Chapter III

EXPERIMENTAL INVESTIGATION

1. Materials

1.1 Soils

This stabilization evaluation study involved the use of two soils, silty sand and lateritic soil.

1.1.1 Silty sand Silty sand sample used in this investigation was taken from road side of the Det Udom - Bantharik highway, 4.2 Kilometers from Ubon. The gradation of this soil is presented graphically in Fig.1 and soil properties are given in Table 2.

1.1.2 Lateritic soil The lateritic soil sample used in this study was obtained from the Ampere Pen-Ban Sumsoi highway, 4.5 Kilometers from Nongkai. Fig.2 shows the gradation of this soil in graphically and soil properties are given in Table 3.

1.2 Asphaltic Materials

1.2.1 Standard asphalt emulsion Slow setting cationic emulsified asphalt (SS-K) obtained from Asphalt Products Company in Thailand was used. The properties of the asphalt are listed in Table 4.

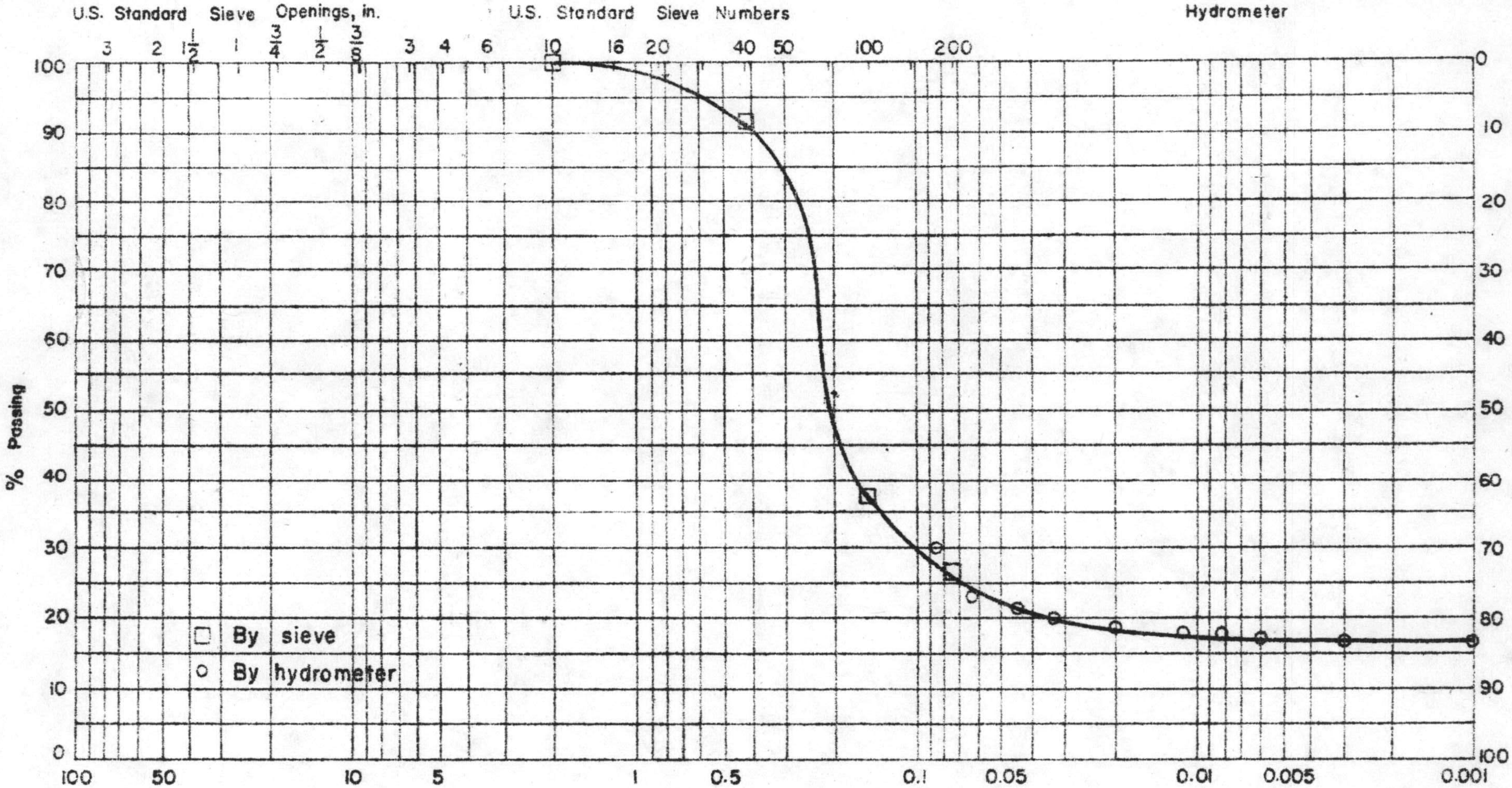
1.2.2 Special asphalt emulsion Penemulsion produced by the Peneprime International Company in the United States was used. The properties of the Penemulsion are given in Table 5.

Table 2

Properties of Silty Sand

Property	Value
Textural Composition :	
Sand 2.000-0.074 mm.,%	73
Silt 0.074-0.005 mm., %	9
Clay . < 0.005 mm.,%	18
< 0.001 mm.,%	17
D50, mm.	0.21
Physical Properties :	
Alterberg's Limits	Non plastic
Shrinkage Limit	17.4
Sand Equivalent	15
Specific Gravity (<No.10)	2.65
Engineering Properties :	
Maximum Dry Density[1], lb/ft^3	122.2
Optimum Moisture Content[1]; %	8.8
Classification :	
U.S. Bureau of Public Roads	Sandy Loam
Mississippi River Commission	Silty Sand
AASHO	A-2-4 (0)
Unified Soil Classification	SM
Chemical Composition :	
SiO_2	95.9 %
Al_2O_3	1.3 %
MgO	0.3 %
Fe_2O_3	0.2 %
Ca O	1.1 %

1. Kneading Compaction using California Kneading Compactor.



USBR	GRAVEL		SAND			SILT or CLAY	
	Coarse	Fine	Coarse	Medium	Fine		
AASHO ASTM	GRAVEL			SAND		SILT	CLAY
				Coarse	Fine		

Figure 1 Grain Size Distribution of Silty Sand

Table 3

Properties of Lateritic Soil

Property	Value
Textural Composition :	
Gravel, > 2.000 mm., %	74
Sand, 2.000-0.074 mm., %	7
Silt, 0.074-0.005 mm. %	4
Clay, < 0.005 mm., %	15
< 0.001 mm., %	13.5
D50, mm.	5
Physical Properties :	
Liquid Limit, %	33.9
Plastic limit, %	19.3
Plasticity index, %	14.6
Specific gravity (< No.10)	2.69
Engineering Properties :	
Maximum Dry Density[1], lb/ft^3	128.8
Optimum Moisture Content[1], %	12.4
Classification :	
U.S. Bureau of Public Roads	Gravelly Clay
AASHO	A-2-6 (0)
Unifined Soil Classification	GC
Chemical Properties :	
SiO_2, %	47.9
Fe_2O_3, %	16.8
Al_2O_3, %	26.7
CaO, %	3.5
MgO, %	1.5
Na_2O, %	2.6
pH	4.4
Organic matter Content, %	0.3
Total soluble salt, %	0.2

1. Kneading Compaction Using California Kneading Compactor.

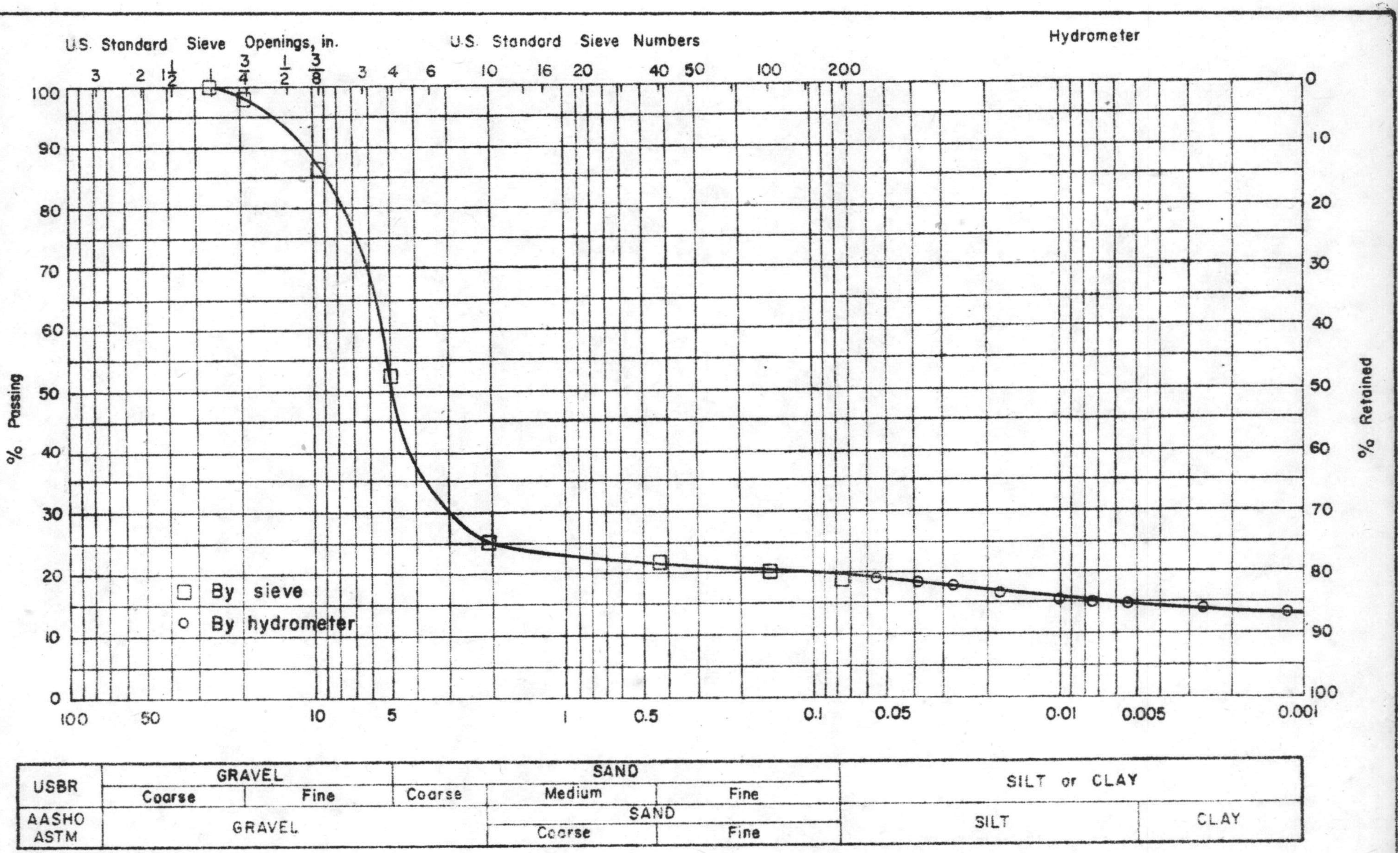


Figure 2 Grain Size Distribution of Lateritic Soil

Table 4

Properties of SS-K Emulsion

Property	Specified	Measured
Tests on Emulsion :		
Viscosity, Saybolt Furol, at 77°F., (25°C), see.	20-100	37.0
Settlement, 5 days, %	5-	-
Storage stability test, 1 day, %	1-	-
Particle charge	Positive	Positive
Sieve test, %	0.10-	0.028
Cement mixing test, %	2.0-	0.02
Distillation, residue, %	57+	65
Tests on Residue from Distillation Test :		
Penetration, 77°F, 100g., 5 see	100-200	133
Ductility, 77°F, 5 cm/min, cm	40+	Over 40
Solubility in Trichloroenthylene, %	97+	99.9

Table 5

Properties of Penemulsion

Property	Specified	Measured
Tests on Penemulsion :		
Viscosity, Saybolt Furol at 77°F, sec.	20-100	15
Settlement, 5 days, %	5-	-
Storage stability test, 1 day	1-	-
Cement mixing test, %	3-	-
Sieve test, %	0.10-	-
Residue by distillation, %	57+	50.5
Tests on Residue from Distillation, Test :		
Penetration, 77°F., 100g., 5 see	18-	14
Ductility, 77°F., 5cm/min,cm	25+	Over 100
Solubility in Trichloroethylene,%	97.5+	100

1.3 Water

Distilled water was used in all tests.

2. Natural Soil Samples Preparation and Testing

2.1 Preparation of Natural Soil Samples

2.1.1 Silty Sand The soil sample was mixed thoroughly and oven-dried at 60°C. The soil was stirred frequently to prevent crusting or formation of hard lumps. Some moisture content (about 3-5%) were allowed to prevent segregation during using. Then the soil was kept in a sealed container ready for further study.

2.1.2 Lateritic soil Air-dried soil passing a 3/4 in sieve was used in this study. After sieving, the soil sample were thoroughly mixed and then kept in sealed containers ready for further study.

2.2 Determination of Index Properties

2.2.1 Grain size determination Both wet and dry sieving methods were employed to determine the particle size distribution. The soil samples were first soaked in distilled water for several hours with frequent stirring. The coarse and fine fractions were then separated by pouring the samples on a No. 200 sieve. The soils retained on the sieve were oven-dried for dry sieving.

The fine fraction of the soils which passing through the No. 200 sieve were analyzed by the hydrometer method according to ASTM D422-63 with sodium metaphosphate (at a concentration of 40 gm/liter) as the dispersant.

2.2.2 Plasticity Plastic limits and liquid limites of the samples were determined according to ASTM D423-66 and D424-59 methods, except that a Casagrande's grooving tool were used for the liquid limit test. Using this tool would cause less disturbance of soils in the cup. For lateritic soil, air-dried samples were used to determine these values.

3. Hveem Stabilometer and Cohesiometer Tests.

Hveem Stabilometer and Cohesiometer are employed to evaluate R and C values of the samples in this study. Method of testing R and C values according to Chevron Asphalt Company Method are titled "Standard" method. In order to determine the strength characteristics and water absorption of the samples in severe condition, the samples were subjected to water vapor in oven at 140°F for 75 hours before strength evaluation (CHEVRON ASPHALT COMPANY, 1967). This type of testing is called Moisture Vapor Susceptibility test ("MVS" test).

3.1 Mixing

In mixing emulsion and Penemulsion with soils to obtain uniform mix, the minimum amount of mixing water required just to moisten the soil would be added and incorporated in the prepared soil. Then, the various selected quantities of emulsion or Penemulsion were added and mixed with the moistened soil samples. A mechanical mixer was employed to obtain uniform mix. The quality of the finished mixs was judged by the uniformity of their colors, spottiness, stripping and balling denoting an unsatisfactory mix. With unsatisfactory mixes as mentioned before, a new sample was prepared, with an additional water content in the soil and the quality again judged visually. The total amount of added water expressed as a percentage of the weight of the oven-dried soil is the minimum water content required for mixing the soil in question. In the case of lateritic soil, seems to be difficult to completely coat some of the large particles. Satisfactory mixes achive, if the fine matrix of the mix is uniformly coated. Because during the compaction process, the filler - emulsion matrix generally surrounds the large aggregate particles.

3.2 Compaction

Before putting the sample into the molds for compaction, the samples were aerated in the oven at about 60°C to lower the moisture content to the designed moisture content of each sample. Then the sample was tipped into 4 in diameter mold in two layers; each layer was rodded 20 times in the center of the mass and 20 times around the edge with a 3/8 in diameter rod. The mixture in the mold was compacted at room temperature by the kneading compaction mechine which imparts a kneading action by a series of individual impresions made with a foot having a face shaped as a sector of a 4-in diameter circle with an approximate area of 3.1 sq in. First the specimens were compacted by 20 tamps of 250 psi pressure to accomplish a semicompacted condition of the mix for being unduly disturbed when the full load is applied. Then raise the compaction pressure to 500 psi and apply 150 temping blows to complete the compaction in the kneading compaction machine. The hight of the compacted specimens were kept approximate 2.5 in.

For "Standard" method, after the kneading compaction had been completed the specimen was leveled by a static load of 12,600 lb (1,000 psi) with a head speed of 0.25 in.per min. The specimens for "Standard" method were tested immediately after compaction. Though it requires a curing period to reach their full strength but it has been claimed that in most instances the SS type emulsion develop tensile strength at fast rate (CHEVRON ASPHALT COMPANY, 1967)

Specimens for Moisture Vapor Susceptibility test (MVS test). Before applying the leveling-off load, force the test specimen upward through the mold so that the surface of the specimen is 1/4 in. below the top of the mold. Place aluminum seal cap on the compacted surface, invert the mold so that the seal cap rests on the pressing standard, and apply the 12,600 lb. leveling-off load. Then seal the edges of the aluminum seal cap, to prevent of moisture vapor, with air-blown asphalt. Place circular felt pad, which has previously been soaked in water, against the bottom surface of the test specimen. Place presoaked felt strip wick in contact with felt pad, the wick to be held in place with a metal spring clamp (see Fig.3). Insert pan of water up into the mold making certain that the free ends of the wick are imersed. Place assembly in a 140°F. oven for a continuous period of 75 hr.

3.3 Stabilometer Tests

The Hveem stabilometer machine is shown in Fig.4 In this study all specimens were tested at room temperature (about 30° C). The specimen was pushed from the mold into the stabilometer by means of the plunger of a compression machine. Before the vertical load was applied, the lateral pressure in

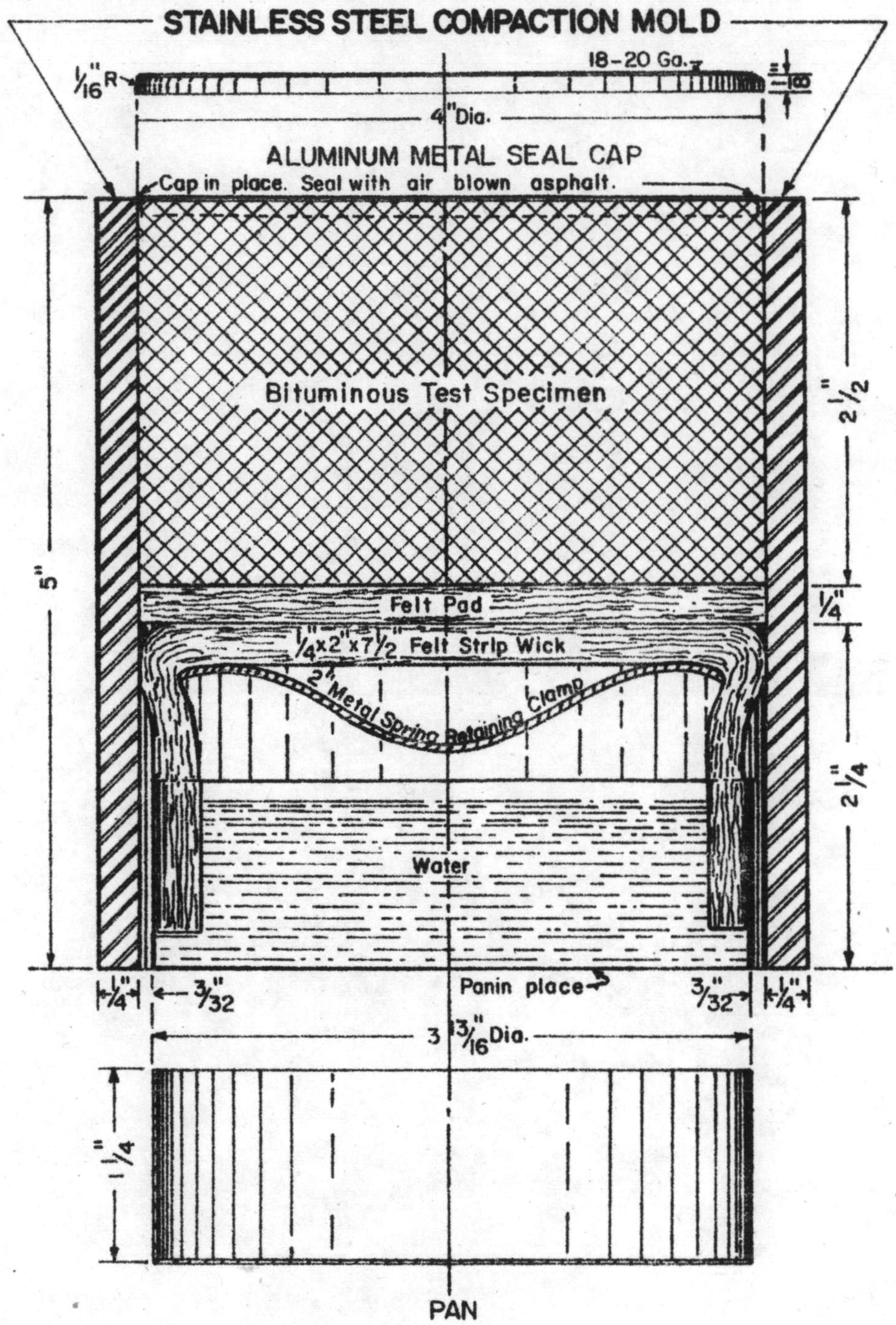


Figure 3 Moisture Vapor Susceptibility Test Assembly

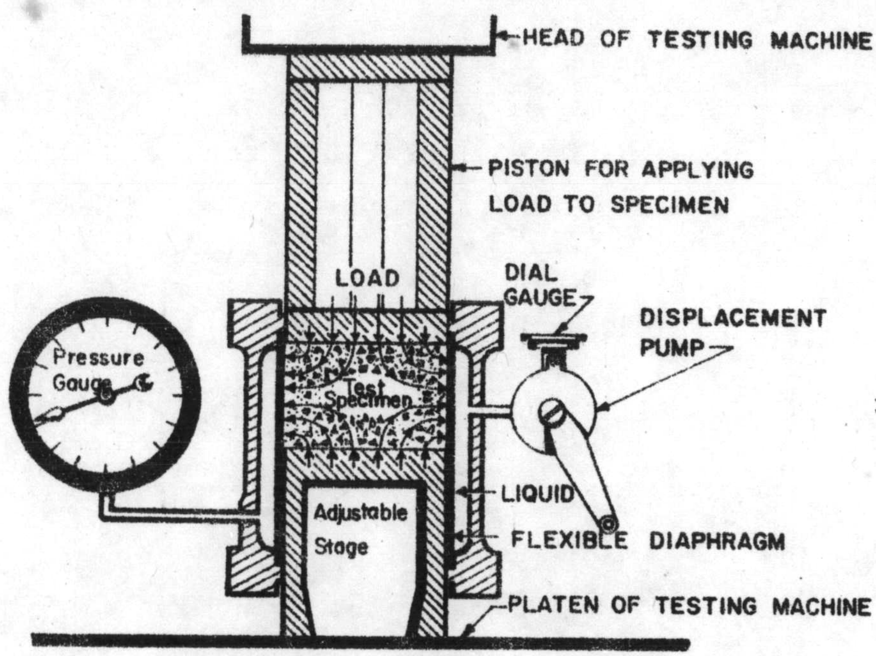


Figure 4 Hveem Stabilometer Test

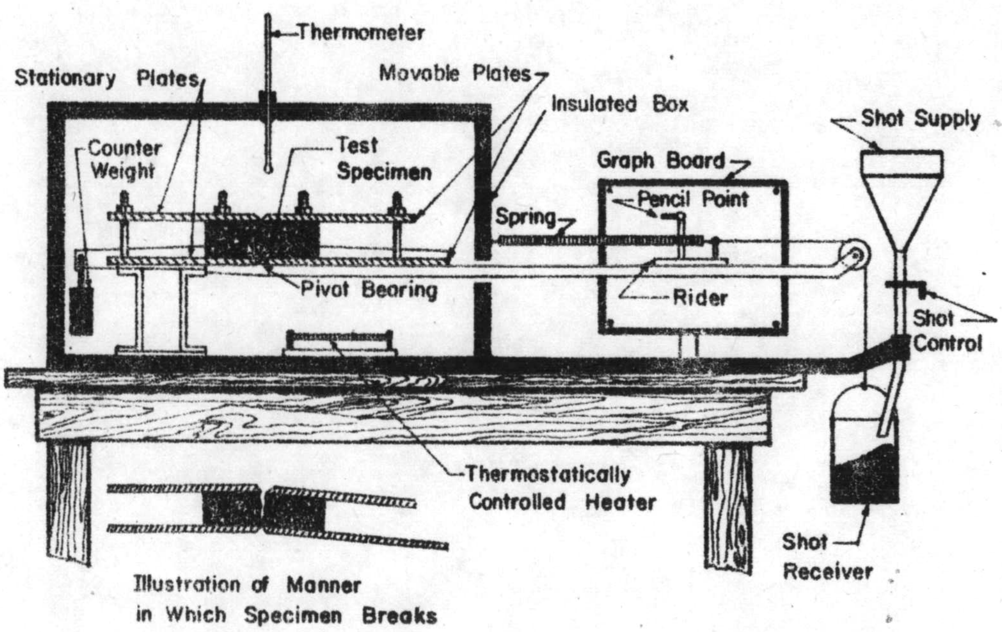


Figure 5 Hveem Cohesiometer Test

the stabilometer was increased to 5 psi. The specimen was then compressed at a rate of 0.05 in.permin. Stabilometer gauge readings, which showed the lateral pressure on the specimen, were recorded when the vertical pressure were 80 and 160 psi.which corresponded to vertical loads of 1000 and 2000 lb respectively. Vertical loading was stopped at 2000 lb and immediately reduced to 1000 lb and the lateral pressure was reduced to 5 psi. The pump handle was then turned to give a lateral pressure of 100 psi and the turns displacement of the handle to achieve this was recorded.

The R-value could be computed from the formula :

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

where Pv = vertical pressure = 160 psi

Ph = horizontal pressure (stabilometer gauge reading for Pv = 160 psi)

D = turns displacement reading

or by means of a nomograph. These were then corrected to an effective specimen height of 2.40 in.by using another nomograph (CALIFORNIA DIVISION OF HIGHWAYS 1963)

3.4 Cohesiometer Tests

The cohesiometer test was performed on the same specimens previously used in the stabilometer. The specimens were tested at room temperature (about 30°C). The specimen was clamped firmly in the cohesiometer shown in Fig 5. Then the releasedpin was pulled and lead shot was allowed to flow continuously until the specimen was broken; this was indicated by a sudden dropping of the beam. In event that the specimens were flexible or ductile ratter than brittle, the flow of shot was stopped when the end of the 30-in.beam lowered 1/2 in.from horizontal. The shot contained in bucket was weighted and recorded as 'shot weight'. Cohesiometer value can be calculated from :

$$C = \frac{L}{W(0.20H+0.044H^2)}$$

C = cohesiometer value (grams per inch width corrected to a 3-in height)

L = weight of shot in grams

W = diameter or width of specimen in inches

H = height of specimen in inches

4. Unconfined Compression Tests

After Stabilometer and Cohesiometer test, the percentages of emulsion, Penemulsion, and optimum liquid contents that gave the Resistance Rt Value (R+0.05C) after M.V.S. suitable for base course were chosen and prepared for Unconfined compression tests.

4.1 Mixing

Mixing with uniform mix that mentions in Stabilometer test and evaporation to the required optimum liquid contents of each type of mixture.

4.2 Compaction

Specimens for unconfined compression test were compacted by dynanic compaction in a cylindrical mold of 4-in. diameter and 4.584-in. high, in 5 layers, with a 10 lb hammer, drop distance 18-in, and 25 blows per layer. (Modified AASHO). The compactive energy equal 56,250 ft-lb/cu.ft. After compaction, some sample were tested immediately to obtain as-molded unconfined compressive strength, whereas the others were left for curing

4.3 Curing of Specimens

Specimens were kept in closed plastic bags at room temperature for 3, 7, 15, and 28 days before testing

4.4 Testing of Specimens

The unconfined compressive strengths of specimens were determined in a universal testing mechine. The specimens were loaded at a rate of 0.2-inch per minute until failure. The maximum load causing failure was taken as the compressive strength of the specimen. The changes in cross-sectional area were taken into account in the computation of unconfined compressive strength. The test results reported are the average of two specimens.

5. Traxial Tests

5.1 Mixing

Use the most economical percentage of emulsions for making the soils suitable for base course mentioned in unconfined compression test. Mix Samples that unconfined compression test. For Triaxial tests, a Harvard Miniaturesize mold, 1.312 in.in diameater is used but the maximum size of laterite is 3/4 in., therefore it is too large for this mold. Thus, after evaporation to the desired liquid content, the mixture passing a 3/8 in sieve was used in the triaxial tests.

5.2 Compaction

The mixtures were compacted in a Harvard Miniature size mold, 1.312 in.in diameter and 2.816 in.in height, in 3 layers, with a 40 lb spring tamper and 25 blows per layer. This compaction effort is approximately equivalent to that of the Standard Proctor compaction method.

5.3 Testing of Specimens

Undrained test without measurement of pore pressure was carried out according to the procedures given by BISHOP and HENKEL (1962). Using 20, 40, and 80 lb per sq.in. lateral pressures for silty sand mixtures and 20, 30, and 40 lb per sq in.for lateritic soil mixtures. Only one rate of strain was used for all samples in order to avoid any changes in strength due to variable rate of strain. In this tests is used 1% strain per minute. The test results reported are the average of two specimens.