SAMPLE SPECIFICATIONS for
HIGH-STRAIN DYNAMIC TESTING OF DRILLED AND CAST-IN-PLACE SHAFTS

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1.0 DESCRIPTION

High-strain dynamic testing is performed by obtaining and analyzing records of shaft force and velocity under drop weight impacts for evaluations of shaft load carrying capacity, structural integrity, and load-movement and shaft-soil load transfer relationships. Testing procedures shall conform to D4945 - Standard Test Method for High-Strain Dynamic Testing of Deep Foundations unless as otherwise noted below. The following are specifications and instructions for high-strain dynamic testing of drilled and cast-in-place foundation shafts.

This work shall consist of furnishing all materials, equipment and labor necessary for conducting high-strain dynamic tests on drilled and cast-in-place shafts (hereafter each noted as test shaft). The test shaft used shall be instrumented and tested by a Dynamic Testing Firm, as approved by the Engineer, meeting requirements outlined in ASTM D4945 as well as those outlined below. The Contractor shall be required to supply material and labor as hereinafter specified and including prior to, during, and after the load test. High-strain dynamic tests (herein also called dynamic tests) are non-destructive tests. It is intended that the test shaft be left in a condition suitable for use in production.

2.0 EQUIPMENT

The Contractor shall supply all materials and equipment required to prepare the test shaft, dynamically test it, and return the test shaft to a condition suitable for use in the finished structure. Equipment and procedures required to perform the test include but are not limited to:

1) If a permanent casing is not used as a feature to construct the test shaft, then a shaft top extension, consisting of a thin walled casing or equivalent, shall be used to extend the test shaft by a length equal to two diameters. This top length, defined as the “test area” must be exposed and readily accessible to the Testing Engineer at the time of the test. If the top of the test shaft is below grade, then the Contractor shall have equipment available to remove surrounding soil (creating a safe working environment) so as to completely expose a test area as described above. For larger shafts, windows on possibly four equidistant sides of the test shaft may have to be cut in the steel casing to reach the concrete. For smaller diameter shafts, complete removal of the steel casing at the location of the sensors is recommended, or if the steel casing is relatively thick then holes can be drilled and tapped in the steel for sensor attachment.

2) Means to insure flat, level, (axial to test shaft) and solid concrete shaft top. Concrete should be level with, or slightly above the casing.

3) A drop weight of approximately two percent (2%) of the anticipated test shaft capacity, or as determined by the Engineer (one percent may be sufficient for shafts with rock sockets); higher percentages are helpful when practical and when available. The impacting surface of the drop weight should have an area between 70 and 130% of the test shaft top area. The shape of the ram weight should be as regular as possible (square, round, hexagonal, etc).

4) A guide allowing variable drop heights typically up to between1 to 2 m (3 and 7 ft), or as determined by the Engineer.

5) A top cushion consisting of new sheets of plywood with total thickness between 50 to 150 mm (2 to 6 inches), or as determined by the Engineer.

6) If protruding reinforcing bars are present, the Contractor has the option to incorporate the reinforcing steel in the test area. Upon successful completion of the dynamic test, the surrounding concrete can then be removed as to make the foundation suitable for use in the structure. If the Contractor selects not to incorporate the steel in such a manner as described above, then a steel beam or pipe (cross sectional area approximately 20% of the shaft cross sectional area) shall be supplied with sufficient length such that the ram impact will not interfere with the reinforcing bars. Steel striker plates and plywood cushion must also be sized so that they cover as much of the impact area as possible.

7) Surveyors transit, laser light, or equivalent for measurements of pile set under each impact.

3.0 DYNAMIC TESTING FIRM

It is the (Owner's / Contractor's, etc) responsibility to employ and compensate a specialized dynamic testing firm. Dynamic testing is to be performed by an independent specialist from a firm with a minimum of five (5) years experience in dynamic testing. The actual dynamic test shall be conducted and/or supervised by a Licensed Professional Engineer with at least two (2) years of dynamic testing experience or who has achieved Advanced Level or better on the PDI / PDCA Dynamic Measurement and Analysis Proficiency Test. Selection of the firm must be acceptable by the Engineer.

The independent dynamic testing firm must supply the following testing instrumentation in addition to that outlined in ASTM Standard D 4945 Section 5:

1) Pile Driving Analyzer® (PDA) system manufactured by Pile Dynamics, Inc. (30725 Aurora Road, Cleveland, OH 44139, USA; www.pile.com; email: info@pile.com; phone: +1.216.831.6131), model 8G or PAX or equivalent.

2) At least four calibrated strain transducers.

3) Four calibrated accelerometers.

Prior to performing the dynamic test, the Testing Engineer must be provided with soil borings, shaft installation records, concrete properties (strength, etc.) and details regarding the anticipated dynamic loading equipment. The test Engineer is required to perform wave equation analyses (using GRLWEAP software by Pile Dynamics, Inc. or equivalent) to determine the suitability of the proposed dynamic load testing equipment and an acceptable range of ram drop heights so as not to cause damage in the test shaft during the test.

4.0 PROCEDURE

1. The test shaft shall be constructed using approved installation techniques.

2. If a permanent casing is not required, then the upper length equal to two shaft diameters, noted as the "test area", must be cased in a thin wall tube or equivalent as noted above. Casing of this test area must be made as a continuation of the construction of the test shaft. There should not be soil contamination or non-uniformities in the concrete located within or below the test area. Test shaft top concrete shall be made level to the casing and smoothed.

3. Prior to testing time, the Contractor shall make the shaft test area length completely accessible to the Testing Engineer. Prior to the test, for attachment of the sensors, an entire band of the casing should be removed to expose a smooth concrete surface, or if the casing wall thickness is sufficient, holes should be drilled and tapped into the casing. Sensors are typically attached at least one diameter below the shaft top. Sensors are preferably attached to the steel if the impedance percentage of the steel is relatively high, and if the permanent casing is relatively long (extending several diameters below the sensors).

4. In cases where casing is not present, the Testing Engineer, or Contractor under the direction of the testing Engineer, shall smooth (by grinding) four equidistant areas around the pile circumference such that proper sensor attachment can be accomplished.

5. Sensors shall be attached by the Testing Engineer or at the direction of the Testing Engineer to the exposed concrete or steel casing in a secure manner as to prevent slippage under impact. Alternatively, a “top transducer” (thick wall steel pipe with impedance approximately equal to the shaft impedance) provided by the Testing Engineer can contain the strain measurement, and accelerometers are attached to the shaft approximately 150 to 300 mm (6 inches to one foot)() below the top of shaft.

6. Shaft top should be examined to insure concrete is flush with or above the casing.

7. Apply plywood cushion and then striker plate to the shaft top. If reinforcing protrudes from the shaft top, then the steel beam or pipe (used to transfer the impact to the shaft top, and with a plate of sufficient area below to sufficiently distribute the impact force) should be secured in such a manner as not to move under impact.

8. At least two (2) hammer impacts should be applied to the top of the shaft. First drop height should be minimal to allow the Testing Engineer to assess the testing equipment, the impact system and the stresses on the foundation. Subsequent impacts can then be applied by utilizing sequentially higher drop heights until either stresses in the foundation are excessive or the shaft permanent set for the applied impact exceeds 2.5 mm (0.1 inch).

9. Upon completion of the test, it is the Contractors' responsibility to return the shaft to acceptable production condition.

5.0 REPORTING OF RESULTS

It is the Testing Engineers' responsibility to submit a timely report of the testing results. In addition to the field results, results from at least one (1) CAPWAP® analysis or equivalent shall be submitted. (CAPWAP software licenses are available from Pile Dynamics, Inc.) CAPWAP analyses shall be performed by an Engineer that has achieved Advanced Level or better on the PDI / PDCA Dynamic Measurement and Analysis Proficiency Test. The report must also provide the following:

1) Wave Equation analysis results obtained prior to testing.

2) CAPWAP (or equivalent) analysis results.

3) For each impact the maximum measured force, maximum calculated tension force, transferred energy to the sensor location, corresponding stresses, and the Case Method bearing capacity.

Assessment of the test results both with respect to pile capacity and integrity. The high strain dynamic testing procedure shall be considered as any material, labor, equipment, etc. required above and beyond the requirements of the installation of the foundation to be tested. This item should include everything necessary to test the shaft, under direction from the Engineer. All costs associated with the normal production of the test shaft are measured and paid for elsewhere in the contract documents.

7.0 BASIS OF PAYMENT

The complete and accepted "High Strain Dynamic Load Test" shall be paid for at the contract price bid for "High Strain Dynamic Load Test", each. This shall constitute full compensation for all costs incurred during the procurement, installation, conducting of test, and subsequent removal of test equipment.

Payments shall be made under:

Pay Item:	Pay Unit:
High Strain Dynamic Load Test	Each