State of Ohio

Department of Transportation

SPECIAL PROVISION

**MICROPILE LOAD TESTING**

January 07, 2020

**Item 507 Piling, Misc.: Micropile Verification Test**

**Item 507 Piling, Misc.: Micropile Proof Test**

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**1.0 Description**

This work consists of applying static test loads to micropiles and furnishing instruments and facilities to obtain load-displacement data required to verify the nominal (ultimate) axial static geotechnical resistance of a sacrificial pre‐production micropile or to prove the axial static geotechnical resistance of a production micropile. The number and location of the load tests shall be as specified in the Plans, or as proposed by the Contractor in accordance with this provision, and as accepted by the Engineer.

**2.0 Definitions**

1. **Design Load:** The maximum load anticipated to be applied to the micropile during its service life. For micropiles designed under LRFD, this is expressed as the Factored Design Load (FDL).
2. **Maximum Permissible Load:** The maximum load that may be applied to the micropile during any stage of the work. The Maximum Permissible Load is 80 percent of the calculated nominal (ultimate) structural resistance of the micropile.
3. **Maximum Test Load:** The largest load applied to the micropile when stressing during a load test. This is defined as the Verification Test Load (VTL) for pre‐production Verification Tests of sacrificial test micropiles, and this is defined as the Proof Test Load (PTL) for Proof Tests of production micropiles.
4. **Alignment Load:** The load maintained on a micropile during testing to assure that the testing equipment remains in proper position, not to exceed 2.5 percent of the Maximum Test Load (VTL or PTL).
5. **Compression Load Test:** The typical and more common static load test performed for micropiles used as structure foundation elements. Compression load tests shall conform to ASTM D1143, “Standard Test Methods for Deep Foundations Under Static Axial Compressive Load,” Procedure A: Quick Test.
6. **Tensile Load Test:** The static load test performed on structure foundation micropiles subject to uplift loads or for micropiles used as tensile elements in slope stabilization projects. Tensile load tests shall conform to ASTM D3689 “Standard Test Methods for Deep Foundations Under Static Axial Tensile Load,” Procedure A: Quick Test.
7. **Verification Test:** A static load test on a sacrificial pre-production micropile, that requires the application of defined incremental loads to the test micropile, in four loading cycles up to the VTL, and unloading of the test micropile. The movement of the micropile is recorded at each loading and unloading increment. At 0.75 VTL, the applied load is maintained constant for a defined time period while creep movement is recorded. Alternately, with the acceptance of the Engineer, the Contractor may opt to increase the test load beyond the VTL to determine ultimate geotechnical resistance for a verification test micropile. In any event, the test load shall not exceed the Maximum Permissible Load.
8. **Proof Test:** A static load test on a production micropile, that requires the application of defined incremental loads to the test micropile up to the PTL and unloading of the test micropile. The movement of the micropile is recorded at each load increment. At the PTL, the applied load is maintained constant for a defined time period while creep movement is recorded.
9. **Creep Movement:** The time‐dependent movements of the micropile at a constant load.
10. **Creep Curve:** A semilogarithmic plot of the creep movement versus time, with the units of time plotted on the logarithmic axis.
11. **Creep Rate:** The slope of the creep curve per log cycle of time over the final decade of the observation period.

**3.0 Construction Submittals**

Submit the following information, in electronic PDF format, to the Engineer for review and acceptance at least 15 calendar days prior to start of micropile construction or incorporation of the respective materials into the Work.

The Contractor shall submit shop drawings for the micropile static load testing method and equipment setup including:

1. Details of the reaction frame.
2. Number and layout of anchor piles and distance between the test micropile and the anchor piles.
3. Equipment list and calibration reports. Provide the identification number and certified calibration records for each test jack and pressure gauge and load cell to be used. Jack and pressure gauge shall be calibrated as a unit. Calibration records shall include the date tested, device identification number and the calibration test results and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.

The Engineer will accept or reject the Contractor’s submittals within 15 calendar days after receipt of a complete submission. The Contractor will not be allowed to begin micropile construction or incorporate respective materials into the work until the submittal requirements are satisfied and found acceptable to the Engineer. Changes or deviations from the accepted submittals must be resubmitted for acceptance. No adjustments in contract time will be allowed due to incomplete submittals.

**4.0 General Requirements**

Install all micropiles in accordance with the AASHTO LRFD Bridge Construction Specifications, Section 33, and the details in the Plans.

No drilling or installation of production micropiles will be permitted until successful pre‐production verification testing of micropiles is completed and accepted by the Engineer. The number and location of the verification tests shall be as specified in the Plans or as accepted by the Engineer. Install verification test micropiles using the same equipment, methods, materials, and diameter as planned for the production micropiles. Changes in the drilling or installation method may require additional verification testing as determined by the Engineer and shall be provided at no additional cost. Payment for additional verification tests required due to differing site conditions, if determined by the Engineer, shall be per the contract unit price.

If the number of proof tests is not specified in the Plans, test a minimum of five percent of the production micropiles, and a minimum of one per substructure unit.

Perform a compression load test according to ASTM D1143, Procedure A: Quick Test, except as modified below. Perform a tensile load test according to ASTM D3689, Procedure A: Quick Test, except as modified below.

For micropiles subject to both tension and compression loads, both tension and compression load tests are performed. When the same micropile is to be tested in both tension and compression, conduct the tension test first. This will allow the micropile to be reseated during compression testing in the event some net upward residual movement occurs during the tension test.

If using anchor piles to apply the load to the test micropile, locate the anchor piles to provide a minimum clear distance of 6 feet (1.8 m) from the test micropile. The Contractor may use battered micropiles as anchor piles, provided the horizontal forces in the anchor system are balanced and excessive bending stresses are not induced in the micropiles. The Contractor may also use bearing micropiles meeting these requirements as anchor piles. After the test has been completed, remove or cut off at least 1 foot (0.3 m) below the bottom of the footing or finished surface of the ground all anchor piles outside the limits of the footing. Cut off anchor piles, other than bearing micropiles, within the limits of the footing 3 inches (75 mm) above the bottom of the footing. If bearing micropiles used as anchor piles are displaced upward during the application of the test load, abandon these micropiles, cut them off 3 inches (75 mm) above the bottom of the footing, and replace these micropiles with identical micropiles.

For the duration of the test, provide adequate facilities to record load and displacement readings. To avoid column buckling of the micropile, ensure that tested micropiles are substantially vertical and that the load is applied to the micropile at a point as near the ground surface as possible.

Provide equipment and loading apparatus to apply a load of twice the Maximum Test Load. Have a Registered Engineer design the loading apparatus. Determine if test micropiles have enough structural resistance to support a load of twice the Maximum Test Load. For this check, use a load factor of 1.00 and resistance factor of 0.80 for the calculated nominal (ultimate) structural resistance of the micropile. The load test is unacceptable if the micropile fails structurally during the test.

**5.0 Test Procedure**

Perform both verification and proof testing of designated test micropiles. Perform pre‐production verification tests on sacrificial test micropiles at locations shown on the Plans or as accepted by the Engineer. Perform proof tests on production micropiles at locations accepted by the Engineer. Any micropile shall only be subjected to either a verification test or proof test but not both. Verification test micropiles will be sacrificial and not incorporated as production micropiles. Required micropile test data shall be recorded by the Engineer.

Apply test loading at least 5 days after placing grout in the micropile (or after post-grouting for Type C or Type D micropiles), and in the anchor piles, if micropiles are to be used as anchor piles.

Use displacement indicators as the primary system to measure axial movement of the test micropile top, with a redundant secondary system as described in ASTM D1143 or ASTM D3689.

Monitor and record the micropile load during load tests with both the pressure gauge and the load cell.

Use the VTL and PTL specified on the Plans. If the VTL and PTL are not specified on the Plans, set the VTL equal to 1.50 times the FDL, and set the PTL equal to the FDL for LRFD projects. If the FDL is unknown, or for an ASD project, set the VTL equal to the design nominal (ultimate) geotechnical resistance of the micropile, and set the PTL equal to 80 percent of the design nominal (ultimate) geotechnical resistance of the micropile.

The alignment load (AL) shall be the minimum load required to align the testing apparatus and shall not exceed 2.5 percent of the VTL or PTL, as applicable. Set displacement indicators to "zero" after the AL has been applied at the beginning of the test.

Load the test micropile incrementally to the Maximum Test Load (VTL or PTL) in accordance with the following Verification Test Load Schedule or Proof Test Load Schedule, as applicable. Hold each load interval for the hold time specified in the load schedule. If it is necessary to remove and reapply the load during the test, use the same loading procedure to reapply the test load.

For intervals specified to be held “Until Stable,” hold until there is no further micropile movement, and for a minimum of one minute, and record the micropile movement at the end of the hold time. At each 1-minute load interval, record the micropile movement at 1 minute. At each 4-minute load interval, record the micropile movements at 1 minute, 2, and 4 minutes. At each 15-minute load interval, record the micropile movements at 1 minute, 2, 4, 8, and 15 minutes.

Monitor verification test micropiles for creep at the 0.75 VTL load interval. Monitor proof test micropiles for creep at the 1.00 PTL load interval. Record the micropile movements during the creep portion of the test at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes. If the micropile moves 0.04 inch or less in the first 10 minutes, then the creep test may be halted at 10 minutes. Otherwise, continue the creep test to 60 minutes. The load during the creep test shall be maintained within 2 percent of the specified applied load by use of the load cell.

At the end of the load test, reduce the load back to AL, and record the permanent set of the micropile.

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| **Verification Test Load Schedule** | | | |
| **Cycle** | **Interval** | **Applied Load** | **Hold Time** |
| 1 | 1 | AL (≤ 0.025 VTL) | Until Stable |
| 2 | 0.05 VTL | 4 minutes |
| 3 | 0.10 VTL | 4 minutes |
| 4 | 0.15 VTL | 4 minutes |
| 5 | 0.20 VTL | 4 minutes |
| 6 | 0.25 VTL | 4 minutes |
| 2 | 7 | AL (≤ 0.025 VTL) | Until Stable |
| 8 | 0.10 VTL | 1 minute |
| 9 | 0.20 VTL | 1 minute |
| 10 | 0.25 VTL | 1 minute |
| 11 | 0.30 VTL | 4 minutes |
| 12 | 0.35 VTL | 4 minutes |
| 13 | 0.40 VTL | 4 minutes |
| 14 | 0.45 VTL | 4 minutes |
| 15 | 0.50 VTL | 4 minutes |
| 3 | 16 | AL (≤ 0.025 VTL) | Until Stable |
| 17 | 0.20 VTL | 1 minute |
| 18 | 0.40 VTL | 1 minute |
| 19 | 0.45 VTL | 1 minute |
| 20 | 0.50 VTL | 1 minute |
| 21 | 0.55 VTL | 4 minutes |
| 22 | 0.60 VTL | 4 minutes |
| 23 | 0.65 VTL | 4 minutes |
| 24 | 0.70 VTL | 4 minutes |
| 25 | 0.75 VTL (Creep Test) | 10 or 60 minutes |
| 4 | 26 | AL (≤ 0.025 VTL) | Until Stable |
| 27 | 0.25 VTL | 1 minute |
| 28 | 0.50 VTL | 1 minute |
| 29 | 0.75 VTL | 1 minute |
| 30 | 0.80 VTL | 4 minutes |
| 31 | 0.85 VTL | 4 minutes |
| 32 | 0.90 VTL | 4 minutes |
| 33 | 0.95 VTL | 4 minutes |
| 34 | 1.00 VTL (Max. Test Load) | 4 minutes |
| 5 | 35 | 0.80 VTL | 4 minutes |
| 36 | 0.60 VTL | 4 minutes |
| 37 | 0.40 VTL | 4 minutes |
| 38 | 0.20 VTL | 4 minutes |
| 39 | AL (≤ 0.025 VTL) | 15 minutes |

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| **Proof Test Load Schedule** | | |
| **Interval** | **Applied Load** | **Hold Time** |
| 1 | AL (≤ 0.025 PTL) | Until Stable |
| 2 | 0.10 PTL | 4 minutes |
| 3 | 0.20 PTL | 4 minutes |
| 4 | 0.30 PTL | 4 minutes |
| 5 | 0.40 PTL | 4 minutes |
| 6 | 0.50 PTL | 4 minutes |
| 7 | 0.60 PTL | 4 minutes |
| 8 | 0.70 PTL | 4 minutes |
| 9 | 0.80 PTL | 4 minutes |
| 10 | 0.90 PTL | 4 minutes |
| 11 | 1.00 PTL (Max. Test Load) | 10 or 60 minutes (Creep Test) |
| 12 | 0.75 PTL | 4 minutes |
| 13 | 0.50 PTL | 4 minutes |
| 14 | 0.25 PTL | 4 minutes |
| 15 | AL (≤ 0.025 PTL) | Until Stable |

If a bearing capacity failure or pullout failure occurs, or if the maximum test load otherwise exceeds the ultimate geotechnical resistance of the micropile, determine the load test nominal (ultimate) axial static compressive load capacity (Rn) using the Davisson criteria (elastic deformation + 0.15” + D/120), where D = diameter of the micropile in inches; determine the load test nominal (ultimate) axial static tensile load capacity (Rup) using a modified criteria (elastic deformation + 0.15”).

Construct a graph showing a plot of micropile movement versus load for each load increment and a Creep Curve plot of micropile movement versus time for each creep test. Supply the testing data and plots of micropile movement to the Engineer for each verification test or proof test.

Within four days of completing the static load test, submit a report to the Engineer which contains the information required according to ASTM D1143 or ASTM D3689, and the load displacement graph described above. The Engineer will evaluate the results of each static load test.

**6.0 Acceptance Criteria**

A test micropile shall be considered acceptable when:

1. The micropile shall sustain the compression and tension design service loads (at the 0.50 VTL load interval or 0.70 PTL load interval) with no more than 1 inch\* total vertical movement at the top of the micropile as measured relative to the top of the micropile prior to the start of testing.

*\* Designer Note: 1 inch is a holding place for this specification. The designer is to determine maximum acceptable total pile top axial displacement at Service Load based on structural design and serviceability requirements per ODOT Bridge Design Manual (BDM) Section 305.1.3 and AASHTO LRFD Bridge Design Specifications Article 10.5.2.2. The allowable displacement should also consider long term pile group settlements at the Service Load.*

1. For creep tests, a total creep movement of less than 0.04 inches is measured between the 1 and 10 minute readings or a total creep movement of less than 0.08 inches is measured between the 6 and 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold interval.
2. A bearing capacity failure or pullout failure does not occur at PTL or before reaching VTL. A bearing capacity failure (in compression) or a pullout failure (in tension) is defined as the load at which attempts to further increase the test load simply result in continued movement of the test micropile. The bearing capacity or pullout failure load shall be recorded as part of the test data. Alternately, with the acceptance of the Engineer, the Contractor may opt to increase the test load beyond the VTL to determine ultimate resistance for a verification test micropile; in this event the test load shall not exceed the Maximum Permissible Load.

At the completion of verification testing, remove or cut off all verification test micropiles at least 1 foot (0.3 m) below the bottom of the footing or finished surface of the ground. Successful proof tested micropiles meeting the above test acceptance criteria may be incorporated as production micropiles.

1. **Test Micropile Rejection:** If a test micropile does not satisfy the acceptance criteria, it will be rejected. The Contractor shall determine the cause for the failure. Any modification to the micropile design that necessitates changes to the structure design shall require the Engineer’s prior review and acceptance. If for any reason other than differing site conditions, any modifications of design or construction procedures, cost of rejected verification test micropiles, cost of rejected verification or proof tests, or cost of replacement production micropiles, shall be at the Contractor’s expense.
2. **Verification Test Micropile Rejection:** If a verification tested micropile is rejected, install and test an additional verification test micropile. Modify the design, the construction procedure, or both. These modifications may include, but are not limited to, modifying the installation methods, increasing the bond length, or changing the micropile type.
3. **Proof Test Micropile Rejection:** If a proof tested micropile is rejected, immediately proof test another micropile within the same substructure unit. For failed micropiles and further construction of other micropiles, the Contractor shall modify the design, the construction procedure, or both. These modifications may include, but are not limited to, installing replacement micropiles, incorporating micropiles at not more than 50% of the maximum load attained, postgrouting, modifying installation methods, increasing the bond length, or changing the micropile type.

**7.0 Method of Measurement**

1. The unit of measurement for micropile load testing will be per each acceptable test micropile. The unit price for each micropile load test includes hydraulic jacks, reaction micropiles if needed, testing equipment including load and displacement measurement devices, and all labor. Load tests of unacceptable (rejected) test micropiles will be considered incidental to the work and will not be paid by the Department.
2. Verification Tests shall be included with Item 507 Piling, Misc.: Micropile Verification Test for payment and shall include all labor, equipment, and materials necessary to complete the work. Costs associated with installation of the verification test micropiles shall be included with this item.
3. Proof Tests shall be included with Item 507 Piling, Misc.: Micropile Proof Test for payment and shall include all labor, equipment, and materials necessary to complete the work. Costs associated with installation of the (production) proof test micropiles shall be paid separately from this item.

**8.0 Basis of Payment**

The Department will pay for accepted quantities at the contract prices as follows:

**Item Unit Description**

507E98010 Each Item 507 Piling, Misc.: Micropile Verification Test

507E98010 Each Item 507 Piling, Misc.: Micropile Proof Test