# 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 (2006), Chapter 4, Part II, Structural Design.

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 C 150 - *Standard Specification for Portland Cement*, Type I, II, V or a combination thereof.

## Fine aggregate

Fine aggregate shall meet the requirements of ASTM C 33 - *Standard Specification for Concrete Aggregates* and be 75% - 80% of total aggregate by weight.

## Coarse aggregate

Coarse aggregate shall meet the requirements of ASTM C 33 - *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. 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 C 494 - *Standard Specifications for Chemical Admixtures*.

**Air Entrainment**

Chemical admixtures shall be specifically designed for air entrainment and meet the requirements of ASTM C 226 - *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 and will change the ultimate compressive strength.**

**Flowability**

Flowability measurement shall be an 8 inch +/- 1 inch spread diameter using a three (3) inch diameter by six (6) inch long cylinder and shall meet the requirements of ASTM D 6103 – *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 100psi to 300psi per ASTM C 39 - *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.*

**Penetrometer**

A penetrometer shall be used to determine the set time for the placed CLSM and meet the requirements of ASTM C 403 - *Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.*

The penetrometer must have a maximum load reading of 700psi and have a one (1) square inch by one (1) inch long cylinder foot attached to a ¼ inch diameter pin. (See ASTM C 403 noted above for configuration.  Also see the attached photo.)

The penetrometer shall be inserted into the CLSM to a depth of one (1) inch and the readings recorded.

The load readings on the penetrometer are penetration resistance and not the compressive strength of the CLSM as measured by the standard concrete cylinder test.

**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.

Penetrometer readings shall be made.

**Placement**
Refer to ASTM C 12 - *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** the following requirements are met:

Penetrometer (as defined herein) readings shall be taken in the CLSM alongside the pipe.

If it is not practical to use the penetrometer in the trench, CLSM may be collected in a cardboard box of approximately 12wx12wx9h inches for each 30 minute interval of pour and penetrometer measurements made from this accessible location.

A **500 psi minimum** penetrometer reading is required.


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


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|---|---|
| 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 inch +/- 1 inch spread diameter<br>(3 inch diameter by 6 inch long cylinder, ASTM D 6103) |
| Compressive strength: | 100-300 psi at 28 days |

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


Cement:                          188 pounds (Type I/II or II/V)

Fine aggregate:                  2028 pounds (Sp. Gr. 2.58)

Course 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 inch +/- 1 inch spread diameter
                                 (3 inch diameter by 6 inch long cylinder, ASTM D 6103)

Compressive strength:            100-300 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 C 12 *Standard Practice for Installing Vitrified Clay Pipe Lines*
- ASTM C 33 *Standard Specification for Concrete Aggregates*
- ASTM C 39 *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens*
- ASTM C 150 *Standard Specification for Portland Cement*
- ASTM C 226 *Standard Specifications for Air-Entrained Additions for Use in the Manufacture of Air Entrained Hydraulic Cement*
- ASTM C 403 *Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance*
- ASTM C 494 *Standard Specifications for Chemical Admixtures*
- ASTM C 618 *Standard Specification for Coal Flyash and Raw or Calcined Natural Pozzolan for Use in Concrete*
- ASTM C 684 *Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens*
- ASTM D 6103 *Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)*