American Concrete Institute®
Advancing concrete knowledge

CLSM from Practice to Theory

ACI Fall 2011 Convention
October 16 – 20, Cincinnati, OH

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ACI Web Sessions

The audio for this web session will begin momentarily and will play in its entirety along with the slides.

However, if you wish to skip to the next speaker, use the scroll bar at left to locate the speaker's first slide (indicated by the icon in the bottom right corner of slides 9 and 51). Click on the thumbnail for the slide to begin the audio for that portion of the presentation.

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ACI is bringing you this Web Session in keeping with its motto of "Advancing Concrete Knowledge." The ideas expressed, however, are those of the speakers and do not necessarily reflect the views of ACI or its committees.

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ACI Web Sessions are recorded at ACI conventions and other concrete industry events. At regular intervals, a new set of presentations can be viewed on ACI's website free of charge.

After one week, the presentations will be temporarily archived on the ACI website or made part of ACI's Online CEU Program, depending on their content.

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ACI offers an easy-to-use Online CEU Program for anyone who needs to earn Continuing Education credits.

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Visit **www.concrete.org/education/edu_online_CEU.htm** for more information.

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ACI Conventions

ACI conventions provide a forum for networking, learning the latest in concrete technology and practices, renewing old friendships, and making new ones. At each of ACI's two annual conventions, technical and educational committees meet to develop the standards, reports, and other documents necessary to keep abreast of the ever-changing world of concrete technology.

With over 1,300 delegates attending each convention, there is ample opportunity to meet and talk individually with some of the most prominent persons in the field of concrete technology. For more information about ACI conventions, visit www.aciconvention.org.

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This ACI Web Session includes 2 speakers presenting at the ACI fall convention held in Cincinnati, OH, October 16 – 20, 2011.

Additional presentations will be made available in future ACI Web Sessions.

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Nausherwan Hasan, Consulting Engineer, URS Corporation, New York, NY.

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ACI 229 Committee Presentation
October 19, 2011

USE OF CLSM AS BEDDING FOR LARGE SIZED STEEL PENSTOCK

Nash Hasan, P.E.
URS–Energy and Construction
New York, New York
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DESIGN PARAMETERS

- Penstock Pipe Diameter: 25 feet +/-
- Trench Dimensions
  - Base Width: 29 feet +/-
  - Side Slope (rock): 10V:1H
  - Trench Height: 44 feet
- Pipe Slope: 2 H : to 1 V
- Design E' (compacted sand): 3000 lb/in^2

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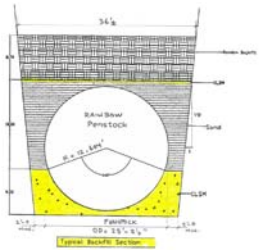
As-Built Cross-Section



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2006 USBR E' Values**

Based on >95% Proctor Density (D698), or >70% Relative Density (D4253) and Pipe Deflection 0.5% max.

- Clays and Silts — 1500* lb/in^2
- (< 30% sand and gravel)
- Sand and Gravel — 2500* lb/in^2
- (13% or more fines)
- Sand and Gravels — 4000* lb/in^2
- (12% or less fines)
- Crushed Rock (compacted) — 6000 lb/in^2

**Refer to Amster Howard's paper, "Composite E' (modulus of Soil Reaction)", ASCE 2009 Pipeline Conference, page 968, Atlanta, GA.

WR Grace CLSM E' Values*

- CLSM (Mix 1) — 3000** lb/in^2
- CLSM (Mix 2) — 3000** lb/in^2
- Darafill CLSM Mixes (lb/yard^3 unless noted)

»	Cement	Fly ash	Sand	Water	Darafill
Mix 1	100	0	2330	328	3 oz
Mix 2	50	250	2193	229	3 oz

- *Refer to WR Grace Darafill CLSM Engineering Bulletin. The air content for Mix 1and Mix 2 varied 25.6% and 29.5% , respectively.
- **Based on the 28-day age of CLSM. The estimated 7-day E' value is 2000 lb/in^2..

WR Grace Darafill CLSM E' Values

Table 12
Modulus of Soil Reaction Values (E')

Cement kg/m³ (lb/yd³)	Flyash kg/m³ (lb/yd³)	Water kg/m³ (lb/yd³)	Sand kg/m³ (lb/yd³)	DaraFill L/m³ (oz/yd³)	Flow mm (in.)	Unit Wt kg/m³ (lb/yd³)	Air (%)	DaraFill CLSM AGE 16 Hour E' - kPa (psi)	7 Day E' - kPa (psi)	28 Day E' - kPa (psi)
DaraFill CLSM 59 kg/m³ (100 lbs/yd³) cement,										
59 (100)	0 (0)	195 (328)	1383 (2330)	0.12 (3)	190 (7.5)	1636 (102)	25.6	7000 (1000)	14000 (2000)	21000 (3000)
DaraFill CLSM 30 kg/m³ (50 lbs/yd³) cement, 148 kg/m³ (250 lbs/yd³) flyash										
30 (50)	148 (250)	136 (229)	1362 (2193)	0.12 (3)	190 (7.5)	1586 (99)	29.5	7000 (1000)	14000 (2000)	21000 (3000)

Soil Category	Compaction Level 85% E' - kPa (psi)	90% E' - kPa (psi)	95% E' - kPa (psi)
Crushed Stone	7000 (1000)	21000 (3000)	21000 (3000)
Coarse grained with little or no fines	1400 (200)	14000 (2000)	21000 (3000)
Coarse grained with fines or fine grained with low plasticity and greater than 25% coarse particles	700 (100)	7000 (1000)	14000 (2000)
Fine grained soils with low plasticity and less than 25% coarse particles	350 (50)	2800 (400)	7000 (1000)

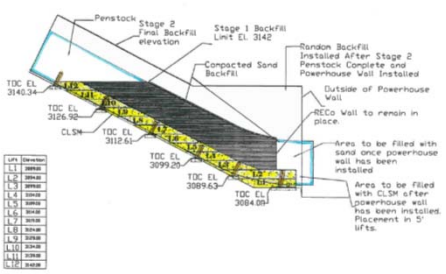
CLSM Benefits

Higher rate of placement
Ideal for Inaccessible areas
Minimal QC
No settlement after hardening

Disadv:

Higher Cost-
CLSM : $85.75/cy
Compacted Backfill: $37.50/cy

Penstock Profile- Stage 1



Excavation Protection

Chain Link Fence

Mixing And Placing

- Centrally Mixed
- Batch Tickets
- Slump Control
- Lift Height
- Time Interval-Lifts

CLSM Mix Proportions

- Cement (Type V): 200 lb/cy
- Fly Ash (type F): 200 lb/cy
- Sand (C33) : 2700 cy
- Water: 520 lb/cy
- HRWRA(C494) : 10-20 oz/cy
- Slump: 6-8 inches
- Comp Strength: 500 psi (28 days)

Thrust Saddles Installation

El 3090 and EL 3099

5/12/10

Section 3224-3A positioning

5/27/10

Fig 2: Selway removing rigging from penstock phase I section 3224-3A after positioning and setting on saddle at Elevation 3112

Section 3225-6A

06/01/10

Penstock Stage I Installation

WEEKLY PROGRESS REPORT

Reporting period 06/07/10 to 06/13/10

Penstock Welding In Progress

Figure 4: Selway working in penstock phase I pipe, all three manlifts in place and beginning preparation of longitudinal seam between sections 3225-1A and 3225-2A

Pumping CLSM

Placing CLSM Under Penstock

(90 cy) 8/05/10

Sand Backfill Top of Penstock

Positioning Manlifts in Penstock

Excavation Equipment CAT 335 and 336

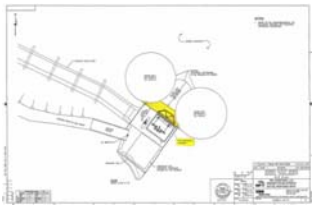
CLSM Placement

COMPACTED SAND BACKFILL

CLSM AS Underwater Backfill

- Design Mix
- Anti-Washout Admixture (AWA)
- 20% Air Entrainment
- Accelerating Admixture

Site Plan



Pump Set Up

CLSM –Truck Discharge

Tremie Pipe

CLSM Washout

After Dewatering

CLSM Mix Proportions

- Cement: 380 lbs
- Sand: 2650 lbs
- Water: 240 lbs
- Slump: 11 inches
- Unit Wt: 108 pcf
- Washout: 13% max
- Strength: 200 psi (7 day)

CLSM Placement Data

- Tremie Pipe: 6-inches
- Water Depth: 26-67 feet
- Lift Height: 3 feet max
- Time Interval: 24 hours
- CLSM Temp: 46-51F
- Air Temp: 33- 50F

Placement Summary

- Volume: 983 cubic yards
- Duration: 15 days
- Material Cost: Approx. $200 per cubic yard
- Advantages
- Eliminated dewatering cost and leakage
- Allowed future excavation and removal

CLSM As Backfill

- 100-200 psi Compressive Strength at 28 Days
- As soil structural fill/backfill
- As base course beneath floor slabs within QA Level 3 and Level 1 structures

CLSM Materials

- Cement Type II/ V Low Alkali.
- Wallach Crusher Fines 95% passing 3/8 inch and more than 30% passing the 200 sieve.
- Air Entraining Admixture
- Potable Water

CLSM Mix Design
per cubic yard

- Cement: 188- 235 lb
- Wallach Fines: 2230 lb
- Water: 541-584 lbs
- Daravair 1000: 5 oz.
- Flow (D6103): 5 inches minimum
- Unit weight(D6023): 110 lb/cft
- Strength (D4832): 200 psi at 28 days

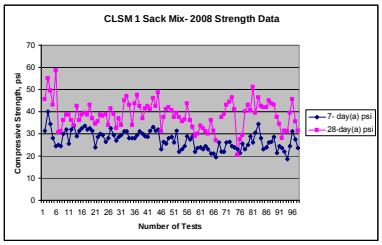
CLSM Production

- Central Plant Batching
- Truck Mixing: 100-150 mixing revolutions
- Tests
  - Flow, and Unit Weight
  - Strength Test Cylinders
    - Presplit and Taped 6x12 Cylinders
    - Molded and Heaped without Rodding/Tapping

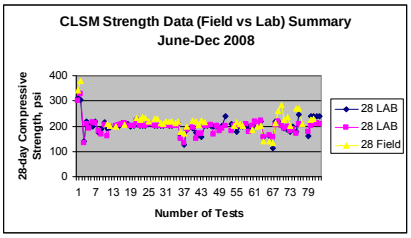
CLSM Mixture Proportions

	CLSM-1	CLSM-2
Cement	94 lbs	188-235 lbs
Fine agg	2230-2400 lb	2400 lbs
Water	563 lbs	625 lbs
AEA	3 oz.	5 oz.

CLSM-1 Strength Data



CLSM-2 Strength Data



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Conclusions

- CLSM - versatile backfill material
- Ideal for accelerating construction
- Establish Design Parameters
- Trial Mixes
- Minimize cost –use local materials

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Brian Green is a Research Geologist, USAE Engineer Research and Development Center, Vicksburg, MS. He is an ACI Fellow and member of ACI Committees 229, Controlled Low-Strength Materials; 236, Material Science of Concrete; 239, Ultra-High Performance Concrete; 552, Cementitious Grouting; and 630, Construction Inspector Certification.

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Development of a Controlled Low Strength Material to Simulate Saturated Soil Conditions or "Mud"

ACI Fall Convention, 19 October 2011
Duke Energy Center, Cincinnati, OH

Brian H. Green, R.P.G., FACI
Concrete and Materials Branch
Bradley Foust
Structural Mechanics Branch
Geotechnical & Structures Laboratory
Engineer Research and Development Center
U.S. Army Corps of Engineers

US Army Corps of Engineers
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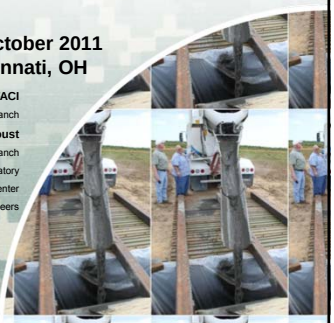

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Controlled Low-Strength Materials CLSM

- Self-compacting, cementitious material used as backfill in lieu of compacted fill
- Less Than 1,200 psi ultimate strength
- Flowable

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Needed for Project

- Material properties needed at "Test Date":
  - ►Wet or saturated material
  - ►Low density
  - ►Low shear strength
  - ►Mimic a saturated, soft, clay soil or **Mud!**
  - ►Repeatable for multiple tests
    - 600 cubic yards placed the first time it was used in the field in 1990s.

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Preliminary Tests of Soil Interaction

- Panels Tested for Two Soil Conditions
  - Wet Sand
    - Inexpensive
    - Commonly Available
    - Difficult to Uniform Moisture Content
  - BEAST Grout
    - ERDC Developed
    - Simulates Saturated Silt
    - Utilizes Specialized Materials
- Important Parameters
  - Simulation of Actual Soil Conditions
  - Cost
  - Availability
  - Time Requirements

Dry Sand Experiment Prior to Test

BEAST Grout Experiment Prior to Test

BEAST Grout Mixture Proportion

Materials	1 Cubic Yard, Mass in Pounds
ASTM Type I Portland Cement, Buzzi Unicem USA, Signal Mountain Cement	94
ASTM Class F Fly Ash, Headwaters Resources, Gaston Plant	956
Bentonite Clay, Baroid AquaGel®	100
Air-Entraining Admixture, W.R. Grace, Darex AEA,	6.6 fl ozs.
Water	1234 lbs or 148 gallons

Placing BEAST Grout

Preliminary Tests of Soil Interaction

Wet Sand Results

BEAST Grout Results

BEAST Grout Properties

- Flow cone test –ASTM C 939
  - 11-second flow (Water is 8.2 seconds)
- Unconfined compressive strength test
  - 3-inch cubes
  - Nine (9) psi

Tests 1 & 2 – Full scale

Construction – Section placement

Tests 1 & 2

Construction – BEAST grout formwork and cast



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Placing BEAST Grout

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Placing BEAST Grout



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Consistency of BEAST Grout


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Exposed Surface


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Post Test – BEAST Grout


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Questions?

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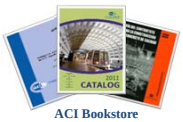
Related Documents

CONTROLLED LOW-STRENGTH MATERIALS

- 229R-99, "Controlled Low-Strength Materials"
- SP-150, "Controlled Low-Strength Materials"
- 523.1R-06, "Guide for Cast-in-Place Low Density Cellular Concrete"
- ACI eLearning course: "Controlled Low-Strength Materials (CLSM) Fundamentals"

SUSTAINABILITY

- ACI eLearning course: "Concrete Sustainability: Basics" and "Concrete Sustainability: Incorporating Environmental, Social, and Economic Aspects"



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