

## **Volume II**

### **Section 2.4**

# **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 to the Florida Department of Transportation (Department) for consideration of approval in the use of polymer slurry products for drilled shaft construction.

## **2.4.2 AUTHORITY**

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

## **2.4.3 REFERENCES**

Florida Department of Transportation Standard Specifications for Road and Bridge Construction (Specifications)

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

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

Resource Conservation and Recovery Act (RCRA)

## **2.4.4 SCOPE**

This procedure is to be used by polymer slurry Suppliers to obtain acceptance 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 accepted. 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.

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 product will be acceptable for use limited to a maximum viscosity value that does not exceed the smaller of the following viscosities:

1. The highest viscosity tested under 2.4.6.2 of this Section.
2. The highest viscosity tested under 2.4.6.3 of this Section.

## 2.4.6 MATERIAL APPROVAL PROCESS

The Supplier shall submit a report that demonstrates the following items

1. The polymer slurries to be used on the project and their waste products are classified as non-hazardous as defined by **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 requirements of all federal and state regulatory authorities.

Laboratory and field testing required above must be performed by companies not related to the Supplier. 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 **CFR 261.24 Table 1 of 40**. 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 **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 **Specification Section 455** 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 **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.

*Note:* 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. Any polymer slurry and viscosity combination that produces a reinforcement bar-concrete bond smaller than the control slurry will be considered unacceptable. Studies from a Florida university performed to evaluate the effect of the polymer slurry on the bond between steel and concrete of drilled shafts may be accepted by the Department for review and evaluation, if the procedures followed by the university are equivalent or exceeds the requirements specified herein.

### **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 **Specification Section 455**. 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 **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 **Department Soils and Foundation Handbook (SFH)** at each of the drilled shaft test locations, to demonstrate that soil conditions **and groundwater elevations** are similar regarding both types and strength. Tests in which the soil types or soil resistance properties are different will not be accepted. 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%.

Determine the actual diameters and shape of the shafts using sonic calipers, or thermal Integrity testing in accordance with **ASTM D7949 (method A or B)**. If these measurements are not performed, extract the shafts, after the load tests are performed, to measure the actual diameter of the shaft throughout the length. In this case, perform diameter measurements using a mechanical caliper every 6 inches along the shaft length

Perform uplift (tension) load test on each test shaft in accordance with ASTM D3689. Compression load tests may be accepted if the load tests include internal strain gauges that allows for the determination of side friction and end bearing separately and side friction load vs top displacement plots are included in the report.

Use the actual measured diameters in every shaft length segment to determine the average side friction for that segment. Determine the actual average side friction of the shafts as follows:

1.  $F_s = Q_s/A_s$ , where
2.  $Q_s$  = Load drop between strain gauge levels.
3.  $A_s = \pi \times D_{avg} \times L_s$ , where
4.  $D_{avg}$  = the average diameter for each segment between strain gauges, measured from the caliper measurements, or Thermal Integrity profiling.
5.  $L_s$  = the length of the segment between

*Note:* If no strain gauges are used in tension tests,  $L_s$  = length of shaft and  $Q_s$  is the total tension load applied.

Produce a table of the side frictions (in  $K_{sf}$  or  $T_{sf}$ ) vs depth.

Adjust the measured load (Kips or Tons) on the polymer test shaft as follows:

1. Total side friction load = Total side friction load measured  $\times C_f$
2.  $C_f$  = correction factor =  $D_{avgc}/D_{avgp}$

Where  $D_{avgp}$  = Average diameter of the polymer load test shaft

$D_{avgc}$  = Average diameter of the control load test shaft

*Note:* the correction factor  $C_f$  for the control shaft is 1.0; no adjustment is needed.

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 adjusted side friction load versus displacement (kips and inch units) curve for each of the test shafts. Do not include the end bearing component from compression load tests

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.
- A description of the load test procedures of the load testing performed on all test shafts constructed with slurry and control fluid.
- Include all of the geotechnical information obtained for the testing shaft, including but no limited to soil borings logs, CPT tests and any other field and lab testing performed at the testing site.
- Include the results of the caliper testing, thermal integrity testing or mechanical caliper testing performed to determine the actual shape of the shaft.
- Adjusted Load (in Tons or Kips) versus Top Displacement charts for tension tests for both the polymer slurry load test and the control fluid load test. For compression load tests include, in addition to the load vs. top displacement charts, include the adjusted side friction Load vs. Top Displacement charts.
- Tables showing the side friction resistance (in Tsf or Ksf) versus depth for both the polymer slurry load test and the control fluid load test.

**Notes:**

The Department will review the report to verify that the effect of the slurry (if any) on the bond between concrete and soil is acceptable. 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).

Studies from a Florida university performed to evaluate the effect of the polymer slurry on drilled shaft friction between concrete and soil may be accepted by the Department for review and evaluation, if the procedures followed by the university are equivalent or exceeds the requirements specified herein.

#### **2.4.6.4 Method of Disposal.**

Submit guidelines for product disposal when used on Department projects. Submit documentation including a certification letter that shows the proposed method of disposal meets the requirements of all federal and state regulatory authorities.

### **2.4.6.5 Additional Documentation**

Submit the Material Safety Data Sheet (SDS) for the product.

### **2.4.7 TRAINING**

None required.

### **2.4.8 FORMS**

None required.