



Florida Department of Transportation

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JARED W. PERDUE, P.E.
SECRETARY

November 15, 2023

Daniel Holt, PE, PTOE
Interim Director, Office of Technical Services
Federal Highway Administration
3500 Financial Plaza, Suite 400
Tallahassee, Florida 32312

Re: State Specifications Office
Section: 929
Proposed Specification: **9290101 Supplementary Cementitious Materials.**

Dear Mr. Holt:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Thomas Frank to identify natural pozzolan as a SCM, reflect ASTM C619 changes regarding coal ash, clarify and strengthen concrete/mortar durability testing requirements, and include blending cement as an option for slag cement sulfate durability testing.

Please review and transmit your comments, if any, within two weeks (10 business days). Comments should be sent via email daniel.strickland@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at (850) 414-4130.

Sincerely,

Signature on File

Daniel Strickland, P.E.
State Specifications Engineer

DS/jb

Attachment

cc: Florida Transportation Builders' Assoc.
State Construction Engineer

SUPPLEMENTARY CEMENTITIOUS MATERIALS.
(REV 5-31-23)

SECTION 929 is deleted and the following substituted:

929-1 General.

Supplementary cementitious materials (SCMs) shall conform to the requirements of this Section. SCMs shall be used in concrete mix designs in accordance with Section 346.

Repulable bags may be accepted by the Engineer, provided a successful demonstration by the producer has indicated complete degradation of the repulable bags during the mixing operation and before the mix is discharged.

The Engineer may require additional testing beyond the requirements of this Section prior to the acceptance of any SCM sources.

929-1.1 Definitions.

The following definitions are applicable to the production and quality control (QC) of SCMs:

1. Approved Laboratory: A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and has corrected all deficiencies noted at the time of inspection. The laboratory must authorize the CCRL to send a copy of the final inspection report and proficiency sample results to the State Materials Office (SMO).

2. SCM Producer: Indicates an SCM supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. Test Report: A certification from the SCM Producer showing that the SCM meets the requirements of this Section. The test report must include, at a minimum, the following information:

- a. The Type of SCM.
- b. The production period.
- c. Chemical and physical analysis of the SCM.
- d. The silo numbers where the SCM is stored.
- e. The specific gravity of the SCM reported as an average of the last twelve monthly tests, updated every six months.
- f. The approved laboratory that performed all tests.

4. Purchaser: The term “purchaser” in the ASTM requirements shall be taken as the Department.

929-2 Quality Control Program.

929-2.1 General: Develop a Producer QC Program as specified in Section 105.

SCM Producers shall submit a proposed QC Plan to the SMO for acceptance.

Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website:

<https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm>. In addition to the QC Plan, the SCM Producer must submit monthly test reports from an approved

laboratory which certifies that the SCM in current production or supply conforms to the requirements of this Section.

SCM Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with the Specification will not be reason for rejection of the material if the SCM Producer's QC Plan indicates that material will be diverted and not used for Department projects.

929-2.2 Sampling and Testing: Representatives from the Department may take verification samples at the SCM Producer's plant, terminal, distribution facility, or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample sizes shall be a minimum of one gallon by volume. ~~At the concrete production facility, cementitious samples shall be jointly obtained by the Department inspector and the concrete producer's representative.~~

Upon request of the Department, the SCM Producer shall provide split samples of the ~~cementitious material~~ SCM collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of the SCM.

Notification of failing verification sample test results will be distributed to the SCM Producer and concrete producers (if applicable). Split samples of the initial sample may be provided to the SCM Producer and concrete producer upon request, as available.

929-3 CoalFly Ash.

929-3.1 General: Sampling and testing of coalfly ash shall follow the requirements of ASTM C311. ~~Fly-Coal~~ ash shall not include the residue resulting from the burning of municipal waste or any other refuse with coal, or the burning of industrial or municipal waste in incinerators. The Engineer may accept sources of coal ash containing bottom ash on a case-by-case basis. The SCM Producer shall report:

1. If the material is fly ash or harvested coal ash.

2. If harvested coal ash is combined with any other material.

929-3.1.12 Fly-Ash (Class F or Class C): ~~Fly-Coal~~ ash derived from the combustion of ground or powdered coal meeting the requirements of ASTM C618 Class F or Class C coal ash, and this Section. ~~shall meet the requirements of ASTM C618 Class F fly ash.~~

929-3.1.23 Harvested Fly-Coal Ash (Class F or Class C): ~~Fly-Coal~~ ash derived from the combustion of ground or powdered coal shall meet the requirements that has been stored in a landfill or surface impoundment and subsequently excavated and processed to meet the requirements of ASTM C618 Class F or Class C coalfly ash, and this Section.

929-3.24 Acceptance Testing of CoalFly Ash: Coal Ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 Class F or Class C coal ash.

Acceptance of coalfly ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F or Class C, and this Section. When the loss on ignition exceeds 65.0%, the Supplementary Optional Physical Requirements shall be mandatory. ~~Fly ash meeting the requirements of ASTM C618 Class F may be used with no further testing.~~

~~Petroleum coke, bark ash, or~~ Class C coalfly ash may be used if the concrete test results provide an improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements, when compared to concrete containing Class F fly ash.

929-3.24.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using an approved Class F ~~coal fly~~ ash and three comparison batches with ~~petroleum coke, bark ash, or~~ Class C ~~coal fly~~ ash, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Follow the below criteria for each mix:-

1. Use a ~~previously approved FDOT~~ Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:-

1. Type II or Type II-L cement.

2. Size No. 57 ~~c~~Coarse ~~a~~Aggregate ~~from an approved FDOT source.~~

3. Control batches: Replace 18 to 22% of the cement with Class F ~~coal fly~~ ash-replacement.

4. Comparison batches: Replace a portion of cement with a quantity of ~~petroleum coke, bark ash, or~~ Class C ~~coal fly~~ ash sufficient to produce properties comparable to those of the control batches.

5. Water/cementitious materials ratio of 0.41.

Water/cementitious materials ratio of 0.41.

The following testing shall be performed on each concrete mix, as appropriate.

Test Description	Standard Test Method	Test Age
Surface Resistivity	AASHTO T 358	28, 56, 91, and 180 days
Compressive Strength	ASTM C39	28, 56, 91, and 180 days
Chloride Diffusion	ASTM C1556 or NT Build 443	6 and months , 12 months ⁽¹⁾
Length Change	ASTM C157	28 days Per ASTM C157 ^(1,2)
<u>Sulfate Resistance ⁽²⁾</u>	<u>ASTM C1012</u>	<u>6, 12, and 18 months</u>
<p>(1) Upon completion of all 28-day and 6-month testing, the SCM producer may present the data to the SMO for acceptance. The 12-month data shall be provided to the SMO upon completion.</p> <p>(1,2) Follow both the Water and the Air Storage procedures.</p> <p><u>(2) Prepare a mortar mix using a fixed water/cementitious materials ratio of 0.485.</u></p>		

Sulfate Resistance testing shall be performed on a mortar mix in accordance with ASTM C1012 and results reported after 6 and 12 months of testing. Upon completion of the 6-month concrete and mortar testing, the SCM Producer may present the data to the SMO for acceptance. The 12 and 18-month data shall be provided to the SMO upon completion.

929-4 Slag Cement.

Slag cement (ground granulated blast furnace slag, GGBFS) is the quenched, ground by-product of the iron ore refinement process conducted in blast furnaces. It is primarily an amorphous material of calcium aluminosilicate constituents.

929-4.1 General: Slag cement and reference cement used for determination of slag activity tests shall meet the requirements of ASTM C989. Sampling and testing procedures shall follow the requirements of ASTM C989.

929-4.2 Acceptance Testing of Slag Cement: Acceptance of slag cement from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C989 and this Section. The test report shall include:

1. For slag granules, provide X-ray Fluorescence (XRF) elemental analysis of the granules, presented in oxide form. Include CaO, SiO₂, Al₂O₃, MgO, Mn₂O₃, TiO₂, Fe₂O₃, and sulfur (as sulfide).

2. For slag cement, provide XRF elemental analysis, presented in oxide form. Include CaO, SiO₂, Al₂O₃, MgO, Mn₂O₃, TiO₂, Fe₂O₃, sulfur as sulfide (S), sulfate sulfur (SO₃), and total sulfur as sulfate (SO₃).

3. The results of all testing listed under Test Methods section of ASTM C989.

4. Indicate the amount of any additions introduced during grinding of the slag granules and report compliance with Section 6 of ASTM C989.

a. Amount of limestone added and its CaCO₃ content.

b. Amount of other inorganic processing additions.

5. For calcium sulfate additions, indicate:

a. Amount of calcium sulfate added.

b. Form of calcium sulfate.

c. SO₃ content.

d. Method used to determine the amount of calcium sulfate that was added.

929-4.2.1 Assessment of Sulfate Resistance: Following guidance in ACI 233R-17 Guide to the Use of Slag Cement in Concrete and Mortar, slag cements with Al₂O₃ contents greater than 11% should be interground with calcium sulfate to avoid an undersulfated cementitious system. Provide ASTM C1012 data with a 50:50 ~~portland~~ cement-slag cement blend, using a Type II or Type II portland cement on the Department's Cementitious Materials Production Facility Listing, with an alkali content of no more than 0.6%, when any of the following conditions occur:

1. The Al₂O₃ content of the slag cement is equal to or greater than 12%.

2. The slag cement is a blend of slag granules from more than one source that are interground during production of the slag cement and for which one or more of the following are true:

a. The Al₂O₃ contents of both slag sources are equal to or greater than 12%.

b. The average Al₂O₃ content of the blend is equal to or greater than 12%.

c. One of the slag sources has an Al₂O₃ content that is equal to or greater than 14%.

The Department will consider the ASTM C1012 data acceptable when the results indicate no more than 0.10% expansion at 12 months.

The Department may grant provisional acceptance if the expansion does not exceed 0.05% at 6 months.

For any slag cements with Al_2O_3 content equal to or greater than 12%, perform a retest of ASTM C1012 if the monthly test report indicates that any of the following conditions have occurred:

1. The Al_2O_3 content increases by greater than or equal to 1.0% of the content measured during qualification of the sulfate resistance.
2. The sulfate sulfur (SO_3) content decreases by 0.25% less than that measured during qualification of the sulfate resistance.
3. The Blaine fineness increases by 50 m^2/kg greater than that measured during qualification of the sulfate resistance.

The Department may grant provisional acceptance of the slag cement source if ASTM C1012 data is required for any of the above retesting conditions.

929-5 Calcined Clay.

929-5.1 General: Sampling and testing of calcined clay shall follow the requirements of ASTM C311. Calcined clay shall meet the requirements of ASTM C618 Class N.

929-5.2 Acceptance Testing of Calcined Clay: Acceptance of calcined clay from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Calcined clay may be used in concrete if the test results provide an improvement or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing ASTM C618 Class F coal fly ash concrete.

929-5.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using an approved Class F coal fly ash and three comparison batches with the calcined clay, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Follow the below criteria for each mix:-

1. Use a previously approved FDOT Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:-

1. Type II or Type II-L cement.

2. Size No. 57 coarse aggregate from an approved FDOT source.

3. Control batches: Replace 18 to 22% of the portland cement with Class F coal fly ash.

4. Comparison batches: Replace a portion of portland cement with a quantity of calcined clay sufficient to produce properties comparable to those for of the control batches.

5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

Sulfate Resistance testing shall be performed on a mortar mix in accordance with ASTM C1012 and results reported after 6, 12, and 18 months of testing.

929-6 Ground Glass.

929-6.1 General: Sampling and testing of ground glass shall follow the requirements of ASTM C311. Ground glass shall meet the requirements of ASTM C1866. Sampling and testing procedures shall follow the requirements of ASTM C1866.

929-6.2 Acceptance Testing of Ground Glass: Acceptance of ground glass from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C1866 and this Section.

Ground glass may be used in concrete if the test results provide ~~an improved~~ improvement or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing ASTM C618 Class F coal fly ash concrete.

929-6.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using ~~an approved~~ approved Class F coal fly ash and three comparison batches with the ground glass, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Follow the below criteria for each mix:-

1. Use a ~~previously approved~~ previously approved FDOT Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:-

1. Type II or Type IL cement.

2. Size No. 57 ~~coarse~~ coarse aggregate ~~from an approved FDOT source~~.

3. Control batches: Replace 18 to 22% of the ~~portland~~ cement with Class F coal fly ash.

4. Comparison batches: Replace a portion of ~~portland~~ cement with a quantity of ground glass sufficient to produce properties comparable to those ~~for of~~ the control batches.

5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

Sulfate Resistance testing shall be performed on a mortar mix in accordance with ASTM C1012 and results reported after 6, 12, and 18 months of testing.

929-7 Natural Pozzolan.

929-7.1 General: Sampling and testing of natural pozzolans shall follow the requirements of ASTM C311. Natural pozzolans shall meet the requirements of ASTM C618 Class N.

929-7.2 Acceptance Testing of Natural Pozzolans: Acceptance of natural pozzolans from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Natural pozzolans may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-7.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the natural pozzolan, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used must be obtained from FDOT approved sources. Use a Class IV Conventional (5,500 psi) binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.

2. Size No. 57 coarse aggregate.

3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.

4. Comparison batches: Replace a portion of cement with a quantity of natural pozzolan sufficient to produce properties comparable to those ~~for~~of the control batches.

5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-~~87~~ Highly Reactive Pozzolans.

929-~~87.1~~ Silica Fume:

929-~~87.1.1~~ General: Silica Fume shall meet the requirements of ASTM C1240 using the referenced test methods and frequencies.

929-~~87.1.2~~ Acceptance Testing of Silica Fume: Acceptance of silica fume from sources operating under an accepted QC Plan shall be based on monthly test reports that the material meets the requirements of ASTM C1240 and this Section.

929-~~87.2~~ Metakaolin:

929-~~87.2.1~~ General: Metakaolin shall meet the requirements of ASTM C618 Class N ~~with and~~ the following ~~modifications~~:

1. The sum of $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ shall be at least 85%.
2. The loss on ignition shall be less than 3.0%.
3. The available alkali-s, as equivalent Na_2O , shall not exceed 1.0%.
4. The strength activity ~~i~~ndex, at 7 days, shall be at least 85%.

929-~~87.2.2~~ Acceptance Testing of Metakaolin: Acceptance of metakaolin from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N, as modified herein, and this Section.

929-~~87.3~~ Ultra-Fine Fly Ash:

929-~~87.3.1~~ General: Sampling and testing of the ultra-fine fly ash shall follow the requirements of ASTM C311. Ultra-fine fly ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 as a Class F fly ash with the following modifications:

1. The ~~pozzolanic-strength~~ activity index, at 7 days, shall be at least 85% of the control and the ~~pozzolanic-strength~~ activity index, at 28 days, shall be at least 95% of the control.
2. The amount of material retained when wet-sieved on a 45- μm sieve shall be less than 6.0%.
3. The moisture content shall be less than 1.0%.
4. The loss on ignition shall be less than 2.0%.

929-~~87.3.2~~ Acceptance Testing of Ultra-Fine Fly Ash: Acceptance of fly ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F fly ash, ~~as modified herein~~, and this Section. When the loss on ignition exceeds 2.0%, the Uniformity Requirements in the Supplementary Optional Physical Requirements shall be mandatory.

929-~~98~~ Shipping and Storage.

SCMs may be delivered in bags or in bulk. SCMs from an SCM ~~P~~roducer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a

delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

- _____ 1. FDOT Facility Identifier
- _____ 2. Type of material (e.g., Class F ~~coal~~fly ash or Grade 120 slag)
- _____ 3. Date shipped
- _____ 4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

929-109 Foreign ~~Supplementary-Cementitious-Material~~ Acceptance.

SCMs being imported from a foreign source shall conform to all requirements of this Section and will be subject the following process:

1. The proposed QC Plan shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the material at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.

2. An initial one gallon by volume sample of the imported SCM shall be sent to the SMO for chemical and physical testing.

3. When the first ship is being loaded from the foreign source, a one gallon by volume verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of ~~cement~~SCM at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.

Test reports representing each shipment shall be sent to the SMO.

SUPPLEMENTARY CEMENTITIOUS MATERIALS.
(REV 5-31-23)

SECTION 929 is deleted and the following substituted:

929-1 General.

Supplementary cementitious materials (SCMs) shall conform to the requirements of this Section. SCMs shall be used in concrete mix designs in accordance with Section 346.

Repulpable bags may be accepted by the Engineer, provided a successful demonstration by the producer has indicated complete degradation of the repulpable bags during the mixing operation and before the mix is discharged.

The Engineer may require additional testing beyond the requirements of this Section prior to the acceptance of any SCM sources.

929-1.1 Definitions.

The following definitions are applicable to the production and quality control (QC) of SCMs:

1. **Approved Laboratory:** A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and has corrected all deficiencies noted at the time of inspection. The laboratory must authorize the CCRL to send a copy of the final inspection report and proficiency sample results to the State Materials Office (SMO).

2. **SCM Producer:** Indicates an SCM supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. **Test Report:** A certification from the SCM Producer showing that the SCM meets the requirements of this Section. The test report must include, at a minimum, the following information:

- a. The type of SCM.
- b. The production period.
- c. Chemical and physical analysis of the SCM.
- d. The silo numbers where the SCM is stored.
- e. The specific gravity of the SCM reported as an average of the last twelve monthly tests, updated every six months.
- f. The approved laboratory that performed all tests.

4. **Purchaser:** The term “purchaser” in the ASTM requirements shall be taken as the Department.

929-2 Quality Control Program.

929-2.1 General: Develop a Producer QC Program as specified in Section 105.

SCM Producers shall submit a proposed QC Plan to the SMO for acceptance.

Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website:

<https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm>. In addition to the QC Plan, the SCM Producer must submit monthly test reports from an approved laboratory which certifies that the SCM in current production or supply conforms to the requirements of this Section.

SCM Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with the Specification will not be reason for rejection of the material if the SCM Producer's QC Plan indicates that material will be diverted and not used for Department projects.

929-2.2 Sampling and Testing: Representatives from the Department may take verification samples at the SCM Producer's plant, terminal, distribution facility, or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample sizes shall be a minimum of one gallon by volume.

Upon request of the Department, the SCM Producer shall provide split samples of the SCM collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of the SCM.

Notification of failing verification sample test results will be distributed to the SCM Producer and concrete producers (if applicable). Split samples of the initial sample may be provided to the SCM Producer and concrete producer upon request, as available.

929-3 Coal Ash.

929-3.1 General: Sampling and testing of coal ash shall follow the requirements of ASTM C311. Coal ash shall not include the residue resulting from the burning of municipal waste or any other refuse with coal, or the burning of industrial or municipal waste in incinerators. The Engineer may accept sources of coal ash containing bottom ash on a case-by-case basis. The SCM Producer shall report:

1. If the material is fly ash or harvested coal ash.
2. If harvested coal ash is combined with any other material.

929-3.1.1 Fly Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal meeting the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.1.2 Harvested Coal Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal that has been stored in a landfill or surface impoundment and subsequently excavated and processed to meet the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.2 Acceptance Testing of Coal Ash: Coal Ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 Class F or Class C coal ash.

Acceptance of coal ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F or Class C, and this Section. When the loss on ignition exceeds 6.0%, the Supplementary Optional Physical Requirements shall be mandatory.

Class C coal ash may be used if the concrete test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements, when compared to concrete containing Class F fly ash.

929-3.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with Class C coal ash, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.

4. Comparison batches: Replace a portion of cement with a quantity of Class C coal ash sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

The following testing shall be performed on each concrete mix, as appropriate.

Test Description	Standard Test Method	Test Age
Surface Resistivity	AASHTO T 358	28, 56, 91, and 180 days
Compressive Strength	ASTM C39	28, 56, 91, and 180 days
Chloride Diffusion	ASTM C1556 or NT Build 443	6 and 12 months
Length Change	ASTM C157	Per ASTM C157 ⁽¹⁾
Sulfate Resistance ⁽²⁾	ASTM C1012	6, 12, and 18 months
<p>(1) Follow both the Water and Air Storage procedures. (2) Prepare a mortar mix using a fixed water/cementitious materials ratio of 0.485.</p>		

Upon completion of the 6-month concrete and mortar testing, the SCM Producer may present the data to the SMO for acceptance. The 12 and 18-month data shall be provided to the SMO upon completion.

929-4 Slag Cement.

Slag cement (ground granulated blast furnace slag, GGBFS) is the quenched, ground by-product of the iron ore refinement process conducted in blast furnaces. It is primarily an amorphous material of calcium aluminosilicate constituents.

929-4.1 General: Slag cement and reference cement used for determination of slag activity tests shall meet the requirements of ASTM C989. Sampling and testing procedures shall follow the requirements of ASTM C989.

929-4.2 Acceptance Testing of Slag Cement: Acceptance of slag cement from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C989 and this Section. The test report shall include:

1. For slag granules, provide X-ray Fluorescence (XRF) elemental analysis of the granules, presented in oxide form. Include CaO, SiO₂, Al₂O₃, MgO, Mn₂O₃, TiO₂, Fe₂O₃, and sulfur (as sulfide).

2. For slag cement, provide XRF elemental analysis, presented in oxide form. Include CaO, SiO₂, Al₂O₃, MgO, Mn₂O₃, TiO₂, Fe₂O₃, sulfur as sulfide (S), sulfate sulfur (SO₃), and total sulfur as sulfate (SO₃).

3. The results of all testing listed under Test Methods section of ASTM C989.

4. Indicate the amount of any additions introduced during grinding of the slag granules and report compliance with Section 6 of ASTM C989.

- a. Amount of limestone added and its CaCO_3 content.
- b. Amount of other inorganic processing additions.

5. For calcium sulfate additions, indicate:

- a. Amount of calcium sulfate added.
- b. Form of calcium sulfate.
- c. SO_3 content.

d. Method used to determine the amount of calcium sulfate that was added.

929-4.2.1 Assessment of Sulfate Resistance: Following guidance in ACI 233R-17 Guide to the Use of Slag Cement in Concrete and Mortar, slag cements with Al_2O_3 contents greater than 11% should be interground with calcium sulfate to avoid an undersulfated cementitious system. Provide ASTM C1012 data with a 50:50 cement-slag cement blend, using a Type II or Type IL cement on the Department's Cementitious Materials Production Facility Listing, with an alkali content of no more than 0.6%, when any of the following conditions occur:

1. The Al_2O_3 content of the slag cement is equal to or greater than 12%.

2. The slag cement is a blend of slag granules from more than one source that are interground during production of the slag cement and for which one or more of the following are true:

- a. The Al_2O_3 contents of both slag sources are equal to or greater than 12%.

- b. The average Al_2O_3 content of the blend is equal to or greater than 12%.

- c. One of the slag sources has an Al_2O_3 content that is equal to or greater than 14%.

The Department will consider the ASTM C1012 data acceptable when the results indicate no more than 0.10% expansion at 12 months.

The Department may grant provisional acceptance if the expansion does not exceed 0.05% at 6 months.

For any slag cements with Al_2O_3 content equal to or greater than 12%, perform a retest of ASTM C1012 if the monthly test report indicates that any of the following conditions have occurred:

1. The Al_2O_3 content increases by greater than or equal to 1.0% of the content measured during qualification of the sulfate resistance.

2. The sulfate sulfur (SO_3) content decreases by 0.25% less than that measured during qualification of the sulfate resistance.

3. The Blaine fineness increases by 50 m^2/kg greater than that measured during qualification of the sulfate resistance.

The Department may grant provisional acceptance of the slag cement source if ASTM C1012 data is required for any of the above retesting conditions.

929-5 Calcined Clay.

929-5.1 General: Sampling and testing of calcined clay shall follow the requirements of ASTM C311. Calcined clay shall meet the requirements of ASTM C618 Class N.

929-5.2 Acceptance Testing of Calcined Clay: Acceptance of calcined clay from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Calcined clay may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-5.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the calcined clay, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of calcined clay sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-6 Ground Glass.

929-6.1 General: Sampling and testing of ground glass shall follow the requirements of ASTM C311. Ground glass shall meet the requirements of ASTM C1866. Sampling and testing procedures shall follow the requirements of ASTM C1866.

929-6.2 Acceptance Testing of Ground Glass: Acceptance of ground glass from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C1866 and this Section.

Ground glass may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-6.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the ground glass, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of ground glass sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-7 Natural Pozzolan.

929-7.1 General: Sampling and testing of natural pozzolans shall follow the requirements of ASTM C311. Natural pozzolans shall meet the requirements of ASTM C618 Class N.

929-7.2 Acceptance Testing of Natural Pozzolans: Acceptance of natural pozzolans from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Natural pozzolans may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-7.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the natural pozzolan, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used must be obtained from FDOT approved sources. Use a Class IV Conventional (5,500 psi) binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of natural pozzolan sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-8 Highly Reactive Pozzolans.

929-8.1 Silica Fume:

929-8.1.1 General: Silica Fume shall meet the requirements of ASTM C1240 using the referenced test methods and frequencies.

929-8.1.2 Acceptance Testing of Silica Fume: Acceptance of silica fume from sources operating under an accepted QC Plan shall be based on monthly test reports that the material meets the requirements of ASTM C1240 and this Section.

929-8.2 Metakaolin:

929-8.2.1 General: Metakaolin shall meet the requirements of ASTM C618 Class N and the following:

1. The sum of $\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$ shall be at least 85%.
2. The loss on ignition shall be less than 3.0%.
3. The available alkalis, as equivalent Na_2O , shall not exceed 1.0%.
4. The strength activity index, at 7 days, shall be at least 85%.

929-8.2.2 Acceptance Testing of Metakaolin: Acceptance of metakaolin from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N, as modified herein, and this Section.

929-8.3 Ultra-Fine Fly Ash:

929-8.3.1 General: Sampling and testing of the ultra-fine fly ash shall follow the requirements of ASTM C311. Ultra-fine fly ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 as a Class F fly ash with the following modifications:

1. The strength activity index, at 7 days, shall be at least 85% of the control and the strength activity index, at 28 days, shall be at least 95% of the control.
2. The amount of material retained when wet-sieved on a 45- μ m sieve shall be less than 6.0%.
3. The moisture content shall be less than 1.0%.
4. The loss on ignition shall be less than 2.0%.

929-8.3.2 Acceptance Testing of Ultra-Fine Fly Ash: Acceptance of fly ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F fly ash, as modified herein, and this Section. When the loss on ignition exceeds 2.0%, the Uniformity Requirements in the Supplementary Optional Physical Requirements shall be mandatory.

929-9 Shipping and Storage.

SCMs may be delivered in bags or in bulk. SCMs from an SCM Producer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

1. FDOT Facility Identifier
2. Type of material (e.g., Class F coal ash or Grade 120 slag)
3. Date shipped
4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

929-10 Foreign SCM Acceptance.

SCMs being imported from a foreign source shall conform to all requirements of this Section and will be subject the following process:

1. The proposed QC Plan shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the material at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.
2. An initial one gallon by volume sample of the imported SCM shall be sent to the SMO for chemical and physical testing.
3. When the first ship is being loaded from the foreign source, a one gallon by volume verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of SCM at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.

Test reports representing each shipment shall be sent to the SMO.