

# RECLAMATION

*Managing Water in the West*

## Strength and Abrasion Testing of Cellular Grout

Research and Development Office  
Science and Technology Program  
Final Report ST-2018-2584-01



# Mission Statements

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## Research and Development Office Science and Technology Program

### Engineering Design, Great Plains Regional Office

#### Final Report ST-2018-2584-01

## Strength and Abrasion Testing of Cellular Grout

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# Main Report

The following document presents the results for strength tests (cube and cylinder) and abrasion testing of cement and grout with cellular/foam material included in the mix. Testing was performed by the Technical Service Center (TSC) in Denver, Colorado. Three mix designs were tested. A summary of the mixes is given in Table 1. Additional details are provided in the Appendix A.

**Table 1 Tested mix designs**

Mix #	Description	Unit Weight prior to adding Foam (lb/ft <sup>3</sup> )	Unit Weight after adding Foam (lb/ft <sup>3</sup> )	Water/Cement Ratio
1	Hydraulic Cement w/ Foam	114	90	0.5
2	Hydraulic Cement w/ 20% Fly Ash and Foam	111.5	90	0.5
3	Hydraulic Cement w/ Sand and Foam	135	110	0.5

Results of the strength tests for the different mixes are provide in Table 2. Cylinder tests were performed using ASTM C39 and cube tests were done using ASTM C109.

**Table 2 Strength tests results.**

Mix #	28-Day Cylinder (psi)	56-Day Cylinder (psi)	28-Day Cube (psi)
1	2555	2865	6142.5
2	2150	2385	5379
3	2525	2890	NA

NA indicates results are not available.


Testing was also conducted to verify that a base grout mix could be foamed, which may enable longer pumping distances, and then “defoamed” after pumping, immediately prior to being placed. A base grout mix was prepared and samples taken for strength testing. Cellular foam was then added and the mix was sampled again for strength testing. The foamed grout was then “defoamed” by adding Tributyl Phosphate and the mix was again sampled for strength testing. Strength test results are presented in Table 3.

**Table 3 "Defoamed" strength test results.**

	7-Day Cylinder (psi)	28-Day Cylinder (psi)
Base Mix	5880	7430
Foam Added	1080	1370
Defoamed	4860	6190

Abrasion testing was performed using ASTM C1138 on mix #1 and #3. Table 4 provides volume loss and depth of abrasion averaged over the samples for mix #1. Table 4 gives the same information for mix #3. See Appendix B for detailed information on the individual tests.

**Table 4 Abrasion testing of hydraulic cement with foam.**

Mix #	Time (hrs)	Average volume loss (%)	Average depth of abrasion (in)	Example specimen after 72 hours of testing
1	12	NA	NA	
	24	4.5	0.2	
	36	7.7	0.3	
	48	13.6	0.6	
	60	17.9	0.8	
	72	20.6	0.9	

**Table 5 Abrasion testing of hydraulic cement with sand and foam.**

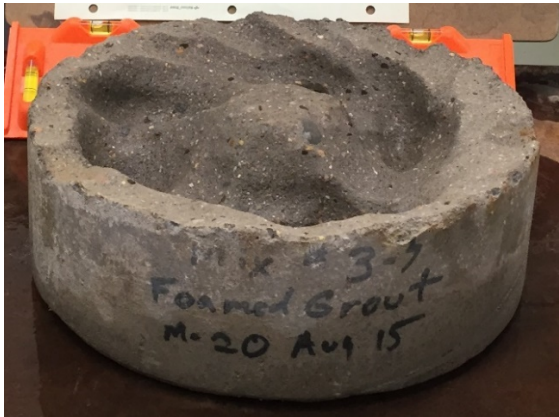
Mix #	Time (hrs)	Average volume loss (%)	Average depth of abrasion (in)	Example specimen after 72 hours of testing
3	12	3.6	0.2	
	24	8.5	0.4	
	36	12.8	0.6	
	48	16.9	0.7	
	60	19.3	0.8	
	72	22.2	1.0	

Photo 1 and 2 show abrasion testing for normal weight concrete performed using ASTM C1138. They are included to allow for visual comparison with the cellular grout samples. Both figures show the same sample.

Photo 1 Abrasion test performed on normal weight concrete.



Photo 2 Abrasion test performed on normal weight concrete.





# Appendix A – Mix Design Details

## Bureau of Reclamation Test Mix 1 - 8-20-2015

User Input  
 Base Mix Results  
 Foamed Slurry Results

Design Density	90	pcf
Base Mix Density	114.5	pcf
Factor	2.061	
Expansion Factor	1.272	yd / yd place

### BASE MIX - INITIAL RATIOS AND BASE YARD CALCULATION

Materials	Spe. Gra.	Density (pcf)	Weight (lb) Ratio	Volume (ft^3)	lb / yd^3	Base Comp. (Vol. / ft^3)
Water	1.00	62.4	500	8.01	1031	16.51
Cement	3.15	196.6	1000	5.09	2061	10.49
Fly Ash	2.33	145.4	0	0.00	0	0.00
Sand	2.65	165.4	0	0.00	0	0.00
<b>TOTALS</b>			1500	13.10	3092	27.00

### BASE MIX WITH A-100 FOAM

Materials	Expanded Weight (lb)	Base Composite Volume
Water	810	12.98
Cement	1620	8.24
Fly Ash	0	0.00
Sand	0	0.00
Sub-Total	2430.0	21.2
Foam		5.8
<b>TOTALS</b>		27.0

## Bureau of Reclamation Test Mix 2 - 8-20-2015

User Input  
 Base Mix Results  
 Foamed Slurry Results

Design Density	90	pcf
Base Mix Density	111.5	pcf
Factor	2.006	
Expansion Factor	1.238	yd / yd place

### BASE MIX - INITIAL RATIOS AND BASE YARD CALCULATION

Materials	Spe. Gra.	Density (pcf)	Weight (lb) Ratio	Volume (ft^3)	lb / yd^3	Base Comp. (Vol. / ft^3)
Water	1.00	62.4	500	8.01	1003	16.08
Cement	3.15	196.6	800	4.07	1605	8.17
Fly Ash	2.33	145.4	200	1.38	401	2.76
Sand	2.65	165.4	0	0.00	0	0.00
<b>TOTALS</b>			1500	13.46	3009	27.00

### BASE MIX WITH A-100 FOAM

Materials	Expanded Weight (lb)	Base Composite Volume
Water	810	12.98
Cement	1296	6.59
Fly Ash	324	2.23
Sand	0	0.00
Sub-Total	2430	21.8
Foam		5.2
<b>TOTALS</b>		27.0



**Bureau of Reclamation Test Mix 3 - 8-20-2015**

- User Input
- Base Mix Results
- Foamed Slurry Results

Design Density	110	pcf
Base Mix Density	135.3	pcf
Factor	1.522	
Expansion Factor	1.230	yd / yd place

**BASE MIX - INITIAL RATIOS AND BASE YARD CALCULATION**

Materials	Spe. Gra.	Density (pcf)	Weight (lb) Ratio	Volume (ft^3)	lb / yd^3	Base Comp. (Vol. / ft^3)
Water	1.00	62.4	400	6.41	609	9.76
Cement	3.15	196.6	800	4.07	1218	6.20
Fly Ash	2.33	145.4	0	0.00	0	0.00
Sand	2.65	165.4	1200	7.26	1827	11.05
<b>TOTALS</b>			2400	17.74	3653	27.00

**BASE MIX WITH A-100 FOAM**

Materials	Expanded Weight (lb)	Base Composite Volume
Water	495	7.93
Cement	990	5.04
Fly Ash	0	0.00
Sand	1485	8.98
Sub-Total	2970	21.9
Foam		5.1
<b>TOTALS</b>		27.0

