STRUCTURAL PORTLAND CEMENT GROUT – AUGER CAST PILES
(REV 4-25-23)

SECTION 346 is deleted and the following substituted for locations of auger cast piles as delineated in the Plans. Dev346ACP does not apply for any other structural concrete delineated in the Plans.

346-1 Description.

Use a Department-approved portland cement grout (grout) mix design for Auger Cast Piles (ACP) composed of a mixture of portland cement, fine aggregate, water, admixtures, fluidifier and supplementary cementitious materials. Deliver the ACP grout to the site of placement in a freshly mixed, unhardened state.

Obtain ACP grout from a plant that is currently on the Department's Concrete Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. If the concrete production facility's Quality Control (QC) Plan is suspended, the Contractor is solely responsible to obtain the services of another concrete production facility with an accepted QC Plan or await the reacceptance of the concrete production facility's QC Plan prior to the placement of any further ACP grout on the project. There will be no changes in the Contract Time because of the suspension, as described. Bear all delay costs and other costs associated with the concrete production facility's QC Plan acceptance or reacceptance.

346-2 Materials.

346-2.1 General: Meet the following requirements:

Fine Aggregate*	Section 902
Portland Cement and Blended Cement	Section 921
Water	Section 923
Admixtures**	Section 924
Fluidifier***	ASTM C937
Supplementary Cementitious Materials	Section 929

*Use only silica sand except as provided in 902.

**Use products listed on the Department's Approved Product List (APL).

***The fluidifier shall not contain chlorides.

Do not use materials containing hard lumps, crusts, or frozen matter, or that is contaminated with materials exceeding the specified limits in the above listed Sections.

346-2.2 Types of Cement: Unless a specific type of cement is designated in the Contract Documents, use Type I, Type IL, Type IP, Type IT, Type IS, Type II or Type II (MH) cement in all classes of ACP grout.

Use only the types of cements designated for each environmental classification in ACP grout as shown in Table 346-1. A mix design for a more aggressive environment may be used in a less aggressive environmental condition.

Table 346-1 Cement Use by Environmental Classification			
Component	Slightly Aggressive Environment	Moderately Aggressive Environment	Extremely Aggressive Environment (1)
ACP grout	Type I	Type I, Type IL, Type II, Type IP, or Type IS	Type II (MH), Type IL or Type IT

Notes:
(1) Cements used in a more aggressive environment may also be used in a less aggressive environment.

346-2.3 Supplementary Cementitious Materials: Use supplementary cementitious materials (SCMs) to produce binary or ternary ACP grout mixes in all classes of ACP grout specified in Table 346-2.

The quantity of portland cement replaced with SCMs must be on an equal weight replacement basis of the total cementitious materials in accordance with Table 346-2.

346-2.3.1 Highly Reactive Pozzolans: Materials that have a very high degree of pozzolanic reactivity due to their very fine particle sizes, including silica fume, metakaolin and ultrafine fly ash.

346-2.3.2 Binary Mixes: Mixes containing portland cement and one SCM.

346-2.3.3 Ternary Mixes: Mixes containing portland cement and any two SCMs.

Table 346-2 Cementitious Materials ACP Grout Proportions (%) (Environmental classification is extremely aggressive, unless otherwise noted)						
Application	Portland Cement	Fly Ash Type F	Slag	Highly Reactive Pozzolans (1)		
				Silica Fume	Metakaolin	Ultra-Fine Fly Ash
ACP Cement Grout	50-82	18-50				
	41-78	15-50		7-9		
	38-77	15-50			8-12	
	38-77	15-50				8-12
	20-60	10-20	30-60			
	30-70		30-70			
	36-43		50-55	7-9		
	33-42		50-55		8-12	
	33-42		50-55			8-12

Notes:
(1) Highly reactive pozzolans may be used below the specified ranges to enhance strength and workability.

346-2.4 Admixtures: Ensure admixtures are used in accordance with the manufacturer's recommendations and meeting the requirements of Developmental Section 9.2, Volume II of the Materials Manual (DevMM9.2ACP).

346-3 Classification of ACP Grout.

346-3.1 General: The classifications of ACP grouts are designated as ACP Grout Class I and ACP Grout Class II. The 56-day specified minimum compressive strength, maximum water to cementitious materials ratio and time of efflux of each class of ACP grout are detailed in Table 346-3. The required air content for all classes of ACP grout is less than or equal to 7.0%.

Use ACP grout for structural cast-in-place auger drilled piles. Produce a fluid grout that is easily pumped, capable of maintaining the solids in suspension without segregation or appreciable bleed water and will fill open voids in the adjacent soil or rock.

346-3.2 Master Proportion Table: Proportion the materials used to produce classes of ACP grout in accordance with Table 346-3.

The calculation of the water to cementitious materials ratio (w/cm) is based on the total cementitious materials including portland cement and any SCMs used in the mix.

Table 346-3
ACP Grout Master Proportion Table

Class of ACP grout	56-day Specified Minimum Compressive Strength (f'c) (psi)	Maximum Water to Cementitious Materials Ratio (pounds per pounds)	Minimum Time of Efflux (1) (seconds)
ACP Grout Class I	5,500	0.53	21
ACP Grout Class II	8,000	0.45	21

Notes:
(1) Use a quantity of water that will produce a fluid homogenous grout that is easily pumped and capable of maintaining the solids in suspension without appreciable bleed water.

346-3.3 Acceptance at other than 56-Days: At the Contractor's option, the Engineer may approve specific mix designs for acceptance at ages other than 56 days. Submit a mix design for approval prior to producing the ACP grout. The mix design shall meet the listed maximum allowable water to cementitious materials ratio and minimum time of efflux for the class of ACP grout as defined in Table 346-3.

346-3.4 Durability for ACP Grout:

346-3.4.1 Minimum Cementitious Materials Content: Ensure that the produced ACP grout contains a minimum amount of 600 pounds per cubic yard.

346-3.4.2 Chloride Content Limits: The maximum allowable chloride content limit for the ACP grout is 0.40 pounds per cubic yard. Immediately suspend ACP grout placement for each affected mix design until corrective measures are made if chloride tests results exceed the limit. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control, to determine if the material meets the intended service life of the structure for all ACP grout produced from the mix design failing chloride test results to the previous passing test results.

346-3.4.3 Surface Resistivity Test: Ensure ACP grout meets or exceeds the surface resistivity requirements in accordance with Table 346-4. Suspend ACP grout placement immediately for each affected mix design until corrective measures are made if the surface resistivity test results fail to meet this limit. Submit an Engineering Analysis Scope in accordance with 6-4 by a Specialty Engineer knowledgeable in the areas of corrosion and corrosion control to determine if the material meets the intended service life of the structure for all ACP grout produced from the mix design.

Table 346-4 ACP Grout 56-Day Specified Minimum Surface Resistivity (kΩ-cm)			
ACP Grout	Slightly Aggressive Environment (1)	Moderately Aggressive Environment (1)	Extremely Aggressive Environment
ACP Grout Class I	Report	Report	29 (2) or 40 (3)
ACP Grout Class II	Report	Report	29 (2) or 40 (3)

Notes:
(1) Surface resistivity values for ACP grout in slightly and moderately aggressive environments are required for information only.
(2) 75-Year Service Life Design.
(3) 100-Year Service Life Design.

346-4 Special Requirements of ACP Grout.

346-4.1 General Requirements: Use ACP grout in the manufacturing of auger cast piles foundations meeting the requirements of Section Dev455ACP and DevMM9.2ACP. Use a Department approved ACP grout mix design based on the satisfactory laboratory trial batch and construction of a field demonstration pile for each pile diameter.

346-4.2 Laboratory Trial Batch of ACP Grout Mix: Submit a proposed ACP Grout mix design meeting the specified minimum compressive strength and the specified minimum surface resistivity. Ensure that the solids of the ACP grout remain in suspension without appreciable bleed water, the grout may be pumped without difficulty and without adversely affecting its properties of the grout, and the grout has sufficient fluidity to fill the open voids in the adjacent soils and rock. The grout mix may include a fluidifier, used in accordance with the manufacturer's recommendations. The in-place maximum core temperature shall not exceed 160°F during curing.

The time of efflux must meet or exceed the minimum time of efflux specified in Table 346-3. Perform unit weight (density) and air content. The air content must meet the specified range of 0 to 7 percent. Cast a minimum of five sets of 4x8-inch cylinders to determine the compressive strength at 1, 3, 7, 28 and 56 days and the surface resistivity at 28 and 56 days. Determine the surface resistivity prior to compressive strength testing or cast two additional sets of cylinders to determine the surface resistivity. The average compressive strength at 56 days must meet or exceed the specified minimum compressive strength. The average surface resistivity at 56 days must meet or exceed the specified minimum surface resistivity.

346-4.3 Field Demonstration of ACP Grout Mix: Produce field demonstration piles in accordance with Dev455ACP of the proposed ACP grout mix design following a satisfactory laboratory trial batch. Ensure that the ACP grout is mixed, delivered, and placed in accordance with the proposed methods and sequences addressed in the producer's QC Plan. During ACP grout placement, ensure that the grout batches meet all plastic property requirements of the Specifications and maintain cohesion without excessive bleeding, segregation, or abnormal retardation. Inspect and test the grout at the point of placement.

Measure the time of efflux of the ACP grout and ensure it meets or exceeds the minimum time of efflux specified in Table 346-3. Perform unit weight (density) and air content tests.

During the curing period of demonstration pile, measure and record the core temperatures and the differential temperatures between the core and the reinforcement of the pile every 15 minutes. Ensure that core temperatures of the demonstration pile do not exceed 160°F and its differential temperatures do not exceed 35°F.

346-5 Sampling and Testing Methods.

Perform ACP grout sampling and testing in accordance with the following methods:

Table 346-5
ACP Grout Sampling and Testing Methods

Description	Method
Flow Cone (Time of Efflux) (1)	ASTM D6449
Bleeding of Concrete	ASTM C232
Unit Weight (density)	ASTM C138
Making and Curing Test Specimens in the Field (2) (3)	ASTM C31
Compressive Strength of Cylindrical Concrete Specimens	ASTM C39
Obtaining and Testing Drilled Core and Sawed Beams of Concrete	ASTM C42
Initial Sampling of Concrete from Revolving Drum Truck Mixers or Agitators	FM 5-501
Low Levels of Chloride in Concrete and Raw Materials	FM 5-516
Determining Density of Construction Slurries (Mud Balance)	ASTM D4380
Temperature of Freshly Mixed Portland Cement Concrete	ASTM C1064
Air Content of Freshly Mixed Concrete by the Volumetric Method	ASTM C173
Sampling Freshly Mixed Concrete (4)	ASTM C172
Concrete Resistivity as an Electrical Indicator of its Permeability	AASHTO T 358

(1) Conduct the calibration initially before its first use and as directed by the Engineer, when there is a question of the flow cone's accuracy.
(2) Pour grout in a single lift into the cylinder mold without rodding, then tap mold 10-15 times with a mallet. Except as specified, plastic property tests are not required. A set of testing cylinders is defined as follows:
- QC and Verification (VT): three specimens each.
- QC resolution (QR) and VT resolution (VR): two specimens each.

(3) Provide curing facilities that have the capacity to store all Quality Control, Verification, and Resolution cylinders simultaneously for the initial curing. Cylinders will be delivered to the testing laboratory in their molds. The laboratory will remove the specimens from the molds and begin final curing.
(4) Take the test sample from the middle portion of the batch in lieu of collecting composite samples from two or more portions, as described in ASTM C172.

346-6 Quality Control.

346-6.1 General: Perform QC activities to ensure materials, methods, techniques, personnel, procedures, and processes utilized during production meet the specified requirements.

Accept the responsibility for QC inspections for all phases of work. Ensure all materials and workmanship incorporated into the project meet the requirements of the Contract Documents.

346-6.2 ACP Grout Mix Design: Provide ACP grout that has been produced in accordance with a Department approved mix design, in a uniform mass free from balls and lumps.

Utilize a grate over the conveyance equipment to capture any lumps or balls that may be present in the mix. The grate must cover the entire opening of the conveyance equipment and have an opening that is a maximum of 3/4 inch in any one direction. Remove the lumps and balls from the grate and discard them. Discharge the ACP grout in a manner satisfactory to the Engineer. Perform demonstration batches to ensure complete and thorough placements when requested by the Engineer.

346-6.3 Delivery Certification: Ensure that an electronic delivery ticket is furnished with each batch of ACP grout before unloading at the placement site. The delivery ticket may be

proprietary software or in the form of an electronic spreadsheet but shall be printed. Ensure that the materials and quantities incorporated into the batch of ACP grout are printed on the delivery ticket.

Include the following information on the delivery ticket:

1. Arrival time at jobsite.
2. Number of revolutions upon arrival at the jobsite.
3. Total gallons of water added at the jobsite.
4. Additional mixing revolutions when water is added.
5. Total number of revolutions.
6. Time that ACP grout mix has been completely discharged.

Ensure the batcher responsible for production of the batch of ACP grout signs the delivery ticket, certifying the batch of ACP grout was produced in accordance with the Contract Documents.

Sign the delivery ticket certifying that the design mix maximum specified water to cementitious materials ratio was not exceeded due to any jobsite adjustments to the batch of ACP grout, and that the batch of ACP grout was delivered and placed in accordance with the Contract Documents.

346-6.4 Plastic Property Tolerances: Reject ACP grout with a time of efflux below the minimum specified requirement and immediately notify the ACP grout production facility that an adjustment of the ACP grout mixture is required. If a load is below the minimum requirement, test each subsequent load and the first adjusted load. If failing ACP grout is not rejected or adjustments are not implemented, the Engineer may reject the ACP grout and terminate further production until the corrections are implemented.

At the Contractor's risk, water may be added at the placement site immediately after completion of the initial time of efflux test to increase the ACP grout workability, provided the addition of water does not exceed the water to cementitious materials ratio as defined by the mix design.

After adding water, perform an additional time of efflux test to confirm the ACP grout is above the minimum time of efflux requirement. If the time of efflux is below the minimum requirement, reject the load. If an adjustment is made at the concrete production facility, perform a time of efflux test on the next load to ensure the ACP grout is above the minimum time of efflux requirement. Do not place ACP grout represented by time of efflux test results below the minimum requirement. Include water missing from the water storage tanks upon arrival at the project site in the jobsite water added.

Do not allow ACP grout to remain in a transporting vehicle to increase time of efflux.

346-7 Mixing and Delivering ACP Grout.

346-7.1 General Requirements: Operate all mixers at speeds and volumes per the manufacturer's design or recommendation as stipulated on the mixer rating plate. Operate all ACP grout mixers at a maximum of 80 percent of the volume specified per the manufacturer's design or recommendation as stipulated on the mixer rating plate. Seek approval from the Engineer prior to using a central mixer and depositing the batch into a truck mixer.

346-7.2 Transit Truck Mixing: Produce a homogenous, uniform mixed ACP grout. Mix for a minimum of 70 revolutions at the mixing speed designated by the truck manufacturer. Prior to starting the discharge of the ACP grout at the jobsite, when water is added, record the added

quantity, and mix the ACP grout a minimum of 30 additional drum mixing revolutions. Do not make more than two mix adjustments.

346-7.2.1 Transit Time: Ensure compliance with Table 346-6 between the initial introduction of water into the mix and completely discharging all the ACP grout from the truck. Reject ACP grout exceeding the maximum transit time.

Table 346-6 Maximum Allowable Transit Time - Agitator Trucks	
ACP Grout Temperatures below 70° F	150 minutes
ACP Grout Temperatures from 70° F to 100° F (1)	120 minutes
Note: (1) Do not place ACP grout when its temperature exceeds 100° F.	

346-7.2.2 Placement Time: All the ACP grout in a load must be in its final placement position a maximum of 15 minutes after the transit time has expired unless a time extension is approved by the Engineer.

The Engineer may perform Independent Verification (IV) testing to verify the plastic and hardened properties of the ACP grout when a time extension is granted.

346-7.3 On-site Batching and Mixing: Seek approval from the Engineer prior to using on-site batching and mixing. Use a mixer of sufficient capacity to prevent delays that may be detrimental to the quality of the work. Ensure that the accuracy of batching equipment is in accordance with requirements of this Section.

346-7.4 Grouting in Cold Weather: Do not mix or place ACP grout when the air temperature is below 40ºF. Protect the fresh ACP grout from freezing in accordance with Section 400.

346-7.5 Grouting in Hot Weather: Hot weather grouting is defined as the production, placing and curing of ACP grout when the ACP grout temperature at placing exceeds 70ºF but is 100ºF or less.

Reject ACP grout when the grout temperature exceeds 100ºF. Predict the ACP grout temperatures at placement time and implement hot weather measures to avoid production shutdown.

346-7.6 Sample Location: Obtain ACP grout acceptance samples from the discharge of the mixer.

346-8 Plastic ACP Grout Sampling and Testing.

QC tests include air content, temperature, time of efflux, density (mud balance) or unit weight (density) and preparation of 4x8-inch cylinders for compressive strength and surface resistivity testing at later dates. In addition, calculate the water to cementitious materials ratio in accordance with FM 5-501 for compliance to the approved mix design.

Ensure that each truck has a rating plate and a valid mixer identification card issued by the Department. Ensure that the revolution counter on the mixer is working properly, and calibration of the water dispenser has been performed within the last twelve months. Reject any ACP grout batches that are delivered in trucks that do not have mixer identification cards. Remove the mixer identification card when a truck mixer is discovered to be in noncompliance and the mixer deficiencies cannot be repaired immediately. When the mixer identification card is removed for noncompliance, make note of the deficiency or deficiencies found, and forward the

card to the District Materials and Research Engineer who has Producer QC Plan acceptance authority.

Perform time of efflux, density (mud balance), and temperature tests on the initial delivery from each plant of each ACP grout mix design each day. Ensure QC technicians meeting the requirements of Section 105 are present and performing tests throughout the placement operation. Ensure a technician is present and performing tests throughout the placement operation at each placement site. If a project has multiple ACP grout placements at the same time, identify the technicians in the QC Plan to ensure minimum sampling and testing frequencies are met. Ensure that the equipment used for delivery, placement and finishing meets the requirements of this Specification.

Reject non-complying loads at the jobsite. Ensure that corrections are made on subsequent loads. Perform time of efflux, density (mud balance), and temperature tests of ACP grout on all trucks prior to the first corrected truck and the corrected truck. Furnish sufficient ACP grout of each design mix as required by the Engineer for VT testing.

On ACP grout placements consisting of only one load of ACP grout, perform initial sampling and testing in accordance with this Section. The acceptance sample and plastic properties tests may be taken from the initial portion of the load.

If the QC time of efflux and temperature tests fail, reject the load, and any other loads that have begun discharging, terminate the LOT and notify the Engineer. Determine the density (mud balance) and cast cylinders representing that LOT from the same sample of ACP grout.

Following termination of a LOT, obtain samples from a new load, and perform time of efflux and temperature tests. Initiate a new LOT once the testing indicates compliance with Specification requirements.

Suspend production when any five loads in two days of production of the same design mix are outside the specified tolerances. Increase the frequency of QC testing to one per load to bring the ACP grout within allowable tolerances. After production resumes, obtain the Engineer's approval before returning to the normal frequency of QC testing.

If ACP grout placement stops for more than 120 minutes, perform initial time of efflux and temperature testing on the next batch and continue the LOT. Cylinders cast for that LOT will represent the entire LOT.

When the Department performs Independent Verification (IV), the Contractor may perform the same tests on the ACP grout at the same time.

346-9 Acceptance Sampling and Testing.

346-9.1 General: Perform time of efflux, density (mud balance), and temperature tests in accordance with 346-8. Cast a minimum of two sets of 4x8-inch QC cylinders for compressive strength and surface resistivity testing for all ACP grout incorporated into the project. Determine the surface resistivity prior to compressive strength testing or cast two additional sets of cylinders to determine the surface resistivity. Take these acceptance samples randomly as determined by a random number generator acceptable to the Department. The Department will independently perform VT testing and cast a minimum of two sets of 4x8-inch VT cylinders. Determine the surface resistivity prior to compressive strength testing or cast two additional sets of cylinders to determine the surface resistivity. The VT cylinders will be from a separate sample from the same load of ACP grout as the Contractor's QC sample.

For each set of QC cylinders verified by the Department, cast two additional cylinders from the same sample, and identify them as the quality control resolution (QR) test cylinders. The Department will also cast two additional verification resolution (VR) test

cylinders from each VT sample. All cylinders will be clearly identified. Deliver the QC samples, including the QR cylinders to the final curing facility in accordance with ASTM C31. Concurrently, the Department will deliver the VT samples, including the VR cylinders, to their final curing facility.

Test the QC laboratory cured samples for surface resistivity and then compressive strength at the ages of 28 and 56 days, in a laboratory meeting and maintaining the qualification requirements listed in Section 105.

Ensure the QC testing laboratory inputs the surface resistivity and compressive strength test results into the Department's Materials Acceptance and Certification (MAC) system within 24 hours after testing. Notify the Engineer when results cannot be inputted into MAC.

The Department will compare the 56-day VT sample compressive strength and surface resistivity test results with the corresponding 56-day QC sample test results.

346-9.2 Sampling Frequency: As a minimum, sample and test ACP grout of each mix design for time of efflux, temperature, density (mud balance), surface resistivity, and compressive strength once per LOT as defined by Table 346-7. The Engineer will randomly verify one of every four consecutive LOTs of each mix design based on a random number generator. The Department may perform Independent Verification (IV) testing to verify compliance with specification requirements. All QC activities, calculations, and inspections will be randomly confirmed by the Department.

Table 346-7
Sampling Frequency

Class of ACP Grout (1)	LOT Size
ACP Grout Class I	50 cubic yards, or one day's production, whichever is less (1)
ACP Grout Class II	

(1) Start a new LOT when there is a gap of more than two hours between the end of one APC grout placement and the beginning of the next ACP grout placement.

346-9.3 Compressive Strength and Surface Resistivity Test Definition: The compressive strength and surface resistivity test of a LOT is defined as the average compressive strengths and surface resistivity tests respectively, of at least two companion cylinders cast from the same sample of ACP grout and tested at the same age.

346-9.4 Acceptance of ACP Grout: The Engineer will accept the ACP grout of a given LOT when the compressive strength and surface resistivity test results are verified and meets the minimum specified compressive strength in Table 346-3 and the minimum specified surface resistivity in Table 346-4. Ensure that the hardened ACP grout compressive strength and surface resistivity test results are obtained in accordance with 346-9.3.

The process of ACP grout compressive strength and surface resistivity verification and acceptance consists of the following steps:

1. Verification of QC and VT data.
2. Resolution of QC and VT data if needed.
3. Structural Adequacy determination.
4. Durability Adequacy determination.

When one of the QC cylinders from a LOT is lost, missing, damaged or destroyed, determination of compressive strength and surface resistivity will be made by averaging the remaining two cylinders. If more than one QC cylinder from a LOT is lost, missing, damaged or destroyed, the Contractor will core the structure at no additional expense to

the Department to determine the compressive strength and surface resistivity. Obtain Engineer's approval prior to coring the structure and for coring location. Acceptance of LOTs may be based on VT data at the discretion of the Engineer.

For each QC and QR cylinder that is lost, missing, damaged or destroyed, payment for that LOT will be reduced by $750.00 per 1,000 psi of the specified design strength Example: loss of two ACP grout Class I QC cylinders that has no VT data will require the element to be cored and a pay reduction will be assessed
[(5,500 psi / 1,000 psi) x $750 x 2 = $8,250]. This reduction will be in addition to any pay adjustment for low compressive strength.

346-9.5 Verification:

346-9.5.1 Compressive Strength: The results of properly conducted test by QC and VT laboratories on specimens prepared from the same sample of ACP grout are not to differ by more than 14%.

$$\text{Difference (\%)} = \text{ABS}\left(\frac{\text{QC}-\text{VT}}{\text{QC}}\right)100$$

Where:

Difference (%) is the absolute percentage difference between QC and VT average compressive strength.

The procedure consists of verifying if the QC and VT compressive strengths data meet the established comparison criteria:

1. When the difference between the average compressive strength of QC and the average compressive strength of VT is less than or equal to 14%, the QC test results are upheld and verified. The Engineer will accept at full pay only LOTs of ACP grout represented by time of efflux and temperature results which meet the requirements of the approved mix design and compressive strength test results which equal or exceed the respective specified minimum strength.

2. When the difference between the average compressive strength of QC and the average compressive strength of VT data exceeds 14%, the compressive strength results are not verified and the Engineer will initiate the resolution procedure.

Maintain the compressive strength QR and VR cylinders for a minimum of 30 days following the testing date of the compressive strength.

346-9.5.2 Surface Resistivity: The results of properly conducted test by QC and VT laboratories on specimens prepared from the same sample of ACP grout are not to differ by more than 32.5%.

$$\text{Difference (\%)} = \text{ABS}\left(\frac{\text{QC-VT}}{\text{QC}}\right)100$$

Where:

Difference (%) is the absolute percentage difference between QC and VT average surface resistivity.

The procedure consists of verifying if the QC and VT surface resistivity data meet the established comparison criteria:

1. When the difference between the average surface resistivity of QC and the average surface resistivity of VT is less than or equal to 32.5%, the QC test results are upheld and verified. The Engineer will accept at full pay only LOTs of ACP grout represented by time of efflux and temperature results which meet the requirements of the approved mix design and surface resistivity test results which equal or exceed the specified minimum surface resistivity.

2. When the difference between the average surface resistivity of QC and the average surface resistivity of VT data exceeds 32.5%, the surface resistivity results are not verified, and the Engineer will initiate the resolution procedure.

Maintain the surface resistivity QR and VR cylinders for a minimum of 30 days following the testing date of the surface resistivity.

346-9.6 Resolution:

346-9.6.1 Compressive Strength: The Engineer will perform the resolution process to identify the reliability of the compressive strength results when the difference between the average compressive strength of QC and the average compressive strength of VT data exceeds 14% as described in 346-9.5(2).

The Engineer will estimate the 56-day strengths (VR_{56} and QR_{56}) for the VR and QR cylinders using the following equation:

$$\text{Estimated 56-Day Compressive Strength (psi)} = \left(\frac{\text{Average Strength at (t) days}}{\text{-17.8 + 46.3(ln t) - 3.3(ln t)}^2}\right) 100$$

Where:

t is the elapsed number of days from grout placement to the resolution cylinder testing.

The Engineer will compare:

1. The VT sample results with the VR_{56} cylinders results.
2. The QC sample results with the QR_{56} cylinders results.

Comparison results must not be greater than 17.5%. Core samples of the hardened ACP grout may be required.

$$V_D\ (\%) = \text{ABS}\left(\frac{VT - VR_{56}}{VT}\right) 100$$

$$Q_D\ (\%) = \text{ABS}\left(\frac{QC - QR_{56}}{QC}\right) 100$$

Where:

V_D (%) is the absolute percentage difference between VT and VR_{56}.

Q_D (%) is the absolute percentage difference between QC and QR_{56}.

The resolution procedure will use the above equations. The Engineer will determine through the resolution procedure whether the QC strength test results or the VT strength test results are deemed to be the most accurate, LOTs will then be considered to be verified.

The Engineer will inform the QC and VT laboratories within three calendar days of the acceptance compressive strength test to transport their QR and VR cylinders to the resolution laboratory. The QC and VT laboratories will transport their own hold cylinders to the resolution testing laboratory within three calendar days after the Engineer notifies the Contractor that a resolution procedure is required. In addition, the Engineer will ensure that the QR and VR cylinders are tested within 14 calendar days of the acceptance strength tests.

The Engineer will determine the most accurate strength test result to represent the four or fewer consecutive LOTs as follows:

1. When both results meet the established comparison criteria, both are deemed accurate and the QC strength will represent the LOTs. The Department will pay for cost of the resolution testing.

2. When only the QC result is within the established comparison criteria, the QC strength is deemed as most accurate and will represent the LOTs. The Department will pay for the cost of the resolution testing.

3. When only the VT result is within the established comparison criteria, the VT strength is deemed as most accurate and will represent the LOTs. The Department will assess a $1,000 pay reduction for the cost of the Resolution Investigation.

4. When both results are outside the established comparison criteria, the Engineer, with input from the District Materials and Research Office (DMRO), will determine if any Department IA evaluations are required and which test results are most accurate. The Department will pay for the cost of the resolution testing.

When the Engineer cannot determine which strength test results are the most accurate, the ACP grout represented by the four consecutive LOTs will be evaluated based on the QC data.

The results of the resolution procedure will be forwarded to the Contractor within five working days after completion of the investigation.

346-9.6.2 Surface Resistivity: The Engineer will perform the resolution process to identify the reliability of the surface resistivity results when the difference between the average surface resistivity of QC and the average surface resistivity of VT data exceeds 32.5% as described in 346-9.5.2 (2).

The Engineer will correlate the 56-day surface resistivity (VR_{56} and QR_{56}) for the VR and QR cylinders and will compare:

1. The VT sample results with the VR_{56} cylinders results.
2. The QC sample results with the QR_{56} cylinders results.

Comparison results must not be greater than 32.5%. Core samples of the hardened ACP grout may be required.

$$V_D\,(\%) = \text{ABS}\left(\frac{\text{VT-VR}_{56}}{\text{VT}}\right)100$$

$$Q_D\,(\%) = \text{ABS}\left(\frac{\text{QC-QR}_{56}}{\text{QC}}\right)100$$

Where:

V_D (%) is the absolute percentage difference between VT and VR_{56}.

Q_D (%) is the absolute percentage difference between QC and QR_{56}.

The resolution procedure will use the above equations. The Engineer will determine through the resolution procedure whether the QC surface resistivity test results or the VT surface resistivity test results are deemed to be the most accurate, LOTs will then be considered to be verified.

The Engineer will inform the QC and VT laboratories within three calendar days of the acceptance surface resistivity test to transport their QR and VR cylinders to the resolution laboratory. The QC and VT laboratories will transport their own hold cylinders to the resolution testing laboratory within three calendar days after the Engineer notifies the Contractor that a resolution procedure is required. In addition, the Engineer will ensure that the QR and VR cylinders are tested within 14 calendar days of the acceptance strength tests.

The Engineer will determine the most accurate strength test result to represent the four or fewer consecutive LOTs as follows:

1. When both results meet the established comparison criteria, both are deemed accurate, and the QC strength will represent the LOTs. The Department will pay for cost of the resolution testing.

2. When only the QC result is within the established comparison criteria, the QC strength is deemed as most accurate and will represent the LOTs. The Department will pay for the cost of the resolution testing.

3. When only the VT result is within the established comparison criteria, the VT strength is deemed as most accurate and will represent the LOTs. The Department will assess a $1,000 pay reduction for the cost of the Resolution Investigation.

4. When both results are outside the established comparison criteria, the Engineer, with input from the DMRO, will determine if any Department IA evaluations are required and which test results are most accurate. The Department will pay for the cost of the resolution testing.

When the Engineer cannot determine which surface resistivity test results are the most accurate, the ACP grout represented by the four consecutive LOTs will be evaluated based on the QC data.

The results of the resolution procedure will be forwarded to the Contractor within five working days after completion of the investigation.

346-9.7 Structural and Durability Adequacy: The Engineer will evaluate the structural adequacy for verified ACP grout that does not meet the minimum specified compressive strength of Table 346-3 and the minimum specified surface resistivity in Table 346-4.

For structural adequacy, with standard molded and cured compressive strength cylinders, the 56-day compressive strength of ACP grout is satisfactory provided that the average compressive strength does not fall below the specified minimum compressive strength.

If using a mix design approved for acceptance at other than 56-day, the mix design shall meet the specified minimum compressive strength at the age for which it was designed and is exempt from the 56-day specified minimum compressive strength in Table 346-3.

346-10 Investigation of Low Compressive Strength and Surface Resistivity ACP grout.

When a verified ACP grout compressive strength or surface resistivity test result does not meet the structural adequacy described in 346-9.7 and the compressive strength falls below the specified minimum requirements by no more than 10%, perform one of the following options:

1. Submit an Engineering Analysis Scope in accordance with 6-4 to establish structural and durability adequacy. When the scope is approved by the Engineer, submit an Engineering Analysis Report (EAR) in accordance with 6-4 that includes a full structural and durability analysis. If the results of the engineering analysis indicate adequate strength to serve its intended purpose with adequate durability, and is approved by the Engineer, the Contractor may leave the ACP grout in place subject to the requirements of 346-11, otherwise, remove and replace the LOT of ACP grout in question at no additional expense to the Department.

2. At the Engineer's discretion, obtain drilled core samples as specified in this Section to determine the in-place compressive strength or surface resistivity of the LOT of ACP grout in question, at no additional expense to the Department. The Engineer will determine whether to allow coring of the in-place ACP grout or require an engineering analysis based on the compressive strength and surface resistivity of the test cylinders.

No EAR will be accepted to validate piles in which the grout compressive strength falls more than 10% of the specified compressive strength.

346-10.1 Coring for Determination of Structural and Durability Adequacy: Core compressive strength and surface resistivity test results obtained from the structure will be accepted by both the Contractor and the Department as the in-place compressive strength and surface resistivity of the LOT of ACP grout in question. The core compressive strength and surface resistivity test results will be used in lieu of the cylinder compressive strength and surface resistivity test results for determination of structural and durability adequacy. The Department will calculate the average of the individual cores as the actual measured compressive strength and surface resistivity.

Obtain and test the cores in accordance with ASTM C42.The Engineer will select the size and location of the drilled cores so that the structure is not impaired and does not sustain permanent damage after repairing the core holes. Obtain the Engineer's written approval before taking any ACP grout core samples. Notify the Engineer 48 hours prior to taking core samples.

Sample three undamaged cores taken from the same approximate location where the questionable ACP grout is represented by the low compressive strength or surface resistivity test cylinders. Repair core holes after samples are taken with non-shrink grout meeting the requirements of 934 and meeting the approval of the Engineer. Report the test results to the Engineer within two calendar days of testing the core samples.

The Engineer, with input from the DMRO, will consider the ACP grout as structurally adequate and sufficiently durable in the area represented by core tests at the actual test age, if the average compressive strength and surface resistivity of cores does not fall below the specified minimum compressive strength (f'c) and specified minimum surface resistivity by more than 10%.

The Engineer may require the Contractor to perform additional testing as necessary to determine structural and durability adequacy of the ACP grout.

346-11 Pay Adjustments for Low Compressive Strength ACP Grout.

346-11.1 General: For any LOT of ACP grout failing to meet the f'c as defined in 346-3, 346-9, and satisfactorily meeting all other requirements of the Contract Documents, including structural adequacy, the Engineer will individually reduce the price of each low strength LOT in accordance with this Section.

346-11.2 Basis for Pay Adjustments: The Engineer will determine payment reductions based on the 56-day compressive strength, represented by either acceptance compressive strength or correlated cores strength test results based on the following criteria:

1. When the acceptance compressive strength test result falls below the specified minimum compressive strength, do not core hardened ACP grout for determining pay adjustments. Use the acceptance compressive strength test results.

2. When the acceptance compressive strength test result falls below the specified minimum compressive strength by more than the 10%, the structure may be cored for determination of structural adequacy as directed by the Engineer. Use the result of the 56-day correlated core compressive strength or the acceptance compressive strength test, whichever is less.

A price adjustment will be applied to the certified invoice price the Contractor paid for the ACP grout or the precast product.

The Engineer will relate the compressive strength at the actual test age to the 56-day strength for the mix design represented by the cores using appropriate strength time correlation equations.

346-11.3 Calculating Pay Adjustments: The Engineer will determine payment reductions for low strength ACP grout accepted by the Department. The 56-day strength (psi) is represented by either cylinders or correlated cores strength test results in accordance with 346-11.2.

Reduction in Pay for low ACP grout compressive strength is calculated as follows:

$$\text{Reduction in Pay (\$)} = \left(\frac{f'c - 56 \text{ day Strength}}{f'c}\right) (\text{LSP x Pay})$$

Where:
f'c is the 56-day specified minimum compressive strength (psi).
LSP is the length of ACP low strength piles (ft).
Pay is the amount of pay ($) per foot of ACP.

When one LOT includes more than one pile, the reduction in pay will be applied to the entire length of all piles containing low strength ACP grout. When an ACP includes grout from two LOTs, the greatest reduction in pay computed for each LOT will apply to the full pile.

346-12 Pay Adjustments for Low Surface Resistivity ACP Grout.

346-12.1 General: For any LOT of ACP grout failing to meet the surface resistivity as defined in 346-3, 346-9, and satisfactorily meeting all other requirements of the Contract Documents, including durability adequacy, the Engineer will individually reduce the price of each low surface resistivity LOT in accordance with this Section. A price adjustment will be applied to the certified invoice price the Contractor paid for the ACP grout.

346-12.2 Pay Adjustments: The Engineer will determine payment reductions for low surface resistivity ACP grout accepted by the Department. The 56-day surface resistivity is represented by either cylinder or core test results in accordance with 346-10.

Reduction in Pay for low ACP grout surface resistivity (SR) is calculated as follows:

$$\text{Reduction in Pay (\$)} = \left(\frac{SR_{min} - SR}{SR_{min}}\right) (\text{LSRP x Pay})$$

Where:
SR_{min} is the specified minimum surface resistivity (kΩ.cm).
LSRP is the length of ACP low surface resistivity piles (ft).
Pay is the amount of pay ($) per foot of ACP.

When one LOT includes more than one pile, the reduction in pay will be applied to the entire length of all piles containing low SR ACP grout. When an ACP includes grout from two LOTs, the greatest reduction in pay computed for each LOT will apply to the full pile.

346-13 Pay Reduction for Time of Efflux and Temperature.

A rejected load in accordance with 346-6.4 is defined as the entire quantity of ACP grout contained within a single ready-mix truck regardless of what percentage of the load was placed. If ACP grout fails the time of efflux or temperature test and is thereby a rejected load but its placement continues after completion of a test having a failing result, payment for the ACP grout will be reduced.

The pay reduction for ACP grout will be twice the certified invoice price per cubic yard of the quantity of ACP grout in the rejected load.

If the Engineer authorizes placement of the ACP grout, even though time of efflux or temperature requires rejection, there will be no pay reduction based on time of efflux or temperature failures; however, any other pay reductions will apply.

AUGER CAST PILES
(REV 4-25-23)

ARTICLES 455-38 through 455-50 are deleted and the following substituted:

455-38 Description.

Furnish and install auger cast piles (ACP), also known as augered-cast-in-place (ACIP) piles, used for structural support.

ACP piles are defined as a foundation made by rotating a hollow-stem auger into the ground to the required pile depth with sufficient crowd (downward thrust) to prevent mining of the soil. Portland Cement Grout (Grout) is injected through the auger shaft under continuous positive pressure as the auger is being withdrawn. A full-length reinforcing cage, as specified, is inserted into the column of fluid grout following the completion of grout placement.

455-39 General Requirements.

455-39.1 Personnel Requirements:

455-39.1.1 Bridge Foundations: Provide a foreman in responsible charge for the ACP operations with a minimum of five years of ACP pile experience on multistory buildings or bridges and a minimum of five successful projects using similar or larger pile diameters, penetrations and loads of those indicated in the Plans. The experience shall include subsurface and project conditions similar to those of the current project. In at least two projects the foreman must have used Automated Monitoring Equipment (AME) to monitor tip depths, torque, crowd, auger rotation rate, grouting pressures, and incremental grouting volumes. Experience in foundations for noise walls, sign structures, mast arms or other types of miscellaneous structures shall not count toward this requirement.

Technicians performing the efflux test must take the FDOT on-line Auger Cast Pile course and pass the final examination to be qualified to test for any auger cast pile installations in the field.

455-39.1.2 Noise Walls and Non-Bridge Structure Foundations: Provide a foreman with a minimum of three years of augered cast-in-place pile experience on noise walls, sign structures, mast arms or any other types of miscellaneous structures, on projects using similar or larger pile diameters, penetrations, and load requirements of the requirements of this project. Experience on bridges or multistory buildings may count towards this requirement.

Technicians performing the efflux test must take the FDOT on-line Auger Cast Pile course and pass the final examination to be qualified to test for any auger cast pile installations in the field.

455-39.2 Contractor's Operations: For bridge foundations, use only fixed mast rigs or fixed lead rigs. For bridge foundations, unless otherwise stated in the Plans, provide equipment capable of constructing piles supporting bridges to a depth equal to the deepest bridge pile shown in the Plans plus 15 feet. For non-bridge piles, unless otherwise stated in the Plans, provide

equipment capable of constructing piles supporting non-bridge structures to a depth equal to the deepest non-bridge pile shown in the Plans plus 5 feet.

Submit an ACP Installation Plan in accordance with 455-47. Demonstrate to the satisfaction of the Engineer, the dependability of the equipment, techniques, and materials by construction of a demonstration pile per pile diameter and per grout mix design prior to the start of load test piles and production piles. Construct demonstration piles at non-production locations selected by the Engineer to the deepest tip elevation for each pile diameter indicated in the Plans. Provide an embedded thermal wire mounted on a center bar, in addition to the reinforcement cage required by the plans, on all demonstration piles and load test piles. Prior to production pile installation, determine the maximum core temperature and time to peak temperature for each project specific grout mix by obtaining temperature measurements at least every 15 minutes during curing of demonstration piles and load test piles.

Demonstration piles may not be used for load tests. Cut off piles installed out of permanent position at an elevation of 2 feet below the ground surface and dispose of the removed portion of the pile.

For non-bridge piles, the first production pile may be used as the demonstration pile to prove the acceptability of the means and methods of pile installation.

455-39.3 Monitoring Equipment: Use an AME system to monitor the installation of all bridge foundation piles, including demonstration piles, load test piles and production piles. Provide a technician to operate and monitor the AME during pile installation. This technician must have at least two (2) years of experience operating and monitoring AME. An AME system may be used to monitor the installation of noise wall and miscellaneous structure foundation piles at the Contractor's option.

Equip the ACP rig with an AME system to accurately record the measurements listed in 455-44.3. Provide the equipment with a rotational position indicator on the auger head system to measure the inclination of the auger. Provide an electronic position indicator on the crane line or boom holding the auger to measure the depth of the auger injection point below ground. Provide torque cells positioned on the auger head system. Provide electronic flowmeters and electronic pressure transducers placed in the grout pressure line. For bridge piles, provide load cells positioned on the auger head system or on the drill rig
hoist winch to monitor crowd.

Prior to each day's drilling operations, provide the baseline torque and crowd pressures, after the hydraulic system is warmed up, to the inspector.

455-39.4 Priming and Calibration Tests: When the Contractor's installation procedure includes priming the grout pump, or grouting lines or auger conduit after drilling the hole, perform a priming demonstration to determine the minimum number of pump strokes required to deliver fresh grout throughout the entire system and flow from the grout injection hole at the bottom of the auger. Perform this grout priming demonstration prior to any calibration test. The Engineer may require additional priming demonstrations when the pump is repaired, a different pump is used, or when the length of the grout lines or hollow auger lengths increase from previous piles for which priming demonstrations were performed.

Calibrate all measuring and recording equipment prior to the construction of demonstration piles and prove that the values indicated by the measuring and recording equipment are within 3% of the values indicated. Calibrations shall be performed in accordance with the equipment manufacturer's recommendations. Recalibrate all measuring and recording equipment when the Engineer determines that drilling and grouting performance has changed.

Maintain all measuring and recording equipment in working order throughout the installation of all piles.

Perform a calibration test of the pumping equipment, prior to construction of the demonstration piles, to determine the average volume of grout for every pump stroke, in accordance with FM 5-612. Connect and test any flowmeters to be used in the project, during the pumping equipment calibration tests and demonstrate the volume recorded by the flowmeters are within 3% of the volume of grout measured in the barrel during the calibration tests. Do not use flow meters that do not meet this requirement. Recalibrate the pump prior to beginning the pile installation of every two piers/bents; recalibrate more frequently if the Engineer determines that the grouting performance has changed.

455-40 Materials.

Meet the following material requirements:

Structural Portland Cement Grout for
Auger Cast Piles……Dev346ACP
Reinforcing…… .....……Section 415

455-41 Grout Mix.

Use an approved grout mix produced in accordance with Dev346ACP.

455-42 Pumping Cement Grout.

Meet the following requirements:

1. Only use pumping equipment approved by the Engineer in the preparation and handling of the grout. Before using the mixers, remove all oil or other rust inhibitors from the mixing drums, stirring mechanisms, and other portions of the equipment in contact with the grout.

2. If there is a lapse in the operation of grout injection, recirculate the grout through the pump, or through the mixer drum or agitator.

3. The Engineer's approval of grout mixers and all other equipment will be contingent on proper performance during construction of the demonstration pile and subsequent production work.

4. Use a positive displacement piston type grout pump equipped with a pressure gauge, capable of developing displacing pressures at the pump not less than 350 psi. The pump shall be appropriately sized to the pile diameter. Provide a grout pressure gauge in clear view of the equipment operator. Provide a second pressure gauge near the drill rig where it can be observed by the Engineer.

5. Accurately monitor the volume and pressure of the grout flow. Provide a pump stroke counter in good working condition on the grout pump.

455-43 Testing Cement Grout Mix.

Test ACP grout in accordance with Dev346ACP.

455-44 Pile Installation.

455-44.1 Drilling: Meet the following requirements:

1. Locate the piles as shown on the drawings.

2. Should soft, compressible muck, organics, clay, or other unsuitable materials (non A-1, A-3, A-2-4 or limestone materials) be encountered, remove the unsuitable material to a

maximum depth of 5 feet, and a radial distance around the pile centerline of 2 pile diameters unless otherwise indicated in the Plans. Backfill with clean granular backfill materials (A-1, A-3, A-2-4), placed and compacted in maximum 12-inch lifts to at least 95% of maximum dry density as determined by FM 1-T180. Complete this work to the Engineer's satisfaction prior to ACP construction. Should more than 5 feet depth or excessive quantities of unsuitable material be encountered, immediately advise the Engineer and proceed with the work as directed by the Engineer.

3. Provide continuous auger flighting from the bottom to the top of auger with no gaps or other breaks other than accommodation for partial or full, drilled displacement piles. Ensure the auger flights are uniform in diameter throughout its length, and of the diameter specified for the piles less a maximum of 3%. Provide augers with a distance between flights of approximately half the diameter of the auger.

4. Use augers with the grout injection hole located at the bottom of the auger head below the bar containing the cutting teeth, and with pile auger leads containing a bottom guide.

5. Construct piles of the diameter shown in the plans and to the required lengths or tip elevations specified in the Plans. When plans show estimated pile lengths or tip elevations, construct the piles to the pile tip elevations, rock socket requirements and minimum embedment length into the bearing stratum specified in the authorized pile tip elevations letter.

6. Clearly mark the auger leads to facilitate monitoring of the incremental drilling and grout placement. Provide individual foot marks with 5-foot increments highlighted and clearly visible. Provide a clear reference mark on the moving auger assembly to facilitate accurately monitoring the vertical movement of the auger.

7. Place piles by rotating a continuous flight hollow shaft auger into the ground at a continuous rate that prevents removal of excess soil. Stop advancement after reaching the predetermined depth.

8. Should auger penetration to the required depth prove difficult due to hard materials/refusal, the pile location may be predrilled, upon approval of the Engineer, through the obstruction using appropriate drilling equipment, to a diameter no larger than one half the prescribed finish diameter of the ACP. Commence grouting immediately upon reaching the required tip elevation to minimize ground loss and soil relaxation. Should non-drillable material be encountered preventing placement to the depth required, immediately advise the Engineer and proceed with the work as directed by the Engineer. Refusal is defined as the depth where the penetration of the standard auger equipment is less than 12 inches per minute.

9. Plug the hole in the bottom of the auger prior to advancing into the ground.

455-44.2 Grouting: Meet the following requirements during grouting operations

1. Remove the plug within 6 inches of the bottom of the hole by the grout pressure. Pump the grout with sufficient pressure as the auger is withdrawn to completely fill the auger hole, preventing hole collapse and to cause the lateral penetration of the grout into soft or porous zones of the surrounding soil or rock. Prior to commencing withdrawal of the auger, establish, for bridge foundations, an initial head of at least 20 feet of grout or 20 percent the length of the pile (rounded up to the next whole foot) whichever is greater; for non-bridge foundations, establish, an initial head of at least 5 feet of grout or 10 percent the length of the pile (rounded up to the next whole foot) whichever is greater. Establish this head by pumping a volume of grout equivalent to this required initial head times the theoretical cross section of pile. Do not include the volume or strokes required to prime the grout pumping system in the volume required to build this initial head. Maintain this head of grout above the injection point around

the perimeter of the auger to displace and remove any loose material from the hole. Maintain positive rotation of the auger at least until placement of the grout.

2. Once the grout head has been established, greatly reduce the speed of rotation of the auger and commence extraction at a rate that allows the requirements of items 3 and 4 to be met. Maintain extraction at a steady rate to prevent a locked-in auger, necking of the pile, or a substantially reduced pile section. Always use this method of placement. Do not depend on the stability of the hole without the earth filled auger.

3. Grout Return Depth is defined as the depth of the injection point below the ground surface at which grout starts flowing out from the hole. Ensure a minimum grout return depth (MGRD) equal to the initial head provided at each pile, as per item 1 of this subarticle.

4. For bridge foundations, continuously monitor grout volumes and pressures for every 1-foot of grouting, using the AME. In piles for noise walls and miscellaneous structures, verify either by pump stroke count or AME the amount of grout placed. Place a minimum volume of grout in the hole of at least 115% of the column of the auger hole from a depth equal to the required MGRD to the tip of the pile. If less than 115% of the theoretical volume of grout is placed in any 5-foot increment (100% when above the MGRD depth), reinstall the pile by advancing the auger 10 feet below the top of the increment or to the bottom of the pile if less, followed by controlled withdrawal and grout injection, meeting the same 115% criteria for all 5-foot increments. If the total grout volume measured with the AME is over 3% greater than the total grout volume measured with pump stroke counting, use the stroke counting method to determine whether reinstallation of the pile is required and whether the pile is acceptable. Perform recalibration of the flowmeter and pump prior to continuing with the next auger cast pile installation and meet 455-39.4. Replace flowmeter if necessary.

5. Do not include the grout volume used to create the initial head, as part of the grout volume used to satisfy the overgrout requirement of item 4. If the grout does not flow out from the hole when the cutting head is at least equal to the required MGRD below the ground surface, redrill the pile. If grouting is interrupted for any reason or grout pressure loss is observed, reinsert the auger by drilling to at least 15 feet below the tip of the auger when the interruption or pressure loss occurred, and then regrout.

6. Immediately and periodically check the grout level within completed piles for grout settlement. Piles that experience up to 6 inches of grout settlement per 12 hours may be topped with grout provided any deleterious material which may have accumulated on top of the pile is removed and the grout does not settle below the groundwater level. However, piles that show a drop in grout level more than 6 inches in 12 hours shall be rejected unless successfully tested with Thermal Integrity Testing.

455-44.3: Automatic Measurements and Recording: Monitor in real-time and record with the AME <u>all</u> drilling and grouting conditions during the installation of all bridge foundation piles. As a minimum, monitor and concurrently record the following measurements at least once per second during drilling and grouting operations with respect to time and depth of auger tip:

1. auger rotation speed.
2. torque delivered to the auger.
3. crowd force (downward thrust on auger).
4. rate of auger penetration.
5. depth of the auger injection point.
6. rate of auger extraction.
7. volume of grout for each foot of pile.

8. cumulative volume of grout.

9. grout pressure.

Reference and plot all measurements to the depth of the auger injection point. Submit AME records to the Engineer at the end of the day for each pile installed that day including all data from the drilling and grouting phases. The real-time AME information, together with all electronic data, shall be made available to the Engineer in the field in addition to being submitted at the end of day after constructing each pile. Provide electronic data in a format compatible with Microsoft Excel™, and using the column arrangement of the Department Form 700-020-05.

455-44.4 Reinforcement: Meet the following requirements:

1. Furnish and install the reinforcing and anchoring bolts as shown in the Contract drawings. Use reinforcement that is without kinks or nonspecified bends, free of mud, oil or other coatings that could adversely affect the bond. Make splices in reinforcement as shown on the Contract drawings, unless otherwise approved by the Engineer.

2. Completely assemble and place as a unit the cage of reinforcing steel. Tie all intersections of reinforcing steel with cross ties or "figure 8" ties. Use double strand ties, ties with larger tie wire, U-bolts, or similar when necessary. Furnish and install the reinforcing steel and anchoring bolts as shown in the Contract drawings. The Engineer will give final approval of the cage construction and placement subject to satisfactory performance in the field.

3. Use wheels or other approved noncorrosive spacing devices within 3 feet of the bottom, within 3 feet of the top, and intervals not exceeding 10 feet along the pile to ensure concentric spacing for the entire length of the cage. For battered piles, intervals between spacing devices shall not exceed 5 feet. Do not use block or wire type spacers. Use a minimum of one spacer per 30 inches of circumference of cage with a minimum of three (3) at each level.

4. Place the reinforcing while the grout is still fluid, and immediately after finishing grouting and clearing it from any contaminating material. Install the reinforcing into the grout by its own weight or manually. Do not use mechanical equipment or tools to impact the reinforcing or to force it into the grout. If the reinforcement does not achieve the required penetration into the grouted pile, remove the reinforcement, re-drill, and re-grout the pile per Section 455-44.1 and 455-44.2.

5. Wait at least 12 hours after completing grouting of one pile before starting drilling at a pile location within 6 diameters center to center of the completed pile. The Engineer may extend this time to a minimum of 24 hours when excessive grout settlement or integrity problems are observed on recently grouted piles from drilling and installation operations in adjacent locations.

6. Hold the reinforcing in position at the ground surface within the fluid grout column with temporary supports. For bridges, leave any temporary supports in place for a minimum of 24 hours after completion of the pile or until the grout reaches its initial set time in accordance with ASTM C403, whichever is longer. For noise walls and miscellaneous structures, this time requirement may be reduced to 12 hours or until the grout reaches its initial set whichever is longer. Do not place wall panels, footings, or other loads on the piles before the piles are accepted and the grout has set a minimum of seven days or reached the compressive strength shown in the Contract Documents.

455-45 Construction Tolerances.

Locate piles as shown on the drawings, or as otherwise directed by the Engineer. Locate pile centers to an accuracy of plus or minus 3 inches. Ensure the grout cover beyond the outer layer of reinforcing is at least 4 inches. Ensure that the axial alignment of the auger cast pile does

not deviate by more than 1/4 inch per foot from the axial alignment indicated in the Plans. For noise walls, ensure the tolerances of 534-5.1 can be met.

Locate the top of piles for noise wall foundations within plus or minus 3 inches of the plan elevation. Locate the top of piles for bridges and structures other than noise walls within plus 1 inch and minus 3 inches from the plan elevation and unless otherwise indicated in the Plans, the top of the reinforcing steel cage is no more than 6 inches above and no more than 3 inches below plan position.

455-46 Unacceptable Piles.

Repair or replace unacceptable piles, as directed by the Engineer, at no cost to the Department. Unacceptable piles are piles that fail for any reason, including but not limited to the following:

1. Piles not meeting the required penetration, minimum tip elevations or the required embedment into the bearing stratum, or minimum rock socket lengths.
2. Piles placed out of specified tolerances for position or axial alignment.
3. Piles not meeting the minimum grout cover, diameter or minimum overgrout requirements.
4. Piles with integrity deficiencies, contaminated grout, lack of grout consolidation (honeycombed), or deficient grout strength.
5. Piles with reinforcement, anchor devices or other components cast, or placed into the fluid grout out of position.
6. Piles in which compressive strength tests indicate that the grout compressive strength is more than 500 psi below the specified design strength when the specified design strength is 5,000 psi or less.
7. Piles in which compressive strength tests indicate that the grout compressive strength is less than 90% of the specified design strength when the specified design strength exceeds 5,000 psi.

When the Engineer determines that a pile is unacceptable, the Contractor may propose a foundation redesign to add piles into pile caps or footings, at no expense to the Department. The Contractor's Engineer of Record must perform any redesign, and sign and seal the redesign drawings and calculations. Do not begin any proposed construction until the redesign has been reviewed for acceptability and approved by the Engineer.

455-47 Auger Cast Pile Installation Plan (ACPIP).

No later than 30 days before auger cast pile construction begins, submit an ACPIP for Engineer's approval. The Engineer will give final approval subject to satisfactory performance in the field. Provide the following detailed information on the plan:

1. Name and experience record of ACP foreman in responsible charge of auger cast pile operations.
2. List and size of the proposed equipment, including cranes, augers, grout pumps, mixing equipment etc. Include the diameter of the hollow stem through which grout will be pumped.
3. Details of grout mixing procedures and proposed calibration procedures.
4. Equipment and procedures for monitoring and recording grout pressures and volumes placed during grouting operations.
5. Details of pile installation methods.

6. Details of reinforcement placement and method of centering in pile, including details of all temporary supports for reinforcement, anchor bolts, precast columns, etc.

7. Required submittals, including shop drawings and approved grout design mixes.

8. Procedures to meet the requirements of Section 108.

9. Evidence of foreman's experience meeting the requirements of 455-39.1. Provide a list of projects performed by the foreman. Include a client contact reference name and contact information for each project listed. Projects that do not meet the requirements of 455-39.1 or that cannot be verified by the Engineer because of insufficient information provided in the ACPIP will not count towards the experience.

10. Evidence that the technicians that will perform the efflux tests meet the requirements of 455-39.1.

11. For bridge foundations, include the following in the ACPIP:

a. Name and experience record of the technician(s) in charge of monitoring the AME.

b. Equipment and procedures for monitoring and recording auger rotation speed, auger penetration rates, auger depths, and crowd pressures during the drilling process.

c. Calibration records for all automated measuring and recording equipment.

d. Details of how the grout volumes will be determined, monitored, and documented.

e. Details of any required load tests, including structural elements, reaction foundations, equipment and procedures, and recent calibrations for any jacks or load cells.

f. Proposed Thermal Integrity Testing Specialty Engineer to supervise, perform, log, analyze, and report the test results.

g. Method for measuring the maximum core temperature of the demonstration piles and test piles.

455-48 Inspection and Records.

Perform the automatic monitoring and recording of the various drilling and grouting parameters. The Engineer will observe the pile installation and complete the ACP Installation record.

455-49 Load Tests and Pilot Holes.

When pilot holes and/or load tests are performed, the Engineer will use the pilot hole and/or load test results to determine the authorized tip elevations and/or the authorized installation criteria of the auger cast piles. Production auger cast piles shall not begin until pilot hole and/or load test reports are approved by the Engineer. Final authorized tip elevations based on pilot hole results and/or load tests may vary from the tip elevations presented in the Plans. Extend auger cast piles deeper when the Engineer determines the material encountered during drilling is unsuitable or is not the same as anticipated in the design of the auger cast piles. In the absence of suitable strength tests, pilot holes or load tests to evaluate materials excavated, construct the auger cast piles no higher than the tip elevations shown in the Plans.

Perform compression and tensile load tests at the locations indicated in the Plans. Design and install reaction foundations to properly resist a load equal to the maximum test load indicated in the Plans plus 25%. Provide and install internal strain gauges throughout the length of the cage. Unless indicated otherwise in the Plans, provide a minimum of three sister bar strain

gauges every five feet along the reinforcing. Provide a readout unit to record the data from all instruments.

455-49.1 Compression Load Tests: Perform compression load tests to the load indicated in the Plans and in accordance with ASTM D1143 except use the loading procedures and failure criterion specified in 455-2.2.1. Do not begin static load testing until the grout has attained a compression strength of at least 90% of the specified design strength.

455-49.2 Tensile Load Tests: Perform tensile load test to the load indicated in the Plans and in accordance with the scope, preparation and procedures of ASTM D3689. Follow Procedure A: Quick Test, except apply and remove the load at the same increments and decrements specified in 455-2.2.1 and at the same time intervals specified in this subarticle.

The failure load shall be the load that causes a deflection equal to the calculated elastic deflection plus 0.15 inches. Consider the nominal resistance of any pile so tested as either the maximum applied load or the failure load, whichever is smaller.

455-49.3 Pilot Holes: When pilot holes are shown in the Plans core a pilot hole, prior to construction of production auger cast piles, in accordance with ASTM D2113 Standard Practice for Diamond Core Drilling for Site Excavation and the Department's Soils & Foundations Handbook using a double or triple wall core barrel through part or all of the pile, to a depth of 3 times the diameter of the auger cast pile below the tip elevation shown in the Plans. The Engineer may require the Contractor to cut any core to a total depth below the bottom of the auger cast pile of up to 5 times the diameter of the auger cast pile. Submit a complete soil boring log or report of core boring, within 48 hours of completing the pilot hole.

455-50 Authorized Pile Tip Elevations.

The tip elevation indicated in the Plans is an estimation that may change for the final construction based on the pilot holes information or the load test results. Within five working days after performing all pilot holes, completing all load tests, and receiving all load test reports, the Engineer will issue a letter with an itemized list of authorized pile tip elevations. This letter may also specify a minimum rock socket requirement. During the drilling operations, the Engineer may require a deeper pile tip than the authorized tip elevation to meet a required socket elevation or for any other reason.

455-51 Non-Destructive Integrity Testing.

455-51.1 Thermal Integrity Testing for ACP (TITACP) Procedure: Engage a qualified Specialty Engineer and personnel for TITACP in accordance with 455-17.6 Thermal Integrity Testing for Drilled Shafts (TITDS) to perform Thermal Integrity Testing in accordance with ASTM D7949 Method B (wires) and 455-17.6.1.1, except that a minimum of 4 equally spaced wires must be used on the reinforcement cage of each pile, and as indicated otherwise herein. When approved by the Engineer, thermal probes (Method A) may be substituted for thermal wires (Method B) in accordance with 455-16.4 and 455-17.6.1. Provide all necessary assistance to the Specialty Engineer to satisfactorily perform the testing.

Test all demonstration piles, all load test piles and all production piles with wires at the time of peak temperature. For demonstration piles and load test piles, determine the core center temperature and the temperatures at the reinforcement using the center wire and wires at the reinforcement respectively.

For each grout mix design and each pile size, determine the Average Delta Temperature between the core temperature and the rebar temperature as follows:

Average Delta Temperature = Average Center Temp. - Average Rebar Temp.

Where:

Average Center Temperature is the average temperature throughout the full depth of the wire measured by the center wire.

Average Cage Rebar Temperature is the average temperature at the rebar cage computed by averaging all cage wire temperatures throughout the full depth of the wires on the rebar cage.

If the radial position of wire changes due to cage configuration changes, then compute the average cage temperature for each region with the same cage configuration. Compute Average Delta Temperatures for each cage configuration in the pile.

Determine the core temperature of the production piles at each depth by adding the Average Delta Temperature computed for each mix grout and pile size, to the temperatures measured at each depth and wire location. The core temperature at any depth determined this way shall not exceed 160°F.

455-51.2 Thermal Integrity Testing Access Tubes: For piles to be used in the foundation of bridges and tested with thermal probes, provide 4 Thermal Integrity Testing Access Tubes attached to the reinforcing cage of all auger cast piles in accordance with 455-16.4 except that the entire length of each access tube may be NPS 1-1/2 or 2-inch diameter Schedule 40 or Schedule 80 PVC pipe, and the tubes must be filled with water and recapped prior to or immediately after inserting the reinforcing cage into the grouted pile.

Unless indicated otherwise in the Plans, neither thermal wires nor access tubes are needed for piles supporting miscellaneous structures and noise walls.

455-51.3 Thermal Integrity Testing Reports: Submit Thermal Integrity Testing reports meeting the requirements of 455-17.6.1.3, together with all electronic data, within 48 hours of testing to the Engineer. Replace all references to shafts in 455-17.6.1.3 with piles. When Method B (wires) is used, include a graph of measured temperatures versus time in the report.

455-51.4 Engineer Testing: The Engineer may perform independent testing using thermal integrity or other means on selected piles.

455-52 Method of Measurement.

455-52.1 Auger Cast Pile: For ACP supporting bridge structures and other structures identified in the Plans, the quantity to be paid for will be at the Contract unit price per foot between the authorized tip elevation and the accepted as-built pile top elevations for all piles completed and accepted. If, during the drilling of a particular pile, the Engineer requires a pile tip deeper than the authorized pile tip, the quantity to be paid will be computed between this final deeper tip elevation and the accepted as-built pile top elevation.

455-52.2 Thermal Integrity Testing: The quantity of the Thermal Integrity tests to be paid for will be the number of auger cast piles tested with this method and accepted based on the results of the test. No payment will be made for any integrity testing performed to evaluate the acceptability of piles as part of an EAR. No payment will be made for any integrity testing performed by the Engineer.

455-52.3 Test Loads (Compression): The quantity to be paid for will be the number of auger cast piles tested in accordance with 455-49.1.

455-52.4 Test Loads (Tensile): The quantity to be paid for will be the number of auger cast piles tested in accordance with 455-49.2.

455-53 Basis of Payment.

455-53.1 Auger Grouted Piles for Tangent and Secant Walls Only: Price and payment will be full compensation for all labor, materials, including grout, reinforcement, and incidentals for construction of auger cast piles, of the sizes and depths indicates on the Contract drawings or otherwise required under this Contract. Price and payment will also include the removal and proper disposal off site of all spoil from the auger operation and all excess grout displaced from the auger hole, unless otherwise approved by the Engineer. Work to remove and replace unsuitable materials, when necessary, as specified in 455-44 will be considered Unforeseeable Work. Payment will be made under item 455-112.

455-53.2 Auger Cast Piles for Bridges: Price and payment will be full compensation for all labor, materials, including grout, reinforcement, wires, and access tubes for TIPACP testing, drilling, and incidentals for construction of auger cast piles for bridge structures, of the sizes and depths indicated on the Contract drawings or otherwise required under this Contract. Price and payment will also include the removal and proper disposal off site of all spoil from the auger operation and all excess grout displaced from the auger hole, unless otherwise approved by the Engineer. Work to remove and replace unsuitable material, when necessary, as specified in 455-44 will be considered Unforeseeable Work.

455-53.3 Auger Cast Piles for other Structures: No separate payment will be made for ACP for privacy walls, noise walls, signs, lighting, mast arms and any other miscellaneous structure. The cost of ACP for these structures is included in the cost of the structure.

455-53.4 Load Test Auger Cast Piles: Price and payment will be full compensation for all labor, materials, including grout, reinforcement, access tubes for TIPACP testing, drilling, and incidentals for construction of load test piles of the sizes and depths indicated on the Contract drawings or otherwise required under this Contract. Price and payment will also include the removal and proper disposal off site of all spoil from the auger operation and all excess grout displaced from the auger hole, unless otherwise approved by the Engineer. Work to remove and replace unsuitable material when necessary as specified in 455-44 will be considered Unforeseeable Work.

455-53.5 Demonstration Piles: No separate payment will be made for demonstration piles. All cost of demonstration piles will be included in the cost of Auger Grouted Piles.

455-53.6 Thermal Integrity Testing: Price and payment will include all costs related to the performance of the Thermal Integrity Testing including any incidentals.

455-53.7 Pilot Holes: Price and payment will be in accordance with 455-24.5.

455-53.8 Static Load Tests (Compression): Price and payment will be full compensation for all labor, materials, and incidentals for the execution of compression tests, including instrumentation and professional services to prepare the report.

455-53.9 Static Load Tests (Tensile): Price and payment will be full compensation for all labor, materials, and incidentals for the execution of tensile tests, including instrumentation and professional services to prepare the report.

455-53.10 Payment Items: Payment will be made under:

Item No. 455-112-	Auger Grouted Piles - per foot.
Item No. 455-113-	Auger Cast Piles for Bridges - per foot.
Item No. 455-148-	Thermal Integrity Testing for Auger Grouted Piles - each.
Item No. 455-119-	Static Load Test (Compression) - each.
Item No. 455-119-	Static Load Test (Tensile) - each.
Item No. 455-111-	Core/Pilot Hole - per foot.

Section 9.2
Volume II

STRUCTURAL CONCRETE PRODUCTION FACILITIES GUIDE

The following new SUBARTICLES are added after SUBARTICLE 9.2.18 and they are only applicable when the use of auger cast pile (ACP) grouts are delineated in the Plans. ***Materials Manual Volume II, Section 9.2*** articles are applicable unless modified in this ***DevMM9.2ACP***.

DevMM9.2ACP does not apply for any other structural concrete.

I.1.A. PURPOSE

For the purposes of this document, the term concrete may also be in reference to auger cast pile (ACP) portland cement grout (grout).

This standard must be used in conjunction with developmental specifications ***Dev346ACP*** and ***Dev455ACP***.

I.1.B. REFERENCES

Florida Department of Transportation. Developmental Specifications, Section 346 ACP Grout ***(Dev346ACP)***.

Florida Department of Transportation. Developmental Specifications, Section 455 ACP (***Dev455ACP)***.

I.1.C. GENERAL INFORMATION

Grout will be produced in an approved structural concrete production facility.

Plants that supply concrete, including ACP grout, to Department projects must have a Producer QC Plan accepted by the Department in accordance with ***Specifications Section 105***. The Department will maintain a list of Plants with accepted QC Plans that meet the requirements of this guide.

Concrete produced in accordance with ***DevMM9.2ACP*** will be accepted based on the proper certification and verification of project compressive strength acceptance criteria.

I.1.D. MATERIAL REQUIREMENTS

Meet the requirements of ***Dev346ACP***.

9.2.22.1 Admixtures

Use only admixtures, including fluidifiers for ACP grout, approved by the Department in the concrete mixes. A certification from the admixture supplier that the admixture meets the requirements of ***Specifications Section 924*** is required. A certification from the fluidifier supplier that the fluidifier meets the requirements of ***ASTM C937*** is required. The admixture dosage rate of the product to be used should be within the range of the admixture manufacturer's technical data sheet. Dosage rates outside of this range may only be used with written recommendation from the admixture producer's technical representative.

Use fluidifiers meeting the requirements of ***ASTM C937*** that do not contain chlorides.

9.2.22.2 Scales, Meters, and other Weighing or Measuring Devices

Calculate the fine aggregate free moisture based upon dry sample weights and adjusting for absorption per ***AASHTO T 255***. For fine aggregate, use a minimum sample size of 500 grams in lieu of the sample sizes required in ***AASHTO T 255*** Table 1.

9.2.22.3 Substitution of Materials

Obtain the Department's approval for portland cement, aggregates, and supplementary cementitious materials substitutions before placing the grout.

The Department may require a single 3.0 cubic yards minimum test batch at the Plant to demonstrate that the properties of the adjusted mix design are within the efflux, unit weight (density), air content, compressive strength, and chloride tolerances provided in ***Specifications Section 346*** or ***Dev346ACP***.

9.2.22.4 ACP Grout Mix Designs

Concrete mix designs shall meet the requirements of ***Specification Section 346*** or ***Dev346ACP***.

Proceed as follows to select the overdesign value in ACP grout mixes:

Use Table 1(a) at the concrete producer's option, or when the concrete producer has no records of field strength tests performed within the past 24 months and spanning no less than 45 calendar days for a class of concrete within 1,000 psi of that f'_c.

TABLE 1a – Overdesign requirements for establishing f'_{cr} when data is not available				
Class of ACP Grout	56-day f'_c (psi)	Overdesign (psi)	56-day f'_{cr} (psi)	Maximum Allowable 56-day Compressive Strength (psi)
ACP Grout Class I	5,500	1,250	6,750	7,850
ACP Grout Class II	8,000	1,500	9,500	11,000

The Department may approve specific ACP grout mix designs for acceptance at 56 days in accordance with Table 1a. The mix design shall meet the durability requirements at 56 days when specified in the ***Contract Documents***. Submit the strength development plot (cylinder compressive strength versus age) for test cylinder ages of 3, 7, 28 and 56 days. Mix designs meeting the overdesign requirements at 28-day will not be approved.

Attach the following supporting documentation with each new mix design submittal:

(1) Submit a certification statement from the admixture manufacturer's technical representative that the proposed admixtures including fluidifier, if used, are compatible with all other admixtures to be included in the ACP grout mix design.

(2) Thermal data from the demonstration pile for ACP grout mixes showing the maximum core temperature does not exceed 160°F. Include the maximum core temperature, the time to peak temperature, and the maximum temperature differential between the core and outer reinforcement.

(3) Initial set time test results of ACP Grout mix in accordance with ***ASTM C403***.

(4) Efflux time test result in accordance with ***ASTM D6449***.

9.2.22.5 Trial Batch Mixes

Ensure that the trial batch grout mix meet the plastic property requirements of the ***Dev346ACP***.

For the hot weather trial batch mixes (mix temperature of 94°F or higher). Hold the trial batch mix in the mixer for 90 minutes (120 minutes for ACP Grout) after completion of initial mixing. During the extended mixing period, turn the drum intermittently for 30 seconds every five minutes. Cover the drum with wet burlap or an impermeable cover material during the rest periods. At the end of the 90 minute (or 120 minute) period, remix the trial batch mix for a minimum of one minute and make a slump (flow cone for ACP Grout) test to verify that the concrete is within the specified range for slump (flow cone). Ensure that the mix temperature is not less than 94ºF at any time.

9.2.22.6 Mixing and Delivering Grout

Operate all Plant mixers at speeds per the mixer manufacturer's design or recommendation. Do not allow the volume of mixed batch material to exceed the mixer manufacturer's rated mixing capacity. Do not allow the volume of mixed batch material to exceed 80 percent of the mixer manufacturer's rated mixing capacity.

Do not haul ACP grout in mixer trucks loaded with more than 80 percent of the rated capacity shown on their attached plates.