TRC 74

VACUUM SATURATION
COMPRESSIVE STRENGTHS

VS

FREEZE-THAW
WEIGHT LOSS
FOR

SOIL CEMENT MIXTURES

ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

AHTD

TRC 74

FINAL REPORT
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TRC-74: VACUUM SATURATION COMPRESSIVE STRENGTHS

Vs.

FREEZE-THAW WEIGHT LOSS FOR SOIL

CEMENT MIXTURES

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By

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SUMMARY

At the present time the Geotechnical/Soils Section of the Arkansas Highway and Transportation Department requires that Freeze-Thaw Durability tests (AASHTO T-136) be performed on all soil-cement designs. This procedure requires approximately 2 months to complete, which creates a delay in a complete soil-cement design.

In order to alleviate this problem TRC-74 was initiated to compare a Vacuum Saturation compressive strength testing procedure with the Freeze-Thaw weight loss procedure. Results were compared in four separate categories; all data points, all data points except + No. 4 material, A-4 Soil, and A-2-4 Soil. In all cases the correlation coefficient was above 0.75, which indicates a good relationship between Vacuum Saturation Compressive Strengths and Freeze-Thaw Weight Loss.

IMPLEMENTATION

Arkansas soils that require a soil cement design must be subjected to durability testing. The present testing procedure takes approximately 31 working days after the samples have been prepared, to complete, possibly resulting in a project delay while construction waits on the design. The testing procedure outlined in this report can be completed in 7 working days after specimen preparation. Implementation of the Vacuum Saturation testing procedure will shorten the potential delay by 24 working days.

METRIC CONVERSION TABLE

SYMBOL	KNOWN UNIT	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	30.48	centimeters	cm
ft	feet	0.30	meters	m
yd	yards	0.91	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.45	square cm	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.84	square meters	m^2
mi^2	square miles	2.59	sq. kilometers	km^2
	acres	0.40	hectares	ha
	acres	4046.87	square meters	m^2
		VOLUME		
in^3	cubic inches	16.39	cubic cm	cm^3, cc
ft^3	cubic feet	0.03	cubic meters	m^3
ft^3	cubic feet	28317.0	cubic cm	cm^3, cc
yd^3	cubic yards	0.76	cubic meters	m^3
gal	gallon (U.S.)	3.79	liter(1000 cc)	l
qt	quart (U.S.)	0.95	liter	l
oz	ounce fluid)	29.57	cubic cm	cm^3, cc
		WEIGHT		
lb	pound(avoirdupois)	0.45	kilogram	kg
lb	" "	453.59	grams	g
oz	ounces(")	28.35	grams	g
	short ton(2000 lb)	0.91	tonnes(1000kg)	t
		FORCE, PRESSURE		
lbf	pounds-force	4.45	newtons	N
psi, lbf/in^2	pound-force/square inch	6.89	kilopascals	kPa
	foot of water(39.2°F)	2.99	"	kPa
	inch of mercury(32°F)	3.39	"	kPa
		ANGLE		
°	degrees	0.017	radians	rad
'	minutes	2.91×10^{-4}	radians	rad
"	seconds	4.85×10^{-6}	radians	rad
		TEMPERATURE		
°F	degrees Fahrenheit	$t°C=(t°F-32)/1.8$	degrees Celcius	°C
°C	degrees Celcius	ADD 273.15	degrees Kelvin	°K

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VACUUM SATURATION PROJECT

INTRODUCTION

A major effect of frost action on pavement systems constructed with stabilized materials such as soil-cement, lime-fly ash, and lime-soil mixtures can be a loss of strength and stability after thawing. This loss of strength and stability results from the deterioration of the cementitious matrix and the presence of excess water in the stabilized material after thawing has occurred.

Freeze-thaw tests have been used to determine the durability of stabilized materials. The Arkansas Highway and Transportation Department uses the standard freeze-thaw test for soil-cement mixtures as described in AASHTO T-136 (ASTM D-560). (1)[1]

Lime-fly ash mixtures are generally tested for durability according to ASTM C-593(2). This procedure involves a vacuum saturation testing procedure for lime-fly ash stabilization.

The standard freeze-thaw test requires a minimum of 31 working days. The vacuum saturation test requires only 7 working days to complete.

This project was designed to compare and correlate the durability data for Arkansas soils by using both testing procedures.

[1]The number in parenthesis corresponds to the listing of the literature cited in the reference section.

HISTORY

In 1935 the first soil-cement job was built near Johnsonville, South Carolina. As a result of this successful job, standard tests were developed to evaluate the performance of future soil-cement jobs. These tests included the moisture density (Proctor) test developed in 1929 and the wet-dry and the freeze-thaw tests adopted by ASTM in 1940. These types of tests have been performed on soil-cement jobs since their development and are still being used today with some minor refinements.

The wet-dry and the freeze-thaw tests were developed to reproduce in the laboratory the phenomenon of moisture changes in soils. The freeze-thaw test was designed to simulate internal expansive forces produced by moisture change in fine-grained soils. Also, this test avoided the accelerated cement hydration present in the wet-dry test.

Since moisture plays a dominant role in the strength of soils and road bases it was essential that water be permitted to play a dominant part in both the wet-dry and freeze-thaw tests. In the wet-dry tests this was accomplished by submerging the specimens in water during the wetting portion of each cycle. In the freeze-thaw test, specimens were permitted to absorb water by capillary action during the thawing portion of each cycle.

The number of cycles of testing and their duration were developed by exploratory tests on freezing temperatures, freezing time, drying temperatures, dry time, and soaking time. Twelve cycles for each test produced interpretable data and also met the requirements of a practical time limit.

The wet-dry and freeze-thaw tests were developed to determine the minimum cement content required to produce a structural material that will resist volume changes produced by changes in moisture. Although the primary intention was to measure the effects of moisture change, the tests also measure the effects of temperature change. Since moisture and temperature changes occur in varying degrees in all climates and geographic areas, use of both the wet-dry and freeze-thaw tests assure that a hardened, structural material is produced for any area. Durabilities of soil-cement mixtures designed using the standard tests and appropriate criteria for determining a minimum cement content to produce a structural material have proven service records. (3)

In July 1967 the Illinois Department of Transportation initiated a study on the Durability Testing of stabilized materials. The research project was performed at the University of Illinois by Marshall R. Thompson and Barry J. Dempsey. Dempsey and Thompson concluded the following:

1. The vacuum saturation testing procedure can be used to predict the freeze-thaw durability of stabilized materials such as soil-cement, lime-fly ash, and lime-soil mixtures.

2. The vacuum saturation procedure is a fast and inexpensive test method.

3. An excellent correlation exists between the vacuum saturation strength and moisture content and the strength and moisture content after 5 and 10 freeze-thaw cycles.

4. Considerable strength loss in stabilized materials can be caused by vacuum-saturation-induced moisture increases.

5. Density has substantial influence on the strength and durability of cement and lime-fly ash-stabilized materials.

Dempsey and Thompson made their comparisons between Unconfined Compressive Strengths after 10 freeze-thaw cycles and Unconfined Compressive Strength after vacuum saturation. (4) (5)

As a result of their successful investigation with Illinois soils the Arkansas Highway and Transportation Department's Materials and Research Division initiated a study to compare the freezing-and-thawing tests of compacted soil-cement mixtures (AASHTO T-136) and the University of Illinois vacuum saturation method of durability testing.

LABORATORY INVESTIGATION

Laboratory investigation began in the summer of 1982. Samples were tested on all soil cement jobs submitted during the summers of 1982 and 1983. (Figure 1)

Freeze-Thaw, Wet-Dry, and Vacuum Saturation tests were performed in the AHTD laboratories according to AASHTO and/or ASTM specifications.

Classification

Grain size analysis, liquid limit, and plastic limit were performed in order to classify the soils. The samples were classified in accordance with AASHTO classification.

Freezing-Thawing Tests

The Freeze-Thaw Testing procedure is used to determine the soil-cement losses, moisture changes, and volume changes produced by repeated freezing and thawing of hardened soil-cement specimens. The specimens are compacted in a mold, before cement hydration, to maximum density at optimum moisture content using the compaction procedure described in AASHTO T-136, Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures.

Two methods, depending on soil gradation, are specified for preparation of material and for molding specimens. For the purpose of this project Method "A" was used for 54 samples and Method "B" was used for 15 samples. Method "A" was used for soil material passing the No. 4 sieve and Method "B" was used for soils having material retained on the No. 4 sieve.

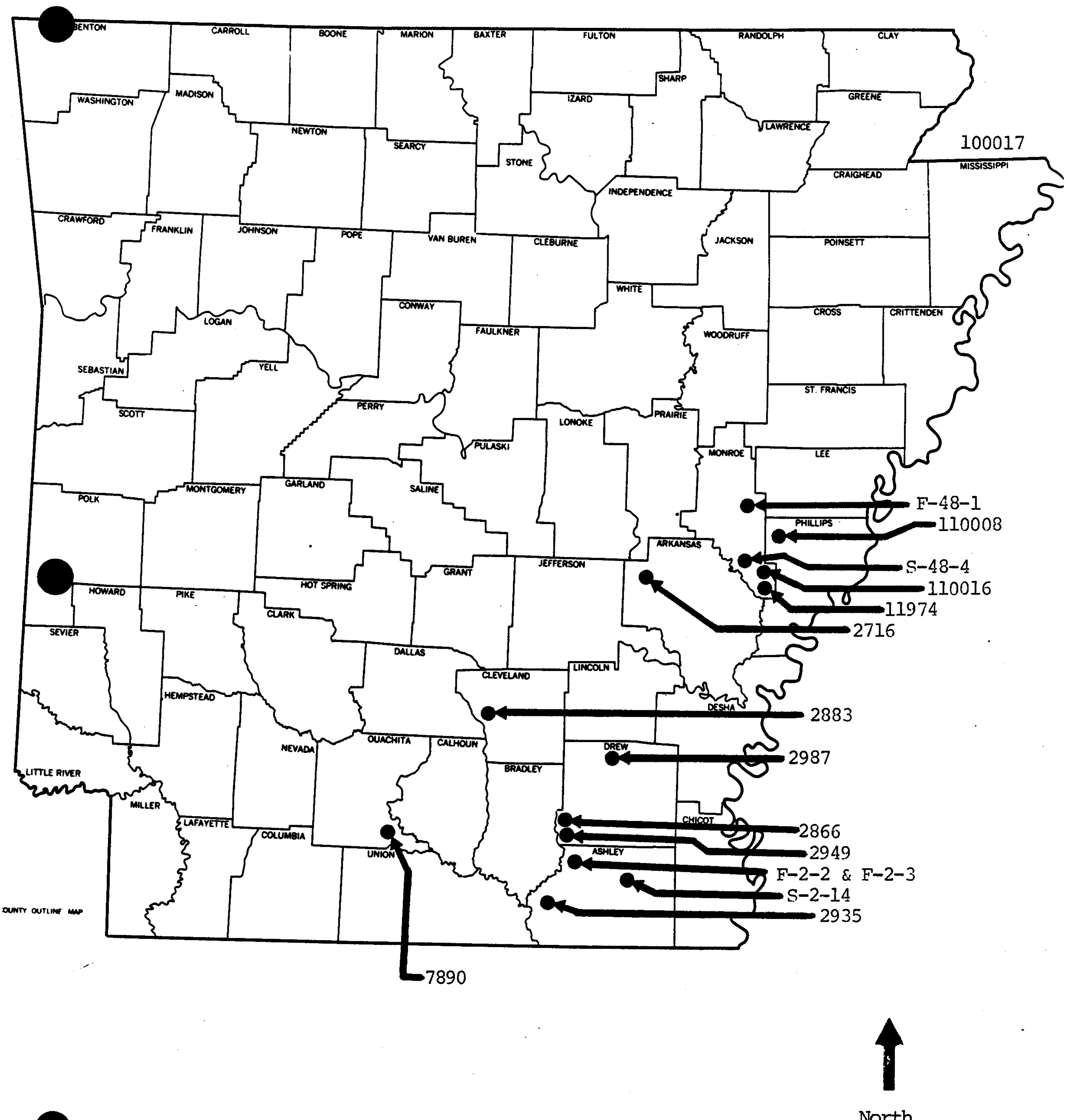


Figure 1: Job Sites

The preparation of the soil samples was also performed in accordance with AASHTO T-136. The required amount of cement conforming to AASHTO M85, Specifications for Portland Cement was mixed with sufficient soil to produce one compacted specimen 4 inches in diameter and approximately 4.5 inches high for each trial cement content. A sufficient amount of water was added to raise the soil-cement mixture to optimum moisture content at time of compaction and mixed thoroughly. The compacted specimens were weighed and placed in a moist room at 100 percent relative humidity at $70 \pm 3^{\circ}F$ for seven days. At the end of the curing period, the specimens were placed on felt absorptive pads and placed in a freezing cabinet having a constant temperature not warmer than $-10^{\circ}F$ for 24 hours. The specimens were then removed from the freezing cabinet and placed in the moist room for 23 hours. The specimens were removed from the moist room and given two firm strokes on all areas with a wire scratch brush. Specimens were then placed back in the freezer and the process was repeated for 12 complete cycles.

Wet-Dry Test

The specimens were prepared in accordance with the procedures described in AASHTO T-135 "Wetting-and-Drying Test of Compacted Soil-Cement Mixtures". One specimen was molded for each trial cement content. At the end of the curing period the specimens were submerged in water in the moist room for 5 hours. The specimens were then placed in the oven at $160 \pm 5^{\circ}F$ for 42 hours. At the end of the drying period the specimens were given two firm strokes on all areas with a wire scratch brush. Specimens were again submerged and the process repeated for 12 complete cycles.

Vacuum Saturation Test

The Vacuum Saturation Durability testing was performed in accordance with part 9 of ASTM C-593(76). The specimens were prepared in accordance with the procedure described in Method "A" or "B" of the test of Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures (AASHTO T-136). The specifications for the Vacuum Saturation Chamber and Vacuum System are in the appendix. Three specimens for each trial cement content were molded.

At the end of the curing period, the specimens were removed from the curing room and allowed approximately 2 hours to reach equilibrium with room temperature. The specimens were sealed to prevent any moisture loss.

The cured specimens were weighed and placed in the vacuum chamber and sealed. The chamber was evacuated to a pressure of 24 inches Hg gradually over a period of not less than 45 seconds and held for 30 minutes in order to remove air from the voids in the specimens. After this de-airing period, the chamber was flooded with water at room temperature to a depth sufficient to cover the specimens. The vacuum was then removed and the specimens were soaked for 1 hour at atmospheric pressure.

At the end of the soaking period the specimens were again weighted and capped. Specimens were only removed from the water for sufficient time to weigh and cap. After the specimens were capped they were soaked for an additional one (1) hour and immediately tested for unconfined compressive strength.

RESULTS AND DISCUSSION

Classification

The soil samples were classified in accordance with AASHTO classification (Table 1). The classifications ranged from A-1-b to A-4 representing several types of material.

Freezing and Thawing Tests

The freezing and thawing tests were performed according to AASHTO T-136. For each soil sample at least three and sometimes four trial cement contents were used to obtain the design cement content. Freeze-Thaw durability tests were performed for each specimen with various trial cement contents. Table 2 presents the weight loss of each specimen after 12 complete cycles of freezing and thawing. The percent weight loss ranged from 25.4 on an A-4(0) soil with 10% cement to 1.5 on an A-3(0) soil with 12% cement.

Table 1 Classification

Job No.	Soil No.*	AASHTO Soil Classification
2935	S-1901	A-4(0)
110016	S-2017	A-3(0)
F-2-2 & F-2-3	S-2097	A-4(0)
2935	S-2130	A-2-4(0)
110008	S-87	A-2-4(0)
110016	S-95	A-3(0)
2883	S-174	A-2-4(0)
2935	S-175	A-2-4(0)
2883	S-206	A-2-4(0)
7890	S-1280	A-2-4(0)
2987	S-1224	A-3(0)
2987	S-1223	A-4(0)
2716	S-1288	A-2-4(0)
F-48-1	S-1297	A-2-4(0)
100017	S-1327	A-4(0)
100017	S-1328	A-2-4(0)
2987	GR-282	A-1-b(0)
2949	S-1336	A-2-4(0)
2866	S-1365	A-4(0)
S-2-14	GR-294	A-2-6(0)
11974	S-1422	A-2-4(0)
S-48-4	S-1451	A-2-4(0)
2866	S-1469	A-2-4(0)

* S = Soil, GR = Gravel

Table 2: Laboratory Results

Job No.	Soil No.	Soil Classification (AASHTO)	Trial Cement Content (%)	Vacuum Saturation Strengths Avg. 7-Day (psi)	Freeze-Thaw Brush Test Loss at 12 cycles (%)	Wet-Dry Brush Test Loss at 12 cycles (%)	Compressive Strength Avg. 7 Day (psi)	Compressive Strength Avg. 28-Day	Absorption During Vac. Sat. (%)
2935	S-1901	A-4(0)	10	241	25.4	2.0	237	306	3.9
			12	322	9.6	1.6	318	492	4.2
			14	403	3.4	1.3	352	520	4.7
11016	S-2017	A-3(0)	8	400	5.5	4.4	359	520	7.0
			10	531	3.0	2.3	519	708	2.9
			12	744	1.5	1.2	767	947	4.4
F-2-2	S-2097	A-4(0)	5	347	6.6	3.4	478	643	2.5
&			7	498	3.7	2.7	560	772	2.5
F-2-3			9	594	2.9	1.8	773	1159	3.3
2935	S-2130	A-2-4(0)	4	370	9.0	5.0	442	615	2.2
			6	506	4.5	2.9	653	904	2.5
			8	675	3.3	1.7	889	1337	2.4
110008	S-87	A-2-4(0)	8	350	5.9	10.3	353	491	5.0
			10	533	4.3	6.5	493	739	3.0
			12	828	3.0	2.4	784	1072	5.5
110016	S-95	A-3(0)	7	265	12.2	17.9	240	341	6.5
			9	465	6.3	6.4	427	595	5.6
			11	661	2.3	2.7	640	951	5.2
2883	S-174	A-2-4(0)	5	522	11.4	7.2	491	618	3.4
			7	605	6.5	4.4	605	775	3.3
			9	682	4.8	2.8	812	1057	3.7
2953	S-175	A-2-4(0)	7	334	7.2	5.1	330	450	4.5
			9	447	4.5	2.6	459	651	5.4
			11	630	3.5	1.9	622	897	4.5

Table 2: Laboratory Results (Continued)

Job No.	Soil No.	Soil Classification (AASHTO)	Trial Cement Content (%)	Vacuum Saturation Strengths Avg. 7-Day (psi)	Freeze-Thaw Brush Test Loss at 12 cycles (%)	Wet-Dry Brush Test Loss at 12 cycles (%)	Compressive Strength Avg. 7 Day (psi)	Compressive Strength Avg. 28-Day	Absorption During Vac. Sat. (%)
2883	S-206	A-2-4(0)	5	449	8.5	3.7	515	715	2.6
			7	689	4.8	2.1	778	1098	3.0
			9	845	3.0	2.0	1081	1485	3.7
7890	S-1280	A-2-4(0)	6	622	6.2	4.4	688	960	4.5
			8	988	3.2	2.1	1085	1406	3.7
			10	1385	2.6	1.9	1499	1916	3.8
2987	S-1224	A-3(0)	6	503	6.9	4.7	496	618	3.5
			8	815	3.0	2.6	813	1042	4.1
			10	1292	1.6	1.9	1259	1744	3.1
2987	S-1223	A-4(0)	4	251	21.3	5.5	295	395	2.2
			6	336	4.7	2.7	433	540	1.7
			8	424	4.0	2.3	576	770	1.8
2716	S-1288	A-2-4(0)	7	420	8.7	7.2	445	545	6.5
			9	637	5.1	3.8	635	908	5.3
			11	806	3.2	2.4	809	1196	6.2
F-48-1	S-1297	A-2-4(0)	7	408	6.5	5.9	396	628	5.3
			9	558	4.4	4.2	547	877	4.4
			11	721	2.6	2.3	733	1164	5.3
100017	S-1327	A-4(0)	6	344	7.5	3.2	416	484	1.8
			8	468	4.7	2.6	529	681	2.4
			10	560	3.3	1.9	664	898	2.9
100017	S-1328	A-2-4(0)	6	325	15.0	12.0	331	466	4.4
			8	486	5.3	6.3	510	696	4.4
			10	610	2.9	3.0	699	977	4.4

Table 2: Laboratory Results (Continued)

Job No.	Soil No.	Soil Classification (AASHTO)	Trial Cement Content (%)	Vacuum Saturation Strengths Avg. 7-Day (psi)	Freeze-Thaw Brush Test Loss at 12 cycles (%)	Wet-Dry Brush Test Loss at 12 cycles (%)	Compressive Strength Avg. 7 Day (psi)	Compressive Strength Avg. 28-Day	Absorption During Vac. Sat. (%)
2987	GR-282	A-1-b(0)	4	263	16.6	14.7	332	439	2.4
			6	450	4.1	5.7	663	903	2.0
			8	727	1.9	2.6	1035	1428	1.6
2949	S-1336	A-2-4(0)	3	241	8.7	6.2	343	431	-
			5	391	4.9	3.4	570	562	-
			7	557	3.3	2.5	723	797	-
2866	S-1365	A-4(0)	6	335	7.6	3.5	447	519	3.0
			8	436	4.1	2.2	572	699	3.0
			10	644	2.5	1.8	723	968	3.3
S-2-14	GR-294	A-2-6(0)	3	374	10.8	21.1	396	471	1.9
			5	715	6.2	6.6	691	921	1.3
			7	968	2.6	3.0	909	1406	1.0
11974	S-1422	A-2-4(0)	6	249	17.6	14.1	289	390	5.3
			8	406	7.7	8.0	461	581	4.2
			10	631	4.7	5.4	636	831	3.9
S-48-4	S-1451	A-2-4(0)	5	269	13.9	9.4	331	429	1.5
			7	362	8.6	4.7	462	550	1.7
			9	458	4.3	2.3	615	758	1.5
2866	S-1469	A-2-4(0)	3	403	13.2	10.7	430	617	2.1
			5	546	8.5	5.3	622	928	2.2
			7	751	5.5	3.3	843	1154	2.3

Vacuum Saturation Testing

The Vacuum Saturation Durability testing was performed in accordance with part 9 of ASTM C-593 (76). Three specimens were prepared in accordance with the procedure described in AASHTO T-136 for each trial cement content.

The average unconfined compressive strengths for each trial cement content is shown in Table 2. The strengths ranged from a low of 241 psi for an A-4 soil at 10% cement and an A-2-4 soil at 3% cement to a high of 1385 psi for an A-2-4 soil at 10% cement. Correlations were performed on vacuum saturation with Freeze-Thaw weight loss. The results of this correlation are illustrated under the Statistical Analysis portion of this report.

Wetting and Drying Testing

The wetting and drying tests were performed according to AASHTO T-135. Table 2 presents the weight loss of each specimen after 12 complete cycles of wetting and drying. The percent weight loss ranged from 21.1% for an A-2-6(0) gravel with 3% cement to 1.2% for an A-3(0) with 12% cement. The data from this testing is shown for informational purposes only. There were no correlations made with this data.

Statistical Analysis

Best fit curve correlations of Vacuum Saturation Strengths vs. Freeze-Thaw Weight Loss was performed on all the test results as a composite and also with various categories of the data. In all cases the coefficient of correlation (R) was above 0.70. Also, in all cases the best fit curve was the "power". The following sections will outline the various correlation combinations and their respective curve equations.

All Data Points

The relationships between Vacuum Saturation Strengths and Freeze-Thaw Weight Loss using all of the data points were compared to four curve types; linear, exponential, logarithmic, and power curve. This included sixty-nine (69) data points.

The best fitted curve for these data points was a "POWER" curve which had a coefficient of correlation (R) of 0.79. This indicates that as the vacuum saturation strengths decrease the freeze-thaw weight losses increase by the relationship of $Y=10754.1226(X)^{-1.2260}$ where Y=F-T weight loss and X= Vac. Sat. strengths. Figure 2 illustrates the best fitted curve.

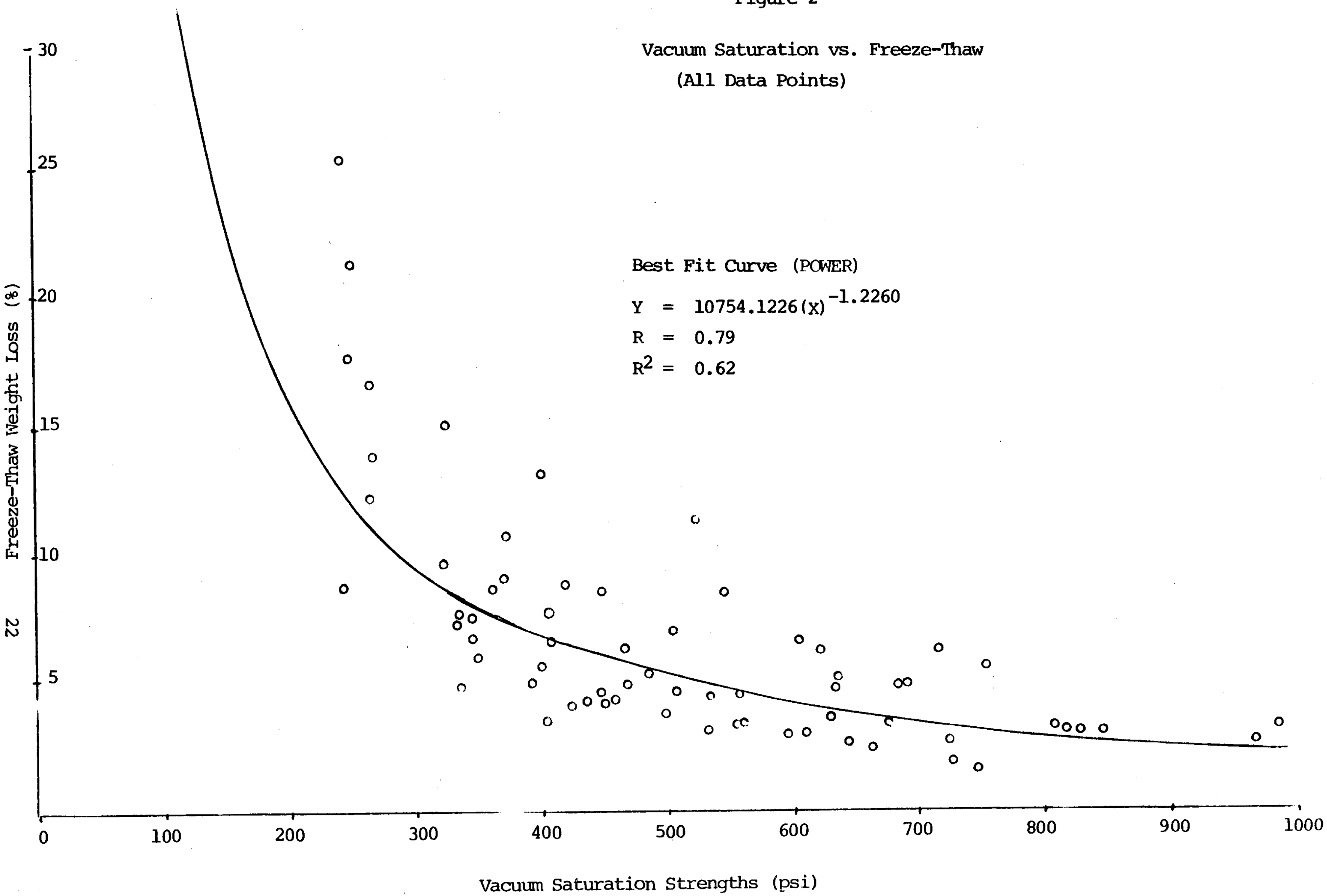
Material Passing No. 4 Sieve

The data points considered in this regression analysis were those soil samples with all of the material passing the No. 4 sieve. This included fifty-four (54) data points.

By regression analysis, the best fitted curve was a "POWER" curve with a coefficient of correlation (R) of 0.82. This indicated that the material retained on the No. 4 sieve has some effect on the relationship between vacuum saturation strengths and freeze thaw weight loss. The equation for this relationship is $Y=12270.2(X)^{-1.2489}$. Figure 3 illustrates this relationship.

Figure 2

Vacuum Saturation vs. Freeze-Thaw
(All Data Points)



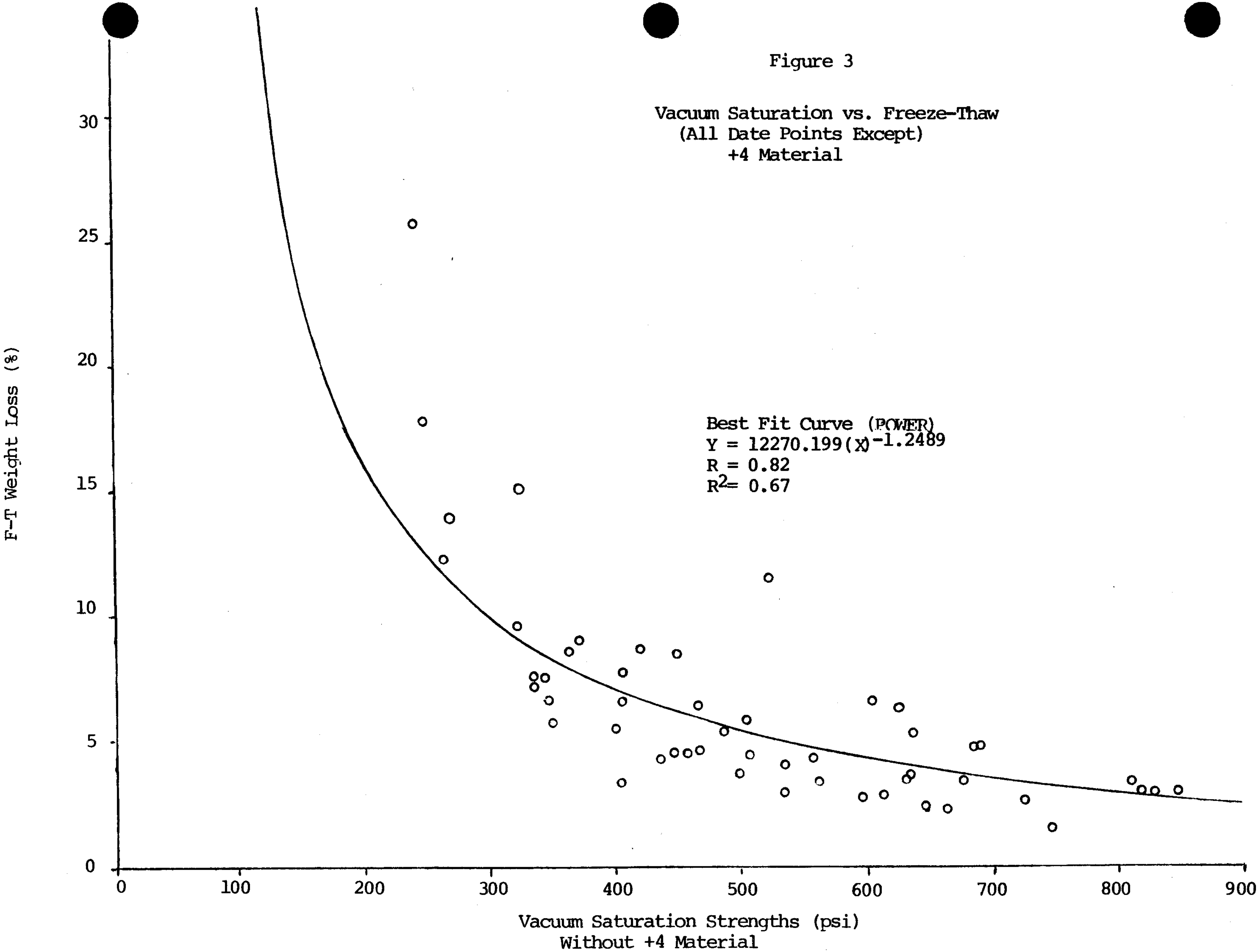


Figure 3
Vacuum Saturation vs. Freeze-Thaw
(All Date Points Except)
+4 Material
Best Fit Curve (POWER)
Y = 12270.199(X)^-1.2489
R = 0.82
R2= 0.67
F-T Weight Loss (%)
Vacuum Saturation Strengths (psi)
Without +4 Material
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800
900

A-4(0) Soil

The soil samples used for this regression analysis were those classified by AASHTO classification system as A-4(0). This included fifteen (15) data points.

By regression analysis the best fitted curve was a "POWER" curve with a coefficient of correlation (R) of 0.91. The equation for this relationship is $Y=2151417.9(X)^{-2.1458}$. Figure 4 illustrates this relationship.

A-2-4(0) Soil

The soil samples used for this regression analysis were those classified by AASHTO classification system as A-2-4(0). This included thirty-nine (39) data points.

By regression analysis the best fitted curve was a "POWER" curve with a coefficient of correlation (R) of 0.78. The equation for this relationship is $Y=4054.8(X)^{-1.0528}$; where Y=F-T Weight Loss and X=Vacuum Saturation strengths. Figure 5 illustrates this relationship.

A-3(0) Soil

No analyses were made for A-3(0) soils due to an insufficient number of samples.

Figur 4

Vacuum Saturation vs. Freeze-Thaw
A-4(0) Soil Only

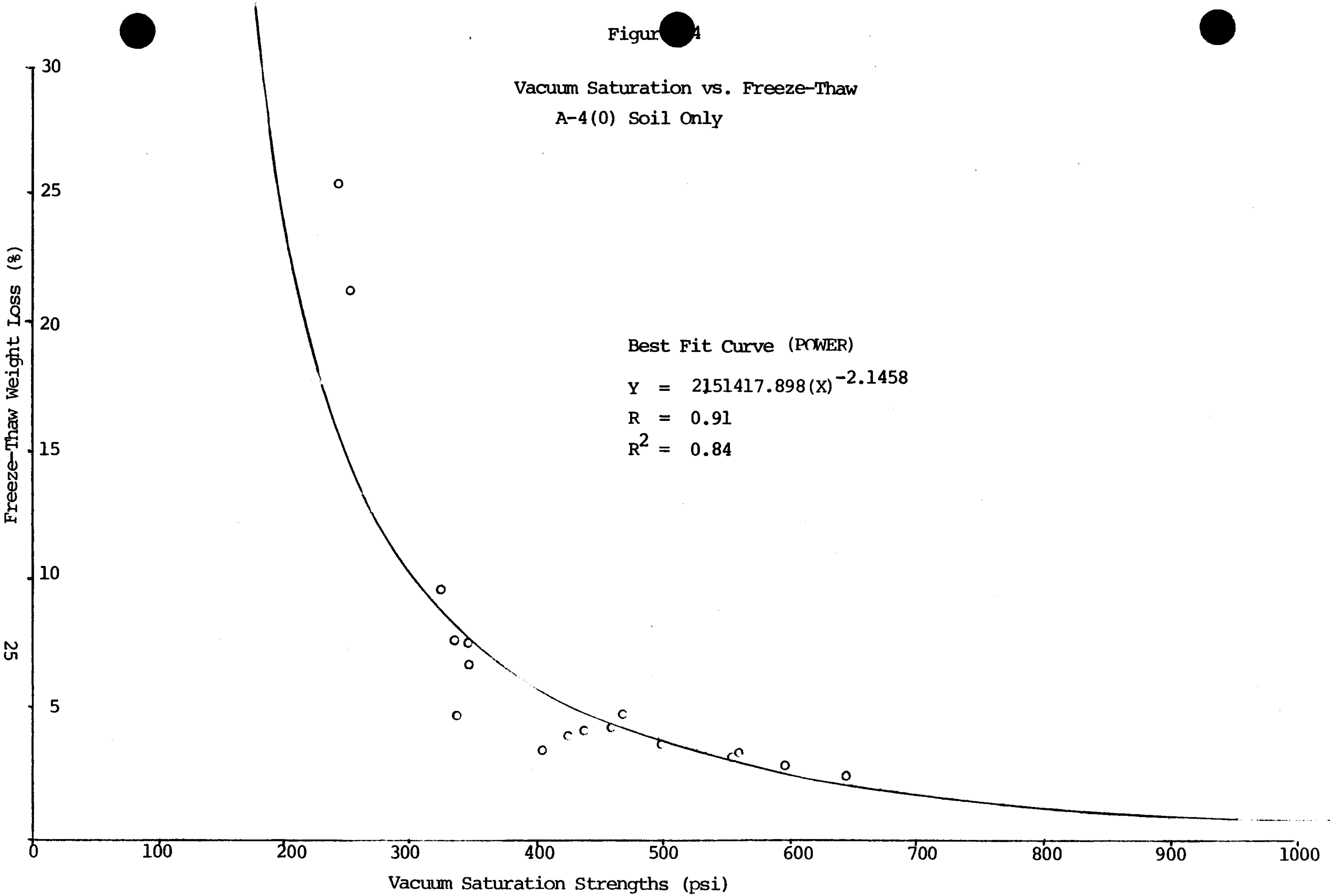
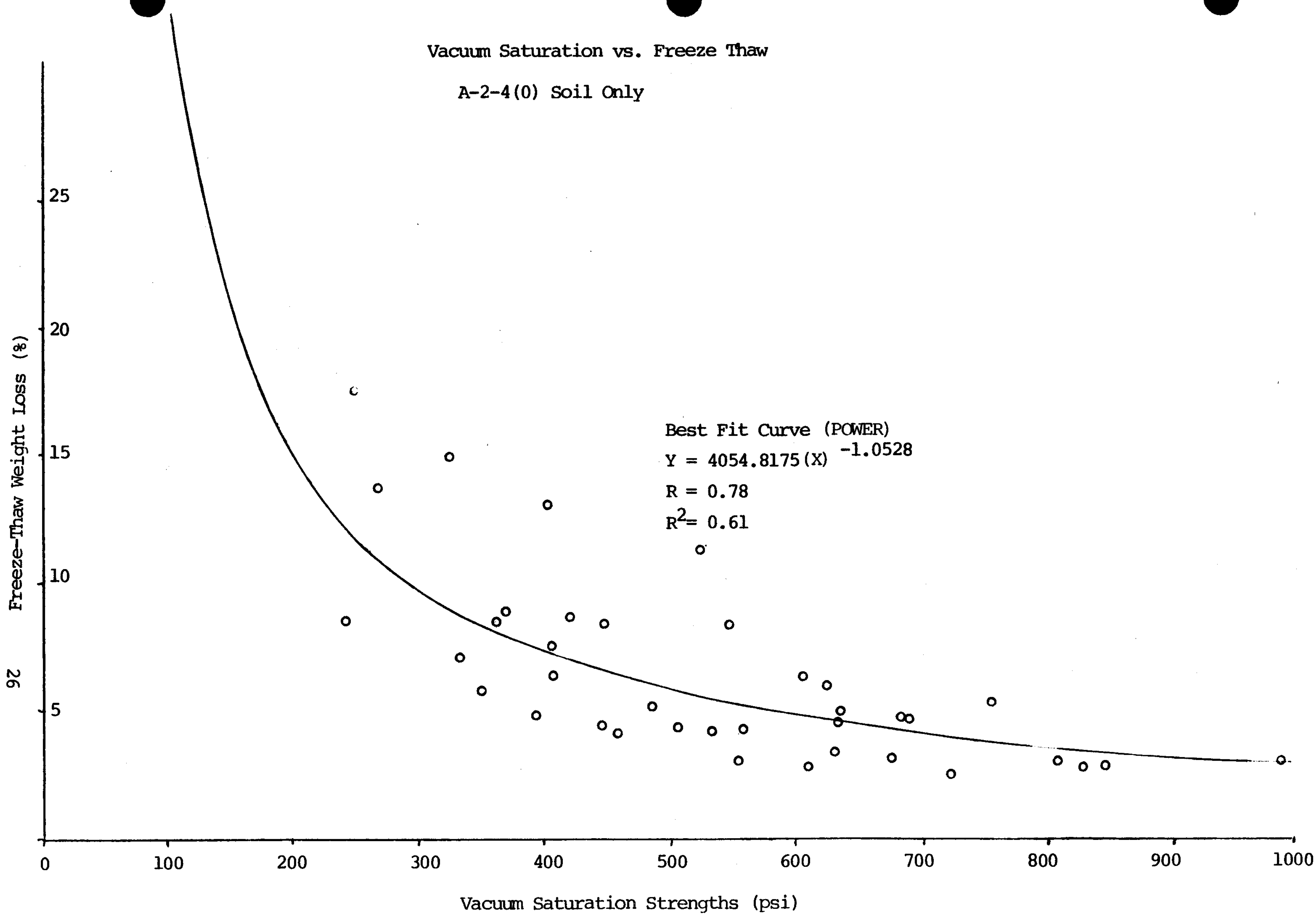


Figure 5

Vacuum Saturation vs. Freeze Thaw

A-2-4(0) Soil Only



Effects of Moisture Absorption

During the vacuum saturation testing procedure some moisture was absorbed into the specimens. It was thought that the amount of moisture absorbed would have some effect on the vacuum saturation compressive strengths. Figure 6 illustrates that no relationship exists between the two variables. The same type relationship exists if the A-4(0) and A-2-4(0) soils were separated into individual graphs.

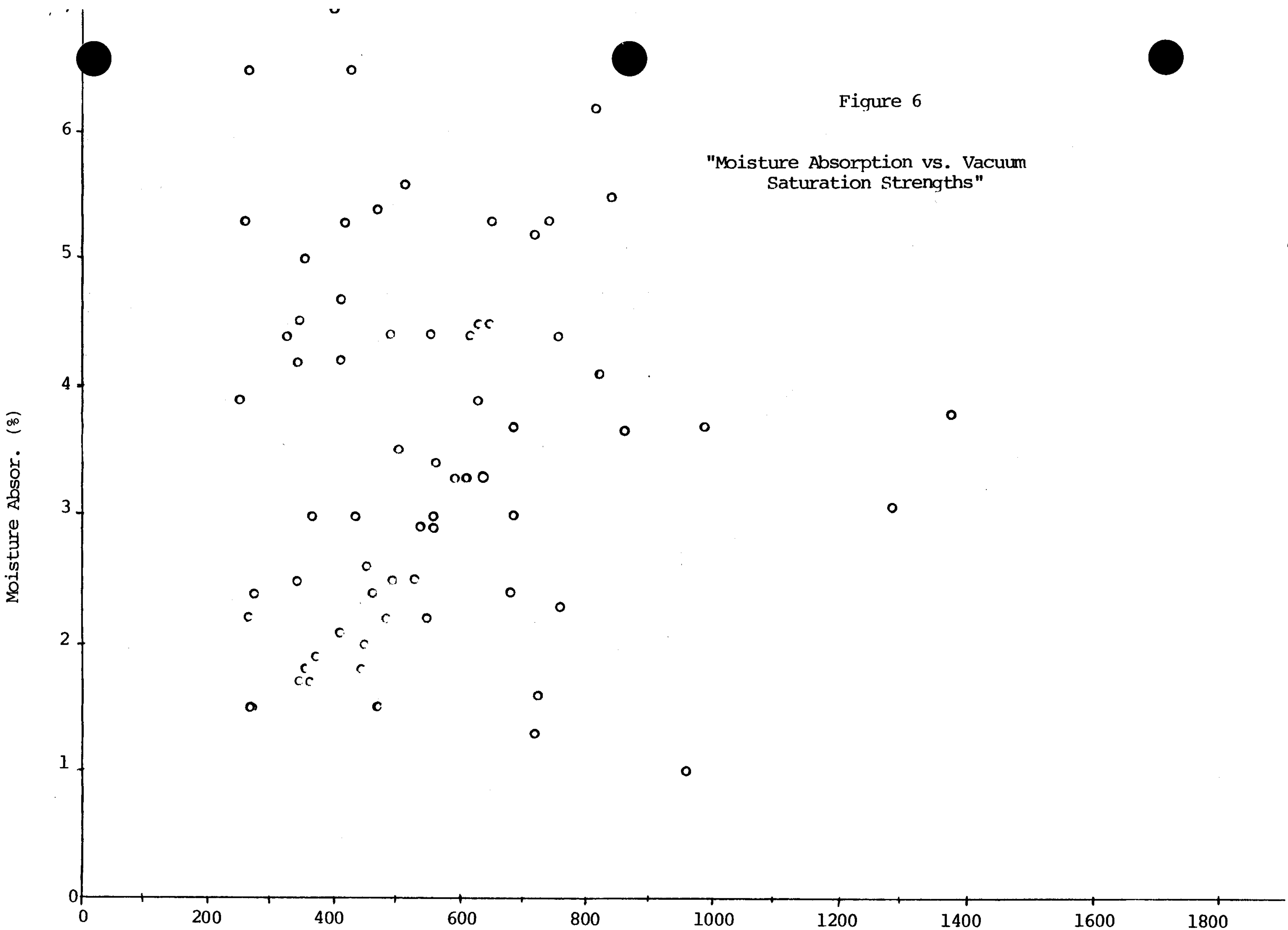


Figure 6
"Moisture Absorption vs. Vacuum
Saturation Strengths"
Moisture Absor. (%)
0
1
2
3
4
5
6
0
200
400
600
800
1000
1200
1400
1600
1800
Vac. Sat. (psi)
Strengths

Figure 6

CONCLUSIONS

On the basis of the experimental work covered by this report and within the limitations of the test procedures and for the range of materials and conditions utilized in this investigation, the following conclusions are warranted:

1. The testing procedures and the equipment employed in this research work may be used to design soil cement jobs with a high level of confidence.

2. The best correlations were obtained on samples which had all material passing the No. 4 sieve and on A-4(0) classified soils.

3. Vacuum saturation durability testing will reduce the testing period by approximately twenty-four working days.

RECOMMENDATIONS

On the basis of the correlations developed during this project, and within the limitations of the test procedures and for the range of materials and conditions utilized in this investigation, the following recommendations are warranted:

1. Apply the appropriate correlation curves (depending on type of soil) to determine the probable Freeze-Thaw Weight Loss for a particular design.

2. Eliminate the 12 cycle Freeze-Thaw test procedure and adopt the vacuum saturation test procedure.

3. Apply the same design criteria to the vacuum saturation test results as are presently applied to Freeze-Thaw test results.

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APPENDIX

ASTM Vacuum Saturation Chamber Specifications

A typical pressure cooker vessel was used for this research work.

1. Vacuum Saturation Chamber - The vacuum saturation chamber is a 12-in. (305-mm) high by 12-in. inside diameter stainless steel cylindrical section welded to a ½-in. (12.7-mm) thick by 14-in. (356-mm) diameter stainless steel base plate. The wall thickness of the cylindrical section is 3/8 in. (9.53 mm). The lid of the vacuum saturation chamber is a poly-(methyl methacrylate) (PMMA) plate 1 in. (25.4 mm) thick and 14 in. in diameter. Both PMMA lid and top of the vacuum cylinder are grooved for a 1/4-in. (6.4-mm) circular O-ring seal having an inside diameter of 12 1/8 in. (308 mm). The lid is fastened to the chamber by six equally spaced threaded 1/4-in. rods which pass along the outside wall of the cylindrical section and thread into the base plate.

2. The specimen support plate inside of the chamber is constructed of 1/2-in. (12.7-mm) thick PMMA which is 11 1/2 in. (292 mm) in diameter. The support plate sits on three 1 1/2-in. (38.1-mm) long legs which elevate it off of the bottom of the chamber. The specimen support plate is perforated (approximately ten 1/8-in. (3.2-mm) diameter holes per square inch) so as to allow complete access of water to the specimens during saturation. For an equivalent size vacuum saturation chamber, a specimen support plate similar to that described above must be provided.

3. The vacuum saturation chamber must be of sufficient size to hold the same number of Proctor-sized specimens for vacuum saturation testing as the number of specimens tested for compressive strength.

4. Vacuum System - A system capable of maintaining a vacuum of 24 inches Hg (11.8 psi) for a minimum of 30 min. is required.