

ITEM SPECIAL - HAMCIN: CLSM-CDF

A PERFORMANCE SPECIFICATION

FOR

CONTROLLED LOW STRENGTH MATERIAL

CONTROLLED DENSITY FILL (CLSM-CDF)

PREPARED BY

HAMILTON COUNTY AND THE CITY OF CINCINNATI, OHIO

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1.0 DESCRIPTION

This work consists of the manufacturing and placement of non-settling (self-compacting) backfill mixtures described as a Controlled Low Strength Material-Controlled Density Fill, hereafter referenced by the acronym: CLSM-CDF. These mixtures are also sometimes referred to as LSM, flowable fill, flowable mortar, flowable CDF, etc. These trench backfill materials possess flowability for placement, support strength for traffic loads, and removability at a later date after placement. This material may be produced off-site or on-site.

The Hamilton County Engineer and the City of Cincinnati Department of Transportation and Engineering (collectively referred to herein as *the Engineer*) will maintain a list of certified Producers and their accepted mixtures. Producers will be required to maintain their mixture certification on a periodic basis as defined herein.

2.0 CERTIFICATION

Prior to manufacture of any CLSM-CDF mixture, the Producer shall comply with the following regulations requirements.

2.1 Producer Certification - Demonstrate the ability to produce a uniform CLSM-CDF mixture as outlined in this specification. The National Ready Mix Concrete Association's (NRMCA) plant and truck certification will satisfy the producer certification requirement.

2.2 Submittal - Engineering data for each mixture should be submitted using the HAMCIN *Producer Certification Form* and *Engineering Data Report Form* with pertinent laboratory test data. The submittal of a mixture should include:

2.2.1 Producer/plant/truck certification (Section 2.1)

2.2.2 Test reports for individual materials (i.e. gradation results for aggregates)

2.2.3 MSDS for all chemical components of the mixture

2.2.4 HAMCIN *Engineering Data Report Form*

2.2.5 Copies of all appropriate test reports for values reported on the form

Note: All tests must have been performed within 1 year of submittal. All tests are to be performed by laboratories approved by Hamilton County and/or the City of Cincinnati. The approved labs are those who have active contracts with the City of Cincinnati DOTE and/or Hamilton County Engineer for providing Geotechnical Engineering/Material Testing services.

The Engineer will review the submitted material and determine acceptance of the mixture based upon the qualifications of the Producer and the consistency of the mix with the material and performance (Section 3.0 and 4.0) requirements of this specification.

The Engineer will maintain a listing of acceptable CLSM-CDF mixtures. Preliminary acceptance can be granted based upon 90-day strength data with the requirement that 12 month strength data be provided for final acceptance. Failure to provide 12-month data will result in removal of the mixture from the list of acceptable products.

Acceptance of a mixture is valid until the beginning of the next acceptance cycle. A new acceptance cycle will begin on January 1 of years divisible by 5 (i.e. 2015, 2020, etc.). In order to

remain on the list in the new acceptance cycle, all Producers must resubmit prior to January 1 of the new cycle year. Any submittals with testing dates approved within one year of the end of an acceptance cycle will automatically be rolled over into the new cycle.

If component materials, proportions or their sources change, the mixture must be resubmitted.

3.0 MATERIALS

3.1 Materials for CLSM-CDF mixtures will be the responsibility of the Producer. All mixture components must be environmentally acceptable. A Material Safety Data Sheet (MSDS) for each component in the mixture must be available upon request.

3.2 Furnish materials conforming to:

3.2.1 Water used for the mixture shall be free from oil, salts, acid, strong alkalis, vegetable matter, and other impurities that would have an adverse effect on the quality of the backfill material.

3.2.2 Aggregates – Natural, manufactured, recycled or synthetic aggregates may be used. Use of manufactured or synthetic aggregates is subject to acceptance by the Engineer.

3.2.3 Portland cement – *ODOT2013 CMS 701.01, 701.02, 701.03, 701.04, 701.05 and 701.09*. Blended cement or other products are subject to acceptance by the Engineer.

3.2.4 Ground Granulated Blast Furnace Slag (GGBFS) – *ODOT 2013 CMS 701.11*

3.2.5 Fly Ash - *ODOT 2013 CMS 701.13*

Note – Other materials may be used, pending acceptance of the Engineer.

4.0 PERFORMANCE REQUIREMENTS

The proportioning of CLSM-CDF mixtures is the responsibility of the Producer. The mixture will be rejected for failure to meet, or sustain, the mixture's consistency for the following properties:

4.1 All Mixes

4.1.1 Compressive Strength – 20 psi < c' < 150 psi, ASTM D4832

4.1.2 Removability Modulus (RE) – less than 1.0

The RE is defined as:
$$RE = \frac{w^{1.5} \times 104 \times c'^{0.5}}{10^6}$$

Where:

w = dry unit weight (pcf) (ASTM D6023)

c' = unconfined compressive strength (psi)

90-day strength data used for preliminary acceptance

12-month strength used for final acceptance

Sampling per ASTM D5971, cylinder preparation and testing per ASTM D4832. The use of the 12-month strength criteria is due to the delayed strength gain of mixtures high in fly ash content.

The following table is provided for quick reference:

		REMOVABILITY MODULUS (RE)					
		Unconfined Compressive Strength (psi)					
Dry Unit Weight (psf)		25	50	75	100	125	150
	50	0.18	0.26	0.32	0.37	0.41	0.45
	60	0.24	0.34	0.42	0.48	0.54	0.59
	70	0.30	0.43	0.53	0.61	0.68	0.75
	80	0.37	0.53	0.64	0.74	0.83	0.91
	90	0.44	0.63	0.77	0.89	0.99	1.09
	100	0.52	0.74	0.90	1.04	1.16	1.27
	110	0.60	0.85	1.04	1.20	1.34	1.47
	120	0.68	0.97	1.18	1.37	1.53	1.67
	130	0.77	1.09	1.33	1.54	1.72	1.89
	140	0.86	1.22	1.49	1.72	1.93	2.11
	150	0.96	1.35	1.65	1.91	2.14	2.34

4.1.3 Flowability – Minimum 8" spread, ASTM D6103-04. Because the ASTM standard is no longer updated, it is summarized here.

The flow test consists of placing a 3" (dia.) x 6" (high) open-ended cylinder on a smooth, non-porous, level surface. The cylinder is filled without vibration or tamping, then struck off at the top. The cylinder is removed by pulling straight up in a 2 to 4 second time period. Flowability is reported as the average of the diameter of the patty measured along its' largest axis and the axis perpendicular to the largest axis.

NOTE – Engineer will accept mixtures with minimum flowability of 4 inches as "Low-Flow Mixtures", provided the mixture is fully tested and meets other criteria. This mix may be utilized in trenches where the surface/pavement slope exceeds 5H:1V.

4.2 Any mix placed in a trench where a **gas** main is being backfilled or has been exposed must also meet the following standard, which is intended to allow for detection of gas leaks:

4.2.1 Permeability – $k \geq 1 \times 10^{-5}$ (cm/sec), ASTM D2434

4.3 Any mix to be used for **Greater Cincinnati Water Works** (GCWW) projects or in any excavations where water mains are exposed, must also meet the following standards for corrosion protection:

4.3.1 Ten Point Soil Evaluation Test for Corrosion Potential - < 10 points

A. *Objective:*

To evaluate the properties of a flowable fill product as to its ability to promote a corrosive environment when utilized as a backfill material in water main trench line construction. The test is based upon The 10-point soil evaluation procedure instituted by Ductile Iron Pipe Research Association and is included in the Appendix to the ANSI/AWWA C105/A21.5 standard. The information drawn from the five tests and observations are: Soil resistivity, pH, Oxidation-reduction (redox) potential, Sulfides, and Moisture ("fair" moisture – 1 point, to be used). The GCWW maximum acceptable point rating is 9 points when the flowable fill is evaluated against the Ten Point Soil Evaluation Test.

B. *Applicable References:*

- i. ANSI/AWWA C105/A21.5 Appendix A – "Polyethylene Encasement for Ductile-Iron Pipe Systems"
- ii. ASTM G187 – "Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method"
- iii. ASTM G200 – "Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil"
- iv. ASTM G51 – "Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing"

C. *Procedure for Laboratory Resistivity Value of Flowable Fill:*

i. *Objective:*

To determine the resistivity value of flowable fill samples, either obtained from in-situ field samples or from laboratory fabricated compression test samples. This test is required as part of the Ten Point evaluation. In addition, the GCWW minimum acceptable electrical resistivity of a flowable fill product is 2,500 ohm-cm when tested after a 24-hour saturation and at a minimum moisture content of 13%.

ii. *Equipment:*

- a) Resistivity Meter. Follow the instructions for use and make the connections appropriate for the type of soil box used.
- b) Soil Box. Use a soil box designed for the measurement of soil resistivity.
- c) Miscellaneous equipment for moisture content, mixing and temperature determination.
- d) Wiring, 18 to 22-gauge insulated stranded copper wire for connections from the meter to the soil box.

iii. *Procedure:*

- a) For non in-situ samples, batch raw materials per the approved mixture number and design criteria and make test samples.
- b) Break down a sufficient amount of selected to a natural grain size and place in a container.
- c) Add distilled water sufficiently to produce a slight amount of surface water
- d) Mix the material and allow to saturate for 24 hours.

- e) After 24 hours, remix the material, then place the material in lifts in the soil box. Compact each lift. If surplus water accumulates on the surface of the compacted lift, introduce this back into the sample and remix prior to placing and compacting the following lift.
- f) Connect the resistivity meter to the soil box as instructed by the Manufacturer, then take and record resistivity reading.
- g) Obtain and record the temperature of the tested sample. If the temperature exceeds 21° C (70° F), correct the resistivity to 15.5° C (60° F) by the following formula:

$$R_{15.5} = R_T \frac{24.5 + T}{40}$$

Where:

T = soil temperature in °C

R_T = resistivity at T

- h) Remove the sample from the soil box and determine oven dried moisture content and unit weight (pcf). If moisture content is less than 13%, the results are unacceptable and the mixture should be reconditioned and the resistivity testing should be repeated.

5.0 PLACING

- 5.1 General** – Provide only a product from the current list of approved mixtures. The CLSM-CDF mixture shall be placed directly into the trench or excavation. The material's flow characteristic will be such that no labor will be required in the trench or excavation. Do not use vibration or compaction equipment.

The basic construction requirement for the use of CLSM-CDF is that the trench or excavation has vertical wall limits. Vertical wall limits mean that the flowable CLSM-CDF mixture must be confined in a given area. Bulkheads can be used for long trenches requiring large amount of CLSM-CDF material.

Bring the CLSM-CDF material up uniformly to the lines or limits shown on the plans or as directed by the Engineer. The following rules govern:

- 5.1.1** Do not place mixtures on frozen ground.
- 5.1.2** Protect the placed mixtures from freezing.
- 5.1.3** If the trench or excavation contains water, use the CLSM-CDF mixture to displace the water to the limit that the water does not appear to dilute the mixture and cause segregation.
- 5.1.4** Place the mixture as continuously as possible.

- 5.2 Setting / Opening** – Do not place fill or paving materials over the CLSM-CDF until initial set has been achieved. The Contractor and Producer are responsible for providing the appropriate product from the list of acceptable mixtures which will achieve initial set within the desired construction time-frame.

- 5.2.1** Initial set has occurred when the in-place material has initiated and terminated bleeding of excess water and when the surface can support foot traffic without deformation.

5.2.2 If it is not clear that initial set has completed per the above criteria, the Engineer may require that the Contractor complete the Ball Drop (Kelly Ball) Test per ASTM D6024. This test is passed and the material may be loaded when both of the following conditions are met:

- A. *the indentation from 5 drops of the ball measures no more than 3 inches*
- B. *there is no additional surface water or sheen resulting from the action of dropping the ball.*

Note that setting time of CLSM-CDF may be affected by temperature. At temperatures near freezing, or below, additional time may be needed for proper setting of the material prior to any type of paving operation.

6.0 ACCEPTANCE OF MATERIAL AND FIELD TESTING

The Engineer may employ a third-party testing agency to provide sampling and testing of the CLSM-CDF.

Sampling is per ASTM D5971.

Tests may consist of:

- 6.1** Unit weight, yield, cement content and air content - ASTM D6023
- 6.2** Flowability - ASTM D6103
- 6.3** Compressive strength - ASTM D4832, using either 6" x 12" or 4" x 8" cylinders. Six (6) cylinders shall be made. Three (3) cylinders shall be broken at 30 and 90 days.

The Contractor is responsible for the curing and protection of the cylinders until such time that they are ready to be picked up by the testing laboratory. The Contractor is to coordinate this activity. The cylinders will be held by a testing laboratory until the required breaking date.

All tests are to be performed by laboratories approved by Hamilton County and/or the City of Cincinnati. Submit copies of all test reports to the material Producer and Governing Agency. All CLSM-CDF tests are to be performed by qualified testing personnel. The minimum acceptable requirement is ACI Level I, Concrete Technician.

If the produced CLSM-CDF material fails to meet the performance criteria established in Section 4.0 of this specification, the material will be rejected with the possibility of removal.

7.0 METHOD OF MEASUREMENT

Measurement for payments (if paid separately) will be based on (cubic yards) computed using plan quantities. No additional compensation will be allowed for over-excavation. The material Producer and the Contractor should be aware that there is a difference between the plastic (wet) state and the material's hardened state. The plastic (wet) state will be greater than the hardened state.