PAVEMENT EVALUATION : R-VALUE AND PAVEMENT DEFLECTIONS PHASE 1 REPORT

RESEARCH PROJECT NO. 51

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

PAVEMENT EVALUATION: R-VALUE AND PAVEMENT DEFLECTIONS

PHASE I REPORT

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INTRODUCTION

Engineering properties of soil, unlike those of other commonly used materials, can be quickly altered by changing the soils environment. Poor performance or failure of the soil as a structural component generally occurs when it has been altered to a weakened condition. The laborabory tests for soils used to support pavements should therefore be run to simulate the worst anticipated field conditions that the soil will be subjected to. If it is still evident that this procedure is not giving satisfactory design criteria for certain areas, other factors that account for location and climate may be necessary.

Many times roadbed failure begins as small localized deterioration where one "bad spot" occurs. Additional moisture then penetrates through the damaged area to contiguous points causing large scale deterioration. Loss of confinement also allows weakened soil to displace laterally and enlarges failure areas.

Obviously then in design we cannot work with the average value of test results or the average value of field compaction obtained. Certainly many test results, both field and laboratory, will be below the average value and may represent areas of possible future problems. So it seems logical that laboratory tests for resistance value should be conducted to simulate the worst conditions of moisture and lowest allowable specified density. This should provide a design that is adequate for all times of the year.

In recognition of problems that now exist in soils testing, a cooperative research program was conducted in 1967, by Washington, Oregon, Montana and Idaho State Highway Departments and the Bureau of Public Roads, Regions 8 and 9, and the Washington D.C. laboratory. The investigation was designed to compare resistance values (R-values) obtained by each agency, following their own testing procedures. Idaho's method yielded R-values that averaged about 30 per cent higher than the other agencies (Figure No. 1). Oregon's test results appear to be close to those of Idaho, but further evaluation found that Oregon uses a method to get a reduced R-value. This is called the "corrected R-value" and accounts for the effect of moisture increase on resistance of fine-grained soils. A study of the results caused concern that Idaho might be relying on overoptimistic R-values and thus underdesigning the structural section of roadways.

Furthermore, Idaho's 1967 "Standard Specifications for Highway Construction" reduced the required subgrade density from 100 per cent to 95 per cent for soils having a maximum dry density of 120 pcf or less, which incorporates nearly all the fine-grained soils. This caused further concern that R-value tests were not adequately simulating poorest anticipated field conditions.

It was decided that a serious evaluation of the R-value test procedure should be undertaken. This report describes the research, presents test results, and denotes conclusions and recommendations.

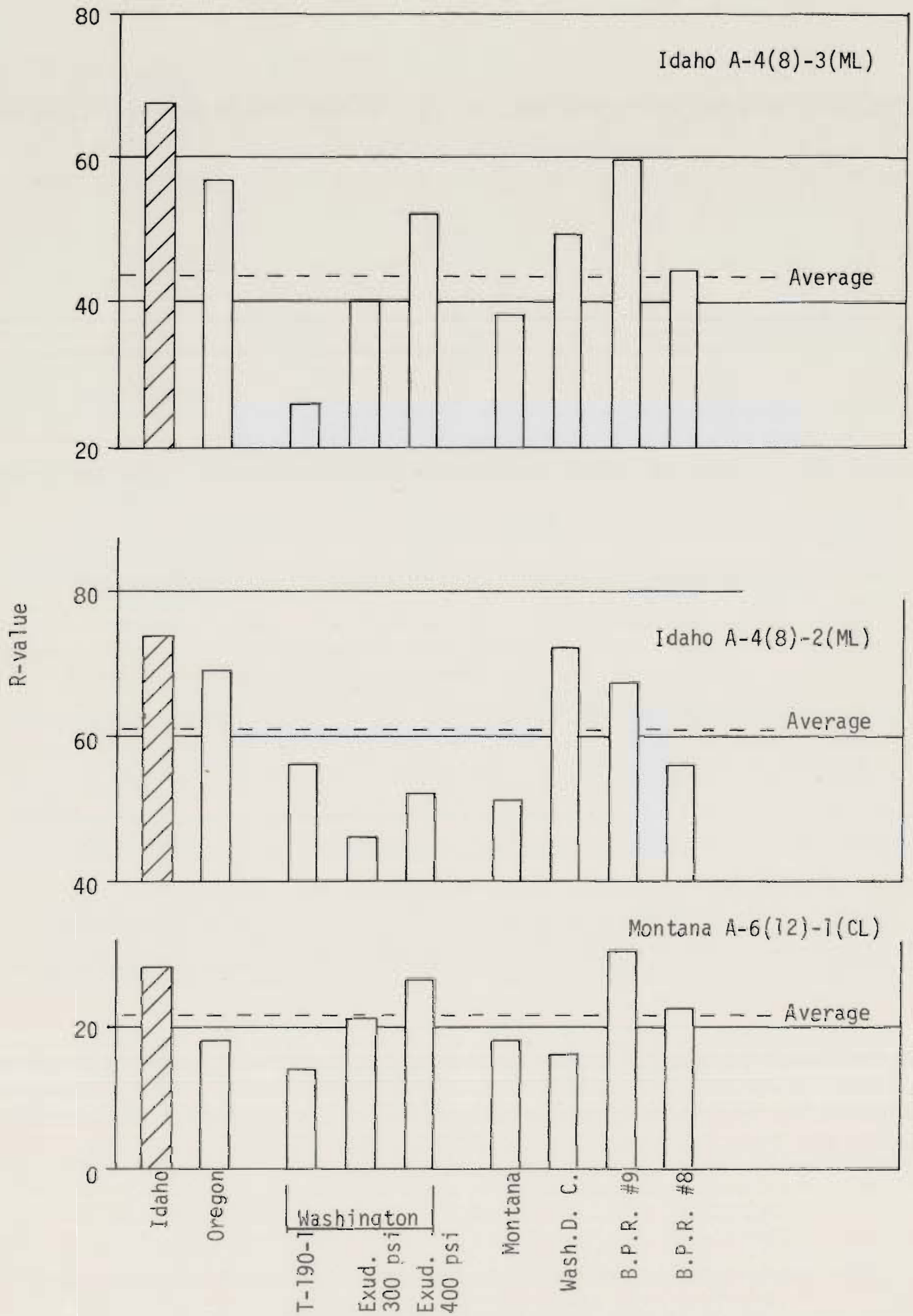


Figure 1 - R-value Comparisons in a Cooperative Research Study (1967)

CONCLUSIONS AND RECOMMENDATIONS

Analysis of the investigation results leads to the following conclusions:

1. R-value test specimens, fabricated by Idaho's standard method, are giving higher densities at lower moisture content than 95 per cent of AASHO T-99 would provide after saturation.
2. Modification of both compaction effort and exudation pressure is required to compose test specimens that adequately reflect present field density standards and anticipated moisture content increases.
3. Modified tests show that a significant reduction of R-value occurs in the fine-grained soils (silts and clays) upon reduction of density and increases in moisture content. This results in approximately a 20 per cent increase in required gravel equivalent.
4. Tests showed that coarse-grained soils (silty sands and sands) had little change of R-value due to the modified procedures of fabricating specimens.
5. The effect of modified test methods on the expansion pressure chosen for design was negligible because both R-value and expansion pressure are directly related to the moisture content of the test specimen. As more moisture is incorporated in the sample, R-value and expansion pressure decrease.

Alternative recommendations are brief and definite:

1. Prepare soil samples and run R-value tests in conformance with modification No. 2: 40 blows @75 psi (material into mold)
   100 blows @100 psi (compaction)
   200 psi Exudation pressure

Since this procedure simulates specified field compaction and anticipated moisture conditions, the ballast thickness is necessarily increased.

2. Require a higher field density by changing the 1967 Specifications to 100 per cent of Standard Proctor for field compaction control. In conjunction with this a slight modification to the laboratory test method would be necessary to achieve higher moisture contents in test specimen.

PRELIMINARY INVESTIGATION

A literature search indicated that several other states have modified California's R-value test method and interpretation procedures to fit their individual needs. Idaho has made some modifications to the California procedure, but after the cooperative testing by Oregon, Washington, Montana, Idaho and the Bureau of Public Roads, it appeared that further modifications were necessary.

Approximately 1000 basic soil summary sheets (DH-803) covering test data for various classes of soil were taken from the files and catergorized into soil types. Data were tabulated, studied and plotted (Figure Nos. 2 through 7).

In nearly all soil classes, and especially in the silts and clays, it is evident that R-value specimens have generally been compacted to too high a density at too low a moisture content for anticipated field conditions. This is noticeable when comparing to the 1961 specification requirements and especially of concern when comparing to the 1967 specification requirements.

It is desirable to fabricate the R-value specimens within a range of density and moisture content that would be expected in the compaction of soils in the field. This range should be about 95 to 98 per cent of the AASHO T-99 maximum density and above the optimum moisture content by about 2 to 5 per cent to reflect moisture increases after construction. Accomplishment of this would require changes in compaction effort and a substantial increase in moisture, from the present standard procedure.

Figure 8(a) illustrates the desirable zone for sample fabrication. Figure 8(b) shows the general relationship of R-value and fabrication moisture content. The importance of recognizing decreasing R-value with increasing moisture is apparent. Oregon chooses the R-value at the intersection of the curve with the 95 per cent density, wet side, for fine grained soils.

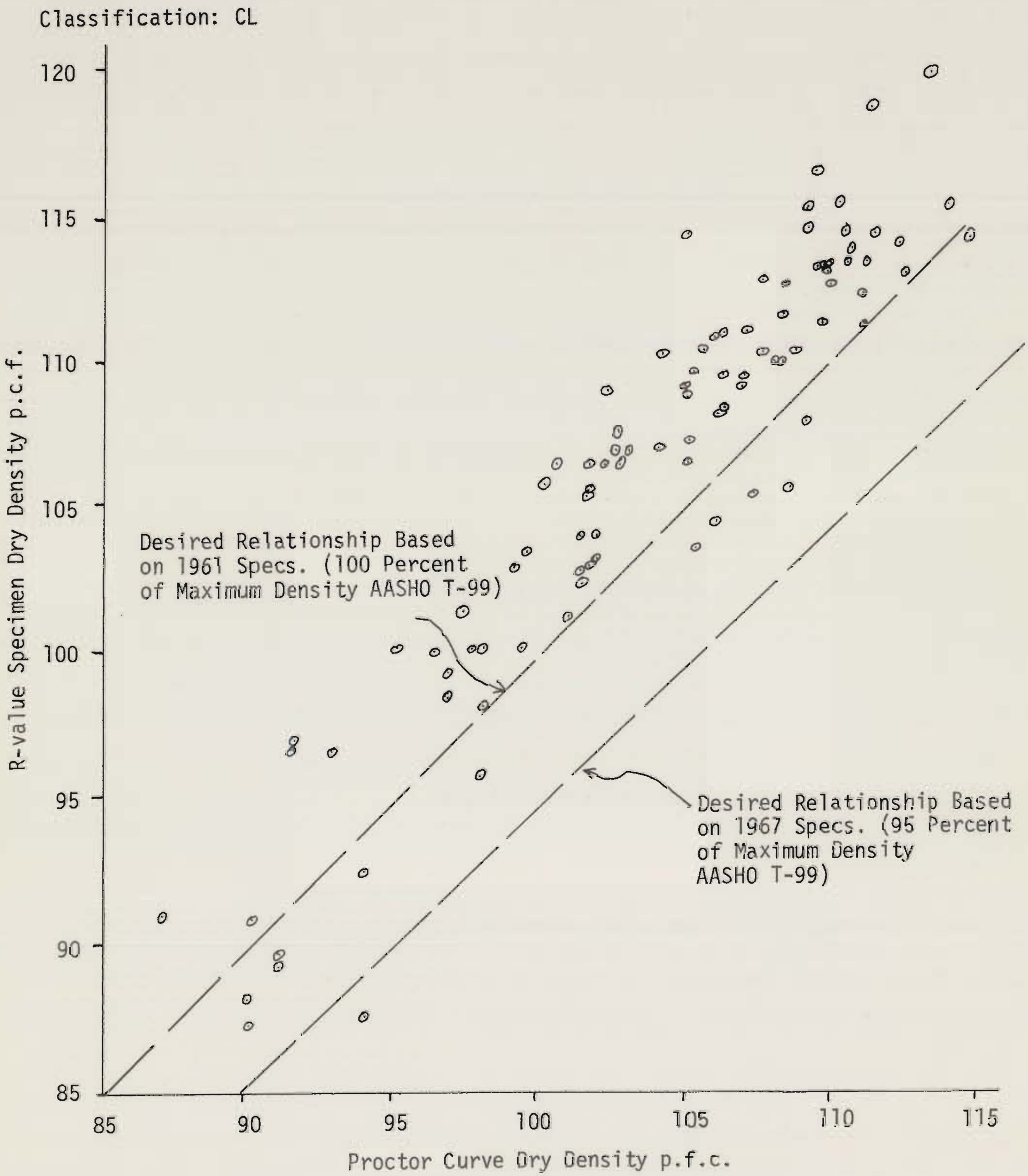


Figure 2 - Density Comparisons Between R-value Specimens and Proctor Curve for Clays

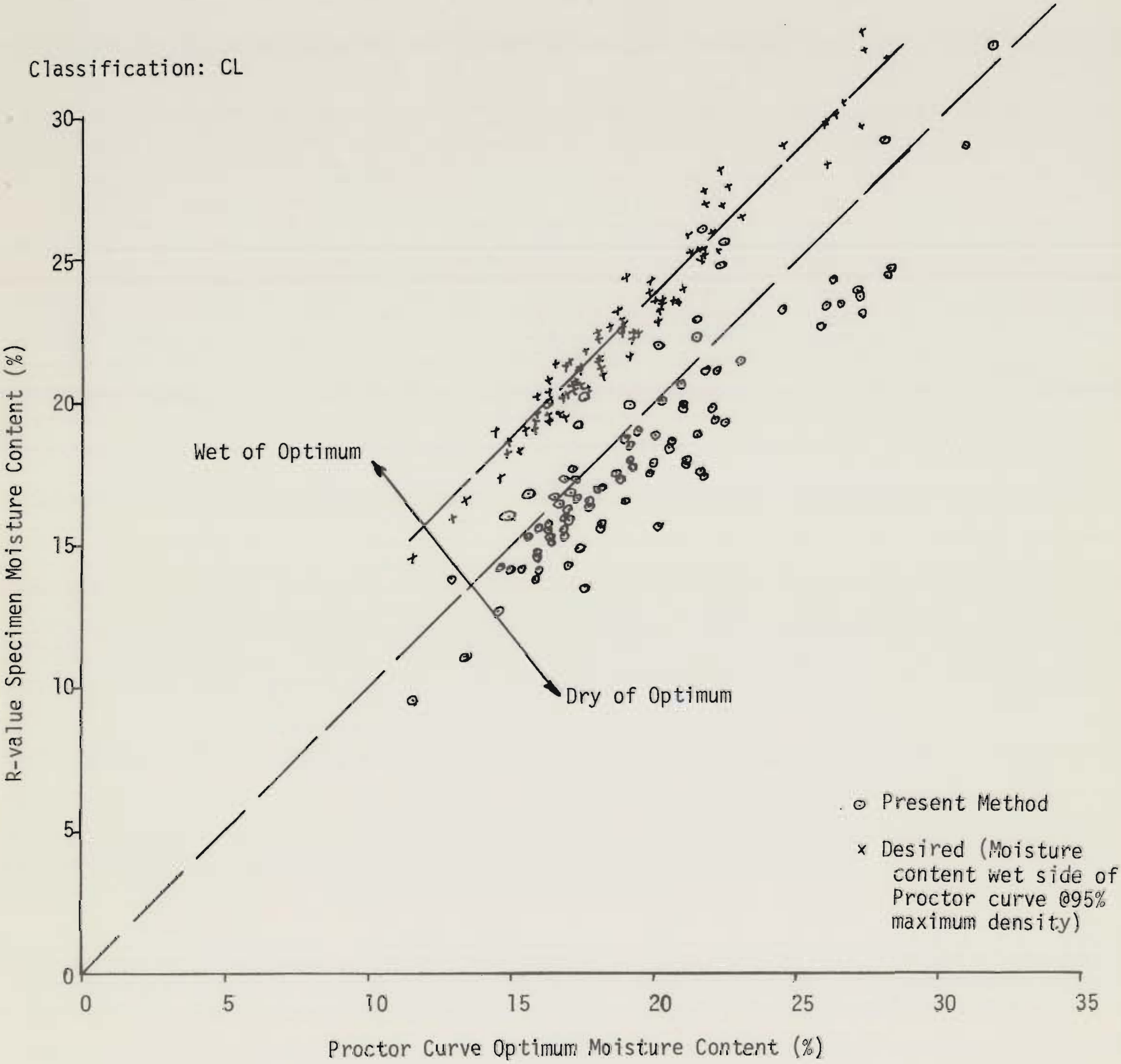


Figure 3 - Moisture Comparisons Between R-value Specimens and Proctor Curve for Clays

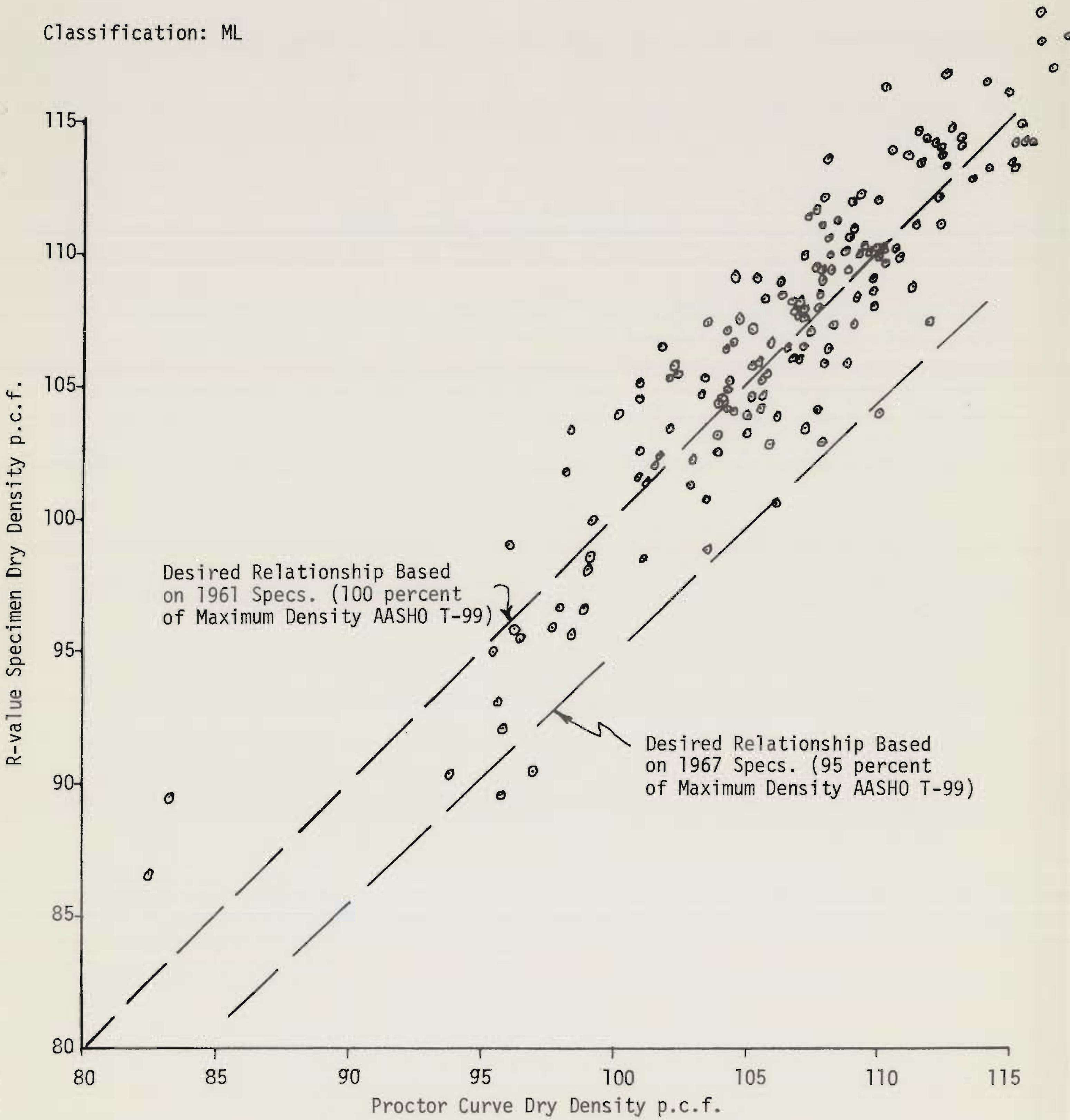


Figure 4 - Density Comparison Between R-value Specimens and Proctor Curves for Silts

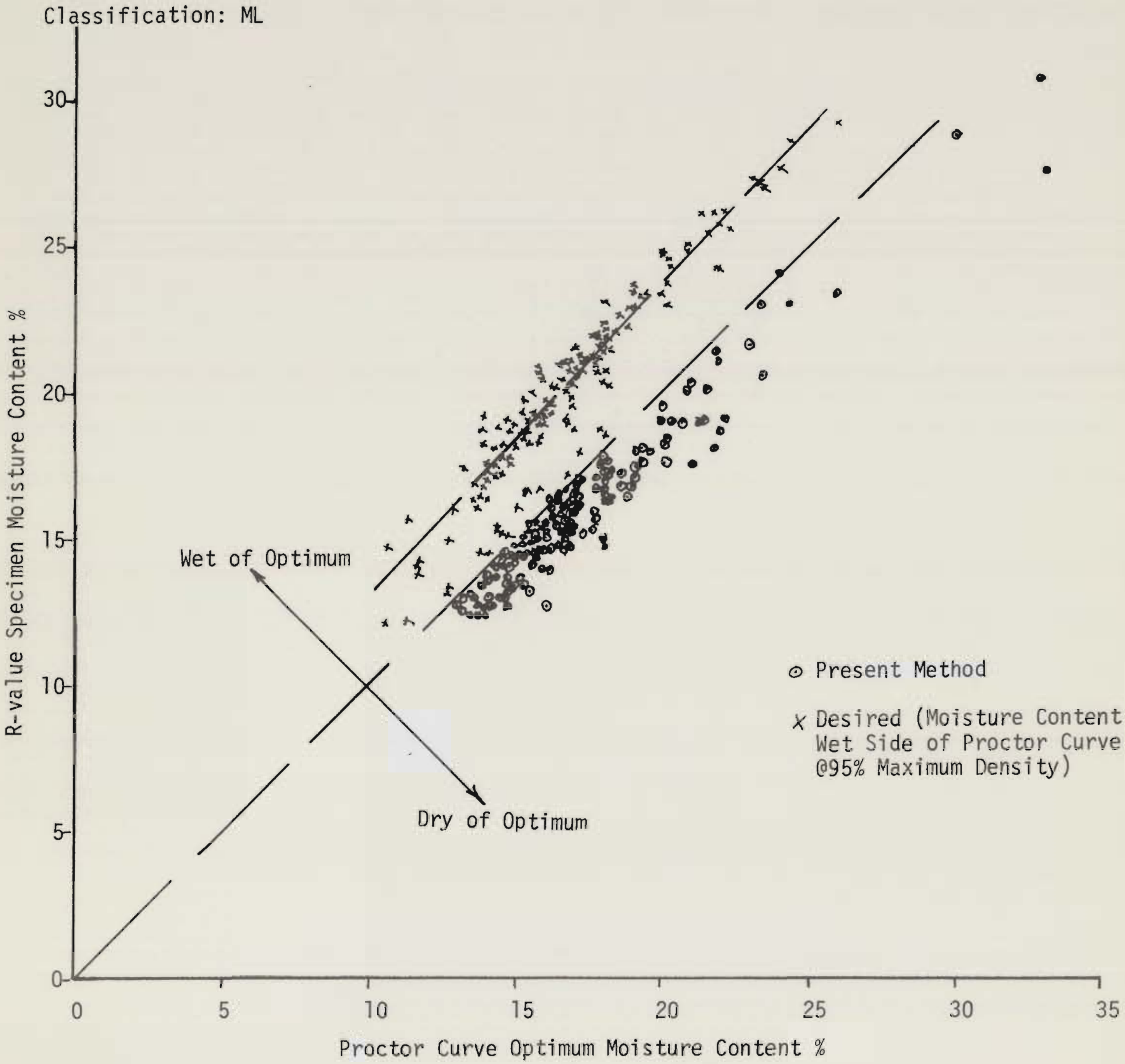


Figure 5 - Moisture Comparisons Between R-value Specimens and Proctor Curve for Silts

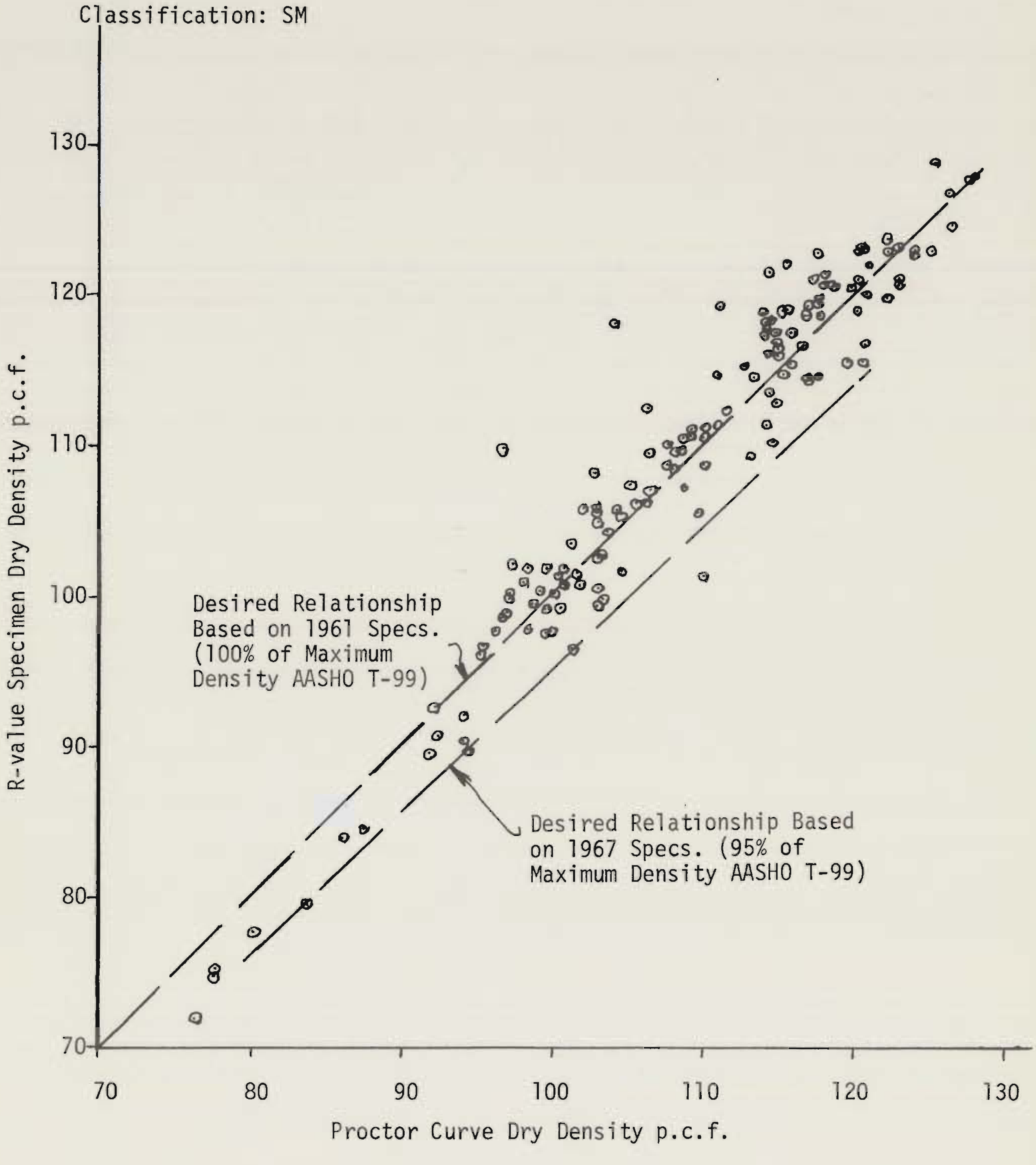


Figure 6 - Density Comparisons Between R-value Specimens and Proctor Curve for Silty Sands

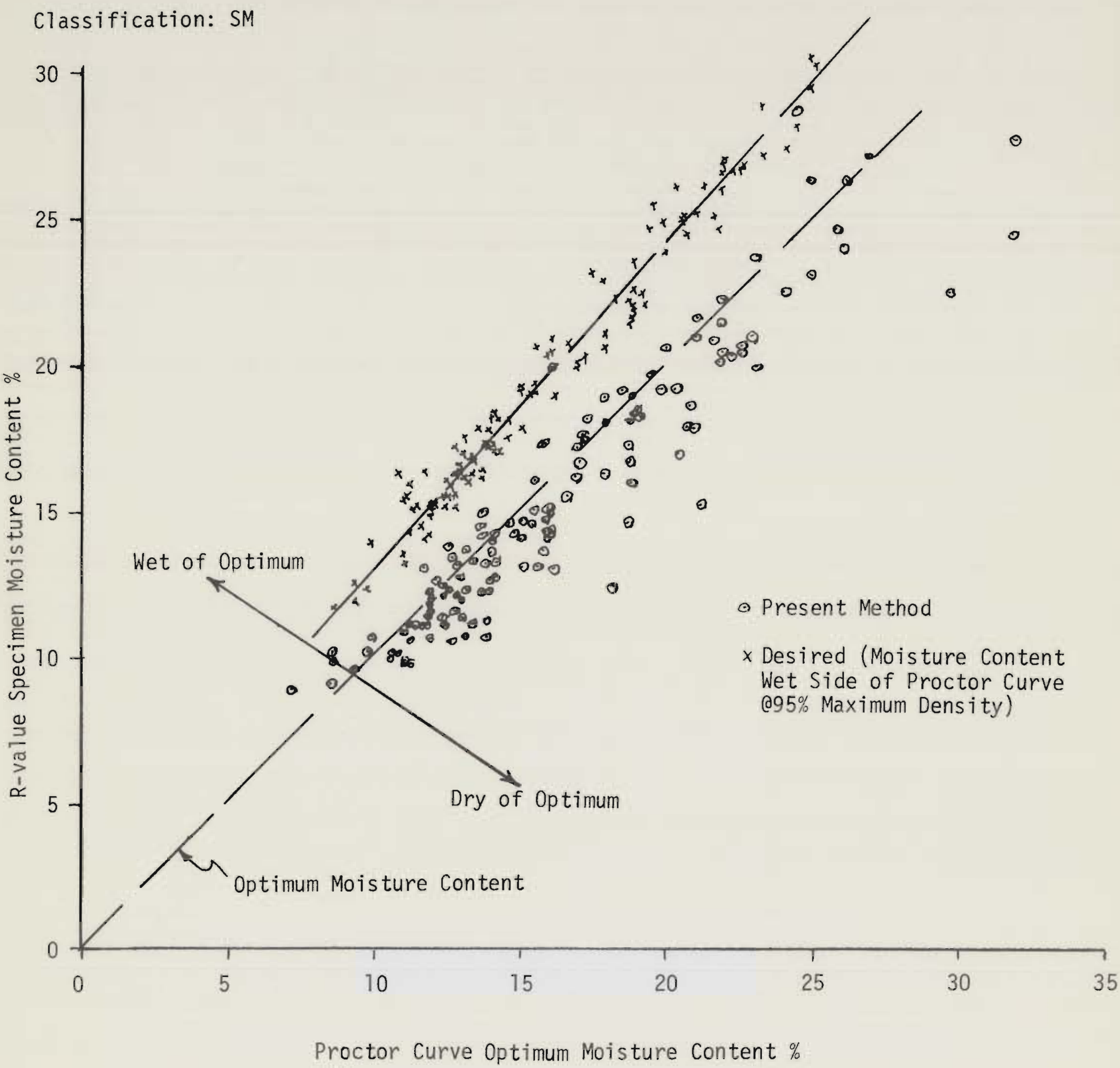


Figure 7 - Moisture Comparisons Between R-value Specimens and Proctor Curve for Silty Sands

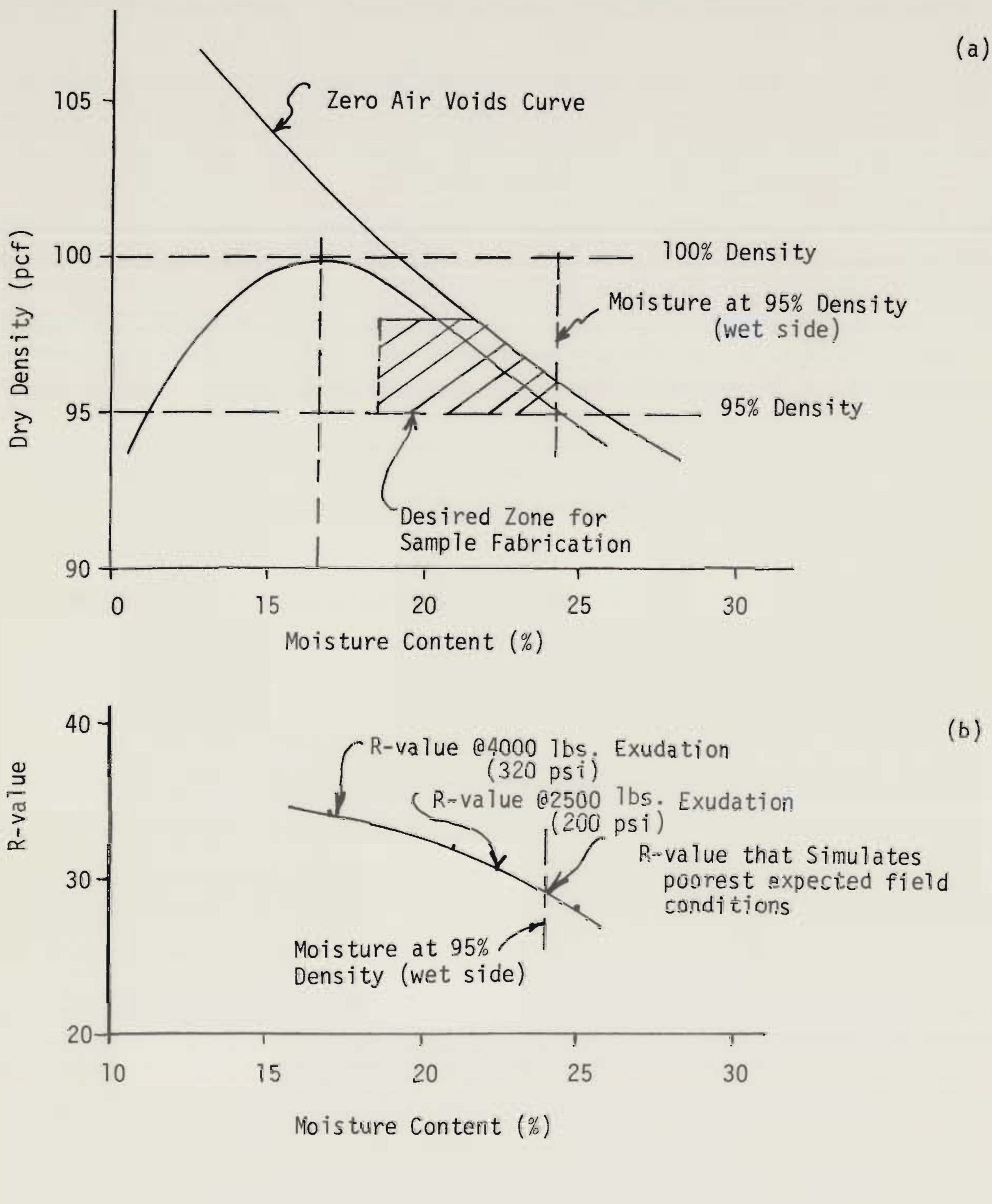


Figure 8 - Density Curve Showing Desired Sample Fabrication

SOIL COMPACTION THEORY

A brief discussion of soil compaction theory is presented here for a better understanding of the changes that were made in R-value specimen fabrication during the research work.

Compaction of soils occurs by the reorientation of particles or the distortion of particles and their adsorbed layers. In cohesionless soils (silts and sands), compaction is largely by reorientation of the grains into a more dense structure. Vibration, shock and flowing water will reduce wedging and friction to permit easier compaction.

In cohesive soils (clays and plastic silts), compaction occurs by both reorientation and distortion. This is achieved by a force that is great enough to overcome the cohesive resistance or interparticle forces. For best efficiency the compaction force should be as great as possible without causing bearing failure and shear-displacements.

As shown in Figure No. 9(a) the effectiveness of a given energy is directly associated with the moisture content and less dependent on efficiency of the effort. As the water content of a soil is increased up to some optimum, interparticle attractive forces and pore water tensions are reduced. Particles can be reorientated and distorted more easily. As the moisture content exceeds optimum, densification and decrease of void ratio leads to saturation. The building of neutral stress in the pore water within the smallest voids prevents further reduction in void ratio so that additional effort is wasted. Saturation of all voids then is the theoretical limit for compaction at any given water content unless the soil permeability is so high that water can escape from the voids during compaction.

Also compared in Figure No. 9(b) is the compaction efforts used for density control by California and Idaho.

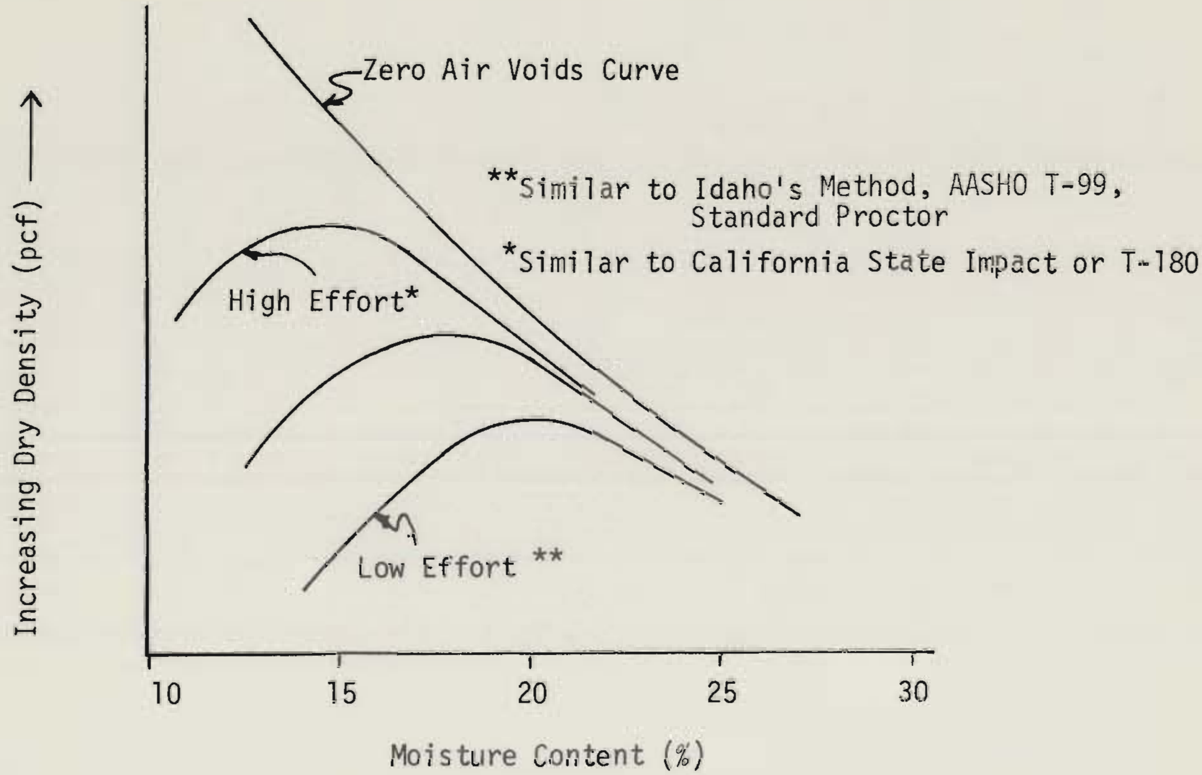


Figure 9(a) - Moisture-Density Curves for Different Compactive Efforts

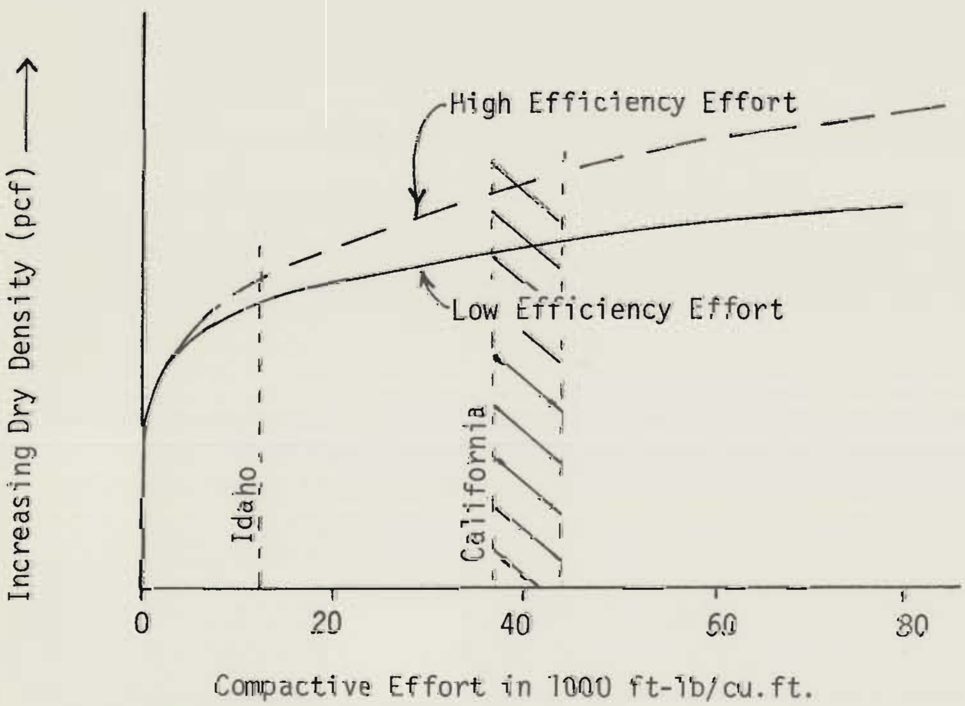


Figure 9(b) - Density as a Function of Compactive Effort

LABORATORY COMPACTION OF R-VALUE SPECIMENS

Idaho's T-8 Method (placed in Appendix A as a part of this report) outlines procedures for sample preparation. It was patterned closely after California's procedure which uses the kneading compactor for forming test specimens. Standard compaction calls for:

IDAHO T-8

20 blows @ 250 psi (material into mold)
120 blows @ 250 psi (compaction)

CALIFORNIA

30 blows @ 240 psi (material into mold)
100 blows @ 300 psi (compaction)

Some soils require a lowering of compaction pressure to prevent the foot from penetrating into the soil surface more than 1/4-inch, after all material is in the mold.

The compaction effort applied by California and Idaho in fabricating test specimens for R-value are nearly equal. However, California requires higher subgrade density than Idaho as can be seen in the comparison of compaction efforts used for density control in Figure No. 9(a) and 9(b).

As a first approach to fabricate a specimen with more moisture and lower density, the compaction effort was reduced. This was a step in the right direction but was still not considered as satisfactory. A further modification was made that incorporated lesser compactive effort and included a lowering of the exudation pressure from 4000 to 2500 pounds (320 to 200 psi) in an attempt to effect large moisture increases in the specimen. A comparison of the three compaction methods is made below:

1. Standard
   20 blows @ 250 psi (material into mold)
   120 blows @ 250 psi (compaction)
   320 psi Exudation pressure

2. Modification No. 1 — 40 blows @ 75 psi (material into mold)
100 blows @ 150 psi (compaction)
320 psi Exudation pressure

3. Modification No. 2 — 40 blows @ 75 psi (material into mold)
100 blows @ 100 psi (compaction)
200 psi Exudation pressure

Previous laboratory research had shown that a change of compactive foot pressure was more significant in altering density than changing the number of blows.

LABORATORY TESTING AND RESULTS

Samples of clay, silt, silty sand and sand were fabricated according to the above procedures and tested for R-value. Thirty seven soil samples were tested and the results are reported in Table 1.

As can be seen in Figure Nos. 10, 11 and 12 the modifications were effective in reducing specimen density and increasing moisture content. Eight samples of clay were tested, but only three allowed direct comparison of results. Modification No. 2 provides sample fabrication within or close to the desired range. It was found that with present equipment, compacting pressures could not be further reduced without causing some inconsistency in the compactor stroke. Therefore, further reduction was not considered advisable.

A decrease of exudation pressure from 320 psi to 200 psi caused the moisture increase that was sought. Most of the specimens that were considerably dry of optimum moisture when prepared by the Standard method were wet of optimum and within the desired range when fabricated by Modification No. 2 method.

Average density reduction was approximately 5 or 6 pounds per cubic foot. The density of Modification No. 2 specimens averaged about 98 per cent of maximum density which is still slightly denser than desirable for meaningful tests. However, this becomes less significant because of accepted practices in selecting R-value for design purposes. The lowest 20 percentile point is chosen as design R-value; e.g. 80 per cent of samples have higher R-values and 20 per cent have lower R-values. This would effectively mean that design R-values would come from the desired range.

The relationship of R-value to expansion pressure for pre-research and research test data indicates a definite correlation exists. This correlation

Class'n.	Lab. No.	Standard Proctor		Standard			Modification No. 1			Modification No. 2					
		γd	MC	γd	MC	R	γd	MC	R	γd	MC	R	LL	PL	PI
ML	231893	111.1	15.0	110.1	14.7	44	109.3	14.6	53				21.5	20.0	1.5
	231941	107.0	18.5	109.9	17.3	52	107.2	17.9	54				NV	21.4	NP
	231942	102.0	21.5	106.8	19.9	54	102.1	21.2	34				27.1	23.3	3.8
	232169	102.3	22.5	106.6	19.4	46	102.7	20.4	40	101.1	22.0	33	34.5	25.6	8.9
	232174	116.2	13.0	118.0	11.8	73	114.3	13.0	64				NV	NP	
	232287	105.5	16.2	106.6	16.5	64	103.9	18.2	55	102.5	18.5	51	NV	NP	
	232289	98.2	23.0	102.9	22.7	33	98.9	22.7	30	97.6	24.2	22	36.2	30.2	6.0
	232393	108.0	15.5	109.5	14.8	65	105.5	16.1	62	106.5	15.9	53	NV	NP	
	240372	110.2	15.5	112.6	13.7	68	109.3	14.7	63	107.8	15.4	55	NV	NP	
	240374	101.4	20.0	104.1	18.0	74	101.2	19.0	69	102.0	20.5	65	NV	NP	
	240376	101.9	20.0	108.0	17.4	49	105.9	17.9	47	102.9	19.2	43	32.3	24.5	7.8
	240891	106.0	16.4	108.4	14.8	69	104.3	16.3	66	104.5	17.5	61	NV	NP	
	241395	112.9	13.6	115.3	14.3	30	114.0	14.6	44	112.6	15.5	27	NV	NP	
	241396	112.5	13.0	115.4	12.5	69	112.2	13.3	68	111.4	13.9	65	NV	NP	
	241397	94.3	22.6	98.6	21.8	63	94.4	23.1	61	93.2	24.7	53	39.6	27.1	12.5
	241399	91.5	25.6	97.7	23.7	29	96.9	24.1	42	94.5	25.6	27	37.5	22.5	5.0
SM	231442	113.1	13.1	111.9	12.0	74	109.8	13.2	72				NV	NP	NP
	231512	125.0	11.5	127.0	10.2	51	124.5	11.1	55				NV	NP	NP
	231892	100.0	21.5	99.5	20.0	75	97.0	21.0	70				NV	NP	NP
	231943	124.5	11.2	125.9	10.1	54	123.5	10.6	56				NV	NP	NP
	232680	112.6	12.6	116.0	13.4	42				114.3	13.6	38	28.0	23.6	4.4
	241381	115.1	12.8	118.4	12.2	66	114.8	12.8	68	113.7	13.5	63	NV	NP	NP
	241382	117.5	11.3	120.6	10.4	71	117.0	11.0	73	116.9	11.4	68	NV	NP	NP
	241398	111.6	13.8	118.7	10.7	73	115.5	11.4	73	114.0	12.1	70	NV	NP	NP
SP-SM	231443	107.8	14.6	107.4	12.9	76	103.7	12.1	75				NV	NP	NP
	231444	107.3	14.3	106.9	12.7	75	104.8	12.6	71				NV	NP	NP
SP	241383	102.4	15.1	104.5	13.1	73	104.0	13.6	73	102.8	13.8	69	NV	NP	NP
	241413	95.9	18.7	98.9	17.3	69	95.5	19.2	67	94.1	20.7	68	NV	NP	NP
	241414	101.6	16.4	105.5	15.9	68	104.2	16.2	69	103.8	16.4	66	NV	NNP	NP
CL	231659	102.0	20.3	104.8	20.6	26	105.2	19.9	36				28.5	20.9	7.6
	23015	None	None	104.4	20.5	38	104.5	20.4	50				33.2	23.2	10.0
	232288	106.1	18.2	99.5	24.1	14						< 5	40.2	13.2	27.0
	239565	102.5	20.4	108.9	18.9	40	107.5	18.9	44	105.1	20.6	25	30.0	20.4	9.6
	239567	103.1	19.5	110.9	18.0	37	107.6	19.1	46	104.9	20.9	28	29.1	18.6	10.5
	240373	104.1	18.6	102.3	21.5	12						< 5	32.6	16.8	15.8
	240375	101.3	21.4	102.9	22.1	17				97.7	25.6	< 5	39.9	18.7	21.2
CH	232392	95.0	25.2	97.0	26.9	18	95.4	27.8	17	90.3	31.0	9	52.5	24.2	28.3

Table 1 - The Effect of Sample Preparation and Testing Procedure on R-Value Specimens

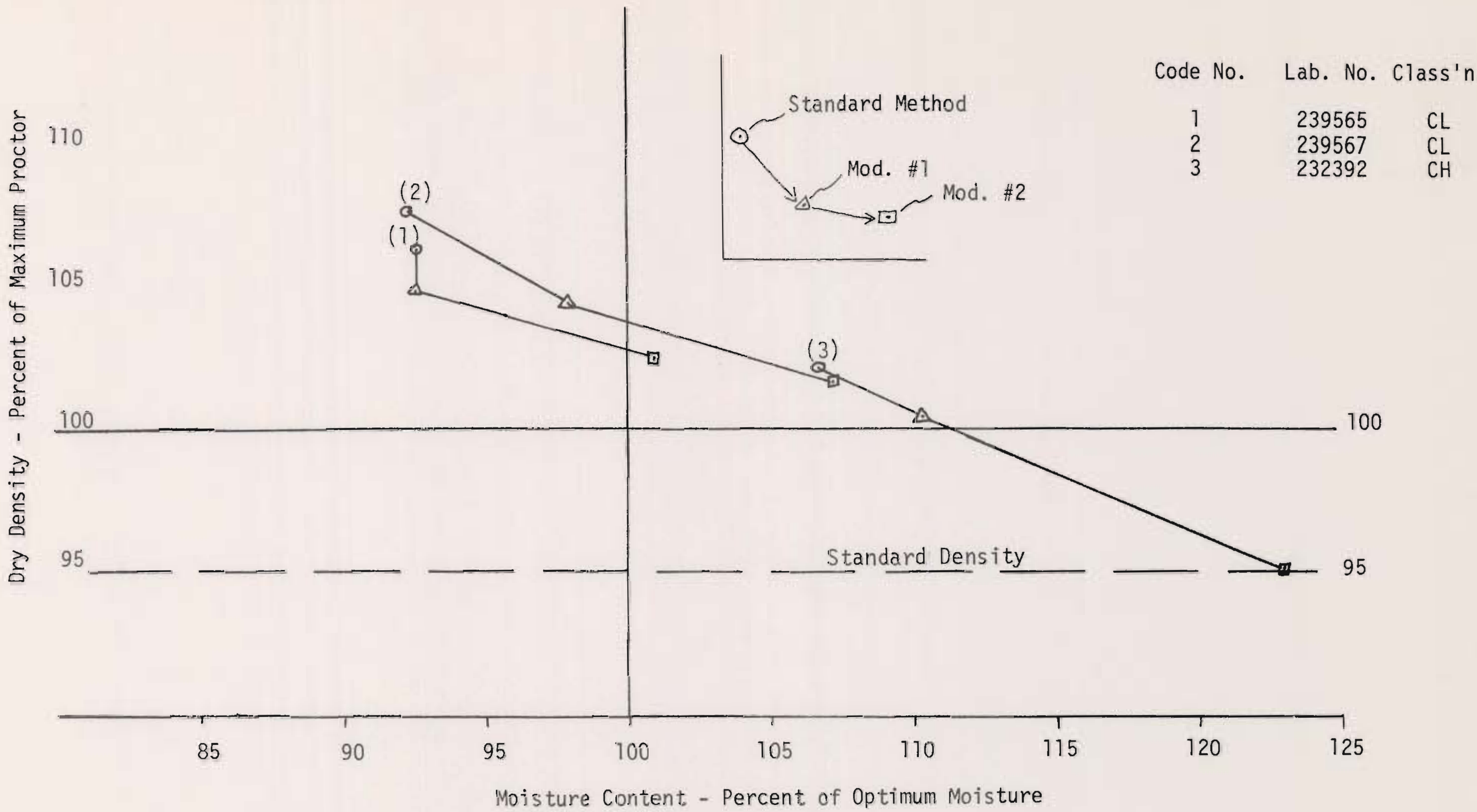


Figure 10 - Effect of Modified R-value Testing on Moisture and Density of Clay Specimens

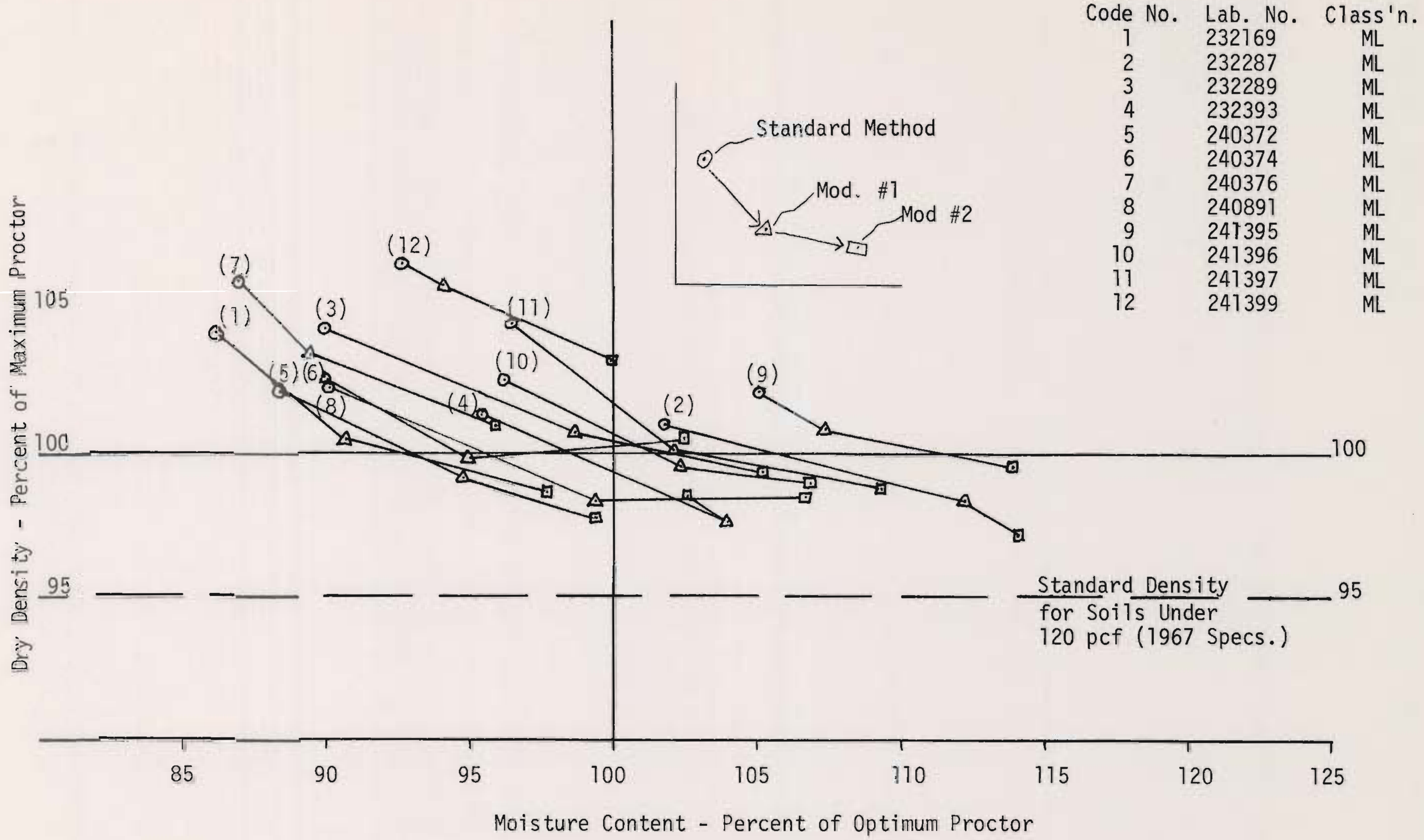


Figure 11 - Effect of Modified R-value Testing on Moisture and Density of Silt Specimens

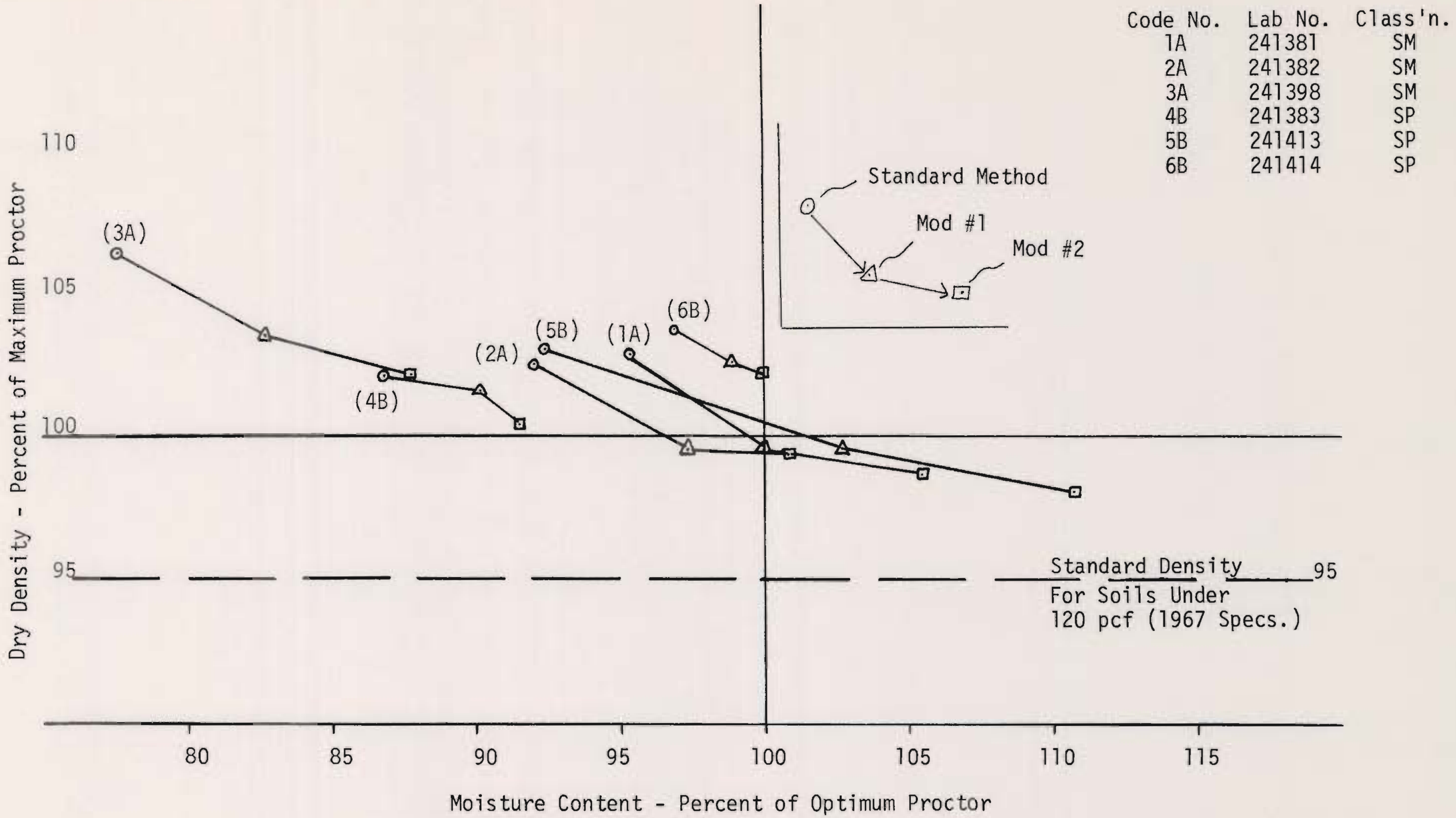


Figure 12 - Effect of Modified R-value Testing on Moisture and Density of Silty Sand and Sand Specimens

was not influenced by the Modification methods as can be seen in Figure Nos. 13 and 14. Therefore, no change in design criteria that considers expansion pressure is necessary.

The influence of specimen preparation on R-value and gravel equivalency is shown in Figure Nos. 15, 16, 17, 18, 19 and 20 (sister samples means the same soil sample was tested by different methods). In the clays and silts rather large decreases in R-value were found for Modification #2 Method, 16 per cent and 31 per cent, respectively. Sandy material showed only very slight decreases in R-value even though density and moisture content were significantly changed by the modifications.

When related to Gravel Equivalent, assuming a TI=10, clay specimens needed 18 per cent increase in ballast, and silt samples required 21 per cent increase. No significant change in required gravel equivalent was found for sandy soils.

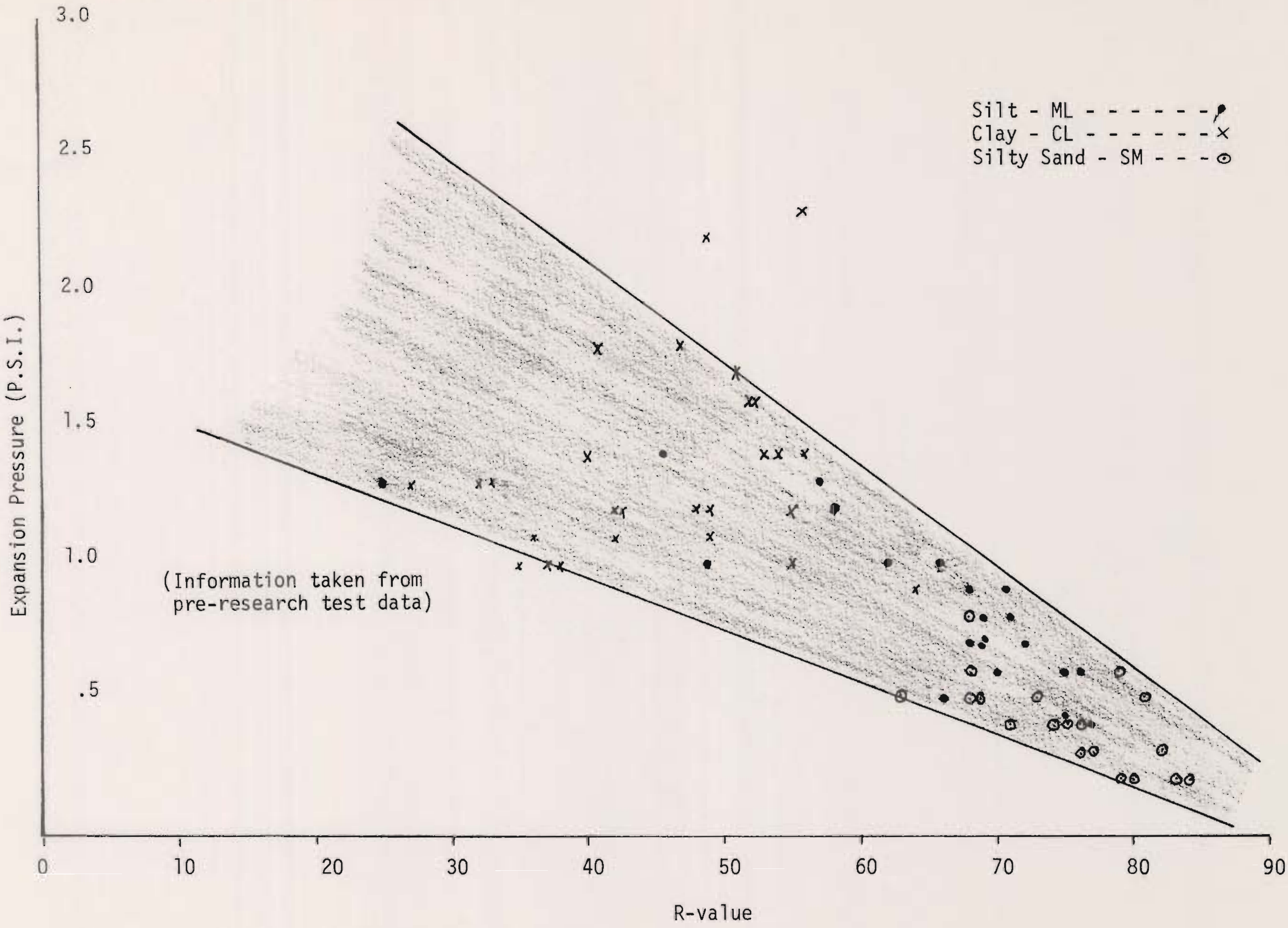


Figure 13 - Relationship of R-value and Expansion Pressure

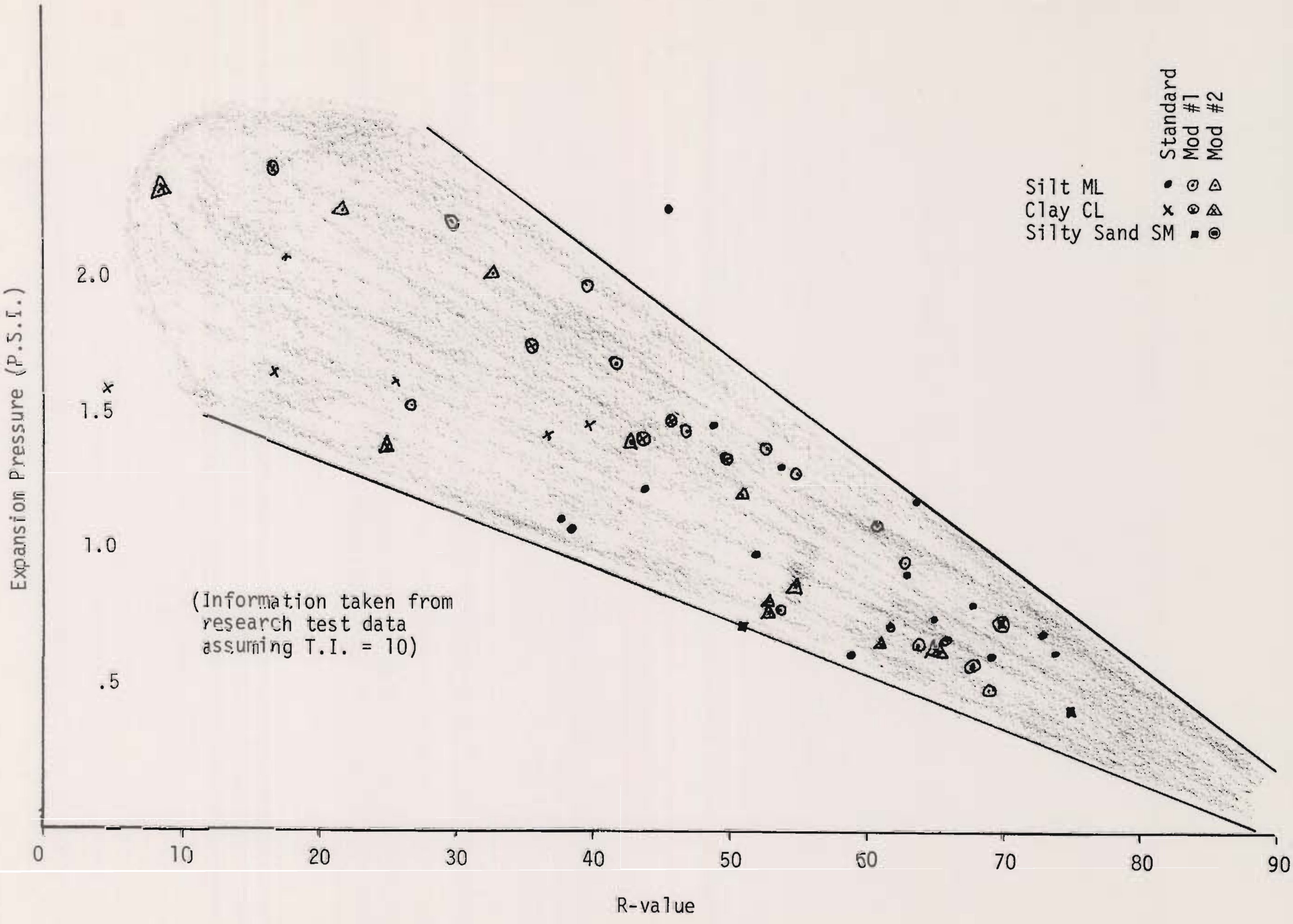


Figure 14 - Relationship of R-value and Expansion Pressure

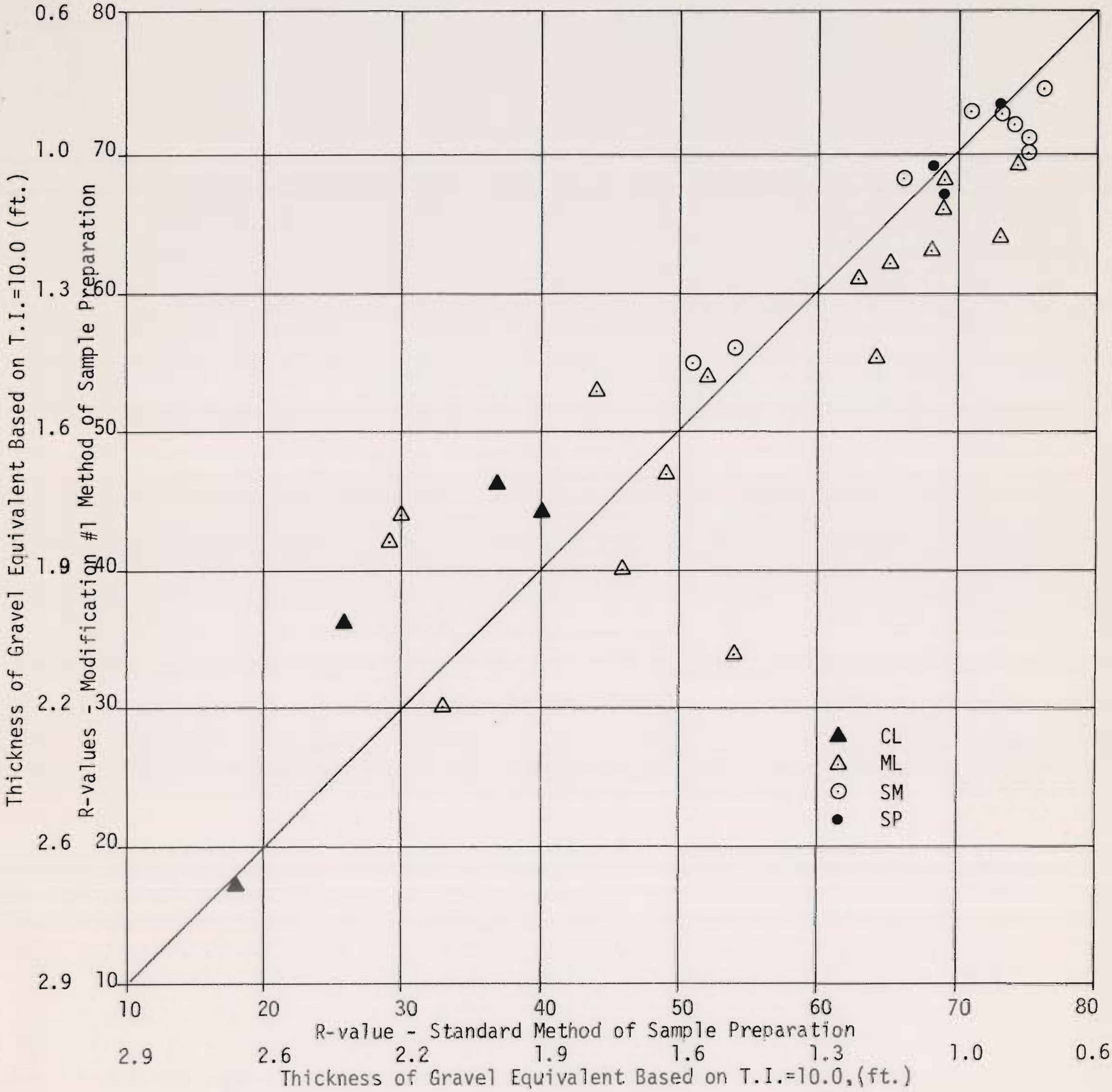


Figure 15 - Effect of Modification #1 on R-value and Thickness of Gravel Equivalent

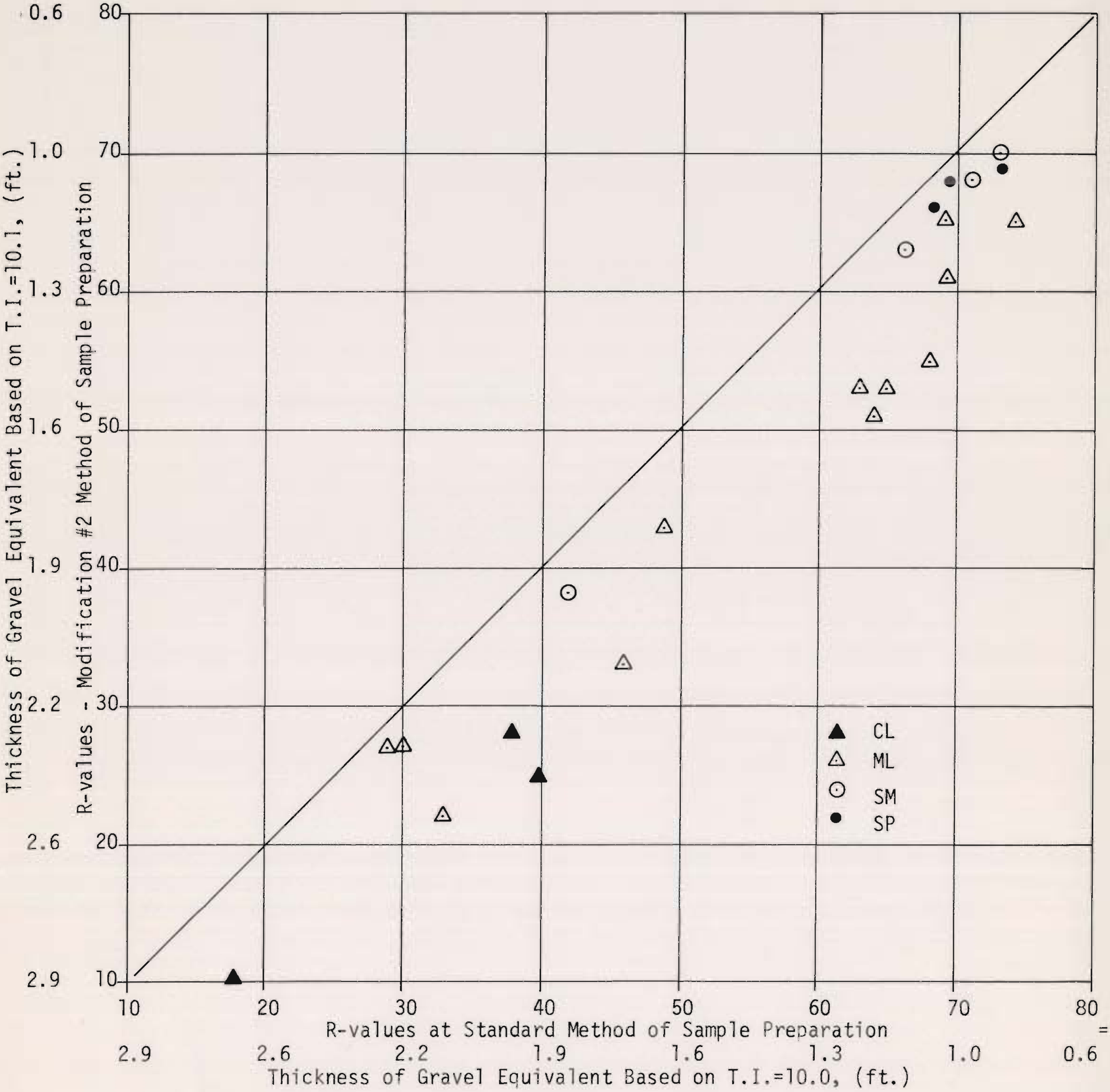


Figure 16 - Effect of Modification #2 on R-value and Thickness of Gravel Equivalent

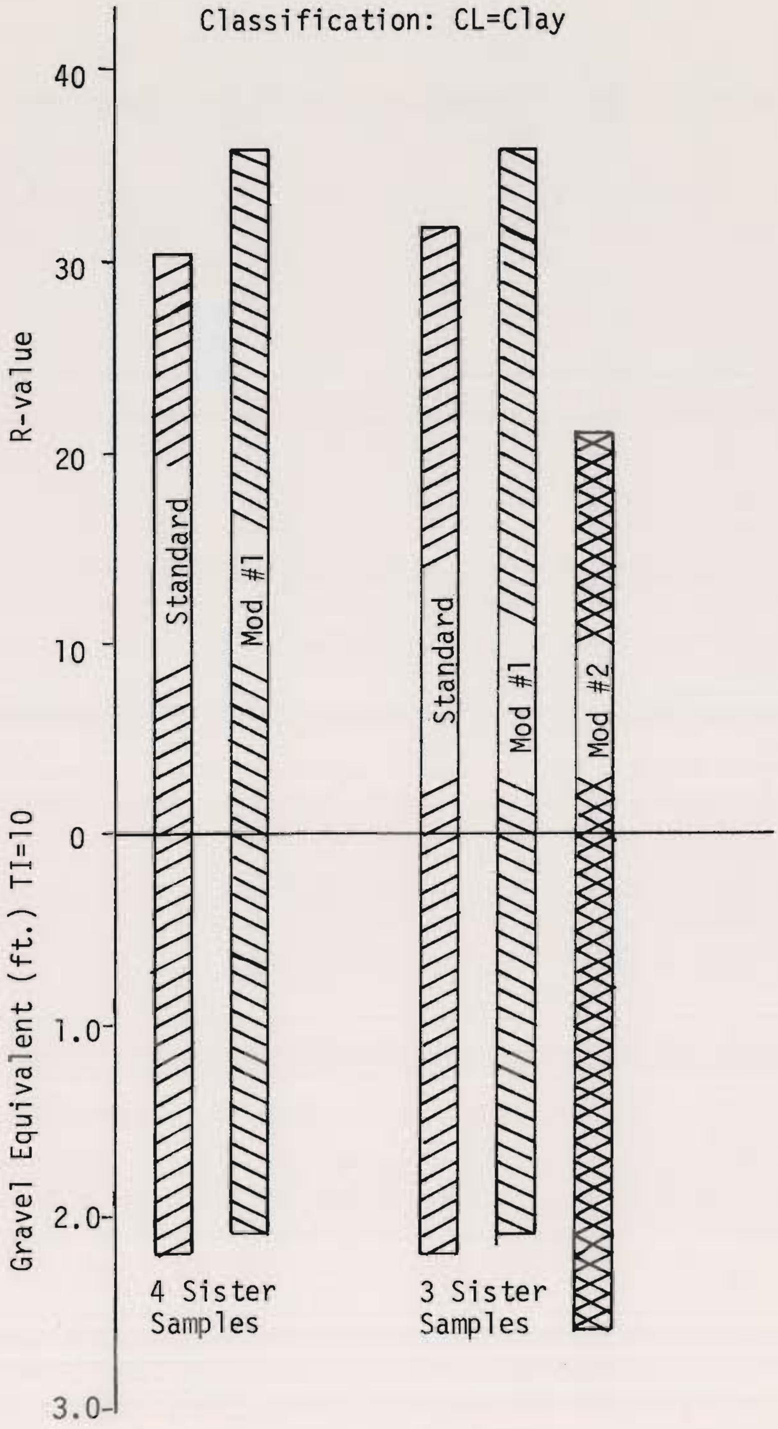


Figure 17 - Influence of Specimen Preparation on R-value & Gravel Equivalent

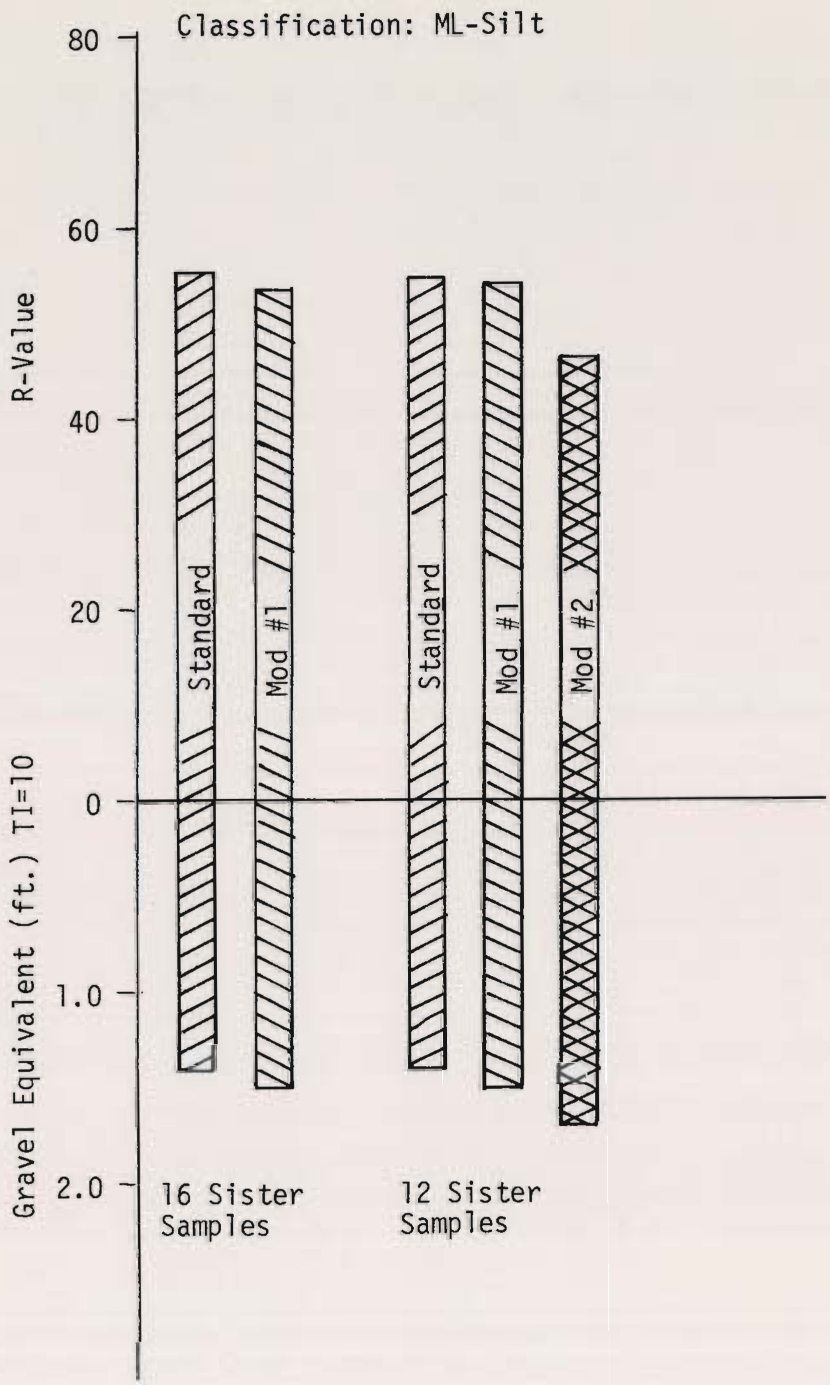


Figure 18 - Influence of Specimen Preparation on R-value & Gravel Equivalent

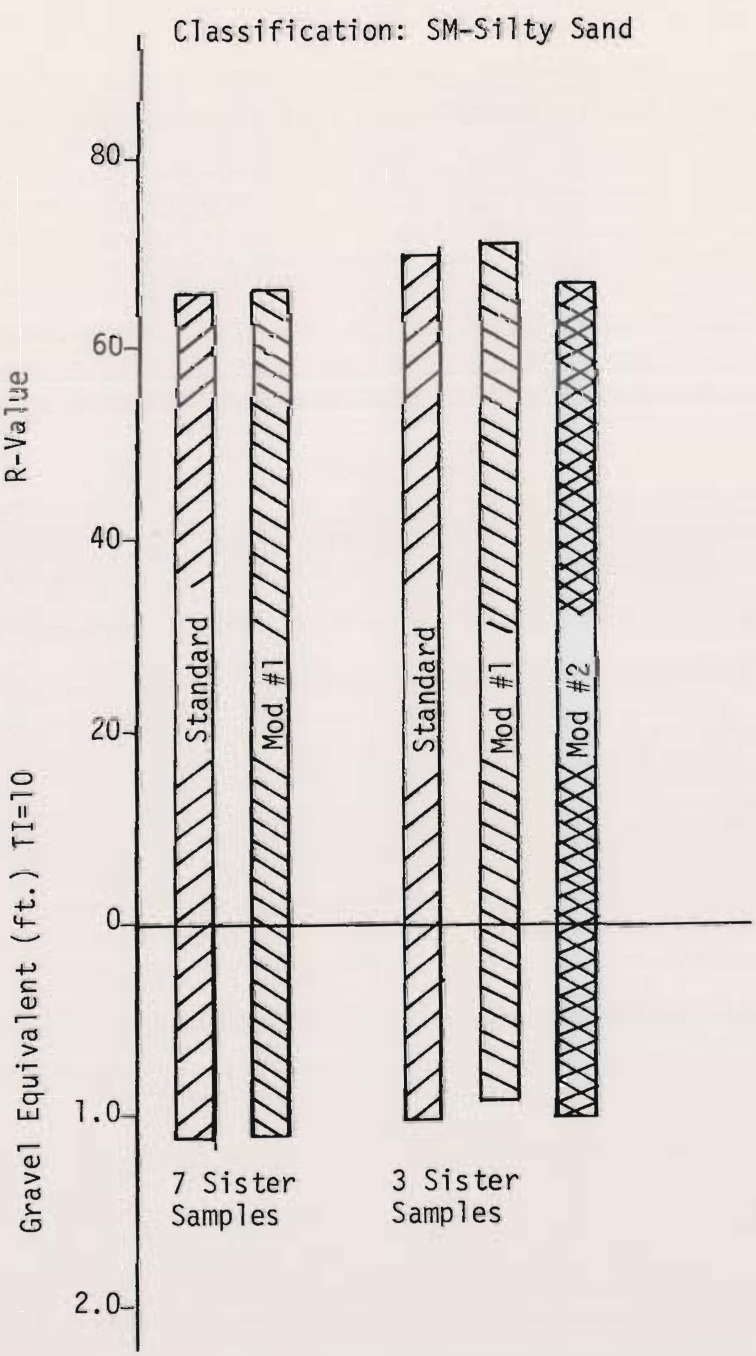


Figure 19 - Influence of Specimen Preparation on R-value & Gravel Equivalent

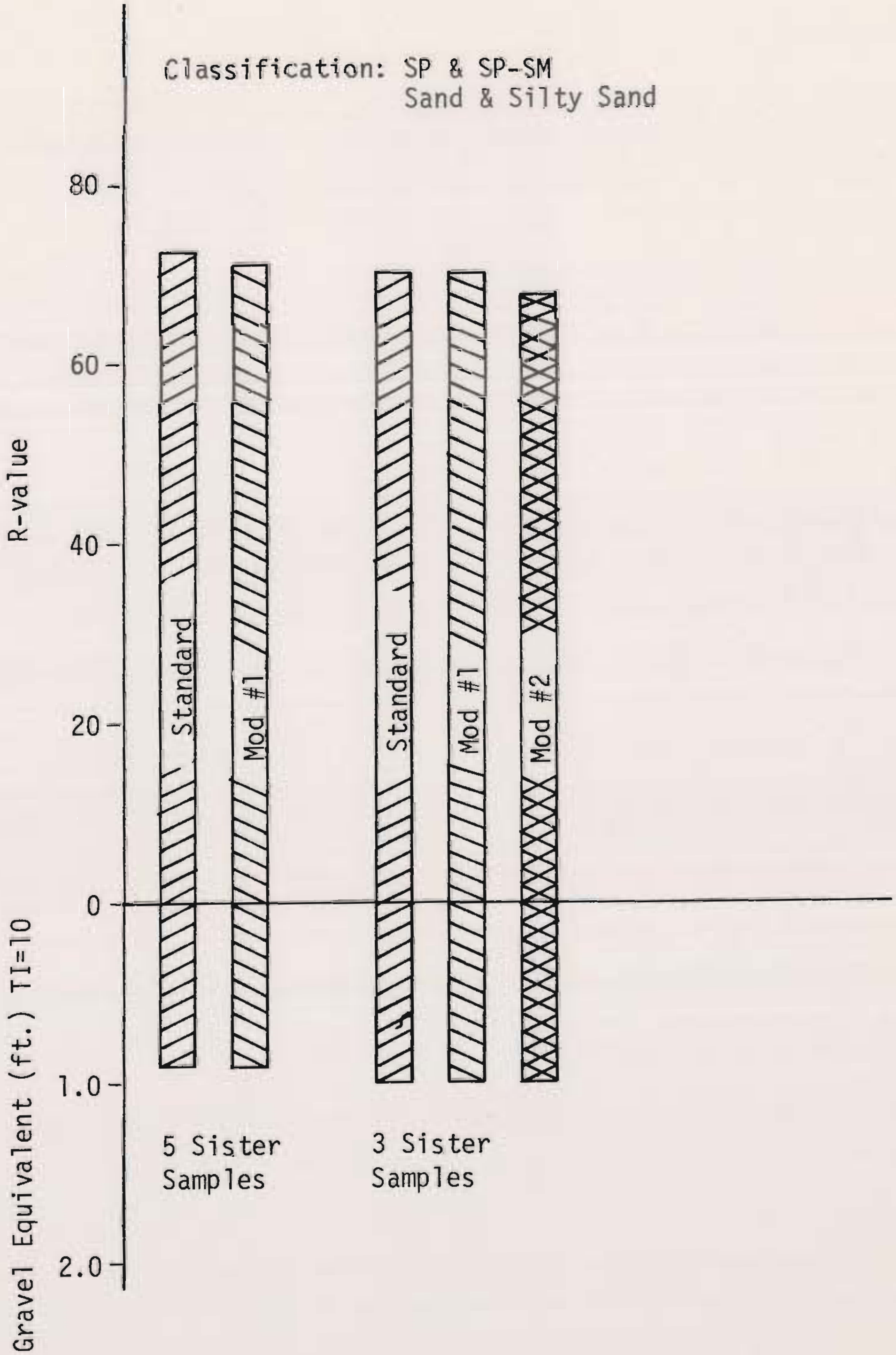


Figure 20 - Influence of Specimen Preparation on R-value & Gravel Equivalent

IDAHO DEPARTMENT OF HIGHWAYS
Boise, Idaho

Idaho T-8-69

STANDARD METHOD OF COMPACTION OF SOILS AND SOIL MIXTURES FOR THE EXPANSION PRESSURE AND HVEEM STABILOMETER TESTS

Reference: AASHO Designation T 173-56, T 174-56 and T 175-56; California Test Method No. 301-F

This method is intended for use with highway base, subbase and subgrade materials (basement soils), which are to be tested in the expansion pressure apparatus and the Hveem Stabilometer. Prepared specimens are designed to give test results indicative of the material which placed by construction equipment and subjected to traffic. The outstanding feature of the compaction procedure is a kneading action which gives the particles the proper orientation and contact pressure.

This test method is divided into the following parts:

I. Method of Preparation of Materials
II. Method of Compaction
III. Method of Determination of Exudation Pressure of R-value Test Specimens
IV. Method of Determining the Expansion Pressure of R-value Test Specimens
V. Method of Determining the Stabilometer Resistance (R-value) by means of the Hveem Stabilometer
VI. Method of Calculating the Densities of R-value Test Specimens

Figure 1. R-value Test Equipment in Operation

PART I. METHOD OF PREPARATION OF MATERIALS

SCOPE

1. This part of the procedure describes the methods of batching materials, the mixing of specimens and the curing of the materials. The initial preparation of the samples is described in Test Method No. Idaho T-59.

APPARATUS

2. (a) Equipment consists of:

(1) Mechanical Mixer. See Figure 2.

(2) Scales, 5000 g. capacity, accurate to 1.0 g.

(3) Scales, 175 lb. capacity, with 0.1 lb. graduations.

(4) Set of screens; 3-inch, 2-inch, 1-inch, 3/4-inch, 1/2 inch and No. 4.

(5) Fiberglass pans.

(6) Vinyl plastic sheets large enough to cover fiberglass pans.

(7) Burette or graduated cylinder for measuring water.

(8) Riffle splitter with chutes 3/4-inch wide.

Figure 2. Mechanical Mixer

TEST RECORD FORM

3. Keep all pertinent data regarding the test specimens on the data sheet DH-882 which is prepared when the sample is received. Final report is issued on DH-803. See pages 29 and 30.

PREPARATION OF SAMPLE

4. (a) Refer to Test Method No. Idaho T-59 for preparation of samples.

(b) The preparation of R-Value test samples must include removal of coatings from coarse aggregates, and clay lumps must be broken down to pass the No. 4 sieve. This is important because relatively small test samples are used. Therefore, it is necessary that the test samples be prepared very accurately.

CALCULATIONS FOR DETERMINING GRADINGS AND BATCH WEIGHTS USED IN PREPARING R-VALUE TEST SAMPLES.

5. (a) Definitions of "original" and "as used" gradings.

(1) "Original." The grading as determined on a sample prior to any adjustment such as scalping, wasting or crushing.

(2) "As used." Before a material can be tested it is often necessary to adjust the grading either to meet specifications or to eliminate material too large to test. This adjusted grading is referred to as the "as used" grading. In cases where 100% of the material as received passes the 3/4-inch sieve and no adjustments are necessary, the "original" and the "as used" gradings will be the same.

(b) Criteria for scalping (removing the oversize material) samples containing oversize material.

(1) If 75% or more of the sample as received passes the 3/4-inch sieve, scalp the sample on the 3/4-inch sieve.

(2) If less than 75% of the sample as received passes the 3/4-inch sieve, scalp the sample on the 1-inch sieve.

(3) A total of 13 lb. is used to insure sufficient material for 5 specimens and a moisture sample.

(4) Calculations necessary for determining the "as used" grading are as follows:

Given an aggregate with the following grading:

NOTE: More than 75% of the sample as received pass the 3/4-inch sieve, so scalp on the 3/4-inch sieve.

Sieve	Original % Passing	Corrected % Passing	Corrected % Retained	Accumulated Lb.
1"	90			
3/4"	85	100	0	0
1/2"	75	88	12	1.6
No. 4	65	77	23	3.0
Weight of Sample				13.0 lb.

(5) Using the above example weight out 1.6 lb. of retained 1/2-inch material, add to this 1.4 lb. of retained No. 4 material and 10.0 lb. of minus No. 4 material to make a total of 13.0 lb.

(6) If the corrected percent retained on the No. 4 sieve is less than 6%, no plus No. 4 material need be added and the sample is treated as though 100% passed the No. 4 sieve.

(c) Add to the sample enough water to approach optimum. This operation is performed by placing the 13.0 lb. sample in the mechanical mixer and adding water. The amount of water added is left to the discretion of the operator and need not be recorded. Continue mixing for at least 30 seconds after the water has been added. The period of mixing given is a minimum requirement. Then place the sample in a large fiberglass pan and cover with a plastic sheet in order to prevent moisture loss. Allow to stand overnight.

(d) Before preparing the individual test specimens an initial moisture sample of approximately 500 g. having the same grading as the test sample is taken. The moisture content is determined by weighing before and after drying to constant weight at 220 - 230 F.

(e) The R-Value test requires the preparation of three or four test briquettes at different moisture contents. The first briquette is used as a pilot specimen. After completing the pilot specimen, it can be used as a guide in the preparation of the other three stabilometer specimens which shall, conform to the following limitations.

Height = 2.5± 0.05 inches
Exudation pressure: One should be above and two below 4000 lb. exudation pressure or two above and one below 4000 lb.

Should the pilot briquette satisfy both height and exudation pressure requirements, it may be used as one of the sample specimens and only three briquettes (two additional) need be fabricated. It is desirable to have 1000 gm. to 1100 gm. material produce a briquette of proper height. Experience will help in amount selection. Any correction of amount necessary may be made by use of Chart Figure 3.

(f) The amount of water needed to bring the exudation pressure into one of the above named ranges is added to the soil and mixed in the mechanical mixer. Very granular and sandy materials can be mixed as thoroughly and as easily with a pan and trowel. It is necessary here to record the amount of water added.

NOTE: With the use of the mixing machine, 30 seconds at a moderate speed is ample time to mix the material. Any amount of time over this may cause excessive loss of water due to evaporation.

(g) To obtain a representative test specimen when the sample contains plus No. 4 aggregate, proceed as follows:

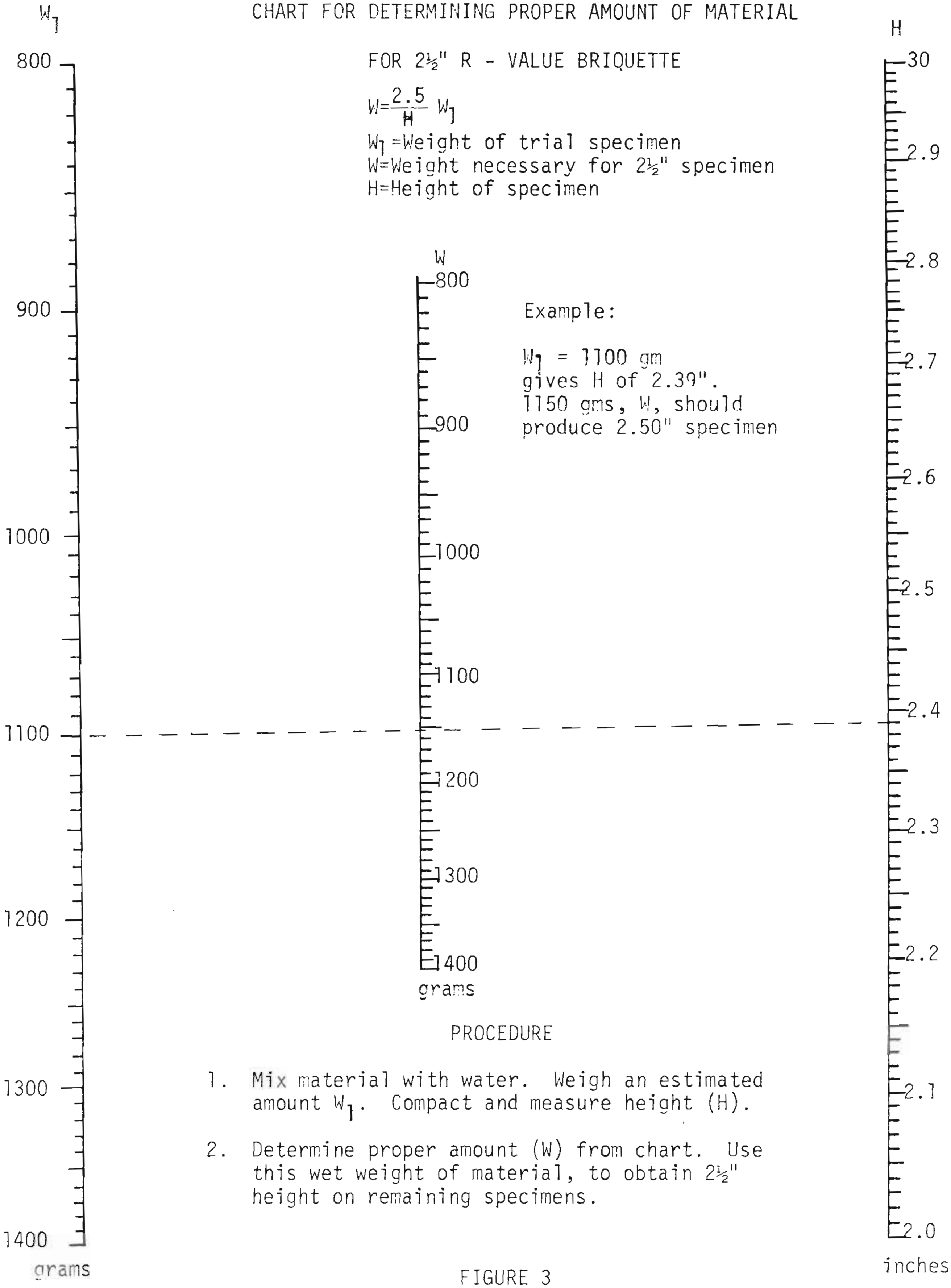
(1) Roll the 13.0 lb. sample on a plastic splitting cloth. See the Method of Quartering described in Idaho Test Method T-1.

CHART FOR DETERMINING PROPER AMOUNT OF MATERIAL

FOR 2½" R - VALUE BRIQUETTE

$W = \frac{2.5}{H} W_1$

W_1 = Weight of trial specimen
W = Weight necessary for 2½" specimen
H = Height of specimen



Example:

W_1 = 1100 gm
gives H of 2.39".
1150 gms, W, should
produce 2.50" specimen

PROCEDURE

1. Mix material with water. Weigh an estimated amount W_1. Compact and measure height (H).

2. Determine proper amount (W) from chart. Use this wet weight of material, to obtain 2½" height on remaining specimens.

FIGURE 3

(2) From the thoroughly rolled and mixed material scoop out a representative portion for the test specimen.

(3) Thoroughly roll the sample again and scoop out the material for the next specimen.

(4) Obtain all additional specimens in this manner.

(h) To prevent evaporation loss of moisture, keep samples covered at all times except during immediate processing.

PART II. METHOD OF COMPACTION

SCOPE

1. This part of the method describes the compaction procedure. The compactor consolidates the material without depending on straight compression or damaging impact, but rather by a series of individual impressions made with a ram having a face shaped as a sector or a 4-inch diameter circle, the kneading action is developed by the application of pressures alternately to small localized areas of the specimen while the remainder of the surface is free to move.

APPARATUS

2. (a) Equipment consists of:

(1) Mechanical Kneading Compactor. See Figure 4.

(2) Tared steel molds 4-inch height.

(3) Mold holders.

(4) Basket fabrication equipment.

(5) Paper strips for making baskets.

(6) Supply of phosphor-bronze perforated disks.

(7) Supply of 4-inch diameter manila disks.

(8) Weighted brass rod.

(9) Trowel shaped to fit trough on compactor.

(10) Separate trough and trowel for use with soils requiring baskets.

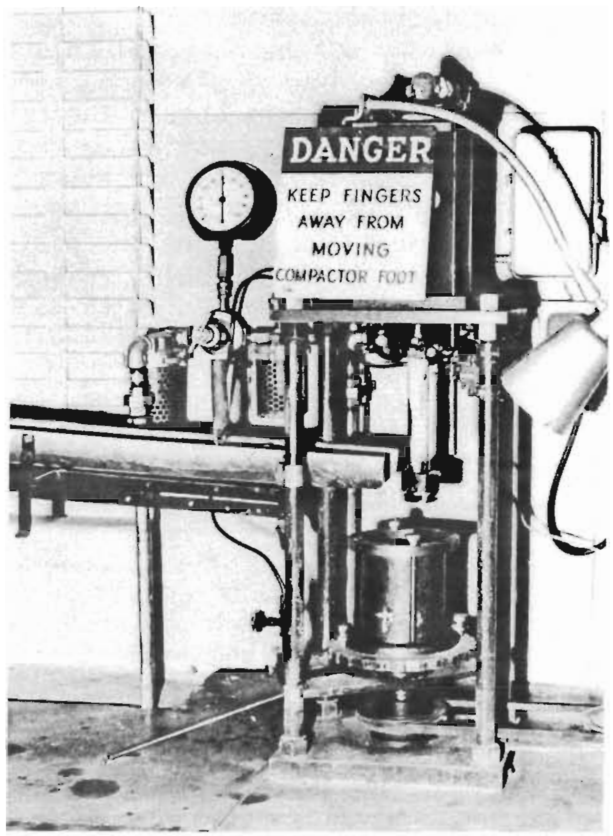


Figure 4. Kneading Compactor

PREPARATION OF SAMPLE

3. Sample is prepared as in Part I.

PROCEDURE

4. (a) Place mold in mold holder that has a rubber disk 1/8-inch thick in the recessed area of the bottom. Place 4-inch diameter manila disk into mold on top of rubber disk. Put assembled mold and holder on compactor turn table, and lock into place with thumb screws.

(b) Place well mixed sample in compactor feeder trough with the loose material distributed evenly along the full length.

(c) Using trowel formed to fit feeder trough, push the lower three inches of material in the trough into the mold. Start compactor and maintain 250 psi foot pressure, if possible. The compactor is adjusted to give 30 blows per minute. For the purpose of calibrating the compactor, some load indicating device must be placed under the tamping foot to register the true applied dynamic loading during the adjustments. Push the remainder of the material into the mold in 20 equal parts, using one part for each blow of the compactor. Constant adjustment of the mold stage must be made to obtain the correct length of stroke. The correct length of stroke does not allow the piston to strike the base of the cylinder, thus insuring continuous pressure on the specimen during the loading part of the cycle. A mark is scribed on the foot guide giving a 3/4-inch clearance between the piston and the cylinder base. When all the material is in the mold, raise and clean the compactor foot. Put a 4-inch diameter, 1/8-inch thick rubber disk on top of the soil and tamp 120 more times for a total of 140 blows, maintaining 250 psi if possible.

(d) Clays and clean sands may require lower compaction pressures. In these cases use the greatest compaction pressure possible, but do not allow the foot to penetrate over 1/4-inch into the surface after all the material is in the mold. If the pressure is reduced, record the pressure used.

(e) If free water should appear around the bottom of the mold during compaction, stop the compactor immediately and note the number of blows. In all probability the sample is too wet.

(f) If the surface is left uneven by the action of the compactor foot, smooth and level the surface by gently tamping with the weighted brass rod. A square tipped spatula is very helpful in removing the accumulation of material along the edge of the mold. Be careful not to allow undue drying of the surface during this operation.

(g) Granular materials are very difficult to handle without damage and require a paper basket to keep the specimen intact. Baskets prevent the specimen from falling out of the mold, and from crumbling when transferred from the mold to the stabilometer. When a basket is used, place the specimen in four approximately equal layers in a mold before compacting by use of the portable trough. Tamp each layer lightly with about ten strokes of the weighted brass rod to arrange the coarser particles in the mold. Apply 140 blows to the specimen with compactor, then remove mold from compactor keeping it upright so specimen will not fall out.

(1) See Appendix "A", Method of Fabricating Paper Baskets.

PRECAUTIONS

5. (a) It is quite important that the operator feed the material into the mold uniformly. Differences in the compactive effort can cause variation in the exudation pressures.

(b) Even distribution of the coarse aggregates throughout the length of the feeder trough is important in order to avoid segregation in the compacted specimen. The material should be evened out and leveled manually with the fingers or spatula along the trough before starting the feeding operations.

(c) The decision whether to use baskets on a given material must be based on experience. They should not be used if they are not needed. If baskets are not used and the specimen breaks up while being transferred into the stabilometer (see Section D, Paragraph 7) the fact may not be apparent at the time, but it will result in both excessive stabilometer pressure readings and excessive displacement readings. Both of these errors tend to lower the R-Value, and a group of four tests will be erratic with respect to one another. When this happens the test must be repeated using baskets.

(d) Care must be taken to select the proper amount of material to produce a 2.5" pat. NO material shall be removed from the trough or mold in order to produce the correct height.

(e) Any and all precautions should be taken to avoid any drying of material during mixing, in the feed trough or in the mold.

HAZARDS

6. Caution must be used to make certain nothing comes in contact with the compactor foot while it is in operation. A finger caught between the edge of the mold and the compactor foot will receive serious injury.

PART III. DETERMINATION OF EXUDATION PRESSURE OF R-VALUE TEST SPECIMENS

SCOPE

1. This part of the method describes the procedure used to determine the pressure required to exude water from the compacted specimen. This pressure is the "Exudation Pressure" for the specimen at that particular moisture content.

APPARATUS

2. (a) Equipment consists of:

(1) Moisture exudation device. See Figure 4.

(2) Perforated phosphor-bronze disks, 4-inch diameter and 28-gage.

(3) Testing machine, 10,000 lb. capacity, with solid head. If head is spherically seated, use proper shims to lock it in such a manner that the contact face is fixed firmly in a horizontal plane.

(4) Press. A lever equipped with a 4-inch diameter foot.

(5) Filter paper. Smooth type, 4-inch diameter BKH qualitative, catalog No. 28310, or equivalent.

(6) Height gage.

(7) Follower ram, 4-inch outside diameter x 6 inches.

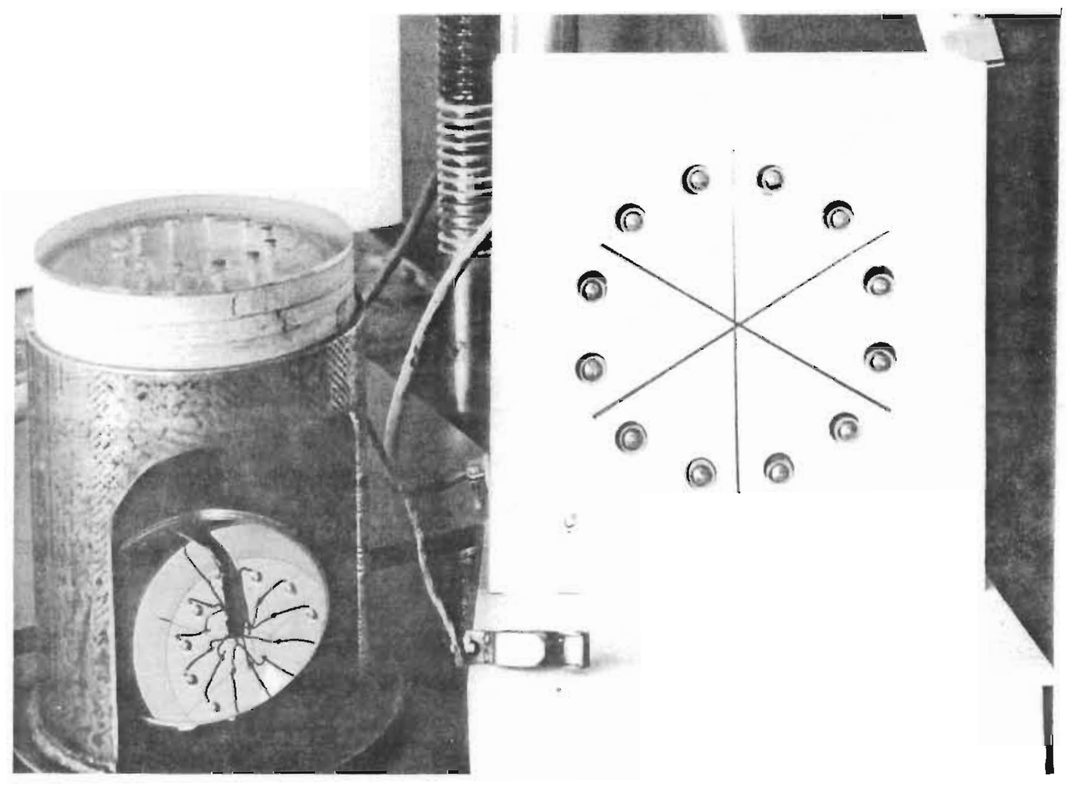


Figure 5. Moisture Exudation Device

SAMPLE

3. The specimens as prepared in Part II.

PROCEDURE

4. (a) Place perforated phosphor-bronze disk directly on tamped surface of specimen in mold and place a single piece of filter paper on the disk.

(b) Invert mold with specimen so that filter paper is on the bottom, and place mold on the moisture exudation device. Place 4" manila disk on top surface. Then push specimen through to other end with press. It is very important that the mold be centered on the exudation device; this is accomplished by viewing in the mirror and adjusting as necessary. In the case of a basket specimen, do not invert the sample prior to placing on the exudation device; simply center a filter paper on the contact plate, wipe moisture from bronze disk. Then place mold containing basket and material on filter paper.

(c) Insert the follower ram in top of the mold on the specimen. Attach battery clamp to mold and place exudation device with mold in the testing machine and center to insure even loading.

(d) Use the testing machine to apply an increasing load at the rate of 2000 lb. per minute until there are lights on in five of the six sections of the exudation pressure control box. Note and record the pressure at this point. However, if free moisture becomes visible around the bottom of the mold, covering an area approximately 2" in length, (which should touch four contact points) and there are lights on in at least three of the six sections, record the pressure at that moment in lieu of waiting for five sections.

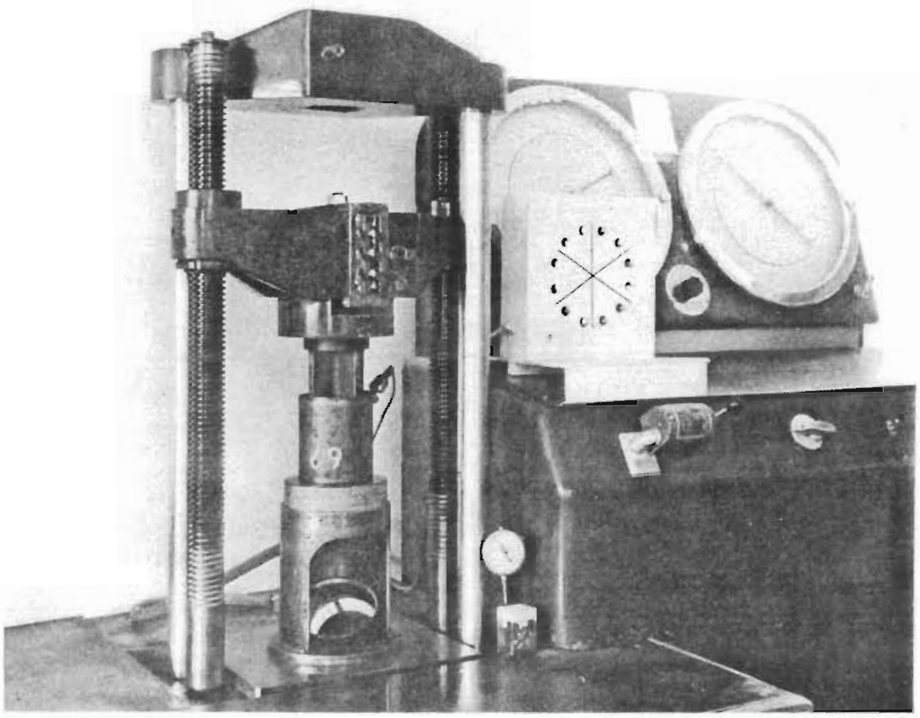


Figure 6. Exudation Device in use. Note lights on in five of the six sections.

(e) Discard the specimen if the exudation pressure does not fall within the required range. A low of 1000 lb. and a high of 9000 lb. will be accepted if necessary.

(f) Leave the mold with follower in place on the exudation device and then place the height gage over mold and follower. Allow dial to come to rest, then read and record. A constant of two inches is understood; that is, if the dial were to read 0.460, the actual height would be 2.460 inches.

(g) Next, remove height gage, follower, manila paper, bronze disk, and filter paper, and weigh the mold with specimen and record. In the cases where a basket is used, the weight of the basket must be taken into consideration and accounted for by adding its weight to the weight of the mold. The basket's average weight is 33 g.

PRECAUTIONS

5. (a) The batteries in the moisture exudation indication device must be replaced every three months to insure efficient operation.

(b) When the exudation contact plate becomes worn or grooved and the contact points become raised or depressed, the plate should be machined to a plane surface or replaced.

(c) The operator must wipe the contact plate dry between tests, since any moisture remaining will prematurely dampen the new filter paper and cause erroneous exudation pressure results.

(d) The height gage must be checked and reset daily to insure correct readings.

(e) Wipe plate of basket prior to contact with filter paper.

NOTES

6. (a) Occasionally material from exceptionally heavy clay test specimens will extrude from under the mold and around the follower ram during the loading operation. Yet, when the 8800-lb. point is reached, less than five sections are lit. When this occurs, the soil is of very poor quality and should be reported as less than five R-Value.

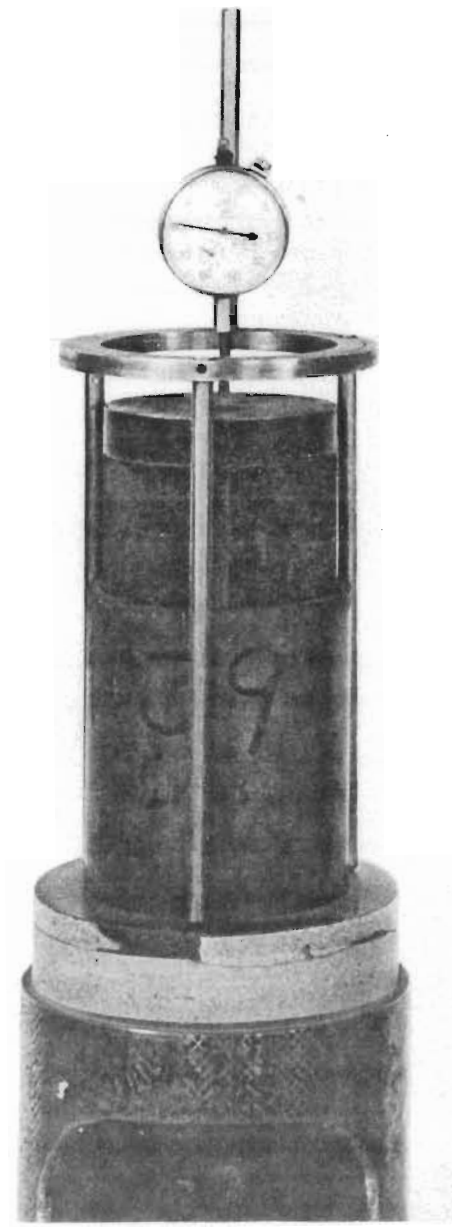


Figure 7. Height Gage

(b) There are many cases where high quality materials of a gravelly-sandy or silty nature, will have exudation pressures that are extremely sensitive to slight changes in moisture content. Very often these pressures will appear erratic and out-of-step with the sequence of moistures. However, these materials generally exhibit uniform R-Values having small variation throughout the entire range of exudation pressures and moisture contents. The R-Value-Exudation curve is drawn as an average value in these cases.

PART IV. DETERMINING THE EXPANSION PRESSURE

SCOPE

1. The expansion test is used to determine the amount of ballast required to prevent a reduction in density of a soil due to expansion when the soil becomes saturated.

APPARATUS

2. (a) Equipment consists of:

(1) Swell frames.

(2) Micrometer dial calibrated to 0.0001-inch mounted on a tripod designed to fit the swell frame.

(3) Proving ring for adjusting swell frames. See Figure 8.

(4) Perforated disks with screw stems.

(5) 5/16-inch open end wrench.

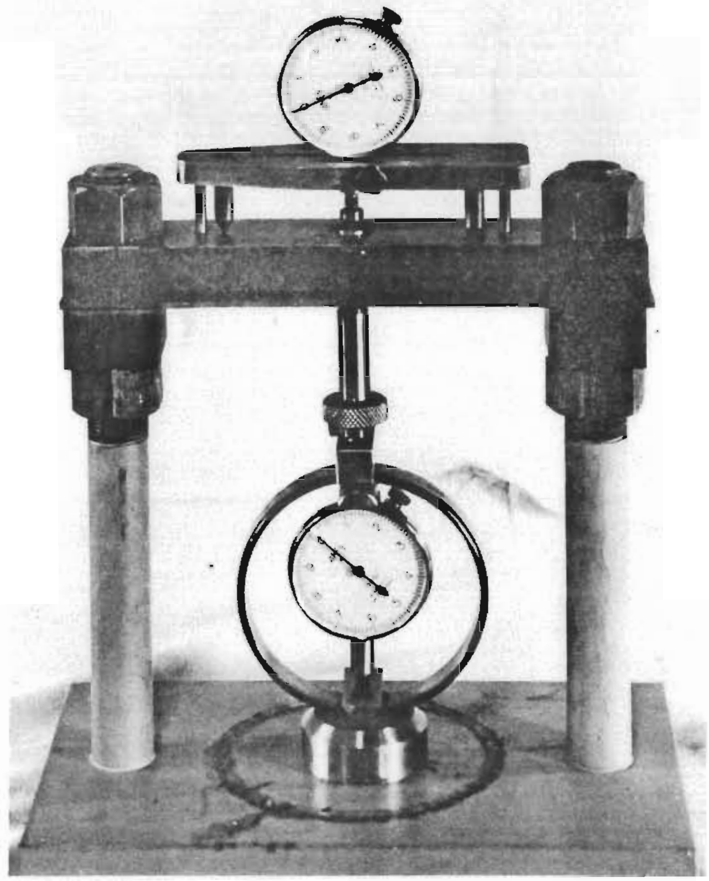


Figure 8. Proving Ring and Swell Frame

SAMPLE

3. The samples are the soil specimens as removed from the exudation device. Each specimen should be allowed to rebound for at least 30 minutes after the exudation test before assembling in the swell frame.

PROCEDURE

4. (a) Place micrometer dial in position on swell frame. Using the 5/16-inch open end wrench, adjust the swell frame for an initial reading of minus 0.0016-inch. (The dial will read 0.0084 inch.) You may notice a variance in the dial as there is a slight amount of play as the dial sits on the swell frame, so for the sake of uniformity the dial is placed as far to the right as possible. The swell frames should be checked periodically with the proving ring and adjusted.

(b) Place one of the perforated plates with screw stems on top of specimen. Place the mold in the swell frame, making sure the base of the frame is dry and free of dirt and sand. After the 30-minute rebound period, adjust the screw stem on the disk until the micrometer dial reads 0.0000 inch with the dial placed as far to the right as possible. This is equivalent to a surcharge of 0.5 psi. It is necessary that the pointed end on the screw stem makes contact with the elastic steel bar exactly in the center. This can be accomplished by visually sighting it in from two different angles. Add water to a depth of approximately 3/4-inch above the perforated disk and allow the mold to remain in the swell frame overnight, or a period of at least 16 hours. Do not re-adjust the screw stem after adding the water to the mold.

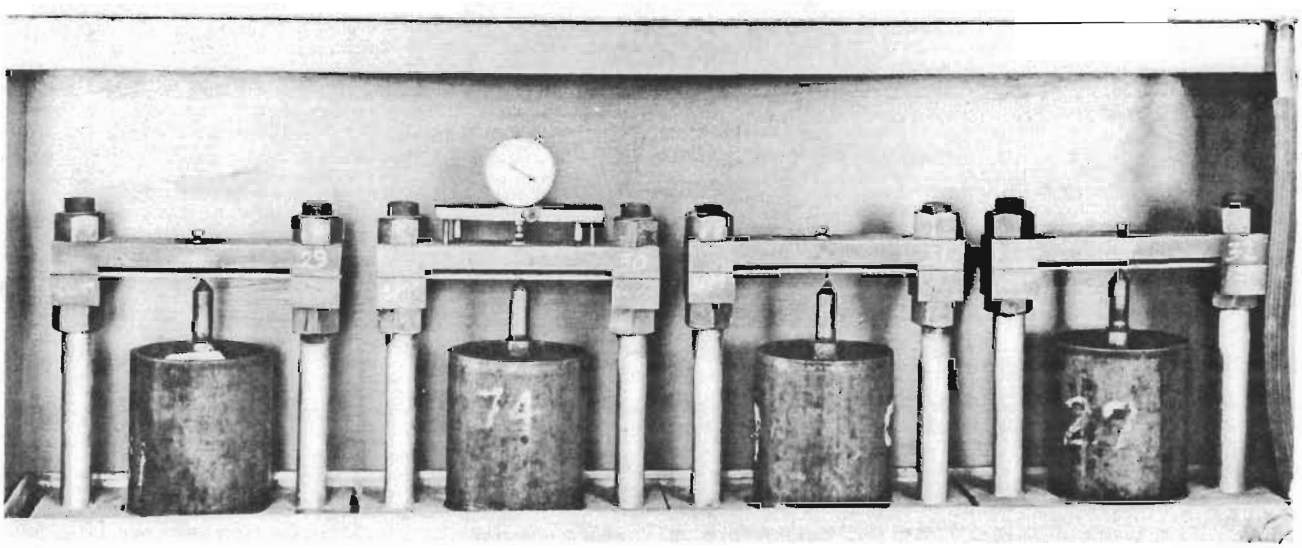


Figure 9. Specimens in Swell Frame

(c) After the 16-hour waiting period, read the deflection by means of the micrometer dial and record on the work sheet. It is again important that the dial be pushed as far to the right as possible. The amount of drainage should also be indicated by the presence or absence of free water at the base of the mold. No drainage at all is indicated by a zero. Slight drainage will be denoted by "Sl." and is recognized by a small amount of free water at the base of the mold. Moderate drainage will be "Mod." and is recognized by free water at the base of the mold and a definite drop of the water level inside the mold. Free drainage or "FD" will be completely void of standing water inside the mold. If the specimen is free draining, a little water must be added and allowed to percolate through in case the sample has dried out considerably.

(d) The next step is to remove the mold from the swell frame, drain off the remaining water and replace the perforated disk with a 4-inch manila paper disk. Save the specimen for the Stabilometer test.

(e) Determine the expansion pressure in psi by multiplying the dial reading by 0.0308, or by using the chart provided, Appendix "D".

PART V. DETERMINING THE R-VALUE

SCOPE

1. This method covers the procedure for determining the resistance (R) of untreated soils or aggregates for use as base or embankment.

APPARATUS

2. (a) Equipment consists of:

(1) Hveem Stabilometer complete with standard metal specimen and follower. See Figure 10.

(2) Testing machine with spherically seated head.

(3) Press. A lever equipped with a 4-inch diameter foot to push soil specimens from mold into stabilometer.

(4) Dial on testing machine to measure head speed.

(5) Stop watch.

(6) Drying oven thermostatically controlled to maintain a temperature of 220 - 230 F.

SAMPLE

3. The specimens as removed from the swell test frames.

PROCEDURE

4. The correct volumetric adjustment of the air cell in the hydraulic chamber of the stabilometer is necessary in order to establish standardized horizontal pressure and displacement readings. The following is an outline of this calibration procedure.

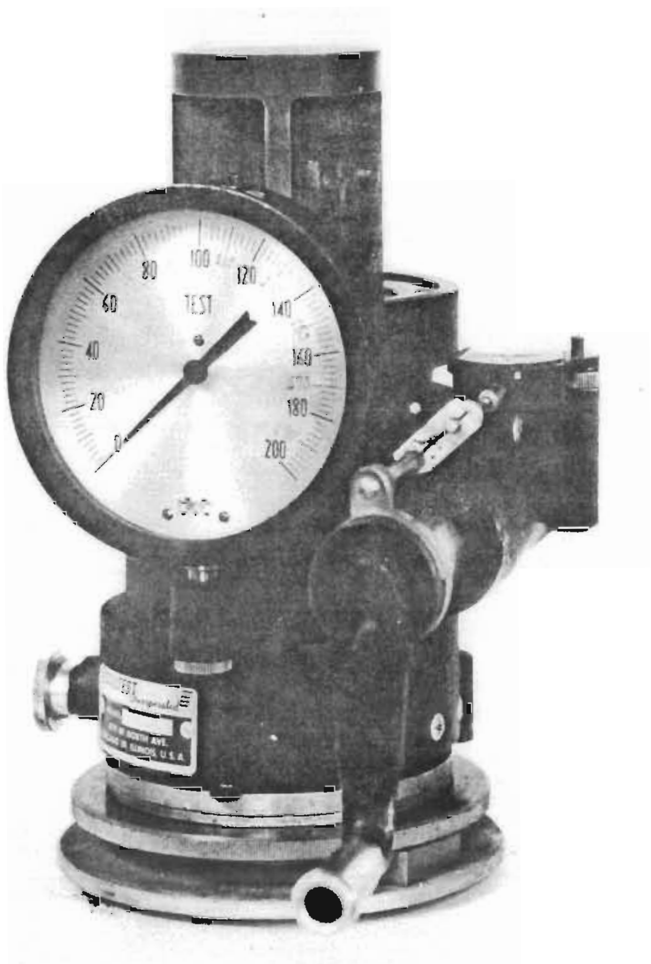


Figure 10. Hveem Stabilometer

(a) Adjust the bronze nut on the stabilometer base so that the top of the stage is three inches below the bottom of the upper tapered ring. Perform all tests at this setting. The object is to have the entire briquette surface in contact with the diaphragm and any surplus diaphragm above the sample, restrained by the follower.

(b) Put standard metal specimen (4-inch diameter steel tube) in place in the stabilometer. Seat it firmly on the stage and by holding it in place with either the hand or a confining load of 100 lb. in the testing machine, turn the pump to a pressure of exactly 5.0 psi. Adjust the turns indicator dial to zero. Turn pump handle at an approximate rate of two turns per second until the stabilometer dial reads 100 psi. The turns indicator dial should read 2.00 ± 0.05 turns. If it does not, the air in the cell must be adjusted. Remove or add air by means of the valve and repeat the displacement measurement after each air change until the proper number of turns is obtained. The initial displacement should be checked after each 3 or 4 specimens have been run through the stabilometer.

(c) Place the mold containing the soil specimen on the stabilometer and push the specimen into the stabilometer using the press. See Figure 11. The displacement pump should be backed off a sufficient number of turns to insure no friction between the specimen and the diaphragm wall. Be certain free diaphragm is exposed above the top edge of specimen. All free diaphragm surface must be in contact with follower. Place the follower on top of the specimen and put the stabilometer in the testing machine with spherically seated head. Lower the testing machine head until it just engages the follower, but does not apply any load to the specimen.

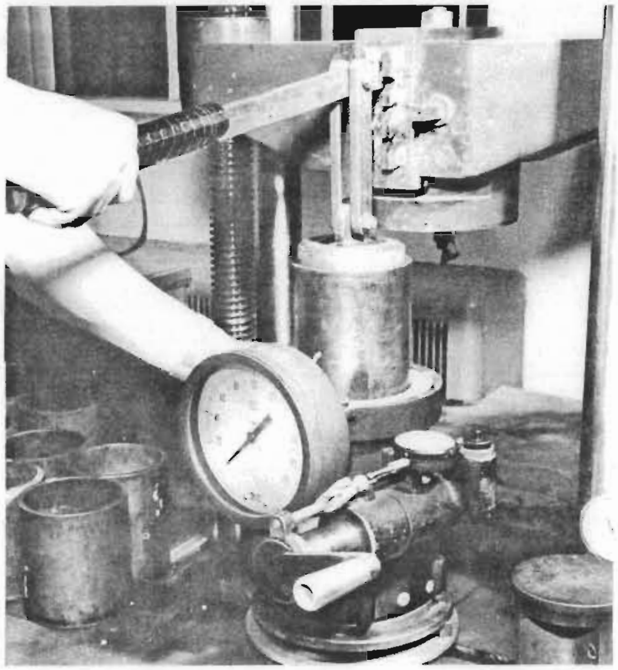


Figure 11.

Pushing the Specimen into the Stabilometer, using the Press.

(d) Turn the displacement pump up to an initial reading of 5.0 psi on the stabilometer gage. Then start the testing machine and adjust for a head speed of 0.05-inch per minute. The head speed must be checked and may need readjusting while the test is being made.

(e) Record the stabilometer gage readings at pressures of 500, 1000, 1500 and 2000 lb. respectively on the testing machine gage. In the case of a very expansive soil, a reading somewhat over 140 psi on the stabilometer gage at 2000-lb. load may be encountered. In any case where 140 psi is reached before the 2000-lb. is applied, do not continue to the 2000-lb. point. Simply record the psi at the 2000-lb. level as 140+.

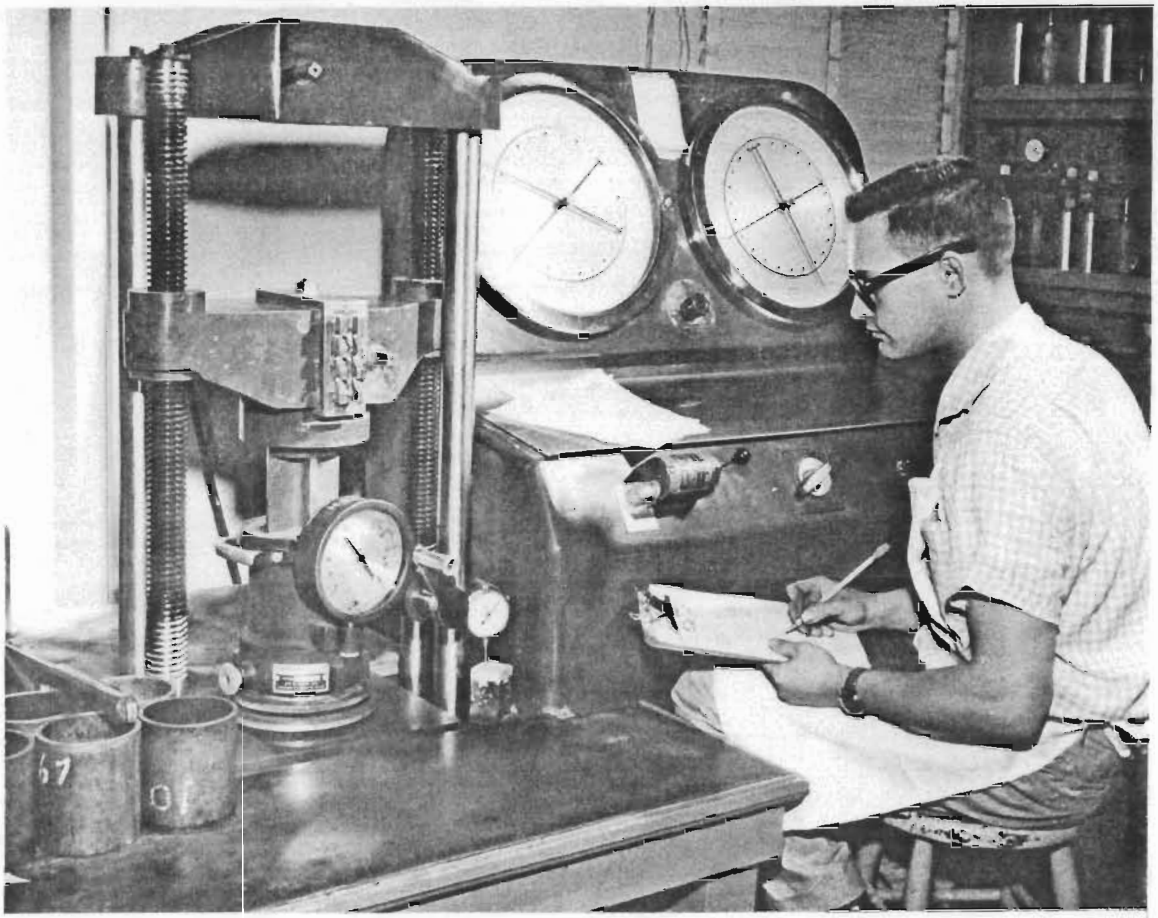


Figure 12. Recording the Stabilometer Gage Readings

(f) Vertical loading by the testing machine must cease at 2000 lb. and the load must immediately be reduced to 1000 lb. Turn the displacement pump so that the stabilometer gage reading is reduced to 5.0 psi. This will result in a further reduction in the applied testing machine load which is normal and should be ignored. Set the displacement dial indicator to zero and turn the displacement pump handle to the right at a speed of 2 turns per second until the stabilometer gage reads 100 psi. During this operation the applied testing machine load will increase and in some cases exceed the initial 1000-lb. load. As before, these changes in testing machine loadings are normal and should be ignored.

(g) Record the number of turns indicated on the dial as the displacement of the specimen. The turn indicator dial reads in 0.001-in. and each 0.1-in. is equal to one turn. Thus a net reading of 0.250-in. indicates that 2.50 turns were made and should be recorded as such.

(h) Remove the stabilometer from the testing machine and release the lateral pressure. Then remove the follower and the specimen from the stabilometer.

(i) The resistance value is computed from the following equation:

$$R = 100 - \frac{100}{\frac{2.5.}{D}\left(\frac{P_v}{P_h} - 1\right) + 1}$$

Where R = Resistance Value

D = Turns Displacement

P_v = 160 psi vertical pressure

P_h = Horizontal Pressure (Stabilometer gage reading for 160 psi vertical pressure)

This value may also be taken from a chart provided. See Appendix "B". A second chart is also provided to correct the "R" Value of any samples which must be used but exceed the limits of 2.45" - 2.55". See Appendix "C". These R-Values are then plotted against the corresponding exudation pressures and connected with a smooth curve. There is a graph provided for this on Form DH-803. Determine the point where the curve crosses the 4000-lb. exudation line and record as the R-Value for the sample. See Appendix "F".

NOTE: See Method No. Calif. 902-A, Mechanics of the Hveem Stabilometer, including its Operation, Calibration and the Installation of the Neoprene Diaphragm.

PART VI. CALCULATING THE DENSITIES OF R-VALUE TEST SPECIMENS

SCOPE

1. Method of calculating the densities of R-Value test specimens.

MATERIAL

2. Idaho Form No. DH-882. See Appendix "E".

SAMPLE

3. The measurements of height and weight of the test specimen neccessary for the density determination are made immediately after the determination of exudation pressure of R-Value test specimens according to Part III of this test method.

PROCEDURE

4. (a) A moisture sample of approximately 500 g. is taken from the original 13-lb. sample as explained in Part I, and the data entered under the block labeled "Moisture Determination before Compaction."

The percent water is computed by the following equation:

$$\%\ \text{Water} = \frac{\text{Wt. of Water}}{\text{Wt. of Dry Soil}} \times 100$$

(b) The cc of water is determined in the following manner:

$$\text{Dry Weight} = \frac{\text{Original Wt.}}{1 + \frac{\%\ \text{water}}{100}}$$

Original Wt. - Dry Wt. = cc water

The cc of water is carried over to the line labeled "wt. of water" and entered for each specimen. This is then added to the figures on the next line labeled "cc of water added" giving the total water for each specimen. In this case, $\%\ \text{water} = \frac{\text{total water}}{\text{Dry Wt.}} \times 100$

(c) The densities are computed from the following equation:

$$\text{Wet Density} = \frac{\text{Net Wt. Soil, wet, } \times 0.303}{\text{Height, Inches}} \qquad \text{Dry Density} = \frac{\text{Wet Density}}{1 + \frac{\%\ \text{water}}{100}}$$

APPENDIX "A"
-1-
State of California
Department of Public Works
Division of Highways
MATERIALS AND RESEARCH DEPARTMENT

METHOD OF FABRICATING PAPER BASKETS FOR STABILOMETER SPECIMENS

SCOPE

1. This method covers the procedure for fabricating paper baskets that are used in Test Methods No. Calif. 301 and 304.

PROCEDURE

2. (a) Apparatus

(1) Basket making device consisting of a 3-7/8-inch diameter cylindrical wooden block and a 1/2-inch masking tape dispenser. See Figure I.

(b) Materials

(1) Strips of notched paper: 60 lb. brown Kraft paper 2-1/2 inches x 13-3/8 inches with slots 1-7/8-inches in length and 3/4-inch apart down the center of the strip. See Figure II.

(2) 4-inch diameter phosphor-bronze perforated exudation pressure disks.

(3) 1/2-inch width masking tape.

(c) Fabrication Procedure

Step 1. Take a piece of slotted paper and fold around the cylindrical wooden block hooking the slotted ends together. See Photos B and C of Figure I.

Step 2. Using 4 strips of 1/2-inch masking tape, tape phosphor-bronze disk to the paper so that the holes in the disk are not obscured in the process. See Photos D and E of Figure I.

NOTE: Do not under any circumstances use an additional amount of tape to secure bottoms.

FABRICATION PROCEDURE

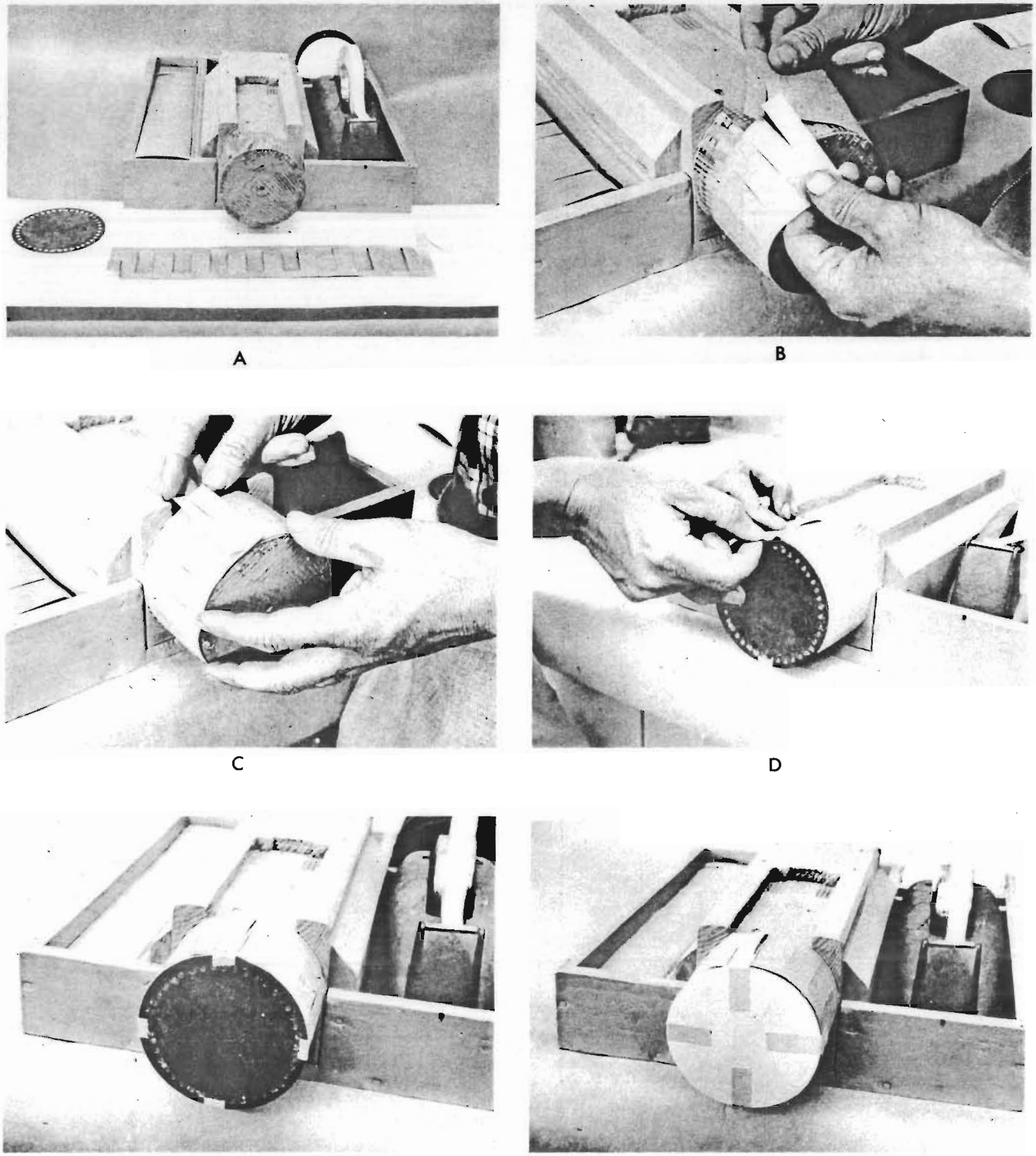
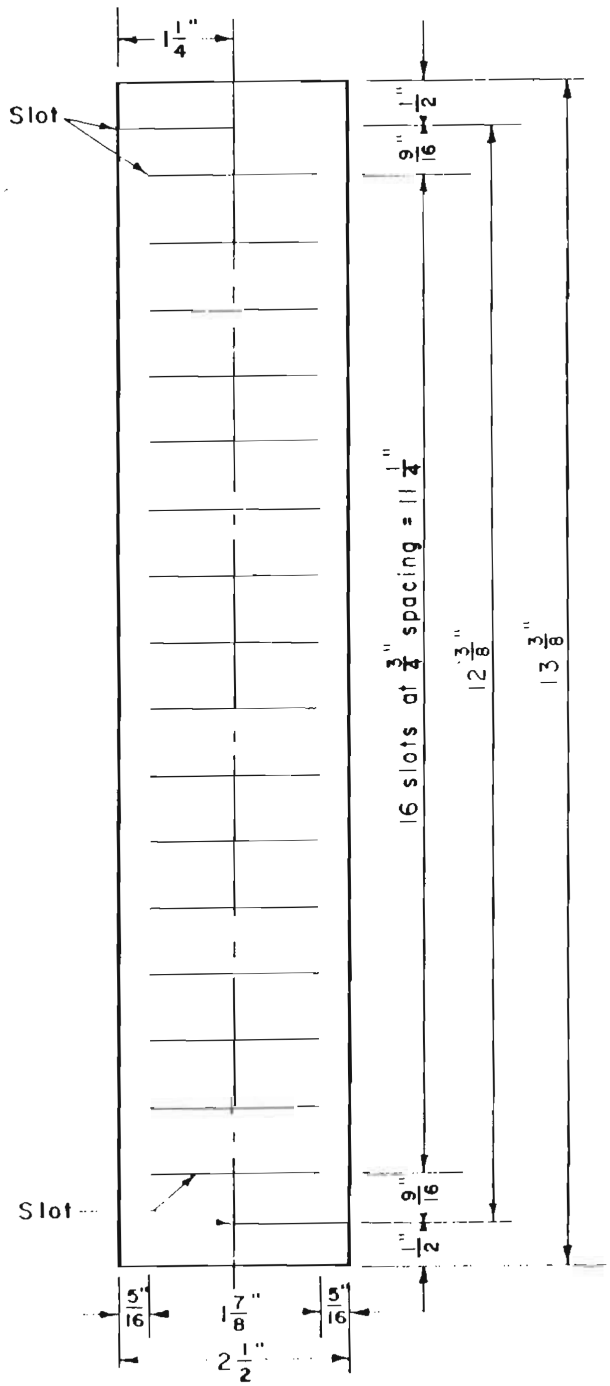


FIGURE 1

SPECIFICATIONS FOR THE SLOTTED PAPER USED IN FABRICATING PAPER BASKETS FOR STABILOMETER SPECIMENS



Note:
Use 60 lb. brown kraft paper.

FIGURE II

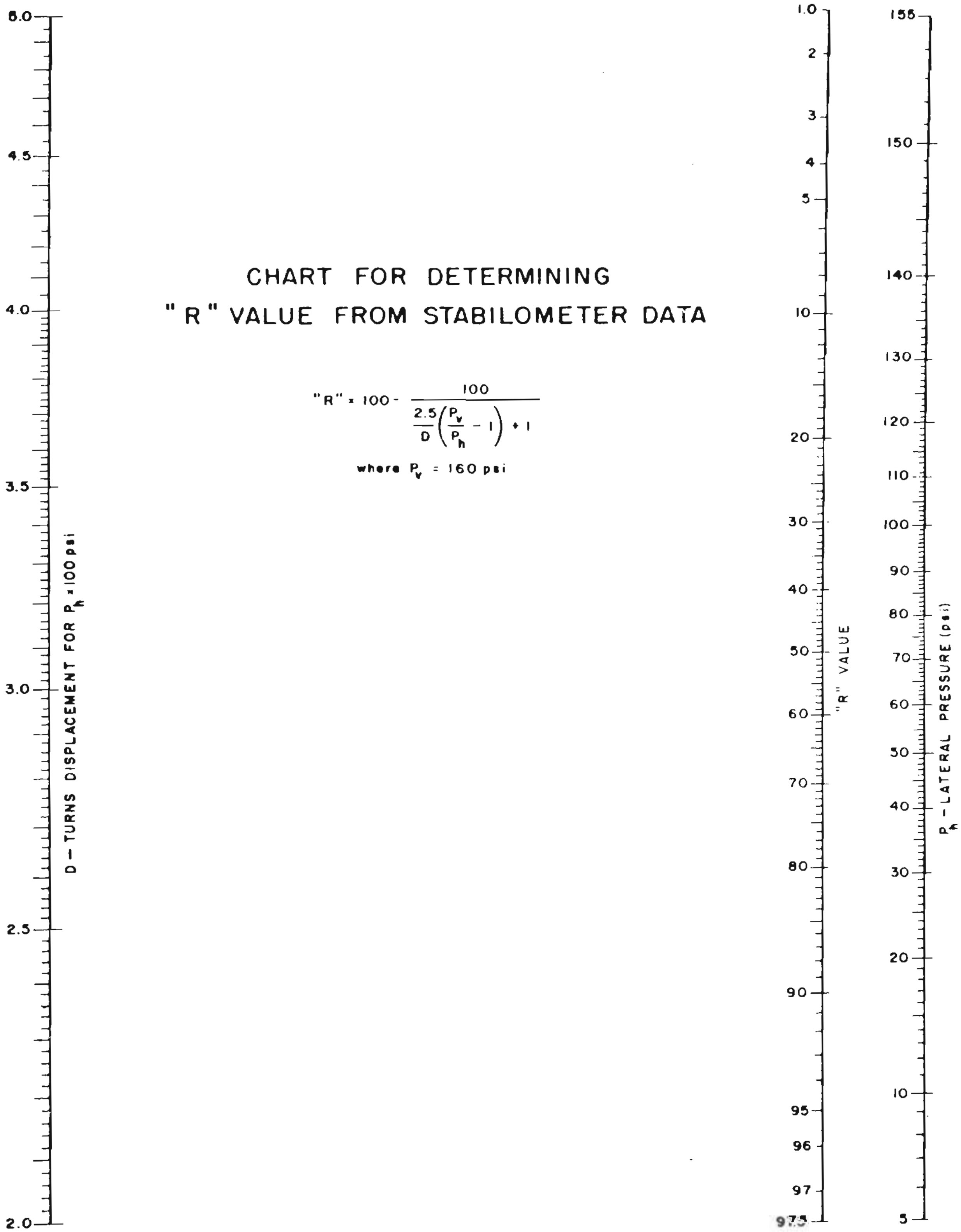


CHART FOR DETERMINING
"R" VALUE FROM STABILOMETER DATA
$$"R" = 100 - \frac{100}{\frac{2.5}{D}\left(\frac{P_v}{P_h} - 1\right) + 1}$$
where P_v = 160 psi
D — TURNS DISPLACEMENT FOR P_h = 100 psi
5.0
4.5
4.0
3.5
3.0
2.5
2.0
"R" VALUE
1.0
2
3
4
5
10
20
30
40
50
60
70
80
90
95
96
97
97.5
P_h – LATERAL PRESSURE (psi)
155
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
5

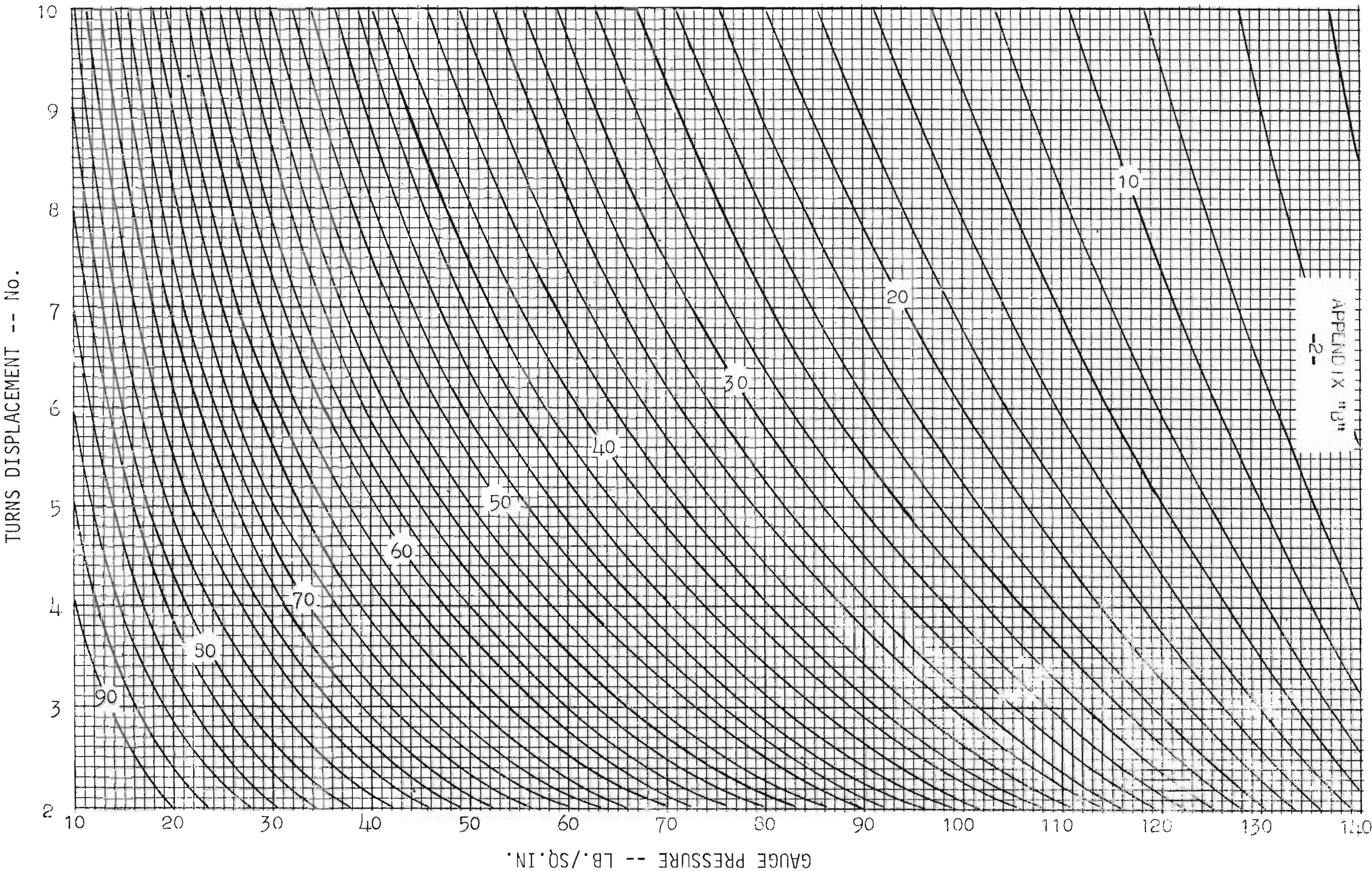
FIGURE VII

CONVERSION CHART FOR HVEEM STABILOMETER

RESISTANCE VALUES

$$R = 100 - \frac{100}{\frac{2.5}{D}\left(\frac{PV}{PH} - 1\right) + 1}$$

D = TURNS DISPLACEMENT
PV = 160 LB./SQ.IN.
PH = GUAGE PRESSURE IN LB./SQ.IN.



APPENDIX "C"

CHART FOR CORRECTING R-VALUES TO SPECIMEN HEIGHT OF 2.50"

HEIGHT CORRECTION SHOULD BE MADE USING THE CHART BELOW.

NOTE: NO CORRECTION FOR SPECIMEN HEIGHTS BETWEEN 2.45" AND 2.55". INTERPOLATE R-VALUE CORRECTIONS FOR OTHER HEIGHTS.

EXAMPLE: OVERALL HEIGHT OF 2.65"
R-VALUE (UNCORRECTED) = 50
R-VALUE (CORRECTED) = 54

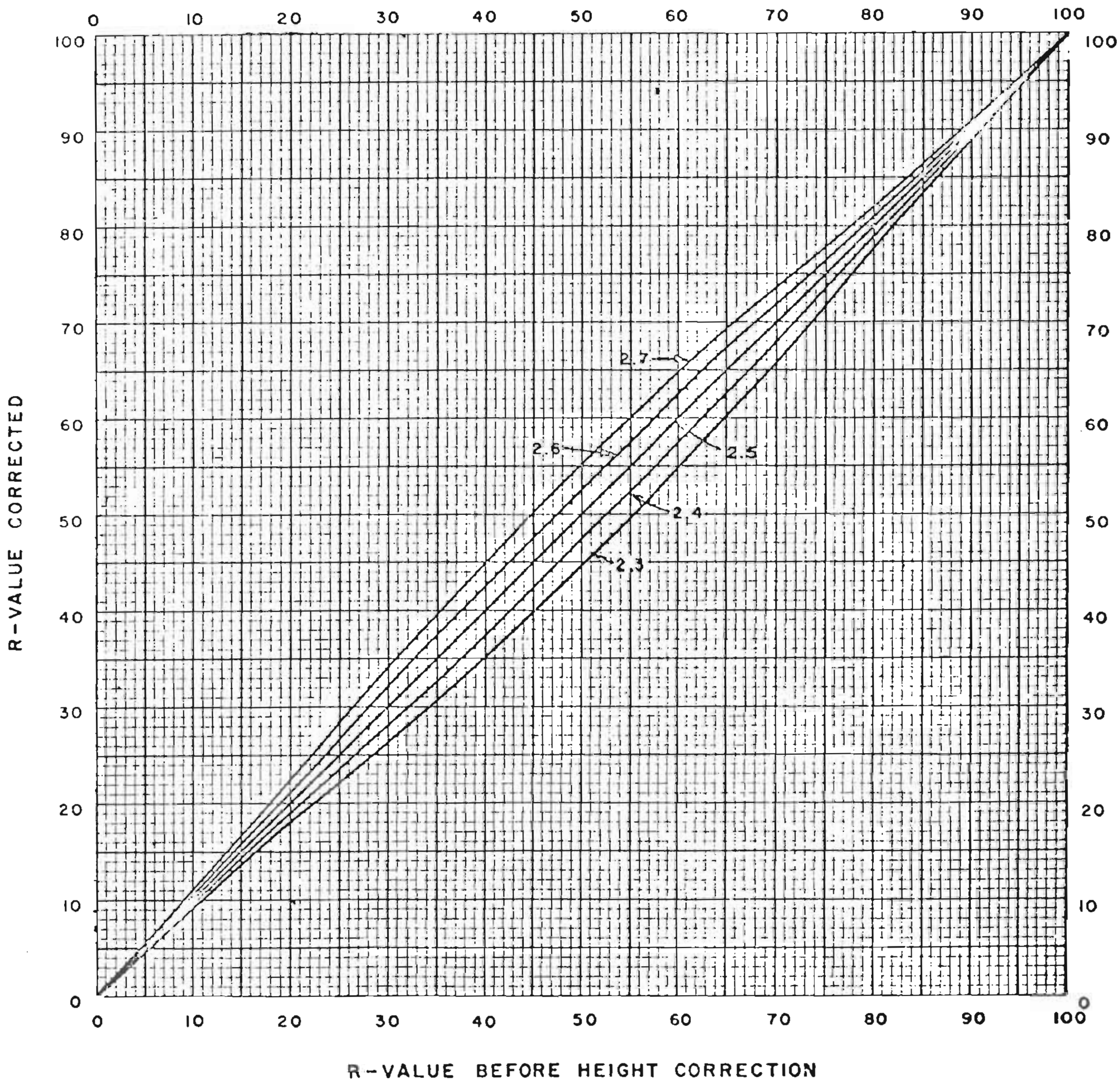


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Figure VIII

APPENDIX "D"

EXPANSION PRESSURE VALUES FOR MICROMETER DIAL READINGS BY TEN-THOUSANDTHS INCH

Dial Reading	PSI	Dial Reading	PSI	Dial Reading	PSI	Dial Reading	PSI
1	0.03	41	1.26	76	2.34	111	3.42
2	0.06	42	1.29	77	2.37	112	3.45
3	0.09	43	1.32	78	2.40	113	3.48
4	0.12	44	1.36	79	2.43	114	3.51
5	0.15	45	1.39	80	2.46	115	3.54
6	0.18	46	1.42	81	2.49	116	3.57
7	0.22	47	1.45	82	2.52	117	3.60
8	0.25	48	1.48	83	2.55	118	3.63
9	0.28	49	1.51	84	2.59	119	3.66
10	0.31	50	1.54	85	2.62	120	3.69
11	0.34	51	1.57	86	2.65	121	3.72
12	0.37	52	1.60	87	2.68	122	3.76
13	0.40	53	1.63	88	2.71	123	3.79
14	0.43	54	1.66	89	2.74	124	3.82
15	0.46	55	1.69	90	2.77	125	3.85
16	0.49	56	1.72	91	2.80	126	3.88
17	0.52	57	1.75	92	2.83	127	3.91
18	0.55	58	1.79	93	2.86	128	3.94
19	0.59	59	1.82	94	2.89	129	3.97
20	0.62	60	1.85	95	2.93	130	4.00
21	0.65	61	1.88	96	2.96	131	4.03
22	0.68	62	1.91	97	2.99	132	4.06
23	0.71	63	1.94	98	3.02	133	4.09
24	0.74	64	1.97	99	3.05	134	4.13
25	0.77	65	2.00	100	3.08	135	4.16
26	0.80	66	2.03	101	3.11	136	4.19
27	0.83	67	2.06	102	3.14	137	4.22
28	0.86	68	2.09	103	3.17	138	4.25
29	0.89	69	2.12	104	3.20	139	4.28
30	0.92	70	2.15	105	3.23	140	4.31
31	0.95	71	2.18	106	3.26	141	4.34
32	0.99	72	2.22	107	3.29	142	4.37
33	1.02	73	2.25	108	3.32	143	4.40
34	1.05	74	2.28	109	3.35	144	4.43
35	1.08	75	2.31	110	3.38	145	4.46
36	1.11					146	4.49
37	1.14					147	4.52
38	1.17					148	4.56
39	1.20					149	4.59
40	1.23					150	4.62

Idaho T-8

DH-803 4-67

IDAHO DEPARTMENT OF HIGHWAYS
Central Laboratory
Boise, Idaho

Distribution:
Hwy. Engr.
Dist.Engr.
Res. Engr.

Lab. No. 260000

Report of Tests on SOIL Embankment & Subgrade

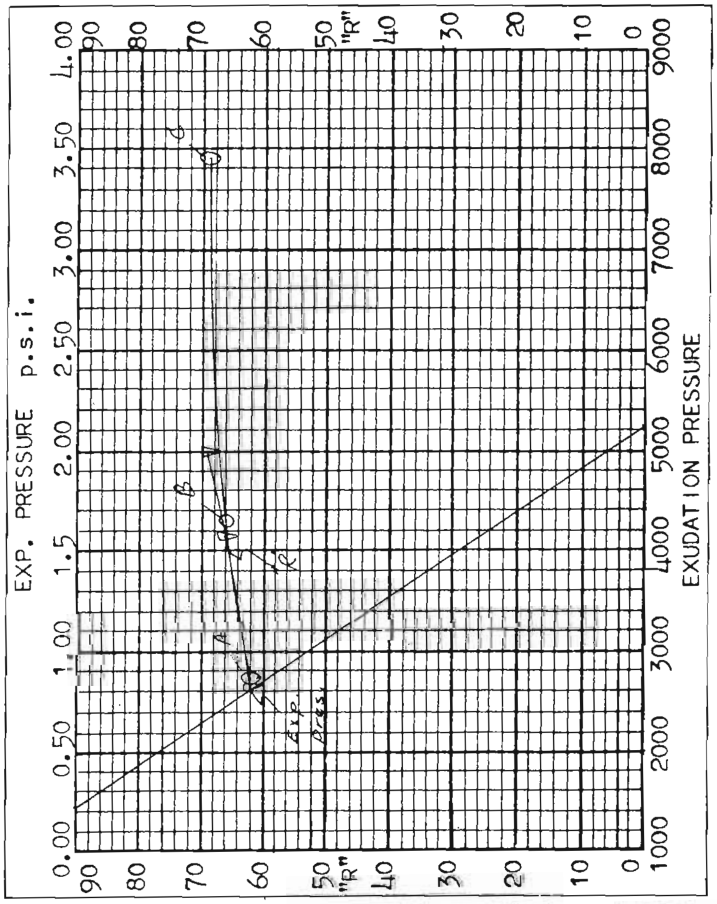
Project S-0000 County Western Source No. ____
Submitted by Sam Brown Ident. No. SB/24027-2213/3-P
Station ____ Layer No. ____ Depth 1.8' - 2.8'
Description of Soil Sandy Slit Date Sampled 2-19-72 Received 3-15-72

Mechanical Anal. % Pass		Soil Constants	
3" Sq.		Liquid Limit	
2" Sq.	100	Plastic Limit	
1" Sq.	99	Plasticity Index	
3/4" Sq.	98	Field Moist.Equiv.	
1/2" Sq.	97	Linear Shrinkage	
No. 4	95	Specific Gravity(+3/4")	
No. 10	95	Specific Gravity(-No.4)	2.58
No. 20	95	Sand Equivalent	
No. 30	94	"R" Value	65
No. 40	94	Exp. Pressure, psi	0.81
No. 50	94	Unified Class'n	
No. 100	87	AASHO Class'n	
No. 200	68	Traffic Index	7.5

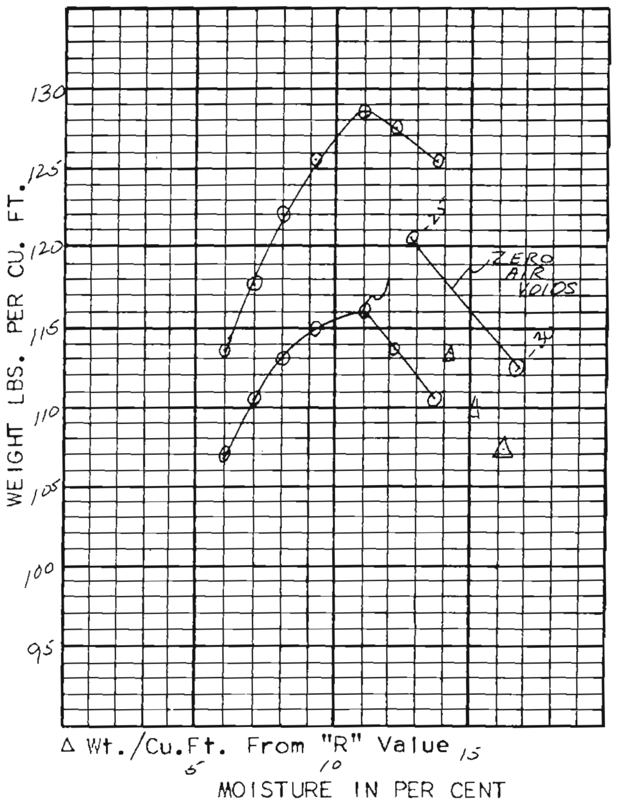
CMP Data

pH- ____ Resistivity ____ ohm. Cm.
Est. Time To Perforation (16 ga.) ____
Add 12 years for Bituminous Coating

Remarks



MOISTURE-DENSITY CURVE
AASHO DESIGNATION T-99 METHOD A
Max.Dry Wt. 116.0 #/Cu.Ft. Opt.Moist. 11.0 %
Corrected Max. Dry Wt.= ____ lb/Cu.Ft.
(Correction at ____ % passing the 3/4")



This report covers only material as represented by this sample and does not necessarily cover all soil from this layer or source.

Date Mailed ____

P. E.
Materials Engineer