

State of Nevada
Department of Transportation
Materials Division

**METHOD OF TEST FOR DETERMINATION OF THE RESISTANCE R-VALUE OF TREATED
AND UNTREATED BASES, SUBBASES AND BASEMENT SOILS BY THE STABILOMETER**

SCOPE

This method covers the procedure for determining the resistance (R-value) of both treated and untreated soils or aggregates for use as base, subbase or basement soil, and also covers the calculation of design thickness of pavement sections.

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 Pressures 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.
- VII. Method of Calculating the Design Thickness of Pavement Sections Based on Stabilometer and Expansion Pressure Measurements.

PART I. METHOD OF PREPARATION OF MATERIALS

SCOPE

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 Nev. T203.

A. APPARATUS

1. Riffle splitter, with chutes 1½ in. (38.1 mm) wide.
2. Scales, 5000 g capacity, accurate 1 g.
3. Scales, 500 g capacity, accurate to 0.1 g.
4. Water spray metering device with turntable.
5. Mixing pans, trowel and ½ gal (.47316 liter) cans with close-fitting lids.

B. TEST RECORD FORM

Keep all pertinent data regarding the test specimens on individual test tickets. Assign a ticket at the time of preparation of the material for the specimen, and keep it with the specimen until the Stabilometer R-value test is made.

C. PREPARATION OF SAMPLE

1. Refer to Test Method Nev. T203 for preparation of sample.
2. 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 (4.75 mm) sieve.¹ This is important because relatively small test specimens are used. Therefore, it is necessary that the test specimen be prepared very accurately.

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

1. Definitions of "as-received" and "as-used" gradings.
 - a. The grading as determined on a sample prior to any adjustment such as scalping, wasting or crushing is known as the "as-received" grading.
 - b. 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 percent of the material as received passes the ¾ in. (19.05 mm) sieve and no adjustments are necessary, the "as-received" and the "as-used" gradings will be the same.
2. Criteria for scalping (removing the oversize material) samples containing oversize material.
 - a. If 75 percent or more of the sample as received passes the ¾ in. (19.05 mm) sieve, scalp the sample on the ¾ in. (19.05 mm) sieve.
 - b. If less than 75 percent of the as received passes the 19 mm sieve, scalp the sample on the 1 in. (25.4 mm) sieve.
3. Calculations necessary for determining the as-used grading are found in Method NHD 930.

¹An exception to this is preparation of materials consisting of aggregate and oil lumps (old base and surfacing); preparation of these consists only of separation on the 1 in. (25.4 mm) sieve and careful splitting of test samples from the passing 1 in. (25.4 mm) fraction.

E. THE BATCHING OF UNTREATED MATERIALS IN PREPARATION FOR FABRICATING R-VALUE TEST SPECIMENS.

1. The term "batching" as used hereinafter in this procedure refers to the act of combining, according to previously calculated proportions, sufficient material in individual samples to fabricate R-value test specimens.
2. Separate the passing No. 4 (4.75 mm) material, using a sample splitter, into approximate quantities needed for each of four specimens.
3. Recombine the coarse fractions (retained No. 4 (4.75 mm)) according to the batch weights calculated from the as-used grading.
4. Weigh out exact amounts of the above passing No. 4 (4.75 mm) portions according to the as-used grading and combine with the coarse portions to make four 1200 g samples.

The use of the increment weight method, is considered the preferable method of combining the various size components of materials for the R-value test. However, they may be combined with equal accuracy by the method described in Test Method Nev. T303.

The following are examples of computations for batching by the increment weight method:

a. Example with single sample:

Given an aggregate with the following grading:

Sieve	As-used percent passing
¾" (19.05 mm)-----	100
⅜" (9.53 mm)-----	89
No. 4 (4.75 mm)-----	78

Calculate the percentage of ¾ in. (19.05 mm) to ⅜ in. (9.53 mm), ⅜ in. (9.53 mm) to No. 4 (4.75 mm) and passing No. 4 (4.75 mm) material and multiply each percentage by the total weight of test specimen desired.

Sieves	Percent of each size	Weight for 1,200-g sample
¾" (19.05 mm) to ⅜" (9.53 mm)	100 - 89 = 11	.11 x 1,200 = 132
⅜" (9.53 mm) to No. 4 (4.75 mm)	89 - 78 = 11	.11 x 1,200 = 132
Passing No. 4 (4.75 mm)	<u>78</u>	.78 x 1,200 = <u>936</u>
Total	100	Total 1,200g

b. Example with two samples to be combined. Given two samples having the gradings and combination as shown:

Sieve	AS-RECEIVED PERCENT PASSING SAMPLE		PROPORTIONED GRADING		Combined Percent Passing	AS USED (Scalp) ¾"(19.05 mm) Percent Passing
	No. 1	No. 2	80 per-cent No. 1	20 per-cent No. 2		
1"(25.4 mm)	100	100	80	20	100	
¾"(19.05 mm)	90	100	72	20	92	100
⅜"(9.53 mm)	80	95	64	19	83	90
No. 4(4.75 mm)	70	90	56	18	74	80

Calculate the percentage of ¾"(19.05 mm) to ⅜"(9.53 mm), ⅜"(9.53 mm) to No. 4 (4.75 mm) and passing No. 4 (4.75 mm) material and multiply each percentage by the weight of test specimen desired.

Sieve size	Sample No. 1	Sample No. 2	Check
¾"(19.05 mm)----	$\frac{100}{92} \times 72 = 78$	$\frac{100}{92} \times 20 = 22$	78 + 22 = 100
⅜"(9.53 mm)-----	$\frac{100}{92} \times 64 = 70$	$\frac{100}{92} \times 19 = 21$	70 + 21 = 91
No. 4(4.75 mm)---	$\frac{100}{92} \times 56 = 61$	$\frac{100}{92} \times 18 = 20$	61 + 20 = 81

Check the sum of the components against the as-used column. They may disagree by 1 percent because fractions have been rounded off.

Sieves	Sample No. 1	Sample No. 2
$\frac{3}{4}$ "(19.05 mm) to $\frac{3}{8}$ "(9.53 mm)	(78-70) $\frac{1200}{100} = 96$ g	(22-21) $\frac{1200}{100} = 12$ g
$\frac{3}{8}$ "(9.53 mm) to No. 4(4.75 mm)	(70-61) $\frac{1200}{100} = 108$ g	(21-20) $\frac{1200}{100} = 12$ g
Passing No. 4(4.75 mm)	(61-0) $\frac{1200}{100} = \underline{732}$ f	(20-0) $\frac{1200}{100} = \underline{240}$ g
	100 936 +	100 264 = 1,200 g

5. As each sample is proportioned, immediately place it into a covered container with an identification ticket.
6. Add to each of the four batched samples approximately one-half to two-thirds the amount of the moisture necessary to saturate the sample as described later under Section I.
 - a. Perform this operation by mixing the material with a hand trowel in a circular pan and at the same time rotating the pan horizontally beneath a fine water spray. Continue mixing for 1 minute after the water has been added.
 - b. Record amount of water added, place each sample of loose material in a covered container, and allow to stand overnight.

F. THE BATCHING AND CURING OF SAMPLES TREATED WITH PORTLAND CEMENT OR HYDRATED LIME.

1. Separate all passing No. 4 (4.75 mm) material into approximate quantities needed for each specimen.
2. Recombine four 1,200 g samples according to the as-used grading.
3. Add the desired percentage of cement or lime to each sample. The amount of cement or lime added is expressed as a percentage of the dry weight of soil.
4. Immediately after each sample is batched, place sample and its identification ticket into a ½ gal. (1.88 L) can and secure the lid. Use of a different colored ticket than used for untreated samples is desirable.

5. Add one-half to two-thirds the amount of moisture necessary to saturate the sample as described in Paragraph 6 of Section E.
6. Allow the loose material to cure overnight in a covered ½ gal. (1.88 L) can before proceeding as described in Section I, Mixing.
7. Mixing, compacting and exudation pressure tests are performed in the same manner as for untreated materials as outlined in Part I, Part II, and Part III, respectively. Upon completion of the exudation pressure determination, Part III, cure the compacted specimens in a moist cabinet for 6 days. At the end of this period make the expansion pressure and R-value determinations as specified in Parts IV and V, respectively.
8. Field control samples which contain portland cement or lime at the time of sampling shall be shipped to the laboratory in two 6 x 12 in. (152.40 mm x 304.80 mm) concrete cylinder cans (per sample) filled to capacity. The lids should be sealed on the cans with tape and the samples shipped immediately to the laboratory. These samples are not normally subjected to sieve analysis, therefore, remove rock over ¾ in. (19.05 mm) in size and separate the passing ¾ in. (19.05 mm) portion in a riffle splitter directly to the 1200 g batch weights. Perform the balance of the preparation and testing in the same manner as for untreated materials with the exception that it will not normally be necessary to add water, as described in Paragraph 6 of Section E above, since the material will usually contain sufficient field moisture. Do not cure the compacted specimens in the moist cabinet for the 6-day period.

G. THE BATCHING OF BASE, SUBBASE AND BASEMENT SOILS CONTAINING PORTIONS OF BITUMINOUS MIX.

1. Break lumps of bituminous mix down to pass the 1 in. (25.4 mm) sieve and remove all rocks over 1 in. (25.4 mm). A sieve analysis is not normally performed on samples such as these.
2. Quarter sample carefully through a riffle splitter and then follow the procedure as outlined in Section E above.

H. INITIAL MOISTURE SAMPLE

For all materials to be tested, weigh out an extra sample of exactly 10% by weight, and having the exact same grading as the test samples, for the determination of initial moisture. Determine the moisture content by weighing accurately before and after drying to constant weight at 230°F (110°C).

I. MIXING

1. The R-value test requires the preparation of 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, when possible, conform to the following limitations:

Height = 2.5 (63.5 mm) 0.1 (2.54 mm)

Exudation pressure: One sample should be above and two below 300 psi (2068.43 kPa) or two above and one below 300 psi (2068.43 kPa).

2. All samples should exude moisture between 100 psi (689.48 kPa) and 800 psi (5515.81 kPa), except when very high expansion pressures are expected. In the latter case, wetter specimens are sometimes necessary to get expansion pressures low enough to provide an intersection with the R-value curve.
3. On the day following the overnight curing period,² add additional moisture in the same manner as described above in Paragraph 6, under Section E, until the estimated saturation moisture is attained. Mix well while adding water and continue mixing for 1 min. thereafter.
4. Weigh out enough material to fabricate a compacted specimen 4 in. (101.6 mm) in diameter and 2½ in. (63.5 mm) high.
5. Immediately cover pan to prevent loss of moisture before beginning Part II of this test method.

J. PRECAUTIONS

1. Exercise care in splitting and batching the passing No. 4 (4.75 mm) mesh fractions to insure a minimum loss of dust from the sample. Tests have shown that differences in the amount of fines can have a profound effect on the R-value test.
2. Complete and thorough mixing of the sample during the process of adding water is essential for uniformity of test results. The period of mixing given in Paragraph 6, Section E, of this procedure must be observed as the minimum requirement. However, to avoid excess moisture loss due to evaporation do not continue mixing longer than 2 min. after the adding of water has ceased.

²Curing in a loose condition over the weekend or over holidays is permissible for untreated materials; however, exercise care to prevent loss of moisture from the containers.

3. At all times except during immediate processing, keep the samples in covered containers to prevent evaporation loss of moisture.

NOTES

The determination of the proper soil weight-moisture relationships of test specimens, which is needed to meet the requirements of the R-value test, requires judgment and experience on the part of the operator. An estimation of the weight of material and moisture must be made for the pilot or trial briquette, and its exudation pressure and height must conform to the above Section I. Then, from the attached chart (Figure 1) use the pilot specimen data and determine the approximate weight of material for a 2½ in. (63.5 mm) high Stabilometer specimen. From the exudation pressure of the pilot specimen, determine whether to use more or less moisture in the remaining samples to obtain the desired results. The decision as to the amount of water to use still rests with the operator. If the pilot specimen conforms to the requirements for a Stabilometer specimen it may be used as such; otherwise, it should be discarded.

Normally three specimens are enough to determine the R-value. However, in the case of critical materials it is sometimes necessary to make additional tests in order that the true shape of the exudation pressure curve will be known at the 300 psi (2068.43 kPa) exudation point. The exact number of tests needed is a matter of judgment.

PART II. METHOD OF COMPACTION

A. APPARATUS

1. Mechanical kneading compactor (see Test Method Nev. T116).
2. Compactor accessories: 4 in. (101.6 mm) x 5 in. (127 mm) high steel molds, mold holder, spatula, rubber disks, 3 ¹⁵/₁₆ (100.01 mm) diam. x ½ in (12.70 mm) thick metal disk trowel, filter paper disks.
3. Basket fabrication equipment (see Test Method Nev. T106). Basket-making device consisting of a 3 7/8 in. (98.43 mm) diam. cylindrical wooden block, ½ in (12.70 mm) masking tape, strips of notched paper, ¹ and phosphor bronze perforated disks that are used in the standard method of determining exudation pressure (see Part III of this test method).

B. MATERIALS

Paper strips for making baskets.

C. TEST RECORD FORM

Record all pertinent data regarding the test specimens on individual test tickets.

D. CONTROL

Control of the compaction pressure shall be made in accordance with the instructions for operation of the mechanical compactor (see Test Method Nev. T116).

E. MIXING AND FABRICATION

1. Place mold in mold holder that has a rubber disk 4 in. (101.6 mm) in diameter and 1/8 in. (3.18 mm) in thickness placed on the plate. Adjust mold for 1/8 in. (3.18 mm) clearance between lower edge of mold and base of mold holder. Clamp in place. Place 4 in. (101.6 mm) diameter filter paper disk into mold on top of rubber disk. Position the assembled mold holder on compactor turntable, and lock it on studs.

¹Brown Kraft wrapping paper, 60 lb (27 kg) substance.

2. Place well mixed sample next to the compactor with the loose material distributed evenly in the mixing bowl.
3. Start compactor and adjust the foot pressure to 100 psi (689.48 kPa). Operate compactor in accordance with instructions for operation of the mechanical compactor (see Test Method Nev. T116).
4. Using trowel, place enough of the material into the mold to cover the bottom. Place the remainder of the sample into the mold in 20 equal parts using one part for each blow of the compactor. Allow 10 additional blows to level and seat the material. Raise and clean compactor foot. Place rubber disk, 4 in. (101.6 mm) diam., 1/8 in. (3.18 mm) thick, on top of specimen. (During the feeding operation, if the soil pushes up around the foot markedly, lower the air pressure below 100 psi (689.48 kPa) to a pressure which will reduce the pushing up).
5. Lower compactor foot and immediately increase foot pressure to obtain a compactor foot pressure of 200 psi (1378.95 kPa).
6. Apply 100 tamps to the specimen (using 200 psi (1378.95 kPa) foot pressure).
7. 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 in. (6.35 mm) into the surface of the specimen after all the material is in the mold. Record pressures below 200 psi (1378.95 kPa).
8. If free water should appear around the bottom of the mold during compaction, stop the compactor immediately and note the number of tamps.
9. If the surface is left uneven by the action of the tamping foot, smooth and level the tamped surface with a 1 1/2 in (38.1 mm) diam. flat ended compaction rod using a gentle tamping.
10. Some granular materials are very difficult to handle without damage and may require a paper basket to keep the specimen intact. Baskets prevent the specimen from falling out of the mold and prevent crumbling when the specimen is transferred from the mold to the Stabilometer.
11. Baskets are designed to restrain the specimen as little as possible during the Stabilometer test. For that reason, great care must be exercised in fabricating them. See Test Method Nev. T106 for details of construction.
12. When compacting a specimen in a basket place all of the soil in the mold before lowering the foot. Use 100 tamps, (200 psi (1378.95 kPa) pressure) and then remove mold from the compactor. The mold should be kept upright so that the specimen will not fall out.

F. PRECAUTIONS

1. In placing the material into the mold from the mixing bowl, it is quite important that the operator execute this function in a uniform manner. Tests have shown that differences in compactive effort can cause variations in the results obtained from the exudation device (see Part III) when certain types of materials are tested.
2. Even distribution of the coarse aggregates throughout the area of the mixing bowl 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, in the bowl before starting the feeding operations.

NOTES

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 Part V) the fact may not be apparent at the time, but it will result both in excessive Stabilometer pressure readings and in excessive displacement readings. Both of these errors tend to lower the R-value, and a group of three tests will be erratic with respect to one another. When this happens the test must be repeated using baskets.

HAZARDS

Caution must be exercised in the operation of the compactor so as not to allow any object other than the sample itself to intercede between the compactor foot and the mold at any time while the ram is in motion. The clearance between the inside edge of the mold and compactor foot is approximately $\frac{1}{16}$ in. (1.59 mm). The applied shearing force of 1100 lb (498.95 kg) could cause severe injury to an operator's hand if caught between the compactor foot and the mold.

**PART III. METHOD FOR THE DETERMINATION
OF EXUDATION PRESSURE OF R-VALUE
TEST SPECIMENS**

A. Apparatus

1. Exudation Device, 6 light Indicator device as per AASHTO requirements.
2. 10,000 lb capacity compression testing machine.
3. Perforated Phosphor Bronze exudation disk of $3\frac{31}{32}$ - inch diameter, 28 gauge with 42 holes of $\frac{5}{32}$ -inch diameter that are equally spaced around the center of the disk at a radius of $1\frac{3}{4}$ inch.
4. Metal Follower, solid walled 3.95 +/- .005 inch diameter by 5 inch long.

B. Test Record Form

Use individual test ticket for recording data.

C. Materials

Filter Paper of 10-cm diameter, 0.15-mm thick, smooth surface, medium filter speed, and medium retention.

D. Control

The testing machine shall be operated in such a manner that the load rate will be 2,000 lb (8896 N) per minute.

E. Testing and Calculations

1. Remove the mold containing the compacted specimen from the compactor. Place a phosphor-bronze disk on the tamped surface of the soil and place a filter paper on top of the disk.

2. Invert the mold and place it on exudation device so that the disk and filter paper are on the bottom. If the specimen requires using a fabricated paper basket, do not invert the specimen in the mold, dry the phosphor-bronze disk that is the bottom of the basket and use this disk for exudation. Place the metal follower on top of the specimen.
3. Place the exudation device, molded specimen, and metal follower in the compression machine taking care that the axis of loading is lined up with the axis of the specimen and follower.
4. Apply a uniformly increasing load at a rate of 2000 lb (8896 N) per minute.
5. Immediately stop loading and record the exudation load when exudation is achieved. Exudation occurs when either 5 of the 6 outer lights on the exudation device are lighted or 3 outer lights are lighted and free water is visible around the bottom of the mold.
6. Calculate exudation pressure by taking the exudation load and dividing by the cross sectional area of the specimen.
7. Discard the specimen if the exudation pressure is found to be less than 100 psi (689kPa) or greater than 800 psi (5516 kPa), with the exception that very expansive material may require an exudation pressure of less than 100 psi (689kPa).
8. Mold a total of three specimens that are within the above-specified range of exudation pressures. One specimen must have an exudation pressure less than 300 psi (2068 kPa), and one specimen must have an exudation pressure greater than 300 psi (2068 kPa).
9. Leave the specimen in a covered mold for at least ½ hour after determination of exudation pressure before beginning part IV of this test method.

F. Precautions

1. Battery operated exudation devices may not operate properly when the batteries begin to run low on power. To properly test the battery voltage, the battery must be tested under load.
2. The operator must wipe the plate and disk dry between tests since any remaining moisture may prematurely dampen the new filter paper and cause erroneous exudation pressure results.

Notes

Occasionally, material from very plastic clay test specimens will extrude from under the mold and around the follower ram during the loading operation. If this occurs when the 800 psi (5516 kPa) point is reached and exudation has not been achieved, then the soil should be reported as less than five R-Value.

**PART IV. METHOD OF DETERMINING THE
EXPANSION PRESSURE OF R-VALUE
TEST SPECIMENS**

A. APPARATUS (See Figures 2 and 3)

1. Expansion pressure device and small pans.
2. 1/10,000 in. (0.0025 mm) deflection gauge (expansion pressure dial).
3. Allen wrench.

B. MATERIALS

Filter papers, 10 cm BKH qualitative, catalogue No. 28310, or equivalent.

C. TEST RECORD FORM

Use individual test tickets for recording test data.

D. CONTROL

1. The brass shims under the spring steel bar of the expansion pressure device must be adjusted properly in order to maintain the correct relationship between the deflection of the spring steel bar and the expansive force generated by the test specimen. The proper adjustment is determined by means of an expansion pressure calibration device.
2. The calibration procedure is described in AASHTO T190 section 5 "Calibration of Expansion-Pressure Apparatus".
3. Expansion pressure devices should be recalibrated at least once every two months.

E. TEST PROCEDURE

1. Allow specimen to set for at least ½ hr. after completion of exudation test (Part III of this test method) before proceeding with the following steps.

2. Clean off all dust and foreign material from the spring steel bar and adjustment plug.
3. Place deflection gauge in position on top bar of expansion pressure device. The single bearing end must rest on the adjustment plug.
4. Use an Allen wrench to raise or lower the adjustment plug until the deflection gauge is on minus 0.0010 in. (0.0025 mm). (The deflection gauge will be on 0.0090 in. (0.0228 mm).
5. Determine gross weight of specimen for density calculations. Tare weight of mold is determined prior to the performance of this test method.
6. Place perforated brass plate with rod on top of test specimen.
7. Place mold on turntable after first placing a filter paper on turntable.
8. Seat perforated brass plate firmly on specimen with pressure applied from fingers.
9. Turn table up until the large dial indicator is on zero.
10. Read and record height for density determination.
11. Pour approximately 200 mL of water on specimen in mold and allow to stand, undisturbed, for 16 to 20 hr.
12. Read and record deflection gauge reading at end of soaking period. If any water has drained through specimen into water trap (pan) pour back on top of specimen, and allow this water to begin percolating through specimen before pouring off excess water. Remove mold with specimen, and pour off excess water.
13. Record whether water drained freely through the specimen into the pan below.

F. PRECAUTIONS

1. Keep the gauge surfaces on the top bar and contact surfaces on the spring steel bar clean and polished. Since deflection measurements are taken to $1/10,000$ in. (0.0025 mm), dust and corrosion on any of the gauge contact points can result in erroneous measurements.
2. Keep the expansion pressure devices free from the influence of any source of vibration during the test. If shelving is used to hold the devices do not attach or brace it to any of the building walls.

3. Recalibrate, before using again, any expansion pressure device which has been used with materials which have developed such extreme pressure as to leave a permanent set in the spring steel bar. A deflection gauge reading at the end of the 16 to 20 hr. test period of over 0.01 in. (0.0254 mm) (one turn around the dial) is generally considered to indicate that the steel bar has been subjected to extreme pressure, and recalibration is required before again using the device.
4. Exercise caution when turning the table up with the specimen in place and engaging the spring steel bar with rod on the perforated brass plate. If too much force is applied, a temporary set will be placed in the bar which will slowly relieve itself during the 16 to 20 hr. soaking period, and result in erroneous deflection readings.
5. Do not, under any circumstances, leave a test specimen unconfined by the expansion pressure device with the layer of free water existing on the specimen in the mold. This is particularly serious with expansive clays and silts since this condition permits the specimen to expand freely taking up excess water and disrupting the density. The net result will be the unjustifiable reduction of the stabilometer R-value.

NOTES

In general, specimens which contain predominant amounts of silt or clay materials will develop the greatest expansion pressures.

The expansion pressures developed in any group of test specimens composed of the same material are the inverse functions of their moisture content at compaction.

**PART V. METHOD OF DETERMINING THE
STABILOMETER RESISTANCE (R) VALUE
BY MEANS OF THE HVEEM
STABILOMETER**

SCOPE

This method covers the procedure for determining the resistance (R) value of both treated and untreated soils or aggregates for use as base, subbase or basement soil.

A. APPARATUS

1. Stabilometer and accessories (See Figure 4).
2. 4 in. (101.6 mm) outer diameter standard metal specimen, 6½ in. (162.5 mm) long.
3. Testing machine, 10,000 lb (4535.92 Kg) minimum capacity.

B. TEST RECORD FORM

Use work card, R-value Work Sheet, for recording test data.

This includes all pertinent data concerning the preparation, compaction, exudation, and expansion pressure of test specimens. The following is a brief discussion relative to the use of a portion of the work sheet (see Figure 5 for a copy of work sheet).

Line 1: A, B, C, etc., represent separate test specimens, and each is fabricated with different moisture contents. For ease of plotting and interpretation, enter the test data for the specimen showing the largest exudation pressure under B, C, etc.

Line 2: The date tested is normally recorded as the date the exudation test is completed.

Line 3: Enter the compactor foot pressure, in psi (kPa), used during the application of the 100 tamps. Some clays cannot be compacted at full pressure and therefore the actual foot pressure used should be recorded.

Line 4: The initial moisture is determined on a sample weighing exactly 10% by weight, and having the same grading (as-used) as the R-value specimens. The moisture sample is taken during the time the R-value samples are being batched (see Part I).

Line 5: "Water added mL." is the milliliters of water added during the mixing operation just prior to compaction (see Part I).

Lines 6 and 7: The weight of the mold and sample (grams), and the weight of the mold (grams).

Lines 8 and 9: The wet weight of the Briquette (grams) and the height of the briquette (to 0.01 in. (0.254 mm)) are determined prior to the expansion pressure test. These values are used with the moisture at compaction in the density compaction (see Part VI).

Lines 10 to 13 inclusive: The stabilometer data are entered as they are determined during the performance of the stabilometer test. The R-value for each specimen is calculated from these data using the alignment chart in Figure 6.

Lines 14 and 15: the exudation pressure is recorded as the compressive stress in total load and in psi (kPa) at which moisture is exuded from the specimen as indicated by the exudation pressure procedure (see Part III).

Line 16: "Stabilometer Thickness – Inches is the inches of cover needed for the individual R-value figured from the design chart (see Figure 8).

Lines 17 and 18: In the space provided for expansion pressure, the deflection measurement of the calibrated bar in the expansion pressure device is entered, and in the space provided for "Expansion Pressure Thickness - Inches, the deflection measurement of the dial indicator is multiplied by 10,000 and divided by 2, then entered.

C. CONTROL

1. Refer to Test Method Nev. T309 for details on the mechanics of the Hveem stabilometer including its operation, calibration and the installation of the Neoprene diaphragm.
2. 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:
 - a. Adjust bronze nut on base of stabilometer so that an effective height of 2.4 in. (60.96 mm) of the test specimen is obtained when the stabilometer shell is in position on the base. The effective height is defined as that depth of test specimen which acts against the liquid phase of the stabilometer. The ideal specimen is 2.5 in. (63.5 mm) high and has an effective height of 2.4 in.(60.96 mm).

- b. Adjust the testing machine so that the testing head moves downward at a rate of 0.05 in. (1.27 mm) per min. The hydraulic testing machines must be run several minutes before the oil warms up sufficiently to maintain a constant speed.
- c. Put standard metal specimen 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. (45.36 kg) in the testing machine, turn the pump to a pressure of exactly 5 psi (34.47 kPa). Adjust the turn indicator dial to zero. Turn pump handle at an approximate rate of two turns per second until the stabilometer dial reads 100 psi (689.48 kPa). Then turn indicator dial shall read $2.00 \pm .05$ turns. If it does not, the air in the cell must be adjusted. Remove or add air by means of the valve and the rubber bulb, and repeat the displacement measurement after each air change until the proper number of turns is obtained. Release horizontal pressure and remove standard metal specimen. The stabilometer is now ready for testing specimens.

D. TEST PROCEDURE AND CALCULATIONS

1. Force specimen which has previously been tested for expansion (see Part IV) into stabilometer. Place follower on top of specimen and center stabilometer assembly under the testing machine head. Lower testing machine head until it just engages the follower but does not apply any load to the specimen. Adjust stabilometer pump to give a horizontal pressure of exactly 5 psi (34.47 kPa). Begin application of a vertical load to the test specimen at a speed of 0.05 in. (1.27 mm) per min.
2. Record the stabilometer gauge readings when the vertical pressures are 80 (551.58 kPa) and 160 psi (1103.16 kPa), which are applied vertical total loads of 1000 (453.59 kg) and 2000 lb (907.18 kg) respectively.
3. Vertical loading by the testing machine must cease at 2000 lb (907.18 kg) and the load must be immediately reduced to 1000 lb (453.59 kg). Turn the stabilometer pump so that the horizontal pressure is reduced to 5 psi (34.47 kPa). This will result in a further reduction in the applied testing machine load which is normal and should be ignored. Set the turns displacement dial indicator to zero. Turn the pump handle at approximately two turns per second until the stabilometer gauge reads 100 psi (689.48 kPa). During this operation the applied testing machine load will increase and in some cases exceed the initial 1000 lb (453.59 kg) load. As before, these changes in testing machine loadings are normal and should be ignored.
4. Record the number of turns indicated on the dial as the displacement of the specimen. The turn indicator dial reads in 0.001 in. (0.03 mm), and each 0.1 in. (2.54 mm) is equal to one turn. thus, a net reading of 0.250 in. (6.35 mm) indicates that 2.50 turns were made with the

displacement pump. This measurement is known as the turns displacement of the specimen.

5. Calculate the stabilometer R-value from the following formula:

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

Where:

P_v = 160 psi (1103.16 kPa) vertical pressure

D = Turns displacement reading

P_h = Horizontal pressure (stabilometer gauge reading for 160 psi (1103.16 kPa) vertical pressure).

The attached stabilometer R-value chart (Figure 6) is normally used to solve the above formula.

6. Every attempt should be made to fabricate test specimens having an overall height between 2.4 (60.96 mm) and 2.6 in. (66.04 mm). However, if for some reason this is not possible, the stabilometer stage height should be adjusted and the R-value corrected as indicated on the accompanying chart (Figure 7).

E. PRECAUTIONS

1. Care must be exercised to avoid disrupting the compacted specimen while transferring it from the mold to the stabilometer. This applies particularly to those samples composed of coarse granular materials.
2. Hydraulic testing machines must be operated several minutes before the oil warms sufficiently to maintain a constant speed.
3. The operator's attention should not be diverted for any reason during the application of the vertical load to the test specimen. Allowing the testing machine to load in excess of 2000 lb (907.18 kg) on soft fluid materials can result in damage to the horizontal pressure gauge on the stabilometer.
5. Do not use anything but the fingers to close the air cell needle valve of the stabilometer. The use of pliers or wrench to tighten it will damage the valve seat and cause it to leak air in subsequent operations.

NOTES

The R-values developed by individual test specimens in a group composed of the same material, are inverse functions of their moisture contents at compaction.

A test specimen which has been destructively disrupted due to rough handling, transfer from the mold to stabilometer, or as a result of the test itself, will exhibit excessively high horizontal pressure and turns displacement readings.

Increasing the roughness or coarseness of the texture on the peripheral surface of a test specimen causes a reduction in the horizontal pressure values obtained from the stabilometer. This influence on the results is brought about by specimen roughness. To compensate for coarse surface texture characteristics the turns displacement determination is applied through the R-value formula as a correction factor. Soft test specimens also have high displacements. However, these specimens also have high transmitted pressures. It will be noted in the attached chart for calculating R-values, Figure 6, that the displacement correction for these materials does not greatly affect the calculated R-value.

HAZARDS

When picking up both the stabilometer and stage base together, make sure that the lock shoe on the bottom of the stabilometer shell is in position to prevent the base from slipping out. The stage weighs about 20 lb (9.07 kg) and could cause serious injury if it fell on the operator's foot. It is good practice when carrying the entire assembly to grip it by the bronze adjusting nut on the stage base.

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

A. TEST RECORD FORM

Use work card for recording test data.

B. TEST AND CALCULATIONS

1. The measurements of the height and weight of the test specimen necessary for the density determination are made during the performance of the method for the determination of expansion pressure of R-value test specimens according to Part IV of this test method.
2. The steps involved in the density calculations are as follows:

Total moisture content at compaction.

$$M = M_1 + M_2$$

M_1 = Initial moisture content, percent

M_2 = Percent moisture added

$$M_2 = \frac{W(100 + M_1)}{W_1}$$

W = Water added in mL .

W_1 = Original batch wt. in g. of soil including initial moisture (1200 g)

$$\text{Density, } D = \frac{30.3W_2}{(100 + M) H} \text{ In lb. per cu. ft. (kg/m}^3\text{)dry wt.}$$

W_2 = Wet wt. in g. of test specimen after compaction prior to addition of water for expansion pressure test.

The molds must be tared and weighed with the specimens.

H = Height of specimen in inches and is normally measured on an expansion pressure device.

Example:

Test Specimen	A	B	C
Initial wt. of Sample (W ₁)-----	1200	1200	1200
Initial moist. (M ₁)--	2.0	2.0	2.0
Water added, mL (W)--	60	75	85
Water added, percent-	$\frac{60(102)}{1,200} = 5.1$	$\frac{75(102)}{1,200} = 6.4$	$\frac{85(102)}{1,200} = 7.2$
Moist. at compaction-	2.0 + 5.1 = 7.1	2.0 + 6.4 = 8.4	2.0 + 7.2 = 9.2
Height, in. (mm)----	2.52(64.01 mm)	2.49 (63.25 mm)	2.50(63.50 mm)
Wet wt. (W ₂)-----	1,175	1,165	1,170
Density-----	132	131	130

NOTES

The accuracy of this method of calculating densities is dependent upon the amount of water lost by evaporation during the test procedure. Therefore, it is extremely important that every precaution be used to prevent such losses. For example, all cans used for moist curing samples should have tight seams. Solder the seam if necessary.

**PART VII. METHOD OF CALCULATING DESIGN
 THICKNESS OF PAVEMENT SECTIONS
 BASED ON STABILOMETER AND
 EXPANSION PRESSURE
 MEASUREMENTS**

A. RECORD TEST FORM

Use work card for recording results of calculations.

B. CALCULATIONS

1. Before any computations for thickness cover can be made, it is necessary to evaluate or assume (a) the cohesiometer value of the cover overlaying the material being tested, and (b) the traffic index of the section under consideration.
 - a. Cover material includes subbase, base and surface courses when the basement soil is being considered. Cover would include only base and surface when the subbase material is being tested. Similarly, when the base is being evaluated, cover would mean the bituminous surface alone if the cover consists of a single layer, the appropriate cohesiometer value may be selected from the following table:

TABLE 1

Cohesiometer Values for Common Pavement and Base Materials

Type materials	Cohesiometer Value
Cement treated base, Class A-----	1,500
Cement treated base, Class B-----	750
Asphalt concrete with paving grades of asphalt (85 to 300 penetration)-----	400
Asphalt concrete with liquid asphalt grades 4 and 5, open graded mixes and road mix asphalt surfacing-----	150
Bituminous surface treatment, Class C cement treated bases and all untreated bases or subbases-----	100

If the cover consists of multilayer construction, the unit cohesiometer value may be determined from the procedure and formulas given in the following example:

Problem: Determine the cohesiometer value for the 3-layer combination of asphalt concrete surfacing, Class A cement treated base and aggregate subbase material.

TABLE 2

<u>Data</u>		Cohesiometer
Material	Thickness (t)	Value (c)
AC-----	4" (101.60 mm)	400
CTB (Class A)-----	8" (203.20 mm)	1,500
AS-----	4" (101.60 mm)	100

First step: Convert the individual thicknesses of AC, CTB and AS to their respective gravel equivalents by multiplying the 5th root of the ratio of a layer's cohesion to that of untreated material by the thickness of the layer. For example, the gravel equivalent of 4 in. (101.60 mm) AC would be

$$\text{g.e.} = \sqrt[5]{\frac{400}{100} \times 4 \text{ in.}} = 5.28 \text{ in.}$$

Similarly, the gravel equivalent of 8 in (203.20 mm) Class A CTB is 13.76 in. (349.50 mm) and for 4 in. (101.60 mm) AS would be 4 in. (203.20 mm). The sum of the gravel equivalents of the individual layers (23 in. (584.20 mm)) is the total gravel equivalent for the system:

Second step: Knowing the actual thickness (16 in. 406.40 mm) of the system and having computed its gravel equivalent, determine the unit cohesiometer value by use of the following formula:

$$C = \frac{(\text{g.e.})^5}{(T)} \times 100$$

Where:

C = unit cohesiometer value

g.e. = Gravel equivalent for system

T = actual thickness of system

*Thus, for the above example

$$C = \frac{(23)^5}{(16)} \times 100 = 620$$

A second method of determining the unit cohesiometer value, in lieu of the above calculations, is provided by use of Figure 8 as described in the following procedure:

Convert the thickness of each individual layer to its gravel equivalent by using a straightedge to intersect scales I and H at the actual thickness and cohesiometer value of the layer; the intersection with scale G is the gravel equivalent of the layer. Sum up the individual layer gravel equivalents to obtain the total gravel equivalent for the system. Connect the point on scale G representing this total gravel equivalent with the point on scale I representing the actual thickness of the system, and the intersection on scale H is the unit cohesiometer value of the system.

In order to eliminate the above calculations and straightedge manipulations, Table 4 has been prepared; this provides a third method of determining the unit cohesiometer value. this table gives the unit cohesiometer values to use for different thicknesses of surfacing, base, and untreated material. (Table 4 is attached at end of test method as Figure 11.)

For convenience and a record, the design cohesiometer value is entered on the work sheet on line 19 (Figure 5).

b. A design traffic index will usually be made available by the Traffic Engineer. However, for the purposes of an example the following problem is worked out. Traffic is expressed in terms of the number of equivalent 18,000 lb (8164.66 kg) wheel loads (EWL) in one direction to be expected during the 10-year period following construction. Calculations involve the multiplication of certain fixed constants which convert average daily traffic¹ to yearly traffic in one direction (excluding passenger vehicles and pickup trucks) for each axle group.

TABLE 3
EWL Constants

No. of axles	Constants
2-----	330
3-----	1,070
4-----	2,460
5-----	4,620
6-----	3,040

¹Current average daily traffic tabulations are compiled by the Traffic Division of the Nevada Department of Transportation and are available on request from that department.

By taking a summation of the products and assuming an additional allowance of 50 percent for anticipated increase in commercial traffic at the end of a 10-year period, the final design value for the 18,000 lb (8164.66 kg) EWL repetitions is determined. For the purposes of calculating design thicknesses, the EWL is converted to a traffic index by means of the formula on the scale F portion of Figure 8. The above method of calculation is illustrated in the following example:

No. of axles	EWL Constants		Current ADT	=	Product
2-----	330	x	774	=	255,000
3-----	1070	x	212	=	227,000
4-----	2460	x	68	=	167,000
5-----	4620	x	118	=	545,000
6-----	3040	x	112	=	<u>340,000</u>

Total Annual EWL Repetitions-----1,534,000

$$10 \times 1,534,000 \times \frac{1.0 + 1.5}{2} = 19.2 \text{ million EWL}$$

Converting to traffic index:
19.2 million EWL = 8.7 T.I.

The traffic index is recorded on line 20 of the work sheet (Figure 5).

2. Knowing the cohesiometer value of the cover material and the estimated traffic index for the road, use the attached design chart (Figure 8) to determine the thickness indicated by stabilometer corresponding to the R-value of each specimen, and record these data on line 16 of the work sheet (Figure 5).
3. The R-value by exudation pressure (300 psi) (2068.43 kPa) is interpolated by utilizing the graph (Figure 9). Plot the R-value for each specimen against the corresponding exudation pressure. Then determine the R-value at the intersection of the curve connecting the points with the 300 psi (2068.43 kPa) line, and record on line 21 of the work sheet (Figure 5).

EXAMPLE

As an example, refer to the attached work sheet and graph, Figures 5 and 9. Individual test R-values are plotted vs. exudation pressure using the R-value scale at the right edge of the graph, Figure 9. It is noted that the curve crosses the 300 psi (2068.43 kPa) exudation line at an R-value of 29, which is recorded on line 21 of the work sheet as the R-value by exudation pressure.

4. To determine the R-value by expansion pressure it is first necessary to calculate the thicknesses of cover required by expansion pressure for each specimen from the dial readings recorded on the work card. For design purposes the unit weight of cover is assumed to be 130 lb per cu. Ft. (2082.40 kg/m³). The expansion pressure devices are so calibrated that it is only necessary to divide the dial readings by two² to obtain the cover thicknesses on the basis of this assumed unit weight. If, in special investigations where more accurate information is available, it is desired to use a different unit weight of cover material, then the cover thicknesses may be determined from the chart in Figure 10. In either case, the cover thicknesses are recorded on line 18 of the work sheet (Figure 5).

The determination of the R-value by expansion pressure is accomplished by first plotting thickness indicated by the stabilometer against thickness indicated by expansion pressure on the graph provided (see Figure 9). Then note the thickness value at which the curve connecting the points crosses the 45-degree balance line. Convert this thickness to R-value with the design chart (Figure 8).

The design chart is used in reverse for this calculation. In the above example, the thickness value is first found from the graph (Figure 9) to be 9.7 in. Using a straightedge, intersect Scale I of the design chart at the value of 9.7 in. of thickness and Scale H at the cohesiometer value of 620. Hold the point of a pencil at the intersection of the straightedge with Scale G. Pivot the straightedge around this point and intersect the traffic index of 8.7 on Scale F. The intersection of the straightedge with Scale E. Then indicate an R-value of 48 for the given conditions. The 48 R-value is recorded in line 22 of the work sheet as the R-value by expansion pressure.

5. The R-value at equilibrium is established by taking the lowest value of the above two R-values and the cover required corresponds to the R-value selected.

²For those who desire to determine the actual expansion pressure in psi, multiply the dial reading by 0.038

NOTES

When determining cohesiometer values for R-value calculations on current contracts, it is necessary to refer to the correct typical section in the contract special provisions. The cover thicknesses used should correspond to the stationing noted on the sample ticket.

It is often convenient to express the thickness of cover determined from the R-value test in terms of the gravel equivalent as a temporary expedient (when the types of cover materials to be used are either unknown or uncertain). The gravel equivalent, as the name implies, is the thickness of gravel required to support a given load, and is based upon a cohesion value of 100 for the cover material. One of the principal advantages in using the gravel equivalent is that it indicates to the designer what maximum thicknesses will be required to meet the conditions of the soil and traffic of the proposed project. Since 100 cohesion is the lowest value used for design purposes, use of 100 will result in the determination of the highest thickness requirements for a given R-value and traffic index. Likewise, any subsequent increase in the cohesion will always reduce the design thickness requirement. The process of determining the gravel equivalent from the design chart (Figure 8) merely consists of intersecting the R-value at equilibrium on Scale E and the traffic index on Scale F with a straightedge and reading its point of intersection of Scale G.

Traffic information for design purposes is usually derived from either of two primary sources. The Traffic Division publishes annually an average daily traffic tabulation entitled "Truck Traffic by Axle Type for Each District in Order by County, Route and Section" from which the traffic index may be computed. Another source is the District Traffic Department and they often have the most up-to-date traffic information regarding specific projects. In any event, all personnel should note design traffic information on the sample ticket when this information is available.

REFERENCE

Test Method No. Calif. 301
Test Method No. Calif. 201
Test Method No. Calif. 304
Test Method No. Calif. 902
Test Method No. Calif. 903
Test Method No. Calif. 904
Test Method No. Calif. 905

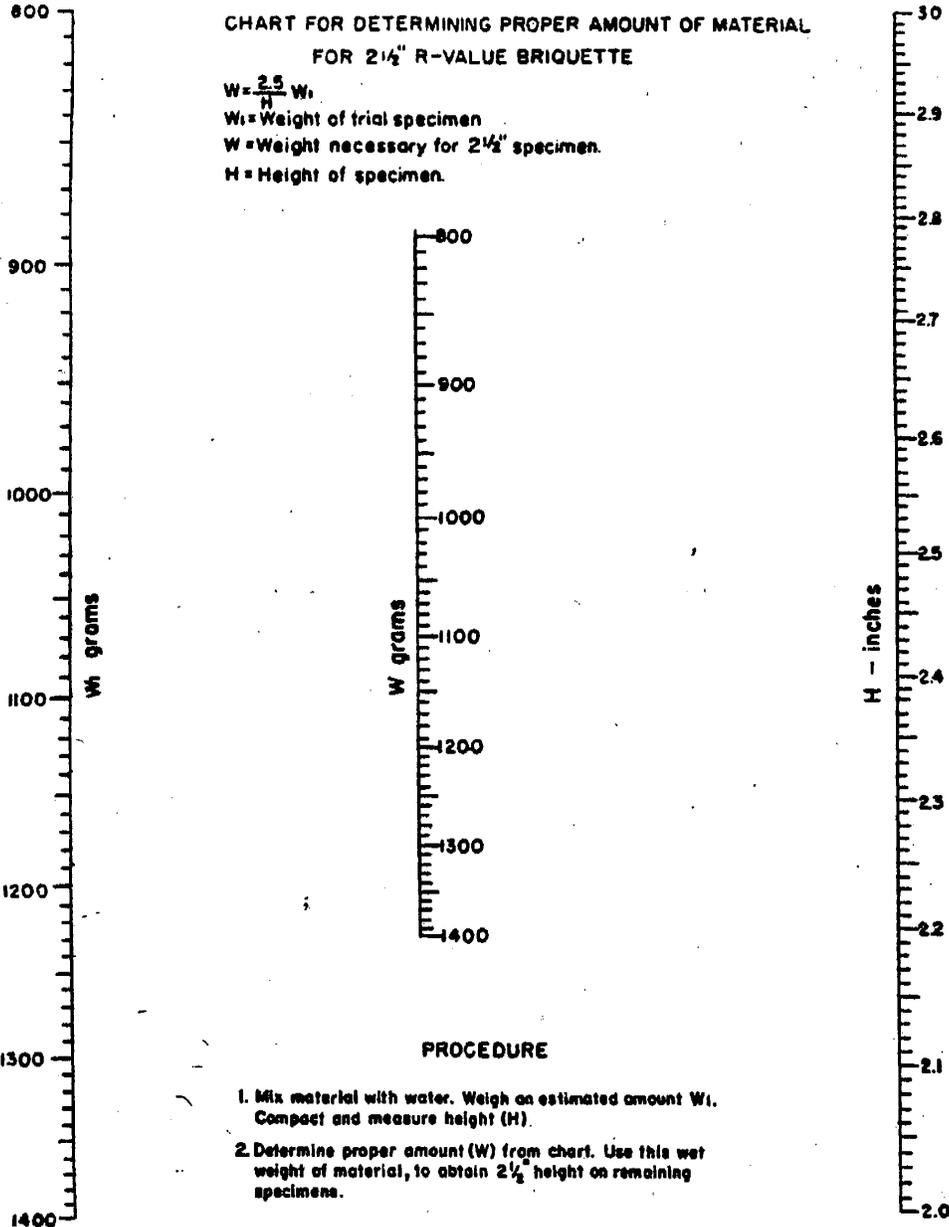


FIGURE 1

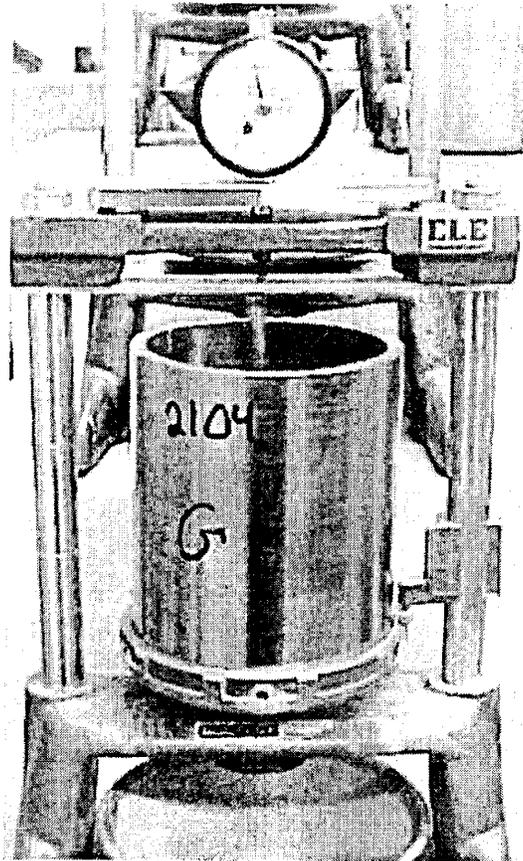


Figure 2

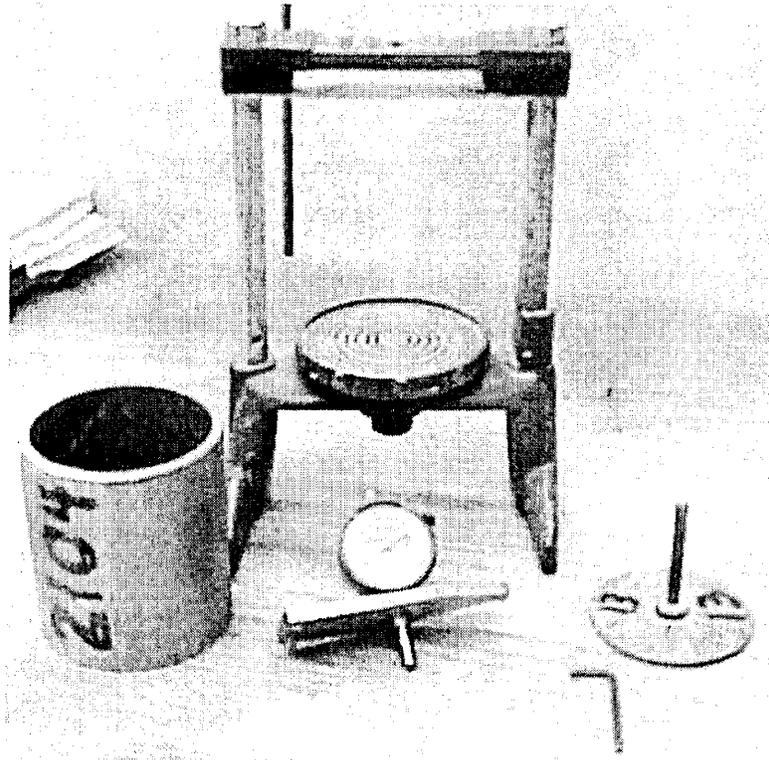


Figure 3

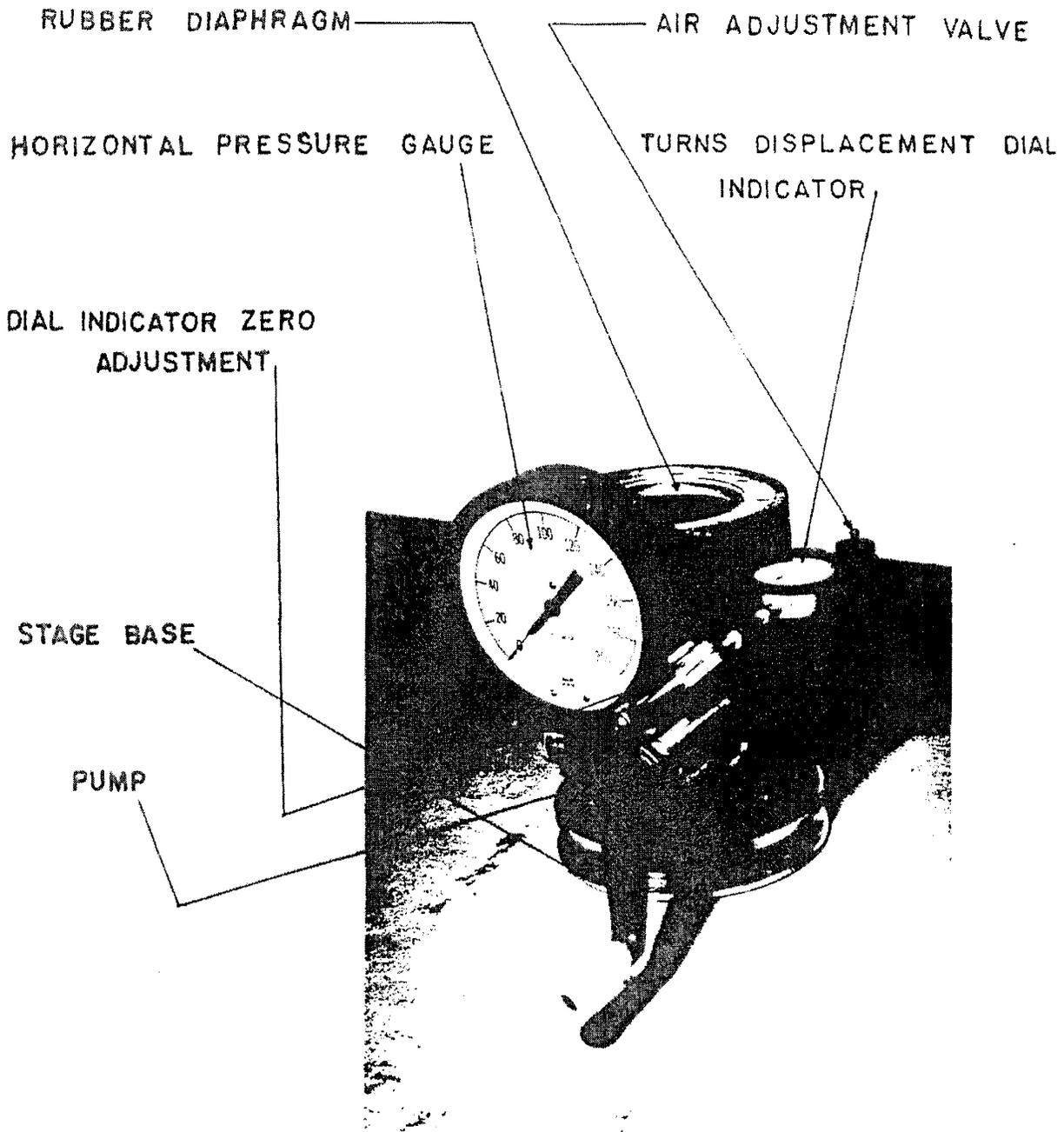


Figure 4

STATE OF NEVADA - DEPARTMENT OF HIGHWAYS
SOILS AND FOUNDATIONS LABORATORY
R-VALUE WORK SHEET

Contract or E. A. No: _____
Project: _____
County & Control Section: _____
Material & Location: _____

Test No: _____
Sampled By: _____
Date Sampled: _____
Date Received: _____

(1) Test Specimen	A	B	C	D	E
(2) Date Tested	_____	_____	_____	_____	_____
(3) Compaction Foot Pressure - P.S.I.	_____	200	200	200	_____
(4) Initial Moisture - %	_____	7.5	7.5	7.5	_____
(5) Water Added - ML	_____	150	160	190	_____
(6) Weight of Mold + Sample	_____	3109	2993	2987	_____
(7) Weight of Mold	_____	2100	1980	1991	_____
(8) Wet Weight of Briquette - Grams	_____	1009	1013	996	_____
(9) Height of Briquette - Inches	_____	2.48	2.50	2.54	_____
(10) Stabilometer Ph at 1000 Lbs.	_____	39	46	60	_____
(11) 2000 Lbs.	_____	68	82	133	_____
(12) Displacement	_____	3.00	3.15	3.20	_____
(13) R-Value	_____	53	43	14	_____
(14) Exudation Pressure - Total Load	_____	7550	5650	2140	_____
(15) Exudation Pressure - P.S.I.	_____	600	450	170	_____
(16) Stabilometer Thickness - Inches	_____	8.6	10.9	17.5	_____
(17) Expansion Pressure	_____	.0033	.0013	0	_____
(18) Expansion Pressure Thickness-Inches	_____	16.5	6.5	0	_____
(19) Cohesion Pressure-	620				
(20) Traffic Index-	8.7				
(21) R-Value by Exud. Pressure--	29				
(22) by Expan. Pressure -	48				
(23) at Equilibrium	29				
(24) Cover for Above Condition - Inches -	14"				
(25) Soil Support Value -	4.75				

Figure 5 - R-Value Work Sheet

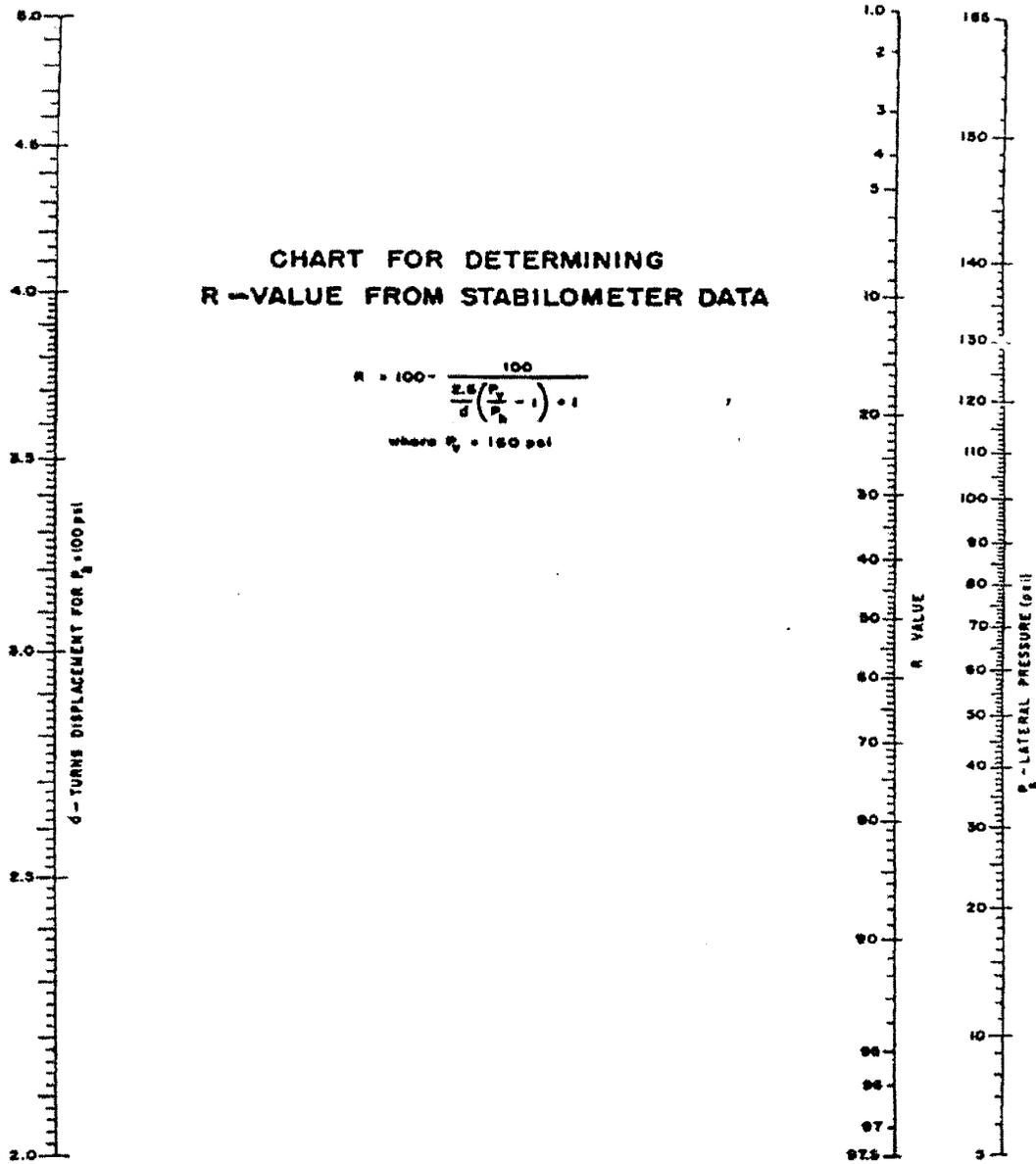


FIGURE 6

**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

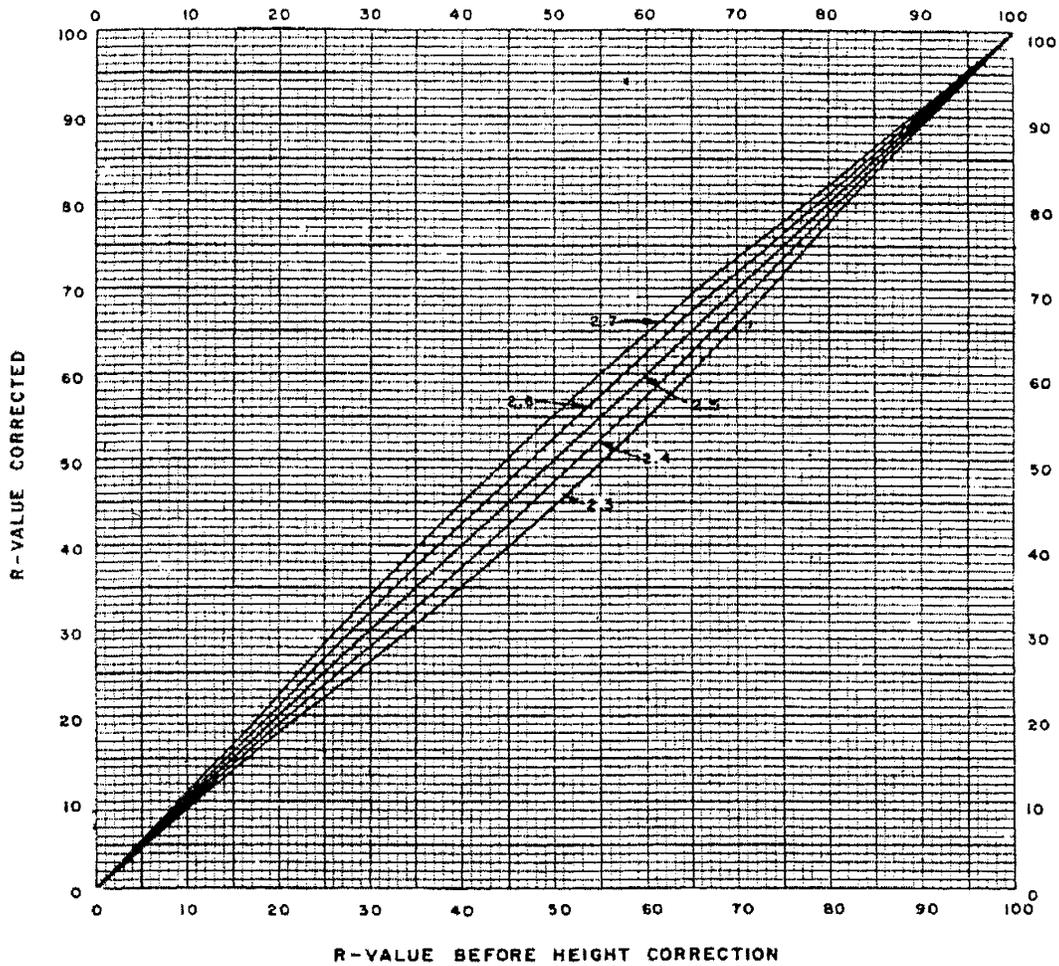


FIGURE 7

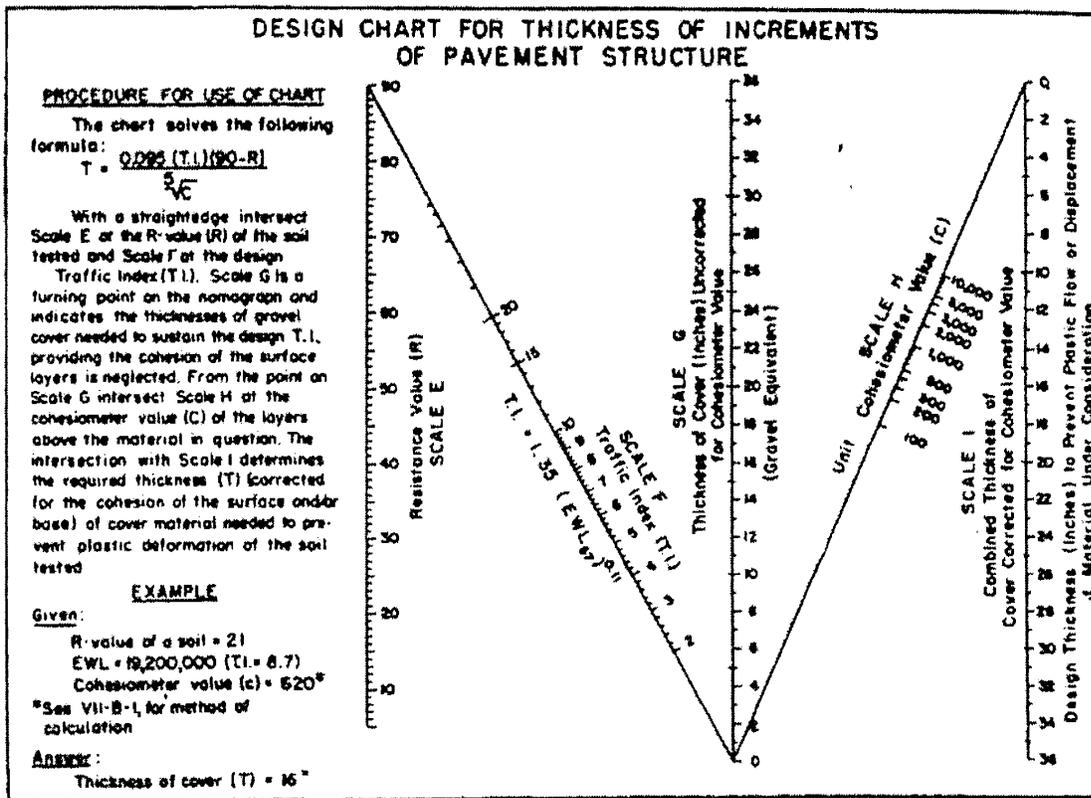


FIGURE 8

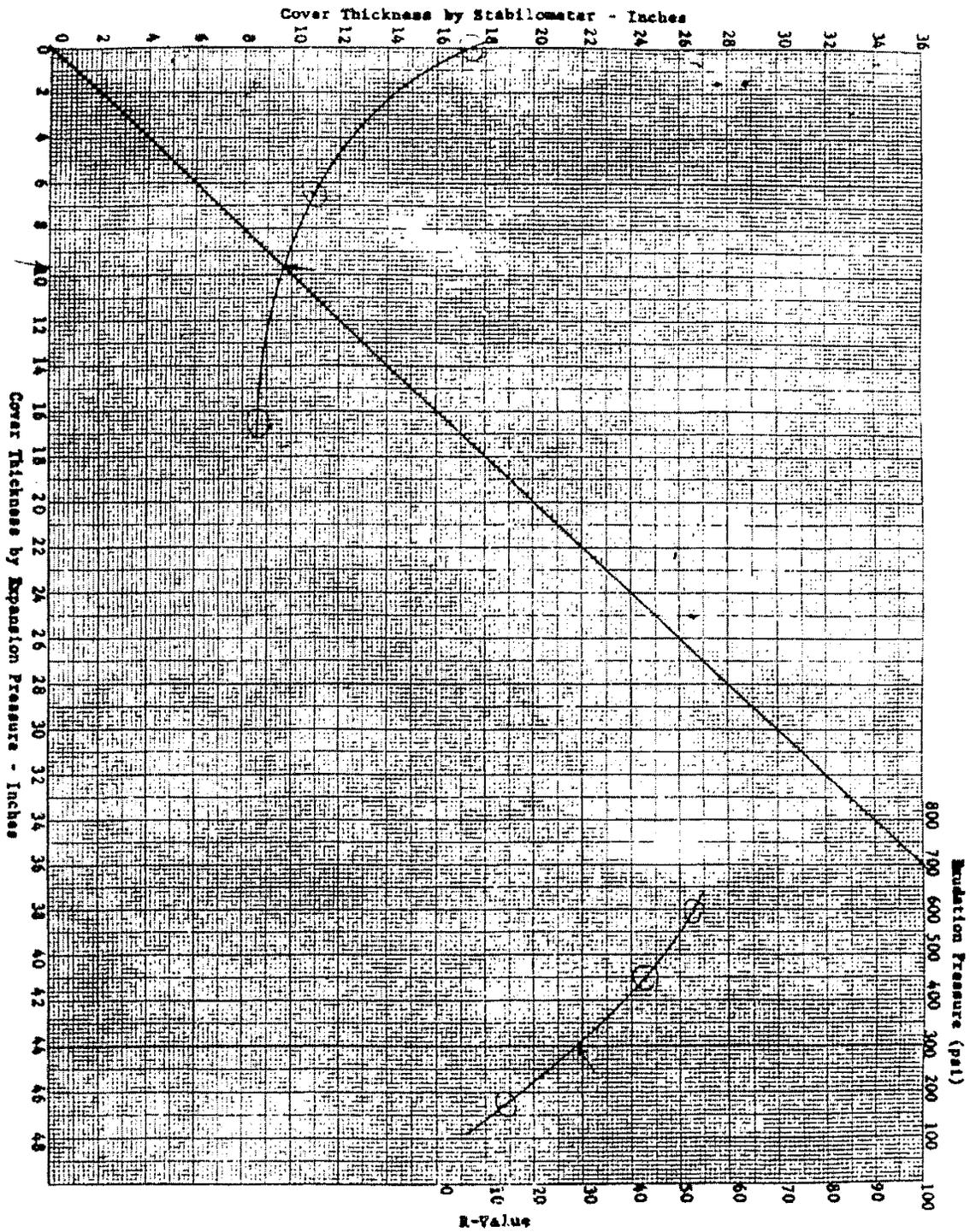


Figure 9 - Graph for Determining R-Values and Cover Thicknesses

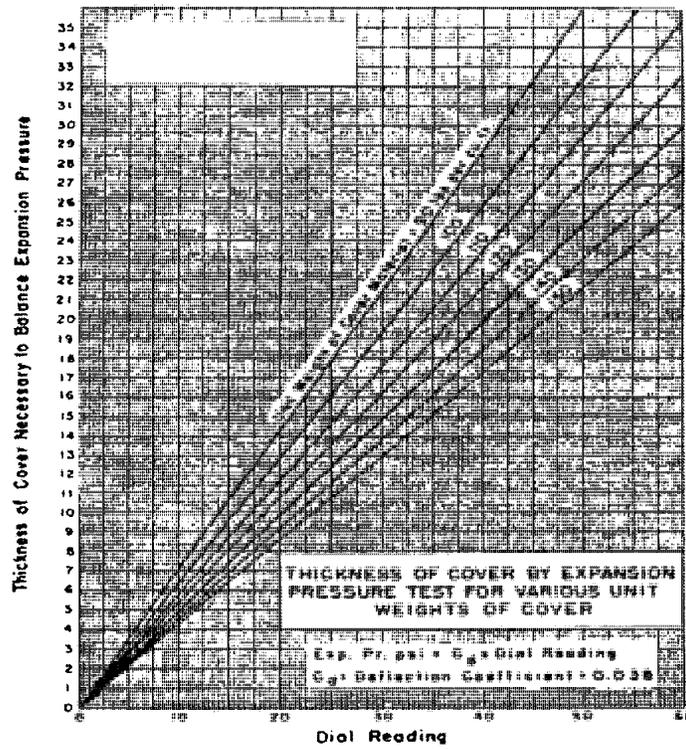


FIGURE 10

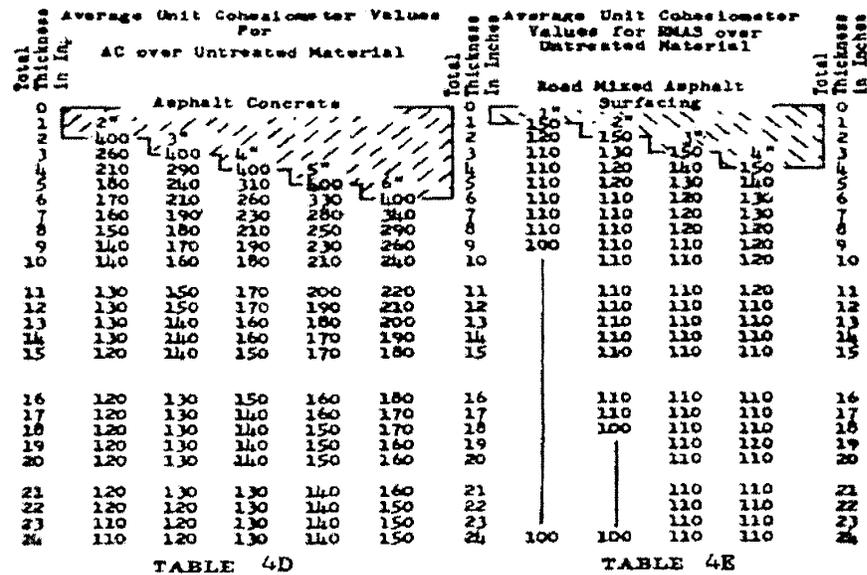
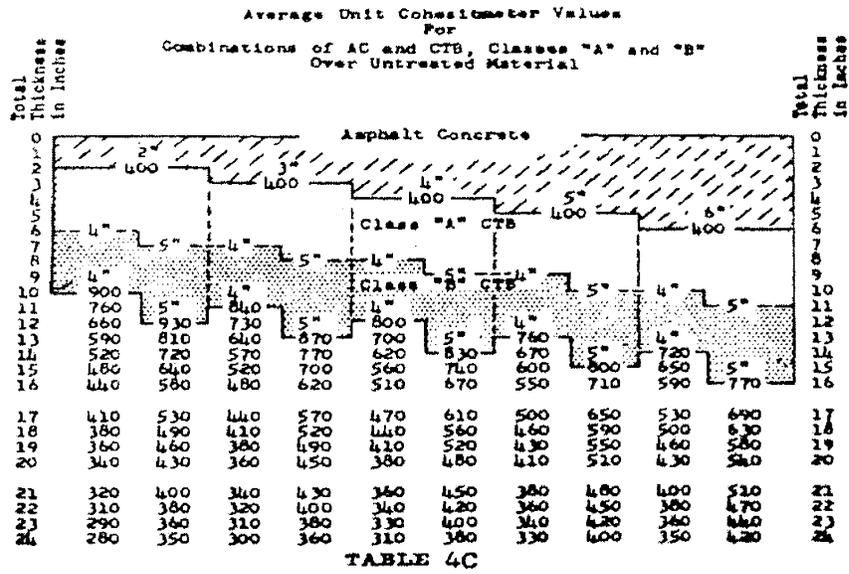


FIGURE 11 (Cont'd.)