EVALUATION OF TWO EXPEDIENTS FOR SOIL PULVERIZATION AND CONSTRUCTION OF A PORTABLE WORKING MODEL

by

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3-05-72-038
January 1973

PREFACE

A great deal of slow, laborious pulverization of soils has been expedited, in the primary laboratories of the Texas Highway Department, during the past two or three decades through the use of mechanical soil pulverizers. These pulverizers historically have been sturdy, heavy and permanently placed machines and have not lent themselves to being portable enough to be taken to other laboratories for temporary use. The cost also has been a major factor in limiting the use of the heavy pulverizers to the District Laboratory and perhaps a few of the Residency Laboratories.

During the 1972 meeting of District Laboratory and/or Engineering Personnel in Brownwood, a real need was expressed for lighter weight and more economical pulverizer devices, for use in non-pulverizer equipped laboratories, in order to expedite the preparation of soils for soil constant or other testing. This report presents data for that purpose.

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LIST OF TABLES AND PHOTOGRAPHS

I. CONCLUSIONS

1. The expedient pulverizers studied are little more than toys and were rejected as being useful in the day to day work of soil preparation.

2. A sturdy, portable working model for pulverizing soils has been produced which performs the same work with the same quality of pulverized soil which requires no test procedure changes.

3. Test results are comparable, and should be, due to the make-up of the equipment.

4. The portable machine can be mass produced at a cost of one-third or less of the cost of our ordinary pulverizers.

II. RECOMMENDATIONS

1. It is recommended that the portable working model pulverizer be authorized for use in all Texas Highway Department Laboratories.

2. When desired by the Districts, that the Procurement and Equipment Division, File D-4, build portable pulverizers in sufficient quantity to hold production costs down, say groups of about 8 machines.

3. That such improvements be made from time to time in production models that will further lighten the machine without impairing its usefulness.

III. DISCUSSION

Numerous comments at the Brownwood meeting had to do with "corn sheller" types of pulverizers and considerable effort was made to try to actually locate a corn sheller to see if the teeth or protrusions on this machine would perform a breakdown of soils in their usual condition at this state of preparation. No such machine was located in Austin, Texas and this idea was dropped.

After considerable searching, a coffee mill that appeared sturdy was found and purchased. The mill had internal workings made of cast iron and had a wooden base; purchase price was $15.00. It was soon found after trials on several soils of varying plasticity that this machine would not work at all on high P.I. materials and very poorly on low P.I. soils. The rate of pulverization at best was very slow even on soils where pulverization by mortar and pestle was not extremely difficult. It appeared that this machine was of little value and its use discontinued. (Photograph 1)

The next expedient or device used was a food chopper or ordinary meat grinder. This device was hand operated and came equipped with three cutter blades at a nominal cost of $6.95. This device was capable of pulverizing to a much better degree than the coffee mill and was able to pulverize very mild soils of, say, 15 P.I. or less in a reasonable manner. Approximately one third of the sample was retained on the No. 40 sieve for breaking down with the mortar and pestle but with milder soils this was not considered excessive.

On soils having higher plasticity indices, however, the grinder had to be extremely well fastened to a table, required much force to move the material through the body of the grinder to the cutter, and showed a great deal of wear. This was felt to be caused by the soil lumps or clods being dry and hard and that meat grinders are designed to cut or grind "wet" materials. It was noted also on high P.I. materials it appeared that the grinder was on the verge of breaking at any time, although it did not. Undoubtedly, there were a good many small pieces of steel in the soil from wear of parts but the amount was not actually determined. (Photograph 2)

The results obtained from usage of the two expedients justified a search for a better means of pulverizing soils and it was decided to try to build a machine that was portable and as inexpensive as possible. It was further desired that the machine be sturdy for long life and be as similar as possible to present means in order that the soil material would not be adversely affected or testing procedures altered.

With the help and cooperation of the Equipment and Procurement Division, File D-4, a pilot pulverizer was built for pulverizing soil materials in the same manner as with Braun type pulverizers. Essentially, the pulverizer consists of a 1/2 horsepower motor, 115 volts, 7.6 amperes and 1725 RPM driving a pulley which is attached to the moving plate of the pulverizer. The stationary plate is mounted in a removable drum-like cylinder which catches the soil when mounted in the operating position. Material is fed into the drum similar to the Braun pulverizer and ordinary Braun pulverizer plates are used, both stationary and revolving. In order to remove the finished material, two nuts equipped with handles are loosened and the drum can be emptied into a sheet metal pan which is furnished, and the material cleaned from the machine. The two pulverizing plates are capable of being spaced or adjusted in an easy manner to prevent breakup of individual grains of soil. The entire assembly is mounted on a wooden base for movement and/or stability, has a belt guard and has a spanner wrench for adjustment of the plates. See Photographs 3 and 4.

Initially, the cost of this machine was estimated to run \$350.00 and the actual cost was \$381.25 for the initial or pilot model. It has been estimated that this expense could be cut by one-third if they could be produced in groups of eight to ten at one time by D-4. The weight of the machine is a little in excess of one hundred pounds but is compact enough to be handled by one man if necessary. This weight could be lessened on production models and the pulverizer can be operated and used on less area than the ordinary 3' x 4' table top.

The working model of the pulverizer is so closely related to pulverizers now in use that it was felt no extensive evaluation of soil testing results would be necessary. As already described, the working model uses the same plates, operates the same distance apart and revolves at about the same speed or a little slower than stationary pulverizers now in use. In order to be more certain that the results would be equal or parallel, five U. S. Soil Conservation Service soil samples were prepared in accordance with Test Method Tex-101-E "Preparation of Soil and Flexible Base

Materials for Testing." These soils were predominantly all minus No. 40. Duplicate samples were prepared and the minus No. 40 material in one being pulverized using the Braun Pulverizer which this Division has had for many years. The duplicate sample was pulverized using the portable model and in both cases, the mortar and pestle was used as set out in par. 11 of Test Method Tex-101-E. Results of tests for the liquid limit, plastic limit, plasticity index and percent minus No. 40 are presented in Table I for both machines. A copy of the above mentioned test method is presented as Appendix 1.

IV. ADDITIONAL DATA ON EXPEDIENTS

1. Coffee mill or grinder

   Cast iron parts with wooden base. Pulverized soil collected in slide out drawer.

   Purchased from J. C. Penney Co., Austin, Texas.

   Mill from Lot No. 2897.

   Cost $15.00.

2. Food Chopper or meat grinder.

   All steel body with wood hand grip on handle.

   Hand operated and equipped with three cutter blades for varying coarseness of meat.

   Purchased from Davis Hardware Co., Austin, Texas.

Model Climax 51.

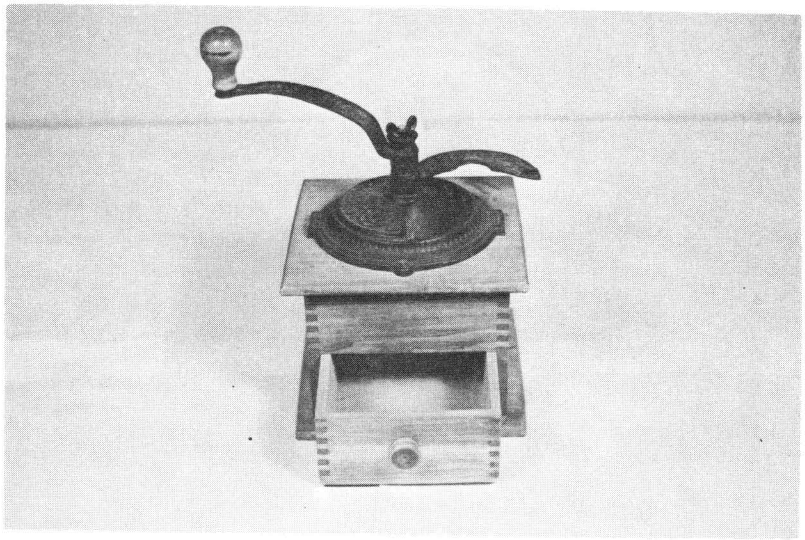
Cost $6.95.

ACKNOWLEDGMENTS

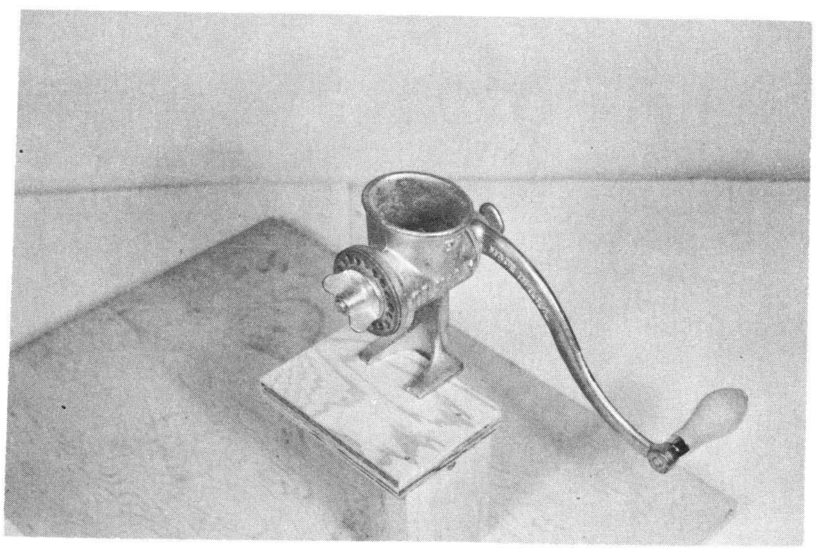
Acknowledgment is made to members of the Texas Highway Department, Materials and Tests Division, under the leadership of Mr. A. W. Eatman, Materials and Tests Engineer. Soil tests and evaluation of expedients was done by the Soils Section. Our special thanks are extended to the Equipment and Procurement Division for their cooperation and help in building the working model.

TABLE I

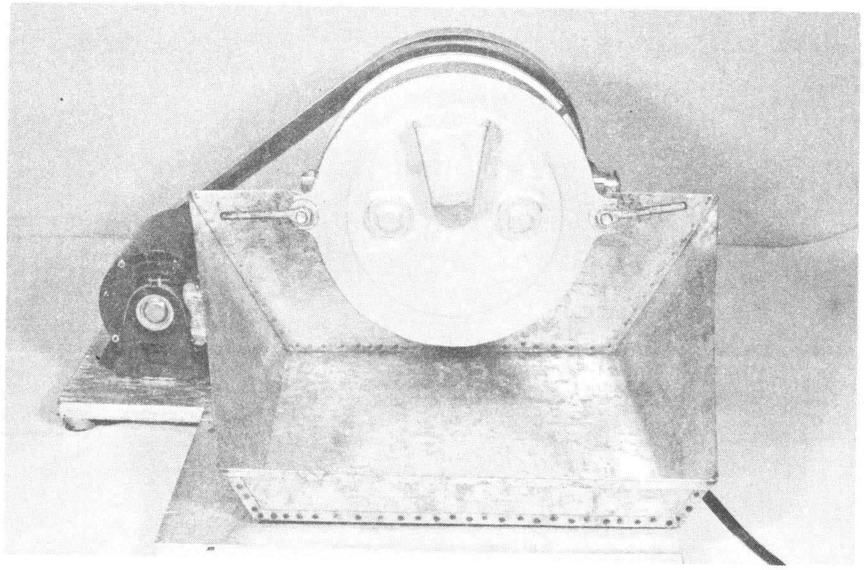
	LL	PL	P.I.	% - No. 40	
72-173-R	42.0	17.2	24.8	98	Braun Pulverizer
	42.9	17.8	25.1	98	Shop Built Pulverizer
72-174-R	42.4	17.6	24.8	99	Braun Pulverizer
	43.4	17.4	26.0	99	Shop Built Pulverizer
72-175-R	35.1	13.9	21.2	98	Braun Pulverizer
	34.4	13.6	20.8	98	Shop Built Pulverizer
72-163-R	47.6	20.3	27.3	100	Braun Pulverizer
	46.9	19.9	27.0	100	Shop Built Pulverizer
72-172-R	39.1	18.1	21.0	98	Braun Pulverizer
	39.2	18.6	20.6	98	Shop Built Pulverizer



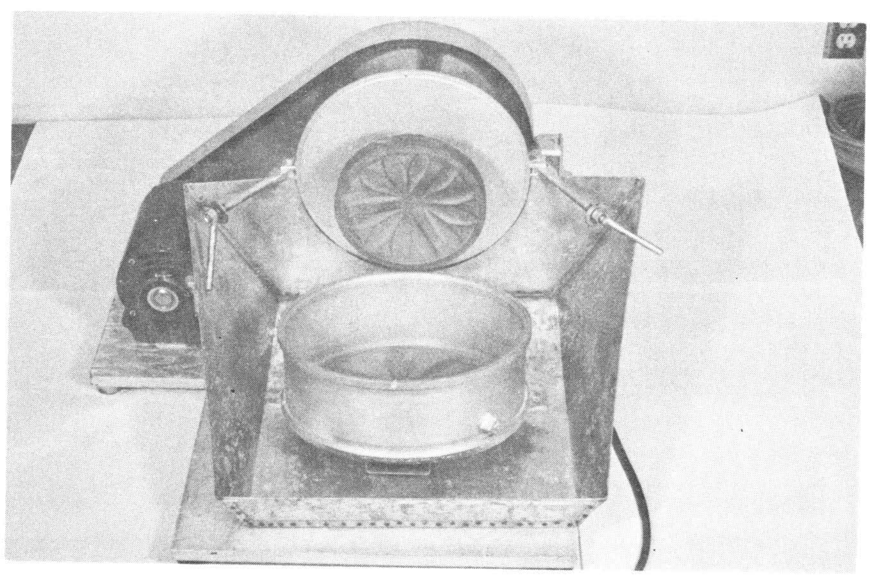
Photograph 1 Coffee Mill



Photograph 2 Meat Grinder



Photograph 3 Pulverizer Working Model



Photograph 4 Showing Drum Open
with Plates Exposed

APPENDIX

Texas Highway Department

Materials and Tests Division

PREPARATION OF SOIL AND FLEXIBLE BASE MATERIALS FOR TESTING

Scope

This test method describes in Part I a procedure for the preparation of disturbed soil samples for mechanical analysis and the determination of the soil characteristics. This portion of the method is in close agreement with wet preparation A.A.S.H.O. Designation T 146-49, but differs from the dry preparation methods A.A.S.H.O. T 87-49 and A.S.T.M. D 421-58 for materials which contain particles larger than the No. 40 mesh sieve. Part II describes dry preparation of soils for tests (compaction, triaxial, and stabilization) which require laboratory molded specimens.

Definitions

Soil Binder: That portion of the material passing the Standard U.S. No. 40-mesh sieve shall be known as soil binder.

Percent Soil Binder: The ratio of the soil binder to the total sample times 100 calculated on the basis of the air-dry weight.

Apparatus

1. Sieves: Standard U. S. woven wire sieves with square openings (A.S.T.M. E 11 specifications) 3-inch, 2-1/2-inch, 2-inch, 1-3/4-inch, 1-1/4-inch, 7/8-inch, 5/8-inch, 1/2-inch, 3/8-inch, No. 4, No. 10, No. 20 and No. 40.
2. Heavy Duty Scale: A scale of adequate capacity and sensitive to 0.5 pound or less.
3. Scale: A scale with 10 to 70 pound capacity and sensitive to 0.01 pound or less. (Class IV-C)
4. Electric air dryer with temperature range 130° - 140°F.
5. Crusher: A 5 inch by 6 inch jaw crusher which can be adjusted to produce material passing the 1/4-inch sieve.
6. A small crusher: A flat face jaw crusher which can be adjusted to produce material passing 10-mesh.
7. Mechanical pulverizer
8. Wedgewood Mortar and Pestle, 165 m.m.
9. Rubber-covered pestle
10. Scoop
11. Small siphon tube
12. Sample containers, metal pans, cardboard cartons
13. Filter paper 20" x 20" cut to convenient size.
14. Absorbent molds (Plaster of Paris or other absorbent material).

Note: The Plaster of Paris molds must be air dried at a temperature not to exceed 140°F after forming and after each use.

Materials

Clear potable water.

Test Record Form

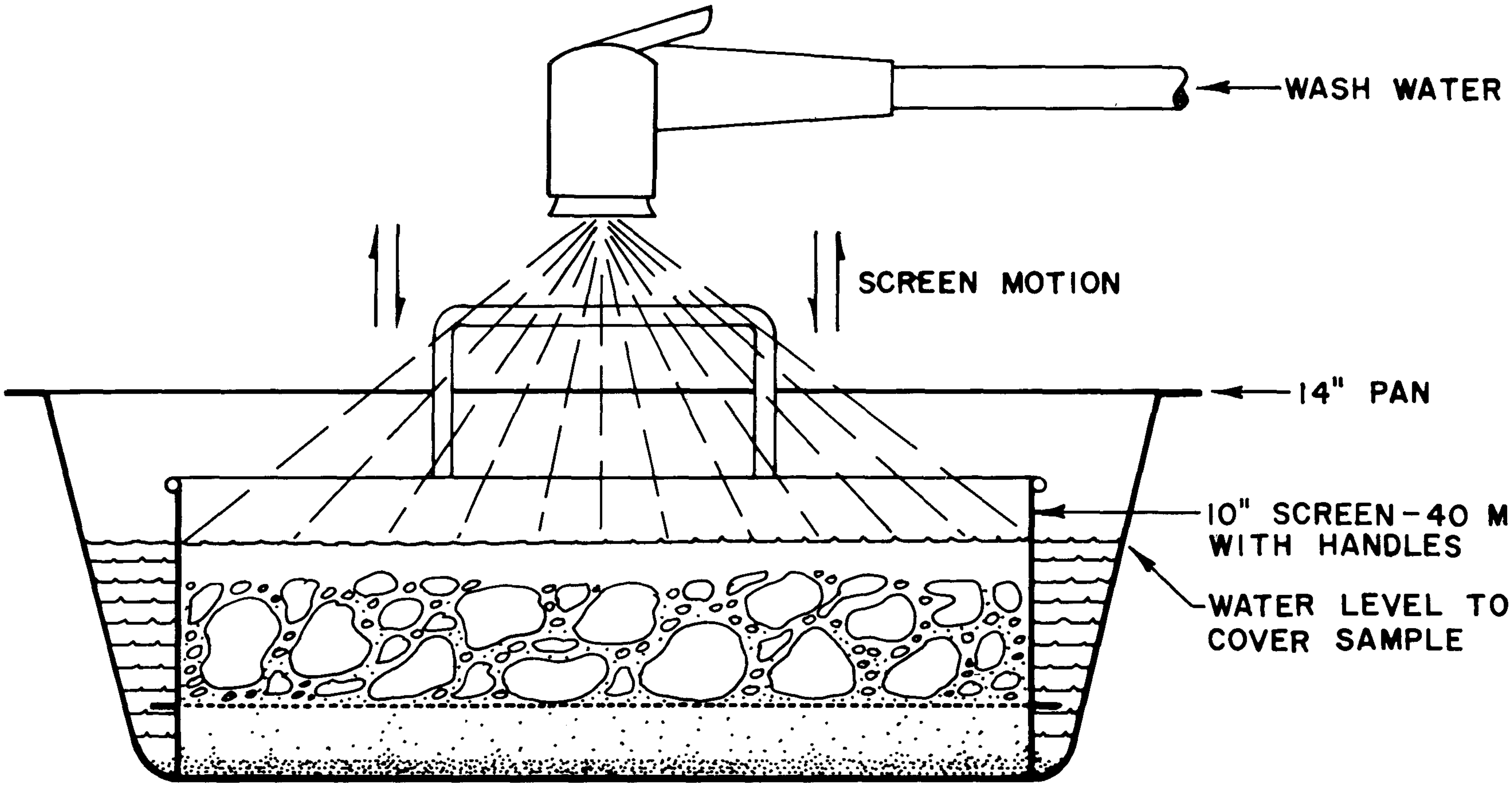
Each soil sample should be given an identification number. This number placed on a suitable card remains with each portion of the sample throughout the processing and testing of the material. Record test data on Form 359, Soil Work Card and Form 409, Soil and Base Materials Work Sheet.

PART I

WET PREPARATION OF DISTURBED SOIL FOR SOIL CONSTANTS AND HYDROMETER ANALYSIS TESTS

Procedure

1. Select a representative sample according to the procedure outlined in Test Method Tex-100-E.
2. Stone or flexible base materials, containing large aggregate, that will be processed in crushing plant or broken down by other means during construction, should be crushed to the maximum size permitted by specifications.
3. Dry the sample in air dryer at a temperature not to exceed 140°F.
4. Examine the sample by visual inspection or slake a small portion in water to determine if the material has any particles larger than the 40 mesh size. If the material contains no particles larger than 40 mesh in size, or if the amount of aggregate is small and can be easily distinguished, remove these particles by hand and proceed to steps 11 and 12 for preparation of sample.
5. For materials containing a considerable amount of aggregate, the fine loose portion may be separated from the coarse particles by means of a 40-mesh sieve. Set the soil binder passing the 40-mesh aside and later recombine with additional binder obtained from steps 6 through 11. If desirable, the total material may be slaked.



WET SEPARATION OF BINDER FROM SOIL SAMPLE

Figure 1

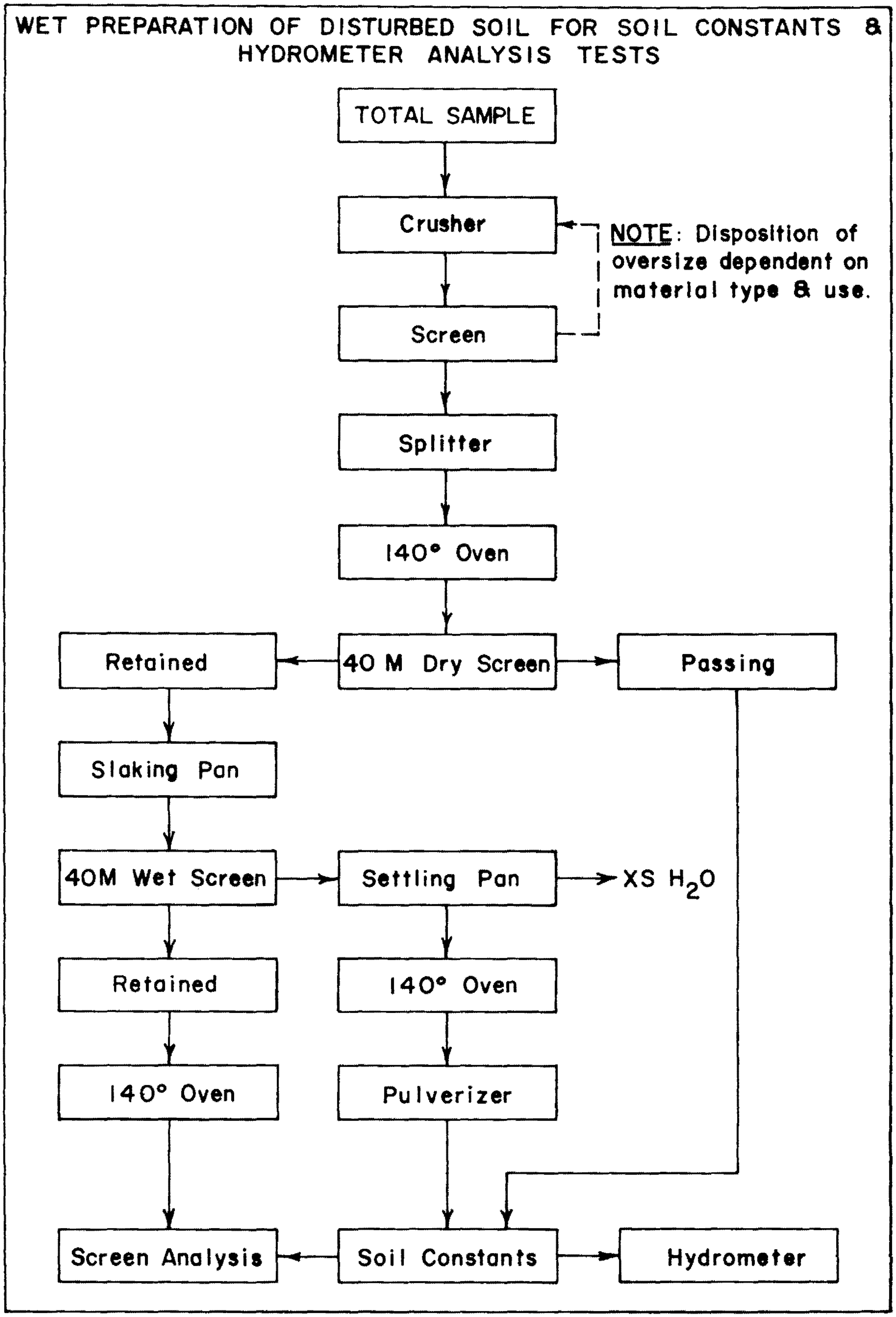

WET PREPARATION OF DISTURBED SOIL FOR SOIL CONSTANTS & HYDROMETER ANALYSIS TESTS
TOTAL SAMPLE
Crusher
NOTE: Disposition of oversize dependent on material type & use.
Screen
Splitter
140° Oven
Retained
40 M Dry Screen
Passing
Slaking Pan
40M Wet Screen
Settling Pan
XS H_2O
Retained
140° Oven
140° Oven
Pulverizer
Screen Analysis
Soil Constants
Hydrometer

Figure 2

6. Place either the total material or material retained on 40-mesh sieve in a pan, cover with clear water and allow to soak for a period of 2 to 24 hours. The slaking time for base materials can be determined by procedure of test method Tex-102-E or Tex-109-E.

7. After slaking, wash the material over a No. 40-mesh sieve in the following manner: Place the empty sieve into a clean pan and pour the liquid from the wet sample through it. Enough additional water is poured into the pan to bring the water level about 1/2-inch above the mesh of the sieve. A small amount of the soaked material is then placed in the water on the sieve and stirred by hand at the same time the sieve is agitated up and down. If the material retained on the sieve contains lumps that have not disintegrated, but which can be crumbled between the thumb and fingers so as to pass the sieve, such lumps shall be broken and washed through the sieve. After all of the soil binder appears to have passed through the sieve, the sieve is held above the pan and the retained aggregate washed clean by pouring a small amount of water over it and letting the water drain into the pan. Transfer the aggregate from the sieve to a clean pan (Figure 1.)

8. Repeat the procedure of step 7 until all of the sample has been washed.

9. Dry the retained portion of the sample and rescreen over the 40-mesh sieve. Add the portion passing to the binder obtained in step 5. Weigh and save the aggregate retained on the 40-mesh sieve for use in the mechanical analysis of aggregate test method Tex-110-E.

10. Place the pan containing the soil binder and wash water aside where it will not be disturbed until all of the soil has settled to the bottom of the pan and the water above the soil is clear. The clear water is then decanted or siphoned off. The soil remaining in the pan is dried in an air dryer at a temperature not to exceed 140°F. If the water is not clear at the top in a reasonable length of time, two to three hours, the water may have to be evaporated or the settling time reduced by placing the pan of material in the 140° F air dryer overnight. In cases where the materials fail to settle in a reasonable time the following procedure may be used:

a. Decant the water and pour into porous molds lined with filter paper.

b. When the water has disappeared, air dry the filter paper with adhering soil. This may be done by placing on a wire rack to be placed on top of pan of wet soil remaining after step a.

c. When the material from steps a and b are air dried sweep the soil from the filter paper with a stiff brush into the pan of fines.

11. The dried soil binder is broken down in a mortar with a pestle. A suitable mechanical pulverizer, with opening set from 0.025 to 0.035 inches by means of a thin blade spatula or other convenient gage, may also be used to pulverize the aggregations of soil particles into separate grains which will just pass the No. 40 sieve. When the mechanical pulverizer is used it is intended that some of the material will have to be reduced using the mortar and pestle in order to preclude the possibility of the mechanical pulverizer breaking up the separate grains of the soil smaller than the No. 40.

12. Combine all of the soil binder obtained from steps 5, 9 and 11 and weigh to nearest gram or .01 pound. Mix thoroughly to produce a uniform sample of all the particles (Figure 2).

13. Add the weight obtained from steps 9 and 12 for the total weight of sample.

Calculations

Calculate the percent soil binder, equals

$$\frac{\text{Dry weight passing No. 40-sieve}}{\text{Total dry weight of sample}} \times 100$$

Note: Alternate Method

The sample may be slaked for wet preparation by use of the method and equipment of Test Method Tex-109-E, PART II.

PART II

DRY PREPARATION OF DISTURBED SOIL SAMPLED FOR COMPACTION, TRIAXIAL AND STABILIZATION TESTS

Scope

This preparation procedure applies to all material except wetted stabilized materials sampled from the roadway during construction. These materials should be quartered to approximate specimen size batches and be compacted without air drying. When M-D curves are desired this material may be dried by exposure to air or fan draft while it is being stirred.

Procedure

1. Select a 200-pound representative sample according to method Tex-100-E. Check specifications for maximum size aggregate.

2. Spread sample on clean floor to air dry or use forced drafts of warm air.

3. Clay and other soils which form into hard lumps when dried but contain no appreciable amount of aggregate should be crushed to pass the No. 10 sieve. The sample is then separated into two portions by means of a No. 20 sieve. In preparing medium heavy and heavy clays for the Moisture Density test for Compaction Ratio (Tex-114-E) at least two thirds of the material passing the No. 10 sieve should pass the No. 20 sieve.

4. Clay and other soils containing aggregate should be broken up to pass a No. 4 sieve without breaking the aggregate. This may be done by means of a plastic mallet, rubber-covered tamp or similar hand tool. The material is then separated as described in step 6.

5. Aggregate materials, caliche, crushed rock, and gravel should be separated into sizes by dry screening to convenient cuts. The following size sieves: 1-3/4", 1-1/4", 7/8", 5/8", 3/8", No. 4 and No. 10 are adequate for average materials. In cases of unusual grading other sieves may be used to give better cuts. (Figure 3 shows 1/2 cu. ft. batch sieve shaker.)

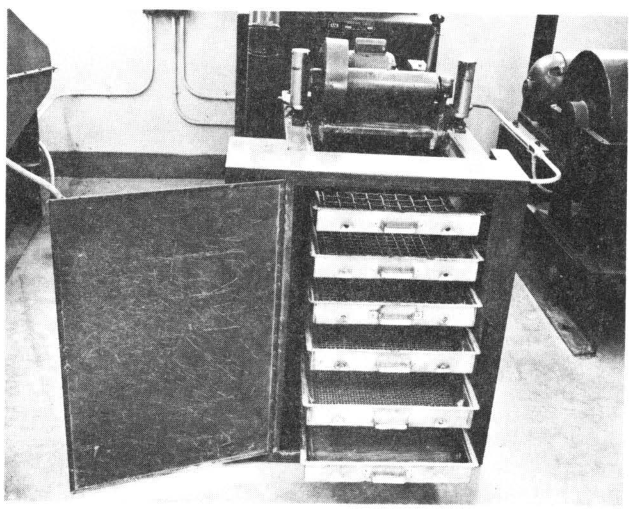


Figure 3
Gilson Shaker

6. Mix each size to make moisture as uniform as possible.

7. Weigh each size of material and compute the percentages, cumulative, retained on each sieve. These values are not to be used as a true sieve analysis, but are to be used in recombining the sample for individual specimens.

8. On the basis of the cumulated sieve size percents obtained in step 6 above, calculate and weigh out a 10-pound representative sample for soil constants and sieve analysis.

Calculations

1. Determine the percentage retained on each sieve, i.e.,

$$\text{Percent retained} = \frac{\text{Weight retained}}{\text{Total Weight of sample}} \times 100$$

2. Weight retained (any sieve) =

$$\frac{10.0 \text{ lbs. x percent retained}}{100}$$

General Notes

1. Sample preparation shall be subject to controls specified by the individual tests.

2. Do not scoop or pour materials to reduce to laboratory test size. Always use sample splitter or quartering cloth.

3. Check sieves for broken mesh or distorted openings.

4. Check mechanical pulverizer for proper adjustment of grinding plates.

5. Prevent the loss of any fine material during the process of crushing or washing of sample.

6. Do not overheat soils. Temperatures higher than 140°F. may change the physical and chemical characteristics of the soil.

7. Do not use chemicals to speed up the slaking and settling of soils in a water suspension. Most chemicals tried for this purpose reduce the plasticity of the soil.

Reporting Test Results

Report the percent of soil binder on Form No. 476-A, Soils and Base Material Report. Note that materials which contain aggregate prepared by Part I of this method usually have a higher percentage of soil binder than those prepared by Dry Method A.S.T.M. D-421-58 and A.A.S.H.O. T 87-49.