4.4 PILE TEST LOADING

4.4.1 Descriptions

4.4.1.1 General

This Section deals with the testing of a pile by the application of an axial load or force. It covers vertical piles tested in compression.

4.4.1.2 Definitions

A) Allowable Load

The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, negative friction, pile spacing, overall bearing capacity of the ground below and allowable settlement.

B) Compression Pile

A pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.

C) Kentledge

The dead weight used in a loading test.

D) Maintained Load Test

A loading test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

E) Pilot Pile

A pile installed before the commencement of the main piling works or a specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity. Pilot piles may be utilised as working piles, subject to the Engineer’s approval.

F) Proof Load

A load applied to a selected pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 200% of the working load on a pile except in circumstances where Special Provisions are provided for the testing of precast piles driven to a set. In these circumstances, 300% is specified.

G) Reaction System

The arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.

H) Tension Pile

A pile which is designed to resist an axial force such as would cause it to be extracted from the ground.
I) Test Pile

Any pile to which a test loading is, or is to be, applied.

J) Ultimate Bearing Capacity

The load at which the resistance of the soil becomes fully mobilised.

K) Working Load

The load which the pile is designed to carry.

L) Working Pile

One of the piles forming the foundation of a structure.

4.4.2 Supervision

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

4.4.3 Safety Precautions

4.4.3.1 General

When preparing for, conducting and dismantling a pile test the Contractor shall carry out the requirement of the various regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

4.4.3.2 Kentledge

Where kentledge is used the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflexion of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart, or becoming unstable because of deflection of the supports.

The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed.

4.4.3.3 Tension Piles and Ground Anchors

Where tension piles or ground anchors are used the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.
4.4.3.4 Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head the whole system shall be stable up to the maximum load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the kentledge stack or test frame so that failure in any part of the system due to overloading, buckling, loss of hydraulic pressure will not constitute a hazard to personnel.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

4.4.4 Construction of a Pilot Pile to be Test Loaded

4.4.4.1 Notice of Construction

The Contractor shall give the Engineer at least 48 hours notice of the commencement of construction of any pilot pile, which is to be test loaded.

4.4.4.2 Method of Construction

Each pilot test pile shall be constructed in a manner similar to that to be used for the construction of the working piles, and by the use of similar equipment and materials. Any variation shall only be permitted with prior approval.

Extra reinforcement and concrete of increased strength shall be permitted in the shafts of pilot piles at the discretion of the Engineer.

4.4.4.3 Boring or Driving Record

For each pilot pile which is to be tested a detailed record of the soils encountered during boring, or of the progress during driving shall be made and submitted to the Engineer daily not later than noon on the next working day.

4.4.4.4 Cut-Off Level

The pile shaft shall terminate at the normal cut-off level, or at a level required by the Engineer.

The pile shaft shall be extended where necessary above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process are not damaged by water or falling debris.

4.4.4.5 Pile Head for Compression Tests

For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement-measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

4.4.5 Preparation of a Working Pile to be Tested
If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with Sections 4.4.4.4 and 4.4.4.5.

4.4.6 Reaction Systems

4.4.6.1 Compression Tests

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages.

Where kentledge is to be used, it shall be supported on cribwork disposed around the pile head so that its centre of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer.

4.4.6.2 Working Piles

Where working piles are used as reaction piles their movement shall be measured to within an accuracy of 0.5 mm.

4.4.6.3 Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3 metres.

The centre to centre spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2 metres, whichever is the greatest.

4.4.6.4 Adequate Reaction

The size, length and number of the piles or anchors, or the area of the rafts, shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

4.4.6.5 Care of Piles

The method employed in the installation of any reaction piles, anchors or rafts shall be such as to prevent damage to any test pile or working pile.

4.4.6.6 Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

4.4.7 Equipment for Applying Load

The equipment used for applying load shall consist of one or more hydraulic rams or jacks with the total capacity of the jacks being at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test.

4.4.8 Measurement of Load
Suitable approved measuring devices for determining the load on the pile shall be supplied by the Contractor. Certificates of calibration shall be supplied to the Engineer.

In addition, large diameter (i.e. exceeding 1.2 metre) test piles shall be instrumented at 5 different depths to measure the load distribution along the piles. The instrumentation shall consist of both a mechanical system and strain gauges for measuring the pile deformation. The mechanical system shall consist of 6 mm steel rods or high tensile steel wires gauge No. 23, placed in steel tubes down to the various depths, and connected to dial gauges at the top. The strain gauges shall be of a stable type, wholly protected by a steel capsule. They shall be welded to the steel reinforcement, 2 gauges at each depth.

The Engineer shall approve the type of gauges to be used and other details on the instrumentation.

4.4.9 Adjustability of Loading Equipment

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

4.4.10 Measuring Movement of Pile Heads

4.4.10.1 General

In a maintained load test movement of the pile head shall be measured by two of the methods as described below. One method for settlement measurements, the other method for control.

4.4.10.2 Levelling Method

An optical or any other levelling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed.

No datum point shall be affected by the test loading or other operations on the site.

Where another method of levelling is proposed this shall be approved in writing.

4.4.10.3 Independent Reference Frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance from the test pile, kentledge support cribs, reaction piles, anchorages and rafts that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the testing. Check observations of any movements of the reference frame shall be made and a check shall be made of the movement of the pile head relative to an external datum during the progress of the test. In no case shall the supports be less than three test pile diameters or 2 metres, whichever is the greater, from the centre of the test pile.
The measurement of pile movement shall be made by two dial gauges rigidly mounted on the reference frame that bear on surfaces normal to the pile axis fixed to the pile cap or head. Alternatively the gauges may be fixed to the pile and bear on surfaces on the reference frame. The dial gauges shall be placed in diametrically opposed positions and be equidistant from the pile axis. The dial gauges shall enable readings to be made to within an accuracy of 0.1 mm.

The reference frames shall be protected from sun and wind.

4.4.10.4 Other Methods

The Contractor may submit for approval any other method for measuring the movement of pile heads.

4.4.11 Protection of Testing Equipment

4.4.11.1 Protection from Weather

Throughout the test period all equipment for measuring load and movement shall be protected from the weather.

4.4.11.2 Prevention of Disturbance

Construction equipment and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

4.4.12 Supervision

4.4.12.1 Notice of Test

The Contractor shall give the Engineer at least 24 hours notice of the commencement of the test.

4.4.12.2 Records

During the progress of a test, the testing equipment and all records of the test as required in Section 4.4.14.2 shall be available for inspection by the Engineer.

4.4.13 Test Procedure

4.4.13.1 Proof Test by Maintained Load Test

The maximum load, which shall be applied in a proof test, is shown on the Drawings. The loading and unloading shall be carried out in stages as shown in Table 4.4-1 or as required by the Engineer.

Following each application of an increment of load the load shall be held for not less than the period shown in Table 4.4-1 or until the rate of settlement is less than 0.25 mm/hour and is slowing down. The rate of settlement shall be calculated from the slope of the curve obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Each stage of unloading shall proceed after the expiry of the period shown in Table 4.4-1.

For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load and at approximately 15 minute intervals for 1 hour,
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at 30 minute intervals between 1 hour and 4 hours, and at 1 hour intervals between 4 hours and 12 hours after the application of the increment of load.

The Engineer may require that the full loading, or any portion of the loading, be maintained on the pile for periods longer than shown in Table 4.4-1.

Table 4.4-1

<table>
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<th>Loading Sequence</th>
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<tr>
<td>Load as Percentage of Working Load</td>
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</table>

4.4.14 Presentation of Results

4.4.14.1 Results to be Submitted

Results shall be submitted as:

a) A summary in writing to the Engineer, unless otherwise directed, within 24 hours of the completion of the test, which shall give for a proof test by maintained load for each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

b) The completed schedule of recorded data as in Section 4.4.14.2 within seven days of the completion of the test.

4.4.14.2 Schedule of Recorded Data
The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

A) General

1) Site location
2) Contract identification
3) Proposed structure
4) Date of test

B) Pile Details

1) Identification (number and location of the test pile)
2) Ground level at pile position
3) Head level as which test load is applied
4) Type of pile
5) Length in ground
6) Level in ground
7) Level of toe
8) Details of Permanent casing

C) Installation Details

1) Dates and times of boring, driving and concreting of test pile and adjacent piles
2) Date and time of casting concrete
3) Driven length of pile or temporary casing at final set
4) Hammer type, size or weight
5) Dolly and packing, type and condition before and after driving
6) Driving log (depth, blows per 250 mm, interruptions or breaks in driving)
7) At final set and at redrive set, for drop or single acting hammers, the length of the drop or stroke, for diesel hammers the length of the stroke and the blows per minutes, for double-acting hammers the number of blows per minute
8) Condition of pile head or temporary casing after driving

D) Test Procedure

1) Weight of kentledge
2) Tension pile, ground anchor or compression pile details
3) Plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles and reference frame to test pile
4) Jack capacity
5) Method of Load measurement
6) Method(s) of penetration measurement
7) Relevant dates and times
E) Test Results

1) In tabular form
2) In graphical form: loads plotted against movements and time

4.4.15 Completion of a Test

4.4.15.1 Measuring Equipment

On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site.

4.4.15.2 Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in further tests or removed from the Site.

4.4.15.3 Temporary Piles

On completion of a preliminary test, temporary tension piles shall be cut off below ground level, removed from the Site and the ground made good with approved material as specified.

4.4.16 Measurement and Payment

Load tests on large diameter (i.e. exceeding 1.2 metre) cast in place bored piles shall normally be carried out on working piles using other working piles as anchor piles. The test pile and anchor piles will be paid for at the normal rates for working piles as provided in Section 4.1. Separate payments will be made for carrying out each load test, individual rates shall be provided for different proof loads, which are specified in the Bill of Quantities. Payment for load tests on large diameter cast in place bored piles shall include provision of special instrumentation to test piles, anchor bars to reaction piles, provision of all testing equipment, carrying out of the tests, dismantling of equipment and removal from site, breaking out pile heads etc. in accordance with the requirements for working piles, preparation of all reports etc.

Load tests on pilot driven piles shall normally be carried out using temporary anchor piles or kentledge. The pilot pile will be paid for at the rates provided for pilot piles in Section 4.2. Separate payment shall not be made for anchor piles. Separate payments will be made for carrying out each load test and individual rates shall be provided for different proof loads, which are specified in the Bill of Quantities. Payment for load tests on pilot driven piles shall include provision of anchor piles or kentledge, provision of all test equipment, carrying out of the tests, dismantling of equipment and removal from site, cutting off below level of temporary anchor piles, preparation of all reports etc.

Load tests on pilot cast in place piles, less than 1.2 metre diameter, shall normally be carried out using temporary anchor piles or kentledge. The pilot pile will be paid for at the rates provided for pilot piles in Section 4.1. Separate payment shall not be made for anchor piles. Separate payments will be made for carrying out each load test and individual rates shall be provided for different proof loads, which are specified in the Bill of Quantities. Payment for load tests on pilot piles shall include provision of anchor piles or kentledge, provision of all test equipment, carrying out of the tests, dismantling of equipment and removal from site, cutting off below level of temporary anchor piles, preparation of all reports etc.

Pay items shall be:
4/4/1 Load Test on Cast in Place Working Pile
(Proof load to be specified in Bill of Quantities)

4/4/2 Load Test on Cast in Place Pilot Pile
(Proof load to be specified in Bill of Quantities)

4/4/3 Load Test on Pilot Driven Pile
(Proof load to be specified in Bill of Quantities)