

**Additional Soil-Cement Compressive Strength and Abrasion Testing,  
Assignment No. 7 - Reata Pass Abrasion Testing,  
Scottsdale Desert Greenbelt - Reata Pass Wash, Scottsdale, Arizona**

**AGRA Earth and Environmental, Inc.**

**for**

**Flood Control District of Maricopa County-FCD**

**FCD 96-13; AEE Job No. 8-117-001034**

**1998**



August 25, 1998  
AEE Job No. 8-117-001034  
Letter No. 2

Flood Control District of Maricopa County  
2801 West Durango Street  
Phoenix, Arizona 85009

**Attention: Warren Rosebraugh, P.E.**

Gentlemen:

**RE: ADDITIONAL SOIL-CEMENT COMPRESSIVE STRENGTH  
& ABRASION TESTING  
FCD ON-CALL CONTRACT 96-13  
ASSIGNMENT NO. 7 - REATA PASS ABRASION TESTING  
SCOTTSDALE DESERT GREENBELT - REATA PASS WASH  
SCOTTSDALE, ARIZONA**

Pursuant to your request, this letter includes the results of additional soil-cement compressive strength mix designs and abrasion tests performed. Included is a brief project update, comparisons of the attached compressive strength and abrasion test results, and a discussion of the results with respect to project requirements for soil-cement.

## **1.0 PROJECT UPDATE**

In accordance with the request of Warren Rosebraugh, P.E., with the Flood Control District of Maricopa County (FCDMC), we have performed soil-cement compressive strength mix designs and abrasion tests on soil-cement plugs developed from the on-site soils processed for testing. The processed materials utilized were based on a gradation band selected during the March 13, 1998 design partnering session held at FCDMC. The gradation band selected was based on a review of available materials along the project alignment, as well as a review of gradation bands selected for other projects where high quality soil-cement materials were required.

## **2.0 RESULTS OF TESTING**

Attached is the gradation of the actual processed sample, which fits within the gradation band previously selected. Also attached are the results of a moisture-density (standard Proctor) test performed on the processed materials. Figure 1 presents the results of average 7-day compressive strength tests performed on the samples at cement contents varying from 5 to

## 7-Day Compressive Strength vs. Cement Content

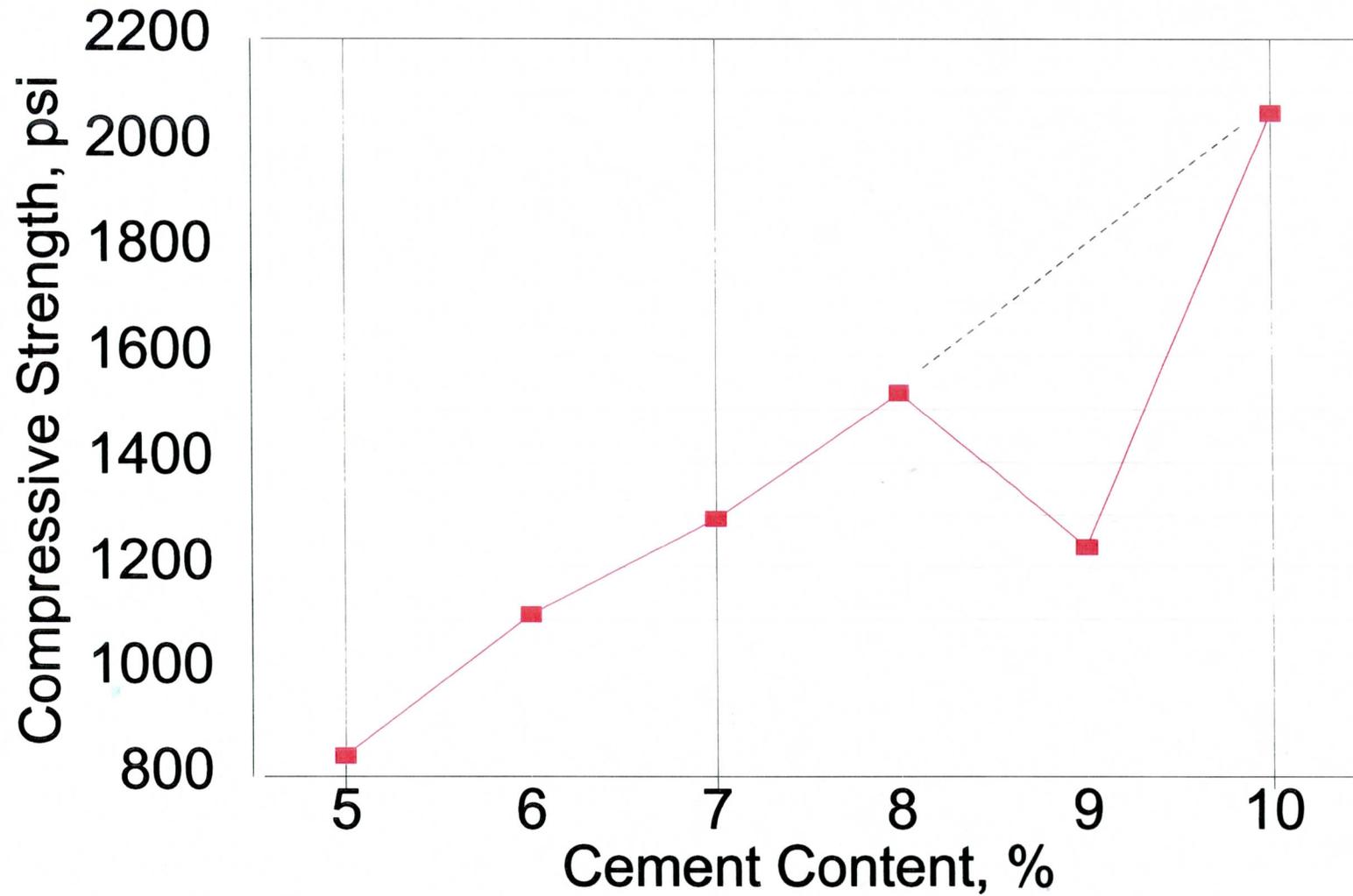


FIGURE 1

10 percent by weight. The results indicate a low of 840 pounds per square inch (psi) at 5 percent increasing to 2,040 psi at 10 percent cement. Based on the generally uniform increases in compressive strength for varying cement contents, it appears that the 9 percent cement samples tested were prepared incorrectly. The projection of the curve from 8 to 10 percent indicates a 7-day compressive strength of about 1,800 psi versus the test value of 1,240 psi indicated. A new set of 9 percent soil-cement plugs has been prepared and will be tested following the 7-day cure period.

The results of abrasion tests performed on samples varying from 5 to 10 percent cement are presented in Figure 2. The results indicate a definite break in abrasion resistance between the 6 and 7 percent cement contents. In general, the 5 and 6 percent cement samples experienced volume losses of about 0.1 to 0.12 times their original volume, with the majority of losses occurring in the initial 8 hours of testing. The samples tested at 7 to 10 percent all experienced similar losses of volume, in the 0.055 to 0.08 range, with the majority of losses also occurring in the initial 8 hours of testing.

The abrasion tests were performed substantially in conformance with ASTM C1138. The only significant variance to the procedure was the testing intervals and the total length of test. ASTM C1138 is a test method to determine the abrasion resistance of concrete. The normal length of the test is 72 hours. The tests performed for this project were terminated at either 36 or 48 hours. As discussed above, the majority of abrasion was experienced within the initial 8 hours of testing. All of the samples were pre-soaked in water for a period of 48 hours prior to running the abrasion tests, in accordance with the referenced test method.

### 3.0 CONCLUSIONS

It appears, based on the limited testing performed to date that a break occurs between the processed materials developed with 6 and 7 percent cement. Compressive strengths for all of the processed materials tested appear to be substantially higher than for those soil-cement plugs developed from on-site non-processed materials. In order to achieve the compressive strength of 1,300 psi determined for the 7 percent cement processed sample, approximately 11 to 14 percent cement in the non-processed materials, as discussed in our Report No. 2A (AEE Job No. 7-117-000062, dated April 6, 1998), would be required.

Given the fact that the 7 percent processed sample exceeds the minimum generally accepted compressive strength value for design of soil-cement embankments of 750 psi, and the fact that the 7 percent sample exhibited abrasion resistance performance similar to the higher compressive strength 8 to 10 percent cement samples, the use of 7 percent cement within the lower velocity reaches of the project should be considered. The value of 7 percent will

# COMPARISON OF ABRASION TEST (ASTM C1138) 5%-10% Cement

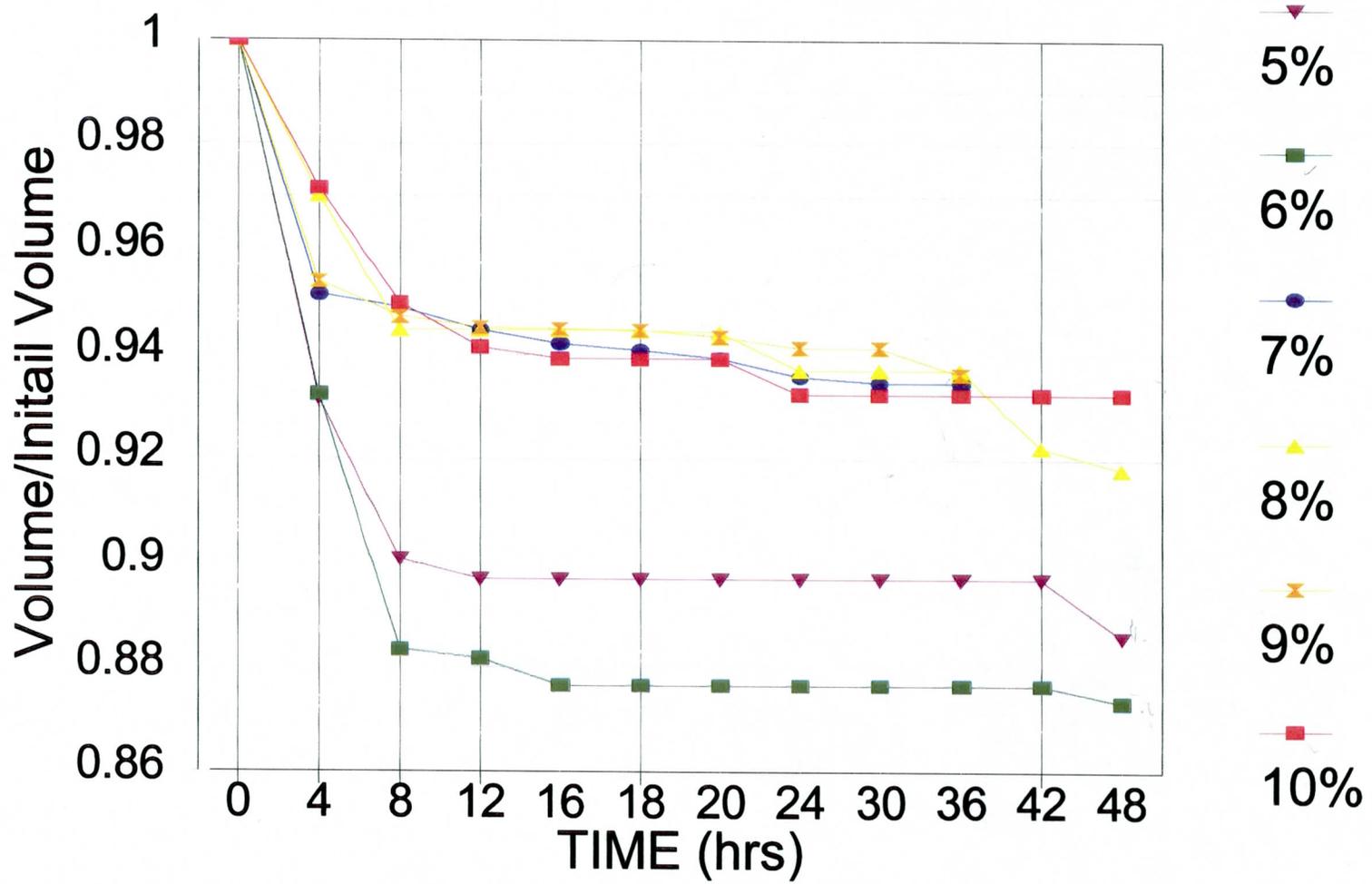


FIGURE 2

Additional Soil-Cement Compressive Strength  
& Abrasion Testing  
FCD On-Call Contract 96-13  
Assignment No. 7 - Reata Pass Abrasion Testing  
Scottsdale Desert Greenbelt - Reata Pass Wash  
Scottsdale, Arizona

AEE Job No. 8-117-001034  
Letter No. 2  
August 25, 1998  
Page 5

provide some buffer for slight material variations, with the knowledge that somewhat lower percentages of cement should still result in acceptable materials. Although the 5 and 6 percent cement samples experienced higher volume losses, none of the volume losses for any of the samples tested are considered to be excessive, given the cross sections of the planned structures. If anything, the results only tend to indicate a break point in terms of abrasion resistance.

For the upper reaches of the project, subject to higher flow velocities, it appears that 8 to 9 percent cement mixed with the processed materials should perform adequately. Compressive strengths of 1,500 to 1,800 psi should be anticipated for such materials within 7 days, likely increasing substantially within the first several months after placement. Although the 10 percent cement sample indicated the highest compressive strength (2,040 psi at 7 days), the material exhibited no material increase in abrasion resistance. The extra cost associated with the additional cement, therefore may not be warranted.

It should be noted that only the highest quality non-processed materials previously tested achieved compressive strengths on the order of what was achieved with the processed materials. The benefit of utilizing processed materials, other than achieving a more consistent product, appears to be about 4 to 6 percent by weight of cement, relative to comparable compressive strengths of the non-processed soils.

Should you have any questions concerning this letter, we would appreciate the opportunity to review and clarify. The results of the additional testing to be performed on the 9 percent cement samples will be forwarded upon completion.

Respectfully submitted,

AGRA Earth & Environmental, Inc.

  
Keith H. Dahlen, P.E.  
Senior Engineer



Reviewed by:





Lawrence A. Hansen, Ph.D., P.E.  
Senior Vice President

c: Addressee (3)  
Simons, Li & Associates  
Attn: Randall Beck, P.E. (1)

njf/J6-98/8-25-98

# AGRA Earth & Environmental, Inc.

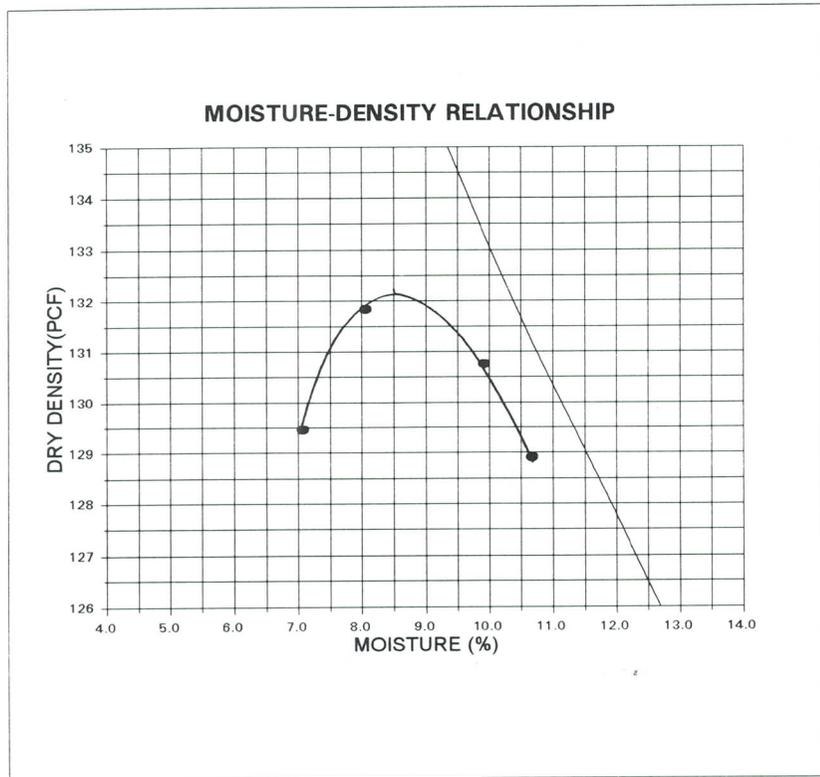
**PROJECT:** ADD INVESTIGATION - DESERT GREENBELT  
**LOCATION:** REATTA PASS WASH CHANNELIZATION  
**MATERIAL:**  
**SAMPLE SOURCE:** TP-25 @ 0-9'

**JOB NO:** 7-117-000062  
**WORK ORDER NO:** 3  
**LAB NO:** 36  
**SAMPLE DATE:** 3-20-98

## MOISTURE DENSITY RELATIONS (ASTM D698C)

MAXIMUM DRY DENSITY (PCF): 132.2  
 OPTIMUM MOISTURE (%): 8.5

SIEVE SIZE	ARTIFICIAL GRADING PERCENT PASSING	SPECS.
6"		
4"		
3"		
2"	100	
1 1/4"		
1"		
3/4"		
1/2"	78	
3/8"		
1/4"		
#4	54	
#8		
#10		
#16	29	
#30	20	
#40		
#50		
#100		
#200	8.0	



NOTE: THE ZERO AIR VOIDS CURVE REPRESENTS A SPECIFIC GRAVITY OF: 2.711

THIS IS A SUMMARIZED REPORT OF THE REFERENCED PROCEDURES AND DOES NOT INCLUDED ALL REPORTING REQUIREMENTS. ADDITIONAL DATA CAN BE PROVIDED AT CLIENT'S REQUEST.

THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PRESENTED. 9% PORTLAND CEMENT WAS ADDED TO THE DRY WEIGHT OF AGGREGATE.

# AGRA Earth & Environmental, Inc.

**PROJECT:** REATA PASS WASH - DESERT GREENBELT  
**LOCATION:** SCOTTSDALE, AZ  
**MATERIAL:**  
**SAMPLE SOURCE:** TP-25 @ 0-9'

**JOB NO:** 8-117-001034  
**WORK ORDER NO:** 2  
**LAB NO:** 36  
**DATE SAMPLED:** 6-2-98

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## SOIL CEMENT PLUGS COMPRESSIVE STRENGTH ARIZONA 241A AS APPLICABLE

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SAMPLE ID	WET SAMPLE WEIGHT (GR)	MOISTURE (%)	DRY DENSITY (PCF)	DIAMETER (IN)	CEMENT CONTENT (%)	MAX LOAD (LBS)	STRESS (PSI)	AGE IN DAYS
A	2175	7.6	133.7	3.99	5.0	10,579	850	7
B	2169	7.9	132.9	4.01	5.0	10,223	810	7
C	2172	7.3	133.8	3.99	5.0	10,856	870	7
AVERAGE STRESS(psi):							840	
A	2195	7.5	135.1	4.00	6.0	15,207	1,210	7
B	2179	7.1	134.6	4.01	6.0	12,913	1,020	7
C	2193	7.8	134.6	4.01	6.0	13,921	1,100	7
AVERAGE STRESS(psi):							1,110	

# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH - DESERT GREENBELT  
LOCATION: SCOTTSDALE, AZ  
MATERIAL:  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 1  
LAB NO: 36  
DATE SAMPLED: 3-20-98

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## SOIL CEMENT PLUGS COMPRESSIVE STRENGTH ARIZONA 241A AS APPLICABLE

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SAMPLE ID	WET SAMPLE WEIGHT (GR)	MOISTURE (%)	DRY DENSITY (PCF)	DIAMETER (IN)	CEMENT CONTENT (%)	MAX LOAD (LBS)	STRESS (PSI)	AGE IN DAYS
A	2167	7.7	133.0	3.99	7.0	17,916	1,430	7
B	2171	8.9	131.8	4.01	7.0	15,763	1,250	7
C	2161	7.9	132.5	4.01	7.0	15,128	1,200	7

AVERAGE STRESS(psi): 1,293

# AGRA Earth & Environmental, Inc.

**PROJECT:** REATA PASS WASH - DESERT GREENBELT  
**LOCATION:** SCOTTSDALE, AZ  
**MATERIAL:**  
**SAMPLE SOURCE:** TP-25 @ 0-9'

**JOB NO:** 8-117-001034  
**WORK ORDER NO:** 3  
**LAB NO:** 36  
**DATE SAMPLED:** 7-16-98

## SOIL CEMENT PLUGS COMPRESSIVE STRENGTH ARIZONA 241A AS APPLICABLE

SAMPLE ID	WET		DRY DENSITY (PCF)	DIAMETER (IN)	CEMENT CONTENT (%)	MAX LOAD (LBS)	STRESS (PSI)	AGE IN DAYS	
	SAMPLE WEIGHT (GR)	MOISTURE (%)							
1A	2175	7.6	133.7	4.00	8.0	17,698	1,410	7	
1B	2188	8.1	133.8	3.99	8.0	19,854	1,590	7	
1C	2199	8.4	134.2	4.00	8.0	19,859	1,580	7	
AVERAGE STRESS(psi):							1,530		
2A	2162	7.8	132.7	4.00	10.0	26,103	2,080	7	
2B	2144	8.2	131.0	4.00	10.0	25,128	2,000	7	
2C	2173	8.8	132.1	4.01	10.0	26,677	2,110	7	
AVERAGE STRESS(psi):							2,060		

# AGRA Earth & Environmental, Inc.

PROJECT: ADDITIONAL INVESTIGATION-DESERT GREENBELT  
LOCATION: REATTA PASS WASH CHANNELIZATION  
MATERIAL: PROCESSED MATERIAL

JOB NO: 7-117-000062  
WORK ORDER NO: 4  
LAB NO: 36  
DATE SAMPLED: 4-15-98

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## SOIL CEMENT PLUGS COMPRESSIVE STRENGTH ARIZONA 241A AS APPLICABLE

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SAMPLE ID	WET SAMPLE WEIGHT (GR)	MOISTURE (%)	DRY DENSITY (PCF)	DIAMETER (IN)	CEMENT CONTENT (%)	MAX LOAD (LBS)	STRESS (PSI)	AGE IN DAYS
1	2121	7.8	130.1	4.03	9.0	15,306	1,200	7
2	2124	7.3	131.0	3.98	9.0	16,769	1,350	7
3	2124	7.8	130.3	3.99	9.0	14,653	1,170	7

AVERAGE STRESS(psi): 1,240

# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH  
LOCATION: SCOTTSDALE, AZ  
MATERIAL: 5% CEMENT @ 8.5% MOISTURE  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 2  
LAB NO: 36A  
DATE SAMPLED: 6-2-98

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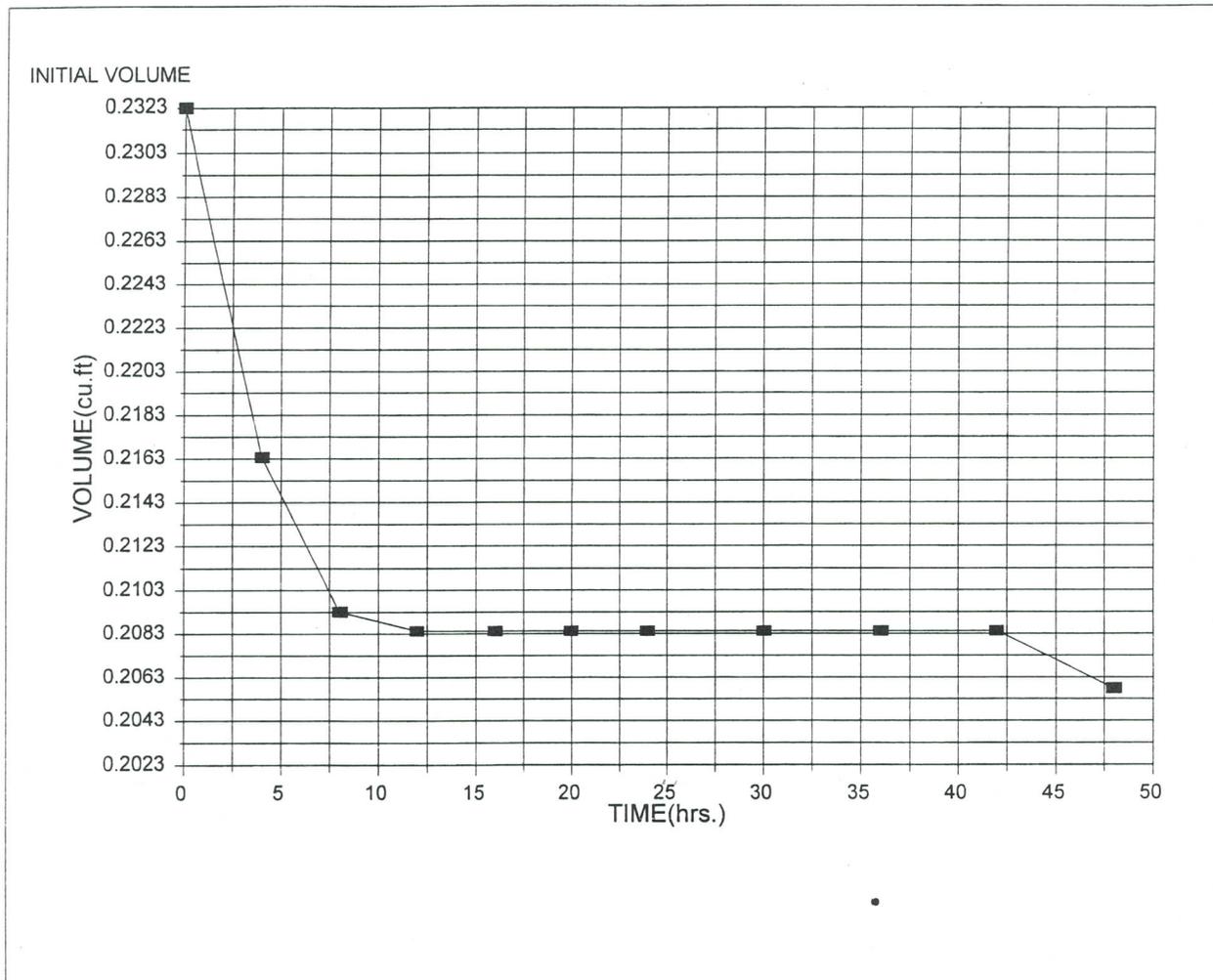
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## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

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INITIAL VOLUME(cu.ft)	0.2323
BALL CHARGE WGT BEFORE (g)	1863
BALL CHARGE WGT AFTER (g)	1863



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDED.

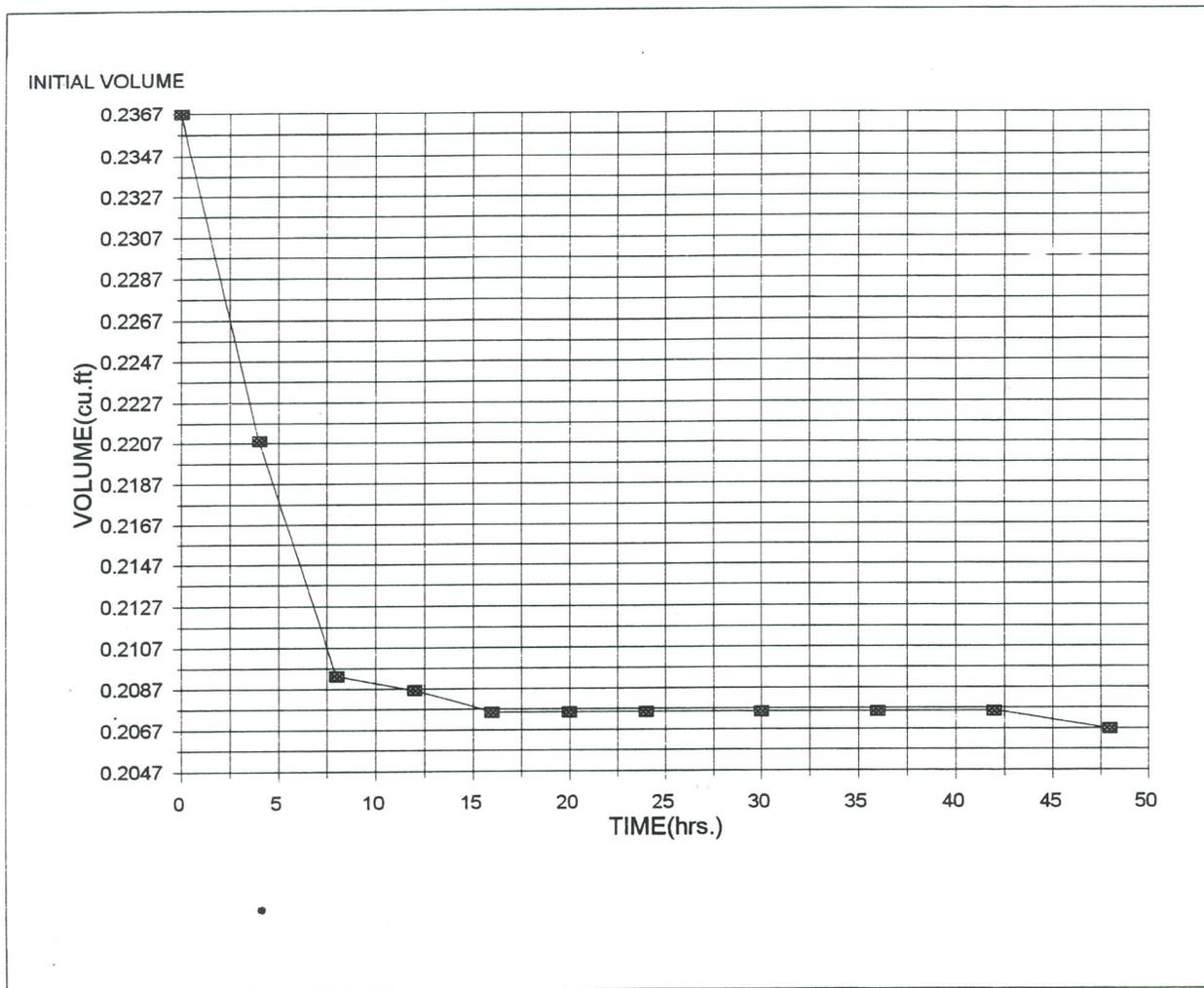
# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH  
LOCATION: SCOTTSDALE, AZ  
MATERIAL: 6% CEMENT @ 8.5% MOISTURE  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 2  
LAB NO: 36  
DATE SAMPLED: 6-2-98

## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

INITIAL VOLUME(cu.ft)	0.2367
BALL CHARGE WGT BEFORE (g)	1863
BALL CHARGE WGT AFTER (g)	1863



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDED.

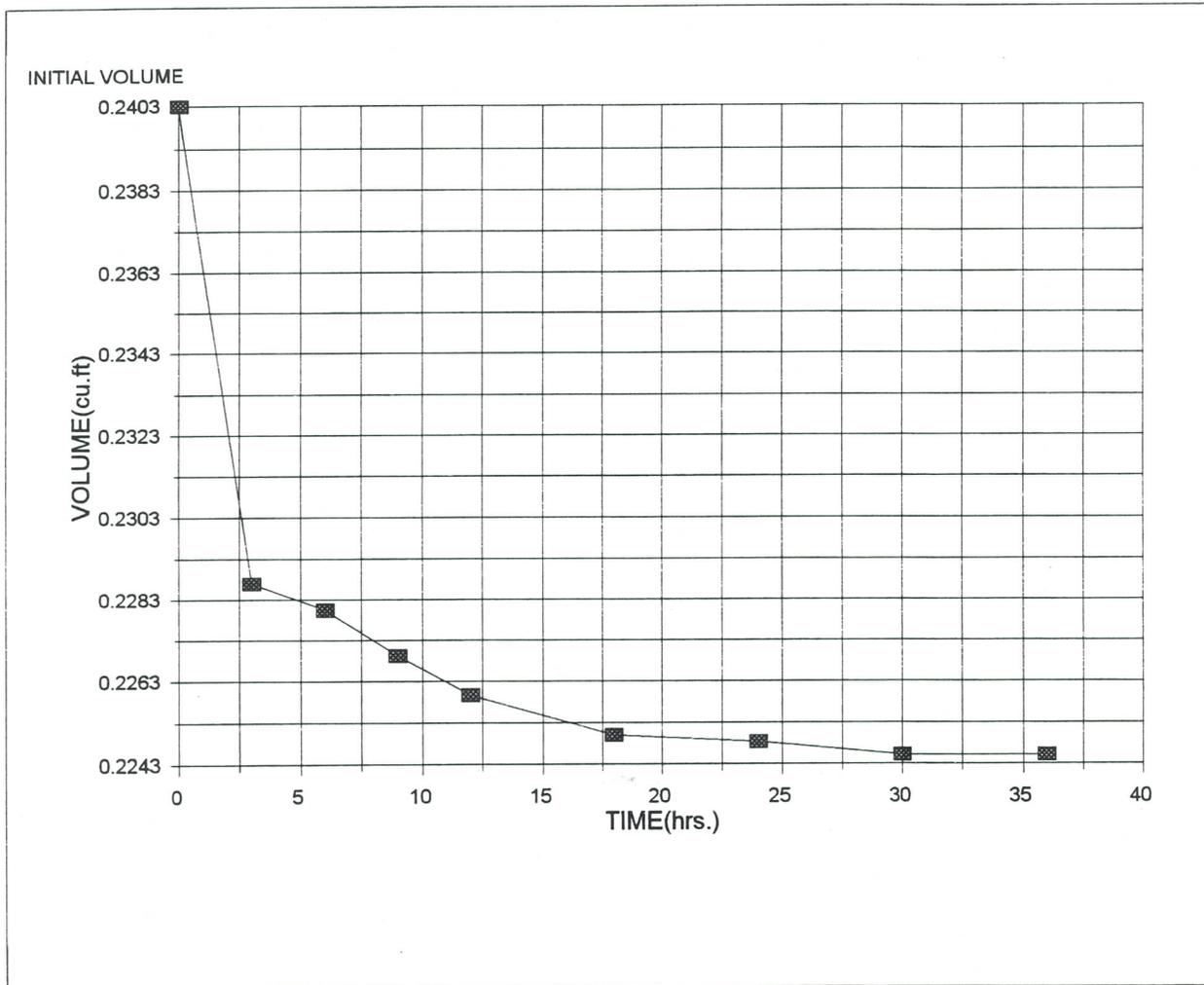
# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH - DESERT GREENBELT  
LOCATION: SCOTTSDALE, AZ  
MATERIAL: NATIVE  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 1  
LAB NO: 36  
DATE SAMPLED: 3-20-98

## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

INITIAL VOLUME(cu.ft) 0.2403  
BALL CHARGE WGT BEFORE (g) Not measured  
BALL CHARGE WGT AFTER (g) Not measured



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDE 7% PORTLAND CEMENT WAS ADDED TO THE DRY WEIGHT OF AGGREGATE.

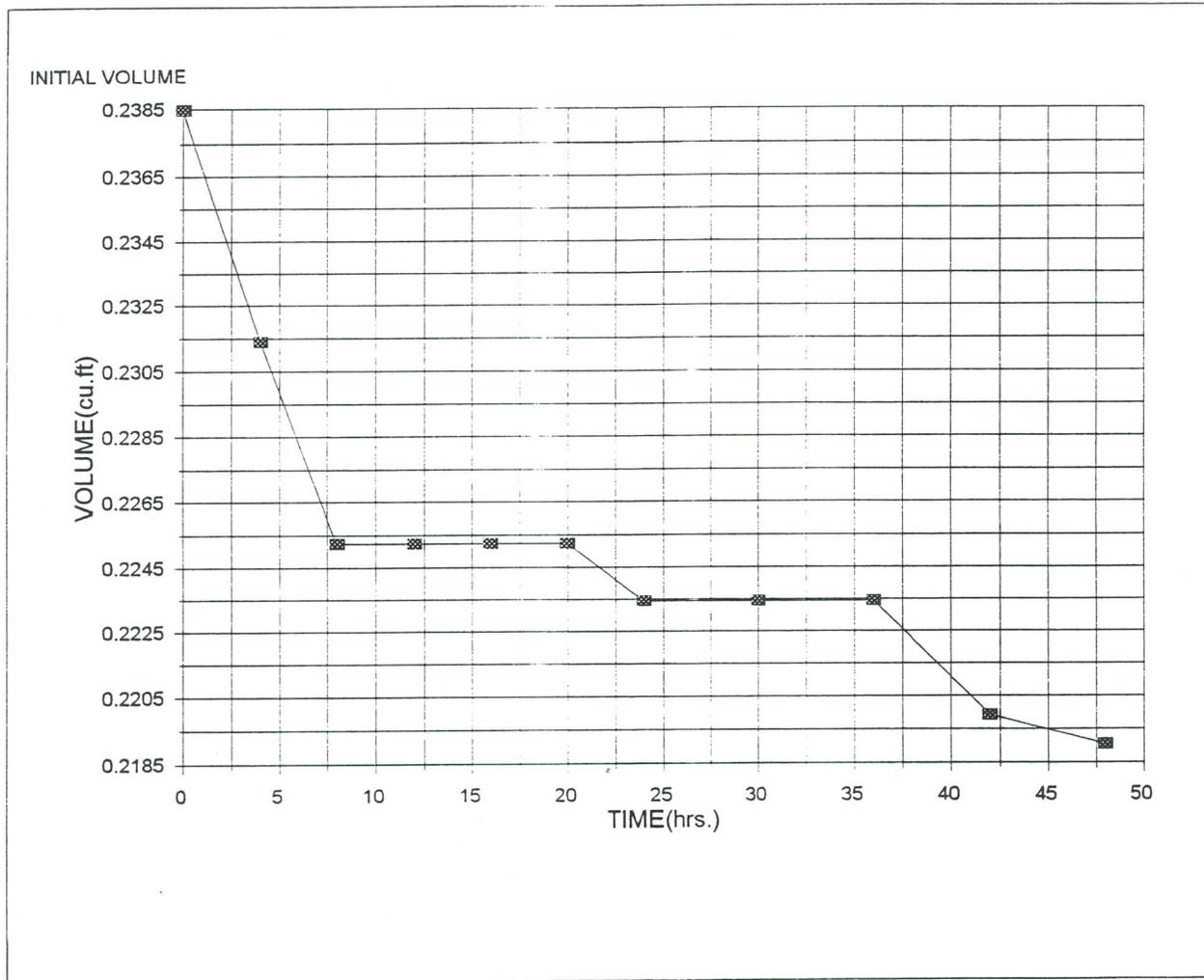
# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH  
LOCATION: SCOTTSDALE, AZ  
MATERIAL: 8% CEMENT  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 3  
LAB NO: 36  
DATE SAMPLED:

## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

INITIAL VOLUME(cu.ft)	0.2385
BALL CHARGE WGT BEFORE (g)	1843
BALL CHARGE WGT AFTER (g)	1843



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDED.

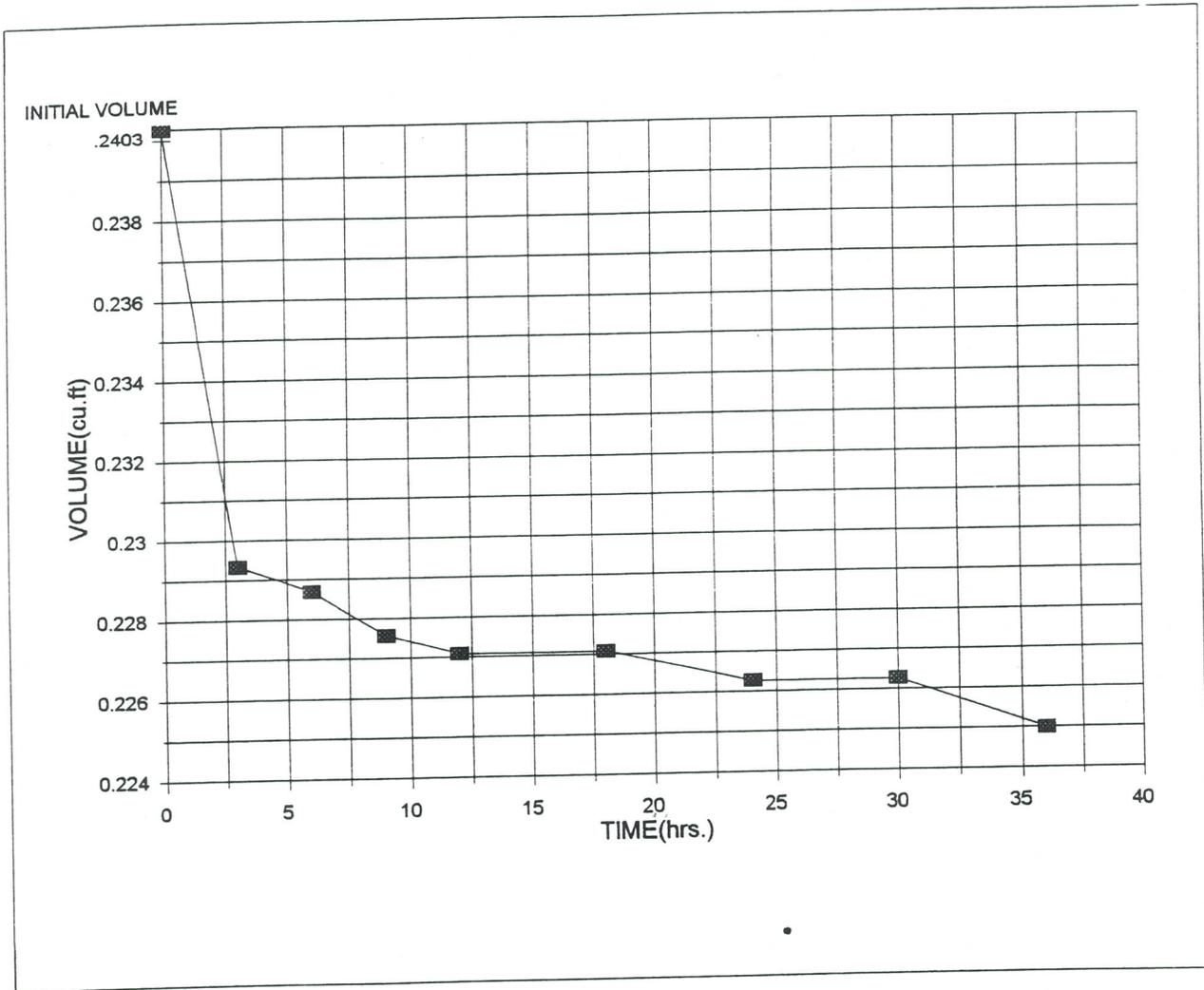
# AGRA Earth & Environmental, Inc.

PROJECT: ADDITIONAL INVESTIGATION-DESERT GREENBELT  
LOCATION: REATTA PASS WASH CHANNELIZATION  
MATERIAL: NATIVE  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 7-119-000062  
WORK ORDER NO: 3  
LAB NO: 36  
DATE SAMPLED: 3-20-98

## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

INITIAL VOLUME(cu.ft) 0.2403  
BALL CHARGE WGT BEFORE (g) 1863  
BALL CHARGE WGT AFTER (g) 1854



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDED.  
9% PORTLAND CEMENT WAS ADDED TO THE DRY WEIGHT OF AGGREGATE.

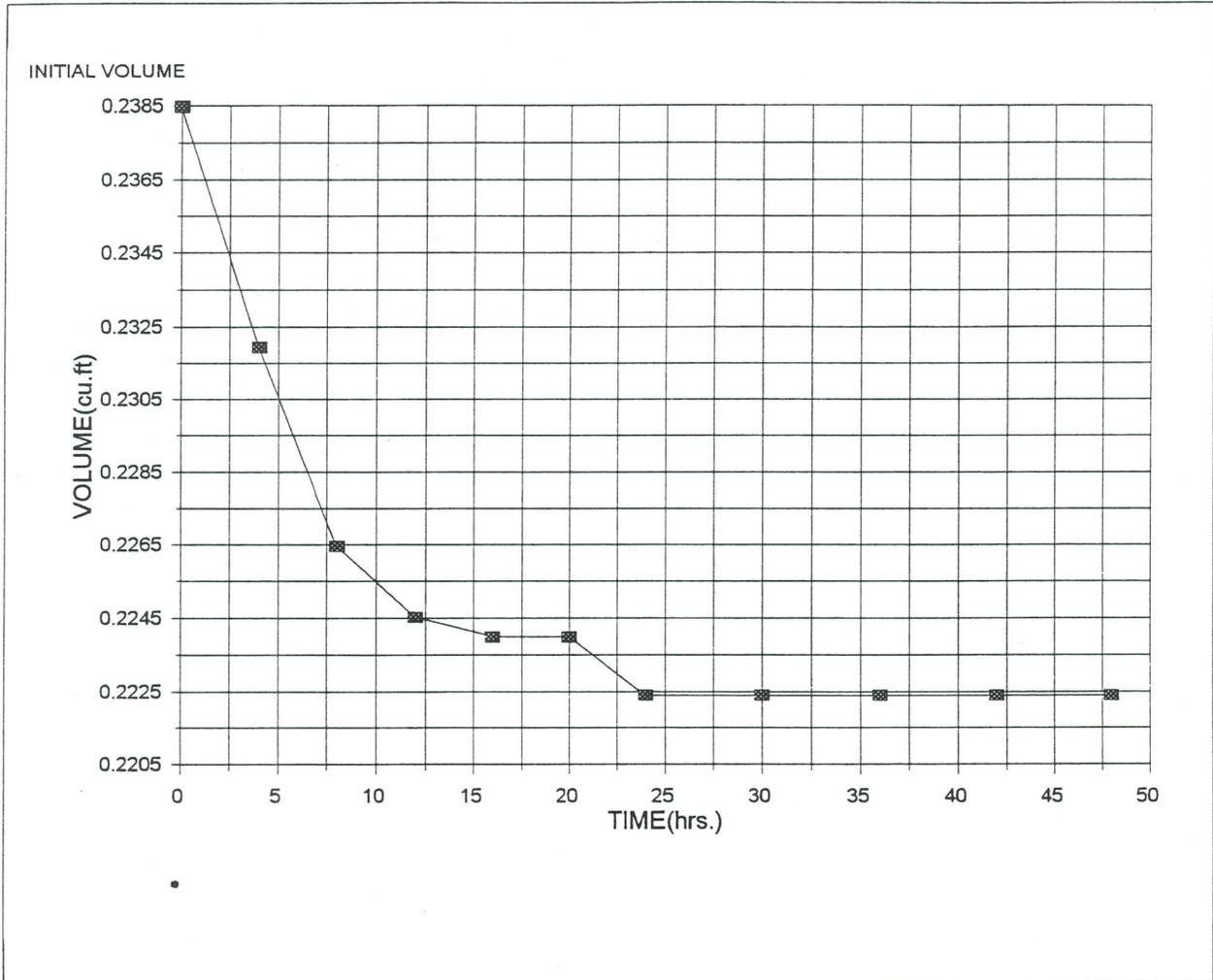
# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH  
LOCATION: SCOTTSDALE, AZ  
MATERIAL: 10% CEMENT  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 3  
LAB NO: 36  
DATE SAMPLED:

## ABRASION RESISTANCE OF CONCRETE(UNDERWATER METHOD)(ASTM C1138)

INITIAL VOLUME(cu.ft)	0.2385
BALL CHARGE WGT BEFORE (g)	1863
BALL CHARGE WGT AFTER (g)	1863



NOTE: THE MATERIAL WAS ARTIFICIALLY GRADED TO REPRESENT THE ARTIFICIAL GRADING PROVIDED.

September 2, 1998  
AEE Job No. 8-117-001034  
Letter No. 3

Flood Control District of Maricopa County  
2801 West Durango  
Phoenix, Arizona 85009

**Attention: Warren Rosebraugh, P.E.**

Gentlemen:

**RE: ADDITIONAL SOIL-CEMENT COMPRESSIVE STRENGTH  
& ABRASION TESTING  
FCD ON-CALL CONTRACT 96-13  
ASSIGNMENT NO. 7 - REATA PASS ABRASION TESTING  
SCOTTSDALE DESERT GREENBELT - REATA PASS WASH  
SCOTTSDALE, ARIZONA**

Transmitted herewith are the results of additional soil-cement 7-day compressive strength tests performed on processed soil samples containing 9 percent by weight cement. The tests at 9 percent were re-run, as the original test results were lower than anticipated based on previous tests performed at 8 and 10 percent cement content. The re-tested average value of 1,680 pounds per square inch (psi) is more in line with what would be anticipated based on the results of the other tests. Attached are both the laboratory results and a revised Figure 1, which was previously presented in our Letter No. 2, dated August 25, 1998. The value of 1,680 psi is slightly less than the anticipated value of 1,800 psi discussed in Letter No. 2.

Should you have any questions concerning this letter, we would appreciate the opportunity to review and clarify.

Respectfully submitted,  
**AGRA Earth & Environmental, Inc.**

  
Keith H. Dahlen, P.E.  
Senior Engineer



Reviewed by:

  
Lawrence A. Hansen, Ph.D., P.E.  
Senior Vice President



c: Addressee (3)  
Simons, Li & Associates  
Attn: Randall Beck, P.E. (1)

## 7-Day Compressive Strength vs. Cement Content

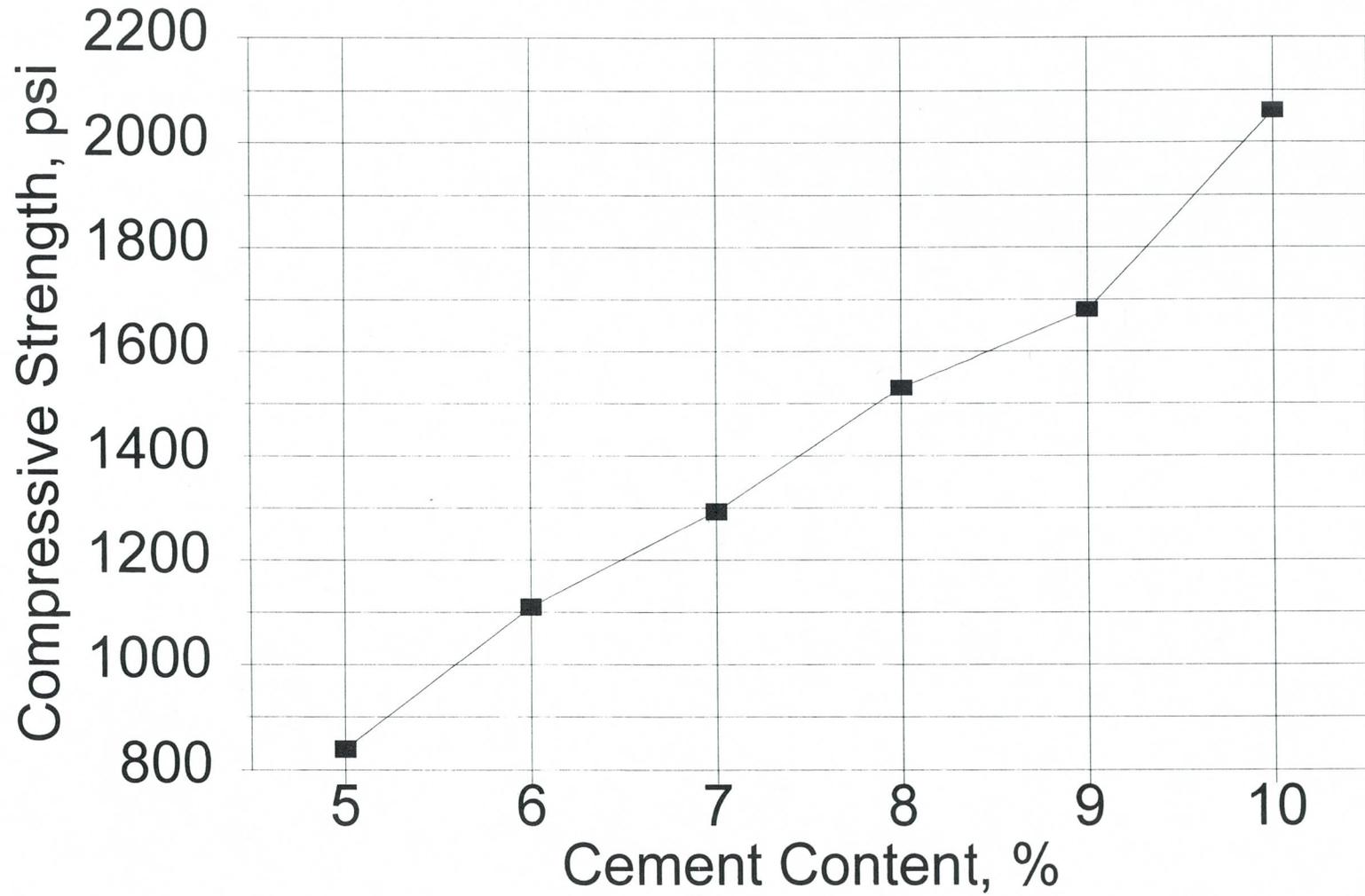


Figure 1

# AGRA Earth & Environmental, Inc.

PROJECT: REATA PASS WASH - DESERT GREENBELT  
LOCATION: SCOTTSDALE, AZ  
MATERIAL:  
SAMPLE SOURCE: TP-25 @ 0-9'

JOB NO: 8-117-001034  
WORK ORDER NO: 3  
LAB NO: 36  
DATE SAMPLED: 7-16-98

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## SOIL CEMENT PLUGS COMPRESSIVE STRENGTH ARIZONA 241A AS APPLICABLE

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SAMPLE ID	WET SAMPLE WEIGHT (GR)	MOISTURE (%)	DRY DENSITY (PCF)	DIAMETER (IN)	CEMENT CONTENT (%)	MAX LOAD (LBS)	STRESS (PSI)	AGE IN DAYS
1A	2162	8.0	132.4	4.03	9.0	22,103	1,730	7
1B	2164	8.4	132.0	4.02	9.0	21,173	1,670	7
1C	2184	8.0	133.8	4.02	9.0	20,644	1,630	7

AVERAGE STRESS(psi): 1,680