SAMPLE SPECIFICATION for BI-DIRECTIONAL STATIC LOAD TESTING

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*The user of this sample specification should recognize that each deep foundation test element has unique length, diameter or plan dimensions, and load requirements. Therefore, the project soil conditions, foundation type and its installation procedures, as well as the load-transfer instrumentation goals should all be considered in modifying this sample specification to address and satisfy project specific requirements. The bi-directional static load testing method can be applied to testing sacrificial or production foundation elements including drilled shafts, augered cast-in-place (ACIP) piles, drilled displacement piles (DDP), barrettes, and slurry wall panels.*

*This specification includes commentary throughout to facilitate final specification development by the end user. In a bi-directional load test, an embedded jack assembly applies static load to the test element. The jack assembly typically consists of one or more embedded hydraulic jacks affixed between one or more upper and lower bearing plates. Since the jack assembly simultaneously applies test load both above and below it, the maximum potential test load is twice the jack assembly capacity. While a single jack assembly level (Figure 1) is the most common configuration, tests can also be performed with jack assemblies at multiple levels (Figure 2), or with unique bearing plate configurations (e.g., the Chicago Method, Figure 3) to maximize measured soil and rock resistances.*

*Since a single jack assembly level is the most common test configuration, “jack assembly” and “jack assembly design” (singular) is used throughout this specification. If more than one jack assembly is used (i.e., jack assemblies at multiple levels), “jack assemblies,” “jack assembly designs,” “jack assembly pressures,” etc. (plural) should be substituted where applicable. Similarly, although multiple jacks are commonly installed within a single jack assembly, “jack” (singular) is used throughout this specification. If more than one jack is used in one or more jack assemblies (i.e., a multi-level test), “jacks” (plural) should be substituted where applicable.*

*Due to the numerous potential test configurations and means of load application, ambiguous specification language can be a frequent source of confusion. Accordingly, jack assembly capacity requirements should be clearly specified in the plans, including the required upward and downward test loads (equal to each other), the required total test load (the sum of the upward and downward test loads), and the minimum required jack assembly capacity (equal to the minimum required upward and downward test loads, and to half the total test load). If the test element is a production foundation, the maximum test load and/or maximum allowable displacement of both the upper and lower foundation portions should be specified by the Engineer of Record with those limits clearly identified on the plans.*

*It should be recognized that jack assembly capacity is also limited by physical constraints of the test element in which it is installed, and the safe working pressures of all associated hydraulic components (e.g., pump, hydraulic lines, fittings, pressure gauges, jack). Physical constraints include test element diameter or geometry, openings to permit concrete flow around and/or through the jack assembly, room for a tremie pipe or slickline to pass through the jack assembly, etc. Specifying jack assembly capacities that require system pressures higher than safe working values should be avoided.*

1. **DESCRIPTION**

**1.1 General.** This work shall consist of furnishing all materials, equipment, labor, specialty services and incidentals necessary for conducting bi-directional static load tests on the specified number of test elements in accordance with the contract documents and this specification. The work shall also include data analysis and reporting of each load test. Bi-directional static load tests shall be conducted in general accordance with ASTM D8169-18, *Standard Test Methods for Deep Foundations Under Bi- Directional Axial Compressive Load*.

## The Contractor, in cooperation with their Specialty Test Provider, shall supply all equipment and supervise the mobilization, assembly, and performance of the bi-directional static load test. The Specialty Test Provider shall provide the bi-directional jack, jack assembly design, the required instrumentation, acquire the test data during the load test, and reduce the data into a report. The load test report shall be submitted to the Contractor and Engineer. Interpretation of the test data and report for final foundation recommendations shall be performed by the Engineer.

* 1. **Definitions**
* **Contractor.** The \_\_\_\_\_\_ *(company, joint-venture, individual)* contracting with the \_\_\_\_\_\_ (*owner, department, agency, engineer, etc.)* to perform the construction work.
* **Specialty Test Provider**. The firm retained by the \_\_\_\_\_\_ *(contractor, engineer, etc.)* responsible for supplying the bi-directional jack, jack assembly design, performing the bi-directional static load test, analyzing the load test data, and preparing the load test report.
* **Engineer**. The engineer of record employed by the \_\_\_\_\_\_\_ *(owner, department, agency, or foundation design firm, etc.)* designated to review and accept or approve the completed work.

**1.3 Test Location, Loads, and Limits.** The bi-directional load test shall be performed on the \_\_\_\_\_\_\_ *(sacrificial, production)* test element(s) at the location(s) specified in the contract documents. The load test(s) shall be performed to the requirements summarized in the following table.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Load Test Location | Foundation Head and Base Elevations\*  (feet) | Approximate Ground Surface Elevation\*  (feet) | Foundation Diameter or Dimensions  at Jack Assembly  (inch) | Jack Assembly  Elevation\*  (feet) | Minimum Total Test Load  (tons) | Minimum Jack Assembly  Capacity  (tons) | Limit on Maximum Jack Assembly Extension  (inch) |
|  | / |  |  |  |  |  |  |

\*Elevations are with respect to \_\_\_\_\_ datum.

***Commentary:*** *The foundation head and base elevations are the specified elevations of the test element concrete or grout at the head and base.*

*The approximate ground surface elevation is the elevation of the ground surface at the test element location if constructed on land, or the mudline if the test element is constructed through water.*

*The foundation diameter or dimensions at the jack assembly is the minimum test element diameter or plan dimension at the jack assembly location. This value may be smaller than the diameter or plan dimension at the head of the test element. For a barrette or slurry wall panel, the plan dimensions of the test element must be provided.*

*The jack assembly elevation is the desired fracture plane elevation at each jack assembly. The facture plane is generally assumed as the top elevation of the bearing plate beneath the bi-directional jack (i.e., the jack extension elevation).*

*The minimum total test load is twice the lesser of the anticipated soil and rock resistances to be overcome either above or below each jack assembly. In a test with a single-level jack assembly, this value should be twice the minimum jack assembly capacity.* *In a multi-level or Chicago Method test, additional geotechnical detail must be provided by the foundation designer as noted on Figure 2 (multi-level) or Figure 3 (Chicago Method).*

*The minimum jack assembly capacity in a test with a single-level jack assembly is one half the minimum total test load. In a multi-level or Chicago Method test, additional geotechnical detail must be provided by the foundation designer as noted on Figure 2 (multi-level) or Figure 3 (Chicago Method).*

*The limit on jack assembly extension during test is typically not specified on a sacrificial test element. However, on a production test element, that element will be reused and required to support structural loads after the test. In those cases, the Engineer may specify the maximum test element upper and/or lower foundation portion movement (such as 0.25 inch of shaft movement) to minimize degradation of the shaft resistance. The Engineer, or their representative, should be present on-site during the bi-directional test to inform the Specialty Test Provider when test element displacements exceed maximum limits and necessitate test termination. Displacement limits often vary based on regional geotechnical practice and/or geomaterial considerations.*

**1.3.1** The \_\_\_\_\_\_\_ *(sacrificial, production)* test element location shall be \_\_\_\_\_\_\_ *(on land / overwater)* as specified in the plans. A sacrificial test element shall maintain a minimum clear distance of 25 feet from any future production foundation locations.

***Commentary:*** *If a production foundation (intended to support structural service loads) is to be load tested, it shall be left in a condition suitable for use as a foundation element in the finished structure. Following load test completion and acceptance, post-test grouting and/or other remediation as specified by the Engineer shall be performed by the Contractor as outlined in Section 8.2 of this specification.*

**1.3.2** Bi-directional static load testing shall not begin until the \_\_\_\_\_\_ *(concrete, grout)* has cured for at least seven calendar days and reached at least 85% of the 28-day design mix strength as specified in the plans.

***Commentary:*** *Representative test element response, especially with* *respect to load-strain response, benefits from a minimum curing time of seven calendar days, regardless of whether the minimum required unconfined compressive strength for testing has been achieved before that time. For this reason, the use of high-early-strength concrete or grout to permit earlier testing is strongly discouraged.*

* 1. **Method Statement.** The Contractor shall submit a load test method statement to the \_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* for review at least \_\_\_\_ *(15, 30, 45)* working days prior to beginning test element construction. The method statement shall be provided electronically, and include all shop drawings, erection plans, details, calculations, and procedures. Review comments on the test method statement will be provided no later than \_\_\_\_ *(three, seven)* working days after its receipt and no less than \_\_\_\_ *(seven, fifteen)* working days prior to commencing test element construction. Method statement review and approval by the \_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* shall not relieve the Contractor from making subsequent changes that may become necessary to perform the test.

**1.4.1** The method statement shall include details with respect to the fabrication of the reinforcing cage (or alternate steel support frame), jack assembly configuration, instrumentation plans, displacement measuring systems, and reference beams (if required).

**1.4.2** The method statement shall include the name and qualifications of the selected Specialty Test Provider.

**1.4.3** The method statement shall include the brand, model, height, width, maximum extension, and capacity for the bi-directional jack to be used in the jack assembly by the Specialty Test Provider. The calibration certificate(s) for the bi-directional jack shall be included with the method statement, if available, or submitted separately at least five working days prior to commencing test element construction.

1. **MATERIALS & EQUIPMENT**

**2.1** The Contractor shall provide all materials, equipment, and labor required to install the jack assembly, conduct the load test, and remove the load test apparatus as required by this specification. The Contractor shall furnish the number of jack assembly as specified in the plans for each test element. The jack assembly shall have sufficient capacity to apply the specified minimum total test load and shall be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gauge(s), and telltale assemblies. The Contractor shall also furnish:

Welding equipment and certified welding personnel to assemble the jack assembly under the supervision of the Specialty Test Provider, and to attach telltale casings to the jack assembly and reinforcing cage (or steel support frame). The certified welder and welding equipment must also be readily available on-site during cage (or steel support frame) placement in the test element.

Equipment and labor to construct the steel reinforcing cage (or steel support frame) required for each \_\_\_\_\_\_\_ *(sacrificial / production)* test element, including steel bearing plates as required.

Equipment and labor to construct, attach, or assist in the installation of vent pipes and hydraulic lines on the steel reinforcing cage (or steel support frame) for each \_\_\_\_\_\_\_ *(sacrificial / production)* test element.

Equipment and operators for handling the jack assembly, instrumentation, and steel reinforcing cage (or steel support frame) during jack assembly installation and during the test, including but not limited to a crane or other lifting device for the jack assembly and instrumentation, manual labor, and hand tools as required by the Specialty Test Provider.

Materials such as steel angle, channel, rebar, pipe, bearing plates, and/or other devices needed to construct the test element (e.g., to attach the jack assembly to the reinforcing cage or carrying frame, to construct tremie guides, to protect hydraulic hoses and instrumentation lines, and lift the completed reinforcing cage) as required.

Equipment and labor sufficient to erect the reference beam system, to be constructed to the requirements of the Engineer and/or Specialty Test Provider, if required.

Air compressor (e.g., minimum 185 cfm at 125 psi) for pump operation during load testing, including sufficient hose length with Chicago-style fittings.

1. Additional materials required include, but are not limited to, the following:

An adequate supply of fresh, clean, drinking water from a source approved by the Specialty Test Provider to be used as hydraulic fluid to pressurize the bi-directional load test jack.

Stable electric power source, as required, for lights, digital survey levels, dataloggers, instruments, etc.

Adequate lighting for the test duration, including setup and teardown.

Materials sufficient to construct a stable reference beam system for monitoring vertical displacement of the test element head during load testing, if required. To minimize reference system disturbance, the system shall be shaded and supported at a minimum distance of three foundation diameters from the center of the test element, but not less than eight feet.

Alternatively, at least two automated digital survey levels may be used to monitor vertical head displacement of the test foundation in lieu of a reference beam. The digital levels shall be located a minimum clear distance of five foundation diameters from the test foundation but not less than 25 feet. The Contractor shall furnish sun, wind, and weather protection for the levels.

Materials sufficient to construct a protected work area (including provisions such as a tent or shed for protection from inclement weather for the load test equipment and personnel) of size and type required by the Engineer and/or the Specialty Test Provider. In the case of cold weather, the protected work area shall be maintained at a temperature above 40° Fahrenheit for proper operation of the pump and load testing equipment.

Materials supplied by the Contractor which do not become a permanent part of the test foundation become the property of the Contractor at the conclusion of the load test and shall be removed from the job site.

## INSTRUMENTATION

## The Contractor or Specialty Test Provider shall furnish all required instrumentation meeting the requirements identified below. All disposable instrumentation (one-time use) shall be supplied with the manufacturer’s original calibration certificate. All reusable instrumentation shall have been calibrated within the allotted time before the load test date as required by ASTM D8169-18 and furnished with their calibration certificates.

* 1. **Bi-Directional Jacks.** The bi-directional jack incorporated in the jack assembly shall be obtained from an approved Specialty Test Provider. Contact information for an approved Specialty Test Provider is as follows:

GRL Engineers, Inc.

30725 Aurora Road

Solon, OH 44129

Tel: 216-831-6131

Web: [www.grlengineers.com](http://www.grlengineers.com)

## 3.2 Pressure Measurement Devices. Pressure gauges and/or vibrating-wire pressure transducers shall be supplied with a range greater than the maximum required jack assembly pressure(s). Pressure measurement devices shall have a minimum resolution of 1% of the maximum required test pressure.

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## 3.3 Linear Vibrating-Wire Displacement Transducers (LVWDTs). LVWDTs shall be supplied with a range compatible with the maximum potential movement at the instrumentation measurement location. When LVWDTs are used to directly measure jack extension, they shall have a minimum range greater than the maximum jack assembly extension and be capable of reading to within 0.001-inch. When used to record telltale movements at other locations, they shall have a minimum range of one to six inches compatible with the expected movement and be capable of reading to within 0.001-inch.

## 3.4 Dial and Electronic Displacement Indicators. Displacement indicators shall be supplied with a range compatible with the maximum potential movement at the instrumentation measurement location. When used for measuring test element movements, they shall have a minimum range of four inches, and be capable of reading to within 0.001-inch. When used to measure test element elastic compression, they shall have a minimum range of one inch, and be capable of reading to within 0.0001-inch.

## 3.5 Strain Gauges. Strain gauges shall be supplied in the specified quantity and type (vibrating-wire sister-bar strainmeters, electrical resistance sister-bar strainmeters, vibrating-wire concrete-embedment strain gauges, or weldable vibrating-wire surface-mounted strain gauges). The number and type of strain gauges shall be as required by the plans and specifications based on the specified number of strain-gauge levels and the required number of strain gauges per level.

***Commentary:*** *The strain gauge type (sister-bar style, concrete embedment style, surface-mounted style) specified by the designer should be based on their purpose, location, and attachment requirements.*

*Strain-gauge data and interpretation is generally improved by maintaining minimum distances from load application sources to strain-gauge levels. Readings from strain gauges located closer than two foundation diameters above or below the outside edge of a jack assembly bearing plate, or closer than one foundation diameter from the test element base, may be adversely affected by bending, uneven stress distribution from misalignment, or load attraction to stiffer elements within the test element. It should be noted that for sister-bar strainmeters, these minimum distances refer to the end, not the centerline, of the strainmeter rebar. If strain measurements are required within this zone, additional strain gauge pairs should be specified to minimize potential adverse effects. With increasing test foundation diameters and/or multiple jack assemblies, these recommended minimum distances may become prohibitive, and may not be practical.*

*Sister-bar strainmeters offer the advantage of transferring concrete strains to the strainmeter over the strainmeter length but have the limitation that they may not fit or will be too close to the loading source or test element base if insufficient distance exists between the jack assembly and the test element base. In that specific case, a shorter concrete embedment strain gauge may be a preferable selection. Similarly, a surface-mounted strain gauge may be appropriate in a test using an alternate steel support frame.*

On circular test elements, strain gauges shall be spaced as evenly as possible around the circumference of a circular reinforcing cage, or as specified on a center bar reinforcement or a steel support frame. On rectangular test elements, strain gauge locations shall be placed on directly opposite surfaces or faces of the reinforcing cage. All costs for supplying the specified number of strain gauges and their appropriate cable lengths shall be included in the price bid for “Bi-Directional Static Load Test.” No additional payment shall be made for this equipment.

***Commentary:*** *The number of specified strain-gauge levels depends on several factors including test element length, subsurface stratigraphy, test purpose and desired outcome, the elevation of the jack assembly, foundation re-design potential, and possible strain gauge use for long-term monitoring in a production element. It should be emphasized that strain is one of the most-important parameters measured in a bi-directional static load test with several other important test results calculated from the strain measurements. Therefore, given the overall scope and cost of a bi-directional static load test as well as the potential for strain gauge mortality in a construction application, the false economy gained by specifying a limited number of strain-gauge levels or the minimum strain gauges per level should be avoided. Additional insight on the need for strain gauge redundancy can be found at:*

[*https://www.grlengineers.com/wp-content/uploads/2023/09/Newsletter\_Q3\_2023.pdf*](https://www.grlengineers.com/wp-content/uploads/2023/09/Newsletter_Q3_2023.pdf)

*The number of strain gauges per strain-gauge level should be a function of the test element diameter for augered cast-in-place (ACIP) piles, drilled displacement piles (DDP), and drilled shafts; or the foundation plan dimensions for slurry wall panels and barrettes. Suggested minimum number of strain gauges per level as a function of the foundation type and size is as follows:*

|  |  |  |  |
| --- | --- | --- | --- |
| *Foundation Type* | *Foundation Diameter or Plan Dimension* | *Reinforcing*  *Type* | *Strain Gauges*  *per Level* |
| *ACIP / DDP* | **≤***18-inch dia.* | *Center Bar* | *one reqd. if sister-bar, two if surface-mounted* |
| *Drilled Shaft / ACIP / DDP* | *> 18 to 42-inch dia.* | *Cage* | *two* |
| *Drilled Shaft / ACIP* | *> 42 to 72-inch dia.* | *Cage* | *two or four* |
| *Drilled Shaft* | *> 72 to 96-inch dia.* | *Cage* | *four* |
| *Drilled Shaft* | *> 96-inch dia.* | *Cage* | *four or eight* |
| *Panel, Barrette* | *N.A.* | *Cage* | *Depends upon shape and size* |

## 3.6 Telltale Extensometers. Embedded compression telltale extensometers shall have a range of at least two inches and be capable of measuring movement to within 0.001-inch. Embedded compression telltales shall be specified below the bottom jack assembly plate in lieu of full-length telltales if the distance between the bottom jack assembly plate and foundation base is greater than four foundation diameters or 16 feet, whichever is greater.

**3.7 Digital Survey Levels.** Self-leveling digital survey levels and related equipment shall be capable of measuring test element head displacement to within 0.001-inch at 100 feet or better. To minimize measurement errors, the levels shall be located at a minimum distance of five foundation diameters or 25 feet from the center of the test element, whichever is greater, and no more than 90 feet from the center of the test element. Invar barcode targets shall be at least six inches in length and provide a reading precision of 0.001 inch. A benchmark or backsight shall be used to check that the level measurements were not adversely impacted during the test.

## 3.8 Data Acquisition System. A compatible data acquisition system shall be furnished with all instrumentation. The system should be capable of simultaneously reading all instrumentation types and channels used for pressure gauges, strain gauges, LVWDTs, dial indicators, extensometers, and digital survey levels. If multiple systems are required, readings must be time stamped to allow data synchronization.

## 4.0 PREPARATION FOR TESTING

**4.1** The Contractor’s Specialty Test Provider shall be furnished pertinent project information, including (but not limited to) project plans and specifications, subsurface exploration records (boring logs, cone penetration test logs) test foundation installation records, concrete or grout mix properties, concrete or grout compressive strength test results, and any site safety requirements as soon as these items are available prior to the method statement preparation.

**4.2** The Specialty Test Provider shall identify specified and/or proposed instrumentation locations as part of the method statement required by Section 1.5.Review comments shall be provided by the \_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* to the Contractor, within \_\_\_\_ (three, five) working days after receiving this information so that the required instrumentation order lengths are available when necessary.

**4.3** Strain and pressure gauge instrumentation, displacement transducers, jack assembly, and any other materials and equipment required by the Specialty Test Provider or by project specifications (e.g. CSL access tubes for cross hole sonic logging, Thermal Wire Cables for Thermal Integrity Profiling (TIP), PVC access tubes for Gamma-Gamma Logging (GGL) shall be installed by the Contractor or Specialty Test Provider on the reinforcing cage (or steel support frame) prior to lifting.

**4.4** Bi-directional static load testing shall not begin until at least four days after any specified integrity testing has been performed, interpreted, and the results reported to the \_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.).* The \_\_\_\_\_\_\_ *(concrete, grout)* shall also have cured for at least seven days and exceeded 85% of the minimum required 28-day compressive strength.

**4.5** The Contractor shall cooperate with \_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* personnel who shall be granted access to all facilities necessary to observe the test and view real-time test results. The Specialty Test Provider shall have the right to restrict all personnel access that might adversely affect the bi-directional load test.

**4.6** The Contractor shall perform the test element excavation, grout or concrete placement, reinforcement (unless alternate steel support frame allowed), and construction using the same means and methods proposed for production foundations in accordance with the project specifications.

**4.7** The jack assembly, hydraulic supply lines, and other instruments shall be assembled and made ready for installation under the direction of the Specialty Test Provider, in a suitable area adjacent to the test element to be provided by the Contractor. The jack assembly shall be welded to the rebar cage (or steel support frame). The plane of the jack assembly bearing plates shall be set at right angles to the long axis of the cage (or frame). The Contractor shall use the utmost care in handling the jack assembly, individual instrumentation, and the instrumented cage (or steel support frame) so as not to cause damage to any of these components during installation. The Contractor shall limit the deflection of the cage (or steel support frame) to two feet between pick points while lifting the cage (or steel support frame) from the horizontal position to vertical. The maximum distance between pick points shall be 25 feet. The Contractor shall provide support bracing, strong backs, etc. to maintain the deflection within the specified tolerance. The jack assembly must remain perpendicular to the long axis of the reinforcing cage (or steel support frame) throughout the lifting and installation process.

**4.8** For drilled shaft, slurry wall panel or barrette foundations, the steel reinforcing cage (or steel support frame) including the integral jack assembly shall be installed in the foundation excavation once the excavation has been completed to the specified depth and the verticality and base cleanliness have met specification requirements. For augered cast-in-place and drilled displacement piles, the steel reinforcing cage (or steel support frame) including the integral jack assembly shall be plunged into the fluid grout filled excavation immediately following auger withdrawal.

**4.9** For drilled shaft, slurry wall panel or barrette foundations, concrete shall be placed in the test element using an approved method. Typically, concrete is placed using a tremie pipe or slick line extending through the jack assembly to the test element base. When a jack assembly configuration at the test element base leaves insufficient space for tremie pipe or slick line use, it may be necessary to deliver a concrete seating layer prior to installing the reinforcing cage. In this case, the cage and jack assembly shall be installed while the concrete at the base is still fluid, and the jack assembly should end up submerged and firmly seated in the fluid concrete. After seating the jack assembly, confirmation of the proper reinforcing cage elevation shall be obtained. The remainder of the test element shall be concreted in the same manner specified for production foundations, ideally using the same concrete mix.

***Commentary:*** *A concrete seating layer at the base of a drilled shaft, barrette, or slurry wall panel base is only required if a jack assembly is in proximity to the base.*

**4.10** At least six test cylinders (or grout cubes), in addition to those specified elsewhere, shall be made from the \_\_\_\_\_\_\_ (concrete, grout) placed in the test element. Compressive strength tests on these specimens shall be performed on the dates directed by the Specialty Test Provider. At least one cylinder shall be tested prior to the load test, and at least two cylinders shall be tested on the specified day of the load test. The concrete cylinder test results shall be provided to the Specialty Test Provider as soon as they become available and shall be included in the load test report.

For bi-directional load tests used to assess geomaterial resistances with embedded strain gauge instrumentation, elastic modulus testing shall be performed in accordance with ASTM C469/C469M-14 on at least one cylinder specimen the day of the load test.

***Commentary:*** *Concrete elastic modulus determination is an essential component of best practice strain-gauge data interpretation.*

## LOAD TESTING

* 1. The load testing shall be performed by a Specialty Test Provider approved in advance by the \_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.).* The Specialty Test Provider must have a demonstrated knowledge of bi-directional load testing procedures and data evaluation and have performed at least \_\_\_\_\_\_\_ bi-directional static load tests within the past \_\_\_\_\_\_\_ years. The load testing shall be performed in general compliance with ASTM D8169-18 using Procedure A: Quick Test method.

***Commentary:*** *The Specialty Test Provider required experience can be adjusted and specified based on the complexity of the test (foundation type, load magnitude, jack assembly levels, foundation length, and whether the test is specified on a sacrificial or production test element). In general, completion of 20 bi-directional static load tests within the past two years is a reasonable experience requirement for routine tests. For complex or high-capacity tests, 50 bi-directional static load tests within the past five years may be appropriate with at least 10 tests conducted on a test element having similar size, length, and test load.*

* 1. The bi-directional static load test shall be performed in general accordance with Procedure A: Quick Test as described in ASTM D8169-18, unless otherwise specified in the plans. The loads shall be applied in equal increments of no more than 5% of the specified upward and downward test load, and jack assembly capacity (i.e., no more than 2.5% of the specified total test load). The load-increments’ magnitude may be slightly increased or decreased depending on project requirements, but the load increment magnitude and load increment duration shall not be changed during the test.

***Commentary:*** *The intent of the prescribed load increments’ magnitude is to provide at least 20 load increments during the test. Due to uncertainties in static capacity prediction methods, this objective may not be met. Accordingly, slightly increasing the load increments’ magnitudes (i.e., decreasing the number of load increments) is not recommended.*

* 1. Loads shall be applied at the prescribed load increments and time intervals until one or more of the following criteria are met:

1. The jack assembly capacity is reached.
2. The jack assembly nears full extension.
3. The foundation portion above or below the jack assembly experiences geotechnical failure (evidenced by continuous displacement and the inability to apply additional test load with the pumping apparatus on-site).
4. Maximum test load or displacement criteria as established by the Designer is reached.
5. As otherwise directed by the \_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.).*

***Commentary:*** *If a multi-level test is specified, the loading sequence and an associated decision tree should be part of the approved method statement package.*

* 1. Once loading terminates, unloading shall be accomplished using at least four approximately equal load decrements. At each load increment and decrement, at a minimum, all instrumentation shall be read and recorded at one-, two-, four-, and eight-minute intervals. During each loading increment, the load shall be held as constant as possible. During each unloading decrement, the hydraulic line to the jack assembly may be closed, and the pressure/load allowed to equilibrate. Additional cycles of loading and unloading using similar procedures may be required by the \_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* following the completion of the initial test cycle.
  2. During load testing, direct movement-indicator measurements shall be made of the jack assembly extension, vertical test element head displacement, shaft elastic compression above the upper most jack assembly, and vertical test element base displacement.

Jack assembly extension shall be measured directly using Linear Vibrating-Wire Displacement Transducers capable of measuring full jack assembly extension. For test elements up to 48 inches in diameter, a minimum of two diametrically opposite measurements across the jack assembly are required. For test element diameters of 48 to 96 inches, a minimum of four diametrically opposite measurements across the jack assembly are required. The number of direct jack assembly extension measurements for test element diameters greater than 96 inches or for slurry wall panels and barrettes shall be as shown on the plans.

***Commentary:*** *Note a plan detail on the number and arrangement of direct jack assembly measurements is required for test element diameters greater than 96 inches, and for slurry wall panels and barrettes.*

Jack assembly extension can also be measured indirectly using indicators mounted atop telltales that extend from the top of the upper bearing plate and from the top of the lower bearing plate to a measurement location above grade. A minimum of two diametrically opposite measurements are required for each monitored bearing plate (four total). Displacement sensors used to measure jack assembly extension should have a minimum travel of nine inches and have a minimum resolution of 0.001-inch.

Vertical test element head displacement. A minimum of two indicators required.

Test element elastic compression above uppermost jack assembly. A minimum of two indicators required.

**5.6** During the load test, no casings or sheet piling shall be vibrated into place within a 100-foot radius of the test element. Drilling shall not continue within a 100-foot radius of the test element. If test results show any effect due to any construction activities at any distance from the test element, such activities shall cease immediately and for the load test duration.

**5.7** After the load test is completed, and at the direction of \_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)*, the Contractor shall remove any equipment, material, waste, etc. which are not to be a part of the finished structure.

## REPORTING

**6.1** The Contractor’s Specialty Test Provider shall prepare and submit a sealed, electronic report to the \_\_\_\_\_\_ *(Engineer, Department, Owner, etc.)* for each bi-directional load test. An initial data report containing the jack assembly upper and lower bearing plates load-displacement curves with supporting data tables shall be submitted within \_\_\_\_\_\_\_ *(typically two)* working days after load testing completion. A final bi-directional static load testing report shall be submitted within \_\_\_\_\_\_\_ *(typically 10)* working days after load testing completion.

***Commentary:*** *Report method statement timing requirements should be realistically selected based on the number of load tests on the project and their complexity. If multiple bi-directional static load tests are performed, it should be clearly stated whether the final test results are to be submitted in separate reports, or in a combined report after the final test. Combined reporting benefits from being able to compare and correlate multiple test results for consistency. In this case, report method statement timing requirements should be reference to completion of the last static test.*

*Multi-level bi-directional static load tests (in which the test foundation contains two or more jack assemblies) include multiple loading stages, with different jack assemblies pressurized, open, or closed) for each stage. Completion of all loading stages constitutes test completion, and results from all loading stages should be included in one report. A longer report preparation time should be specified for a multi-level, multi-stage test than for a more-routine single-level test.*

## 7.0 METHOD OF MEASUREMENT

**7.1** The Bi-Directional Static Load Test shall be considered to include all material, labor, equipment, jack assemblies, instrumentation, etc. required in addition to the requirements of the production foundation installation necessary to install, conduct, and remove test element at the direction of the *\_\_\_\_\_\_\_\_\_\_ (Engineer, Owner, Department, etc.)* and the Specialty Test Provider. All costs of the load test, including subcontracting to the Specialty Test Provider shall be included in the bid price for this work.

**7.2** The quantity of the pay item “Bi-Directional Static Load Test” is measured by each (EA) completed and accepted by the \_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.).* A completed Bi-Directional Static Load Test shall be one test conducted on a test foundation element using a Bi-Directional Static Load Testing System.

**7.3** All costs associated with the normal construction and acceptance of the tested foundation element are measured and paid for elsewhere in the contract documents.

## TEST ELEMENT DISPOSITION OR REMEDIATION

**8.1** After the completion of all testing, submittal of the specified reports, and acceptance of the load test result by the \_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)* the test element shall be cut off at a depth of \_\_\_\_ feet *(typically at least two feet)* below the ground surface. The cut-off portion of the test foundation shall be properly disposed of by the Contractor, and the resulting hole shall be backfilled with soil in accordance with Section \_\_\_\_\_\_\_ of the project specifications. The test area shall be graded smoothly. In addition, the location of each test element shall be surveyed and indicated on the As-Built plans for this project.

***Commentary:*** *Section 8.1 should be used if the bi-directional test is performed on a sacrificial (non-production) test element. This section should be eliminated and substituted with Section 8.2 if the bi-directional test is to be performed on a production foundation.*

**8.2** After completing all testing, and the submittal and acceptance of the required reports by the\_\_\_\_\_\_\_\_\_\_ *(Engineer, Owner, Department, etc.)*, post-test grouting shall be performed to fill the jack assembly jack, the annular space created around the jack assembly due to jack assembly extension, and the telltale casings. Vent pipes, CSL or GGL tubes may be used to grout the annular space.

The same grout mix shall be used to grout the jack assembly jack, the jack assembly annular space, and the telltale casings. The neat cement grout shall consist of Portland cement and water only (no sand). The grout shall be mixed thoroughly to eliminate lumps of dry cement, should be passed through a window-screen mesh before pumping, and shall be fluid and pumpable. The grout mix shall be compatible with the test element’s required concrete strength.

To grout the jack, the grout pump outlet shall be connected to one hydraulic line (inlet) of each jack. The other line (outlet) of each jack shall be opened, and water flow shall be established through the system. Grout shall then be pumped through the system, while effluent from the outlet line is collected and monitored. When the effluent matches the pumped grout, pumping can stop.

Water shall also be pumped through all vent pipes and all CSL or GGL tubes to establish a flow. If the vent pipes are used to grout the annular space around the jack assembly, grout shall be pumped through one of the vent pipes (inlet) until equivalent grout flows from the rest of the vent pipes (outlet) and all the CSL or GGL tubes, or until 1.5 times the theoretical annular space volume has been pumped (whichever comes first). If no grout effluent flows from one or more vent pipes or one or more CSL or GGL tubes, grout shall be pumped into each non-effluent vent pipe and each non-effluent CSL or GGL tube until a minimum of 1.5 times the theoretical annular space volume has been pumped into each non-effluent location.

If the CSL or GGL tubes are used to grout the annular space around the jack assembly, grout shall be pumped through one of the CSL or GG) tubes until equivalent grout flows from all the other CSL or GGL tubes and all the vent pipes, or until 1.5 times the theoretical annular space volume has been pumped (whichever comes first). If no grout effluent flows from one or more CSL or GGL tubes or one or more vent pipes, grout shall be pumped into each non-effluent CSL or GGL tube and each non-effluent vent pipe until a minimum of 1.5 times the theoretical annular space volume has been pumped into each non-effluent location.

***Commentary:*** *Section 8.2 applies to bi-directional load tests performed on production foundations. Section 8.2 should be eliminated if the load testing is performed on a sacrificial test element.*

## PAYMENT BASIS

* 1. The complete and accepted "Bi-Directional Static Load Test" shall be paid for at the contract lump sum price for each. This shall constitute full compensation for all costs incurred during the procurement, installation, conducting and reporting of the test, subsequent removal of test apparatus and appurtenances, and sacrificial test element disposal or production foundation remediation as described in Section 8.0.

## PAYMENT

* 1. Payments shall be made under Pay Item \_\_\_\_\_\_\_, “Bi-Directional Static Load Test.”

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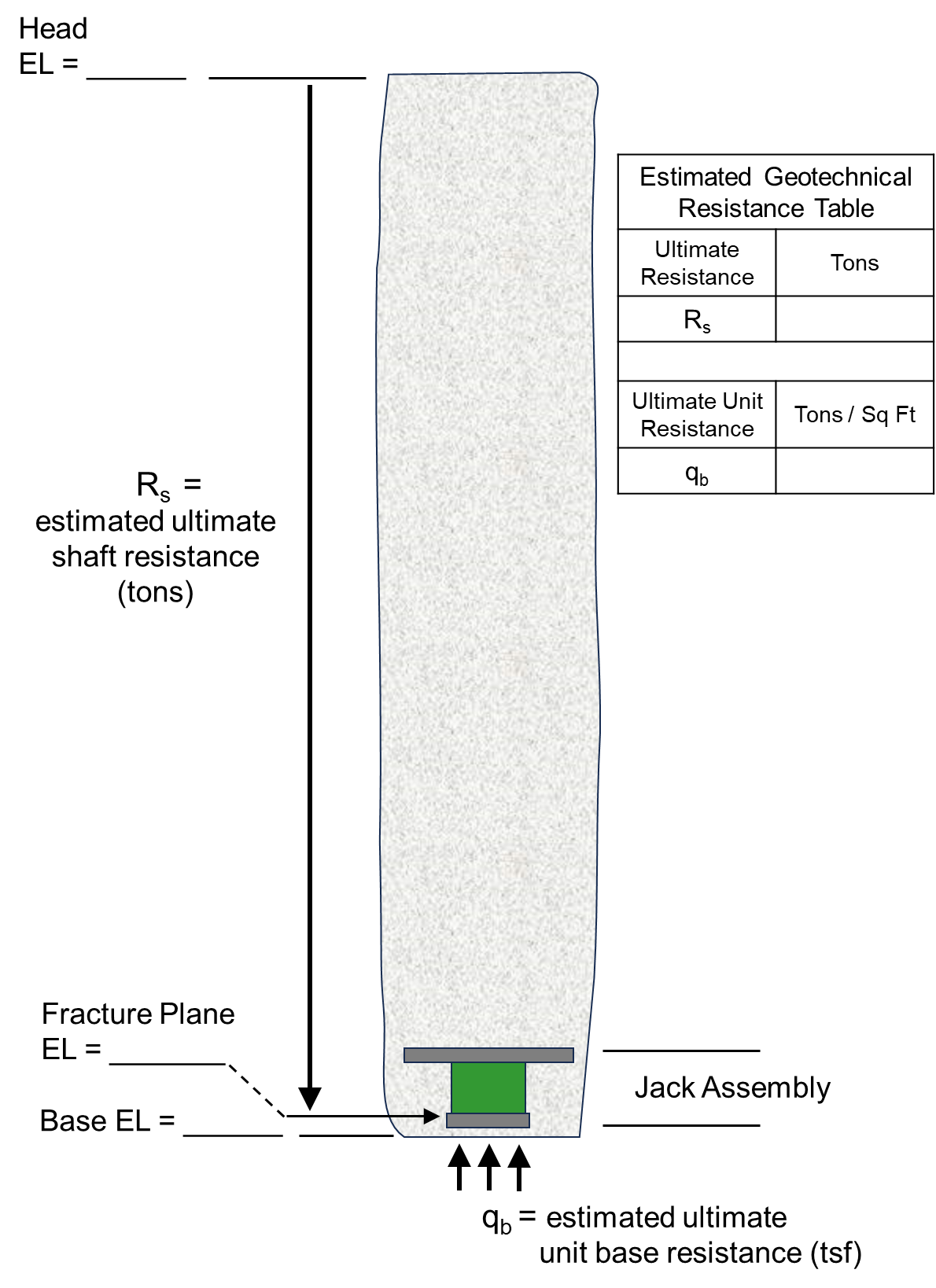
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**Figure 1. Estimated Geotechnical Resistances and Elevations for a Single Level Jack Assembly**

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**Figure 2. Estimated Geotechnical Resistances and Elevations for a Multi-Level Jack Assembly**

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**Figure 3. Estimated Geotechnical Resistances and Elevations - Chicago Method Test**