



NATIONAL CLAY PIPE INSTITUTE

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National Clay Pipe Institute

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GUIDELINES FOR CONTROLLED LOW STRENGTH MATERIAL (CLSM) MIX DESIGN, PLACEMENT AND TESTING FOR USE AS A BEDDING MATERIAL FOR VITRIFIED CLAY PIPE

General

Controlled Low Strength Material (CLSM) is used as a bedding material for Vitrified Clay Pipe to meet the requirements of ASTM C12 *Standard Practice for Installing Vitrified Clay Pipe*, Section 6, Bedding and Encasement, and the National Clay Pipe [Engineering Manual](#) (2017), Chapter 4, *Structural Analysis of Rigid Conduits, Underground*.

The CLSM mix shall consist of Portland cement, fine aggregate, coarse aggregate, water and chemical admixtures to accelerate cure time and entrain air.

The actual mix design shall be determined by the producer of the CLSM within these guidelines and be approved by the Engineer.

These Guidelines are for CLSM when it is desirable for a mix to cure rapidly to facilitate initial backfilling at the earliest possible time.

Portland cement

Portland cement shall meet the requirements of ASTM C150 *Standard Specification for Portland Cement*, Type I, II, V or a combination thereof.

Fine aggregate

Fine aggregate shall meet the requirements of ASTM C33 *Standard Specification for Concrete Aggregates* and be 75% - 80% of total aggregate by weight.

Coarse aggregate

Coarse aggregate shall meet the requirements of ASTM C33 *Standard Specification for Concrete Aggregates*, be 3/8 inch in size and 25% - 20% of total aggregate by weight.

It is preferable to use rounded coarse aggregate versus crushed where available.

Water

Water shall be potable, and the amount added shall be adjusted for moisture content of the aggregates.

Accelerator

Chemical admixtures for the use in accelerating the CLSM cure time shall be 4% of the cement content. Calcium Chloride (CaCl) shall not be used because of its corrosive nature and the availability of admixtures specifically designed for the purpose.

Accelerating admixtures shall meet the requirements of ASTM C494 *Standard Specifications for Chemical Admixtures*.

Air Entrainment

Chemical admixtures shall be specifically designed for air entrainment and meet the requirements of ASTM C226 *Standard Specifications for Air-Entrained Additions for Use in the Manufacture of Air Entrained Hydraulic Cement*.

The mix shall have 15 – 20% air entrainment including entrapped air.

Fly ash

Fly ash is not necessary for this mix design. The mix contains entrained air that provides adequate flowability.

The addition of fly ash will retard the cure rate/ set time and will change the ultimate compressive strength.

Flowability

Flowability measurement shall be an 8 – 12 inch spread diameter using a three (3) inch diameter by six (6) inch long cylinder and shall meet the requirements of ASTM D6103 *Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)*. **A standard concrete slump cone should not be used to measure the flowability of a CLSM mix.**

Compressive strength

The 28-day compressive strength of the CLSM shall be 100 – 200 psi per ASTM C39 *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*.

Set Time prior to backfill

The ball drop method is the most appropriate method for determination of when backfill load can be introduced and applied. Prior to backfilling, the measured diameter of the indentation left by the ball shall be 3 inches or less as determined by Test Method ASTM D6024/D6024M *Standard Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application*.

Mixing

The supplier shall determine the unit weights based upon the specific gravity of the fine and coarse aggregates. The ratio shall be 75% - 80% fine aggregate to 25% - 20% coarse aggregate by weight.

Admixtures shall be added per the suppliers' recommendations.

Water shall be added as specified and yield a flowability as above.

The minimum mix time required shall be specified by the supplier. Maximum mix time shall not exceed 2 ½ hours.

Field Testing

Tests shall be performed to determine the flowability and set time for backfill load.

Placement

Refer to ASTM C12 *Standard Practice for Installing Vitrified Clay Pipe Lines* for bedding detail.

CLSM must be thoroughly mixed in the delivery truck immediately before discharge and carefully placed by tremie, chute, conveyer, bucket or pump and placed on top of the pipe and alternating equally on both sides of the pipe in a manner so as not to move the pipe from the installed position. CLSM should not be free fall placed from a height greater than seven (7) feet or impact against the trench walls.

CLSM may be placed in one lift.

CLSM must be placed continuous to the trench sidewalls. In extreme conditions where this is not possible, contact the project engineer and NCPI for alternative placement options.

Vibratory equipment must not be used.

Backfill

Initial backfill **shall only commence after** a Ball Drop test is conducted and the measured diameter of the indentation left by the ball is 3 inches or less as determined by Test Method D6024/D6024M.

CLSM MIX DESIGN (Per 27 cu. ft. of mix)

| | |
|--------------------------|--|
| Cement: | 188 pounds (Type I/II or II/V) |
| Fine aggregate: | 75% - 80% (by weight) |
| Coarse aggregate (3/8"): | 25% - 20% (by weight) |
| Water: | water necessary to obtain slump (see slump) |
| Accelerator: | 4% (as a percent of cement) |
| Air Entrainment: | 15%-20% |
| Flowability: | 8 – 12 inch spread diameter (3-inch diameter by 6-inch-long cylinder, ASTM D6103) |
| Compressive strength: | 100 – 200 psi at 28 days |

EXAMPLE MIX (Per 27 cu. ft. of mix)

| | |
|--------------------------|--|
| Cement: | 188 pounds (Type I/II or II/V) |
| Fine aggregate: | 2,028 pounds (Sp. Gr. 2.58) |
| Coarse aggregate (3/8"): | 507 pounds (Sp. Gr. 2.61) |
| Water: | 375 pounds (total water) |
| Accelerator: | 4 % (as a percent of cement) |
| Air Entrainment: | 18% total air including entrapped air. |
| Flowability: | 8 – 12 inch spread diameter (3-inch diameter by 6-inch-long cylinder, ASTM D6103) |
| Compressive strength: | 100 – 200 psi at 28 days |

Appendix

The information provided in this document is derived from the methodology prescribed in the Standard Specifications for Public Works Construction, Greenbook, and laboratory and field studies conducted by the National Clay Pipe Institute, Elkhorn, Wisconsin and Mission Clay Products, Corona, California.

Results obtained from the use of this CLSM mix is the responsibility of the owner and the design engineer.

Installation of CLSM in trenches containing ground water, unstable soils or where a trench shield is located in the pipe zone, requires special consideration for placement.

Referenced ASTM:

- *ASTM C12 Standard Practice for Installing Vitrified Clay Pipe Lines*
- *ASTM C33 Standard Specification for Concrete Aggregates*
- *ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*
- *ASTM C150 Standard Specification for Portland Cement*
- *ASTM C226 Standard Specifications for Air-Entrained Additions for Use in the Manufacture of Air Entrained Hydraulic Cement*
- *ASTM C494 Standard Specifications for Chemical Admixtures*
- *ASTM C618 Standard Specification for Coal Flyash and Raw or Calcined Natural Pozzolan for Use in Concrete*
- *ASTM C684 Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens*
- *ASTM D6024/D6024M Standard Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application.*
- *ASTM D6103 Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)*