Section 2.4
Volume II

TESTING AND SUBMITTAL REQUIREMENTS FOR POLYMER SLURRY PRODUCTS TO BE USED IN DRILLED SHAFT CONSTRUCTION

2.4.1 PURPOSE

This procedure provides instructions for testing and reports that need to be submitted for consideration of approval in the use of polymer slurry products for drilled shaft construction.

2.4.2 AUTHORITY

Code of Federal Regulations (CFR), Federal-Aid Policy Guide (FAPG), Construction Inspection and Approval, Subpart B – Quality Assurance Procedures for Construction

334.044(2), 334.044(10) (a), and 334.048 Florida Statutes

2.4.3 REFERENCES

Standard Specifications for Road and Bridge Construction, Florida Department of Transportation

American Society for Testing and Materials (ASTM) Standard Test Methods and Specifications, Philadelphia, Pennsylvania

Code of Federal Regulations (CFR)

Resource Conservation and Recovery Act (RCRA)

2.4.4 SCOPE

This procedure is to be used by polymer slurry Suppliers and Contractors to obtain approval for a particular polymer product to be used in the stabilization of drilled shaft excavations.

2.4.5 GENERAL INFORMATION

In this procedure, the word “Supplier” is the supplying entity requesting a particular polymer product to be approved. It may refer to a Supplier or a Contractor (or both) interested for a product to be used on Department projects. All the costs required to comply with these requirements (including but not limited to construction, fabrication of

samples, testing, load testing, soil field and lab testing, integrity testing, shaft extraction, any concrete removal, site restoration, engineering, analysis and reports) shall be borne by the Supplier.

2.4.6 MATERIAL APPROVAL PROCESS

The Supplier needs to submit a report that demonstrates the following items (in accordance with Sub-Section 455-15.8.2 of the Standard Specifications for Road and Bridge Construction):

1. The polymer slurries to be used on the project and their waste products are classified as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subpart C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.
2. Pull out tests demonstrate the bond between the bar reinforcement and the concrete is not materially affected by exposure to the slurry under typical construction conditions, over the typical range of slurry viscosities to be used.
3. Load tests demonstrate the bond between the concrete and the soil is not materially affected by exposure to the polymer slurry under typical construction conditions, over the typical range of polymer slurry viscosities to be used.
4. The method of disposal meets the approval of all federal, state and local regulatory authorities.

Separate reports will be accepted when different testing companies are used to address the above items. Report(s) must be signed and sealed by a Professional Engineer in the state of Florida. Report(s) signed and sealed by a Professional Engineer licensed in another state may be accepted by the Department provided they meet the requirements specified herein. All submitted electronic documents must be text searchable.

2.4.6.1 Compliance with Environmental Statutes

The report shall include lab chemical analysis for all the contaminants listed in Table 1 of 40 CFR 261.24. The report shall include a statement signed and sealed by a Professional Engineer stating that the product being submitted for consideration is classified as non-hazardous as defined by Resource Conservation and Recovery Act (RCRA) Subpart C rules, Table 1 of 40 CFR 261.24 Toxicity Characteristic.

2.4.6.2 Bar Reinforcement-Concrete Pull Out Tests

The Supplier shall submit test results revealing the bond between the bar reinforcement and the concrete is not materially affected by exposure to the slurry under typical construction conditions. Use the following criteria to develop the method of testing:

a) Test samples must be fabricated and tested at a laboratory certified to perform ASTM C192 and ASTM A944 testing.

b) Test samples are required over the range of viscosities of the slurry for which the Supplier is seeking approval, for a minimum of 3 viscosities, including the lowest viscosity, highest viscosity and one intermediate viscosity. Include any additives in the slurry at the dosages for which the Supplier is seeking approval. Fabricate at least 3 samples per viscosity tested and 3 control test samples using water or mineral slurry. When mineral slurry is selected as the fluid of the control samples, use clean mineral slurry and mix thoroughly to produce a fluid that meets the Florida Department of Transportation (FDOT) requirements for density, viscosity and pH of mineral slurry. The report shall include the procedure of how the polymer and control fluid samples were prepared and the results of the properties for all of the polymer and control samples.
c) Immerse the bottom 6 inches of #5 deformed A615 reinforcement bars, 18 inches in length, into the polymer slurry. Every sample will require 1 bar and there will be 3 samples per viscosity. A minimum of 3 viscosity levels are required and 3 samples per viscosity level are required. Therefore, a minimum of nine bars are required for the polymer slurry samples. Allow the bars to soak in the slurry for 4 to 6 hours.
d) Remove bars from the slurry and position each bar at the center of an empty concrete test cylinder mold (6 inches in diameter by 12 inches in length). Ensure the tip of the bar is at 6 inches below the top of the concrete test cylinder mold.
e) For the control test samples, follow the procedure described in steps (c) and (d) using the control fluid (water or mineral slurry) instead of polymer slurry. Since 3 control samples are required, a total of 3 bars will be required. Soaking times of the polymer test bars and the control bars must be the same.
f) Immediately following the positioning of the bars in the concrete test cylinder molds, fabricate the concrete test cylinders per ASTM C192. Since there are 3 samples required per viscosity level and at least 3 viscosity levels required, and 3 control cylinder required, a minimum of 12 test cylinders will be required. The concrete mix design must meet the requirements of FDOT Standard Specifications Section 346 for Class IV (Drilled Shaft) concrete with a minimum 28-day compressive strength of 4,000 psi.
g) Record the amount of force needed to pull the reinforcement bar from each concrete test cylinder per ASTM A944.
h) If the test results for any of the 3 viscosity levels contain an individual result outside of two standard deviations from the mean, refabricate and retest the 3 samples for that viscosity level.

The report should include, as a minimum, the following:

- Detailed description of the preparation of the polymer and control fluids.
- Clearly identify the product used, any additives used, and the final viscosities tested in the preparation of the polymer fluids used to soak the reinforcement bars.

- Clearly identify the control fluid used. If it is mineral slurry, include the properties tested (viscosity, density and pH) for the control fluids. If clean water is used as a control fluid, no testing is required.
- Detailed description of the preparation of the reinforcement bars, cylinders and testing procedures.
- Photographs documenting all steps of the testing procedures and apparatus.
- Test results in a tabulated format.
- Signature and seal of a registered Professional Engineer.

The Department will review the report to verify that the effect of the slurry (if any) on the bond between the bar reinforcement and the concrete is acceptable based on the following criteria:

- For drilled shafts for miscellaneous structures, any polymer slurry and viscosity combination that produces a reduction of more than 5% in the reinforcement bar-concrete bond from the control samples will be considered unacceptable.
- For drilled shafts for bridges and major structures, any polymer slurry and viscosity combination that produces a reinforcement bar-concrete bond smaller than the control slurry will be considered unacceptable.

2.4.6.3 Load Tests to Evaluate Drilled Shaft Bond between Concrete and Soil

The Supplier shall submit test results revealing that the bond between the concrete and the soil is not materially affected by exposure to the polymer slurry under typical construction conditions, over the typical range of polymer slurry viscosities to be used.

Submit for review test results showing that the skin friction between the drilled shaft concrete and the surrounding soil is not affected by the polymer slurry used at the desired viscosity. Construct a set of two uniform test shafts of the same diameter for the polymer slurry product seeking approval in each soil type proposed for use: (1) one shaft with the polymer slurry seeking approval including additives, and (2) the other shaft with no polymer slurry to be used as a control drilled shaft. The construction of the shafts must meet the requirements of articles 455-13 through 455-22 of the FDOT Standard Specifications. The Supplier may use either water or mineral slurry in the construction of the control drilled shaft. When mineral slurry is used in the control drilled shaft, meet the FDOT specifications for drilled shaft construction with mineral slurry. The polymer slurry used to construct the test shaft shall be over the typical range of dosages (or viscosities) for which the Supplier is seeking approval. The slurry-to-drilled-hole exposure time shall be between 8 to 12 hours. The Supplier shall perform non-destructive load testing on the test and control shafts.

The shafts shall be uniform in diameter using the same equipment and construction methods. The test shafts shall be a minimum of 18 inches in diameter and 15 feet in

length. Design reinforcement to prevent structural failure. In any case, a minimum reinforcement of 4 longitudinal bars must be included. The shafts must be within 30 feet distance of each other.

Prior to construction of the shafts, perform Standard Penetration Test (SPT) soil borings and/or Cone Penetration Test (CPT) soundings in accordance with the FDOT Soils and Foundation Handbook (SFH) at each of the drilled shaft test locations, to demonstrate that soil conditions are similar. The load tests will not be accepted if the soils at the test locations are different. Perform classification tests (sieve analysis, plasticity limits, natural water content, and organic content) and classify the soils in accordance with ASTM D2487 to show that the shaft load tests will be performed under similar soil conditions. Do not perform load tests on soils with organic contents greater than 5%.

Perform a load capacity drilled shaft analysis based on each SPT and/or CPT to estimate the theoretical side nominal resistance at each load test location, calculated in accordance with the Structure Design Guidelines and Soils and Foundation Handbook (current edition). Determine a normalization factor for local soil conditions as follows: CNs = side resistance of the load test divided by the side friction of the control shaft. Therefore, the CNs value for the control shaft would be 1.

Perform Thermal Integrity Profiling to verify integrity per ASTM D7949 (method A or B). Other integrity tests such as Gamma-Gamma (GG) and Cross Hole Sonic Logging (CSL) per ASTM D6760 may be accepted by the Department if the drilled shaft tests are at least 36 inches in diameter. Only drilled shafts that pass the integrity testing and maintain a relatively constant cross-section throughout the shaft length may be used for load testing.

Perform uplift (tension) load test on each test shaft in accordance with ASTM D3689.

Unless Thermal Integrity is performed as per ASTM D7949 (method A or B), extract the shafts to measure the actual diameter of the shaft throughout the length. Perform diameter measurements using a mechanical caliper every 6 inches along the shaft length.

Determine the actual average side area of the shafts as follows: $As=\pi \times D_{avg} \times$ shaft length, where D_{avg} is the average diameter measured from the caliper measurements or Thermal Integrity profiling. For each load applied, compute the average side friction by dividing the load by the actual average side area.

Divide the average side frictions by the corresponding normalization factor CNs. This will be the normalized side frictions.

Produce plots that show the comparison between the polymer load test shaft and the control fluid load test shaft. Tabulate and plot (on one chart) the load versus displacement (kips and inch units) curve for each of the test shafts. Tabulate and plot

(on one chart) the normalized average side friction versus displacement (in Ksf and inch units) curve for each of the test shafts.

The Supplier shall submit a final detailed report signed and sealed by a registered Professional Engineer. The report shall include, as a minimum, the following:

- A description of the construction methods and procedures used during the construction of the shafts, including but not limited to the types of slurries used, temporary casing, fluid properties measured, cleaning procedures, steel reinforcement and concreting, times of drilling, inclusion of slurry, and times of concrete placement.
- Clearly identify the polymer product used, and any additives used. Indicate how the polymer slurry was prepared prior to introducing it into the shaft and the final properties tested, including viscosity prior to the concrete placement.
- Include an aerial photograph and/or a location plan map/diagram that clearly indicates the location of and the distances between the test borings and the drilled shafts.
- Clearly identify the control fluid used and its preparation. If it is a mineral slurry, include the properties tested (viscosity, density and pH). If clean water is used as a control fluid, no testing is required.
- Document the construction details in the Department's Drilled Shaft Log, Form Number 700-010-084 and include all forms in the report's appendix.
- A description of the load test procedures including pictures showing different steps of the load testing performed on all test shafts constructed with slurry and control fluid.
- Include all of the geotechnical information for the test shafts.
- Include Load versus Top Displacement and Side Friction versus Top Displacement curves for both the polymer slurry load test and the control fluid load test.

Notes:

The polymer side friction curve should show that, for top displacements of up to 1.0 inch, the side friction for the polymer is equal to or greater than the side friction observed in the control load test. Any polymer slurry and viscosity combination that produces a side friction less than the control slurry will be considered unacceptable.

Testing of the density, viscosity, pH and sand content of the polymer and control slurry must be performed by a FDOT CTQP qualified technician (Drilled Shaft Inspector).

2.4.6.4 Method of Disposal.

Submit guidelines for product disposal when used on Florida Department of Transportation projects. Submit documentation that shows the proposed method of disposal meets the approval of all federal, state and local regulatory authorities.

2.4.6.5 Approval Limitations Additional Requirements

A polymer product is considered as the combination of polymer and additives (if any) being proposed and with the composition submitted for evaluation. The approval is only valid for the proposed products and combination that were used in the evaluation. Polymers with different additives or different compositions from those tested will be considered as a different polymer product and are subjected to a separate submittal.

The Department may approve the use of a polymer product with an upper viscosity limit that has already been approved for a particular project to be used for another project in Florida without the need of additional testing. However, additional submittals will be required if the product is requested to be approved for higher viscosities than the upper viscosity limit that was already tested and accepted.