STRUCTURAL PORTLAND CEMENT GROUT.
(REV 8-22-22)

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 Section 9.2, Volume II of the Materials Manual.

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.

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

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

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 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.