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Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
CENTRAL OFFICE
Manila

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Department Order No. 206 Series of 2022 dt 10/6/2022

SUBJECT: Bi-Directional Static Load Test for Bored Piles

In order to provide an alternative testing method for bored piles and to ensure quality and soundness of foundations for various infrastructure projects, the use of Bi-Directional Static Load Test (BDSLT) is hereby prescribed for guidance of DPWH Implementing Offices.

The BDSLT on bored piles utilizes a specialized hydraulic jack assembly, embedded at an equilibrium resistant point (predetermined based on geotechnical investigation results). Said hydraulic jack assembly is then pressurized to apply loads onto the pile in both upward and downward directions. Standard materials, equipment, test procedure, and results interpretation shall conform to *ASTM D8169 – 18 "Standard Test Methods for Deep Foundations Under Bi-Directional Static Axial Compressive Load".* Refer to ***Annex "A"*** for the detailed test procedure.

This alternative deep foundation testing method may be used for bored piles such as but not limited to:

1. Bored piles having diameters of 2.5 meters or greater; or those with bored pile demand load greater than 15,000 kN.
2. Bored piles near existing structures, where High-Strain Pile Dynamic Test using Pile Dynamic Analyzer (PDA) may cause disturbance to the adjacent foundation/structural members.
3. Deep offshore piles, at sites where installation of cofferdams for the conduct of PDA is not feasible.

This Order supplements Department Order No. 37, series of 2016, and shall take effect immediately.

MANUEL M. BONOAN
Secretary

5.1 BSR/ECM

Department of Public Works and Highways
Office of the Secretary
WIN2R01548

ANNEX "A"

TEST PROCEDURES FOR BI-DIRECTIONAL STATIC AXIAL COMPRESSIVE LOAD TEST (BDSLT)

PRINCIPLES

Bi-Directional Static Load Test (BDSLT) tests deep foundations such as bored piles to determine the resistance distribution along its length and assess the pile behavior under static loading. The test method measures the axial displacement of a single deep foundation loaded in bi-directional static axial compression using an embedded bi-directional jack assembly. The bi-directional axial compressive load test provides separate, direct measurements of the pile side shear mobilized above an embedded jack assembly and the pile end bearing plus any side shear mobilized below the jack assembly.

The maximum mobilized pile resistance equals two times the maximum load applied by the jack assembly. Test results also provide information used to assess the distribution of side shear resistance along the pile, the amount of end bearing mobilized at the pile bottom, and the long-term load-displacement behavior. The main purpose of the BDSLT is to measure the displacement at design load and maximum test load (determined by the foundation engineer) stages, and to assess structural stability by checking whether the test results are within the specified design criteria.

The test shall be performed by a qualified testing personnel in accordance with the "ASTM D8169/D8186M-18" Standard Test Method for Deep Foundations Under Bi-Directional Static Axial Compressive Load.

TEST PILE PREPARATION

For cast-in-place piles constructed by excavating an open hole in the ground such as drilled shafts or bored piles, position the jack assembly at the desired location within the pile prior to placing the concrete. Use a steel reinforcement cage and ensure that the location and orientation of the setup during concrete placement will be maintained. Obtain sound concrete around the assembly by using a fluid concrete mixture, placing concrete at a slow and steady rate, and providing adequate clearance around the jack assembly to avoid restricting concrete flow and trapping any sediments. The jack assembly should be placed at a minimum distance of one-half pile diameter above the pile bottom. Provide a minimum clearance of the lesser of 75 mm or 8 times the diameter of the largest coarse aggregate, between the jack and the sidewalls of the excavation

Typical schematic of an embedded bi-directional cell assembly is shown in Figure 1. The resultant line of force of the bi-directional cell assembly shall coincide with the central axis of

the foundation element. During initial bi-directional cell pressurization, a fracture plane will form through the concrete surrounding the bi-directional cell assembly, and the pile reinforcement and instrumentation shall not restrain the subsequent expansion of the assembly after the fracture occurs. As indicated below, different types of deep foundations require different methods of bi-directional cell installation.

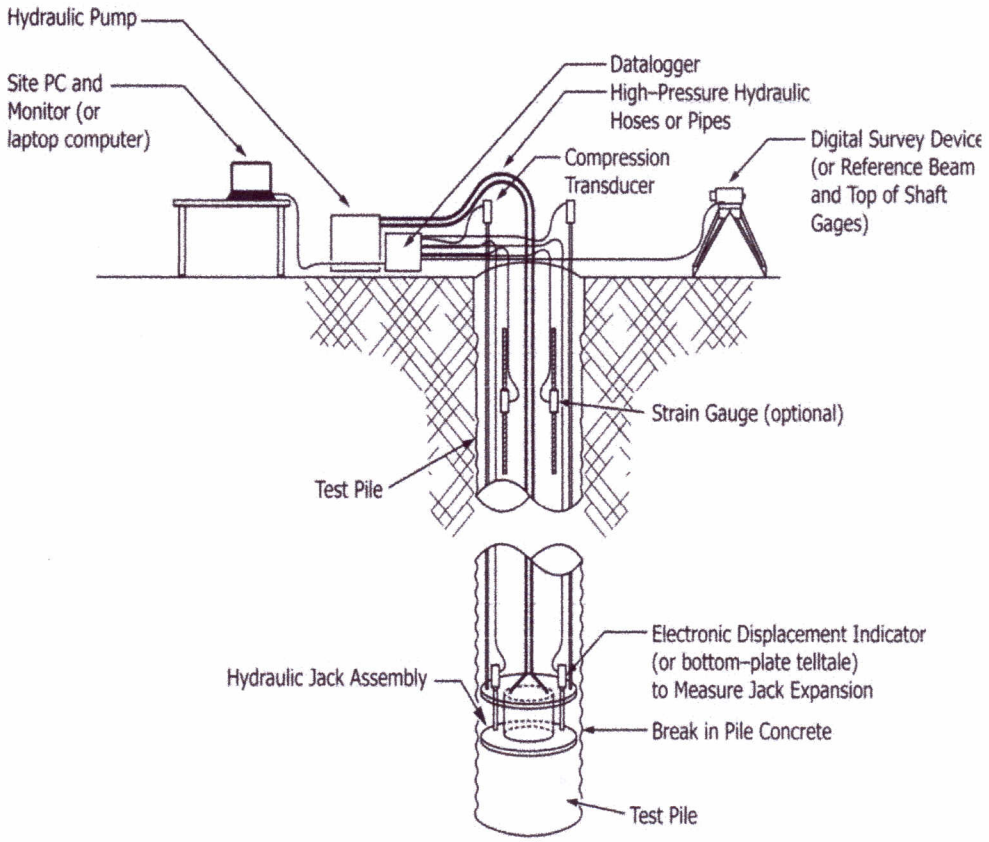

Figure 1. Schematic of Bi-Directional Load Test Instrumentation

The assembly shall comprise of bi-directional cell and steel bearing plates. Fabrication of the bi-directional cell assembly may be carried out on site or at the piling contractor's workshop, where the bi-directional cell will be accurately positioned and welded to steel bearing plates above and below the bi-directional cell. Fabrication drawings for the bi-directional cell assembly for bearing plates are included Figure 2 below:

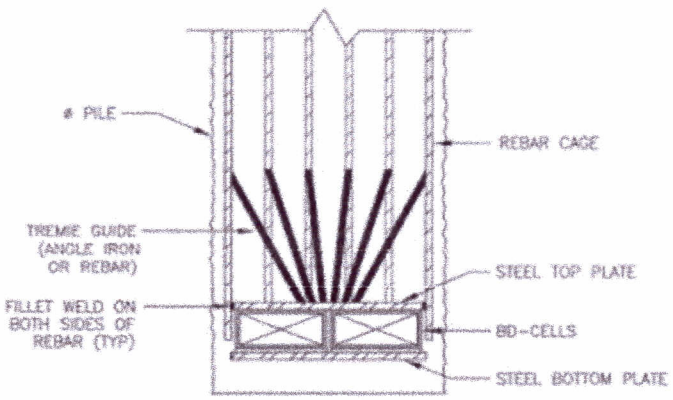

Figure 2. Bi-Directional Cell Assembly

A single level bi-directional cell assembly will be installed in the test pile along with the necessary hydraulic system and instrumentation attached to the steel reinforcing cage. The final bi-directional cell assembly position is subjected to the approval of the Implementing Office upon recommendation of the geotechnical design engineer. For the purpose of fully mobilizing the axial compressive capacity, it is recommended to locate the bi-directional cell assembly at a location within the pile where the capacity above the assembly equals the capacity below it. The position of bi-directional cell assembly herein is a preliminary estimate based on assessment of the soil exploration/geotechnical investigation conducted.

To ensure that no damage occurs to the bi-directional cell during handling or lifting the assembly, temporary reinforcement shall be installed across the bi-directional cell assembly. Two or more pieces of reinforcing steel will be welded between the top and bottom of the bearing plates as to temporarily reinforce the bi-directional cell assembly. Temporary reinforcement at the bi-directional cell assembly will be cut once the cage is vertical and is being lowered into the excavated bore, such that no steel crosses the bi-directional cell opening level.

Install a minimum of two hydraulic hoses or pipes (input and return) extending from top of pile to the jack assembly. Jacks directly connected together within an assembly shall be tested together to verify flow continuity and to check for pressure leaks.

EQUIPMENT

1. Bi-Directional Jacks
2. Pressure Gauges
3. Pressure Sensors
4. Strain Gauges
5. Pressure Gauge
6. Hydraulic Pump
7. Hydraulic Hoses and Fittings
8. Digital Survey Levels
9. Data Taker Geologger
10. Laptop Computer
11. Bearing Plates / Stiffeners
12. Reinforcement Cage

PILE TESTING PROCEDURE

Use the embedded jack assembly to apply load to the test pile. The resulting test load applied to the pile is twice the load measured in the jack assembly.

Bi-Directional Load Test may commence when minimum pile compressive strength as required by the project specifications is reached. Apply at least ten (10) equal increments of jack assembly load to the pile, with each increment being no more than 5% of the maximum specified test load. The load change from any one increment to another should not deviate from any other preceding increment by more than 5%, and the maximum specified jack assembly load will be 50% of the maximum specified test load.

Immediately after the completion of the final readings for each load increment, add the next load increment in a continuous manner within two (2) minutes. If significant movement occurs above or below the jack assembly, extend the loading time to apply the load increment to the opposing portion of the pile. Add load increments until half of the maximum specified test load, maximum expansion, or load capacity of the jack assembly is reached. Also observe if continuing, progressive expansion of the jack assembly with no significant increase in jack pressure is present.

Upon attaining the load, keep the load constant for at least four (4) minutes but not more than 16 minutes. Remove the load in five (5) to ten (10) approximately equal decrements, keeping the load constant for 4 – 16 minutes as well. The geotechnical design engineer may specify a longer time interval for the final load increment to assess long-term creep, and for the final zero unload to assess rebound behavior.

ACCEPTANCE AND REJECTION

The load will be removed and testing is considered completed when either of the following cases occur:

1. Maximum required test load has been applied
2. Load capacity of the jack assembly is reached
3. Maximum settlement is exceeded

The final analyzed allowable bearing capacity should satisfy the design load and the displacement measured should not exceed 25 mm.

REPORTS

As a minimum, record the following test information:

1. Description of test conducted including methodology, equipment, and photographs. All relevant project information shall be indicated as well.
2. Complete test data and description of every procedure conducted (e.g., jack pressure, load from load sensing device, pile movement, jack assembly movement, plot of load versus plate movement, jack calibration, among others)
3. Evaluation and Recommendations

References:

1. Standard Test Methods for Deep Foundations Under Bi-Directional Static Axial Compressive Load. ASTM D9169M-18. American Society for Testing and Materials. 2018
2. Bi-Directional Static Axial Compressive Load Test for Piling https://www.civil-engineers-2020.com/2020/09/bi-directional-static-axial-compressive.html