CUMBERLAND

Dry Fly Ash (Units 1-2)
Bottom Ash - From Pond
Scrubber Gypsum

CUMBERLAND

Dry Fly Ash (Units 1-2)

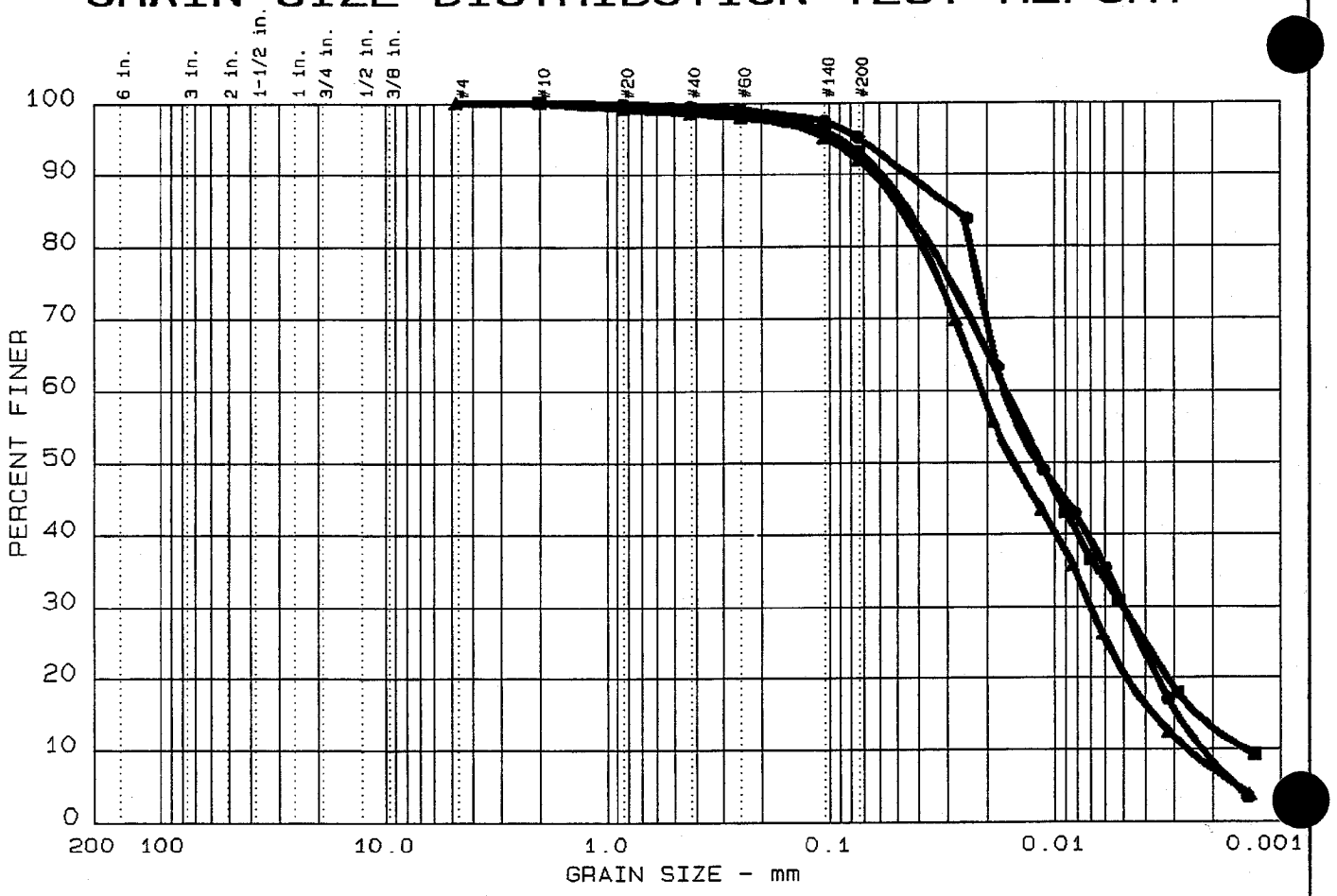
Grain Size Distribution Test Report
Moisture-Density Relationship (Standard Proctor)
Moisture-Density Relationship (Modified Proctor)
Consolidation Test Report
Hydraulic Conductivity - Falling Head (2 Pages)
Triaxial Compression Test (2 Pages)
Direct Shear Test
California Bearing Ratio
Resilient Modulus (Standard Proctor) (9 Pages)
Resilient Modulus (Modified Proctor) (9 Pages)

TVA - CUMBERLAND
DRY FLY ASH (UNITS 1-2)

Description	Test Method	Property	Sample 1	Sample 2	Sample 3
Grain Size	ASTM D 422	Percent Retained on the #4 Sieve Percent Passing the #200 Sieve Percent Passing the 0.005 mm Sieve	0.0 95.1 30.0	0.0 92.0 20.7	0.0 93.2 29.8
Atterberg Limits	ASTM D 4318	Liquid Limit Plastic Limit Plasticity Index	NL NP N/A	NL NP N/A	NL NP N/A
Specific Gravity	ASTM D 854	Specific Gravity at 20°C	2.57	2.64	2.65
Classification	ASTM D 2487 AASHTO M 145	Unified Soil Classification System (USCS) AASHTO Classification	ML A-4(0.0)	ML A-4(0.0)	ML A-4(0.0)
			Composite Sample		
Moisture-Density Relations (Standard Effort)	ASTM D 698	Maximum Dry Density, pcf Optimum Moisture Content, %	111.4 13.2		
Moisture-Density Relations (Modified Effort)	ASTM D 1557	Maximum Dry Density, pcf Optimum Moisture Content, %	116.3 11.5		
			Result	Dry Density, pcf	Moisture Content, %
Consolidation	ASTM D2435	Compression Index C_c	0.01	104.8	11.6
Hydraulic Conductivity	ASTM D 5084	Hydraulic Conductivity, cm/sec	2.2E-5	106.3	12.4
Triaxial Shear Strength Consolidated-Undrained (CU)	ASTM D4767	Effective Stress, Cohesion, c', ksf Effective Stress, Internal Friction Angle, ϕ',degrees	0.00 53.5	106.3	12.2
		Total Stress, Cohesion, c, ksf Total Stress, Internal Friction Angle, ϕ, degrees	1.70 50.5	106.3	12.2
Direct Shear Strength	ASTM D 3080	Cohesion, c, ksf Internal Friction Angle, ϕ, degrees	2.53 33.4	93.7	12.9
California Bearing Ratio	ASTM D 1883	CBR, %	24	106.6	13.1
Resilient Modulus (Standard Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	11,612	104.4	13.0
Resilient Modulus (Modified Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	19,021	107.6	10.2
Soil Resistivity	AASHTO T 288	Minimum Resistivity, Ohm-cm	2,600		
pH of Soil	AASHTO T 289	pH	11.6		
Water Soluble Sulfate Ion	AASHTO T 290	Sulfate Ion Content, mg/kg	5020		
Water Soluble Chloride Ion	AASHTO T 290	Chloride Ion Content, mg/kg	<10		

cuf-fa.xls

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	15	0.0	0.0	4.9	65.1	30.0
▲	16	0.0	0.0	8.0	71.3	20.7
■	17	0.0	0.0	6.8	63.4	29.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	NL	NP			0.01	0.005	0.0029	0.0022	0.67	7.5
▲	NL	NP			0.02	0.007	0.0037	0.0026	0.89	8.1
■	NL	NP			0.01	0.005	0.0024	0.0014	1.07	11.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Units 1-2	ML	A-4 (0.0)
▲ Units 1-2	ML	A-4 (0.0)
■ Units 1-2	ML	A-4 (0.0)

Project No.: 5810860101
Project: TVA - Cumberland
● Location: Dry Fly Ash A & B
▲ Location: Dry Fly Ash C & D
■ Location: Dry Fly Ash E & F
Date: July 18, 1995

GRAIN SIZE DISTRIBUTION TEST REPORT

LAW ENGINEERING, INC.

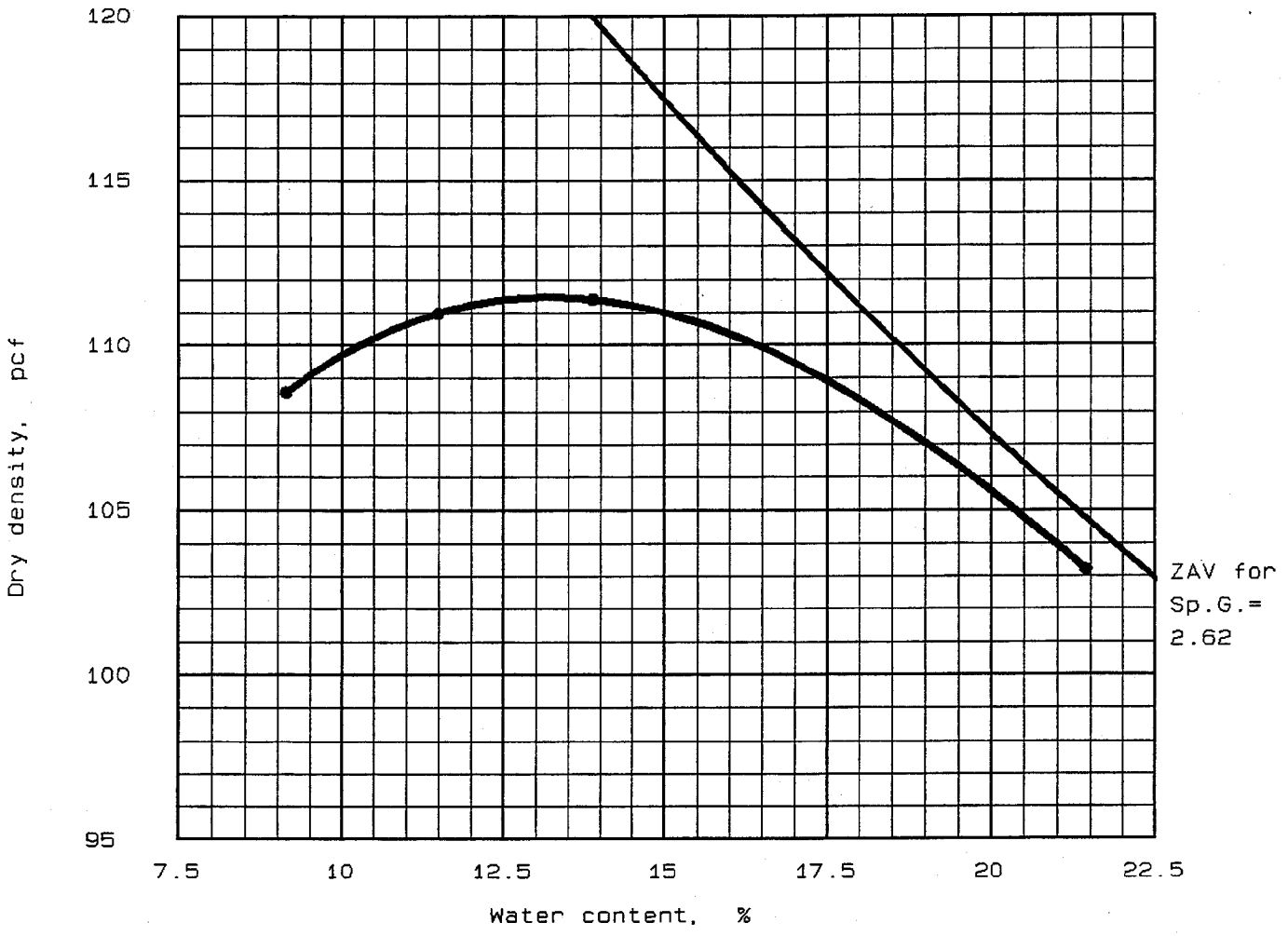
Remarks:

Tested by: JCR

Reviewed by: HS

Figure No.

MOISTURE-DENSITY RELATIONSHIP



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	ML	A-4(0.0)	.160 %	2.62	NL	NP	0 %	93.4 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 13.2 % Maximum dry density = 111.4 pcf	

Project No.: 5810860101
Project: TVA - Cumberland
Location: Dry Fly Ash
Units 1-2
Date: July 25, 1995

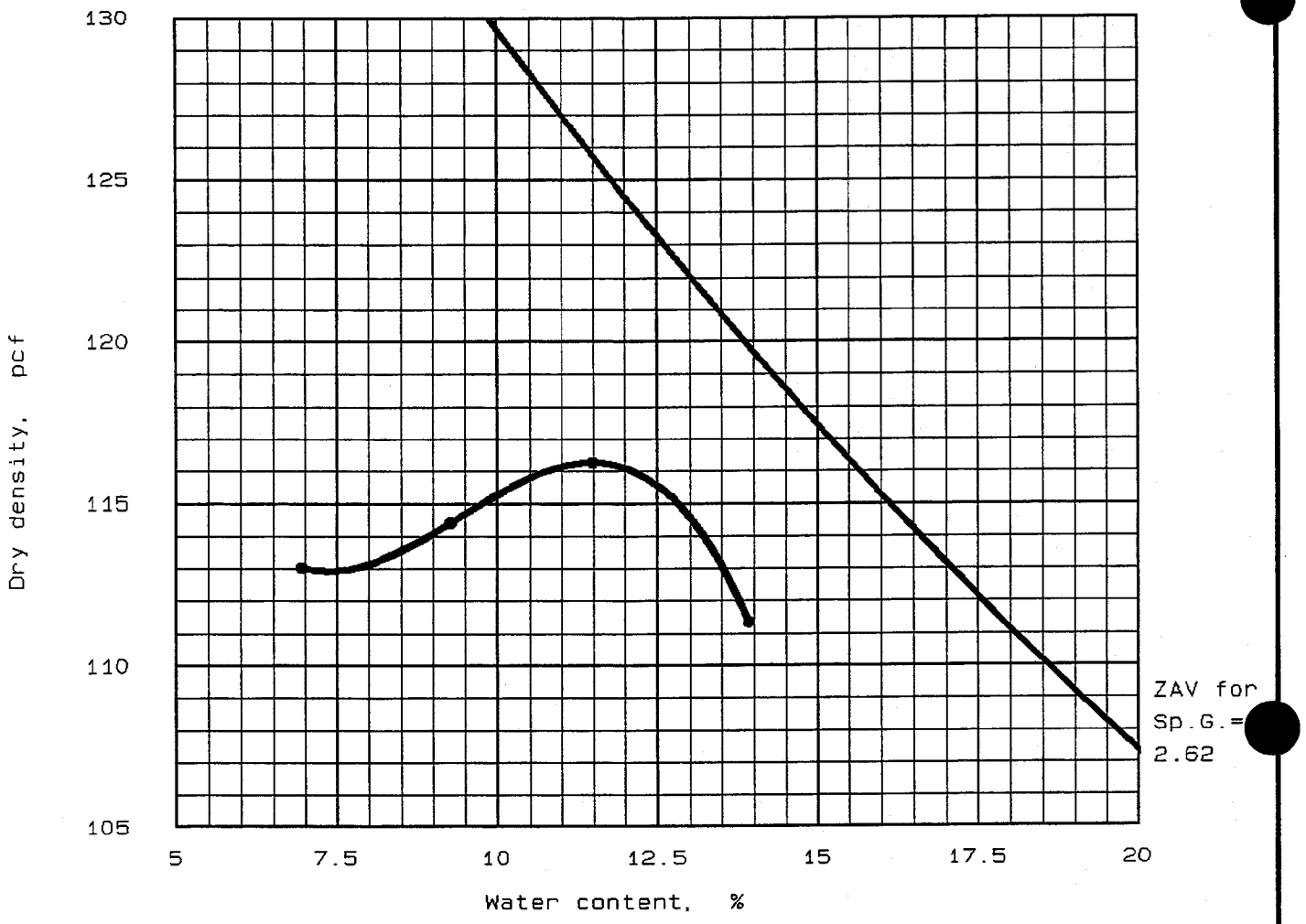
Remarks:
Tested by: JCR
Reviewed by: HS/RWB

MOISTURE-DENSITY RELATIONSHIP

LAW ENGINEERING, INC.

Figure No. _____

MOISTURE-DENSITY RELATIONSHIP



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	ML	A-4 (0.0)	.160 %	2.62	NL	NP	0 %	93.4 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 11.5 % Maximum dry density = 116.3 pcf	

Project No.: 5810860101
Project: TVA - Cumberland
Location: Dry Fly Ash
Units 1-2
Date: July 25, 1995

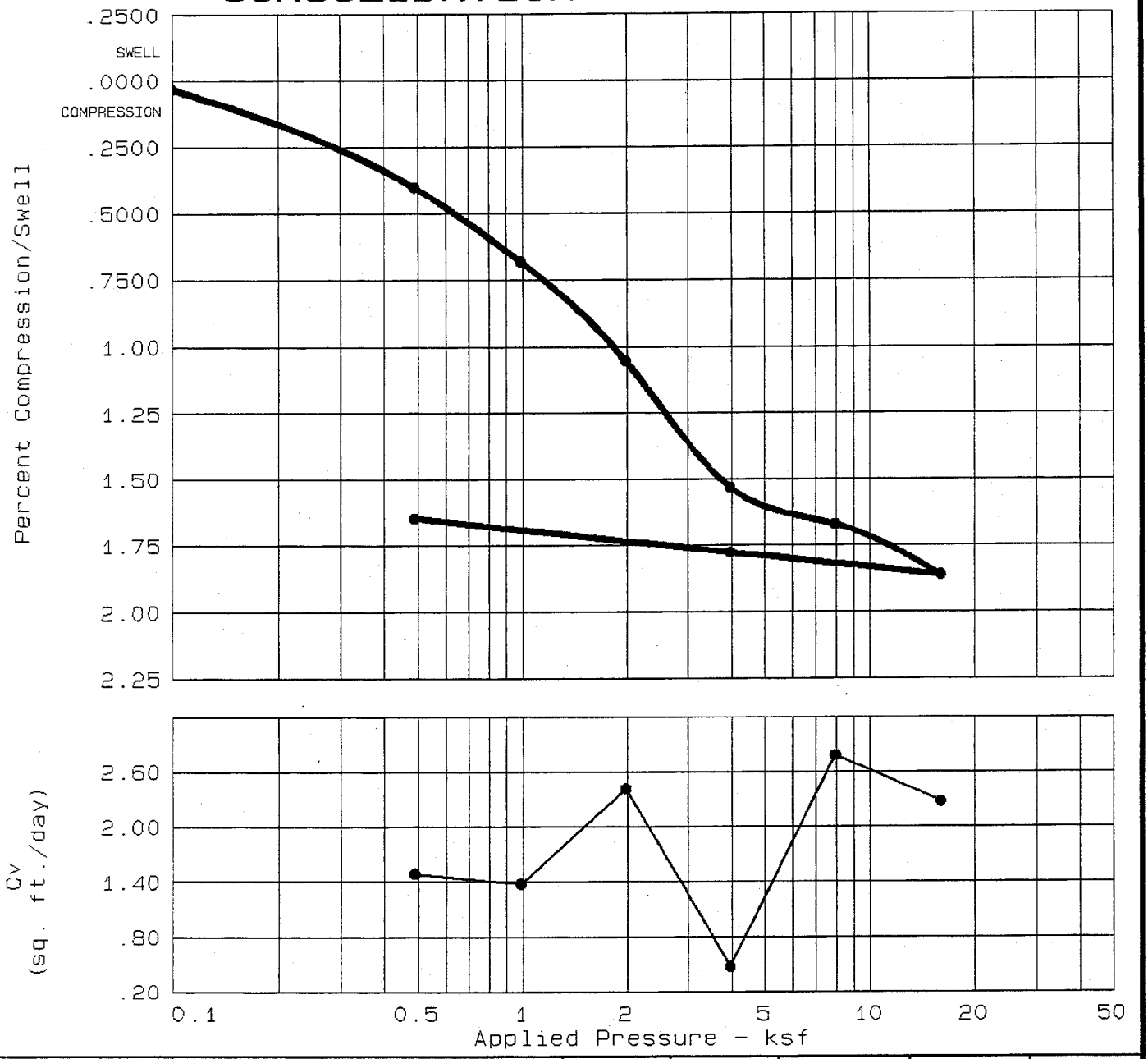
Remarks:
Tested by: JCL
Reviewed by: RWB

MOISTURE-DENSITY RELATIONSHIP

LAW ENGINEERING, INC.

Figure No. _____

CONSOLIDATION TEST REPORT



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_C	e_0
54.1 %	11.6	104.8	NL	NP	2.620	11.98	0.01	0.5600

TEST RESULTS

Compression Index = 0.01

MATERIAL DESCRIPTION

Class: USCS: ML

Project No.: 5810860101
Project: TVA - Cumberland
Location: Dry Fly Ash
Units 1-2
Date: July 11, 1995

Remarks:

Tested by: ADK
Reviewed by: HD

CONSOLIDATION TEST REPORT

LAW ENGINEERING, INC.

Fig. No. _____

HYDRAULIC CONDUCTIVITY

LAW ENGINEERING

Project No.	*5810860101*	Tested By	*HEJ*
Project Name	*TVA - Cumberland*	Test Date	*06/05/95*
Material (Source)	*Dry Fly Ash (Units 1-2)*	Reviewed By	*RLB*
		Review Date	*09/06/95*

ASTM D5084 - Falling Head

Sample Type:	*Remolded*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*12.4*
Wet Unit Weight, pcf:	*119.4*
Dry Unit Weight, pcf:	*106.3*
Compaction, %:	*95.4*
Hydraulic Conductivity, cm/sec. @20 °C:	***2.2E-05***

PERMEABILITY TEST - FALLING HEAD
(ASTM D5084 - 90)

LAW ENGINEERING

Job Number	5810860101	Tested By	HEJ
Project Name	TVA - Cumberland	Test Date	06/05/95
Material (Source)	Dry Fly Ash (Units 1-2)	Reviewed By	RLB
		Review Date	09/06/95

Sample Data

Length, in		Diameter, in		Pan No.	
Location 1	6.000	Location 1	2.830	Dry Soil+Pan, grams	1100.00
Location 2	6.000	Location 2	2.830	Pan Weight, grams	47.35
Location3	6.000	Location 3	2.830		
Average	6.000	Average	2.830	Moisture Content, %	12.4
		Wet Soil + Tare, grams	1182.83	Wet Unit Wt, pcf	119.4
		Tare Weight, grams	0.00	Dry Unit Wt, pcf	106.3

Chamber Pressure, psi	47
Back Pressure, psi	33
Confining Pressure, psi	14

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	Division Start	Division Finish	H0 (cm)	Hf (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				3000	0.0	20.0	128.25	108.25	2.1E-05	21	2.1E-05
				3600	0.0	25.0	128.25	103.25	2.3E-05	21	2.2E-05
				3400	0.0	24.0	128.25	104.25	2.3E-05	21	2.2E-05

No. of Trial	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
3	Remolded	111.4	95.4	Vertical

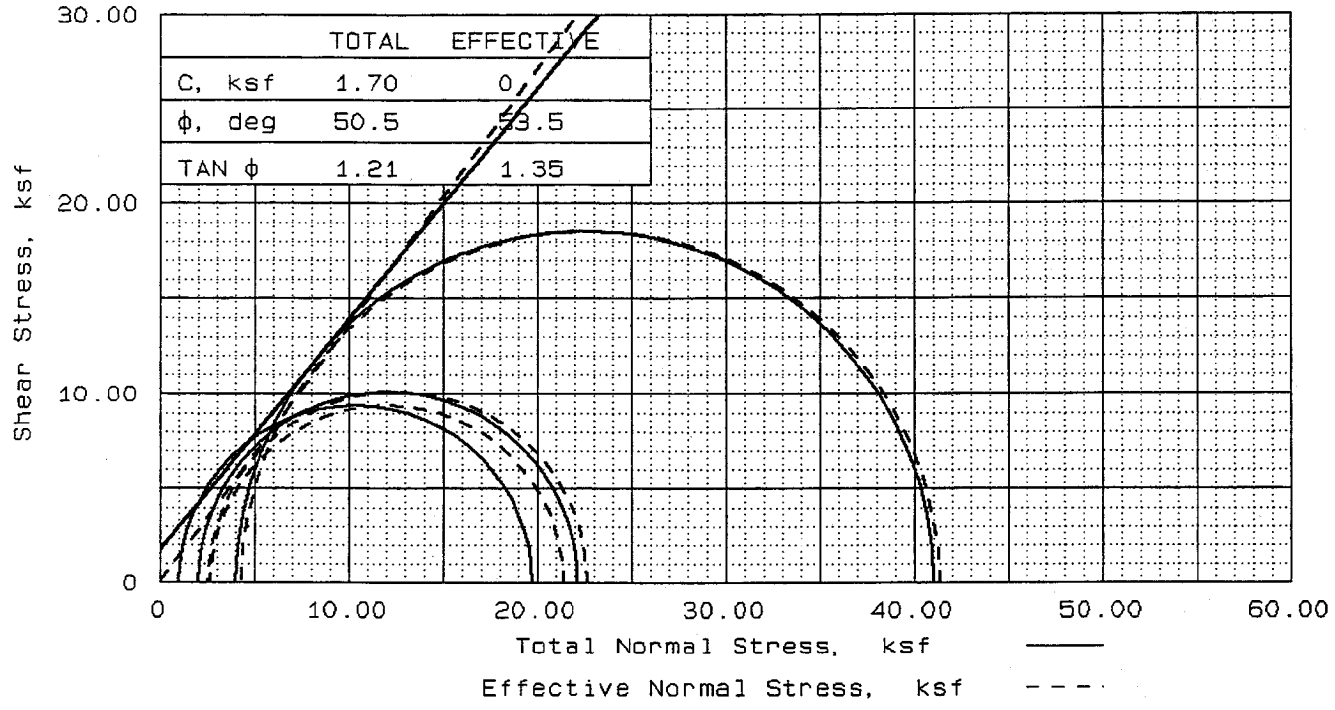
Avg. k at 20 °C 2.2E-05 cm/sec

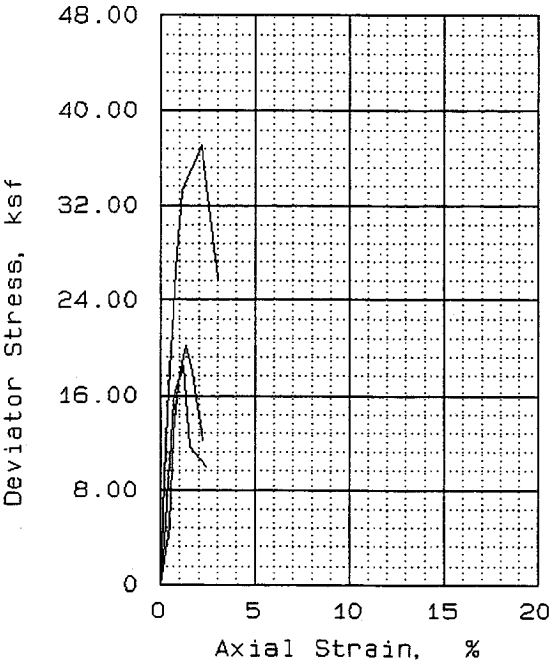
a = area of burette in cm²
L = length of sample in cm
A = area of sample in cm²

H_0 = initial head in cm
H_f = final head in cm
t = time in seconds

a = 1.00 cm²
A = 40.582 cm²
L = 15.24 cm

TVA-00011868





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	12.2	12.4	12.1
	DRY DENSITY, pcf	106.3	106.3	106.4
	SATURATION, %	59.6	60.1	59.3
	VOID RATIO	0.538	0.539	0.537
	DIAMETER, in	2.83	2.83	2.83
	HEIGHT, in	6.00	6.00	6.00
AT TEST	WATER CONTENT, %	20.5	20.3	20.1
	DRY DENSITY, pcf	106.5	106.8	107.1
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.536	0.531	0.527
	DIAMETER, in	2.84	2.82	2.82
	HEIGHT, in	5.97	6.00	6.00
BACK PRESSURE, ksf		4.08	2.94	4.09
CELL PRESSURE, ksf		5.07	4.94	8.09
FAILURE STRESS, ksf		18.74	20.16	37.05
PORE PRESSURE, ksf		2.40	2.43	3.80
STRAIN RATE, %/min.		0.100	0.100	0.100
ULTIMATE STRESS, ksf				
PORE PRESSURE, ksf				
$\bar{\sigma}_1$ FAILURE, ksf		21.41	22.67	41.35
$\bar{\sigma}_3$ FAILURE, ksf		2.67	2.51	4.29

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Remolded
DESCRIPTION:

LL= NL PL= NP PI=
SPECIFIC GRAVITY= 2.62
REMARKS: Tested by: HJ

Reviewed by: RLB

FIG. NO.

CLIENT:

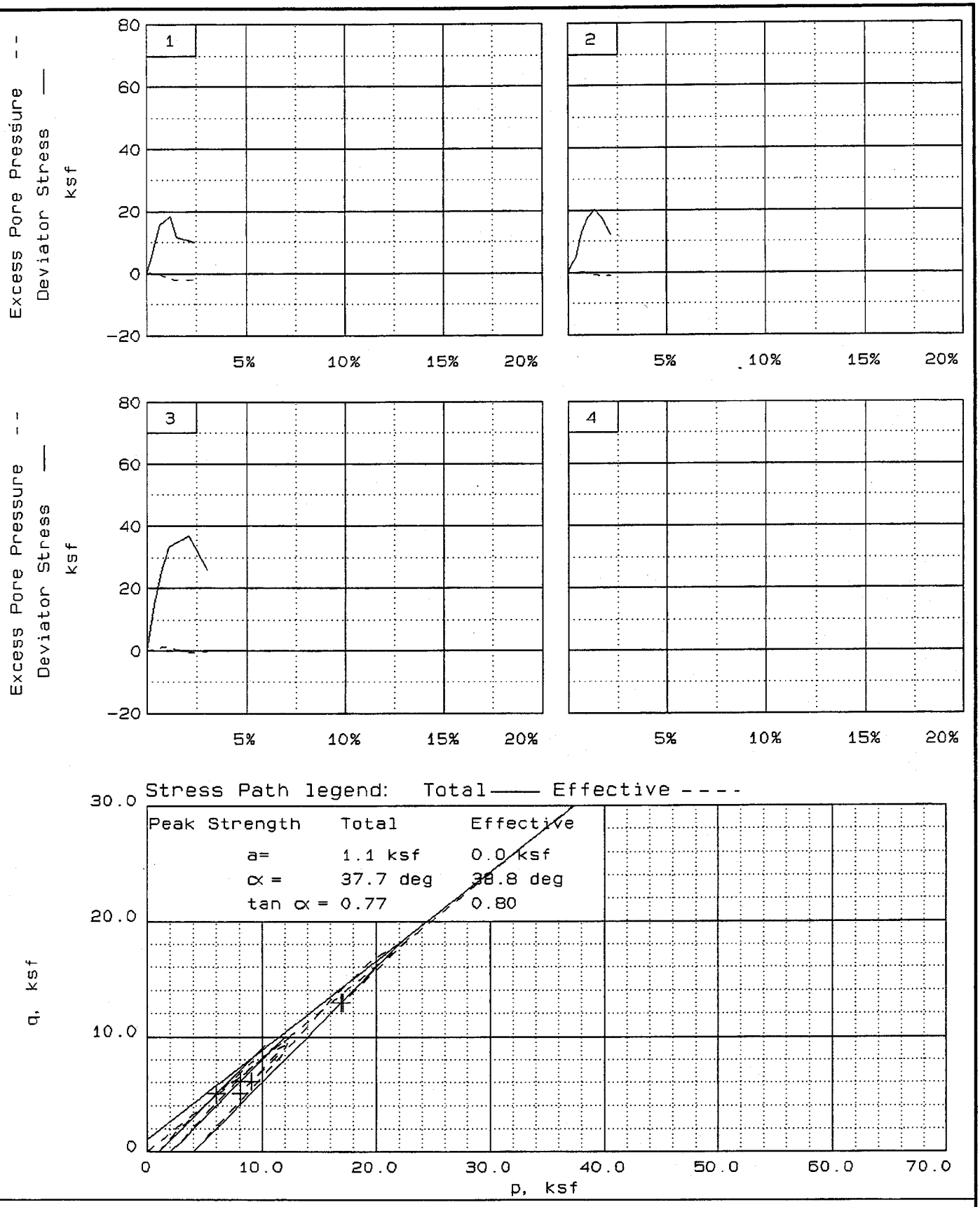
PROJECT: TVA - Cumberland

SAMPLE LOCATION: Dry Fly Ash
Units 1-2

PROJ. NO.: 5810860101 DATE: August 23, 1995

TRIAXIAL COMPRESSION TEST

LAW ENGINEERING, INC.

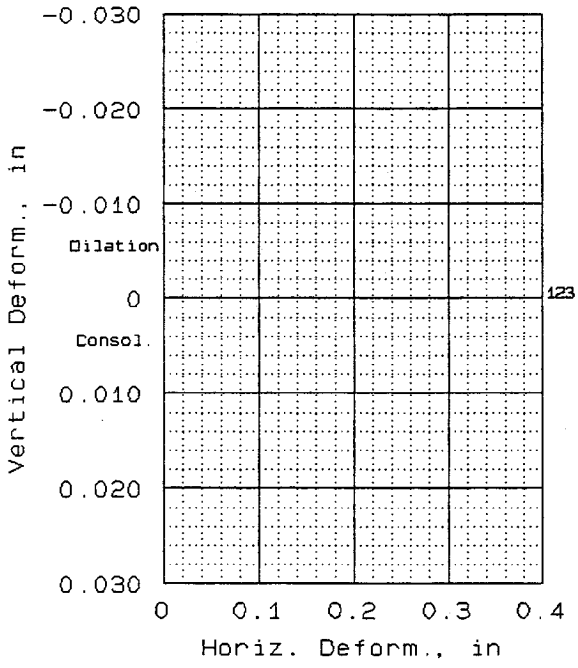


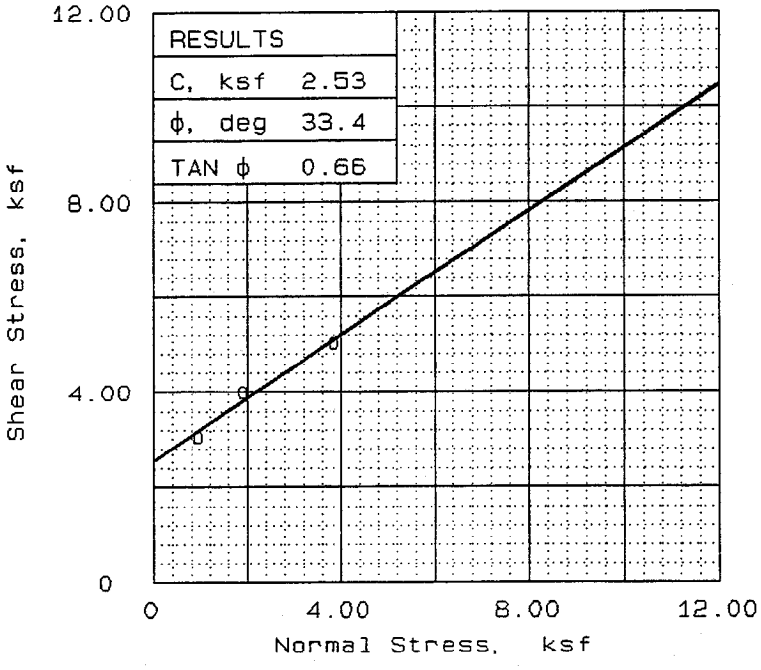
Client:

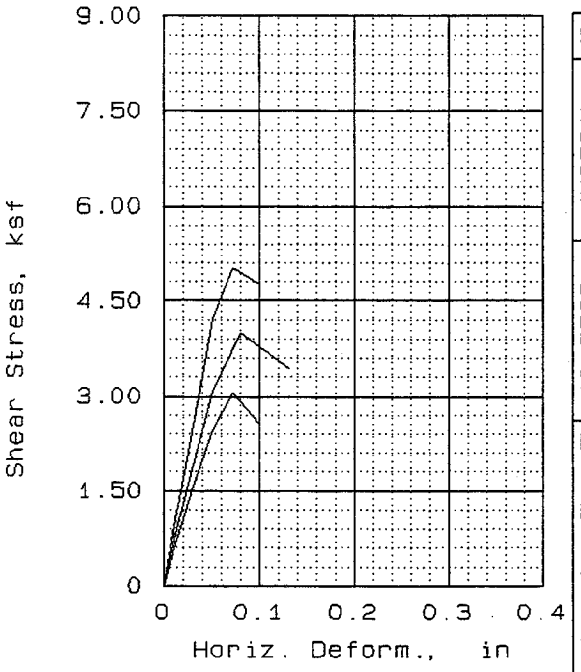
Project: TVA - Cumberland

Location: Dry Fly Ash Units 1-2

File: 8601D Project No.: 5810860101 Page 2/2 Fig. No. ____







SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	13.0	12.9	12.8
	DRY DENSITY, pcf	94.6	93.1	93.4
	SATURATION, %	46.8	44.6	44.8
	VOID RATIO	0.728	0.757	0.750
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.81	0.81	0.81
AT TEST	WATER CONTENT, %	13.0	12.9	12.8
	DRY DENSITY, pcf	94.6	93.1	93.4
	SATURATION, %	46.8	44.6	44.8
	VOID RATIO	0.728	0.757	0.750
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.81	0.81	0.81
NORMAL STRESS, ksf		0.97	1.94	3.88
MAX. SHEAR, ksf		3.04	4.00	5.02
STRAIN RATE, %/min.		0.500	0.500	0.500
ULT. SHEAR, ksf				

SAMPLE DATA

SAMPLE TYPE: Remolded

DESCRIPTION:

LL= NL PL= NP PI=

SPECIFIC GRAVITY= 2.62

REMARKS: Tested by: KS

Reviewed by: RLB

FIG. NO.

CLIENT:

PROJECT: TVA - Cumberland

SAMPLE LOCATION: Dry Fly Ash
Units 1-2

PROJ. NO.: 5810860101 DATE: August 23, 1995

DIRECT SHEAR TEST

LAW ENGINEERING, INC.

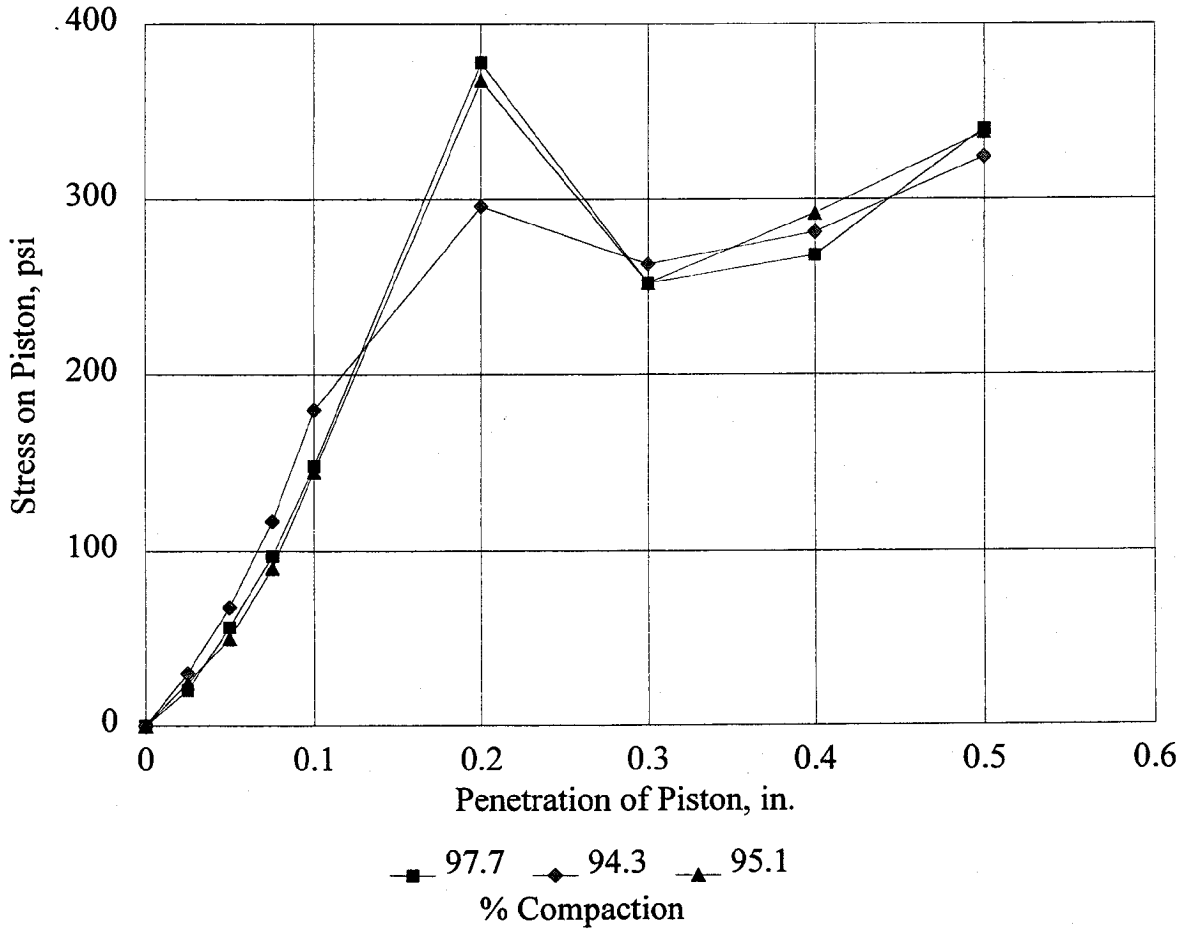
California Bearing Ratio

(ASTM D1883-92)

LAW ENGINEERING

Project No.	5810860101	**Tested By**	EM
Project Name	TVA - Cumberland	**Test Date**	07/20/95
Material (Source)	Dry Fly Ash (Units 1-2)	**Reviewed By**	RLB
		Review Date	08/23/95

Compaction, %	97.7	94.3	95.1
Before Soak Dry Density, pcf	108.8	105.1	105.9
Before Soak Moisture Content,	13.2	13.0	13.0
After Soak Dry Density, pcf	104.0	100.8	101.6
After Soak Moisture Content, %	21.1	22.2	22.2
CBR @ 0.1 in.	14.8	18.0	14.5
CBR @ 0.2 in.	25.2	19.7	24.5



LABORATORY MATERIAL HANDLING AND TESTING SHEET NO 1 OF 2

LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: **LAW ENGINEERING, INC. - ATLANTA, GEORGIA**

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland	
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)	
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content	
4.	*MATERIAL TYPE* (Type 1 or Type 2)		2
5.	*TEST INFORMATION*		
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)		N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)		N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)		15
6.	*SPECIMEN INFO.*:		
	SPECIMEN DIAM., inch		
	TOP		2.86
	MIDDLE		2.86
	BOTTOM		2.86
	AVERAGE		2.86
	MEMBRANE THICKNESS (1), inch		0.01
	MEMBRANE THICKNESS (2), inch		0.01
	NET DIAM., inch		2.84
	HEIGHT OF SPECIMEN, CAP AND BASE, inch		6.04
	HEIGHT OF CAP AND BASE, inch		0.00
	INITIAL LENGTH, L_0, inch		6.04
	INITIAL AREA, A_0, in^2		6.32
	INITIAL VOLUME A_0L_0, in^3		38.19
7.	*SOIL SPECIMEN WEIGHT*:		
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams		1183.24
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams		0.00
	WEIGHT OF WET SOIL USED, grams		1183.24
8.	*SOIL PROPERTIES*.:		
	IN SITU MOISTURE CONTENT (NUCLEAR), %		N/A
	IN SITU WET DENSITY (NUCLEAR), pcf		N/A
	or		
	OPTIMUM MOISTURE CONTENT, %		13.2
	MAX. DRY DENSITY, pcf		111.4
	95 % MAX. DRY DENSITY, pcf		105.8
9.	*SPECIMEN PROPERTIES:*		
	COMPACTION MOISTURE CONTENT, %		13.0
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %		13.9
	COMPACTION DRY DENSITY, γ_d pcf		104.4
10.	*QUICK SHEAR TEST*		
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)		Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi		38.5
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)		Y
11.	*COMMENTS* (Section 10.4 of Protocol P46)		
	(a) *CODE*	0 0 0 0 0 0	
	(b) *NOTE*		
12.	*TEST DATE*		07-25-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

R J Boudreau 9/5/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Dry Fly Ash (Units 1-2)
3. *REMOLDING TARGETS:* 95% Standard Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 07-25-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P'_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε	
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	_ _ _ ._	_ _ _ ._	_	_ _ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ ._	_ ._ _ _ _ _	_ ._ _ _ _ _	_ ._ _ _ _ _	_ ._ _ _ _ _	_ _ _ _ .
SEQUENCE 1	6.0	2.0	1	12.8	11.5	1.3	2.0	1.8	0.2	0.00078	0.00072	0.00075	0.00012	14,611
			2	12.8	11.5	1.3	2.0	1.8	0.2	0.00079	0.00073	0.00076	0.00013	14,479
			3	12.8	11.5	1.3	2.0	1.8	0.2	0.00078	0.00073	0.00076	0.00013	14,492
			4	12.8	11.5	1.3	2.0	1.8	0.2	0.00080	0.00073	0.00076	0.00013	14,348
			5	12.8	11.4	1.3	2.0	1.8	0.2	0.00077	0.00073	0.00075	0.00012	14,624
	COLUMN AVERAGE			12.8	11.5	1.3	2.0	1.8	0.2	0.00078	0.00073	0.00076	0.00013	14,511
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	113

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	1	25.4	22.9	2.4	4.0	3.6	0.4	0.00142	0.00132	0.00137	0.00023	16,003
			2	25.3	22.9	2.4	4.0	3.6	0.4	0.00141	0.00132	0.00136	0.00023	16,084
			3	25.3	22.9	2.4	4.0	3.6	0.4	0.00141	0.00134	0.00137	0.00023	15,926
			4	25.3	22.9	2.4	4.0	3.6	0.4	0.00141	0.00132	0.00136	0.00023	16,052
			5	25.3	22.9	2.4	4.0	3.6	0.4	0.00144	0.00132	0.00138	0.00023	15,818
	COLUMN AVERAGE			25.3	22.9	2.4	4.0	3.6	0.4	0.00142	0.00132	0.00137	0.00023	15,976
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	107
SEQUENCE 3	6.0	6.0	1	37.9	34.2	3.7	6.0	5.4	0.6	0.00227	0.00217	0.00222	0.00037	14,762
			2	37.9	34.2	3.7	6.0	5.4	0.6	0.00228	0.00216	0.00222	0.00037	14,762
			3	37.9	34.2	3.7	6.0	5.4	0.6	0.00228	0.00215	0.00222	0.00037	14,749
			4	37.9	34.2	3.7	6.0	5.4	0.6	0.00229	0.00215	0.00222	0.00037	14,727
			5	37.9	34.1	3.7	6.0	5.4	0.6	0.00228	0.00217	0.00223	0.00037	14,680
	COLUMN AVERAGE			37.9	34.2	3.7	6.0	5.4	0.6	0.00228	0.00216	0.00222	0.00037	14,736
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	34
SEQUENCE 4	6.0	8.0	1	50.7	45.6	5.1	8.0	7.2	0.8	0.00324	0.00311	0.00317	0.00053	13,745
			2	50.6	45.6	5.0	8.0	7.2	0.8	0.00327	0.00314	0.00321	0.00053	13,597
			3	50.7	45.6	5.1	8.0	7.2	0.8	0.00327	0.00312	0.00320	0.00053	13,649
			4	50.6	45.5	5.0	8.0	7.2	0.8	0.00326	0.00311	0.00318	0.00053	13,674
			5	50.5	45.5	5.1	8.0	7.2	0.8	0.00327	0.00313	0.00320	0.00053	13,573
	COLUMN AVERAGE			50.6	45.6	5.1	8.0	7.2	0.8	0.00326	0.00312	0.00319	0.00053	13,648
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00001	0.00001	0.00000	68

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	1	63.0	56.8	6.2	10.0	9.0	1.0	0.00424	0.00413	0.00419	0.00069	12,983
			2	63.0	56.8	6.2	10.0	9.0	1.0	0.00427	0.00415	0.00421	0.00070	12,900
			3	63.0	56.8	6.2	10.0	9.0	1.0	0.00427	0.00414	0.00421	0.00070	12,922
			4	63.0	56.8	6.2	10.0	9.0	1.0	0.00423	0.00412	0.00418	0.00069	13,024
			5	63.0	56.8	6.2	10.0	9.0	1.0	0.00427	0.00415	0.00421	0.00070	12,913
	COLUMN AVERAGE			63.0	56.8	6.2	10.0	9.0	1.0	0.00425	0.00414	0.00420	0.00069	12,949
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00002	0.00002	0.00002	0.00000	53
SEQUENCE 6	4.0	2.0	1	13.2	11.6	1.6	2.1	1.8	0.3	0.00095	0.00088	0.00091	0.00015	12,094
			2	13.2	11.6	1.6	2.1	1.8	0.3	0.00094	0.00089	0.00091	0.00015	12,110
			3	13.2	11.6	1.6	2.1	1.8	0.3	0.00094	0.00087	0.00090	0.00015	12,275
			4	13.2	11.6	1.6	2.1	1.8	0.3	0.00092	0.00088	0.00090	0.00015	12,316
			5	13.1	11.5	1.6	2.1	1.8	0.3	0.00094	0.00087	0.00091	0.00015	12,140
	COLUMN AVERAGE			13.2	11.6	1.6	2.1	1.8	0.3	0.00094	0.00088	0.00091	0.00015	12,187
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	101
SEQUENCE 7	4.0	4.0	1	25.3	23.4	1.9	4.0	3.7	0.3	0.00188	0.00179	0.00183	0.00030	12,194
			2	24.8	22.9	2.0	3.9	3.6	0.3	0.00182	0.00174	0.00178	0.00029	12,297
			3	24.8	22.8	2.0	3.9	3.6	0.3	0.00184	0.00176	0.00180	0.00030	12,137
			4	25.0	23.1	1.9	4.0	3.7	0.3	0.00185	0.00176	0.00180	0.00030	12,267
			5	24.9	22.9	1.9	3.9	3.6	0.3	0.00184	0.00174	0.00179	0.00030	12,275
	COLUMN AVERAGE			25.0	23.0	1.9	3.9	3.6	0.3	0.00184	0.00175	0.00180	0.00030	12,234
	STANDARD DEV.			0.2	0.2	0.0	0.0	0.0	0.0	0.00002	0.00002	0.00002	0.00000	66

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	1	37.8	34.3	3.5	6.0	5.4	0.5	0.00281	0.00269	0.00275	0.00046	11,914
			2	37.7	34.2	3.5	6.0	5.4	0.6	0.00283	0.00272	0.00277	0.00046	11,808
			3	37.7	34.2	3.5	6.0	5.4	0.6	0.00283	0.00270	0.00276	0.00046	11,823
			4	37.7	34.2	3.5	6.0	5.4	0.6	0.00282	0.00269	0.00276	0.00046	11,873
			5	37.8	34.3	3.5	6.0	5.4	0.5	0.00283	0.00270	0.00277	0.00046	11,873
	COLUMN AVERAGE			37.7	34.3	3.5	6.0	5.4	0.6	0.00282	0.00270	0.00276	0.00046	11,858
	STANDARD DEV.			0.0	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	43
SEQUENCE 9	4.0	8.0	1	50.5	45.6	4.9	8.0	7.2	0.8	0.00374	0.00364	0.00369	0.00061	11,828
			2	50.6	45.7	4.9	8.0	7.2	0.8	0.00374	0.00364	0.00369	0.00061	11,837
			3	50.5	45.6	4.9	8.0	7.2	0.8	0.00373	0.00364	0.00369	0.00061	11,840
			4	50.6	45.7	4.9	8.0	7.2	0.8	0.00374	0.00364	0.00369	0.00061	11,840
			5	50.5	45.6	4.9	8.0	7.2	0.8	0.00374	0.00362	0.00368	0.00061	11,859
	COLUMN AVERAGE			50.5	45.7	4.9	8.0	7.2	0.8	0.00374	0.00364	0.00369	0.00061	11,841
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	11
SEQUENCE 10	4.0	10.0	1	63.3	57.1	6.2	10.0	9.0	1.0	0.00461	0.00448	0.00455	0.00075	12,015
			2	63.3	57.1	6.2	10.0	9.0	1.0	0.00461	0.00450	0.00455	0.00075	12,008
			3	63.2	57.1	6.2	10.0	9.0	1.0	0.00463	0.00450	0.00456	0.00075	11,965
			4	63.4	57.2	6.2	10.0	9.1	1.0	0.00461	0.00450	0.00456	0.00075	12,009
			5	63.2	57.1	6.2	10.0	9.0	1.0	0.00461	0.00451	0.00456	0.00075	11,968
	COLUMN AVERAGE			63.3	57.1	6.2	10.0	9.0	1.0	0.00462	0.00450	0.00456	0.00075	11,993
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	24

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	1	13.6	11.6	2.0	2.1	1.8	0.3	0.00106	0.00101	0.00104	0.00017	10,712
			2	13.5	11.6	2.0	2.1	1.8	0.3	0.00103	0.00099	0.00101	0.00017	10,936
			3	13.5	11.6	1.9	2.1	1.8	0.3	0.00105	0.00100	0.00103	0.00017	10,802
			4	13.5	11.5	2.0	2.1	1.8	0.3	0.00105	0.00100	0.00103	0.00017	10,746
			5	13.6	11.6	1.9	2.1	1.8	0.3	0.00105	0.00101	0.00103	0.00017	10,771
	COLUMN AVERAGE			13.5	11.6	2.0	2.1	1.8	0.3	0.00105	0.00100	0.00103	0.00017	10,793
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	86
SEQUENCE 12	2.0	4.0	1	25.2	22.8	2.4	4.0	3.6	0.4	0.00211	0.00203	0.00207	0.00034	10,558
			2	25.2	22.8	2.4	4.0	3.6	0.4	0.00212	0.00203	0.00208	0.00034	10,485
			3	25.2	22.8	2.4	4.0	3.6	0.4	0.00212	0.00202	0.00207	0.00034	10,535
			4	25.3	22.9	2.4	4.0	3.6	0.4	0.00212	0.00203	0.00208	0.00034	10,528
			5	25.3	22.9	2.4	4.0	3.6	0.4	0.00210	0.00202	0.00206	0.00034	10,624
	COLUMN AVERAGE			25.2	22.8	2.4	4.0	3.6	0.4	0.00211	0.00203	0.00207	0.00034	10,546
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	51
SEQUENCE 13	2.0	6.0	1	38.0	34.3	3.7	6.0	5.4	0.6	0.00322	0.00312	0.00317	0.00052	10,361
			2	38.0	34.3	3.7	6.0	5.4	0.6	0.00324	0.00314	0.00319	0.00053	10,285
			3	38.0	34.3	3.7	6.0	5.4	0.6	0.00322	0.00312	0.00317	0.00052	10,360
			4	37.9	34.3	3.7	6.0	5.4	0.6	0.00324	0.00313	0.00318	0.00053	10,299
			5	38.0	34.3	3.7	6.0	5.4	0.6	0.00320	0.00312	0.00316	0.00052	10,397
	COLUMN AVERAGE			38.0	34.3	3.7	6.0	5.4	0.6	0.00323	0.00312	0.00318	0.00053	10,340
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00002	0.00001	0.00001	0.00000	47

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	1	50.7	45.8	4.9	8.0	7.2	0.8	0.00420	0.00409	0.00414	0.00069	10,574
			2	50.7	45.8	4.9	8.0	7.2	0.8	0.00422	0.00409	0.00415	0.00069	10,552
			3	50.8	45.9	4.9	8.0	7.3	0.8	0.00422	0.00411	0.00417	0.00069	10,535
			4	50.7	45.8	4.9	8.0	7.2	0.8	0.00420	0.00411	0.00415	0.00069	10,550
			5	50.7	45.8	4.9	8.0	7.2	0.8	0.00422	0.00411	0.00416	0.00069	10,521
	COLUMN AVERAGE			50.8	45.8	4.9	8.0	7.3	0.8	0.00421	0.00410	0.00416	0.00069	10,547
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	20
SEQUENCE 15	2.0	10.0	1	63.4	57.2	6.2	10.0	9.1	1.0	0.00512	0.00500	0.00506	0.00084	10,817
			2	63.5	57.3	6.2	10.1	9.1	1.0	0.00512	0.00502	0.00507	0.00084	10,819
			3	63.4	57.2	6.2	10.0	9.1	1.0	0.00510	0.00499	0.00504	0.00083	10,856
			4	63.4	57.2	6.2	10.0	9.1	1.0	0.00510	0.00500	0.00505	0.00084	10,838
			5	63.3	57.1	6.2	10.0	9.0	1.0	0.00511	0.00500	0.00506	0.00084	10,799
	COLUMN AVERAGE			63.4	57.2	6.2	10.0	9.1	1.0	0.00511	0.00500	0.00506	0.00084	10,826
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	22

SUBMITTED BY, DATE

RJ Boudreau 9/5/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	07-25-1995

$$M_R = K1\,(S_C)^{K2}\,(1+S_3)^{K5}$$

K1 =	7,531
K2 =	-0.03317
K5 =	0.34550
R^2 =	0.87

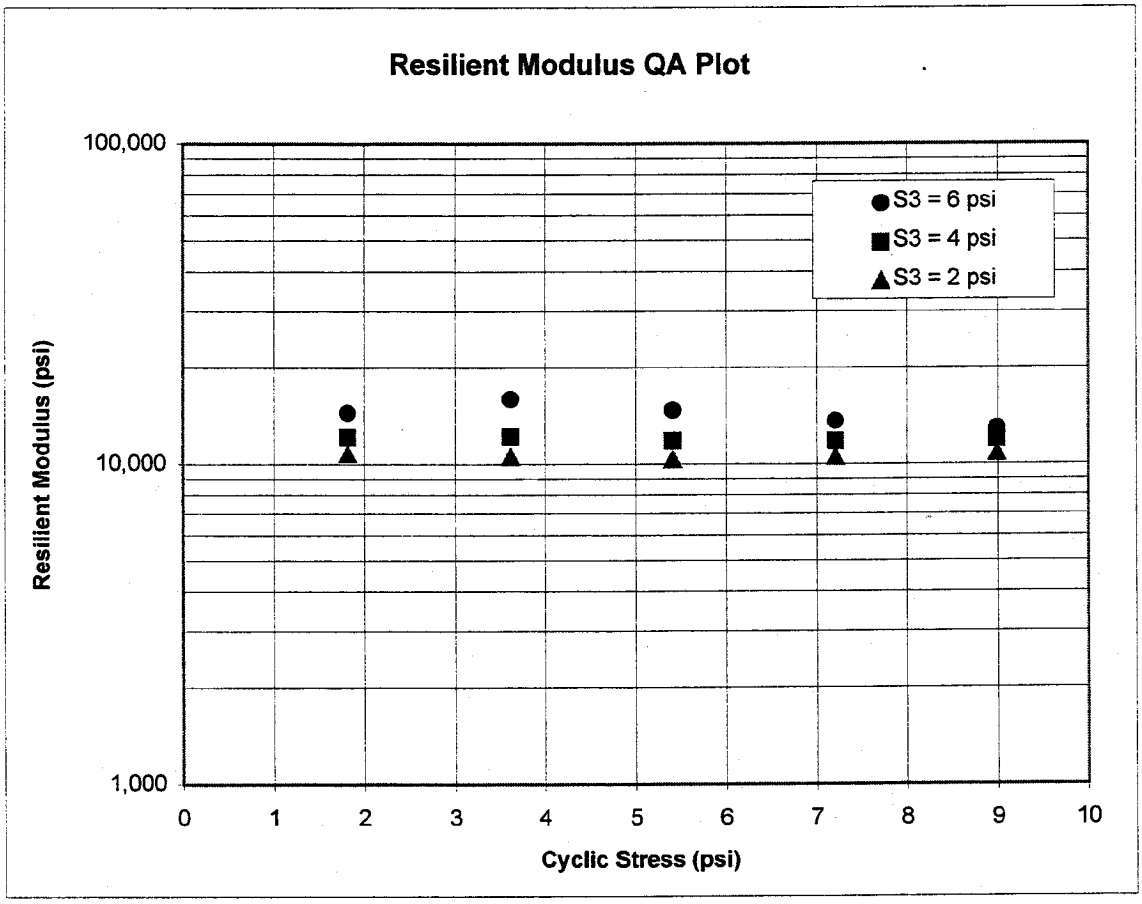
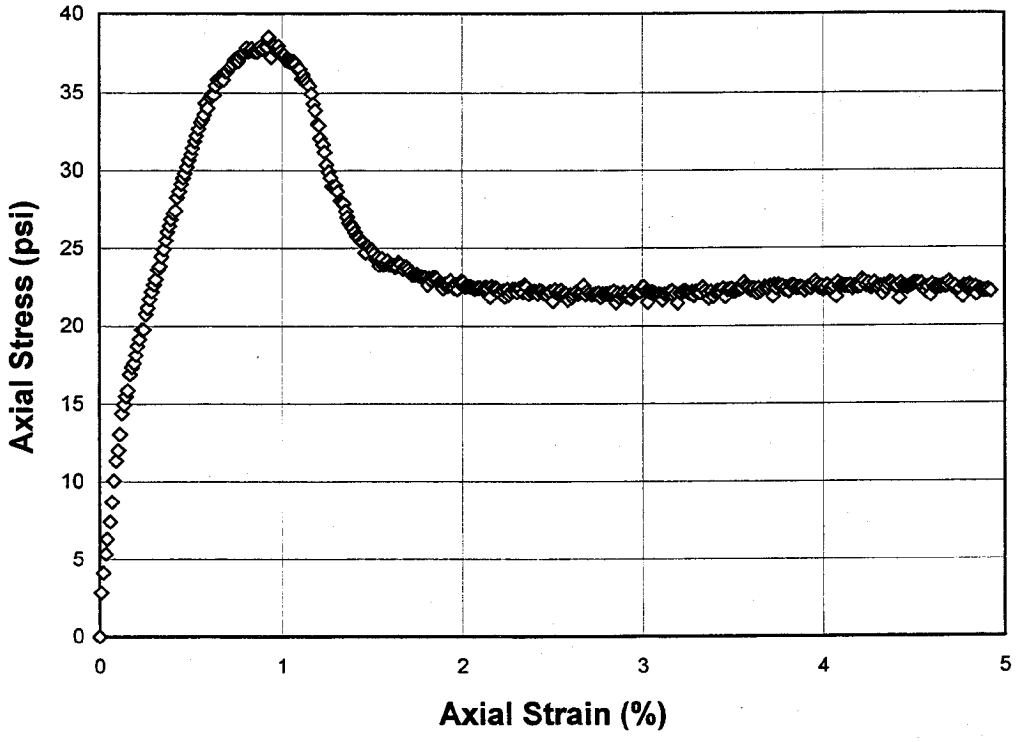


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	07-25-1995



LABORATORY MATERIAL HANDLING AND TESTING
LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: **LAW ENGINEERING, INC. - ATLANTA, GEORGIA**

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE* (Type 1 or Type 2)	2
5.	*TEST INFORMATION*	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	15
6.	*SPECIMEN INFO .:*	
	SPECIMEN DIAM., inch	
	TOP	2.86
	MIDDLE	2.86
	BOTTOM	2.86
	AVERAGE	2.86
	MEMBRANE THICKNESS (1), inch	0.01
	MEMBRANE THICKNESS (2), inch	0.01
	NET DIAM., inch	2.83
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	6.10
	HEIGHT OF CAP AND BASE, inch	0.00
	INITIAL LENGTH, L_0 , inch	6.10
	INITIAL AREA, A_0 , in^2	6.31
	INITIAL VOLUME $A_0 L_0$, in^3	38.51
7.	*SOIL SPECIMEN WEIGHT*:	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	1199.56
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	0.00
	WEIGHT OF WET SOIL USED , grams	1199.56
8.	*SOIL PROPERTIES .:*	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	N/A
	IN SITU WET DENSITY (NUCLEAR), pcf	N/A
	or	
	OPTIMUM MOISTURE CONTENT, %	11.5
	MAX. DRY DENSITY, pcf	116.3
	95 % MAX. DRY DENSITY, pcf	110.5
9.	*SPECIMEN PROPERTIES:*	
	COMPACTION MOISTURE CONTENT, %	10.2
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	10.1
	COMPACTION DRY DENSITY, γ_d pcf	107.6
10.	*QUICK SHEAR TEST*	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	87.0
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	N
11.	*COMMENTS* (Section 10.4 of Protocol P46)	
	(a) *CODE*	0 0 0 0 0 0
	(b) *NOTE*	
12.	*TEST DATE*	07-20-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

R J Boudreau 9/5/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Dry Fly Ash (Units 1-2)
3. *REMOLDING TARGETS:* 95% Modified Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 07-20-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε	
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	___.__	___.__	_	____.__	___.__	___.__	___.__	___.__	__.__	_.______	_.______	_.______	_.______	___.
SEQUENCE 1	6.0	2.0	1	12.7	11.4	1.3	2.0	1.8	0.2	0.00059	0.00055	0.00057	0.00009	19,291
			2	12.7	11.4	1.3	2.0	1.8	0.2	0.00061	0.00056	0.00059	0.00010	18,829
			3	12.7	11.4	1.3	2.0	1.8	0.2	0.00059	0.00056	0.00058	0.00009	19,209
			4	12.7	11.4	1.3	2.0	1.8	0.2	0.00060	0.00055	0.00058	0.00009	19,114
			5	12.7	11.4	1.3	2.0	1.8	0.2	0.00061	0.00057	0.00059	0.00010	18,708
	COLUMN AVERAGE			12.7	11.4	1.3	2.0	1.8	0.2	0.00060	0.00056	0.00058	0.00010	19,030
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	251

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	1	25.1	22.7	2.4	4.0	3.6	0.4	0.00097	0.00095	0.00096	0.00016	22,968
			2	25.2	22.7	2.4	4.0	3.6	0.4	0.00095	0.00092	0.00094	0.00015	23,531
			3	25.1	22.7	2.4	4.0	3.6	0.4	0.00097	0.00094	0.00096	0.00016	22,968
			4	25.2	22.7	2.4	4.0	3.6	0.4	0.00095	0.00092	0.00094	0.00015	23,528
			5	25.1	22.7	2.4	4.0	3.6	0.4	0.00098	0.00094	0.00096	0.00016	22,962
	COLUMN AVERAGE			25.1	22.7	2.4	4.0	3.6	0.4	0.00096	0.00093	0.00095	0.00016	23,192
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	309
SEQUENCE 3	6.0	6.0	1	37.8	34.1	3.7	6.0	5.4	0.6	0.00138	0.00134	0.00136	0.00022	24,245
			2	37.8	34.1	3.7	6.0	5.4	0.6	0.00135	0.00132	0.00133	0.00022	24,732
			3	37.7	34.0	3.7	6.0	5.4	0.6	0.00137	0.00133	0.00135	0.00022	24,377
			4	37.7	34.0	3.7	6.0	5.4	0.6	0.00136	0.00132	0.00134	0.00022	24,619
			5	37.7	34.0	3.7	6.0	5.4	0.6	0.00137	0.00133	0.00135	0.00022	24,401
	COLUMN AVERAGE			37.7	34.0	3.7	6.0	5.4	0.6	0.00136	0.00133	0.00135	0.00022	24,475
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	197
SEQUENCE 4	6.0	8.0	1	50.3	45.3	5.0	8.0	7.2	0.8	0.00186	0.00181	0.00184	0.00030	23,890
			2	50.4	45.4	4.9	8.0	7.2	0.8	0.00184	0.00179	0.00181	0.00030	24,214
			3	50.3	45.4	4.9	8.0	7.2	0.8	0.00185	0.00179	0.00182	0.00030	24,113
			4	50.2	45.3	4.9	8.0	7.2	0.8	0.00187	0.00182	0.00184	0.00030	23,783
			5	50.3	45.4	4.9	8.0	7.2	0.8	0.00186	0.00179	0.00183	0.00030	24,027
	COLUMN AVERAGE			50.3	45.4	4.9	8.0	7.2	0.8	0.00186	0.00180	0.00183	0.00030	24,006
	STANDARD DEV.			0.1	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	172

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	1	63.0	56.7	6.2	10.0	9.0	1.0	0.00240	0.00236	0.00238	0.00039	23,032
			2	62.9	56.7	6.2	10.0	9.0	1.0	0.00240	0.00236	0.00238	0.00039	23,050
			3	62.9	56.7	6.2	10.0	9.0	1.0	0.00241	0.00233	0.00237	0.00039	23,137
			4	62.9	56.7	6.2	10.0	9.0	1.0	0.00242	0.00234	0.00238	0.00039	23,065
			5	62.9	56.7	6.2	10.0	9.0	1.0	0.00240	0.00233	0.00236	0.00039	23,189
	COLUMN AVERAGE			62.9	56.7	6.2	10.0	9.0	1.0	0.00241	0.00235	0.00238	0.00039	23,095
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00002	0.00001	0.00000	66
SEQUENCE 6	4.0	2.0	1	13.1	11.4	1.7	2.1	1.8	0.3	0.00066	0.00062	0.00064	0.00011	17,205
			2	13.1	11.4	1.7	2.1	1.8	0.3	0.00064	0.00061	0.00062	0.00010	17,677
			3	13.1	11.4	1.7	2.1	1.8	0.3	0.00066	0.00062	0.00064	0.00010	17,251
			4	13.1	11.4	1.7	2.1	1.8	0.3	0.00066	0.00063	0.00065	0.00011	17,123
			5	13.1	11.4	1.7	2.1	1.8	0.3	0.00063	0.00060	0.00062	0.00010	17,950
	COLUMN AVERAGE			13.1	11.4	1.7	2.1	1.8	0.3	0.00065	0.00062	0.00063	0.00010	17,441
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	356
SEQUENCE 7	4.0	4.0	1	25.2	22.7	2.5	4.0	3.6	0.4	0.00114	0.00110	0.00112	0.00018	19,683
			2	25.2	22.7	2.5	4.0	3.6	0.4	0.00115	0.00109	0.00112	0.00018	19,621
			3	25.2	22.7	2.5	4.0	3.6	0.4	0.00116	0.00111	0.00114	0.00019	19,315
			4	25.1	22.6	2.5	4.0	3.6	0.4	0.00117	0.00110	0.00113	0.00019	19,301
			5	25.2	22.7	2.5	4.0	3.6	0.4	0.00116	0.00110	0.00113	0.00019	19,402
	COLUMN AVERAGE			25.2	22.7	2.5	4.0	3.6	0.4	0.00116	0.00110	0.00113	0.00018	19,465
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	177

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	1	37.8	34.0	3.7	6.0	5.4	0.6	0.00164	0.00156	0.00160	0.00026	20,616
			2	37.7	34.0	3.7	6.0	5.4	0.6	0.00162	0.00154	0.00158	0.00026	20,824
			3	37.8	34.0	3.7	6.0	5.4	0.6	0.00161	0.00153	0.00157	0.00026	20,959
			4	37.7	34.0	3.7	6.0	5.4	0.6	0.00163	0.00155	0.00159	0.00026	20,684
			5	37.7	34.0	3.7	6.0	5.4	0.6	0.00162	0.00155	0.00159	0.00026	20,763
	COLUMN AVERAGE			37.7	34.0	3.7	6.0	5.4	0.6	0.00162	0.00155	0.00158	0.00026	20,769
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	132
SEQUENCE 9	4.0	8.0	1	50.4	45.4	5.0	8.0	7.2	0.8	0.00209	0.00200	0.00204	0.00033	21,483
			2	50.4	45.4	5.0	8.0	7.2	0.8	0.00207	0.00200	0.00204	0.00033	21,581
			3	50.3	45.4	4.9	8.0	7.2	0.8	0.00208	0.00203	0.00206	0.00034	21,357
			4	50.3	45.4	5.0	8.0	7.2	0.8	0.00208	0.00199	0.00203	0.00033	21,567
			5	50.4	45.4	5.0	8.0	7.2	0.8	0.00206	0.00199	0.00203	0.00033	21,679
	COLUMN AVERAGE			50.4	45.4	5.0	8.0	7.2	0.8	0.00208	0.00200	0.00204	0.00033	21,533
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00002	0.00001	0.00000	121
SEQUENCE 10	4.0	10.0	1	62.9	56.7	6.2	10.0	9.0	1.0	0.00250	0.00247	0.00249	0.00041	22,068
			2	62.9	56.8	6.2	10.0	9.0	1.0	0.00251	0.00247	0.00249	0.00041	22,035
			3	62.9	56.7	6.2	10.0	9.0	1.0	0.00252	0.00247	0.00250	0.00041	21,961
			4	62.9	56.7	6.2	10.0	9.0	1.0	0.00253	0.00249	0.00251	0.00041	21,845
			5	62.9	56.7	6.2	10.0	9.0	1.0	0.00253	0.00249	0.00251	0.00041	21,832
	COLUMN AVERAGE			62.9	56.7	6.2	10.0	9.0	1.0	0.00252	0.00248	0.00250	0.00041	21,948
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	107

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	1	13.5	11.5	2.1	2.1	1.8	0.3	0.00075	0.00066	0.00070	0.00012	15,770
			2	13.5	11.4	2.1	2.1	1.8	0.3	0.00074	0.00066	0.00070	0.00011	15,775
			3	13.5	11.4	2.1	2.1	1.8	0.3	0.00075	0.00068	0.00072	0.00012	15,459
			4	13.5	11.4	2.1	2.1	1.8	0.3	0.00075	0.00067	0.00071	0.00012	15,494
			5	13.5	11.4	2.1	2.1	1.8	0.3	0.00076	0.00068	0.00072	0.00012	15,307
	COLUMN AVERAGE			13.5	11.4	2.1	2.1	1.8	0.3	0.00075	0.00067	0.00071	0.00012	15,561
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	206
SEQUENCE 12	2.0	4.0	1	25.1	22.7	2.4	4.0	3.6	0.4	0.00132	0.00121	0.00127	0.00021	17,317
			2	25.2	22.7	2.4	4.0	3.6	0.4	0.00131	0.00119	0.00125	0.00020	17,646
			3	25.1	22.7	2.4	4.0	3.6	0.4	0.00132	0.00121	0.00127	0.00021	17,296
			4	25.2	22.7	2.4	4.0	3.6	0.4	0.00131	0.00121	0.00126	0.00021	17,445
			5	25.2	22.7	2.4	4.0	3.6	0.4	0.00134	0.00121	0.00128	0.00021	17,245
	COLUMN AVERAGE			25.1	22.7	2.4	4.0	3.6	0.4	0.00132	0.00121	0.00126	0.00021	17,390
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	161
SEQUENCE 13	2.0	6.0	1	37.6	34.0	3.7	6.0	5.4	0.6	0.00182	0.00169	0.00175	0.00029	18,756
			2	37.8	34.1	3.7	6.0	5.4	0.6	0.00180	0.00171	0.00176	0.00029	18,770
			3	37.8	34.1	3.7	6.0	5.4	0.6	0.00181	0.00170	0.00176	0.00029	18,805
			4	37.8	34.1	3.7	6.0	5.4	0.6	0.00182	0.00171	0.00176	0.00029	18,731
			5	37.8	34.1	3.7	6.0	5.4	0.6	0.00180	0.00168	0.00174	0.00028	18,976
	COLUMN AVERAGE			37.8	34.1	3.7	6.0	5.4	0.6	0.00181	0.00170	0.00175	0.00029	18,808
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	98

Source: Cumberland Description: Dry Fly Ash (Units 1-2) 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	1	50.4	45.4	5.0	8.0	7.2	0.8	0.00227	0.00219	0.00223	0.00037	19,704
			2	50.3	45.3	5.0	8.0	7.2	0.8	0.00229	0.00217	0.00223	0.00037	19,661
			3	50.5	45.5	5.0	8.0	7.2	0.8	0.00227	0.00218	0.00222	0.00036	19,800
			4	50.3	45.4	5.0	8.0	7.2	0.8	0.00229	0.00218	0.00224	0.00037	19,612
			5	50.4	45.4	5.0	8.0	7.2	0.8	0.00227	0.00217	0.00222	0.00036	19,790
	COLUMN AVERAGE			50.4	45.4	5.0	8.0	7.2	0.8	0.00228	0.00218	0.00223	0.00036	19,713
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	81
SEQUENCE 15	2.0	10.0	1	63.0	56.8	6.2	10.0	9.0	1.0	0.00273	0.00265	0.00269	0.00044	20,412
			2	62.9	56.7	6.2	10.0	9.0	1.0	0.00276	0.00264	0.00270	0.00044	20,311
			3	62.8	56.6	6.2	10.0	9.0	1.0	0.00275	0.00265	0.00270	0.00044	20,297
			4	62.9	56.7	6.2	10.0	9.0	1.0	0.00273	0.00264	0.00269	0.00044	20,413
			5	62.9	56.7	6.2	10.0	9.0	1.0	0.00273	0.00264	0.00269	0.00044	20,404
	COLUMN AVERAGE			62.9	56.7	6.2	10.0	9.0	1.0	0.00274	0.00264	0.00269	0.00044	20,367
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00001	0.00000	58

SUBMITTED BY, DATE

RS Bouchieau 9/5/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	07-20-1995

$$M_R = K1\ (S_C)^{K2}\ (1+S_3)^{K5}$$

K1 =	10,959
K2 =	0.14896
K5 =	0.24877
R^2 =	0.92

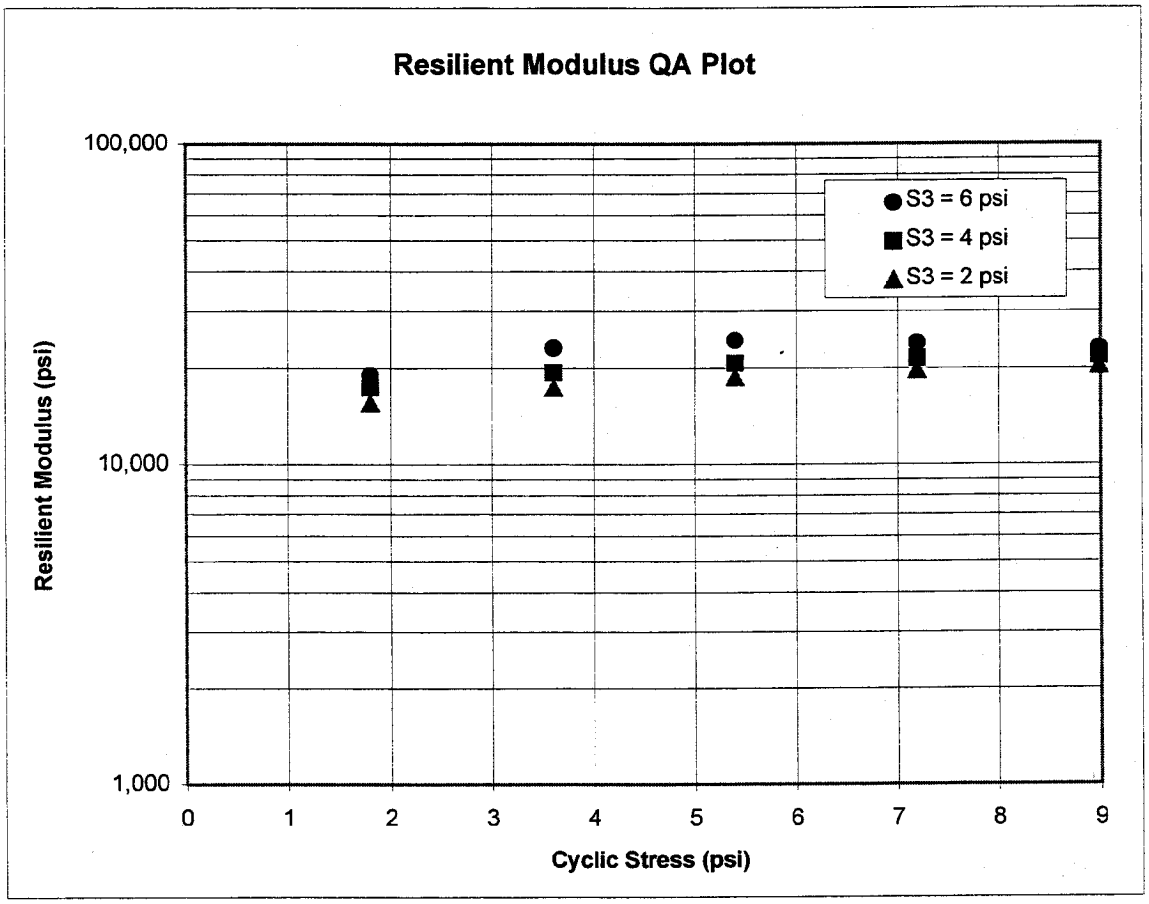
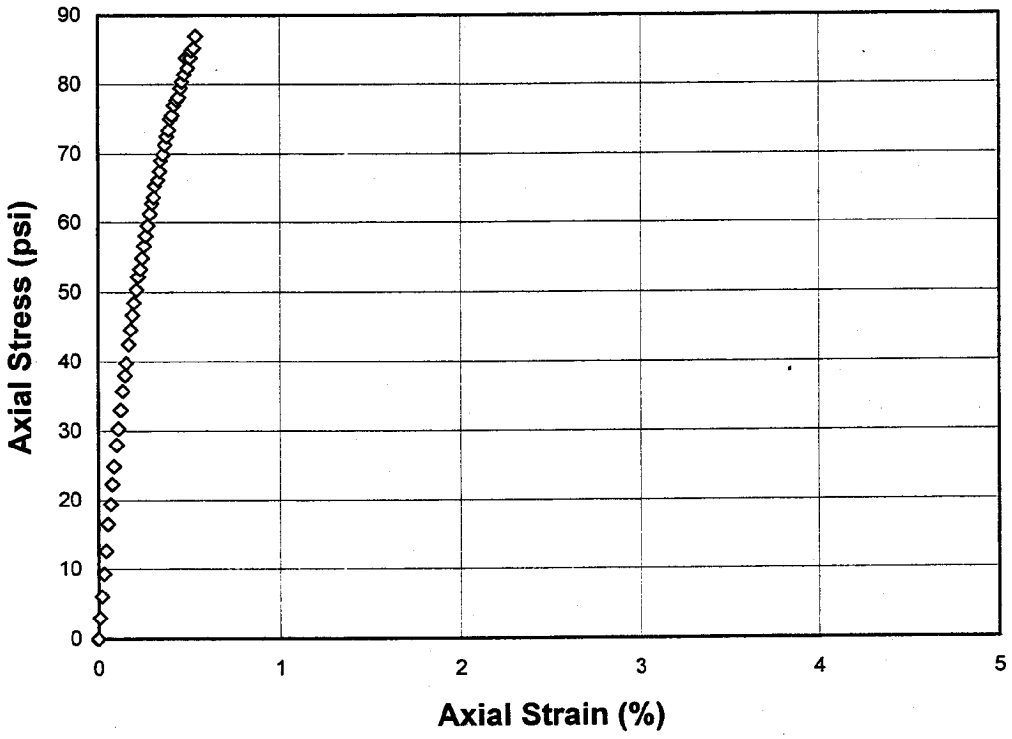


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Dry Fly Ash (Units 1-2)
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	07-20-1995



CUMBERLAND

Bottom Ash - From Pond

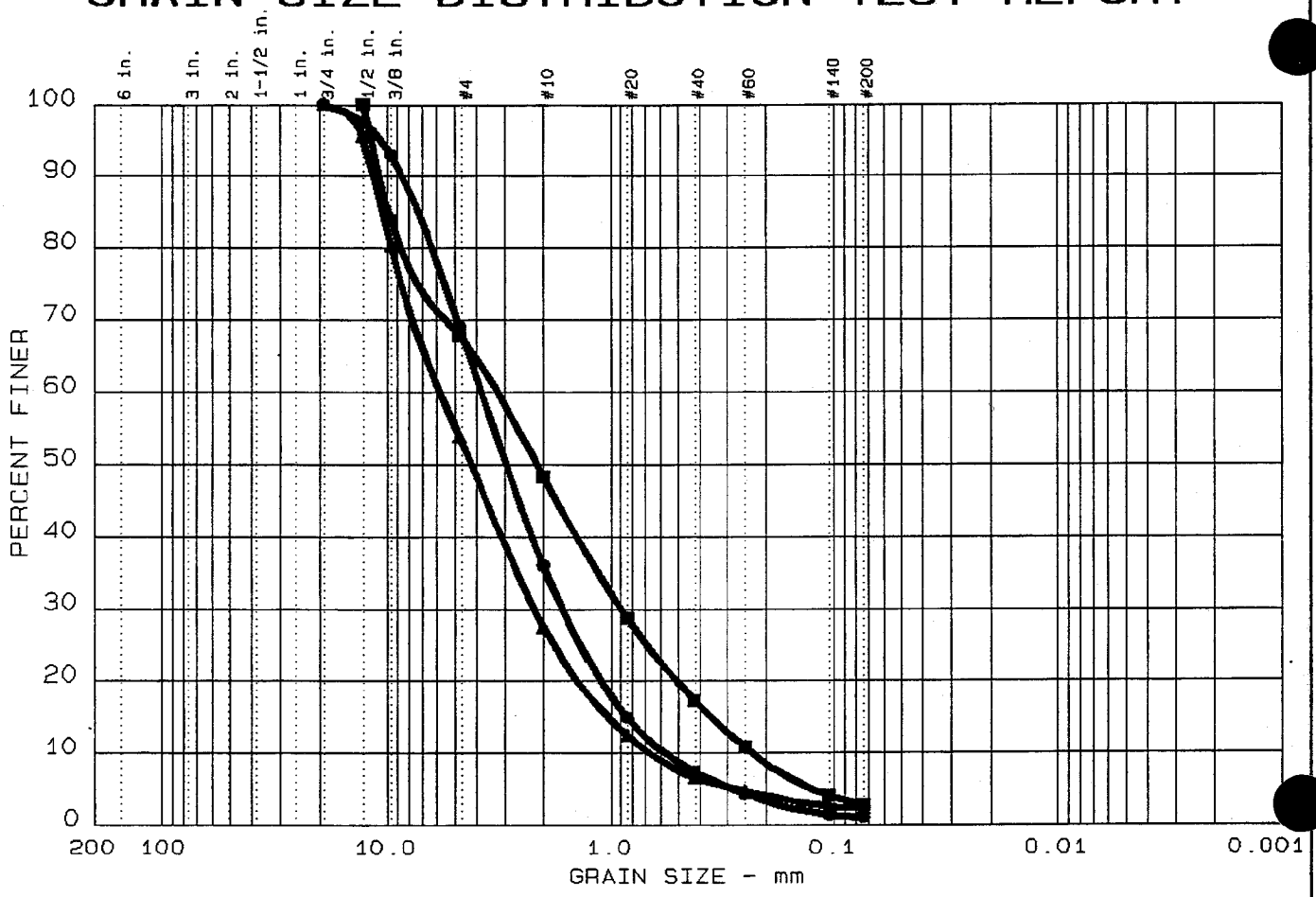
Grain Size Distribution Test Report
Moisture-Density Relationship (Standard Proctor)
Moisture-Density Relationship (Modified Proctor)
Relative Density Test
Hydraulic Conductivity - Constant Head (2 Pages)
California Bearing Ratio
Resilient Modulus (Standard Proctor) (9 Pages)
Resilient Modulus (Modified Proctor) (9 Pages)

TVA - CUMBERLAND
BOTTOM ASH - FROM POND

Description	Test Method	Property	Sample 1	Sample 2	Sample 3
Grain Size	ASTM D 422	Percent Retained on the #4 Sieve Percent Passing the #200 Sieve	30.9 1.1	46.2 2.2	32.2 2.8
Atterberg Limits	ASTM D 4318	Liquid Limit Plastic Limit Plasticity Index	NL NP N/A	NL NP N/A	NL NP N/A
Specific Gravity	ASTM D 854	Specific Gravity at 20°C	2.59	2.66	2.63
Classification	ASTM D 2487 AASHTO M 145	Unified Soil Classification System (USCS) AASHTO Classification	SW A-1-a	SW A-1-a	SW A-1-a
				Composite Sample	
Moisture-Density Relations (Standard Effort)	ASTM D 698	Maximum Dry Density, pcf Optimum Moisture Content, %		90.1 15.4	
Moisture-Density Relations (Modified Effort)	ASTM D 1557	Maximum Dry Density, pcf Optimum Moisture Content, %		103.3 15.7	
Relative Density	ASTM D 4254 ASTM D 4253	Minimum Dry Density, pcf Maximum Dry Density (Dry Method), pcf		67.0 87.1	
			Result	**Dry Density, pcf**	**Moisture Content, %**
Hydraulic Conductivity	ASTM D 2434	Hydraulic Conductivity, cm/sec	6.8E-2	77.0	0.0
Angle of Repose	LAW TP6	Angle of Repose, degrees	30.8	67.0	0.0
California Bearing Ratio	ASTM D 1883	CBR, %	15	81.6	14.1
Resilient Modulus (Standard Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	6,417	84.4	14.2
Resilient Modulus (Modified Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	6,945	96.7	14.6
Soil Resistivity	AASHTO T 288	Minimum Resistivity, Ohm-cm		1,200	
pH of Soil	AASHTO T 289	pH		2.7	
Water Soluble Sulfate Ion	AASHTO T 290	Sulfate Ion Content, mg/kg		4790	
Water Soluble Chloride Ion	AASHTO T 290	Chloride Ion Content, mg/kg		<10	

cuf-ba.xls

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	18	0.0	30.9	68.0	1.1	
▲	19	0.0	46.2	51.6	2.2	
■	20	0.0	32.2	65.0	2.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	NL	NP	7.23	3.79	2.94	1.637	0.8395	0.5675	1.24	6.7
▲	NL	NP	10.39	5.81	4.21	2.203	1.0304	0.6653	1.26	8.7
■	NL	NP	9.76	3.20	2.14	0.898	0.3536	0.2309	1.09	13.8

	MATERIAL DESCRIPTION	USCS	AASHTO
●		SW	A-1-a
▲		SW	A-1-a
■		SW	A-1-a

Project No.: 5810860101
Project: TVA - Cumberland
● Location: Bottom Ash A & B
▲ Location: Bottom Ash C & D
■ Location: Bottom Ash E & F
Date: July 18, 1995

Remarks:

Tested by: JCL

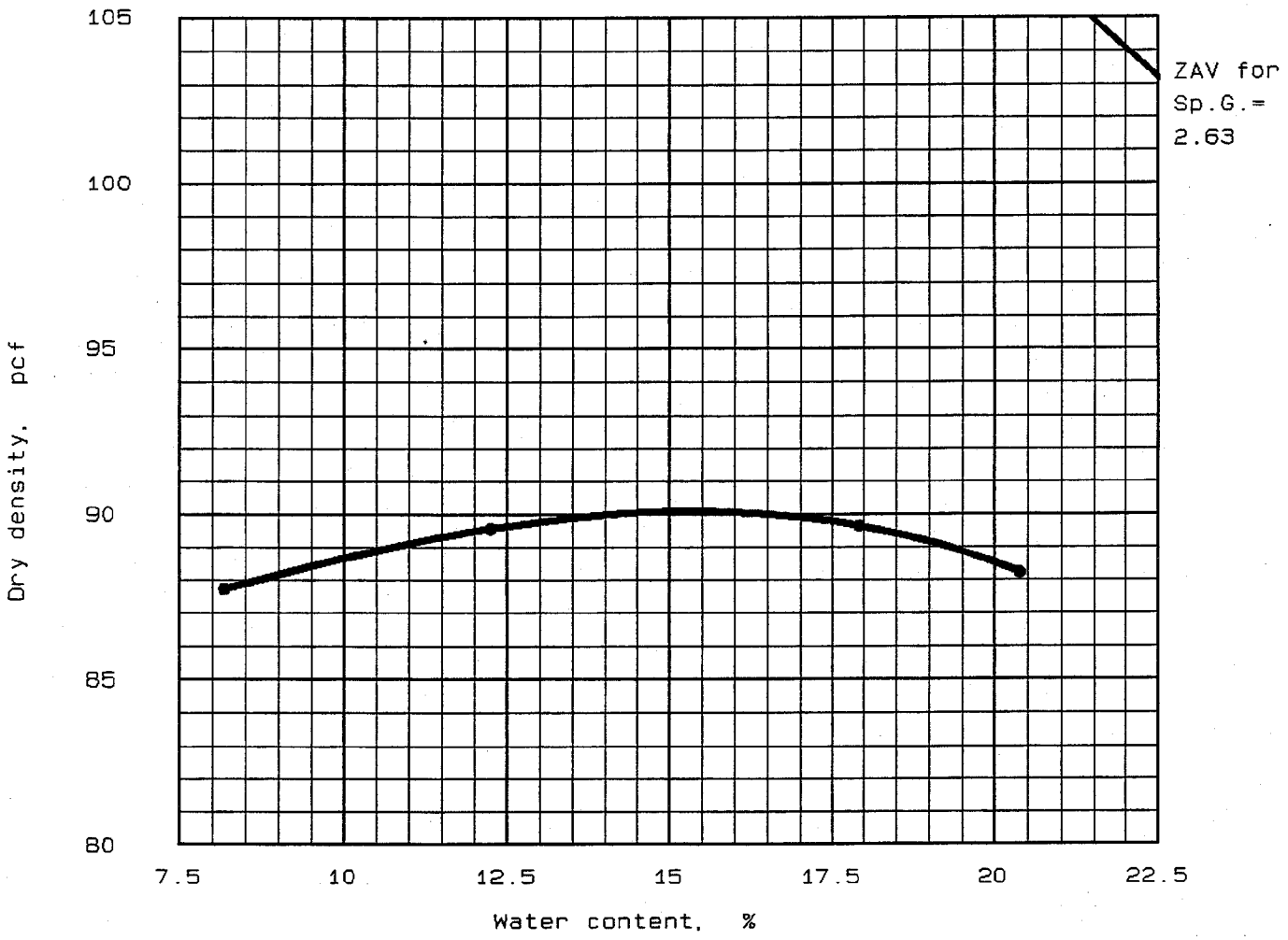
Reviewed by: HS

GRAIN SIZE DISTRIBUTION TEST REPORT

LAW ENGINEERING, INC.

Figure No.

MOISTURE-DENSITY RELATIONSHIP



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SW	A-1-a	11.0 %	2.63	NL	NP	36.4 %	3.03 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 15.4 % Maximum dry density = 90.1 pcf	

Project No.: 5810860101
Project: TVA - Cumberland
Location: Bottom Ash

Date: July 25, 1995

Remarks:

Tested by: EM

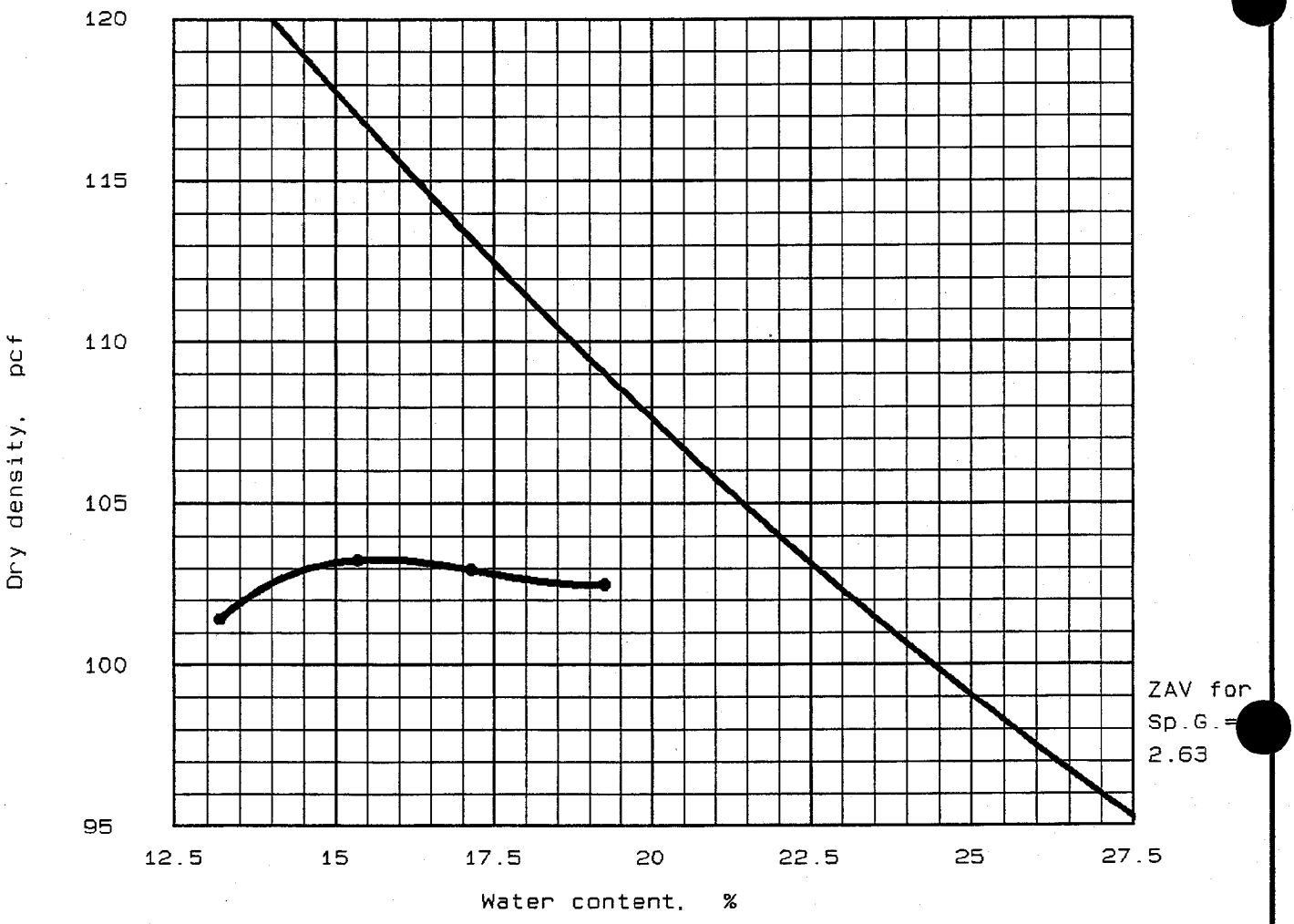
Reviewed by: RLB

MOISTURE-DENSITY RELATIONSHIP

LAW ENGINEERING, INC.

Figure No. _____

MOISTURE-DENSITY RELATIONSHIP



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SW	A-1-a	11.0 %	2.63	NL	NP	36.4 %	3.03 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 15.7 % Maximum dry density = 103.3 pcf	

Project No.: 5810860101
Project: TVA - Cumberland
Location: Bottom Ash

Date: July 25, 1995

Remarks:

Tested by: JCR

Reviewed by: PLB

MOISTURE-DENSITY RELATIONSHIP

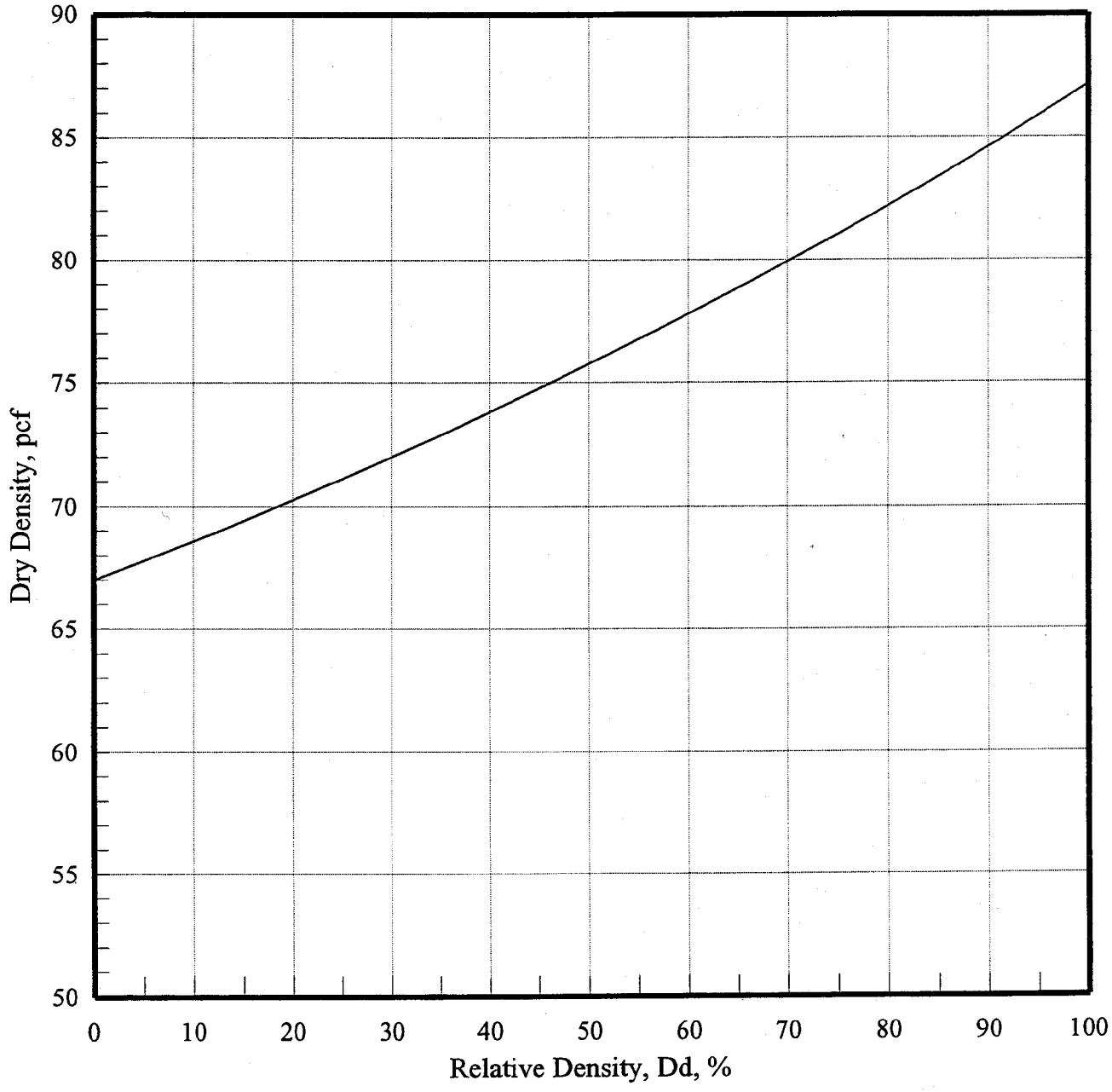
LAW ENGINEERING, INC.

Figure No. _____

Relative Density Test

TVA - Cumberland, Bottom Ash

Law Project No. 5810860101



HYDRAULIC CONDUCTIVITY

LAW ENGINEERING

Project No.	*5810860101*	Tested By	*JCR*
Project Name	*TVA - Cumberland*	Test Date	*08/17/95*
Material	*Bottom Ash*	Reviewed By	*RLB*
		Review Date	*09/06/95*

ASTM D2434-68 Constant Head Permeability

Sample Type:	*Remolded*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*0.0*
Wet Unit Weight, pcf:	*77.0*
Dry Unit Weight, pcf:	*77.0*
Compaction, %:	*85.5*
Hydraulic Conductivity, cm/sec. @20° C:	***6.8E-02***

PERMEABILITY TEST - Constant Head
(ASTM D2434 - 68)

LAW ENGINEERING

Project No. 5810860101
Project Name TVA - Cumberland
Material Bottom Ash

Tested By JCR
Test Date 08/17/95
Reviewed By RLB
Review Date 09/06/95

Sample Data

Length, in		Diameter, in		Pan No.	
Location 1	5.564	Location 1	2.858	Wet Soil + Pan, grams	726.73
Location 2	5.540	Location 2	2.875	Dry Soil+Pan, grams	726.73
Location3	5.600	Location 3	2.868	Pan Weight, grams	0.00
Average	5.568	Average	2.867	Moisture Content, %	0.0
		Sample wet weight, grams	726.73	Wet Unit Wt, pcf	77.0
		Membrane, Cap weight, grams	0.00	Dry Unit Wt, pcf	77.0

Time (sec)	Q (cm^3)	H (cm)	k (cm/sec)	Temp ° C	k (cm/sec at 20° C)	i (cm/cm)
600	710.00	5.08	7.9E-02	20.0	7.9E-02	0.36
1200	1215.00	5.08	6.8E-02	20.0	6.8E-02	0.36

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
2	Remolded	90.1	85.5	Vertical

L = length of sample in cm
A = area of sample in cm^2
H = constant head in cm
t = time in seconds

A = 41.65 cm^2
L = 14.143 cm

Avg. k at 20° C 6.8E-02 cm/sec

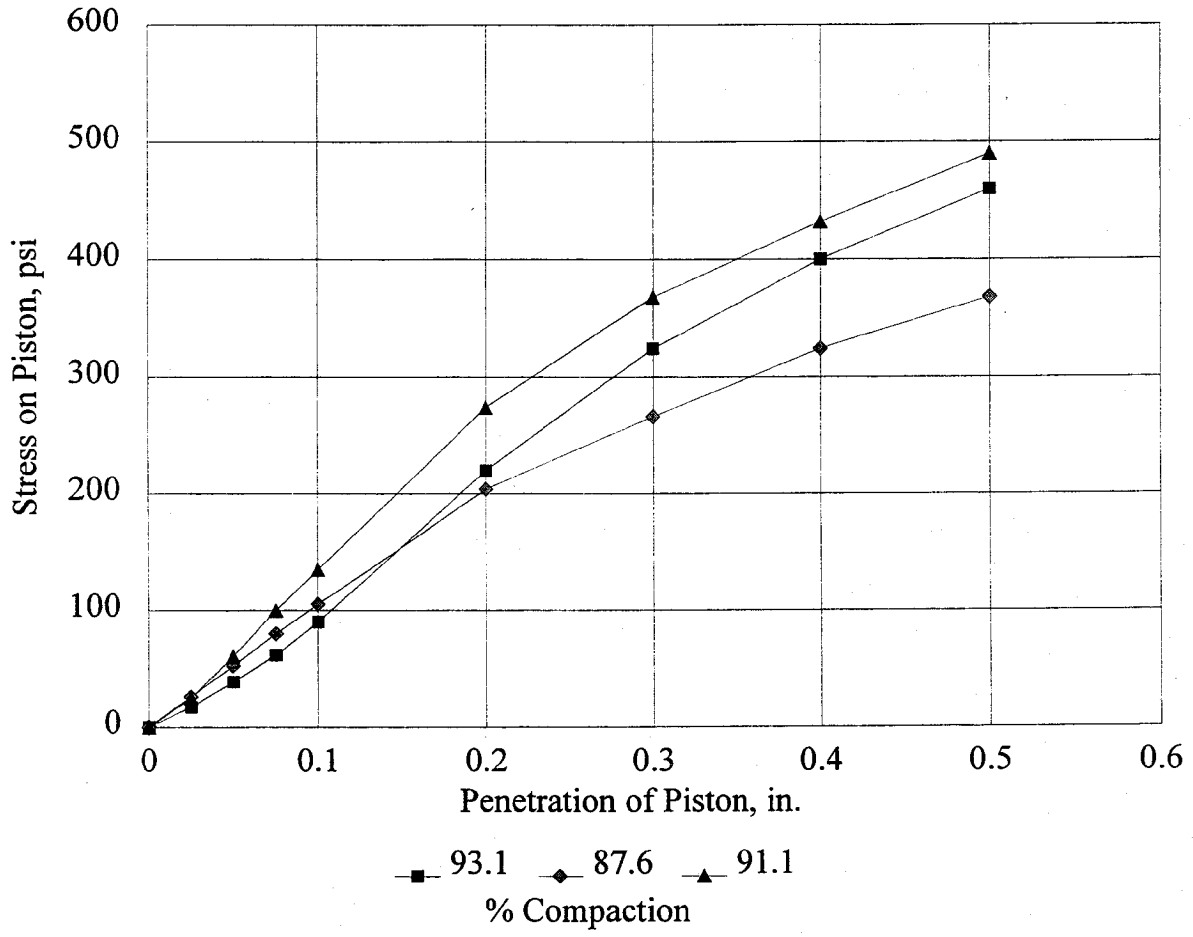
California Bearing Ratio

(ASTM D1883-92)

LAW ENGINEERING

Project No.	5810860101	**Tested By**	EM
Project Name	TVA - Cumberland	**Test Date**	08/25/95
Material (Source)	Bottom Ash	**Reviewed By**	RLB
		Review Date	08/30/95

Compaction, %	93.1	87.6	91.1
Before Soak Dry Density, pcf	83.8	79.0	82.1
Before Soak Moisture Content,	14.0	14.1	14.3
After Soak Dry Density, pcf	84.3	79.5	82.3
After Soak Moisture Content, %	22.5	21.7	22.3
CBR @ 0.1 in.	9.0	10.5	13.5
CBR @ 0.2 in.	14.7	13.6	18.3



LABORATORY MATERIAL HANDLING AND TESTING
LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: **LAW ENGINEERING, INC. - ATLANTA, GEORGIA**

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE* (Type 1 or Type 2)	2
5.	*TEST INFORMATION*	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	15
6.	*SPECIMEN INFO.:*	
	SPECIMEN DIAM., inch	
	TOP	2.86
	MIDDLE	2.86
	BOTTOM	2.86
	AVERAGE	2.86
	MEMBRANE THICKNESS (1), inch	0.01
	MEMBRANE THICKNESS (2), inch	0.01
	NET DIAM., inch	2.84
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	6.07
	HEIGHT OF CAP AND BASE, inch	0.00
	INITIAL LENGTH, L_0, inch	6.07
	INITIAL AREA, A_0, in^2	6.32
	INITIAL VOLUME $A_0 L_0$, in^3	38.35
7.	*SOIL SPECIMEN WEIGHT:*	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	971.35
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	0.00
	WEIGHT OF WET SOIL USED, grams	971.35
8.	*SOIL PROPERTIES.:*	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	N/A
	IN SITU WET DENSITY (NUCLEAR), pcf	N/A
	or	
	OPTIMUM MOISTURE CONTENT, %	15.4
	MAX. DRY DENSITY, pcf	90.1
	95 % MAX. DRY DENSITY, pcf	85.6
9.	*SPECIMEN PROPERTIES:*	
	COMPACTION MOISTURE CONTENT, %	14.2
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	14.2
	COMPACTION DRY DENSITY, γ_d pcf	84.4
10.	*QUICK SHEAR TEST*	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	34.5
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	Y
11.	*COMMENTS* (Section 10.4 of Protocol P46)	
	(a) *CODE*	0 0 0 0 0 0
	(b) *NOTE*	
12.	*TEST DATE*	08-18-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

RJ Bardhan 9/10/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Bottom Ash
3. *REMOLDING TARGETS:* 95% Standard Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 08-18-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε_r	M_r
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	_ _ _._	_ _ _._	_	_ _ _ _._	_ _ _._	_ _ _._	_ _ _._	_ _ _._	_ _._	_._ _ _ _	_._ _ _ _	_._ _ _ _	_._ _ _	_ _ _.
SEQUENCE 1	6.0	2.0	1	12.6	11.4	1.2	2.0	1.8	0.2	0.00111	0.00122	0.00116	0.00019	9,396
			2	12.6	11.4	1.2	2.0	1.8	0.2	0.00112	0.00123	0.00117	0.00019	9,357
			3	12.6	11.3	1.2	2.0	1.8	0.2	0.00113	0.00123	0.00118	0.00019	9,254
			4	12.7	11.4	1.2	2.0	1.8	0.2	0.00112	0.00122	0.00117	0.00019	9,368
			5	12.6	11.4	1.2	2.0	1.8	0.2	0.00112	0.00124	0.00118	0.00019	9,263
	COLUMN AVERAGE			12.6	11.4	1.2	2.0	1.8	0.2	0.00112	0.00123	0.00117	0.00019	9,328
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	65

Source: Cumberland Description: Bottom Ash 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	1	25.3	23.0	2.3	4.0	3.6	0.4	0.00220	0.00239	0.00229	0.00038	9,623
			2	25.5	23.1	2.3	4.0	3.7	0.4	0.00221	0.00239	0.00230	0.00038	9,651
			3	25.3	23.0	2.3	4.0	3.6	0.4	0.00220	0.00239	0.00230	0.00038	9,624
			4	25.3	22.9	2.3	4.0	3.6	0.4	0.00220	0.00240	0.00230	0.00038	9,596
			5	25.3	22.9	2.3	4.0	3.6	0.4	0.00219	0.00240	0.00229	0.00038	9,600
	COLUMN AVERAGE			25.3	23.0	2.3	4.0	3.6	0.4	0.00220	0.00239	0.00230	0.00038	9,619
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00000	0.00000	22
SEQUENCE 3	6.0	6.0	1	37.8	34.2	3.6	6.0	5.4	0.6	0.00328	0.00352	0.00340	0.00056	9,668
			2	37.8	34.3	3.6	6.0	5.4	0.6	0.00328	0.00352	0.00340	0.00056	9,688
			3	37.9	34.3	3.6	6.0	5.4	0.6	0.00328	0.00354	0.00341	0.00056	9,664
			4	38.0	34.4	3.6	6.0	5.4	0.6	0.00329	0.00352	0.00340	0.00056	9,716
			5	37.9	34.2	3.6	6.0	5.4	0.6	0.00327	0.00351	0.00339	0.00056	9,701
	COLUMN AVERAGE			37.9	34.3	3.6	6.0	5.4	0.6	0.00328	0.00352	0.00340	0.00056	9,687
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	22
SEQUENCE 4	6.0	8.0	1	50.8	46.0	4.8	8.0	7.3	0.8	0.00437	0.00468	0.00452	0.00074	9,778
			2	50.9	46.1	4.8	8.1	7.3	0.8	0.00438	0.00467	0.00452	0.00074	9,796
			3	50.9	46.1	4.8	8.1	7.3	0.8	0.00437	0.00468	0.00452	0.00075	9,801
			4	50.9	46.0	4.8	8.1	7.3	0.8	0.00440	0.00468	0.00454	0.00075	9,745
			5	50.7	45.9	4.8	8.0	7.3	0.8	0.00437	0.00468	0.00452	0.00074	9,753
	COLUMN AVERAGE			50.9	46.0	4.8	8.1	7.3	0.8	0.00438	0.00468	0.00453	0.00075	9,774
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00001	0.00000	25

Source: Cumberland Description: Bottom Ash 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	1	63.7	57.6	6.1	10.1	9.1	1.0	0.00535	0.00569	0.00552	0.00091	10,027
			2	63.6	57.5	6.0	10.1	9.1	1.0	0.00534	0.00570	0.00552	0.00091	10,021
			3	63.7	57.6	6.1	10.1	9.1	1.0	0.00536	0.00568	0.00552	0.00091	10,038
			4	63.6	57.5	6.1	10.1	9.1	1.0	0.00536	0.00568	0.00552	0.00091	10,023
			5	63.7	57.6	6.0	10.1	9.1	1.0	0.00534	0.00570	0.00552	0.00091	10,029
	COLUMN AVERAGE			63.7	57.6	6.1	10.1	9.1	1.0	0.00535	0.00569	0.00552	0.00091	10,028
	STANDARD DEV.			0.1	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	7
SEQUENCE 6	4.0	2.0	1	13.0	11.4	1.7	2.1	1.8	0.3	0.00146	0.00155	0.00151	0.00025	7,250
			2	12.9	11.2	1.7	2.0	1.8	0.3	0.00146	0.00156	0.00151	0.00025	7,146
			3	12.8	11.2	1.7	2.0	1.8	0.3	0.00146	0.00153	0.00150	0.00025	7,176
			4	13.0	11.3	1.7	2.1	1.8	0.3	0.00146	0.00154	0.00150	0.00025	7,224
			5	12.9	11.3	1.7	2.0	1.8	0.3	0.00144	0.00155	0.00150	0.00025	7,224
	COLUMN AVERAGE			12.9	11.3	1.7	2.0	1.8	0.3	0.00146	0.00155	0.00150	0.00025	7,204
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	42
SEQUENCE 7	4.0	4.0	1	25.2	22.9	2.3	4.0	3.6	0.4	0.00308	0.00327	0.00318	0.00052	6,919
			2	25.2	22.9	2.3	4.0	3.6	0.4	0.00307	0.00326	0.00317	0.00052	6,937
			3	25.1	22.8	2.3	4.0	3.6	0.4	0.00308	0.00326	0.00317	0.00052	6,900
			4	25.2	22.9	2.3	4.0	3.6	0.4	0.00308	0.00327	0.00317	0.00052	6,929
			5	25.3	22.9	2.3	4.0	3.6	0.4	0.00310	0.00328	0.00319	0.00053	6,904
	COLUMN AVERAGE			25.2	22.9	2.3	4.0	3.6	0.4	0.00308	0.00327	0.00318	0.00052	6,918
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	16

Source: Cumberland Description: Bottom Ash 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	1	38.2	34.6	3.6	6.0	5.5	0.6	0.00445	0.00472	0.00459	0.00076	7,246
			2	38.0	34.5	3.6	6.0	5.5	0.6	0.00445	0.00473	0.00459	0.00076	7,218
			3	38.2	34.7	3.6	6.0	5.5	0.6	0.00445	0.00472	0.00458	0.00075	7,270
			4	38.1	34.5	3.6	6.0	5.5	0.6	0.00444	0.00473	0.00458	0.00075	7,237
			5	38.1	34.6	3.6	6.0	5.5	0.6	0.00444	0.00471	0.00458	0.00075	7,259
	COLUMN AVERAGE			38.1	34.5	3.6	6.0	5.5	0.6	0.00445	0.00472	0.00458	0.00075	7,246
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	20
SEQUENCE 9	4.0	8.0	1	51.1	46.2	4.9	8.1	7.3	0.8	0.00562	0.00594	0.00578	0.00095	7,686
			2	51.1	46.2	4.9	8.1	7.3	0.8	0.00562	0.00593	0.00578	0.00095	7,692
			3	51.1	46.2	4.8	8.1	7.3	0.8	0.00565	0.00591	0.00578	0.00095	7,690
			4	51.1	46.2	4.9	8.1	7.3	0.8	0.00564	0.00594	0.00579	0.00095	7,668
			5	51.0	46.1	4.9	8.1	7.3	0.8	0.00563	0.00595	0.00579	0.00095	7,658
	COLUMN AVERAGE			51.1	46.2	4.9	8.1	7.3	0.8	0.00563	0.00593	0.00578	0.00095	7,679
	STANDARD DEV.			0.0	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	15
SEQUENCE 10	4.0	10.0	1	63.7	57.6	6.1	10.1	9.1	1.0	0.00679	0.00713	0.00696	0.00115	7,953
			2	63.6	57.5	6.1	10.1	9.1	1.0	0.00679	0.00712	0.00695	0.00115	7,952
			3	63.7	57.6	6.1	10.1	9.1	1.0	0.00680	0.00711	0.00695	0.00115	7,962
			4	63.8	57.7	6.1	10.1	9.1	1.0	0.00681	0.00714	0.00697	0.00115	7,956
			5	63.6	57.5	6.1	10.1	9.1	1.0	0.00680	0.00711	0.00696	0.00115	7,937
	COLUMN AVERAGE			63.7	57.6	6.1	10.1	9.1	1.0	0.00680	0.00712	0.00696	0.00115	7,952
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	9

Source: Cumberland Description: Bottom Ash 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	1	13.1	11.1	2.0	2.1	1.8	0.3	0.00217	0.00224	0.00221	0.00036	4,850
			2	13.1	11.2	2.0	2.1	1.8	0.3	0.00218	0.00226	0.00222	0.00037	4,830
			3	13.2	11.2	2.0	2.1	1.8	0.3	0.00218	0.00226	0.00222	0.00037	4,845
			4	13.0	11.1	2.0	2.1	1.8	0.3	0.00217	0.00227	0.00222	0.00037	4,800
			5	13.0	11.0	2.0	2.1	1.7	0.3	0.00219	0.00225	0.00222	0.00037	4,773
	COLUMN AVERAGE			13.1	11.1	2.0	2.1	1.8	0.3	0.00218	0.00226	0.00222	0.00037	4,820
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	32
SEQUENCE 12	2.0	4.0	1	24.6	22.2	2.4	3.9	3.5	0.4	0.00445	0.00466	0.00455	0.00075	4,688
			2	24.5	22.2	2.3	3.9	3.5	0.4	0.00445	0.00464	0.00455	0.00075	4,693
			3	24.5	22.2	2.3	3.9	3.5	0.4	0.00445	0.00466	0.00455	0.00075	4,683
			4	24.6	22.2	2.3	3.9	3.5	0.4	0.00447	0.00468	0.00457	0.00075	4,675
			5	24.7	22.3	2.3	3.9	3.5	0.4	0.00447	0.00467	0.00457	0.00075	4,698
	COLUMN AVERAGE			24.6	22.2	2.3	3.9	3.5	0.4	0.00446	0.00466	0.00456	0.00075	4,687
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	9
SEQUENCE 13	2.0	6.0	1	37.7	34.2	3.6	6.0	5.4	0.6	0.00595	0.00624	0.00609	0.00100	5,387
			2	37.9	34.3	3.6	6.0	5.4	0.6	0.00597	0.00623	0.00610	0.00100	5,411
			3	37.9	34.3	3.6	6.0	5.4	0.6	0.00597	0.00623	0.00610	0.00100	5,407
			4	38.1	34.6	3.5	6.0	5.5	0.6	0.00597	0.00624	0.00611	0.00101	5,437
			5	38.0	34.5	3.6	6.0	5.5	0.6	0.00598	0.00623	0.00611	0.00101	5,423
	COLUMN AVERAGE			37.9	34.4	3.6	6.0	5.4	0.6	0.00597	0.00624	0.00610	0.00101	5,413
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	19

Source: Cumberland Description: Bottom Ash 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	1	50.7	45.8	4.9	8.0	7.3	0.8	0.00729	0.00760	0.00745	0.00123	5,911
			2	50.7	45.9	4.8	8.0	7.3	0.8	0.00728	0.00760	0.00744	0.00123	5,934
			3	50.7	45.9	4.8	8.0	7.3	0.8	0.00730	0.00761	0.00746	0.00123	5,919
			4	50.6	45.8	4.8	8.0	7.3	0.8	0.00730	0.00759	0.00745	0.00123	5,911
			5	50.7	45.9	4.8	8.0	7.3	0.8	0.00730	0.00760	0.00745	0.00123	5,922
	COLUMN AVERAGE			50.7	45.9	4.8	8.0	7.3	0.8	0.00729	0.00760	0.00745	0.00123	5,920
	STANDARD DEV.			0.0	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	10
SEQUENCE 15	2.0	10.0	1	63.5	57.4	6.1	10.1	9.1	1.0	0.00845	0.00874	0.00859	0.00142	6,418
			2	63.4	57.3	6.1	10.0	9.1	1.0	0.00845	0.00874	0.00859	0.00142	6,410
			3	63.6	57.5	6.1	10.1	9.1	1.0	0.00844	0.00875	0.00859	0.00142	6,433
			4	63.6	57.4	6.1	10.1	9.1	1.0	0.00844	0.00873	0.00859	0.00141	6,426
			5	63.4	57.3	6.1	10.0	9.1	1.0	0.00844	0.00872	0.00858	0.00141	6,417
	COLUMN AVERAGE			63.5	57.4	6.1	10.1	9.1	1.0	0.00844	0.00874	0.00859	0.00141	6,421
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	9

SUBMITTED BY, DATE

RS Bradham 9/10/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	08-18-1995

$$M_R = K1\ (S_C)^{K2}(1+S_3)^{K5}$$

K1 =	2,194
K2 =	0.09530
K5 =	0.67882
R^2 =	0.95

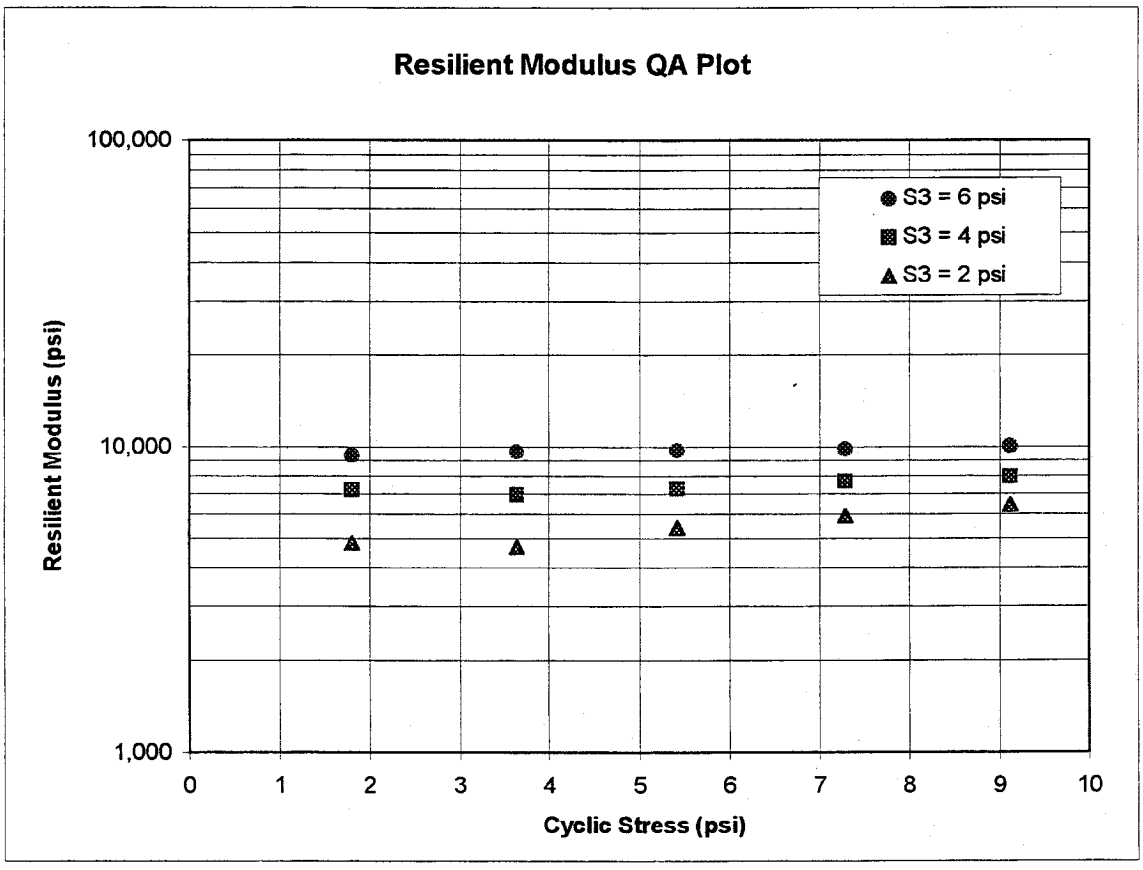
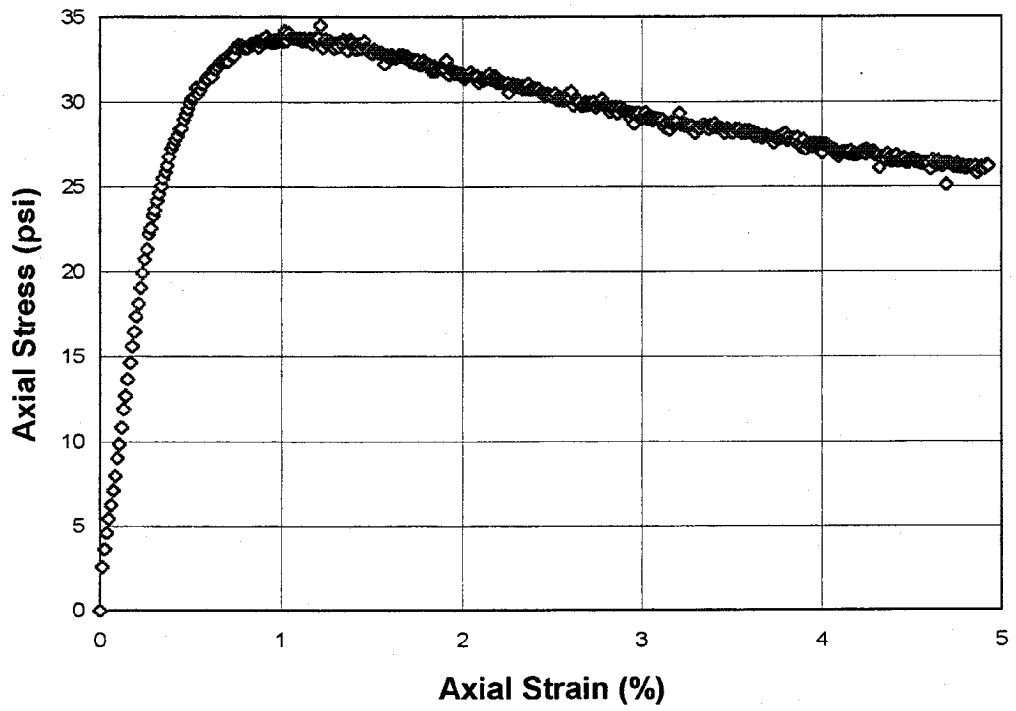


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	08-18-1995



LABORATORY MATERIAL HANDLING AND TESTING
LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: LAW ENGINEERING, INC. - ATLANTA, GEORGIA

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE* (Type 1 or Type 2)	2
5.	*TEST INFORMATION*	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	15
6.	*SPECIMEN INFO .:*	
	SPECIMEN DIAM., inch	
	TOP	2.86
	MIDDLE	2.86
	BOTTOM	2.86
	AVERAGE	2.86
	MEMBRANE THICKNESS (1), inch	0.01
	MEMBRANE THICKNESS (2), inch	0.01
	NET DIAM., inch	2.83
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	6.08
	HEIGHT OF CAP AND BASE, inch	0.00
	INITIAL LENGTH, L_0 , inch	6.08
	INITIAL AREA, A_0 , in^2	6.31
	INITIAL VOLUME $A_0 L_0$, in^3	38.35
7.	*SOIL SPECIMEN WEIGHT:*	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	1116.95
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	0.00
	WEIGHT OF WET SOIL USED , grams	1116.95
8.	*SOIL PROPERTIES .:*	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	N/A
	IN SITU WET DENSITY (NUCLEAR), pcf	N/A
	or	
	OPTIMUM MOISTURE CONTENT, %	15.7
	MAX. DRY DENSITY, pcf	103.3
	95 % MAX. DRY DENSITY, pcf	98.1
9.	*SPECIMEN PROPERTIES:*	
	COMPACTION MOISTURE CONTENT, %	14.6
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	14.6
	COMPACTION DRY DENSITY, γ_d pcf	96.7
10.	*QUICK SHEAR TEST*	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	52.0
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	Y
11.	*COMMENTS* (Section 10.4 of Protocol P46)	
	(a) *CODE*	0 0 0 0 0 0
	(b) *NOTE*	
12.	*TEST DATE*	08-18-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

RJ Bowdren 9/11/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Bottom Ash
3. *REMOLDING TARGETS:* 95% Modified Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 08-18-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε_r	M_r
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	_ _ _ ._	_ _ _ ._	_	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ _ _ ._	_ ._ _ _ _ _	_ ._ _ _ _ _	_ ._ _ _ _ _	_ ._ _ _ _	_ _ _ .
SEQUENCE 1	6.0	2.0	1	12.9	11.7	1.3	2.0	1.8	0.2	0.00105	0.00103	0.00104	0.00017	10,779
			2	12.9	11.6	1.3	2.0	1.8	0.2	0.00105	0.00105	0.00105	0.00017	10,667
			3	12.8	11.5	1.2	2.0	1.8	0.2	0.00105	0.00103	0.00104	0.00017	10,704
			4	12.8	11.6	1.2	2.0	1.8	0.2	0.00105	0.00103	0.00104	0.00017	10,771
			5	12.9	11.6	1.3	2.0	1.8	0.2	0.00104	0.00104	0.00104	0.00017	10,785
	COLUMN AVERAGE			12.9	11.6	1.3	2.0	1.8	0.2	0.00105	0.00103	0.00104	0.00017	10,741
	STANDARD DEV.			0.1	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	53

Source: Cumberland Description: Bottom Ash 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	1	25.4	23.1	2.3	4.0	3.7	0.4	0.00192	0.00202	0.00197	0.00032	11,265
			2	25.5	23.2	2.3	4.0	3.7	0.4	0.00194	0.00203	0.00198	0.00033	11,256
			3	25.4	23.0	2.3	4.0	3.7	0.4	0.00193	0.00202	0.00197	0.00032	11,243
			4	25.3	23.0	2.3	4.0	3.7	0.4	0.00193	0.00203	0.00198	0.00033	11,218
			5	25.4	23.1	2.3	4.0	3.7	0.4	0.00193	0.00203	0.00198	0.00033	11,255
	COLUMN AVERAGE			25.4	23.1	2.3	4.0	3.7	0.4	0.00193	0.00202	0.00198	0.00033	11,247
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	18
SEQUENCE 3	6.0	6.0	1	37.9	34.3	3.6	6.0	5.4	0.6	0.00285	0.00302	0.00294	0.00048	11,262
			2	37.8	34.1	3.6	6.0	5.4	0.6	0.00283	0.00301	0.00292	0.00048	11,260
			3	37.6	34.0	3.6	6.0	5.4	0.6	0.00284	0.00301	0.00293	0.00048	11,201
			4	37.8	34.2	3.6	6.0	5.4	0.6	0.00283	0.00301	0.00292	0.00048	11,268
			5	37.8	34.2	3.6	6.0	5.4	0.6	0.00285	0.00303	0.00294	0.00048	11,193
	COLUMN AVERAGE			37.8	34.2	3.6	6.0	5.4	0.6	0.00284	0.00302	0.00293	0.00048	11,237
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	36
SEQUENCE 4	6.0	8.0	1	50.7	45.8	4.9	8.0	7.3	0.8	0.00383	0.00402	0.00393	0.00065	11,251
			2	51.0	46.1	4.9	8.1	7.3	0.8	0.00384	0.00402	0.00393	0.00065	11,303
			3	50.5	45.7	4.8	8.0	7.2	0.8	0.00380	0.00402	0.00391	0.00064	11,267
			4	50.6	45.7	4.8	8.0	7.3	0.8	0.00382	0.00402	0.00392	0.00065	11,238
			5	50.6	45.7	4.9	8.0	7.2	0.8	0.00381	0.00402	0.00391	0.00064	11,247
	COLUMN AVERAGE			50.7	45.8	4.9	8.0	7.3	0.8	0.00382	0.00402	0.00392	0.00064	11,261
	STANDARD DEV.			0.2	0.2	0.0	0.0	0.0	0.0	0.00002	0.00000	0.00001	0.00000	26

Source: Cumberland Description: Bottom Ash 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	1	63.2	57.1	6.1	10.0	9.1	1.0	0.00470	0.00497	0.00484	0.00080	11,379
			2	63.4	57.3	6.1	10.1	9.1	1.0	0.00475	0.00497	0.00486	0.00080	11,367
			3	63.4	57.3	6.1	10.1	9.1	1.0	0.00471	0.00498	0.00485	0.00080	11,392
			4	63.4	57.3	6.1	10.1	9.1	1.0	0.00473	0.00498	0.00485	0.00080	11,377
			5	63.3	57.3	6.1	10.0	9.1	1.0	0.00473	0.00497	0.00485	0.00080	11,379
	COLUMN AVERAGE			63.4	57.2	6.1	10.0	9.1	1.0	0.00472	0.00497	0.00485	0.00080	11,379
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00001	0.00001	0.00000	9
SEQUENCE 6	4.0	2.0	1	13.1	11.4	1.7	2.1	1.8	0.3	0.00150	0.00145	0.00147	0.00024	7,458
			2	13.1	11.4	1.7	2.1	1.8	0.3	0.00151	0.00144	0.00147	0.00024	7,469
			3	13.2	11.5	1.7	2.1	1.8	0.3	0.00150	0.00143	0.00146	0.00024	7,554
			4	13.2	11.5	1.7	2.1	1.8	0.3	0.00151	0.00145	0.00148	0.00024	7,533
			5	13.2	11.5	1.7	2.1	1.8	0.3	0.00151	0.00146	0.00148	0.00024	7,456
	COLUMN AVERAGE			13.1	11.5	1.7	2.1	1.8	0.3	0.00150	0.00144	0.00147	0.00024	7,494
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	46
SEQUENCE 7	4.0	4.0	1	25.5	23.2	2.3	4.0	3.7	0.4	0.00296	0.00302	0.00299	0.00049	7,493
			2	25.5	23.3	2.3	4.0	3.7	0.4	0.00296	0.00303	0.00300	0.00049	7,480
			3	25.5	23.3	2.3	4.0	3.7	0.4	0.00297	0.00302	0.00300	0.00049	7,480
			4	25.4	23.1	2.3	4.0	3.7	0.4	0.00298	0.00301	0.00299	0.00049	7,443
			5	25.7	23.4	2.3	4.1	3.7	0.4	0.00298	0.00302	0.00300	0.00049	7,515
	COLUMN AVERAGE			25.5	23.2	2.3	4.0	3.7	0.4	0.00297	0.00302	0.00299	0.00049	7,482
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	26

Source: Cumberland Description: Bottom Ash 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	1	38.2	34.6	3.6	6.1	5.5	0.6	0.00410	0.00427	0.00419	0.00069	7,968
			2	38.1	34.5	3.6	6.0	5.5	0.6	0.00407	0.00425	0.00416	0.00068	7,992
			3	38.1	34.5	3.6	6.0	5.5	0.6	0.00409	0.00426	0.00417	0.00069	7,974
			4	38.1	34.5	3.6	6.0	5.5	0.6	0.00408	0.00425	0.00417	0.00069	7,980
			5	38.1	34.5	3.6	6.0	5.5	0.6	0.00410	0.00425	0.00417	0.00069	7,963
	COLUMN AVERAGE			38.1	34.5	3.6	6.0	5.5	0.6	0.00409	0.00426	0.00417	0.00069	7,975
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	11
SEQUENCE 9	4.0	8.0	1	50.6	45.8	4.9	8.0	7.3	0.8	0.00505	0.00529	0.00517	0.00085	8,534
			2	50.7	45.9	4.8	8.0	7.3	0.8	0.00506	0.00528	0.00517	0.00085	8,550
			3	50.8	46.0	4.9	8.1	7.3	0.8	0.00507	0.00529	0.00518	0.00085	8,559
			4	50.6	45.7	4.9	8.0	7.3	0.8	0.00507	0.00528	0.00517	0.00085	8,523
			5	50.7	45.8	4.9	8.0	7.3	0.8	0.00506	0.00530	0.00518	0.00085	8,529
	COLUMN AVERAGE			50.7	45.8	4.9	8.0	7.3	0.8	0.00506	0.00529	0.00517	0.00085	8,539
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	15
SEQUENCE 10	4.0	10.0	1	63.6	57.5	6.1	10.1	9.1	1.0	0.00601	0.00624	0.00612	0.00101	9,047
			2	63.8	57.7	6.1	10.1	9.2	1.0	0.00600	0.00627	0.00613	0.00101	9,071
			3	63.6	57.5	6.1	10.1	9.1	1.0	0.00600	0.00627	0.00614	0.00101	9,031
			4	63.6	57.5	6.1	10.1	9.1	1.0	0.00600	0.00626	0.00613	0.00101	9,042
			5	63.5	57.3	6.1	10.1	9.1	1.0	0.00598	0.00627	0.00613	0.00101	9,024
	COLUMN AVERAGE			63.6	57.5	6.1	10.1	9.1	1.0	0.00600	0.00626	0.00613	0.00101	9,043
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	18

Source: Cumberland Description: Bottom Ash 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	1	13.3	11.2	2.1	2.1	1.8	0.3	0.00229	0.00222	0.00226	0.00037	4,775
			2	13.2	11.1	2.1	2.1	1.8	0.3	0.00228	0.00220	0.00224	0.00037	4,777
			3	13.2	11.1	2.1	2.1	1.8	0.3	0.00228	0.00220	0.00224	0.00037	4,760
			4	13.2	11.1	2.1	2.1	1.8	0.3	0.00229	0.00223	0.00226	0.00037	4,741
			5	13.2	11.1	2.1	2.1	1.8	0.3	0.00230	0.00221	0.00225	0.00037	4,748
	COLUMN AVERAGE			13.2	11.1	2.1	2.1	1.8	0.3	0.00229	0.00221	0.00225	0.00037	4,760
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	16
SEQUENCE 12	2.0	4.0	1	24.9	22.5	2.4	3.9	3.6	0.4	0.00436	0.00440	0.00438	0.00072	4,947
			2	24.9	22.4	2.4	3.9	3.6	0.4	0.00437	0.00440	0.00438	0.00072	4,934
			3	24.9	22.5	2.4	3.9	3.6	0.4	0.00436	0.00437	0.00437	0.00072	4,968
			4	24.9	22.5	2.4	3.9	3.6	0.4	0.00434	0.00439	0.00437	0.00072	4,966
			5	24.9	22.5	2.4	4.0	3.6	0.4	0.00436	0.00440	0.00438	0.00072	4,952
	COLUMN AVERAGE			24.9	22.5	2.4	3.9	3.6	0.4	0.00436	0.00439	0.00438	0.00072	4,953
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	14
SEQUENCE 13	2.0	6.0	1	37.8	34.2	3.6	6.0	5.4	0.6	0.00558	0.00573	0.00565	0.00093	5,837
			2	37.9	34.3	3.6	6.0	5.4	0.6	0.00558	0.00575	0.00566	0.00093	5,830
			3	37.8	34.2	3.6	6.0	5.4	0.6	0.00559	0.00572	0.00565	0.00093	5,832
			4	37.8	34.2	3.6	6.0	5.4	0.6	0.00559	0.00574	0.00566	0.00093	5,820
			5	37.7	34.1	3.6	6.0	5.4	0.6	0.00559	0.00573	0.00566	0.00093	5,815
	COLUMN AVERAGE			37.8	34.2	3.6	6.0	5.4	0.6	0.00558	0.00573	0.00566	0.00093	5,827
	STANDARD DEV.			0.1	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	9

Source: Cumberland Description: Bottom Ash 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	1	50.8	46.0	4.9	8.1	7.3	0.8	0.00662	0.00680	0.00671	0.00110	6,611
			2	50.8	46.0	4.8	8.1	7.3	0.8	0.00659	0.00681	0.00670	0.00110	6,609
			3	50.9	46.0	4.8	8.1	7.3	0.8	0.00660	0.00681	0.00670	0.00110	6,618
			4	51.0	46.1	4.9	8.1	7.3	0.8	0.00662	0.00680	0.00671	0.00110	6,629
			5	50.9	46.0	4.9	8.1	7.3	0.8	0.00661	0.00681	0.00671	0.00110	6,610
	COLUMN AVERAGE			50.9	46.0	4.9	8.1	7.3	0.8	0.00661	0.00680	0.00671	0.00110	6,615
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	9
SEQUENCE 15	2.0	10.0	1	63.6	57.5	6.1	10.1	9.1	1.0	0.00758	0.00780	0.00769	0.00126	7,207
			2	63.8	57.7	6.1	10.1	9.1	1.0	0.00756	0.00778	0.00767	0.00126	7,246
			3	63.7	57.6	6.1	10.1	9.1	1.0	0.00757	0.00779	0.00768	0.00126	7,236
			4	63.7	57.5	6.1	10.1	9.1	1.0	0.00758	0.00782	0.00770	0.00127	7,206
			5	63.6	57.5	6.1	10.1	9.1	1.0	0.00758	0.00779	0.00769	0.00126	7,210
	COLUMN AVERAGE			63.7	57.6	6.1	10.1	9.1	1.0	0.00757	0.00780	0.00768	0.00126	7,221
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	19

SUBMITTED BY, DATE

RJ Burchem 9/11/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:	TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:	5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	08-18-1995

$$M_R = K1\,(S_C)^{K2}(1+S_3)^{K5}$$

K1 =	1,994
K2 =	0.13866
K5 =	0.76150
R^2 =	0.94

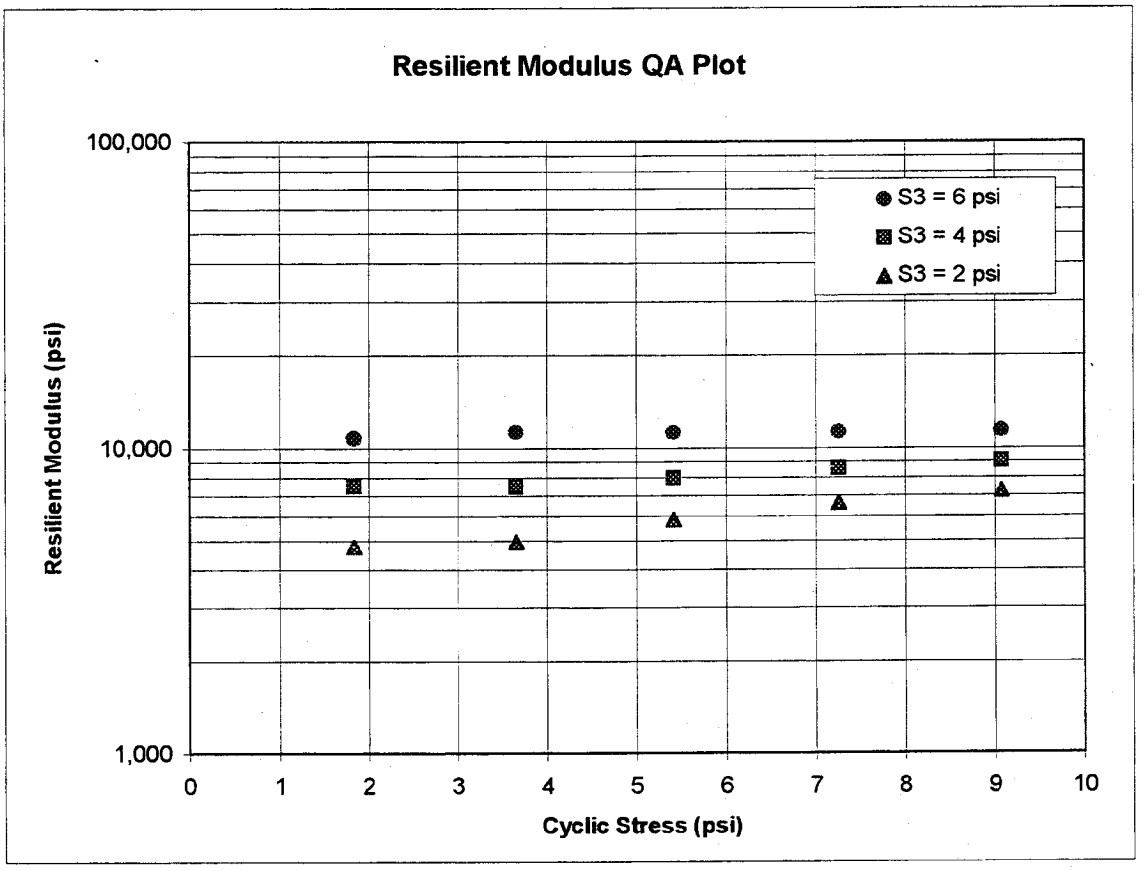
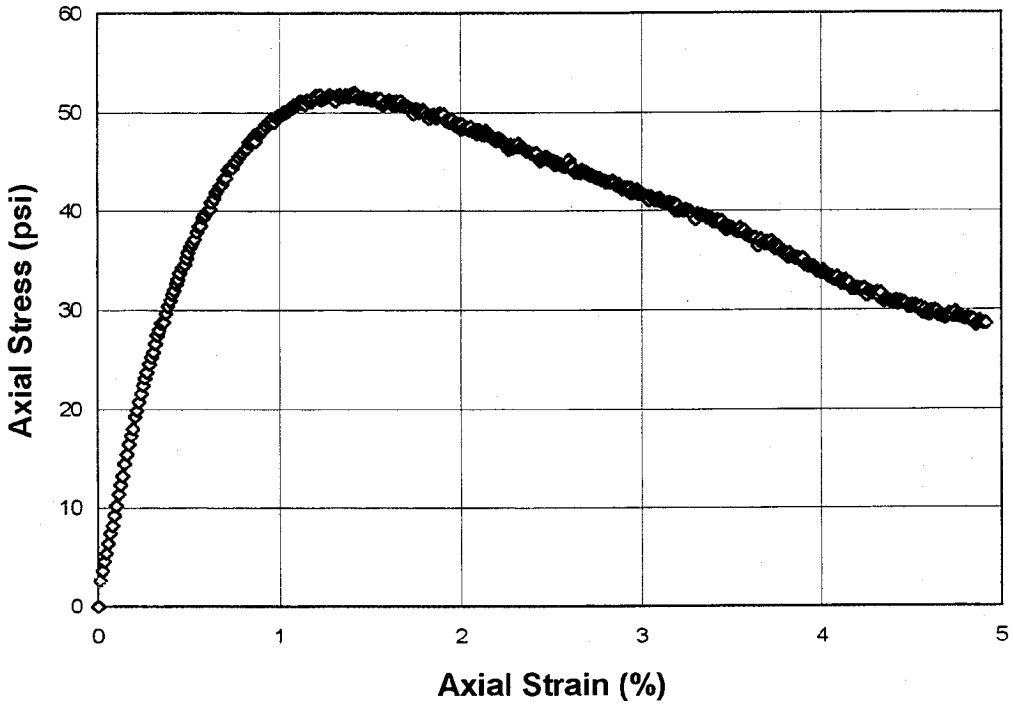


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Bottom Ash
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	08-18-1995



CUMBERLAND

Scrubber Gypsum

Grain Size Distribution Test Report (**Not Performed**)
Moisture-Density Relationship (Standard Proctor)
Moisture-Density Relationship (Modified Proctor)
Consolidation Test Report
Hydraulic Conductivity - Falling Head (2 Pages)
Triaxial Compression Test (2 Pages)
Direct Shear Test
California Bearing Ratio
Resilient Modulus (Standard Proctor) (9 Pages)
Resilient Modulus (Modified Proctor) (9 Pages)

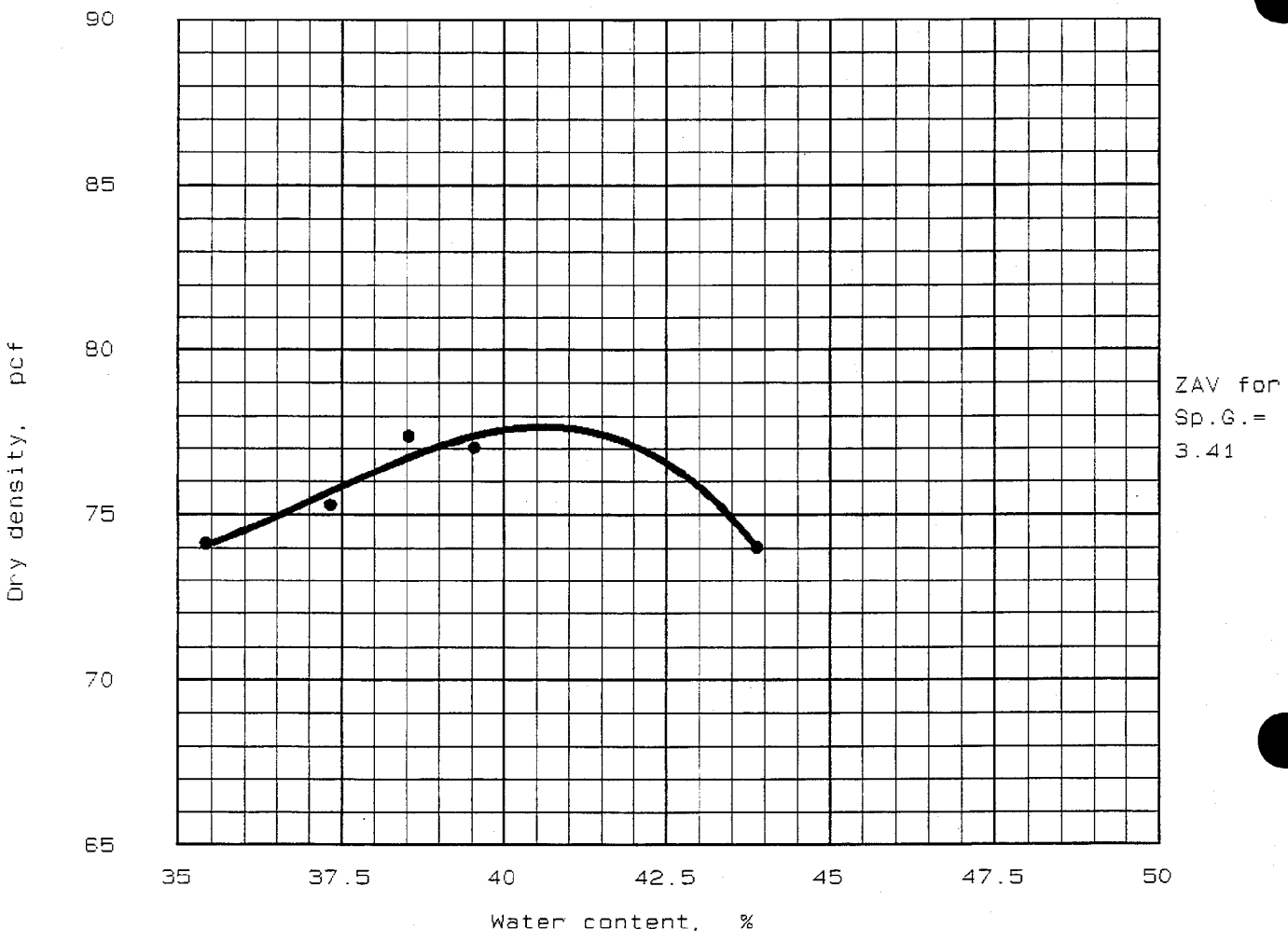
TVA - CUMBERLAND
SCRUBBER GYPSUM

Description	Test Method	Property	Sample 1	Sample 2	Sample 3
Grain Size	ASTM D 422	Percent Retained on the #4 Sieve Percent Passing the #200 Sieve Percent Passing the 0.005 mm Sieve	see note 1 see note 1 see note 1	see note 1 see note 1 see note 1	see note 1 see note 1 see note 1
Atterberg Limits	ASTM D 4318	Liquid Limit Plastic Limit Plasticity Index	NL NP N/A	NL NP N/A	NL NP N/A
Specific Gravity	ASTM D 854	Specific Gravity at 20°C		3.41 (see note 2)	
Classification	ASTM D 2487 AASHTO M 145	Unified Soil Classification System (USCS) AASHTO Classification	see note 3 see note 3	see note 3 see note 3	see note 3 see note 3
			Composite Sample		
Moisture-Density Relations (Standard Effort)	ASTM D 698	Maximum Dry Density, pcf Optimum Moisture Content, %	77.6 40.6		
Moisture-Density Relations (Modified Effort)	ASTM D 1557	Maximum Dry Density, pcf Optimum Moisture Content, %	85.9 29.7		
			Result	Dry Density, pcf	Moisture Content, %
Consolidation	ASTM D2435	Compression Index C_c	0.12	73.5	56.9
Hydraulic Conductivity	ASTM D 5084	Hydraulic Conductivity, cm/sec	1.2E-3	67.6	52.3
Triaxial Shear Strength Consolidated-Undrained (CU)	ASTM D4767	Effective Stress, Cohesion, c', ksf Effective Stress, Internal Friction Angle, ϕ',degrees	0.00 38.1	68.1	51.4
		Total Stress, Cohesion, c, ksf Total Stress, Internal Friction Angle, ϕ, degrees	3.33 33.4	68.1	51.4
Direct Shear Strength	ASTM D 3080	Cohesion, c, ksf Internal Friction Angle, ϕ, degrees	1.32 41.4	67.8	52.7
California Bearing Ratio	ASTM D 1883	CBR, %	20	74.0	42.0
Resilient Modulus (Standard Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	15,646	70.5	46.0
Resilient Modulus (Modified Compactive Effort)	SHRP P46	Resilient Modulus at 4psi axial stress and 4psi confining pressure	17,515	74.7	40.0
Soil Resistivity	AASHTO T 288	Minimum Resistivity, Ohm-cm	1,100		
pH of Soil	AASHTO T 289	pH	7.8		
Water Soluble Sulfate Ion	AASHTO T 290	Sulfate Ion Content, mg/kg	4830		
Water Soluble Chloride Ion	AASHTO T 290	Chloride Ion Content, mg/kg	<10		

Note 1: Material observed to chrystalize/set-up upon wetting. Test could not be performed.
Note 2: A test was performed on a composite sample from the 3 independant samples.
Note 3: A classification could not be performed without the ASTM D 422 results.

cuf-gy.xls

MOISTURE-DENSITY RELATIONSHIP



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
				3.41	NL	NP		

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 40.6 % Maximum dry density = 77.6 pcf	Gypsum

Project No.: 5810860101
Project: TVA - Cumberland
Location: Scrubber Gypsum

Date: September 28, 1995

Remarks:

Tested by: CS

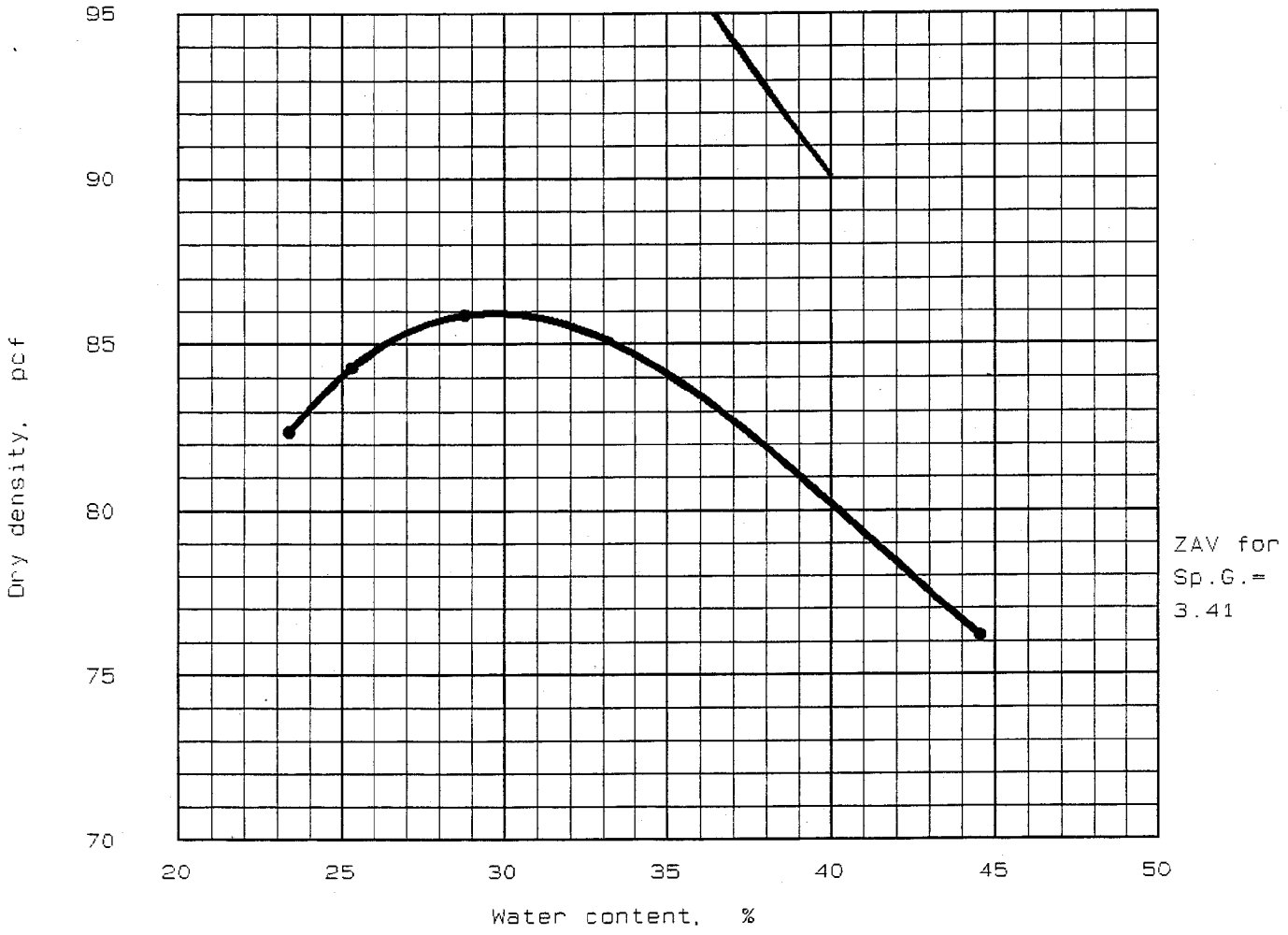
Reviewed by: HD

MOISTURE-DENSITY RELATIONSHIP

LAW ENGINEERING, INC.

Figure No. _____

MOISTURE-DENSITY RELATIONSHIP



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
				3.41	NL	NP		

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 29.7 % Maximum dry density = 85.9 pcf	Gypsum

Project No.: 5810860101
Project: TVA - Cumberland
Location: Scrubber Gypsum

Date: September 27, 1995

Remarks:

Tested by: EM

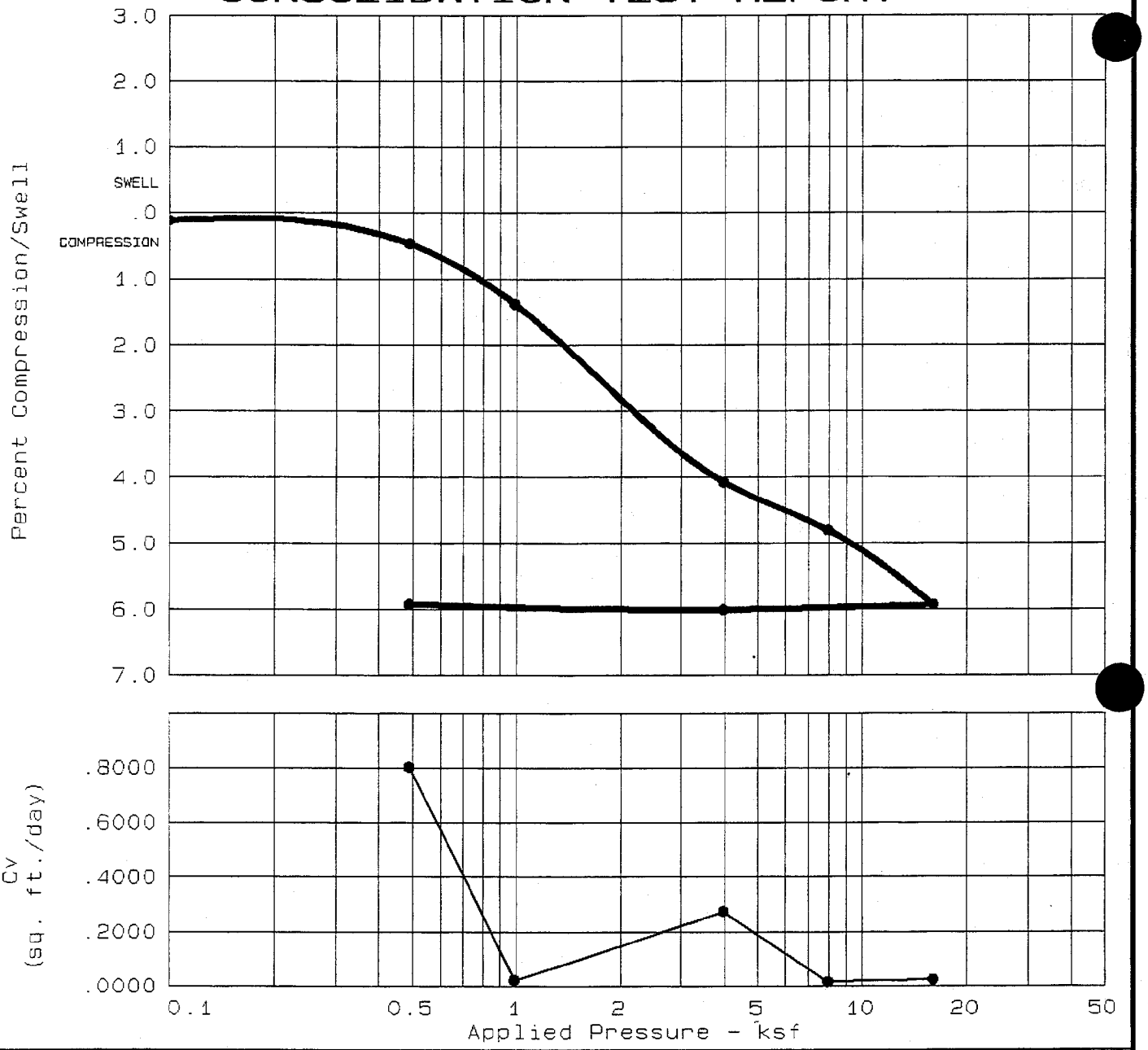
Reviewed by: HB

MOISTURE-DENSITY RELATIONSHIP

LAW ENGINEERING, INC.

Figure No. _____

CONSOLIDATION TEST REPORT



Natural Saturation	Natural Moisture	Dry Density	LL	PI	Sp.Gr.	Precons. press.	C_c	e_0
89.7 %	56.9	73.5	NL	NP	3.410	5.79	0.12	2.1616

TEST RESULTS

Compression Index = 0.12

MATERIAL DESCRIPTION

Project No.: 5810860101
Project: TVA - Cumberland
Location: Gypsum

Date: 9/28/95

Remarks:

Tested by: AdK
Reviewed by: KD

CONSOLIDATION TEST REPORT

LAW ENGINEERING, INC.

Fig. No. _____

HYDRAULIC CONDUCTIVITY

LAW ENGINEERING

Project No.	*5810860101*	Tested By	*HEJ*
Project Name	*TVA-Cumberland*	Test Date	*10/09/95*
Boring No.	*Scrubber Gypsum*	Reviewed By	*RLB*
Sample No.	*Bag*	Review Date	10/19/95
Sample Depth			
Sample Description	*Gypsum*		

ASTM D5084 - Falling Head

Sample Type:	*Bag*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*52.3*
Wet Unit Weight, pcf:	*103.1*
Dry Unit Weight, pcf:	*67.6*
Compaction, %:	*87.2*
Hydraulic Conductivity, cm/sec. @20 °C:	***1.2E-03***

PERMEABILITY TEST - FALLING HEAD
(ASTM D5084 - 90)

LAW ENGINEERING

Job Number 5810860101
Project Name TVA-Cumberland
Boring No. Scrubber Gypsum
Sample No. Bag
Sample Depth
Sample Description Gypsum

Tested By HEJ
Test Date 10/09/95
Reviewed By RLB
Review Date 10/19/95

Sample Data

Length, in		Diameter, in		Pan No.	AB-6
Location 1	6.000	Location 1	2.830	Dry Soil+Pan, grams	756.76
Location 2	6.000	Location 2	2.830	Pan Weight, grams	86.60
Location3	6.000	Location 3	2.830		
Average	6.000	Average	2.830	Moisture Content, %	52.3
		Wet Soil + Tare, grams	1020.95	Wet Unit Wt, pcf	103.1
		Tare Weight, grams	0.00	Dry Unit Wt, pcf	67.6

Chamber Pressure, psi	49
Back Pressure, psi	35
Confining Pressure, psi	14

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	Division Start	Division Finish	H0 (cm)	Hf (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				75	50.0	0.0	93.94	43.94	1.3E-03	21	1.3E-03
				78	50.0	0.0	93.94	43.94	1.3E-03	21	1.2E-03
				79	50.0	0.0	93.94	43.94	1.2E-03	21	1.2E-03

No. of Tria	Sample Type	Max. Densit (pcf)	Compaction %	Sample Orientation
3	Bag	78	87.2	Vertical

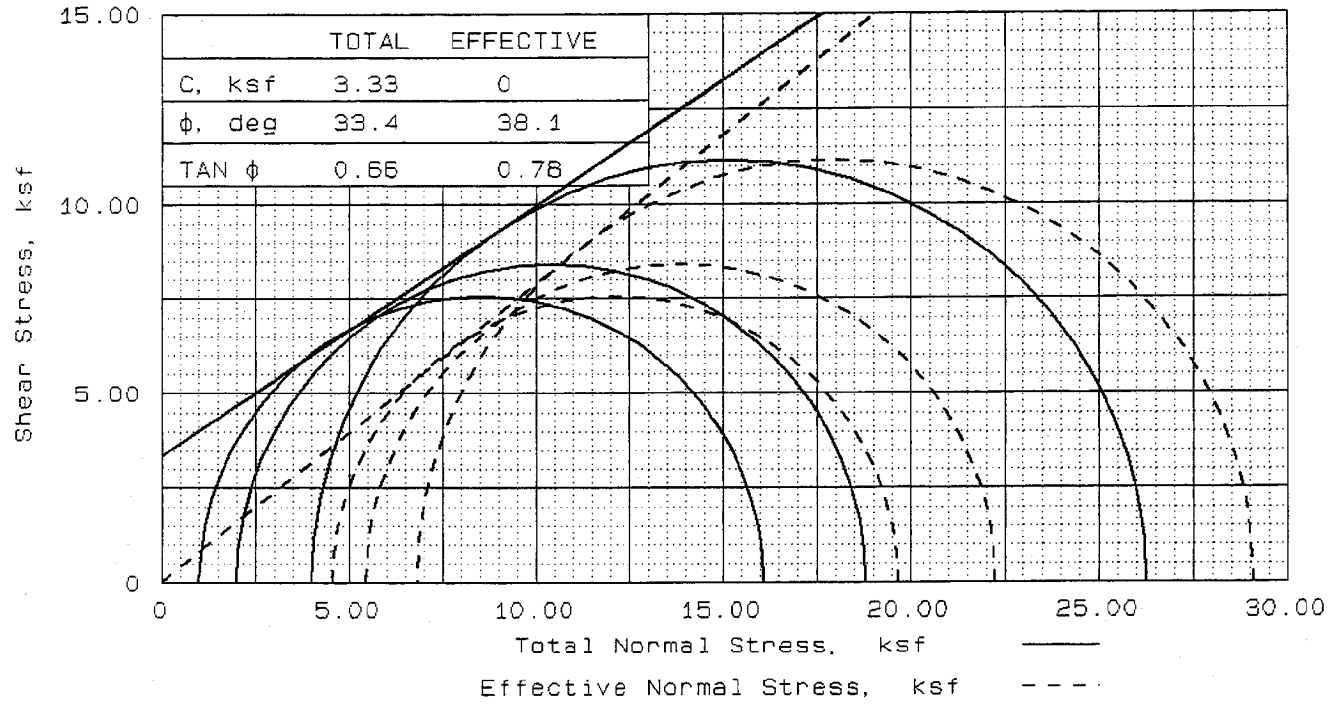
Avg. k at 20 °C 1.2E-03 cm/sec

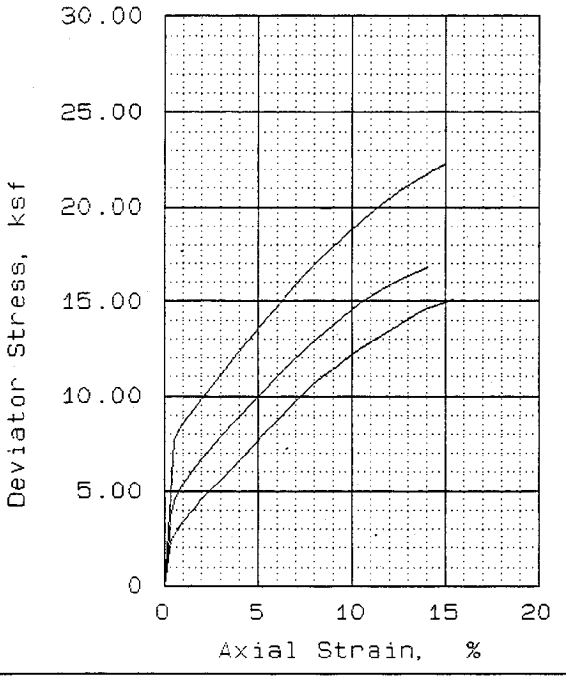
a = area of burette in cm²
L = length of sample in cm
A = area of sample in cm²

H0 = initial head in cm
Hf = final head in cm
t = time in seconds

a = 0.34 cm²
A = 40.582 cm²
L = 15.24 cm

TVA-00011927





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	52.9	52.3	48.9
	DRY DENSITY, pcf	67.5	67.6	69.2
	SATURATION, %	83.6	83.1	80.3
	VOID RATIO	2.156	2.147	2.075
	DIAMETER, in	2.83	2.83	2.83
	HEIGHT, in	6.00	6.00	6.00
AT TEST	WATER CONTENT, %	61.7	60.9	58.5
	DRY DENSITY, pcf	58.6	69.2	71.1
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	2.105	2.076	1.994
	DIAMETER, in	2.81	2.80	2.80
	HEIGHT, in	5.98	5.97	5.96
BACK PRESSURE, ksf		4.98	5.08	5.08
CELL PRESSURE, ksf		5.98	7.08	9.08
FAILURE STRESS, ksf		15.11	16.82	22.27
PORE PRESSURE, ksf		1.43	1.64	2.26
STRAIN RATE, %/min.		0.100	0.100	0.100
ULTIMATE STRESS, ksf				
PORE PRESSURE, ksf				
$\bar{\sigma}_1$ FAILURE, ksf		19.67	22.26	29.09
$\bar{\sigma}_3$ FAILURE, ksf		4.56	5.44	6.82

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: Remolded
DESCRIPTION: Gypsum

LL= NL PL= NP PI=
SPECIFIC GRAVITY= 3.41
REMARKS: Tested by: HB

Reviewed by: RLB

FIG. NO.

CLIENT:

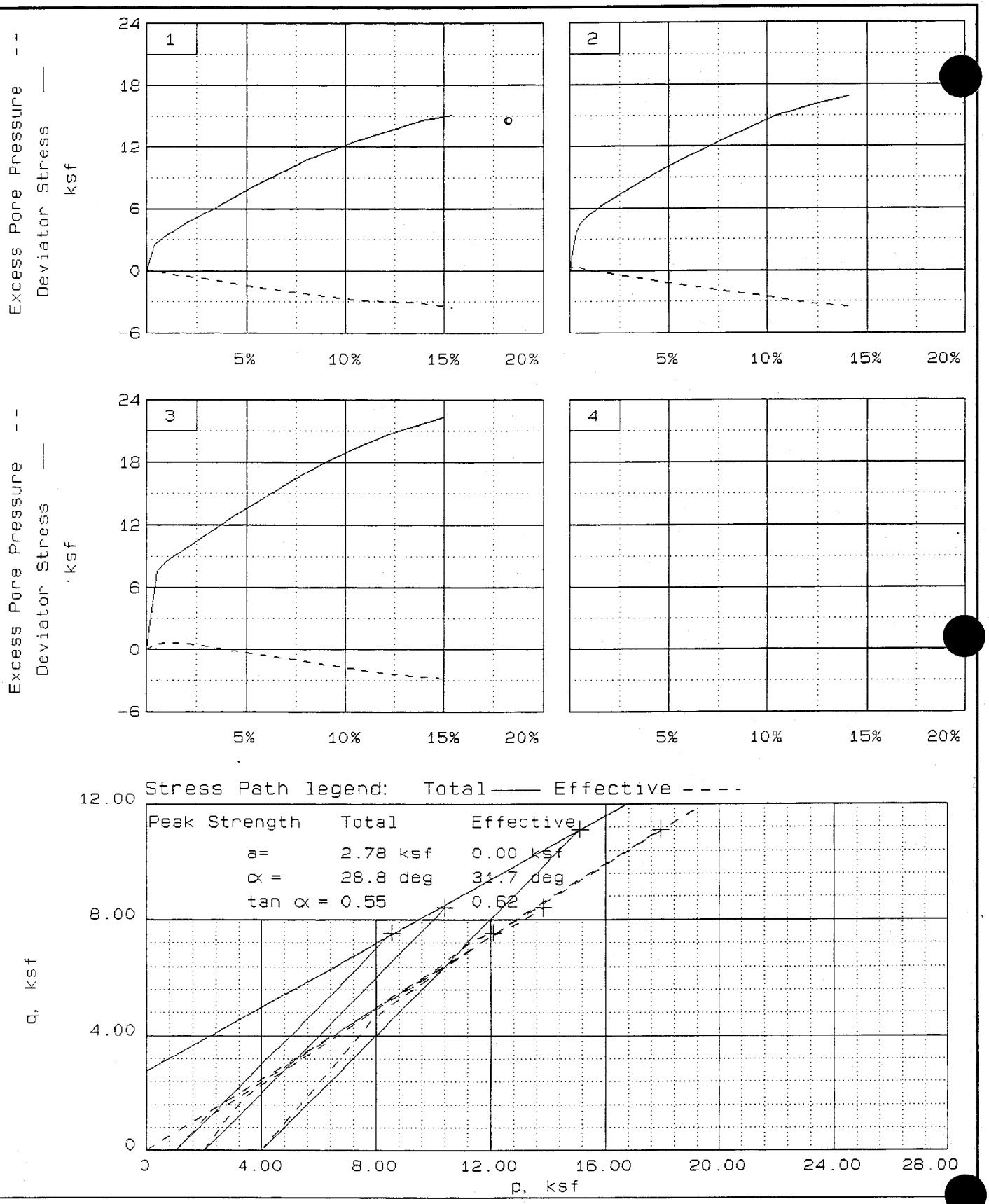
PROJECT: TVA - Cumberland

SAMPLE LOCATION: Scrubber Gypsum

PROJ. NO.: 5810860101 DATE: 10/23/95

TRIAXIAL COMPRESSION TEST

LAW ENGINEERING, INC.

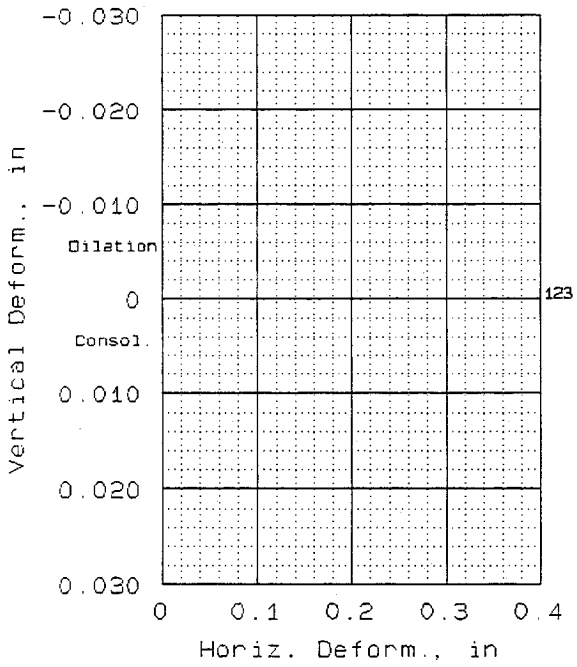


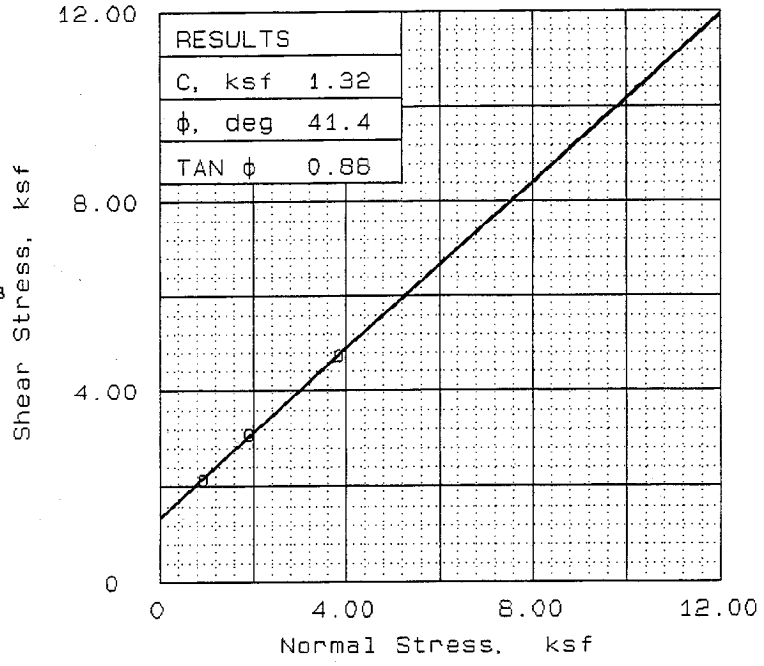
Client:

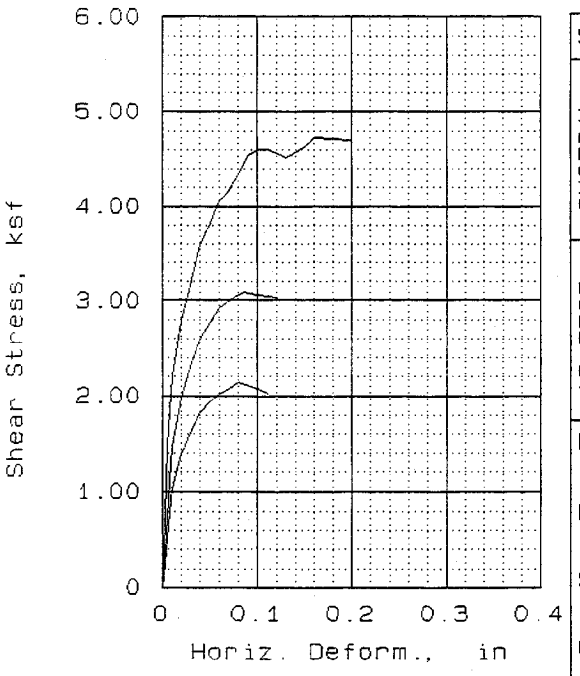
Project: TVA - Cumberland

Location: Scrubber Gypsum

File: 8601P Project No.: 5810860101 Page 2/2 Fig. No. ____







SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	52.4	52.3	53.3
	DRY DENSITY, pcf	68.2	67.7	67.5
	SATURATION, %	97.4	96.0	97.4
	VOID RATIO	1.427	1.444	1.451
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.81	0.81	0.81
AT TEST	WATER CONTENT, %	52.4	52.3	53.3
	DRY DENSITY, pcf	68.2	67.7	67.5
	SATURATION, %	97.4	96.0	97.4
	VOID RATIO	1.427	1.444	1.451
	DIAMETER, in	2.50	2.50	2.50
	HEIGHT, in	0.81	0.81	0.81
NORMAL STRESS, ksf		0.97	1.94	3.88
MAX. SHEAR, ksf		2.14	3.08	4.73
STRAIN RATE, %/min.		0.500	0.500	0.500
ULT. SHEAR, ksf				

SAMPLE DATA

SAMPLE TYPE: Remolded

DESCRIPTION: Gypsum

LL= NL PL= NP PI=

SPECIFIC GRAVITY= 3.41

REMARKS: Tested by: HD

Reviewed by: RLB

FIG. NO.

CLIENT:

PROJECT: TVA - Cumberland

SAMPLE LOCATION: Scrubber Gypsum

PROJ. NO.: 5810860101 DATE: 10/10/95

DIRECT SHEAR TEST

LAW ENGINEERING, INC.

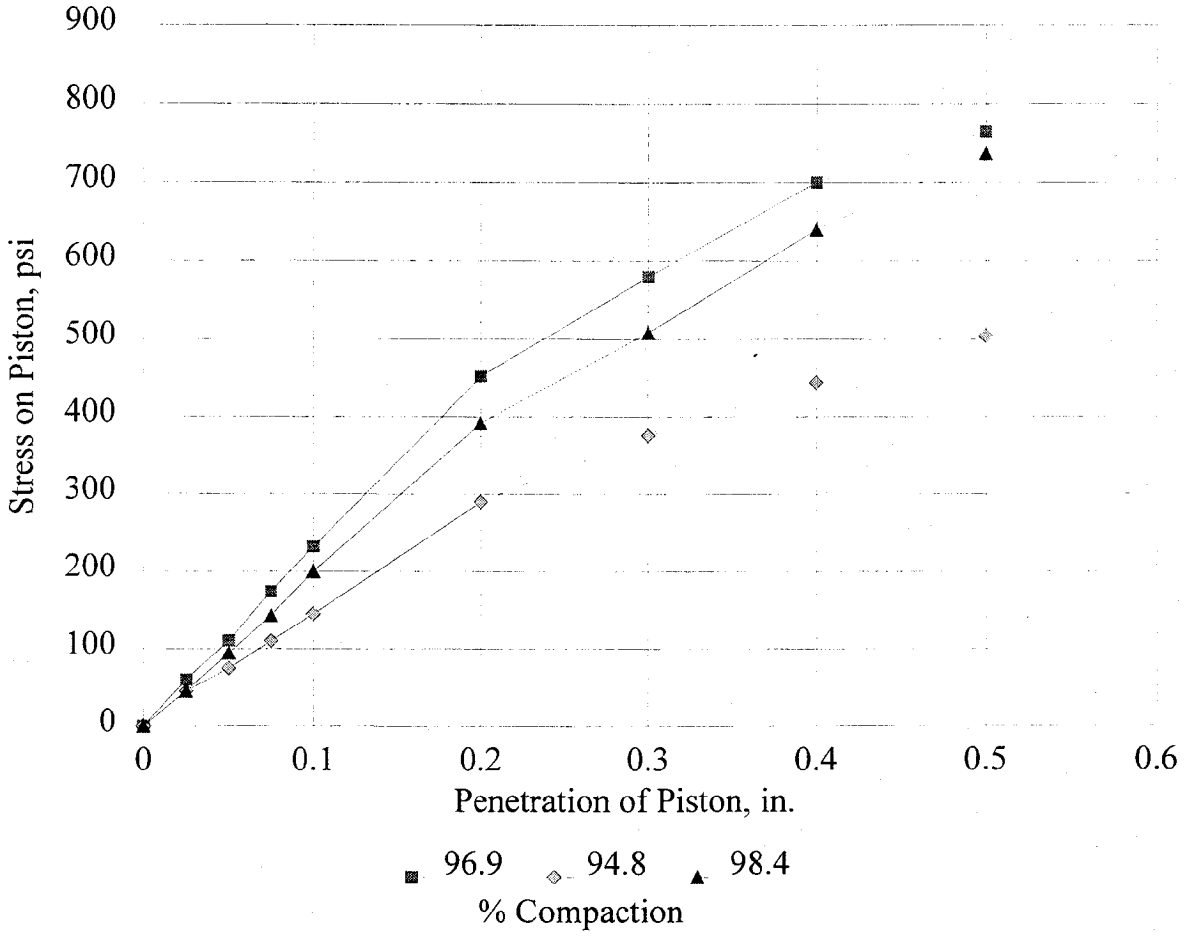
California Bearing Ratio

(ASTM D1883-92)

LAW ENGINEERING

Project No.	5810860101	**Tested By**	EM
Project Name	TVA - Cumberland	**Test Date**	10/09/95
Material (Source)	Gypsum	**Reviewed By**	RLB
		Review Date	10/10/95

Compaction, %	96.9	94.8	98.4
Before Soak Dry Density, pcf	75.2	73.5	76.3
Before Soak Moisture Content,	43.7	41.1	39.3
After Soak Dry Density, pcf	75.1	73.6	76.6
After Soak Moisture Content, %	46.5	48.6	46.5
CBR @ 0.1 in.	23.2	14.5	20.0
CBR @ 0.2 in.	30.1	19.3	26.1



LABORATORY MATERIAL HANDLING AND TESTING
LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: **LAW ENGINEERING, INC. - ATLANTA, GEORGIA**

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Gypsum
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE* (Type 1 or Type 2)	2
5.	*TEST INFORMATION*	
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)	N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)	15
6.	*SPECIMEN INFO.:*	
	SPECIMEN DIAM., inch	
	TOP	2.85
	MIDDLE	2.85
	BOTTOM	2.85
	AVERAGE	2.85
	MEMBRANE THICKNESS (1), inch	0.01
	MEMBRANE THICKNESS (2), inch	0.01
	NET DIAM., inch	2.83
	HEIGHT OF SPECIMEN, CAP AND BASE, inch	6.00
	HEIGHT OF CAP AND BASE, inch	0.00
	INITIAL LENGTH, L_0 , inch	6.00
	INITIAL AREA, A_0 , in^2	6.28
	INITIAL VOLUME $A_0 L_0$, in^3	37.70
7.	*SOIL SPECIMEN WEIGHT*:	
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams	1018.96
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams	0.00
	WEIGHT OF WET SOIL USED, grams	1018.96
8.	*SOIL PROPERTIES.:*	
	IN SITU MOISTURE CONTENT (NUCLEAR), %	N/A
	IN SITU WET DENSITY (NUCLEAR), pcf	N/A
	or	
	OPTIMUM MOISTURE CONTENT, %	41.0
	MAX. DRY DENSITY, pcf	77.5
	95 % MAX. DRY DENSITY, pcf	73.6
9.	*SPECIMEN PROPERTIES:*	
	COMPACTION MOISTURE CONTENT, %	46.0
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %	46.9
	COMPACTION DRY DENSITY, γ_d pcf	70.5
10.	*QUICK SHEAR TEST*	
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)	Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi	26.1
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)	Y
11.	*COMMENTS* (Section 10.4 of Protocol P46)	
	(a) *CODE*	0 0 0 0 0 0
	(b) *NOTE*	
12.	*TEST DATE*	09-29-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

Richard J. Bradham 10/18/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Gypsum
3. *REMOLDING TARGETS:* 95% Standard Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 09-29-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε_r	M_r
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	_ _ _ . _	_ _ _ . _	_	_ _ _ _ . _	_ _ _ . _	_ _ _ . _	_ _ _ . _	_ _ _ . _	_ _ . _	. _ _ _ _ _	. _ _ _ _ _	. _ _ _ _ _	. _ _ _ _	_ _ _ _ .
SEQUENCE 1	6.0	2.0	95	12.7	11.3	1.4	2.0	1.8	0.2	0.00062	0.00071	0.00066	0.00011	16,299
			96	12.7	11.4	1.3	2.0	1.8	0.2	0.00062	0.00069	0.00066	0.00011	16,564
			97	12.7	11.4	1.3	2.0	1.8	0.2	0.00062	0.00071	0.00067	0.00011	16,340
			98	12.8	11.4	1.4	2.0	1.8	0.2	0.00064	0.00071	0.00067	0.00011	16,270
			100	12.7	11.4	1.4	2.0	1.8	0.2	0.00062	0.00068	0.00065	0.00011	16,638
	COLUMN AVERAGE			12.7	11.4	1.3	2.0	1.8	0.2	0.00063	0.00070	0.00066	0.00011	16,422
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	167

Source: Cumberland Description: Gypsum 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	95	25.2	22.7	2.4	4.0	3.6	0.4	0.00116	0.00126	0.00121	0.00020	17,961
			96	25.2	22.7	2.4	4.0	3.6	0.4	0.00117	0.00125	0.00121	0.00020	17,919
			97	25.1	22.7	2.4	4.0	3.6	0.4	0.00116	0.00126	0.00121	0.00020	17,893
			98	25.1	22.7	2.4	4.0	3.6	0.4	0.00117	0.00126	0.00121	0.00020	17,907
			100	25.1	22.7	2.4	4.0	3.6	0.4	0.00117	0.00126	0.00121	0.00020	17,870
	COLUMN AVERAGE			25.1	22.7	2.4	4.0	3.6	0.4	0.00117	0.00126	0.00121	0.00020	17,910
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00000	0.00000	0.00000	34
SEQUENCE 3	6.0	6.0	95	37.8	34.1	3.7	6.0	5.4	0.6	0.00169	0.00181	0.00175	0.00029	18,627
			96	37.8	34.1	3.7	6.0	5.4	0.6	0.00169	0.00183	0.00176	0.00029	18,531
			97	37.8	34.1	3.7	6.0	5.4	0.6	0.00169	0.00183	0.00176	0.00029	18,555
			98	37.7	34.1	3.7	6.0	5.4	0.6	0.00170	0.00183	0.00177	0.00029	18,446
			100	37.8	34.1	3.7	6.0	5.4	0.6	0.00169	0.00183	0.00176	0.00029	18,520
	COLUMN AVERAGE			37.8	34.1	3.7	6.0	5.4	0.6	0.00169	0.00183	0.00176	0.00029	18,536
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	65
SEQUENCE 4	6.0	8.0	95	50.3	45.4	4.9	8.0	7.2	0.8	0.00220	0.00237	0.00228	0.00038	18,992
			96	50.4	45.5	4.9	8.0	7.2	0.8	0.00220	0.00239	0.00230	0.00038	18,937
			97	50.4	45.4	4.9	8.0	7.2	0.8	0.00220	0.00239	0.00229	0.00038	18,948
			98	50.4	45.5	4.9	8.0	7.2	0.8	0.00221	0.00238	0.00229	0.00038	18,943
			100	50.4	45.5	4.9	8.0	7.2	0.8	0.00220	0.00237	0.00229	0.00038	19,011
	COLUMN AVERAGE			50.4	45.4	4.9	8.0	7.2	0.8	0.00220	0.00238	0.00229	0.00038	18,966
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	33

Source: Cumberland Description: Gypsum 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	95	63.0	56.8	6.2	10.0	9.0	1.0	0.00269	0.00291	0.00280	0.00047	19,364
			96	63.0	56.8	6.2	10.0	9.0	1.0	0.00269	0.00294	0.00281	0.00047	19,308
			97	63.0	56.8	6.2	10.0	9.0	1.0	0.00267	0.00294	0.00281	0.00047	19,342
			98	63.0	56.8	6.2	10.0	9.0	1.0	0.00269	0.00292	0.00281	0.00047	19,352
			100	62.9	56.8	6.2	10.0	9.0	1.0	0.00271	0.00294	0.00283	0.00047	19,208
	COLUMN AVERAGE			63.0	56.8	6.2	10.0	9.0	1.0	0.00269	0.00293	0.00281	0.00047	19,315
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	63
SEQUENCE 6	4.0	2.0	95	13.1	11.4	1.7	2.1	1.8	0.3	0.00069	0.00072	0.00071	0.00012	15,417
			96	13.2	11.4	1.7	2.1	1.8	0.3	0.00069	0.00071	0.00070	0.00012	15,622
			97	13.1	11.4	1.7	2.1	1.8	0.3	0.00069	0.00071	0.00070	0.00012	15,536
			98	13.1	11.4	1.7	2.1	1.8	0.3	0.00069	0.00071	0.00070	0.00012	15,486
			100	13.1	11.4	1.7	2.1	1.8	0.3	0.00069	0.00072	0.00071	0.00012	15,453
	COLUMN AVERAGE			13.1	11.4	1.7	2.1	1.8	0.3	0.00069	0.00072	0.00070	0.00012	15,503
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	80
SEQUENCE 7	4.0	4.0	95	25.1	22.8	2.4	4.0	3.6	0.4	0.00125	0.00137	0.00131	0.00022	16,623
			96	25.2	22.7	2.4	4.0	3.6	0.4	0.00124	0.00134	0.00129	0.00022	16,832
			97	25.1	22.7	2.4	4.0	3.6	0.4	0.00127	0.00136	0.00131	0.00022	16,503
			98	25.1	22.7	2.4	4.0	3.6	0.4	0.00126	0.00136	0.00131	0.00022	16,540
			100	25.2	22.7	2.5	4.0	3.6	0.4	0.00125	0.00135	0.00130	0.00022	16,721
	COLUMN AVERAGE			25.1	22.7	2.4	4.0	3.6	0.4	0.00126	0.00136	0.00131	0.00022	16,644
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	134

Source: Cumberland Description: Gypsum 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	95	37.8	34.1	3.7	6.0	5.4	0.6	0.00181	0.00197	0.00189	0.00031	17,266
			96	37.8	34.1	3.7	6.0	5.4	0.6	0.00180	0.00198	0.00189	0.00031	17,262
			97	37.8	34.1	3.7	6.0	5.4	0.6	0.00181	0.00196	0.00189	0.00031	17,301
			98	37.8	34.1	3.7	6.0	5.4	0.6	0.00182	0.00196	0.00189	0.00031	17,258
			100	37.8	34.1	3.7	6.0	5.4	0.6	0.00180	0.00196	0.00188	0.00031	17,285
	COLUMN AVERAGE			37.8	34.1	3.7	6.0	5.4	0.6	0.00181	0.00197	0.00189	0.00031	17,274
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	18
SEQUENCE 9	4.0	8.0	95	50.3	45.3	4.9	8.0	7.2	0.8	0.00235	0.00254	0.00244	0.00041	17,747
			96	50.4	45.4	4.9	8.0	7.2	0.8	0.00234	0.00253	0.00243	0.00041	17,843
			97	50.3	45.4	4.9	8.0	7.2	0.8	0.00234	0.00254	0.00244	0.00041	17,756
			98	50.4	45.4	4.9	8.0	7.2	0.8	0.00234	0.00255	0.00245	0.00041	17,759
			100	50.3	45.4	4.9	8.0	7.2	0.8	0.00234	0.00254	0.00244	0.00041	17,791
	COLUMN AVERAGE			50.3	45.4	4.9	8.0	7.2	0.8	0.00234	0.00254	0.00244	0.00041	17,779
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	39
SEQUENCE 10	4.0	10.0	95	62.9	56.7	6.2	10.0	9.0	1.0	0.00287	0.00314	0.00300	0.00050	18,054
			96	62.9	56.7	6.2	10.0	9.0	1.0	0.00288	0.00315	0.00302	0.00050	17,968
			97	62.9	56.7	6.2	10.0	9.0	1.0	0.00288	0.00314	0.00301	0.00050	18,045
			98	62.9	56.7	6.2	10.0	9.0	1.0	0.00286	0.00313	0.00300	0.00050	18,090
			100	63.0	56.8	6.2	10.0	9.0	1.0	0.00288	0.00315	0.00301	0.00050	18,035
	COLUMN AVERAGE			62.9	56.7	6.2	10.0	9.0	1.0	0.00287	0.00314	0.00301	0.00050	18,038
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	45

Source: Cumberland Description: Gypsum 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	95	13.4	11.3	2.1	2.1	1.8	0.3	0.00082	0.00078	0.00080	0.00013	13,517
			96	13.4	11.3	2.1	2.1	1.8	0.3	0.00084	0.00078	0.00081	0.00013	13,334
			97	13.4	11.3	2.1	2.1	1.8	0.3	0.00083	0.00078	0.00081	0.00013	13,400
			98	13.4	11.3	2.1	2.1	1.8	0.3	0.00084	0.00079	0.00082	0.00014	13,269
			100	13.4	11.3	2.1	2.1	1.8	0.3	0.00082	0.00078	0.00080	0.00013	13,523
	COLUMN AVERAGE			13.4	11.3	2.1	2.1	1.8	0.3	0.00083	0.00078	0.00081	0.00013	13,409
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00001	0.00000	112
SEQUENCE 12	2.0	4.0	95	25.1	22.7	2.4	4.0	3.6	0.4	0.00149	0.00153	0.00151	0.00025	14,315
			96	25.1	22.7	2.4	4.0	3.6	0.4	0.00151	0.00152	0.00151	0.00025	14,340
			97	25.1	22.6	2.4	4.0	3.6	0.4	0.00149	0.00154	0.00152	0.00025	14,265
			98	25.2	22.7	2.5	4.0	3.6	0.4	0.00149	0.00155	0.00152	0.00025	14,268
			100	25.2	22.7	2.4	4.0	3.6	0.4	0.00148	0.00153	0.00151	0.00025	14,402
	COLUMN AVERAGE			25.1	22.7	2.4	4.0	3.6	0.4	0.00149	0.00154	0.00151	0.00025	14,318
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00000	0.00000	57
SEQUENCE 13	2.0	6.0	95	37.8	34.1	3.7	6.0	5.4	0.6	0.00208	0.00224	0.00216	0.00036	15,110
			96	37.8	34.1	3.7	6.0	5.4	0.6	0.00210	0.00223	0.00217	0.00036	15,039
			97	37.8	34.1	3.7	6.0	5.4	0.6	0.00209	0.00226	0.00217	0.00036	15,014
			98	37.8	34.1	3.7	6.0	5.4	0.6	0.00208	0.00224	0.00216	0.00036	15,070
			100	37.8	34.1	3.7	6.0	5.4	0.6	0.00209	0.00224	0.00216	0.00036	15,090
	COLUMN AVERAGE			37.8	34.1	3.7	6.0	5.4	0.6	0.00209	0.00224	0.00216	0.00036	15,065
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	39

Source: Cumberland Description: Gypsum 95% Standard Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	95	50.3	45.3	4.9	8.0	7.2	0.8	0.00269	0.00292	0.00280	0.00047	15,469
			96	50.2	45.2	4.9	8.0	7.2	0.8	0.00267	0.00292	0.00280	0.00047	15,473
			97	50.2	45.3	4.9	8.0	7.2	0.8	0.00271	0.00292	0.00282	0.00047	15,380
			98	50.2	45.3	4.9	8.0	7.2	0.8	0.00269	0.00293	0.00281	0.00047	15,422
			100	50.2	45.3	4.9	8.0	7.2	0.8	0.00268	0.00292	0.00280	0.00047	15,474
	COLUMN AVERAGE			50.2	45.3	4.9	8.0	7.2	0.8	0.00269	0.00292	0.00280	0.00047	15,444
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	42
SEQUENCE 15	2.0	10.0	95	62.7	56.6	6.2	10.0	9.0	1.0	0.00336	0.00368	0.00352	0.00059	15,364
			96	62.8	56.6	6.2	10.0	9.0	1.0	0.00335	0.00366	0.00350	0.00058	15,440
			97	62.8	56.6	6.2	10.0	9.0	1.0	0.00336	0.00368	0.00352	0.00059	15,383
			98	62.8	56.6	6.2	10.0	9.0	1.0	0.00337	0.00370	0.00354	0.00059	15,310
			100	62.8	56.6	6.2	10.0	9.0	1.0	0.00337	0.00369	0.00353	0.00059	15,330
	COLUMN AVERAGE			62.8	56.6	6.2	10.0	9.0	1.0	0.00336	0.00368	0.00352	0.00059	15,365
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	51

SUBMITTED BY, DATE

Richard L. Bowman 10/10/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Gypsum
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	09-29-1995

$$M_R = K1\,(S_c)^{K2}(1+S_3)^{K5}$$

K1 =	9,623
K2 =	0.09590
K5 =	0.25471
R^2 =	0.99

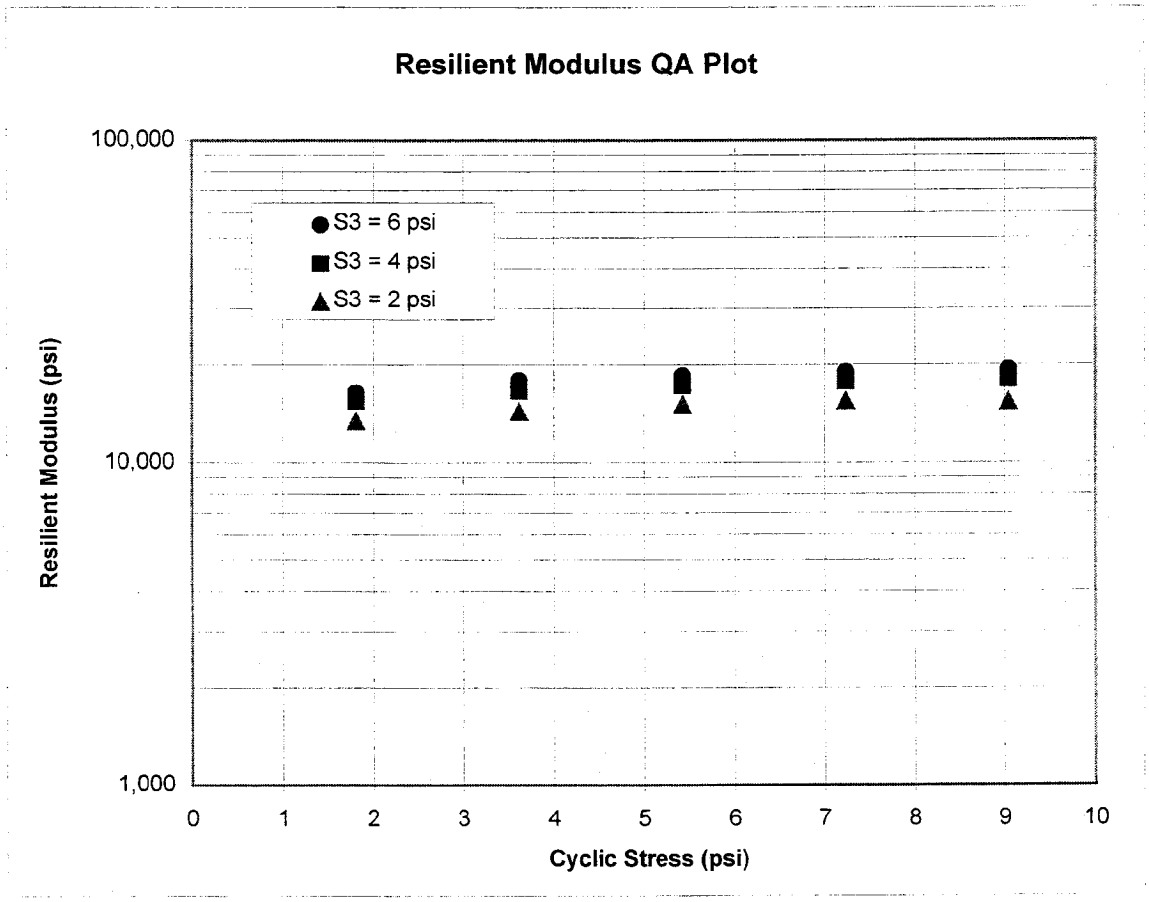
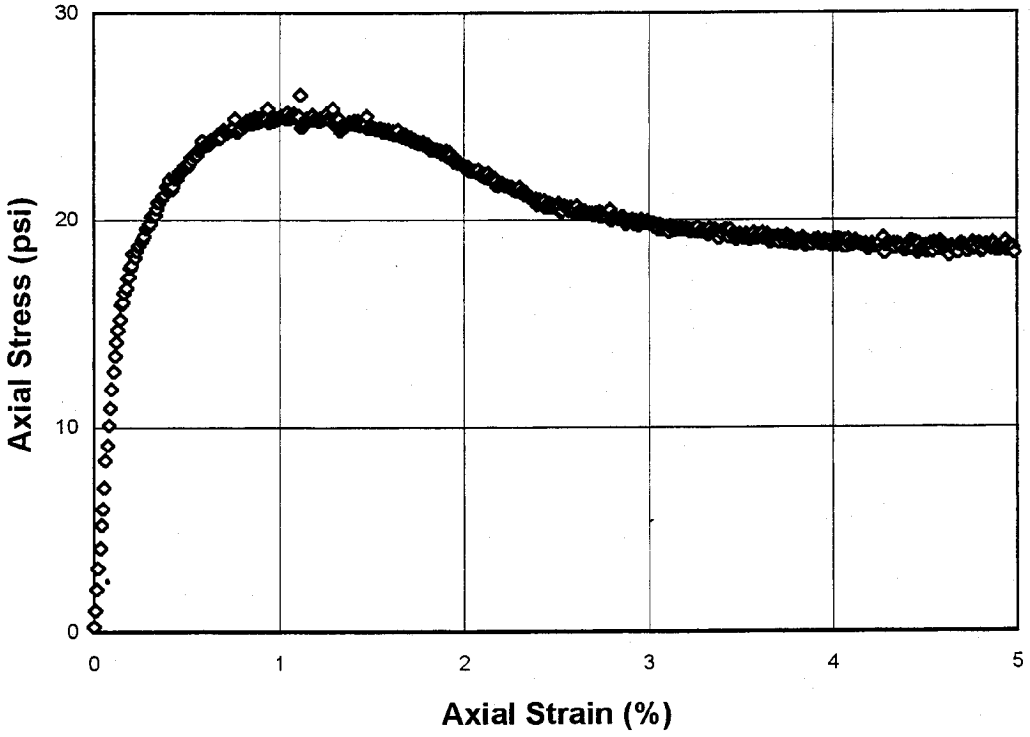


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Gypsum
3.	*REMOLDING TARGETS:*	95% Standard Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	09-29-1995



LABORATORY MATERIAL HANDLING AND TESTING SHEET NO 1 OF 2

LABORATORY MATERIAL TEST DATA
RESILIENT MODULUS OF UNBOUND GRANULAR BASE/SUBBASE MATERIALS AND SUBGRADE SOILS
LAB DATA SHEET T46 - RECOMPACTED SAMPLES

UNBOUND GRANULAR BASE/SUBBASE LAYERS AND SUBGRADE SOILS
SHRP TEST DESIGNATION UG07, SS07/SHRP PROTOCOL P46

LABORATORY PERFORMING TEST: **LAW ENGINEERING, INC. - ATLANTA, GEORGIA**

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study

LAW PROJECT NO.: 5810860101

1.	*MATERIAL SOURCE:*	Cumberland	
2.	*MATERIAL DESCRIPTION:*	Gypsum	
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content	
4.	*MATERIAL TYPE* (Type 1 or Type 2)		2
5.	*TEST INFORMATION*		
	PRECONDITIONING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)		N
	TESTING - GREATER THAN 5% PERM. STRAIN? (Y = YES OR N = NO)		N
	TESTING - NUMBER OF LOAD SEQUENCES COMPLETED (0 - 15)		15
6.	*SPECIMEN INFO.:*		
	SPECIMEN DIAM., inch		
	TOP		2.85
	MIDDLE		2.85
	BOTTOM		2.85
	AVERAGE		2.85
	MEMBRANE THICKNESS (1), inch		0.01
	MEMBRANE THICKNESS (2), inch		0.01
	NET DIAM., inch		2.83
	HEIGHT OF SPECIMEN, CAP AND BASE, inch		6.02
	HEIGHT OF CAP AND BASE, inch		0.00
	INITIAL LENGTH, L_0, inch		6.02
	INITIAL AREA, A_0, in^2		6.28
	INITIAL VOLUME $A_0 L_0$, in^3		37.83
7.	*SOIL SPECIMEN WEIGHT:*		
	INITIAL WEIGHT OF CONTAINER AND WET SOIL, grams		1039.81
	FINAL WEIGHT OF CONTAINER AND WET SOIL, grams		0.00
	WEIGHT OF WET SOIL USED, grams		1039.81
8.	*SOIL PROPERTIES.:*		
	IN SITU MOISTURE CONTENT (NUCLEAR), %		N/A
	IN SITU WET DENSITY (NUCLEAR), pcf		N/A
	or		
	OPTIMUM MOISTURE CONTENT, %		30.0
	MAX. DRY DENSITY, pcf		85.9
	95 % MAX. DRY DENSITY, pcf		81.6
9.	*SPECIMEN PROPERTIES:*		
	COMPACTION MOISTURE CONTENT, %		40.0
	MOISTURE CONTENT AFTER RESILIENT MODULUS TESTING, %		40.0
	COMPACTION DRY DENSITY, γ_d pcf		74.7
10.	*QUICK SHEAR TEST*		
	STRESS - STRAIN PLOT ATTACHED (Y = YES, N = NO)		Y
	TRIAXIAL SHEAR MAXIMUM STRENGTH (MAX. LOAD/X-SECTION AREA), psi		44.6
	SPECIMEN FAIL DURING TRIAXIAL SHEAR? (Y = YES, N = NO)		Y
11.	*COMMENTS* (Section 10.4 of Protocol P46)		
	(a) *CODE*	0 0 0 0 0 0	
	(b) *NOTE*		
12.	*TEST DATE*		09-29-1995

GENERAL REMARKS:

SUBMITTED BY, DATE

Richard S. Boudreau 10/18/95

LABORATORY MANAGER

PROJECT NAME: TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.: 5810860101
1. *MATERIAL SOURCE:* Cumberland
2. *MATERIAL DESCRIPTION:* Gypsum
3. *REMOLDING TARGETS:* 95% Modified Dry Density at Optimum Moisture Content
4. *MATERIAL TYPE* 2
5. *TEST DATE* 09-29-1995
6. *RESILIENT MODULUS TESTING*

COLUMN #	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PARAMETER	*Chamber Confining Pressure*	*Nominal Maximum Axial Stress*	*Cycle No.*	*Actual Applied Max. Axial Load*	*Actual Applied Cyclic Load*	*Actual Applied Contact Load*	*Actual Applied Max. Axial Stress*	*Actual Applied Cyclic Stress*	*Actual Applied Contact Stress*	*Recov. Def. LVDT #1 Reading*	*Recov. Def. LVDT #2 Reading*	*Average Recov Def. LVDT 1 and 2*	*Resilient Strain*	*Resilient Modulus*
DESIGNATION	S_3	S_{cyclic}	c_1	P_{max}	P_{cyclic}	$P_{contact}$	S_{max}	S_{cyclic}	$S_{contact}$	H_1	H_2	H_{avg}	ε_r	M_r
UNIT	psi	psi	---	lbs	lbs	lbs	psi	psi	psi	in.	in.	in.	in/in	psi
PRECISION	_._	_._	_	_._	_._	_._	_._	_._	_._	_._	_._	_._	_._	_._
SEQUENCE 1	6.0	2.0	95	12.7	11.5	1.2	2.0	1.8	0.2	0.00066	0.00059	0.00062	0.00010	17,679
			96	12.7	11.4	1.3	2.0	1.8	0.2	0.00064	0.00057	0.00060	0.00010	18,168
			97	12.7	11.5	1.3	2.0	1.8	0.2	0.00065	0.00057	0.00061	0.00010	18,046
			98	12.7	11.5	1.3	2.0	1.8	0.2	0.00067	0.00057	0.00062	0.00010	17,665
			100	12.8	11.5	1.3	2.0	1.8	0.2	0.00066	0.00057	0.00062	0.00010	17,822
	COLUMN AVERAGE			12.7	11.5	1.3	2.0	1.8	0.2	0.00066	0.00057	0.00061	0.00010	17,876
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	224

Source: Cumberland Description: Gypsum 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 2	6.0	4.0	95	25.3	23.0	2.3	4.0	3.7	0.4	0.00120	0.00108	0.00114	0.00019	19,305
			96	25.2	22.9	2.4	4.0	3.6	0.4	0.00120	0.00108	0.00114	0.00019	19,234
			97	25.3	22.9	2.4	4.0	3.6	0.4	0.00120	0.00108	0.00114	0.00019	19,264
			98	25.2	22.9	2.3	4.0	3.6	0.4	0.00122	0.00107	0.00115	0.00019	19,128
			100	25.3	23.0	2.4	4.0	3.7	0.4	0.00119	0.00107	0.00113	0.00019	19,437
	COLUMN AVERAGE			25.3	22.9	2.4	4.0	3.6	0.4	0.00120	0.00108	0.00114	0.00019	19,273
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00000	0.00001	0.00000	112
SEQUENCE 3	6.0	6.0	95	37.9	34.3	3.6	6.0	5.5	0.6	0.00171	0.00156	0.00163	0.00027	20,147
			96	37.9	34.3	3.6	6.0	5.5	0.6	0.00171	0.00155	0.00163	0.00027	20,190
			97	38.1	34.4	3.6	6.1	5.5	0.6	0.00171	0.00157	0.00164	0.00027	20,148
			98	38.0	34.4	3.6	6.0	5.5	0.6	0.00171	0.00156	0.00163	0.00027	20,168
			100	37.9	34.3	3.6	6.0	5.5	0.6	0.00171	0.00156	0.00163	0.00027	20,152
	COLUMN AVERAGE			38.0	34.4	3.6	6.0	5.5	0.6	0.00171	0.00156	0.00163	0.00027	20,161
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00000	0.00000	18
SEQUENCE 4	6.0	8.0	95	50.6	45.7	4.9	8.0	7.3	0.8	0.00221	0.00205	0.00213	0.00035	20,558
			96	50.7	45.8	4.8	8.1	7.3	0.8	0.00221	0.00204	0.00212	0.00035	20,666
			97	50.6	45.8	4.8	8.1	7.3	0.8	0.00221	0.00204	0.00212	0.00035	20,652
			98	50.7	45.8	4.8	8.1	7.3	0.8	0.00221	0.00206	0.00214	0.00035	20,549
			100	50.6	45.8	4.8	8.1	7.3	0.8	0.00221	0.00204	0.00213	0.00035	20,655
	COLUMN AVERAGE			50.6	45.8	4.8	8.1	7.3	0.8	0.00221	0.00205	0.00213	0.00035	20,616
	STANDARD DEV.			0.0	0.1	0.0	0.0	0.0	0.0	0.00000	0.00001	0.00001	0.00000	57

Source: Cumberland Description: Gypsum 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 5	6.0	10.0	95	63.1	57.0	6.1	10.0	9.1	1.0	0.00267	0.00250	0.00258	0.00043	21,156
			96	63.1	57.0	6.1	10.0	9.1	1.0	0.00268	0.00252	0.00260	0.00043	21,024
			97	63.0	56.9	6.1	10.0	9.1	1.0	0.00267	0.00251	0.00259	0.00043	21,079
			98	63.1	57.0	6.1	10.0	9.1	1.0	0.00270	0.00253	0.00261	0.00043	20,914
			100	63.1	57.0	6.1	10.0	9.1	1.0	0.00268	0.00251	0.00259	0.00043	21,069
	COLUMN AVERAGE			63.1	57.0	6.1	10.0	9.1	1.0	0.00268	0.00251	0.00260	0.00043	21,048
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	89
SEQUENCE 6	4.0	2.0	95	13.1	11.4	1.7	2.1	1.8	0.3	0.00066	0.00058	0.00062	0.00010	17,642
			96	13.0	11.4	1.6	2.1	1.8	0.3	0.00069	0.00058	0.00064	0.00011	17,167
			97	13.1	11.4	1.6	2.1	1.8	0.3	0.00066	0.00058	0.00062	0.00010	17,619
			98	13.2	11.6	1.7	2.1	1.8	0.3	0.00068	0.00057	0.00062	0.00010	17,755
			100	13.1	11.4	1.6	2.1	1.8	0.3	0.00068	0.00058	0.00063	0.00010	17,315
	COLUMN AVERAGE			13.1	11.4	1.7	2.1	1.8	0.3	0.00068	0.00058	0.00063	0.00010	17,500
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	247
SEQUENCE 7	4.0	4.0	95	25.2	22.9	2.3	4.0	3.6	0.4	0.00123	0.00112	0.00117	0.00019	18,706
			96	25.4	23.0	2.4	4.0	3.7	0.4	0.00127	0.00112	0.00120	0.00020	18,435
			97	25.3	22.9	2.4	4.0	3.7	0.4	0.00126	0.00115	0.00121	0.00020	18,204
			98	25.3	22.9	2.3	4.0	3.6	0.4	0.00125	0.00114	0.00120	0.00020	18,341
			100	25.2	22.8	2.4	4.0	3.6	0.4	0.00124	0.00112	0.00118	0.00020	18,520
	COLUMN AVERAGE			25.3	22.9	2.4	4.0	3.6	0.4	0.00125	0.00113	0.00119	0.00020	18,441
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00002	0.00002	0.00001	0.00000	189

Source: Cumberland Description: Gypsum 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 8	4.0	6.0	95	38.0	34.4	3.6	6.1	5.5	0.6	0.00178	0.00167	0.00173	0.00029	19,080
			96	38.0	34.4	3.6	6.0	5.5	0.6	0.00180	0.00168	0.00174	0.00029	18,953
			97	38.0	34.4	3.6	6.1	5.5	0.6	0.00179	0.00167	0.00173	0.00029	19,095
			98	38.0	34.4	3.6	6.0	5.5	0.6	0.00180	0.00168	0.00174	0.00029	18,960
			100	38.0	34.4	3.6	6.0	5.5	0.6	0.00182	0.00169	0.00175	0.00029	18,776
	COLUMN AVERAGE			38.0	34.4	3.6	6.0	5.5	0.6	0.00180	0.00168	0.00174	0.00029	18,973
	STANDARD DEV.			0.0	0.0	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	128
SEQUENCE 9	4.0	8.0	95	50.5	45.7	4.8	8.0	7.3	0.8	0.00229	0.00217	0.00223	0.00037	19,594
			96	50.4	45.6	4.8	8.0	7.3	0.8	0.00230	0.00216	0.00223	0.00037	19,610
			97	50.6	45.8	4.9	8.1	7.3	0.8	0.00231	0.00218	0.00225	0.00037	19,525
			98	50.7	45.8	4.8	8.1	7.3	0.8	0.00232	0.00220	0.00226	0.00037	19,459
			100	50.7	45.8	4.8	8.1	7.3	0.8	0.00230	0.00218	0.00224	0.00037	19,571
	COLUMN AVERAGE			50.6	45.7	4.8	8.0	7.3	0.8	0.00230	0.00218	0.00224	0.00037	19,552
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	61
SEQUENCE 10	4.0	10.0	95	63.1	57.0	6.0	10.0	9.1	1.0	0.00283	0.00267	0.00275	0.00046	19,873
			96	63.1	57.0	6.1	10.0	9.1	1.0	0.00282	0.00266	0.00274	0.00046	19,916
			97	63.1	57.1	6.1	10.1	9.1	1.0	0.00282	0.00267	0.00275	0.00046	19,900
			98	63.1	57.0	6.1	10.0	9.1	1.0	0.00281	0.00267	0.00274	0.00046	19,947
			100	63.2	57.1	6.1	10.1	9.1	1.0	0.00283	0.00269	0.00276	0.00046	19,852
	COLUMN AVERAGE			63.1	57.0	6.1	10.0	9.1	1.0	0.00282	0.00267	0.00275	0.00046	19,898
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	37

Source: Cumberland Description: Gypsum 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 11	2.0	2.0	95	13.4	11.3	2.1	2.1	1.8	0.3	0.00075	0.00066	0.00070	0.00012	15,458
			96	13.4	11.4	2.0	2.1	1.8	0.3	0.00074	0.00064	0.00069	0.00011	15,808
			97	13.6	11.5	2.1	2.2	1.8	0.3	0.00075	0.00065	0.00070	0.00012	15,767
			98	13.5	11.4	2.0	2.1	1.8	0.3	0.00074	0.00066	0.00070	0.00012	15,698
			100	13.5	11.4	2.0	2.1	1.8	0.3	0.00074	0.00064	0.00069	0.00011	15,880
	COLUMN AVERAGE			13.5	11.4	2.0	2.1	1.8	0.3	0.00074	0.00065	0.00070	0.00012	15,722
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	162
SEQUENCE 12	2.0	4.0	95	25.2	22.8	2.4	4.0	3.6	0.4	0.00140	0.00130	0.00135	0.00022	16,158
			96	25.1	22.7	2.4	4.0	3.6	0.4	0.00141	0.00132	0.00136	0.00023	15,980
			97	25.4	23.1	2.4	4.0	3.7	0.4	0.00141	0.00130	0.00136	0.00023	16,279
			98	25.1	22.8	2.4	4.0	3.6	0.4	0.00139	0.00130	0.00135	0.00022	16,223
			100	25.1	22.7	2.4	4.0	3.6	0.4	0.00140	0.00130	0.00135	0.00022	16,139
	COLUMN AVERAGE			25.2	22.8	2.4	4.0	3.6	0.4	0.00140	0.00131	0.00135	0.00022	16,156
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	113
SEQUENCE 13	2.0	6.0	95	37.9	34.3	3.6	6.0	5.5	0.6	0.00201	0.00191	0.00196	0.00033	16,773
			96	37.8	34.2	3.6	6.0	5.4	0.6	0.00203	0.00194	0.00199	0.00033	16,522
			97	37.9	34.3	3.6	6.0	5.5	0.6	0.00202	0.00191	0.00197	0.00033	16,703
			98	37.9	34.3	3.6	6.0	5.5	0.6	0.00201	0.00192	0.00196	0.00033	16,769
			100	38.0	34.4	3.6	6.0	5.5	0.6	0.00203	0.00192	0.00197	0.00033	16,697
	COLUMN AVERAGE			37.9	34.3	3.6	6.0	5.5	0.6	0.00202	0.00192	0.00197	0.00033	16,693
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	102

Source: Cumberland Description: Gypsum 95% Modified Dry Density at Optimum Moisture Content

SEQUENCE 14	2.0	8.0	95	50.5	45.7	4.8	8.0	7.3	0.8	0.00260	0.00249	0.00254	0.00042	17,194
			96	50.4	45.6	4.8	8.0	7.3	0.8	0.00258	0.00247	0.00253	0.00042	17,272
			97	50.4	45.6	4.8	8.0	7.3	0.8	0.00260	0.00249	0.00254	0.00042	17,180
			98	50.5	45.6	4.9	8.0	7.3	0.8	0.00261	0.00249	0.00255	0.00042	17,125
			100	50.3	45.4	4.9	8.0	7.2	0.8	0.00259	0.00246	0.00252	0.00042	17,254
	COLUMN AVERAGE			50.4	45.6	4.8	8.0	7.3	0.8	0.00260	0.00248	0.00254	0.00042	17,205
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	59
SEQUENCE 15	2.0	10.0	95	63.1	57.0	6.1	10.0	9.1	1.0	0.00317	0.00302	0.00310	0.00051	17,626
			96	63.1	57.0	6.1	10.0	9.1	1.0	0.00319	0.00304	0.00312	0.00052	17,531
			97	63.0	56.9	6.1	10.0	9.1	1.0	0.00318	0.00302	0.00310	0.00051	17,585
			98	63.0	57.0	6.0	10.0	9.1	1.0	0.00320	0.00303	0.00311	0.00052	17,539
			100	63.0	56.9	6.1	10.0	9.1	1.0	0.00318	0.00301	0.00310	0.00051	17,604
	COLUMN AVERAGE			63.0	57.0	6.1	10.0	9.1	1.0	0.00319	0.00303	0.00311	0.00052	17,577
	STANDARD DEV.			0.1	0.1	0.0	0.0	0.0	0.0	0.00001	0.00001	0.00001	0.00000	41

SUBMITTED BY, DATE

Richard S. Bruehan 10/18/95

LABORATORY MANAGER

FIGURE 1 - Logarithmic Plot of Resilient Modulus (M_R) vs Cyclic Stress (S_C)

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Gypsum
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	09-29-1995

$$M_R = K1\ (S_C)^{K2}(1+S_3)^{K5}$$

K1 =	11,738
K2 =	0.08396
K5 =	0.20475
R^2 =	0.98

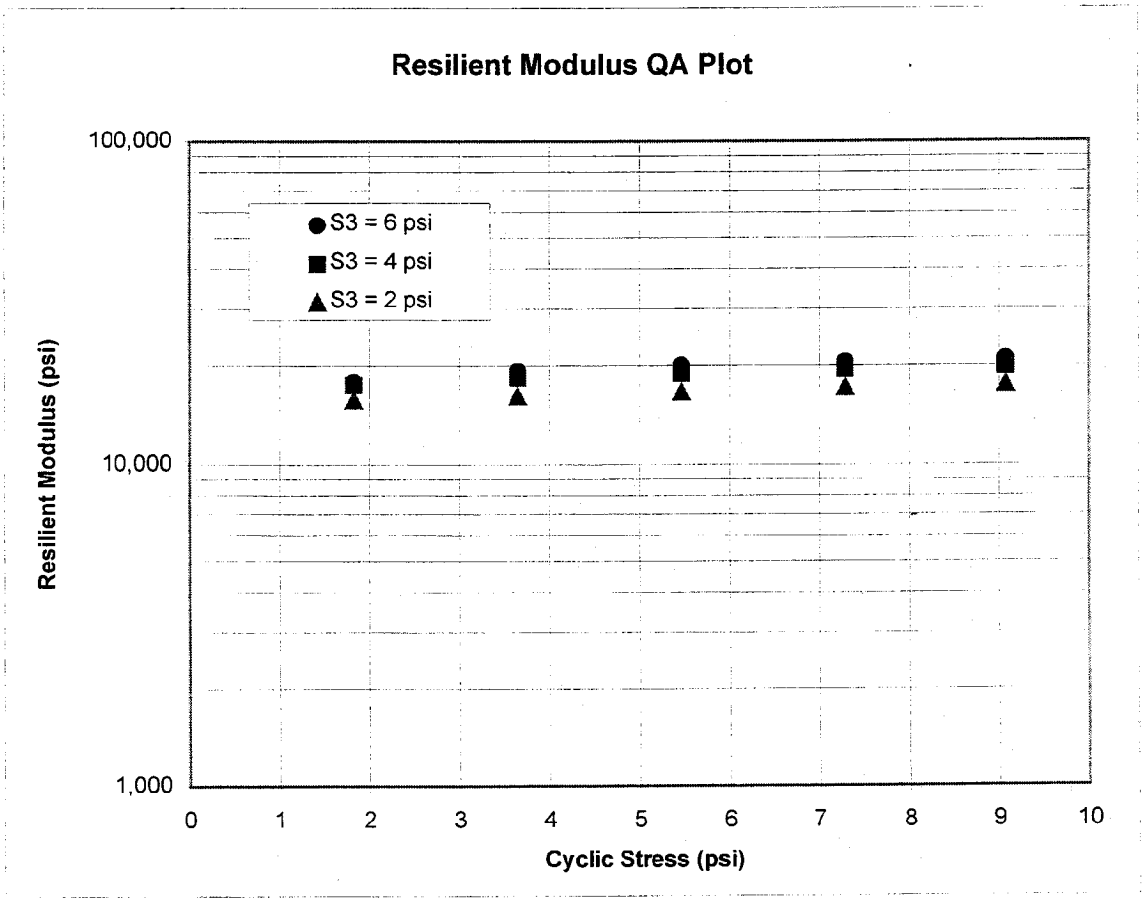


FIGURE 2 - Quick Shear Stress vs Strain

PROJECT NAME:		TVA - Fly Ash, Bottom Ash and Scrubber Gypsum Study
LAW PROJECT NO.:		5810860101
1.	*MATERIAL SOURCE:*	Cumberland
2.	*MATERIAL DESCRIPTION:*	Gypsum
3.	*REMOLDING TARGETS:*	95% Modified Dry Density at Optimum Moisture Content
4.	*MATERIAL TYPE*	2
5.	*TEST DATE*	09-29-1995