February 13, 2006

MEMORANDUM NO. 1 TO: **A.E.S. Puerto Rico**
PO Box 1890
Guayama, PR 00785

ATTENTION: **Mr. Neil Watlington**

PROJECT: **A.E.S. Plant**
Guayama, Puerto Rico

SUBJECT: **Manufactured Aggregate Laboratory Test Results**

REPORT:

Herein submitted are the results of several laboratory tests ran on a manufactured aggregate sample (by-product of plant process), secured by your personnel at the plant premises and transported by our personnel to our laboratory on December 2005. The following tests were conducted according to the standards procedures as described on the American Society for Testing and Materials (ASTM) or the American Association of State Highway and Transportation Officials (AASHTO) latest specifications. The following standards were followed:

- ASTM D422-63 (2002) - Test Method for Particle-Size Analyses of Soils.
- ASTM D854-02 - Test Method for Specific Gravity of Soils Solids by Water Pycnometer.
- ASTM D1140-00 - Test Method for Amount of Material in Soils Finer Than No. 200 Sieve (75μm) Sieve.
- ASTM D1557-02 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 KN-m/m^3).
- ASTM D1883-99 - Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils.
- ASTM D2216-98 - Test Method for Laboratory Determination of Water Moisture Content of Soil and Rock by Mass.

VICTOR E. RIVERA ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS
& CONCRETE TESTING LABORATORIES

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- ASTM D2434-68 (2000) - Test Method for Permeability of Granular Soils (Constant Head).
- ASTM D2487-00 - Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
- ASTM D2488-00 - Practice for Description and Identification of Soils (Visual-Manuel Procedure).
- ASTM D3282-93 (2004) - Practice for Classification of Soils and Soils -Aggregate Mixtures for Highway Construction Purposes.
- ASTM D4220-95 (2000) - Practice for Processing and Transporting Soil Samples.
- ASTM D4318-00 - Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

One California Bearing Ratio (CBR) was performed (sample #2). The test was performed at a moisture content of about 2 percent of the sample optimum moisture content (OMC). The test laboratory data sheet as well as a graphic representation of the CBR versus percent of compaction is attached to this report. The CBR for 95% compaction of the material maximum dry density as obtained from ASTM standard D1557 is approximately 13% and increases to 35 % when compacted the material to 100%.

Table I: Summary of Test Results

ASTM Standard	Test Description		Sample #1	Sample #2
D2216-98	As-received Water Moisture Content (w_n)		56.3%	54.6%
D2488-00[a]	Sample Description		Silty sandy gravel, some clay (weak reaction to HCL) Gravel (%) = 37.9 Sand (%) = 27.6 Fines (%) = 34.5	Silty sandy gravel, trace clay (weak reaction to HCL) Gravel (%) = 43.7 Sand (%) = 27.7 Fines (%) =28.6
D422-63 (2002)	Particle-Size Analysis of Soils	#4	62.1	56.3
		#10	56.0	48.2
		#40	46.6	38.1
		#200	34.5	28.6

D1140-00	**Amount of Material in Soils Finer Than No. 200 Sieve (Method B-soaked by 2h)**	**Silt Fraction**	24.1	20.1
		Clay Fraction	10.4	8.5
D4318-00	**Atterberg Limits**	**Liquid Limit**	Non-viscous (NV[b])	Non-viscous (NV)
		Plastic Limit	Non plastic (NP[c])	Non plastic (NP)
		Plasticity Index	NP	NP
D2487-00	**Unified Soil Classification System (USCS)**		GM	GM
D3282-93 (2004)	**Classification of Soils for Highway Construction Purposes**		A-2-4 (0)	A-2-4 (0)
D854-02	**Specific Gravity of Soils – Method B**		2.727	2.754
D2434-68 (2000)	**Permeability of Granular Soils (Constant Head)**		4.40 X 10^{-6} cm/sec	4.45 X 10^{-6} cm/sec
D1557-02	**Laboratory Compaction Characteristic of Soils Using Modified Effort – Method A**	**Maximum Dry Density (MDD)**	67.3 pcf	63.0 pcf
		Optimum Moisture Content (OMC)	44.5%	34.0%

Notes:

a] Sample description is based on the material particle size distribution

b] NV = non viscous

c] NP = non plastic

d] pcf = pounds per cubic foot

Please find attached test results.

LUIS J. URQUIZA ROMAN
INGENIERO
LIC. NUM.
PUERTO RICO

Respectfully Submitted,

Luis Urquiza Román, MCE, PE
Project Engineer

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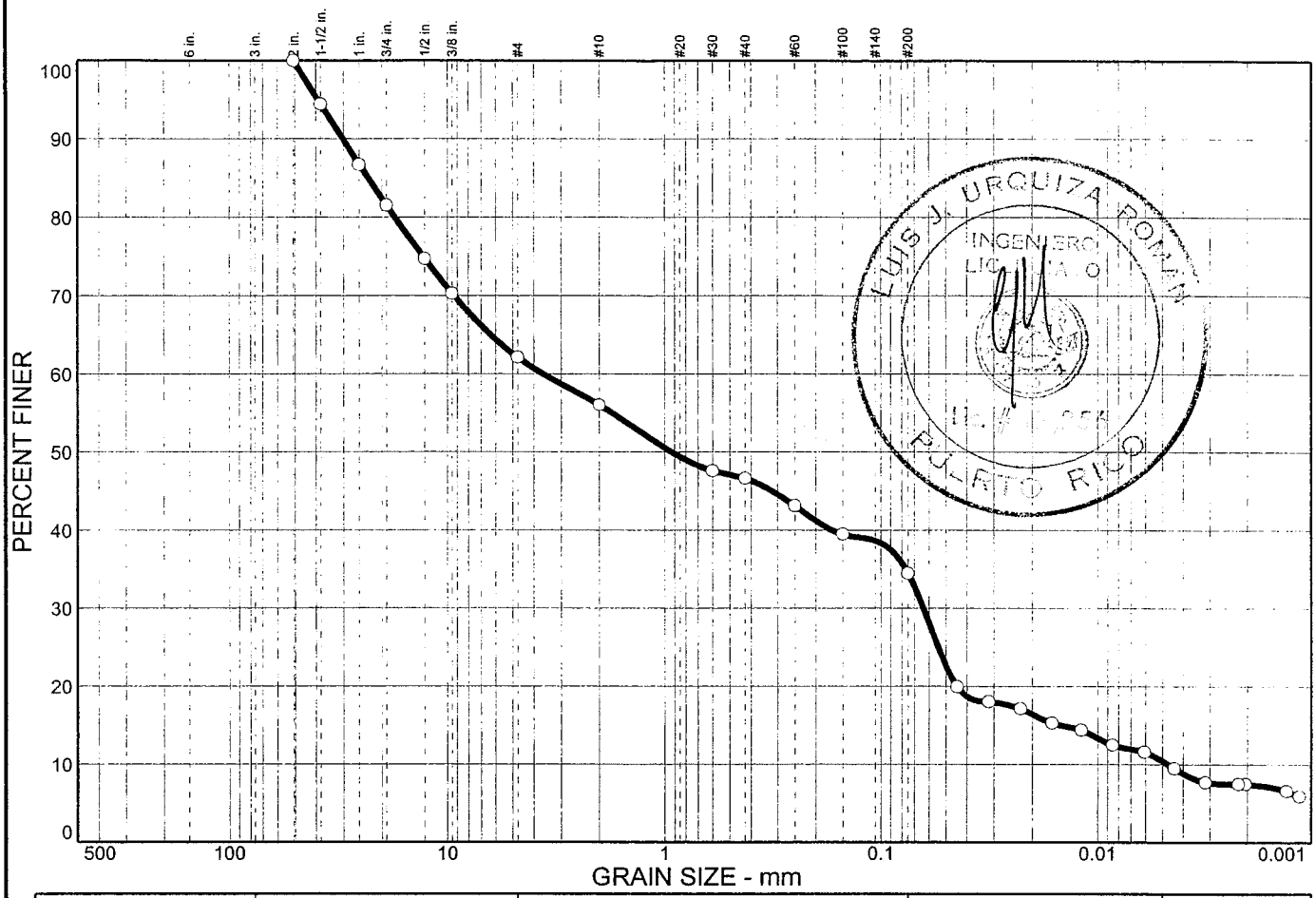
Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	37.9	27.6	24.1	10.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.0 in.	100.0		
1.5 in.	94.4		
1.0 in.	86.7		
0.75 in.	81.5		
0.50 in.	74.7		
0.375 in.	70.3		
#4	62.1		
#10	56.0		
#30	47.6		
#40	46.6		
#60	43.1		
#100	39.5		
#200	34.5		

* (no specification provided)

Soil Description

silty sandy gravel, some clay - gray

Atterberg Limits

PL= np LL= nv PI= np

Coefficients

D_{85}= 23.2 D_{60}= 3.64 D_{50}= 0.930
D_{30}= 0.0638 D_{15}= 0.0147 D_{10}= 0.0047
C_u= 774.56 C_c= 0.24

Classification

USCS= GM AASHTO= A-2-4(0)

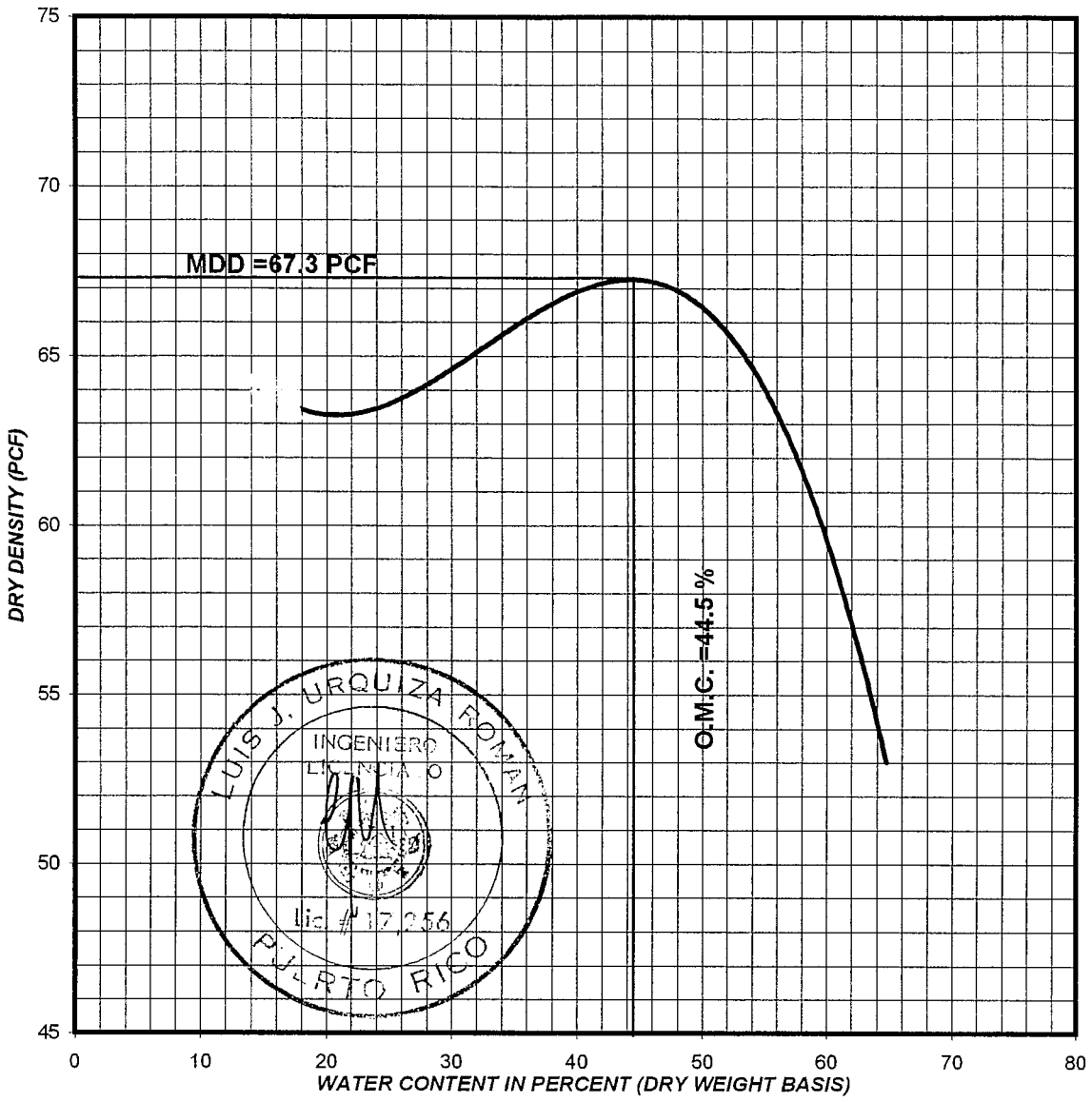
Remarks

F.M.=2.05

Sample No.: 1 **Source of Sample:** AES Plant **Date:** 02/13/06
Location: Guayama **Elev./Depth:** ---

VICTOR E. RIVERA ASSOCIATES

Client: AES Plant
Project: Manufacturated Aggregate Characterization, AES Plant Premises, Guayama, P.R.
Project No: 06-2573 **Approved by:** L. Urquiza



COMPACTION CURVE

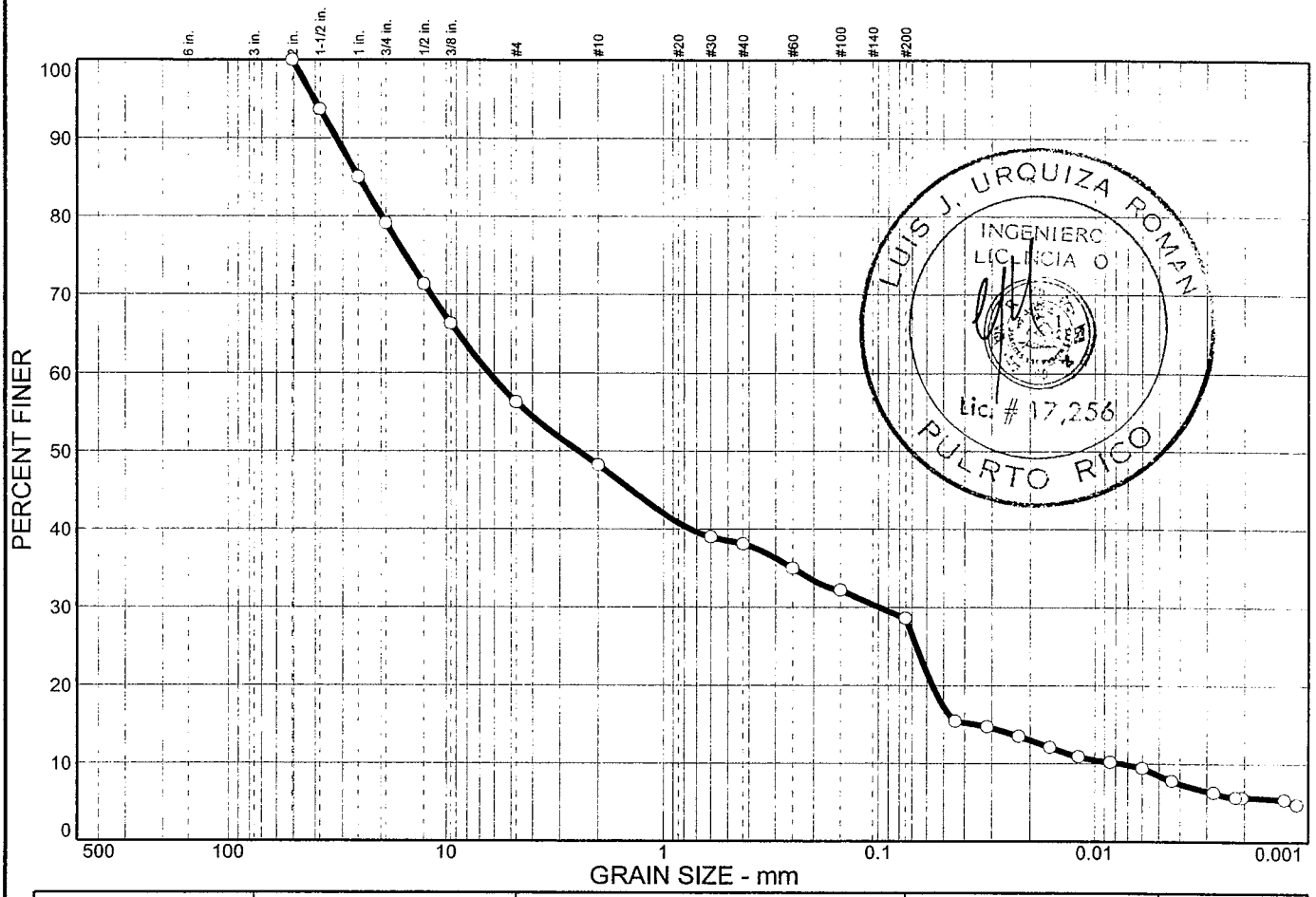
ASTM D 1557 - 00, METHOD "A"

SOIL SAMPLE: MANUFACTURED AGGREGATE SAMPLED AS SILTY SANDY GHRAVEL, SOME CLAY - GRAY
SOURCE : AES PLANT, GUAYAMA, PUERTO RICO

LIQUID LIMIT	NV		
PLASTICITY INDEX	NP	% GRAVEL	37.9
% PASSING NO. 4 SIEVE	62.1	% SAND	27.6
% PASSING NO. 10 SIEVE	56.0	% FINE	34.5
% PASSING NO. 40 SIEVE	46.6		
% PASSING NO. 200 SIEVE	34.5		
AASHTO M-145 CLASSIFICATION	A-2-4		
GROUP INDEX	0		
USCS	GM		

VICTOR E. RIVERA ASSOCIATES GEOTECHNICAL ENGINEERS		
A.E.S. Plant Guayama, PR A.E.S. Puerto Rico		
DATE	TEST NO.	APPROVED
2/13/2006	1	

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	43.7	27.7	20.1	8.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2.0 in.	100.0		
1.5 in.	93.7		
1.0 in.	85.0		
0.75 in.	79.1		
0.50 in.	71.3		
0.375 in.	66.3		
#4	56.3		
#10	48.2		
#30	39.0		
#40	38.1		
#60	35.0		
#100	32.2		
#200	28.6		

* (no specification provided)

Soil Description

silty sandy gravel, trace clay - gray

Atterberg Limits

PL= np LL= nv PI= np

Coefficients

D_{85}= 25.4 D_{60}= 6.33 D_{50}= 2.46
D_{30}= 0.0987 D_{15}= 0.0354 D_{10}= 0.0075
C_u= 845.48 C_c= 0.21

Classification

USCS= GM AASHTO= A-2-4(0)

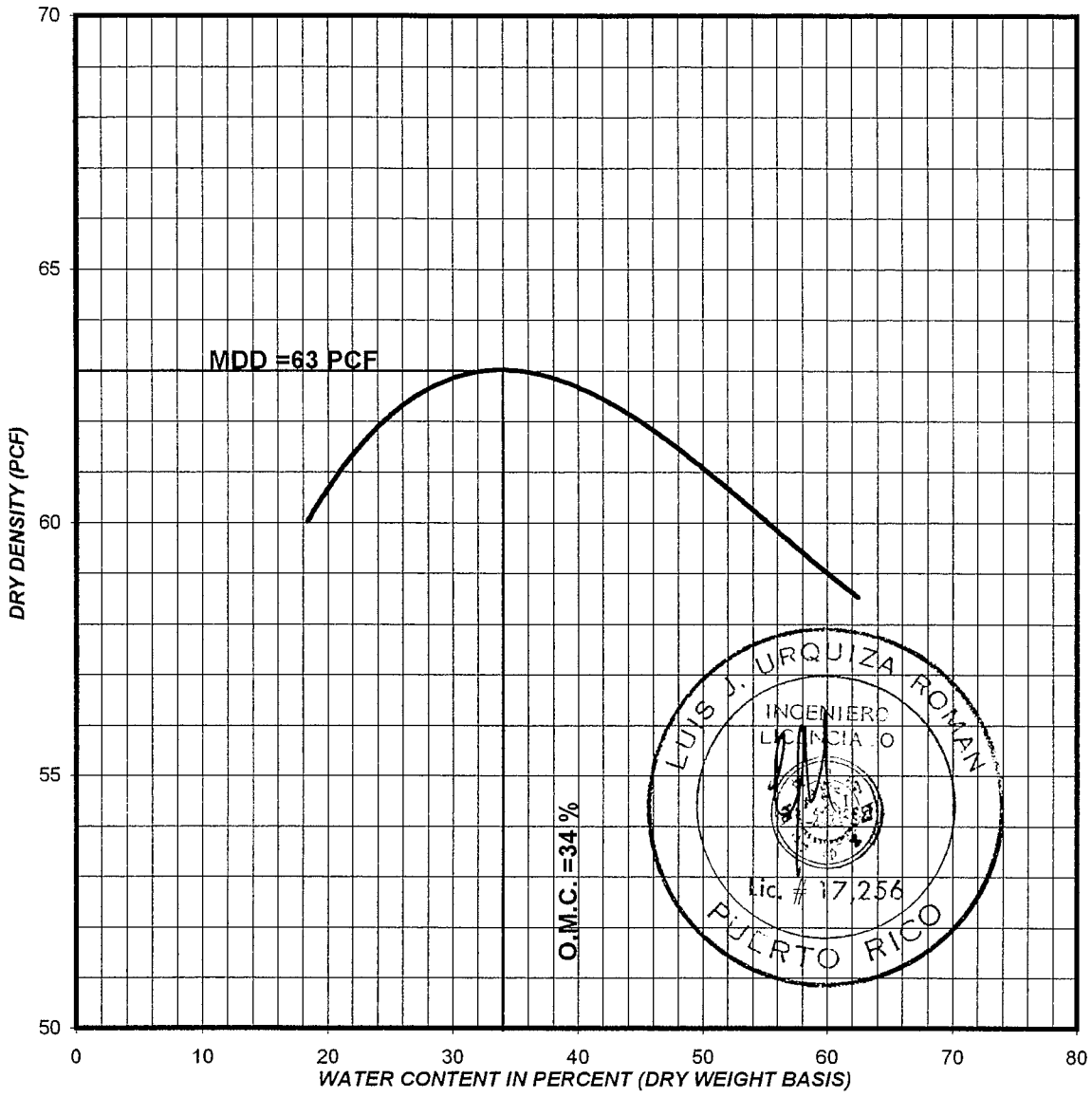
Remarks

F.M.=2.33

Sample No.: 2 **Source of Sample:** AES Plant **Date:** 02/13/06
Location: Guayama **Elev./Depth:** ---

VICTOR E. RIVERA ASSOCIATES

Client: AES Plant
Project: Manufacturated Aggregate Characterization, AES Plant Premises, Guayama, P.R.
Project No: 06-2573 **Approved by:** L. Urquiza



COMPACTION CURVE

ASTM D 1557 - 00, METHOD "A"

SOIL SAMPLE: MANUFACTURED AGGREGATE SAMPLED AS SILTY SANDY GRAVEL - GRAY
SOURCE : AES PLANT, GUAYAMA, PUERTO RICO

LIQUID LIMIT	NV		
PLASTICITY INDEX	NP	% GRAVEL	43.7
% PASSING NO. 4 SIEVE	56.3	% SAND	27.7
% PASSING NO. 10 SIEVE	48.2	% FINE	28.6
% PASSING NO. 40 SIEVE	38.1		
% PASSING NO. 200 SIEVE	28.6		
AASHTO M-145 CLASSIFICATION	A-2-4		
GROUP INDEX	0		
USCS	GM		

VICTOR E. RIVERA ASSOCIATES
GEOTECHNICAL ENGINEERS

A.E.S. Plant
Guayama, PR
A.E.S. Puerto Rico

DATE	TEST NO.	
12/23/2005	2	APPROVED

Client: AES Plant, [illegible]   Date 01/23/06

Project [illegible]

Sample Source [illegible] Plant

Sample Description: [illegible]

Type of Proctor Test ☐ Standard ☑ Modified

Mold Diameter (in) 6.0   Sample Height (in) 4.5   Sample Volume (ft³) 0.0[illegible]

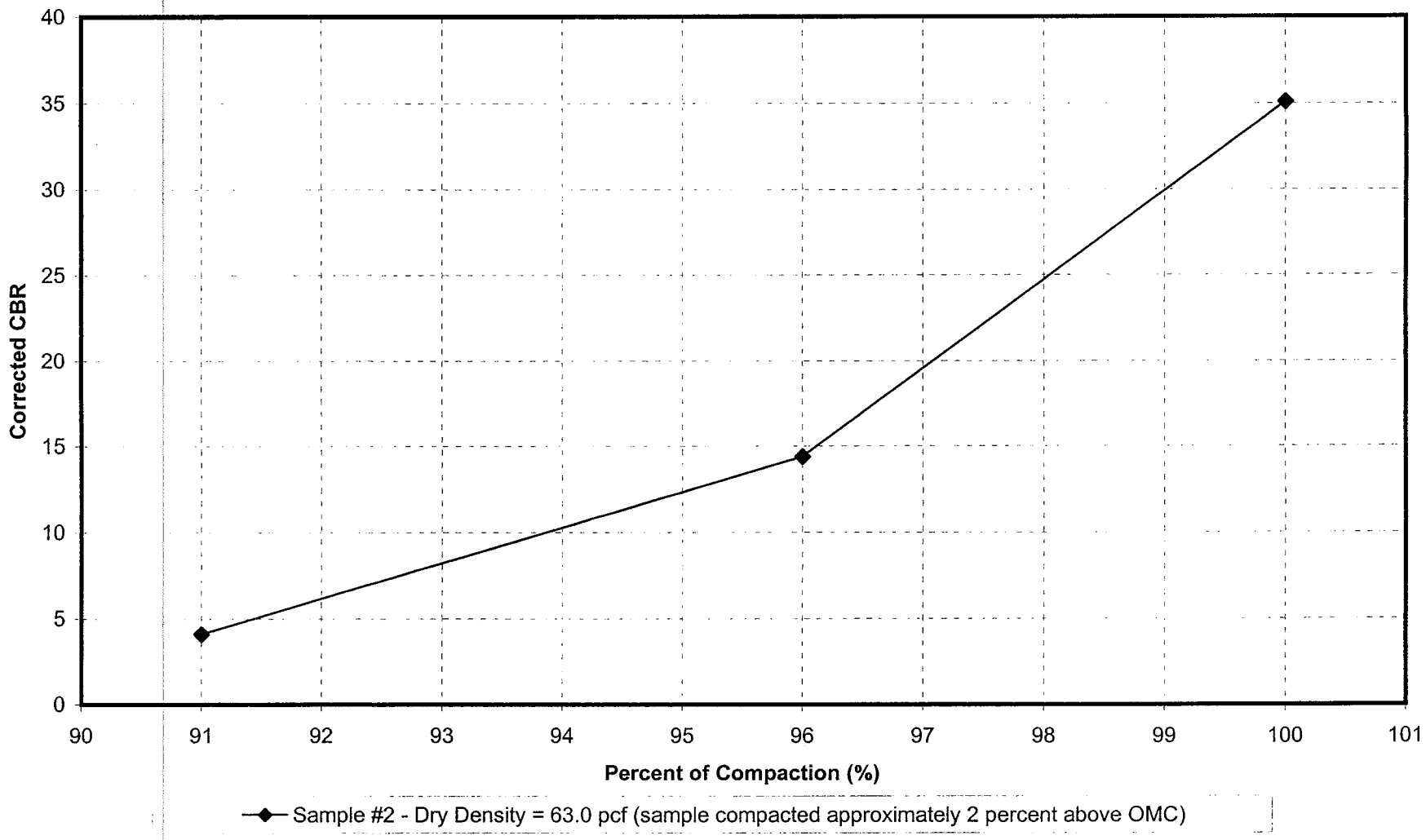
Point No.	10 Blows		25 Blows		56 Blows	
Wt Compacted Soil	6814.1#		6791.4#		1098.3#	
Mold Weight	4238.0#		4229#		4226.0#	
Tare No.	215	164	187	30	144	204
Wet Weight	133.47g	126.20g	126.19g	120.12g	106.08g	110.23g
Dry Weight	99.06g	99.70g	100.53g	97.09g	86.37g	89.37g
Moisture	35.2%	36.4%	26.4%	34.9%	35.5%	35.0%
Average Moisture	26.8%		35.7%		35.3%	
Dry Density (pcf)	[illegible].3 (99%)		60.8 (97%)		63.4 (100%)	
Initial Dial Reading	1.000		0.000		2.000	
day 1 1/24/06	1.000		0.008		2.009	
day 2 1/25/06	1.000		0.008		2.010	
day 3 1/26/06	1.001		0.009		2.011	
day 4						
Swell (in)	0.001		0.009		0.011	
Swell (%)	0.02		0.20		0.24	

Wt. after Soaking	9120.4#			10425.8#			10443.8#		
Tare No.	T 94	C 109	B 100	T 207	C 73	B 85	T 86	C 143	B 203
Wet Weight (g)	125.89	125.45	143.57	153.31	154.27	143.54	146.97	140.11	144.53
Dry Weight (g)	88.26	88.10	98.23	107.83	110.49	99.51	102.73	100.90	100.70
Moisture (%)	66.6	65.5	47.4	61.8	65.1	65.4	62.4	56.5	[illegible].6
Average Moisture (%)	64.3			65.1			[illegible]2.0		
Dry Density (pcf)	57.2 (91%)			60.7 (96%)			[illegible]1 (100%)		

Technician : [illegible]   Engineer : [illegible]

California Bearing Ratio (CBR)

Pecent of Compaction Versus CBR



Campbell

TEXAS A&M UNIVERSITY
Department of Civil Engineering

Dallas N. Little Ph.D., P.E.
E.B. Snead Chair Professor

November 16, 2004

Technical Memorandum
Comparison of Rock Fly Ash with AASHTO Classification A-2-4 Fill Material

Prepared by: Dallas N. Little
To: Mr. Neil Watlington, AES, Puerto Rico

My opinion is that the Rock Fly Ash (RFA) will perform very well as a fill material and should be equal or superior to an AASHTO classification A-2-4 material from a structural standpoint. An A-2-4 soil classification allows up to 35 percent fine material (smaller than 75 μm), a liquid limit of up to 40 percent, and a plasticity index of up to 10 percent. In a typical RFA gradation, less than about 5 percent is smaller than 75 μm, and the material is essentially non-plastic. The smaller fines-content is an advantage for the RFA and generally lessens it moisture sensitivity. While some plasticity in the A-2-4 may be beneficial as it provides some cohesive strength, the inherent pozzolanic activity of the fly ash provides substantial and more than offsets the benefit of natural soil cohesion in the A-2-4, in my view.

Our testing has shown that over time of curing (about 28-days) the RFA will achieve a compressive strength of about 50 to 70 psi. Some of this strength will be lost upon saturation, but the residual strength would be substantially greater than that of the A-2-4 soil. Furthermore, resilient modulus testing shows that the resilient modulus; which defines the ability of the fill to spread load and protect soft, underlying soil; of the RFA will be substantially greater than the resilient modulus of a typical A-2-4. Finally, we have just completed California Bearing Ratio (CBR) testing that shows a typical CBR value of the RFA to be around 30 percent after the traditional 4-day soak period. This compares to a typical CBR value of an A-2-4 of less than 10 percent.

In summary, from a structural standpoint alone, the RFA will provide an excellent fill. Some expansive potential is present with the RFA depending on the age of the RFA and the processing variances. The impact of expansion potential must be evaluated on a case-by-case basis.