers hydraulic jacks of 750T capacities were placed for this purpose over the pile head suitably designed to accommodate the jacks. Secondary girders were supported on built-up section of 2 ISMB 500 and flanges connected with 25 mm thick plates at top & bottom. These two supporting girders were placed on steel stool columns of about 3 m height over the piles at cut off levels.

During the loading stage, appearance of fine lines of warping was reported on the web of the supporting girders. To avoid any buckling or any distress in the Kentledge arrangement, the webs of the girders were strengthened with additional plates and stiffeners after unloading the concrete blocks.

During the stage of subsequent loading on reaching about 1000 T, similar appearance was reported on the web of stool columns. Rigorous checks on the design were undertaken by independent Design Consultant and also by Design Group of Project Management Consultant, but no design deficiencies were found. Being skeptic about the materials used or any unforeseen reasons it was decided to strengthen the stool columns also by providing additional plates and stiffeners in loaded condition. This may be a cosmetic cover over the already stressed columns.

Figure 1. Kentledge being erected for load test

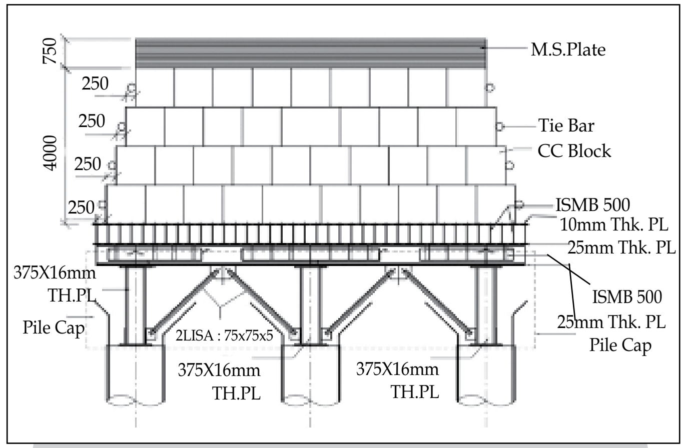

Figure 2. Section AA

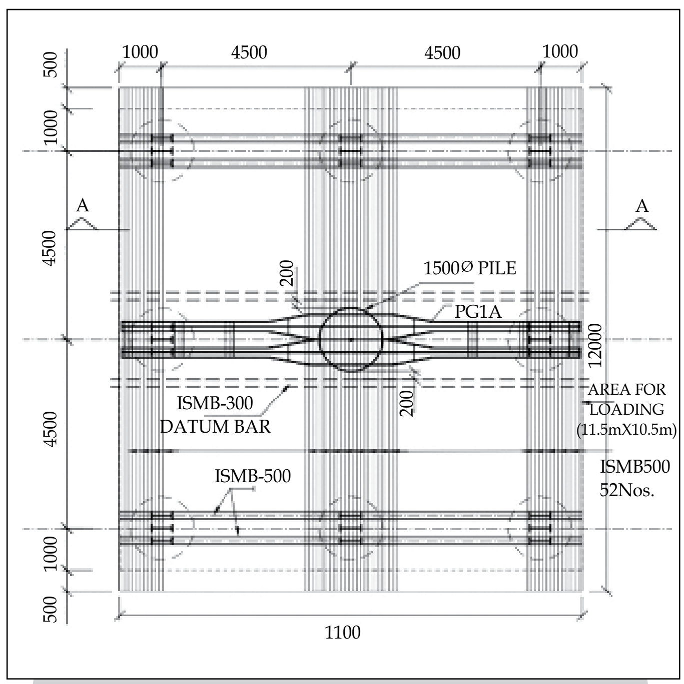

Figure 3. Plan

The test was conducted safely under the cover of the plates. The test results plotted in graph is shown in Figure 4. The process of design checks, re-checks, loading and unloading and strengthening/retrofitting took more than 3 months.

The above proves the contention that Routine Load Tests in this case was not a must since the piles have proved the Safe Load carrying capacity both considering soil conditions and structural design. Further in a group of 27 piles the desired capacity of only one pile could be established. Also, when settlements are noted in terms of millimeters, we should not ignore the effect of axial compression and thermal contraction of the 3 m long stool columns and 9 m long supporting girders. These might have some variation in the reading of the dial gauges. The warping observed could have been due to unequal contraction between parent material and the scale formation on the surface.

HORIZONTAL LOAD TESTS

Test load for horizontal load carrying capacity

Normally Routine horizontal load test is done for 1.5 times the design load and deflection limit becomes the criteria of acceptance. This design load as applied to the pile head through the pile cap remains in fixed head condition. But when an individual pile is tested, the pile remains in free head condition and as such will produce more deflection. In reality the observed deflection in such case does not represent the condition after pile cap and superstructures are erected.

Test load can be reduced to an equivalent load causing deflection as that of the fixed head piles with 1.5 times the design load and the test load is reduced to 30% - 40%.

Assessment criteria for horizontal load capacity

In case of bridges of Indian Railways, the permissible limit of horizontal deflection is only 5 mm irrespective of pile diameters. Tests not being done on reduced equivalent load for the test pile, sometimes, 8 to 9 piles of 1200 mm dia have been provided for pier/abutment of bridges spanning only 10.3 m to satisfy this requirement.

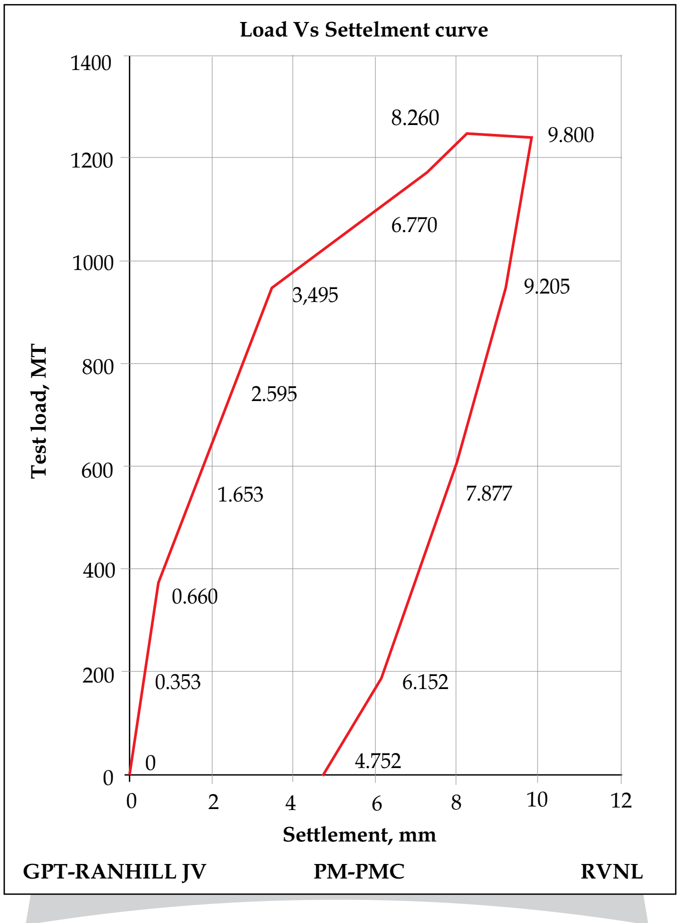

Figure 4. Routine vertical load test at pylon location

Determination of horizontal load carrying capacity using soil data

The computation of depth of fixity causing deflection, moment and shear force is too complex. A rational solution to the problem was first presented by Reese & Matlock in a paper in the 8th International Conference at Texas in 1956. Under Clause No. 5.5.2 reference of this was made in publication of IS Code in 1979 for the first time. A recommended method is also given using charts and graphs under Appendix-C, but the same was amended in 1987. The method of estimation cannot be very accurate since figures are to be read from charts graphs by interpolating values in very close ranges.

Indian Railways' on the other hand, in the Manual on the Design & Construction of Well & Pile Foundations (1985) has simply mentioned "The deflection and the slope below scour depth can be calculated by referring

Reese & Matlock curves presented in the 8th Texas Conference 1956". The Author [1] had also presented a simplified method for use of Reese & Matlock approach and the same was published with examples of designing a massive foundation having excessive horizontal load in in-house journal of Mecon (I) Ltd.

We may also mention here that the provision in the Latest Revision 2010, Indian Code IS 2911 (Part-I, Sec-2,) regarding determination of depth of fixity lacks in clarity for clayey soil. Because of this many of the organizations prefer to use the older version of the Code.

CONCLUSION

Load Test of Pile using Kentledge is a time consuming process and routine tests sometimes are superfluous if the soundness of the piles passes the Integrity Test and Geotechnical Investigation in the areas does not show significant variation in the strata.

Horizontal load test need not be done for 1.5 times the design load since the design load acts under fixed head condition under the pile cap. It should be reduced to make it compatible to free head condition and the value of the test load will be considerably reduced.

Guideline for evaluation of horizontal load capacity should be revised in the related IS Codes to bring some clarity and accuracy in the process of evaluation.

References

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3. REESE L.C. and MATLOCK H., *Non-Dimensional Solutions for Laterally Loaded Piles with Soil Modulus Assumed Proportional to Depth*, 8th Texas Conference on Soil Mechanics and Foundation Engineering 1956.
4. DAS S.K., *Determination of Lateral Load Capacity of Vertical Piles*, In house Journal of MECON (I) Ltd. 1971.
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