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Comparative Analysis of Static Axial Compressive Load Test (Reaction Test) with Kentledge Pile in the Construction of TLT Tower 1 Supporting Facility Building

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ABSTRACT

The foundation plays a crucial role in building structures by transferring loads from the superstructure to the stable soil layer beneath. Ensuring the adequacy of the foundation's load-bearing capacity is critical, and *Static Axial Compressive Load Testing* on foundation piles is essential to verify whether the piles can support the intended design loads. This study compares two commonly used static load test methods: the *reaction pile test* and the *kentledge test*, within the context of the TLT Tower 1 Supporting Facility Building Construction Project. The research aims to evaluate these methods based on implementation efficiency, result accuracy, cost-effectiveness, and worksite safety. A comparative analysis approach was employed, utilizing both test methods on the project site to assess their performance under field conditions. The results demonstrate that both methods possess distinct advantages and limitations. The *reaction pile test* method offers higher accuracy and operational efficiency under certain conditions, particularly in constrained site environments. Conversely, the *kentledge test* method is generally more cost-effective but may present limitations in terms of load precision and logistical complexity. These findings suggest that the selection of an appropriate static load testing method should be based on specific site conditions, testing objectives, and budgetary considerations. The study recommends a project-specific approach to foundation pile testing, aligning method selection with the unique requirements of the construction project.

Keywords: mast testing, static load, reaction pile, kentledge, mast bearing capacity, load test

INTRODUCTION

The *reaction pile* method is commonly utilized to provide a counterforce during static load testing by anchoring the test frame to installed reaction piles (Aitzhanov, 2024). This technique is particularly advantageous in constrained urban environments due to its minimal footprint compared to kentledge systems. Kitiyodom et al. (2015) emphasized the significance of pile spacing and stiffness ratio in maintaining system stability during static tests. Gouw and Gunawan (2020) further suggested that load tests conducted near failure provide more accurate estimations of the ultimate bearing capacity, albeit with higher risk and cost. According to Caltrans (2015), reaction systems must be carefully designed to suit soil type, access, and testing apparatus to ensure reliable data. Oh et al. (2023) highlighted that uniform force distribution is crucial to prevent torsional imbalances in the reaction frame. For projects like TLT Tower 1, which are limited by space, this method is considered more technically and economically feasible. Experimental validation by Arifianto et al. (2018) confirmed the accuracy of reaction pile testing, particularly for soft clay soils common in Indonesian urban areas. Additionally, Zhang et al. (2022) recommended the integration of digital monitoring systems to enhance settlement measurement precision throughout the test duration.

Bore pile foundation is a type of pile foundation whose installation is done by drilling the ground first, then filled with steel reinforcement and cast with concrete. These foundations are often used on difficult soils or in narrow locations between existing buildings.

In the TLT Tower 1 Supporting Facility Building Construction Project, bored pile foundations are used with the following data:

1) Bored Pile Diameter 800 mm
2) Number of poles 124 points with a depth of 16-19 m with a load of 2x200 tons.

Static Load Test is carried out by applying a vertical load to the pole head and measuring the deformation (settlement). This test is considered the most accurate method for assessing the actual bearing capacity of a mast in the field. Testing is carried out in accordance with ASTM D1143 and SNI 8460:2017 standards.

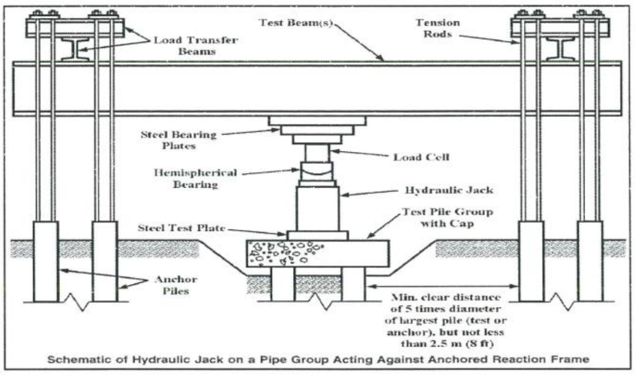

Figure 1. ***Schematic of the Hydrolic Jack***

Purpose

1) Determine the ultimate (maximum) bearing capacity of the piles.
2) Evaluate the mast descent against the applied load.
3) Compare the results of the field test with theoretical calculations or sondir/SPT results.
4) Assess the elastic and plastic behavior of the pole against vertical loads.

Table 1. General Procedures (As per ASTM D1143/SNI 8460:2017)

Stages	Description
Tool preparation	Test poles, lowering measuring devices (LVDT/displacement transducer), hydraulic pumps, reaction beams, anchor poles
Reaction system setup	The mast is loaded through a hydraulic jack that reacts to the beam or anchor mast
Gradual load assignment	Loads are added per 25% of the design load to the maximum (usually 200%)
Decrease measurement	Taken at regular intervals (e.g. 0, 1, 5, 10, 15, 20 minutes) for each load stage
Load cycle	Can consist of multiple cycles (loading-unloading) to test the mast re-response

The Kentledge method is a method of testing static loads on piles using dead loads (usually concrete, steel, or other heavy material blocks) that are placed on a reaction frame (platform) to apply vertical pressure to the test pole. This load is applied gradually to measure the settlement of the pole in response to the given load (Figure 2.).

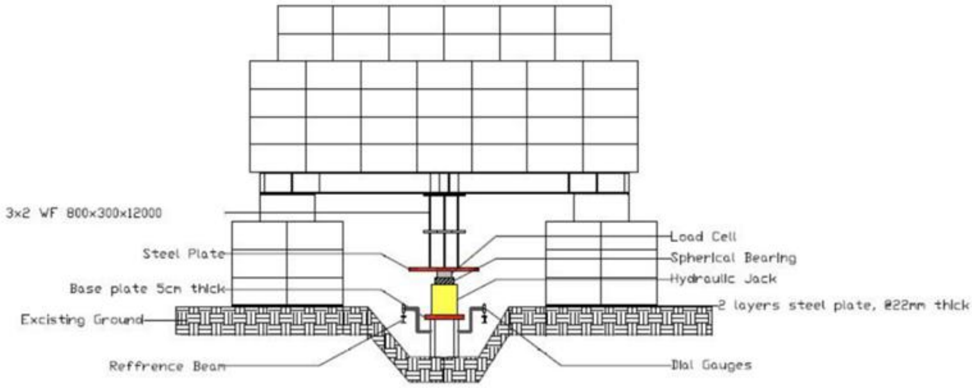

Figure 2. Kentledge test

Purpose:

1) Determine the axial bearing capacity of the mast (ultimate load).
2) Knowing the relationship between load and decline (load–settlement curve).
3) Evaluate the performance of the pole before mass production.

Implementation Procedure

a) Preparation

The site is leveled and conditioned to be able to withstand total loads (load + tools). The test pole is nailed or drilled to the design. The reaction platform/construction is arranged on the test pole, ensuring an even and safe distribution of the load. The load is stacked systematically and symmetrically.

b) Testing

The hydraulic jack is placed between the mast head and the load system. The load is applied in stages according to the load plan (e.g. 25%, 50%, 75%, 100%, etc. from the plan's carrying capacity)

At each stage of load:

Decreases are recorded in specific time intervals (e.g.: 0, 1, 2, 4, 8, 15, 30 minutes). The load is held until the rate of decline is stable or the maximum time is reached (usually 1–2 hours). Testing is continued until it reaches maximum load (often 2x the workload), or fails if the drop exceeds the specified limit.

c) Load Relief

After maximum load, gradual unloading is carried out and recovery measurements (rebound) are recorded.

Sutrisno et al. (2020) provided a valuable comparison between the reaction test pile and kentledge pile methods in urban foundation testing, demonstrating that the kentledge approach offers greater cost efficiency and spatial effectiveness. However, the study did not comprehensively evaluate how varying soil profiles, load demands, and site geometries influence the choice of method. Recent research by Nwankwo et al. (2023) underscores that soil stratification and plasticity significantly alter load–settlement behavior, highlighting the need for tailored test strategies. Likewise, Zhang et al. (2022) revealed that in soft clay layers, reaction pile systems paired with real-time digital monitoring can substantially reduce both testing time and budget overruns. Oh et al. (2023) further noted that uniform distribution of surcharge pressure in kentledge systems depends heavily on reaction setup design, which can affect schedule reliability when improperly configured. Mahendra et al. (2021) added that kentledge mobilization and demobilization duration may extend project timelines unless optimized logistics are employed. Furthermore, Haryanto et al. (2017) reported that reaction pile systems tend to require less manpower and equipment setup, offering a 35 % reduction in budget and time on constrained sites. Finally, Chen et al. (2020) explored bi-directional static load tests (BDSLT) as an alternative that can dramatically shorten test duration—though it demands specialized interpretation, which impacts project planning and resource allocation.

The second study by Wibowo and Surya (2021) also compared reaction test pile and kentledge methods in offshore construction projects. They found that the reaction test pile provided more accurate results and was better suited for large-scale projects due to its ability to simulate real-life load-bearing conditions. However, the study did not explore the practical application of these methods in areas with tight space, such as in the TLT Tower 1 Supporting Facility Construction Project, which is constrained by urban land. This left a gap in understanding how these methods would perform under more complex logistical conditions.

The purpose of this study is to compare the reaction test pile and kentledge pile methods for static load testing on foundation piles in the TLT Tower 1 Supporting Facility Construction Project. The benefit of this study is to provide valuable insights for engineers and construction managers in choosing the appropriate method based on project-specific constraints, ultimately contributing to more cost-effective and efficient foundation testing practices.

METHOD

The method used in this study is a comparative analysis approach, which examines two common *Static Axial Compressive Load Testing* methods—*Reaction Test* and *Kentledge Test*—for foundation piles in the context of the TLT Tower 1 Facility Building project. This approach enables an evaluation of the suitability, effectiveness, and practicality of each method based on the specific conditions of the project site. One notable constraint is the site's narrow configuration, which poses challenges in maneuvering large concrete blocks required for the *Kentledge Test* method. Due to these spatial limitations, the *Reaction Test* method was selected for the project, as it is more adaptable to restricted spaces and does not necessitate the use of heavy, cumbersome kentledge assemblies. This method is evaluated in terms of its implementation, operational efficiency, and its ability to fulfill the project's requirements for safety, cost-effectiveness, and technical precision. Given the limited working area on site, maneuvering and positioning concrete blocks for the *Kentledge Test* would have been impractical, reinforcing the suitability of the *Reaction Test* under such conditions.

Figure 3. Project Location Layout

Table 2. Difference Between Reaction Test and Kentlage Test

No	Aspect	Reaction Pile	Kentlage Pile
1	Mobilization	Fast	Slow (Requires Heavy Loads)
2	Area Size	Compact	Wide
3	Cost	More economical	High
4	Load Stability	Requires strong reaction system	Very stable
5	Safety Risk	Safer	High during loading
6	Data Accuracy	High if reaction system is optimal	High

From theory and expert judgment, the TLT Tower 1 Facility Building project uses the Reaction Test method because the location of the area is quite narrow.

RESULTS AND DISCUSSION

Implementation

This report is the result of static axial compressive load testing (Static Axial Compressive Load Test) at two pole foundation points that has been carried out by PT. The Core Regio Geotes at the TLT Tower 1 Supporting Facility Building Project, located in the city of South Jakarta, DKI Jakarta Province, on August 09 & August 20, 2024. The project is a Building Construction which is precisely located in Mampang Prapatan District.

The purpose of this static compressive axial load test was to determine the relationship between the permissible load and the ultimate pressure of the planned pile foundation against its decline (Load-Displacement Curve). No information was obtained related to Land Investigation Data. The installation of the pile foundation in this project uses the bored pile method. Documentation of axial testing of the mast foundation in Figure 4.

Figure 4. Documentation of Axial Testing of Pile Foundations

Test Pole Foundation

The test pile foundation is a bored pile foundation with dimensions of Ø 800 mm. The total planned length of the pillar foundation is 18.15 m and 19.00 m. For static load testing conditioning, the pole foundation head has been cut and the pole foundation head has been strengthened with grouting. Excavation was carried out around the foundation head of the pile with a minimum depth of ± 30 cm. Information related to the pile foundation that has been tested can be seen in the following table.

Table 3. Test Pole Foundation Data

No	Foundation Pile ID	Foundation Pile Dimension	Foundation Pile Type	Planned Foundation Pile Length (m)	Axial Compression Test Load	Installation Date	Testing Date
1	TP1 / BP38	Ø 800 mm	Cast In-Situ	18.15	200% × 210 tons	–	09-08-2024
2	TP2 / BP98	Ø 800 mm	Cast In-Situ	19.00	200% × 210 tons	22-06-2024	20-08-2024

There is no information about the existence of a coating layer on the wall of the pillar foundation. The test pile foundation is a vertical pile foundation (without inclination). After conditioning was carried out for static compressive axial load testing, the exposed pile foundation was in good condition, no cracks were found in the pile foundation, and the head wall of the pile foundation was relatively flat. Static compressive axial load testing was carried out at the final stage of the pile foundation installation process for the project.

Axial Load Testing Static Press Piercing Mast Foundation

Static compressive axial load testing of the mast foundation is carried out in accordance with ASTM D1143. Some of the equipment used for testing the axial load of static press of the pile foundation in this project includes:

a. Hydraulic Jack, ENERPAC-CLRG 2006, capacity = 1000 tons-700 Bar/10,000 Psi
b. Electric Pump, ENERPAC ZE-Series, capacity 700 Bar/10,000 Psi
c. Six pieces of Dial Indicator, Mitutoyo 3058F, Travel = 50 mm
d. Six Magnetic Stands, Mitutoyo 7011S-10
e. Pressure Gauge, Enerpac, capacity 700 Bar/10,000 Psi
f. Load Cell, Geokon 4900X, capacity 500 tons
g. Reaction Systems consists of two sets of test beams and tension bars with a planned capacity to withstand a maximum test load of 420tons.

The preparations that have been made before testing the axial load of static press of the pile foundation are as follows:

1) Conditioning the exposed test pole foundation head in such a way that it is relatively flat and there is no significant damage.
2) Dig the area around the test pile foundation head so that the preparation of the test equipment and counterweight can be straight with the pile foundation.
3) Positioning the hydraulic jack and load cell on the test pole foundation head axle.
4) Prepare reference beams, install magnetic stands and dial gauges, and connect hydraulic hoses on the hydraulic jack to the electric pump.
5) After conducting a final check on all equipment and other safety tools, static compressive axial load testing on the pile foundation is carried out.

Static pressure axial load testing is carried out using the maintained load-cyclic loading method, which is to gradually increase and decrease the pressure axial load and carry out load containment within the required period of time. Any movement of the pile foundation, both vertical descent-rebound, as well as the lateral displacement of the pile foundation (X-Y) that occurs due to the rise and fall of the pressure axial load, is measured by the dial gauge that has been installed and recorded on the reading sheet. The amount of axial pressure exerted is determined by the pressure gauge that has been installed on the electric pump and also the load cell (optional) installed on top of the hydraulic jack. After the static compressive axial load test is carried out, a plot of compressive axial load is carried out against the decrease (Load-Displacement Curve). From the plot, it will be known the behavior of the movement of the test pole foundation to the compressive axial load that occurs on the test pole foundation. The reading schedule for the pressure axial test can be seen in Table II. Reaction system load scheme – test documentation can be seen in Figure 5.

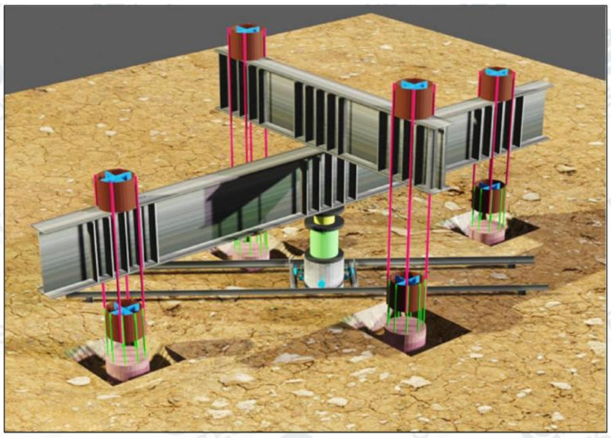

Figure 5. Schematic Reaction System for Axial Load Test Pressing Beam Foundation

The static compressive axial load testing was performed on two bored pile foundation points at the TLT Tower 1 Supporting Facility Building project in South Jakarta. This testing aimed to determine the relationship between the permissible load and the ultimate bearing capacity of the pile foundation, assessed through the Load-Displacement Curve. The pile foundations, with a diameter of Ø 800 mm and lengths of 18.15 m and 19.00 m, were subjected to static load testing as the final stage of the foundation installation process.

The test revealed important insights into the pile foundation's behavior under axial load. Using equipment such as a hydraulic jack, electric pump, dial indicators, and load cells, the test was conducted in accordance with ASTM D1143 standards. The preparation for the test involved conditioning the pile head, ensuring it was flat and free of cracks, and excavating the area around the foundation to facilitate the proper placement of testing equipment. During the test, the load was applied gradually, and the vertical and lateral displacements of the pile were measured.

The results indicated that the pile foundation exhibited a predictable and stable response to the increasing axial load. The Load-Displacement Curve demonstrated clear elasticity and plasticity behaviors, with the pile foundation performing well within the expected limits. The maximum axial load that the pile could withstand was recorded, providing valuable data for future assessments of the foundation's capacity and stability.

The study also showed the importance of the reaction system and its role in stabilizing the load application. The reaction beams and tension bars performed effectively, allowing for a controlled load application and accurate measurement of pile movements. The results contribute significantly to understanding the performance of bored pile foundations under static load testing and will inform the design and construction processes in future projects.

CONCLUSION

The narrow project site posed challenges for implementing the *Reaction Test* method in foundation testing; however, the method was successfully applied to evaluate the axial load performance of pile foundations. For the TP1 BP38 Pole Foundation, total displacement under a 210-ton load (Cycle II – 100% WL) was 1.71 mm with a plastic displacement of 0.04 mm, increasing to 8.10 mm total and 2.03 mm plastic displacement at 420 tons (Cycle IV – 200% WL). In comparison, the TP2 BP98 Pole Foundation showed 1.42 mm total and 0.26 mm plastic displacement at 210 tons, rising to 4.87 mm total and 1.55 mm plastic displacement at 420 tons. These results indicate that the piles remained stable under applied loads, though increased displacement at higher loads highlights the importance of continued monitoring. For future research, it is recommended to conduct long-term testing under varying environmental conditions—including dynamic loading and seasonal effects—to assess the durability and behavior of pile foundations over time. Additionally, further investigation into testing method optimization for spatially constrained urban sites could lead to improved efficiency and accuracy in *Static Axial Compressive Load Testing*.

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