

**MANUAL FOR SAMPLING  
ESKER DEPOSITS AND LABORATORY  
TESTING PROCEDURES**

0701-11546

JULY, 1994



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**SUBMITTED TO:**

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**SECTION 1**  
**SAMPLE DESCRIPTION**

## **1.0 SAMPLE DESCRIPTION**

### **1.1 GENERAL**

This manual has been prepared to enable field personnel to describe soils as they are encountered and used for engineering purposes. It is not intended to be a soil classification system. Whenever possible terminology used should conform with that of the Unified Soil Classification System (USC).

The word soil, as used in engineering, refers to all surficial materials that are found overlying bedrock. Soil may be grouped into three major divisions: coarse-grained, fine-grained, and organic.

Coarse-grained soils may be described as those made up largely of particles visible to the naked eye. This group includes boulders, cobbles, gravel and sand particles. Fine-grained soils are made up of particles not visible to the naked eye. Plasticity and particle size cannot be accurately determined without the use of refined testing. For field identification, fine-grained soils may be classed as silt or clay by their behaviour in a few simple tests. The simple tests listed below may be used to establish the identity of the soils:

- **Shaking Test**

When a wet pat of soil is shaken vigorously in the hand, the surface will become glossy and show free water. If the pat of soil is then squeezed in the fingers, the free water may disappear and the surface become dull, i.e. dilates. With clay soils this phenomenon will not be noticeable but with silts and fine sands a rapid or good reaction will be exhibited.

- **Shine Test**

If a moist lump is stroked with considerable pressure with the flat of a pen knife blade or finger-nail, the type of surface imparted is an indication of the soil: if a shiny surface results, the presence of clay is indicated; silt is indicated if a dull surface is produced.

- **Dry Strength Test**

If a small piece of dry fine-grained soil is broken or crushed with the fingers, the breaking strength is an indication of the relative amounts of silt or clay. Very low dry strength is indicated when the soil powders readily in the fingers, and may be taken as an indication of a sandy silt or silt. Medium dry strength is shown by difficulty in powdering the soil by finger pressure, but the soil can be broken into small pieces without great difficulty. This state indicates silty clays and clays of medium plasticity. High dry strength is indicated when the pat of dry soil cannot be broken with the fingers. A highly plastic clay is indicated by this condition.

In addition to the tests mentioned above, clay sticks to the fingers when wet, and does not wash off readily, whereas silt will wash away easily or brush off if dry. When a small amount of soil is placed between the teeth, the presence of grit will indicate silt or sand, but if no grit is detected a pure clay is present.

Organic soils are placed in a separate group because of their appreciable content of organic matter. Organic soils are very compressible and spongy. Purely organic soils are easily recognized by their matted or fibrous structure. Partly organic soils may behave as a silt or clay, but are very compressible and usually have a characteristic odour.

The order in which a soil is described is as follows:

1. Principal Component (capital letters).
2. Unified Soil Classification (in parentheses)
3. Principal component modifiers (record in decreasing order)
4. Particle shape, size and grading.
5. Moisture
6. Colour (Munsell colour chart for reference).

Most soils consist of a mixture of various particle sizes. Therefore, the first step is to decide which is the principal fraction and the components which act as a modifier. Table 1 lists the principal soil divisions with their characteristics which lead to identification.

**TABLE 1**  
**GENERAL BASIS FOR FIELD DESCRIPTION OF SOILS**

MAJOR DIVISION	SUBDIVISION	FIELD IDENTIFICATION
COARSE- GRAINED SOILS	Boulders Cobbles	<ul style="list-style-type: none"> <li>- boulders greater than 200 mm.</li> <li>- cobbles smaller than 200 mm but larger than 75 mm.</li> </ul>
	Gravel	<ul style="list-style-type: none"> <li>- smaller than 75 mm but larger than 5 mm</li> <li>- coarse-grained gravel is smaller than 75 mm but larger than 20 mm</li> <li>- fine-grained gravel is smaller than 20 mm but larger than 5 mm</li> </ul>
	Sand	<ul style="list-style-type: none"> <li>- smaller than 5 mm but larger than 0.075 mm.</li> <li>- coarse-grained sand is smaller than 5 mm but larger than 2 mm</li> <li>- medium-grained sand is smaller than 2 mm but larger than 0.4 mm</li> <li>- fine-grained sand is smaller than 0.4 mm but larger than 0.075 mm</li> </ul>
FINE-GRAINED SOILS	Silt	<ul style="list-style-type: none"> <li>- exhibits dilatancy (reacts to shaking test)</li> <li>- powders easily when dry, only slight dry strength</li> <li>- gritty to the teeth</li> <li>- dries rapidly</li> <li>- no shine imparted when moist and stroked with knife blade</li> </ul>
	Clay	<ul style="list-style-type: none"> <li>- not dilatant</li> <li>- possesses appreciable dry strength</li> <li>- when moist, sticks to fingers and does not wash off readily</li> <li>- not gritty to the teeth</li> <li>- when moist, a shiny surface is imparted when stroked with a knife blade.</li> </ul>
ORGANIC SOILS	Partly organic - organic clay - organic silt etc.	<p>Depending on amount of organic material, these soils usually have some of the characteristics of their inorganic counterparts:</p> <ul style="list-style-type: none"> <li>- usually highly compressible (spongy)</li> <li>- usually have characteristic odour</li> </ul>
	Organic Material	<p>Fibrous structure - usually brown or black when moist. Spongy. Usually has characteristic odour.</p>



## 1.2 TEXTURAL DESCRIPTION

The textural description is named after the principal component and modified by other components as follows:

Presence of Component "XXX"	Modifier
> 35%	and xxx
21 - 35%	xxx - cy
11 - 20 %	some xxx
1 - 10 %	trace of xxx

### Examples:

Clay	Silt	Sand	Gravel	Description
61	22	13	4	CLAY (C__) - silty, some sand, trace of gravel
-	5	55	40	SAND (S__) - AND GRAVEL - trace of silt
12	63	25		SILT (M__) - sandy, some clay

## 1.3 UNIFIED SOIL CLASSIFICATION

The Unified Soil Classification (USC) is determined in accordance with the chart presented in Figure 1.

## 1.4 PARTICLE SHAPE AND TEXTURE

The terms used to describe particle shape and texture as presented in Figure 2 are:

rounded, subrounded, angular, subangular,  
very rough, rough, smooth, polished.

# UNIFIED SOIL CLASSIFICATION †

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	CLASSIFICATION CRITERIA				
COARSE-GRAINED SOILS  More than 50% retained on No. 200 sieve *	GRAVELS 50% or more of coarse fraction retained on No. 4 sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines  GW, GP, SW, SP GM, GC, SM, SC Borderline Classification requiring use of dual symbols.	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3			
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW			
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols		
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7			
	SANDS More than 50% of coarse fraction passes No. 4 sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines.		$C_u = D_{60}/D_{10}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3			
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW			
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures		Atterberg limits plot below "A" line or plasticity index less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols		
			SC	Clayey sands, sand-clay mixtures		Atterberg limits plot above "A" line and plasticity index greater than 7			
			FINE-GRAINED SOILS  50% or more passes No. 200 sieve *	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands		<p><b>PLASTICITY CHART</b> For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols. Equation of A-line: <math>PI = 0.73(LL - 20)</math></p>
						CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
OL	Organic silts and organic silty clays of low plasticity								
SILTS AND CLAYS Liquid limit greater than 50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts							
	CH	Inorganic clays of high plasticity, fat clays							
	OH	Organic clays of medium to high plasticity							
HIGHLY ORGANIC SOILS	Pt	Peat, muck and other highly organic soils	* Based on the material passing the 3-in. (75-mm) sieve † ASTM Designation D 2487						

FIGURE 1 UNIFIED SOIL CLASSIFICATION CHART

PARTICLE SHAPE



*Rounded*



*Sub - Rounded*



*Sub - Angular*



*Angular*

PARTICLE TEXTURE



*Very - Rough*



*Rough*



*Smooth*



*Polished*

**FIGURE 2      PARTICLE SHAPE AND TEXTURE**

## 1.5 GRADATION

Grading is the term applied to the particle-size distribution of the soil. A uniform soil has a predominance of particles of one size, well-graded material has sizes assorted over a wide range with no one size predominating, while gap-graded material has sizes assorted over a wide range with a certain size lacking. Illustrations of the three gradations previously listed are presented on Figure 3.

## 1.6 MOISTURE CONTENT

The following terms are used to describe the moisture content:

dry, damp, moist, wet, saturated

## 1.7 COLOUR

Colour is given the least priority in order of soil description. Colour gives some indication as to whether or not the soil has been oxidized and provides a means for field identification.

Soil colour is determined by comparison with a Munsell colour chart. By using a standardized colour chart any discrepancies due to the difference in which individuals perceive colour are eliminated. For this reason, the Hue, Value and Chrome should be recorded.

## PARTICLE - SIZE ANALYSIS OF SOILS

Project: \_\_\_\_\_

Project Number: \_\_\_\_\_

Date Tested: \_\_\_\_\_

Borehole Number: \_\_\_\_\_

Depth: \_\_\_\_\_

Soil Description: \_\_\_\_\_

Cu: \_\_\_\_\_

Cc: \_\_\_\_\_

Natural Moisture Content: \_\_\_\_\_ %

Remarks: \_\_\_\_\_

SIEVE	PERCENTAGE PASSING
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	
No. 10	
No. 20	
No. 40	
No. 60	
No. 100	
No. 200	

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

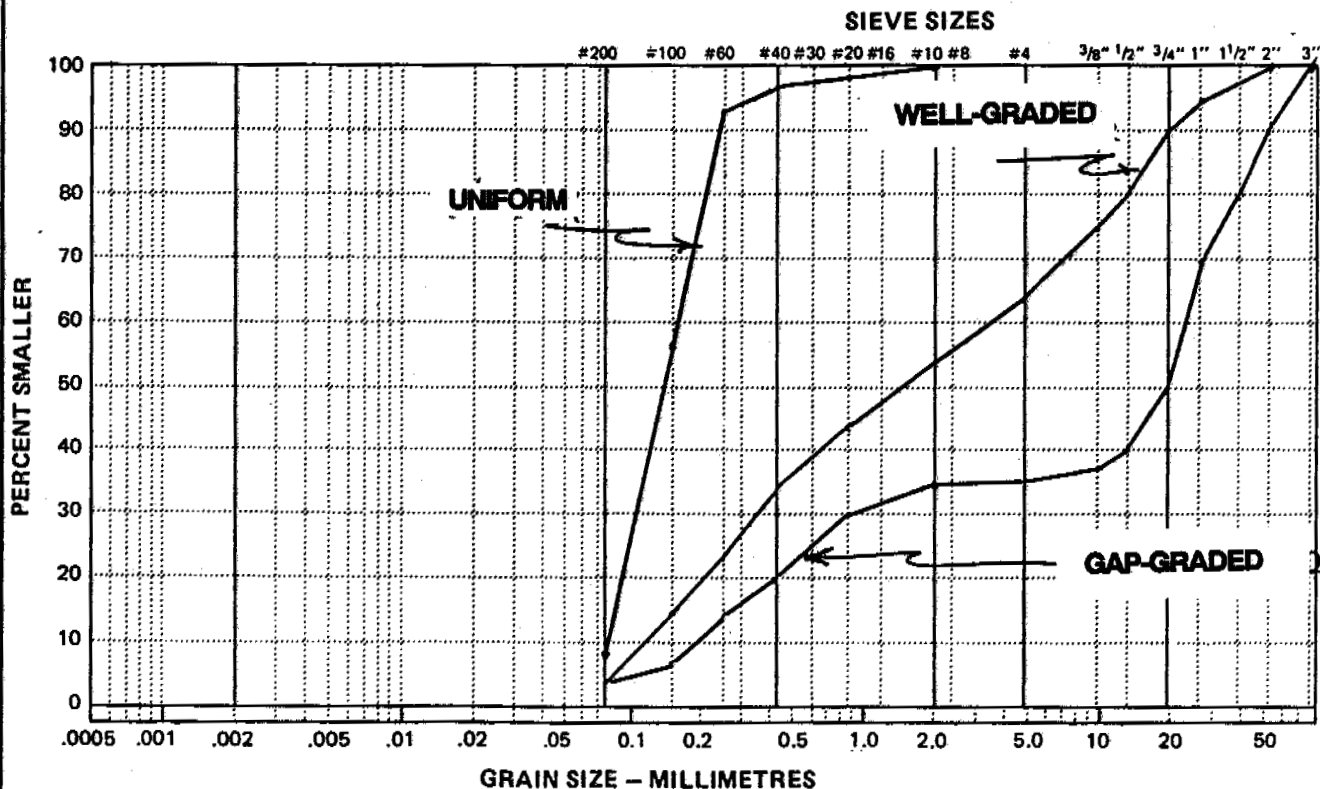


FIGURE 3

GENERALIZED SOIL GRADING CURVES

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA.

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.



## CHECK LIST FOR DESCRIPTION OF COARSE-GRAINED SOILS

1. *Typical Name:*      Boulders      Cobbles      Gravel      Sand

Add descriptive adjectives for minor constituents

2. *USC Symbol:*      Estimate if desired. See Figure 1

3. *Gradation:* (Well-graded) (Poorly-graded) (Uniformly-graded) (Gap-Graded)

Describe range of particle sizes or predominant size or sizes as coarse, medium, or fine sand or gravel.

4. *Maximum Particle Size:*      Note percent by volume of both boulders and cobbles

5. *Size Distribution:*      Approximate percent gravel, sand and fines in fraction finer than 75 mm.

6. *Grain Shape/Texture:*      Angular      Subangular      Subrounded      Rounded

Very rough      Rough      Smooth      Polished

7. *Colour:*      Use Munsell notation, if possible

8. *Odour:*      None      Earthy      Organic

May be neglected except for dark coloured soils.

9. *Moisture Content:*      Dry      Damp      Moist      Wet      Saturated





## Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)<sup>1</sup>

This standard is issued under the fixed designation D 2487; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

### 1. Scope

1.1 This standard describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.

NOTE 1—Use of this standard will result in a single classification group symbol and group name except when a soil contains 5 to 12 % fines or when the plot of the liquid limit and plasticity index values falls into the crosshatched area of the plasticity chart. In these two cases, a dual symbol is used, for example, GP-GM, CL-ML. When the laboratory test results indicate that the soil is close to another soil classification group, the borderline condition can be indicated with two symbols separated by a slash. The first symbol should be the one based on this standard, for example, CL/CH, GM/SM, SC/CL. Borderline symbols are particularly useful when the liquid limit value of clayey soils is close to 50. These soils can have expansive characteristics and the use of a borderline symbol (CL/CH, CH/CL) will alert the user of the assigned classifications of expansive potential.

1.2 The group symbol portion of this system is based on laboratory tests performed on the portion of a soil sample passing the 3-in. (75-mm) sieve (see Specification E 11).

1.3 As a classification system, this standard is limited to naturally occurring soils.

NOTE 2—The group names and symbols used in this test method may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. See Appendix X2.

1.4 This standard is for qualitative application only.

NOTE 3—When quantitative information is required for detailed designs of important structures, this test method must be supplemented by laboratory tests or other quantitative data to determine performance characteristics under expected field conditions.

1.5 This standard is the ASTM version of the Unified Soil Classification System. The basis for the classification scheme is the Airfield Classification System developed by A. Casagrande in the early 1940's.<sup>2</sup> It became known as the Unified Soil Classification System when several U.S. Government Agencies adopted a modified version of the Airfield System in 1952.

1.6 *This standard does not purport to address all of the*

*safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 117 Test Method for Materials Finer Than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing<sup>3</sup>
- C 136 Method for Sieve Analysis of Fine and Coarse Aggregates<sup>3</sup>
- C 702 Practice for Reducing Field Samples of Aggregate to Testing Size<sup>3</sup>
- D 420 Guide for Investigating and Sampling Soil and Rock<sup>4</sup>
- D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants<sup>4</sup>
- D 422 Test Method for Particle-Size Analysis of Soils<sup>4</sup>
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>4</sup>
- D 1140 Test Method for Amount of Material in Soils Finer than the No. 200 (75- $\mu$ m) Sieve<sup>4</sup>
- D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock<sup>4</sup>
- D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants<sup>4</sup>
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>4</sup>
- D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)<sup>4</sup>
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils<sup>4</sup>
- D 4427 Classification of Peat Samples by Laboratory Testing<sup>4</sup>
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>3</sup>

### 3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

<sup>1</sup> This standard is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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<sup>2</sup> Casagrande, A., "Classification and Identification of Soils," *Transactions, ASCE*, 1948, p. 901.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 04.02.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 04.08.



NOTE 4—For particles retained on a 3-in. (75-mm) U.S. standard sieve, the following definitions are suggested:

**Cobbles**—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) U.S. standard sieve, and  
**Boulders**—particles of rock that will not pass a 12-in. (300-mm) square opening

3.1.1 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) U.S. standard sieve with the following subdivisions:

**Coarse**—passes 3-in. (75-mm) sieve and retained on ¾-in. (19-mm) sieve, and  
**Fine**—passes ¾-in. (19-mm) sieve and retained on No. 4 (4.75-mm) sieve.

3.1.2 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) U.S. standard sieve with the following subdivisions:

**Coarse**—passes No. 4 (4.75-mm) sieve and retained on No. 10 (2.00-mm) sieve,  
**Medium**—passes No. 10 (2.00-mm) sieve and retained on No. 40 (425-μm) sieve, and  
**Fine**—passes No. 40 (425-μm) sieve and retained on No. 200 (75-μm) sieve.

3.1.3 *clay*—soil passing a No. 200 (75-μm) U.S. standard sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents and that exhibits considerable strength when air dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line.

3.1.4 *silt*—soil passing a No. 200 (75-μm) U.S. standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4 or if the plot of plasticity index versus liquid limit falls below the "A" line.

3.1.5 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.6 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.7 *peat*—a soil composed of vegetable tissue in various stages of decomposition usually with an organic odor, a dark-brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

### 3.2 Descriptions of Terms Specific to This Standard:

3.2.1 *coefficient of curvature, C<sub>c</sub>*—the ratio  $(D_{30})^2 / (D_{10} \times D_{60})$ , where  $D_{60}$ ,  $D_{30}$ , and  $D_{10}$  are the particle diameters corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve, respectively.

3.2.2 *coefficient of uniformity, C<sub>u</sub>*—the ratio  $D_{60} / D_{10}$ , where  $D_{60}$  and  $D_{10}$  are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve, respectively.

## 4. Summary

4.1 As illustrated in Table 1, this classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soil groups.

4.2 Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. The flow charts, Fig. 1 for fine-grained soils, and Fig. 2 for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name.

## 5. Significance and Use

5.1 This standard classifies soils from any geographic location into categories representing the results of prescribed laboratory tests to determine the particle-size characteristics, the liquid limit, and the plasticity index.

5.2 The assigning of a group name and symbol(s) along with the descriptive information required in Practice D 2488 can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.3 The various groupings of this classification system have been devised to correlate in a general way with the engineering behavior of soils. This standard provides a useful first step in any field or laboratory investigation for geotechnical engineering purposes.

5.4 This standard may also be used as an aid in training personnel in the use of Practice D 2488.

5.5 This standard may be used in combination with Practice D 4083 when working with frozen soils.

## 6. Apparatus

6.1 In addition to the apparatus that may be required for obtaining and preparing the samples and conducting the prescribed laboratory tests, a plasticity chart, similar to Fig. 3, and a cumulative particle-size distribution curve, similar to Fig. 4, are required.

NOTE 5—The "U" line shown on Fig. 3 has been empirically determined to be the approximate "upper limit" for natural soils. It is a good check against erroneous data, and any test results that plot above or to the left of it should be verified.

## 7. Sampling

7.1 Samples shall be obtained and identified in accordance with a method or methods, recommended in Recommended Guide D 420 or by other accepted procedures.

7.2 For accurate identification, the minimum amount of test sample required for this test method will depend on which of the laboratory tests need to be performed. Where only the particle-size analysis of the sample is required, specimens having the following minimum dry weights are required:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (¾ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

Whenever possible, the field samples should have weights two to four times larger than shown.

**TABLE 1 Soil Classification Chart**

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests<sup>a</sup>

Soil Classification

Group Symbol	Group Name <sup>b</sup>
--------------	-------------------------

<b>COARSE-GRAINED SOILS</b> More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines <sup>c</sup>	$Cu \geq 4$ and $1 \leq Cc \leq 3^e$	GW	Well-graded gravel <sup>f</sup>
			$Cu < 4$ and/or $1 > Cc > 3^e$	GP	Poorly graded gravel <sup>f</sup>
		Gravels with Fines More than 12 % fines <sup>c</sup>	Fines classify as ML or MH	GM	Silty gravel <sup>f,g,h</sup>
			Fines classify as CL or CH	GC	Clayey gravel <sup>f,g,h</sup>
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines <sup>c</sup>	$Cu \geq 6$ and $1 \leq Cc \leq 3^e$	SW	Well-graded sand <sup>i</sup>
			$Cu < 6$ and/or $1 > Cc > 3^e$	SP	Poorly graded sand <sup>i</sup>
		Sands with Fines More than 12 % fines <sup>c</sup>	Fines classify as ML or MH	SM	Silty sand <sup>g,h,i</sup>
			Fines classify as CL or CH	SC	Clayey sand <sup>g,h,i</sup>
<b>FINE-GRAINED SOILS</b> 50 % or more passes the No. 200 sieve	Silt and Clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line <sup>j</sup>	CL	Lean clay <sup>k,l,m</sup>
			$PI < 4$ or plots below "A" line <sup>j</sup>	ML	Silt <sup>k,l,m</sup>
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$	OL	Organic clay <sup>k,l,m,n</sup> Organic silt <sup>k,l,m,o</sup>
	Silt and Clays Liquid limit 50 or more	Inorganic	$PI$ plots on or above "A" line	CH	Fat clay <sup>k,l,m</sup>
			$PI$ plots below "A" line	MH	Elastic silt <sup>k,l,m</sup>
		Organic	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$	OH	Organic clay <sup>k,l,m,p</sup> Organic silt <sup>k,l,m,q</sup>
<b>HIGHLY ORGANIC SOILS</b>	Primarily organic matter, dark in color, and organic odor			PT	Peat

<sup>a</sup> Based on the material passing the 3-in. (75-mm) sieve.

<sup>b</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>c</sup> Gravels with 5 to 12 % fines require dual symbols:

GW-GM well-graded gravel with silt  
GW-GC well-graded gravel with clay  
GP-GM poorly graded gravel with silt  
GP-GC poorly graded gravel with clay

<sup>d</sup> Sands with 5 to 12 % fines require dual symbols:

SW-SM well-graded sand with silt  
SW-SC well-graded sand with clay  
SP-SM poorly graded sand with silt  
SP-SC poorly graded sand with clay

<sup>e</sup>  $Cu = D_{60}/D_{10}$      $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

<sup>f</sup> If soil contains  $\geq 15$  % sand, add "with sand" to group name.

<sup>g</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>h</sup> If fines are organic, add "with organic fines" to group name.

<sup>i</sup> If soil contains  $\geq 15$  % gravel, add "with gravel" to group name.

<sup>j</sup> If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

<sup>k</sup> If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>l</sup> If soil contains  $\geq 30$  % plus No. 200, predominantly sand, add "sandy" to group name.

<sup>m</sup> If soil contains  $\geq 30$  % plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>n</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>o</sup>  $PI < 4$  or plots below "A" line.

<sup>p</sup>  $PI$  plots on or above "A" line.

<sup>q</sup>  $PI$  plots below "A" line.

<sup>a</sup> Based on the material passing the 3-in. (75-mm) sieve.

<sup>b</sup> If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

<sup>c</sup> Gravels with 5 to 12 % fines require dual symbols:

GW-GM well-graded gravel with silt  
GW-GC well-graded gravel with clay  
GP-GM poorly graded gravel with silt  
GP-GC poorly graded gravel with clay

<sup>d</sup> Sands with 5 to 12 % fines require dual symbols:

SW-SM well-graded sand with silt  
SW-SC well-graded sand with clay  
SP-SM poorly graded sand with silt  
SP-SC poorly graded sand with clay

$$Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

<sup>e</sup> If soil contains  $\geq 15$  % sand, add "with sand" to group name.

<sup>f</sup> If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

<sup>g</sup> If fines are organic, add "with organic fines" to group name.

<sup>h</sup> If soil contains  $\geq 15$  % gravel, add "with gravel" to group name.

<sup>i</sup> If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

<sup>j</sup> If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

<sup>k</sup> If soil contains  $\geq 30$  % plus No. 200, predominantly sand, add "sandy" to group name.

<sup>l</sup> If soil contains  $\geq 30$  % plus No. 200, predominantly gravel, add "gravelly" to group name.

<sup>m</sup>  $PI \geq 4$  and plots on or above "A" line.

<sup>n</sup>  $PI < 4$  or plots below "A" line.

<sup>o</sup>  $PI$  plots on or above "A" line.

<sup>p</sup>  $PI$  plots below "A" line.

7.3 When the liquid and plastic limit tests must also be performed, additional material will be required sufficient to provide 150 g to 200 g of soil finer than the No. 40 (425- $\mu$ m) sieve.

7.4 If the field sample or test specimen is smaller than the minimum recommended amount, the report shall include an appropriate remark.

## 8. Classification of Peat

8.1 A sample composed primarily of vegetable tissue in various stages of decomposition and has a fibrous to amorphous texture, a dark-brown to black color, and an organic odor should be designated as a highly organic soil and shall be classified as peat, PT, and not subjected to the classification procedures described hereafter.

8.2 If desired, classification of type of peat can be performed in accordance with Classification D 4427.

## 9. Preparation for Classification

9.1 Before a soil can be classified according to this standard, generally the particle-size distribution of the minus 3-in. (75-mm) material and the plasticity characteristics of the minus No. 40 (425- $\mu$ m) sieve material must be determined.

See 9.8 for the specific required tests.

9.2 The preparation of the soil specimen(s) and the testing for particle-size distribution and liquid limit and plasticity index shall be in accordance with accepted standard procedures. Two procedures for preparation of the soil specimens for testing for soil classification purposes are given in Appendixes X3 and X4. Appendix X3 describes the wet preparation method and is the preferred method for cohesive soils that have never dried out and for organic soils.

9.3 When reporting soil classifications determined by this standard, the preparation and test procedures used shall be reported or referenced.

9.4 Although the test procedure used in determining the particle-size distribution or other considerations may require a hydrometer analysis of the material, a hydrometer analysis is not necessary for soil classification.

9.5 The percentage (by dry weight) of any plus 3-in. (75-mm) material must be determined and reported as auxiliary information.

9.6 The maximum particle size shall be determined (measured or estimated) and reported as auxiliary information.

9.7 When the cumulative particle-size distribution is required, a set of sieves shall be used which include the

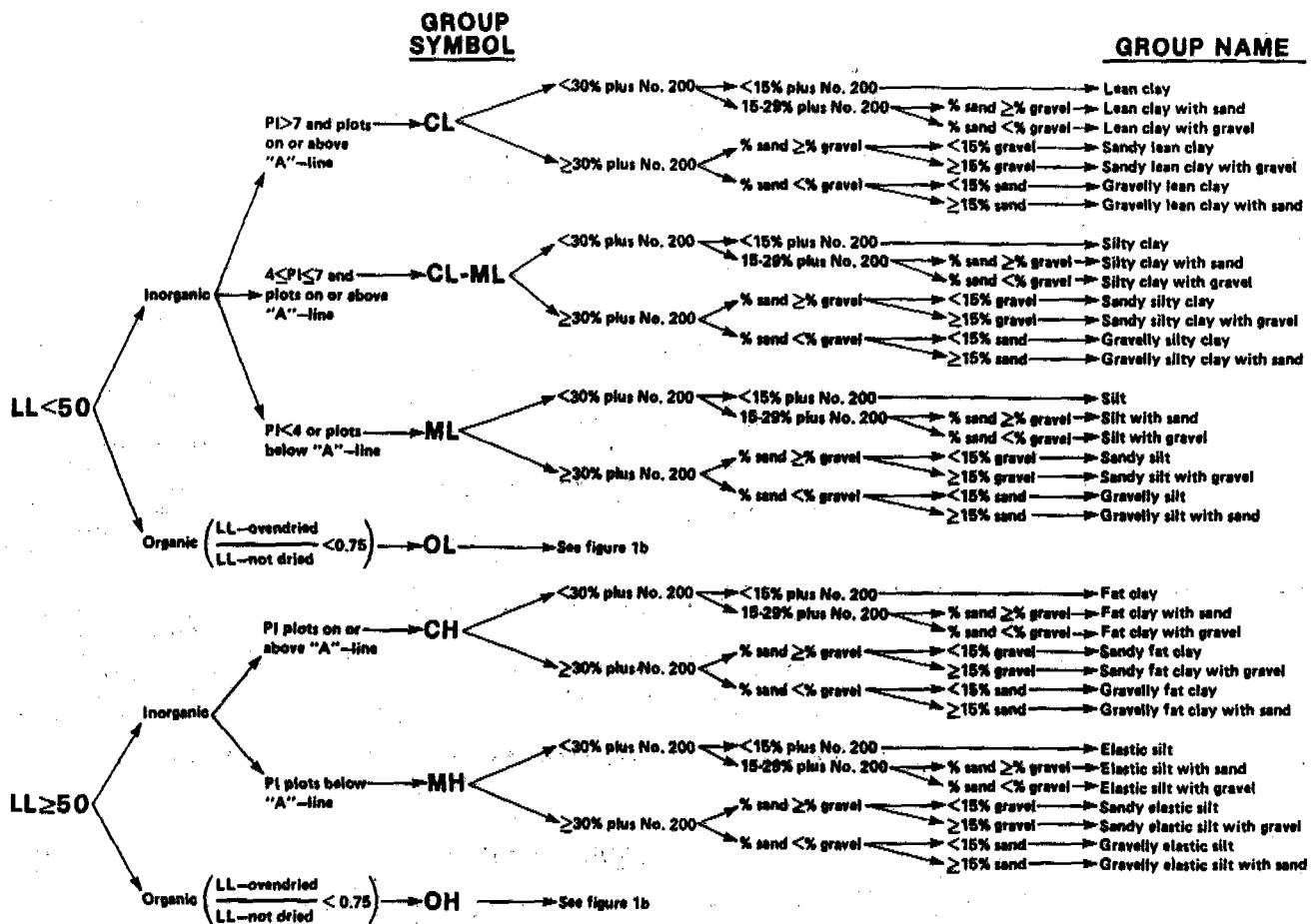


FIG. 1a Flow Chart for Classifying Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

following sizes (with the largest size commensurate with the maximum particle size) with other sieve sizes as needed or required to define the particle-size distribution:

- 3-in. (75-mm)
- 3/4-in. (19.0-mm)
- No. 4 (4.75-mm)
- No. 10 (2.00-mm)
- No. 40 (425-μm)
- No. 200 (75-μm)

9.8 The tests required to be performed in preparation for classification are as follows:

9.8.1 For soils estimated to contain less than 5 % fines, a plot of the cumulative particle-size distribution curve of the fraction coarser than the No. 200 (75-μm) sieve is required. The cumulative particle-size distribution curve may be plotted on a graph similar to that shown in Fig. 4.

9.8.2 For soils estimated to contain 5 to 15 % fines, a cumulative particle-size distribution curve, as described in 9.8.1, is required, and the liquid limit and plasticity index are required.

9.8.2.1 If sufficient material is not available to determine the liquid limit and plasticity index, the fines should be estimated to be either silty or clayey using the procedures described in Practice D 2488 and so noted in the report.

9.8.3 For soils estimated to contain 15 % or more fines, a determination of the percent fines, percent sand, and percent gravel is required, and the liquid limit and plasticity index

are required. For soils estimated to contain 90 % fines or more, the percent fines, percent sand, and percent gravel may be estimated using the procedures described in Practice D 2488 and so noted in the report.

## 10. Preliminary Classification Procedure

10.1 Class the soil as fine-grained if 50 % or more by dry weight of the test specimen passes the No. 200 (75-μm) sieve and follow Section 11.

10.2 Class the soil as coarse-grained if more than 50 % by dry weight of the test specimen is retained on the No. 200 (75-μm) sieve and follow Section 12.

## 11. Procedure for Classification of Fine-Grained Soils (50 % or more by dry weight passing the No. 200 (75-μm) sieve)

11.1 The soil is an inorganic clay if the position of the plasticity index versus liquid limit plot, Fig. 3, falls on or above the "A" line, the plasticity index is greater than 4, and the presence of organic matter does not influence the liquid limit as determined in 11.3.2.

NOTE 6—The plasticity index and liquid limit are determined on the minus No. 40 (425 μm) sieve material.

11.1.1 Classify the soil as a *lean clay*, CL, if the liquid limit is less than 50. See area identified as CL on Fig. 3.

11.1.2 Classify the soil as a *fat clay*, CH, if the liquid limit

GROUP SYMBOL

GROUP NAME

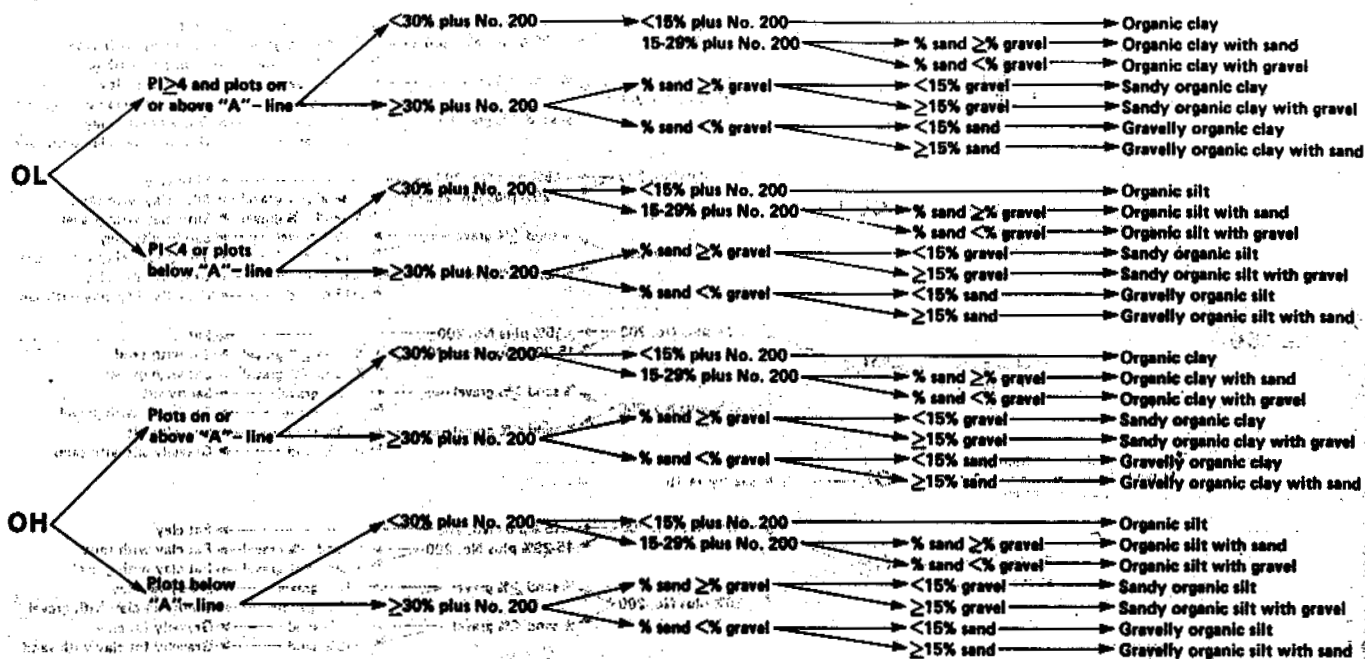


FIG. 1b Flow Chart for Classifying Organic Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

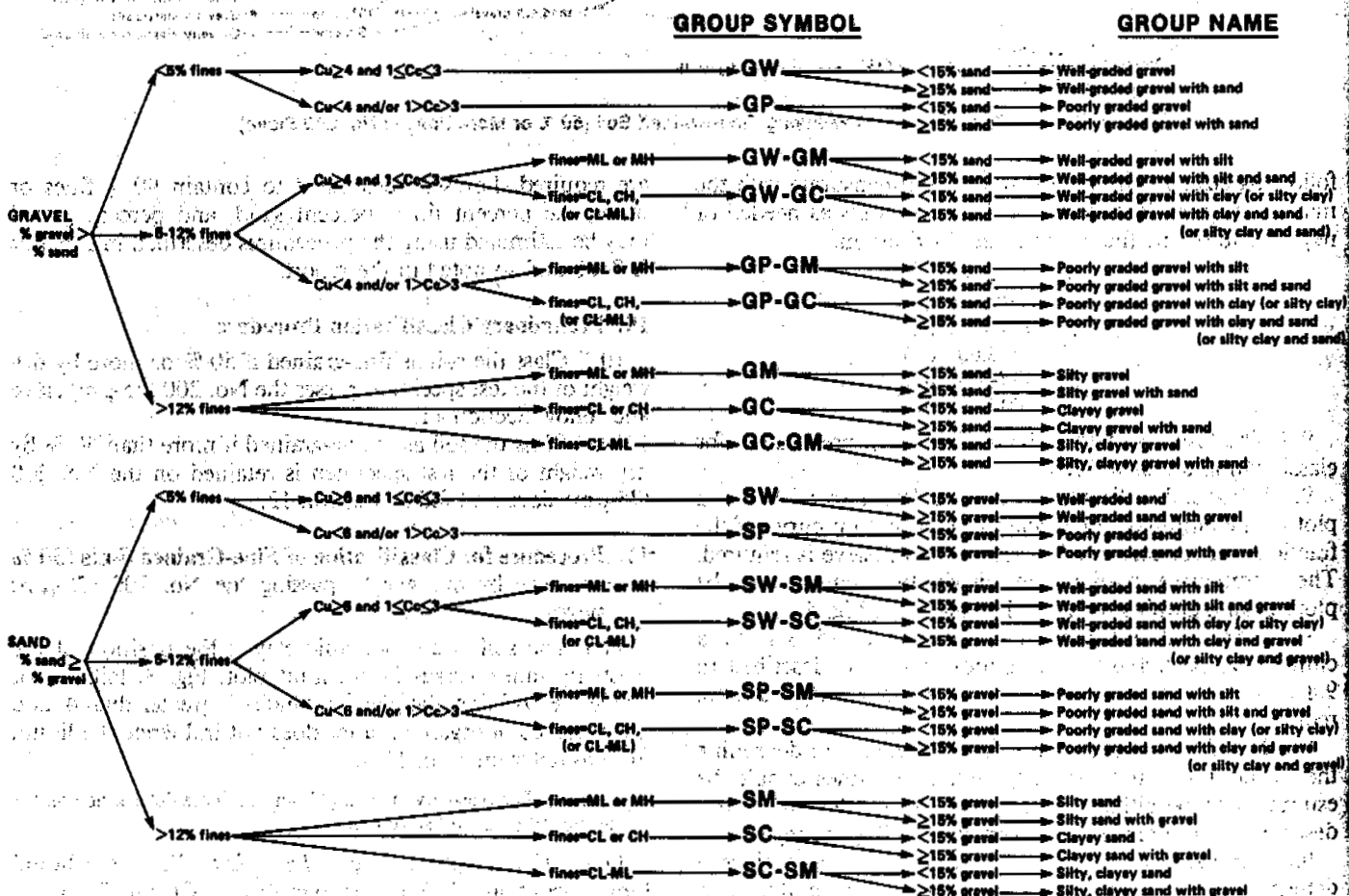


FIG. 2 Flow Chart for Classifying Coarse-Grained Soils (More Than 50 % Retained on No. 200 Sieve)

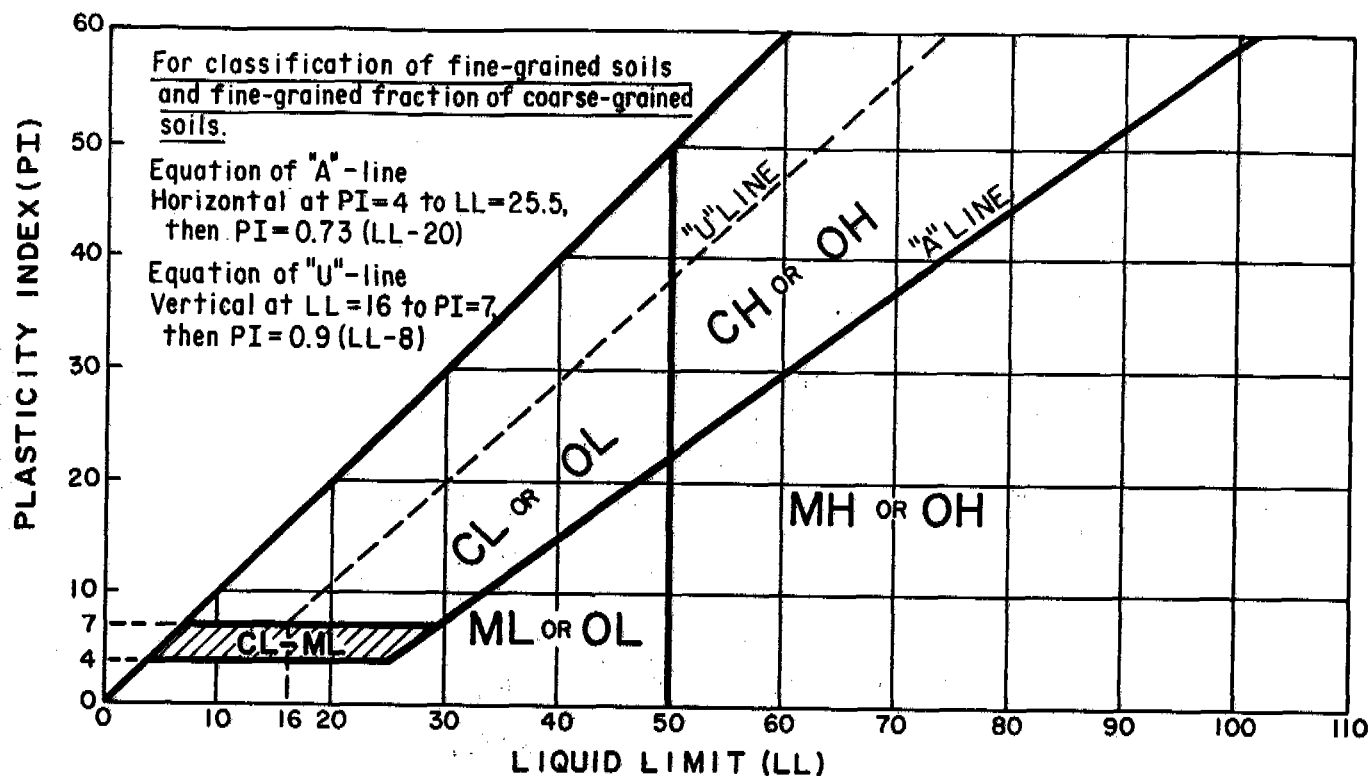


FIG. 3 Plasticity Chart

is 50 or greater. See area identified as CH on Fig. 3.

NOTE 7—In cases where the liquid limit exceeds 110 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the "A" line at the indicated slope:

11.1.3 Classify the soil as a *silty clay*, CL-ML, if the position of the plasticity index versus liquid limit plot falls on or above the "A" line and the plasticity index is in the range of 4 to 7. See area identified as CL-ML on Fig. 3.

11.2 The soil is an inorganic silt if the position of the plasticity index versus liquid limit plot, Fig. 3, falls below the "A" line or the plasticity index is less than 4, and presence of organic matter does not influence the liquid limit as determined in 11.3.2.

11.2.1 Classify the soil as a *silt*, ML, if the liquid limit is less than 50. See area identified as ML on Fig. 3.

11.2.2 Classify the soil as an *elastic silt*, MH, if the liquid limit is 50 or greater. See area identified as MH on Fig. 3.

11.3 The soil is an organic silt or clay if organic matter is present in sufficient amounts to influence the liquid limit as determined in 11.3.2.

11.3.1 If the soil has a dark color and an organic odor when moist and warm, a second liquid limit test shall be performed on a test specimen which has been oven dried at  $110 \pm 5^\circ\text{C}$  to a constant weight, typically over night.

11.3.2 The soil is an organic silt or organic clay if the liquid limit after oven drying is less than 75 % of the liquid limit of the original specimen determined before oven drying (see Procedure B of Practice D 2217).

11.3.3 Classify the soil as an *organic silt* or *organic clay*, OL, if the liquid limit (not oven dried) is less than 50 %.

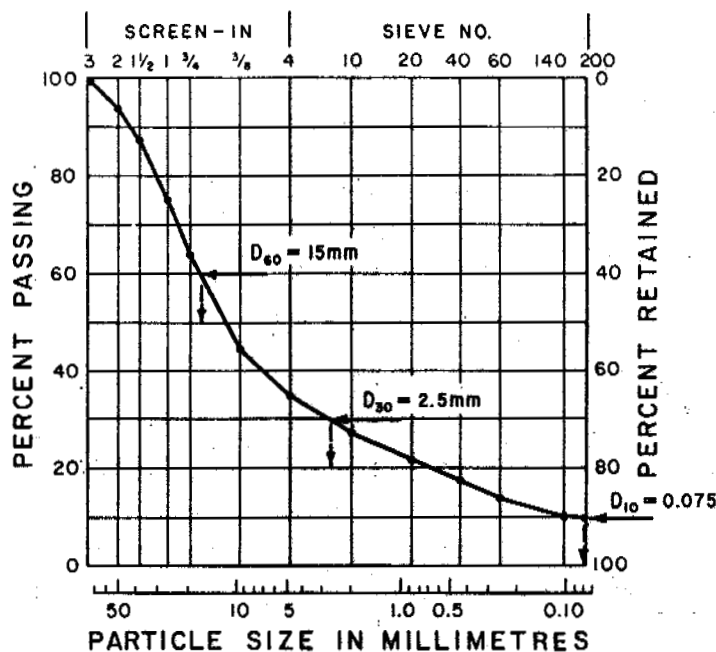
Classify the soil as an *organic silt*, OL, if the plasticity index is less than 4, or the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OL, if the plasticity index is 4 or greater and the position of the plasticity index versus liquid limit plot falls on or above the "A" line. See area identified as OL (or CL-ML) on Fig. 3.

11.3.4 Classify the soil as an *organic clay* or *organic silt*, OH, if the liquid limit (not oven dried) is 50 or greater. Classify the soil as an *organic silt*, OH, if the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OH, if the position of the plasticity index versus liquid limit plot falls on or above the "A" line. See area identified as OH on Fig. 3.

11.4 If less than 30 % but 15 % or more of the test specimen is retained on the No. 200 (75- $\mu\text{m}$ ) sieve, the words "with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example, lean clay with sand, CL; silt with gravel, ML. If the percent of sand is equal to the percent of gravel, use "with sand."

11.5 If 30 % or more of the test specimen is retained on the No. 200 (75- $\mu\text{m}$ ) sieve, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if 30 % or more of the test specimen is retained on the No. 200 (75- $\mu\text{m}$ ) sieve and the coarse-grained portion is predominantly sand. Add the word "gravelly" if 30 % or more of the test specimen is retained on the No. 200 (75- $\mu\text{m}$ ) sieve and the coarse-grained portion is predominantly gravel. For example, sandy lean clay, CL; gravelly fat clay, CH; sandy silt, ML. If the percent of sand is equal to the percent of gravel, use "sandy."

SIEVE ANALYSIS



$$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

FIG. 4 Cumulative Particle-Size Plot

12. Procedure for Classification of Coarse-Grained Soils (more than 50 % retained on the No. 200 (75- $\mu$ m) sieve)

12.1 Class the soil as gravel if more than 50 % of the coarse fraction [plus No. 200 (75- $\mu$ m) sieve] is retained on the No. 4 (4.75-mm) sieve.

12.2 Class the soil as sand if 50 % or more of the coarse fraction [plus No. 200 (75- $\mu$ m) sieve] passes the No. 4 (4.75-mm) sieve.

12.3 If 12 % or less of the test specimen passes the No. 200 (75- $\mu$ m) sieve, plot the cumulative particle-size distribution, Fig. 4, and compute the coefficient of uniformity,  $C_u$ , and coefficient of curvature,  $C_c$ , as given in Eqs 1 and 2.

$$C_u = D_{60}/D_{10} \quad (1)$$

$$C_c = (D_{30})^2/(D_{10} \times D_{60}) \quad (2)$$

where:

$D_{10}$ ,  $D_{30}$ , and  $D_{60}$  = the particle-size diameters corresponding to 10, 30, and 60 %, respectively, passing on the cumulative particle-size distribution curve, Fig. 4.

NOTE 8—It may be necessary to extrapolate the curve to obtain the  $D_{10}$  diameter.

12.3.1 If less than 5 % of the test specimen passes the No. 200 (75- $\mu$ m) sieve; classify the soil as a *well-graded gravel*, GW, or *well-graded sand*, SW, if  $C_u$  is greater than 4.0 for gravel or greater than 6.0 for sand, and  $C_c$  is at least 1.0 but not more than 3.0.

12.3.2 If less than 5 % of the test specimen passes the No. 200 (75- $\mu$ m) sieve, classify the soil as *poorly graded gravel*, GP, or *poorly graded sand*, SP, if either the  $C_u$  or the  $C_c$  criteria for well-graded soils are not satisfied.

12.4 If more than 12 % of the test specimen passes the No. 200 (75- $\mu$ m) sieve, the soil shall be considered a

coarse-grained soil with fines. The fines are determined to be either clayey or silty based on the plasticity index versus liquid limit plot on Fig. 3. (See 9.8.2.1 if insufficient material available for testing). (See NOTE 6)

12.4.1 Classify the soil as a *clayey gravel*, GC, or *clayey sand*, SC, if the fines are clayey, that is, the position of the plasticity index versus liquid limit plot, Fig. 3, falls on or above the "A" line and the plasticity index is greater than 7.

12.4.2 Classify the soil as a *silty gravel*, GM, or *silty sand*, SM, if the fines are silty, that is, the position of the plasticity index versus liquid limit plot, Fig. 3, falls below the "A" line or the plasticity index is less than 4.

12.4.3 If the fines plot as a silty clay, CL-ML, classify the soil as a *silty, clayey gravel*, GC-GM, if it is a gravel or a *silty, clayey sand*, SC-SM, if it is a sand.

12.5 If 5 to 12 % of the test specimen passes the No. 200 (75- $\mu$ m) sieve, give the soil a dual classification using two group symbols.

12.5.1 The first group symbol shall correspond to that for a gravel or sand having less than 5 % fines (GW, GP, SW, SP), and the second symbol shall correspond to a gravel or sand having more than 12 % fines (GC, GM, SC, SM).

12.5.2 The group name shall correspond to the first group symbol plus "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example, well-graded gravel with clay, GW-GC; poorly graded sand with silt, SP-SM (See 9.8.2.1 if insufficient material available for testing).

NOTE 9—If the fines plot as a *silty clay*, CL-ML, the second group symbol should be either GC or SC. For example, a poorly graded sand with 10 % fines, a liquid limit of 20, and a plasticity index of 6 would be classified as a poorly graded sand with silty clay, SP-SC.



12.6 If the specimen is predominantly sand or gravel but contains 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example, poorly graded gravel with sand, clayey sand with gravel.

12.7 If the field sample contained any cobbles or boulders or both, the words "with cobbles," or "with cobbles and boulders" shall be added to the group name. For example, silty gravel with cobbles, GM.

### 13. Report

13.1 The report should include the group name, group symbol, and the results of the laboratory tests. The particle-size distribution shall be given in terms of percent of gravel, sand, and fines. The plot of the cumulative particle-size distribution curve shall be reported if used in classifying the soil. Report appropriate descriptive information according to

the procedures in Practice D 2488. A local or commercial name or geologic interpretation for the material may be added at the end of the descriptive information if identified as such. The test procedures used shall be referenced.

NOTE 10—Example: *Clayey Gravel with Sand and Cobbles (GC)*—46 % fine to coarse, hard, subrounded gravel; 30 % fine to coarse, hard, subrounded sand; 24 % clayey fines, LL = 38, PI = 19; weak reaction with HCl; original field sample had 4 % hard, subrounded cobbles; maximum dimension 150 mm.

In-Place Conditions—firm, homogeneous, dry, brown,

Geologic Interpretation—alluvial fan.

NOTE 11—Other examples of soil descriptions are given in Appendix X1.

### 14. Keywords

14.1 Atterberg limits; classification; clay; gradation; gravel; laboratory classification; organic soils; sand; silt; soil classification; soil tests

## APPENDICES

### (Nonmandatory Information)

#### X1. EXAMPLES OF DESCRIPTIONS USING SOIL CLASSIFICATION

X1.1 The following examples show how the information required in 13.1 can be reported. The appropriate descriptive information from Practice D 2488 is included for illustrative purposes. The additional descriptive terms that would accompany the soil classification should be based on the intended use of the classification and the individual circumstances.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—73 % fine to coarse, hard, subangular gravel; 23 % fine to coarse, hard, subangular sand; 4 % fines; Cc = 2.7, Cu = 12.4.

X1.1.2 *Silty Sand with Gravel (SM)*—61 % predominantly fine sand; 23 % silty fines, LL = 33, PI = 6; 16 % fine, hard, subrounded gravel; no reaction with HCl; (field sample smaller than recommended). *In-Place Conditions*—Firm, stratified and contains lenses of silt 1 to 2 in. thick, moist,

brown to gray; in-place density = 106 lb/ft<sup>3</sup> and in-place moisture = 9 %.

X1.1.3 *Organic Clay (OL)*—100 % fines, LL (not dried) = 32, LL (oven dried) = 21, PI (not dried) = 10; wet, dark brown, organic odor, weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—74 % fine to coarse, hard, subangular reddish sand; 26 % organic and silty dark-brown fines, LL (not dried) = 37, LL (oven dried) = 26, PI (not dried) = 6, wet, weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—78 % fine to coarse, hard, subrounded to subangular gravel; 16 % fine to coarse, hard, subrounded to subangular sand; 6 % silty (estimated) fines; moist, brown; no reaction with HCl; original field sample had 7 % hard, subrounded cobbles and 2 % hard, subrounded boulders with a maximum dimension of 18 in.

#### X2. USING SOIL CLASSIFICATION AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, ETC.

X2.1 The group names and symbols used in this standard may be used as a descriptive system applied to materials that exist in situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, etc.).

X2.2 Materials such as shells, crushed rock, slag, etc., should be identified as such. However, the procedures used in this standard for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, a classification in accordance with this standard may be assigned to aid in describing the material.

X2.3 If a classification is used, the group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how soil classifications could be incorporated into a description system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. pieces of shale from power auger hole, dry, brown, no reaction with HCl. After laboratory processing by slaking in water for 24 h, material classified as "Sandy Lean Clay (CL)"—61 % clayey fines, LL = 37, PI = 16; 33 % fine to medium sand; 6 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"—91 % fine to medium sand; 9 % silty (estimated) fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—62 % gravel-size broken shells;

31 % sand and sand-size shell pieces; 7 % fines; would be classified as "Poorly Graded Gravel with Sand (GP)".

X2.4.4 *Crushed Rock*—Processed gravel and cobbles from Pit No. 7; "Poorly Graded Gravel (GP)"—89 % fine,

hard, angular gravel-size particles; 11 % coarse, hard, angular sand-size particles, dry, tan; no reaction with HCl;  $C_c = 2.4$ ,  $C_u = 0.9$ .

### X3. PREPARATION AND TESTING FOR CLASSIFICATION PURPOSES BY THE WET METHOD

X3.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification using a wet-preparation procedure.

X3.2 Samples prepared in accordance with this procedure should contain as much of their natural water content as possible and every effort should be made during obtaining, preparing, and transporting the samples to maintain the natural moisture.

X3.3 The procedures to be followed in this standard assume that the field sample contains fines, sand, gravel, and plus 3-in. (75-mm) particles and the cumulative particle-size distribution plus the liquid limit and plasticity index values are required (see 9.8). Some of the following steps may be omitted when they are not applicable to the soil being tested.

X3.4 If the soil contains plus No. 200 (75- $\mu$ m) particles that would degrade during dry sieving, use a test procedure for determining the particle-size characteristics that prevents this degradation.

X3.5 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X3.6 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X3.6.1 Separate the field sample into two fractions on a 3-in. (75-mm) sieve, being careful to maintain the natural water content in the minus 3-in. (75-mm) fraction. Any particles adhering to the plus 3-in. (75-mm) particles shall be brushed or wiped off and placed in the fraction passing the 3-in. (75-mm) sieve.

X3.6.2 Determine the air-dry or oven-dry weight of the fraction retained on the 3-in. (75-mm) sieve. Determine the total (wet) weight of the fraction passing the 3-in. (75-mm) sieve.

X3.6.3 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve. Determine the water content, in accordance with Test Method D 2216, of a representative specimen with a minimum dry weight as required in 7.2. Save the water-content specimen for determination of the particle-size analysis in accordance with X3.8.

X3.6.4 Compute the dry weight of the fraction passing the 3-in. (75-mm) sieve based on the water content and total (wet) weight. Compute the total dry weight of the sample and calculate the percentage of material retained on the 3-in. (75-mm) sieve.

X3.7 Determine the liquid limit and plasticity index as follows:

X3.7.1 If the soil disaggregates readily, mix on a clean,

hard surface and select a representative sample by quartering in accordance with Practice C 702.

X3.7.1.1 If the soil contains coarse-grained particles coated with and bound together by tough clayey material, take extreme care in obtaining a representative portion of the No. 40 (425- $\mu$ m) fraction. Typically, a larger portion than normal has to be selected, such as the minimum weights required in 7.2.

X3.7.1.2 To obtain a representative specimen of a basically cohesive soil, it may be advantageous to pass the soil through a 3/4-in. (19-mm) sieve or other convenient size so the material can be more easily mixed and then quartered or split to obtain the representative specimen.

X3.7.2 Process the representative specimen in accordance with Procedure B of Practice D 2217.

X3.7.3 Perform the liquid-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test.

X3.7.4 Perform the plastic-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test, and calculate the plasticity index.

X3.8 Determine the particle-size distribution as follows:

X3.8.1 If the water content of the fraction passing the 3-in. (75-mm) sieve was required (X3.6.3), use the water-content specimen for determining the particle-size distribution. Otherwise, select a representative specimen in accordance with Practice C 702 with a minimum dry weight as required in 7.2.

X3.8.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of required sieves.

X3.8.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Method C 136. See 9.7 for the set of required sieves. The specimen should be soaked until all clayey aggregations have softened and then washed in accordance with Test Method C 117 prior to performing the particle-size distribution.

X3.8.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method C 117, being sure to soak the specimen long enough to soften all clayey aggregations, followed by Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75- $\mu$ m) sieve.

X3.8.5 Calculate the percent fines, percent sand, and percent gravel in the minus 3-in. (75-mm) fraction for classification purposes.



#### X4. AIR-DRIED METHOD OF PREPARATION OF SOILS FOR TESTING FOR CLASSIFICATION PURPOSES

X4.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification when air-drying the soil before testing is specified or desired or when the natural moisture content is near that of an air-dried state.

X4.2 If the soil contains organic matter or mineral colloids that are irreversibly affected by air drying, the wet-preparation method as described in Appendix X3 should be used.

X4.3 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X4.4 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X4.4.1 Air dry and weigh the field sample.

X4.4.2 Separate the field sample into two fractions on a 3-in. (75-mm) sieve.

X4.4.3 Weigh the two fractions and compute the percentage of the plus 3-in. (75-mm) material in the field sample.

X4.5 Determine the particle-size distribution and liquid limit and plasticity index as follows (see 9.8 for when these tests are required):

X4.5.1 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve.

X4.5.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of sieves that is required.

X4.5.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 1140 followed by Method C 136. See 9.7 for the set of sieves that is required.

X4.5.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method D 1140 followed by Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75- $\mu$ m) sieve.

X4.5.5 If required, determine the liquid limit and the plasticity index of the test specimen in accordance with Test Method D 4318.

#### X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graph-log logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix	Suffix
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = cobbles
	b = boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-Sm, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

#### X6. RATIONALE

X6.1 Changes in this version from the previous D 2488 - 92 include the addition of X5 on Abbreviated Soil

Classification Symbols.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.*





# Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>1</sup>

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

## 1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.*

1.5 The values stated in inch-pound units are to be regarded as the standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>2</sup>
- D 1452 Practice for Soil Investigation and Sampling by Auger Borings<sup>2</sup>
- D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils<sup>2</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.

D 1587 Practice for Thin-Walled Tube Sampling of Soils<sup>2</sup>

D 2113 Practice for Diamond Core Drilling for Site Investigation<sup>2</sup>

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)<sup>2</sup>

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)<sup>2</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

**Cobbles**—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

**Boulders**—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1.2 **clay**—soil passing a No. 200 (75- $\mu$ m) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.1.3 **gravel**—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

**coarse**—passes a 3-in. (75-mm) sieve and is retained on a 3/4-in. (19-mm) sieve.

**fine**—passes a 3/4-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.1.4 **organic clay**—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

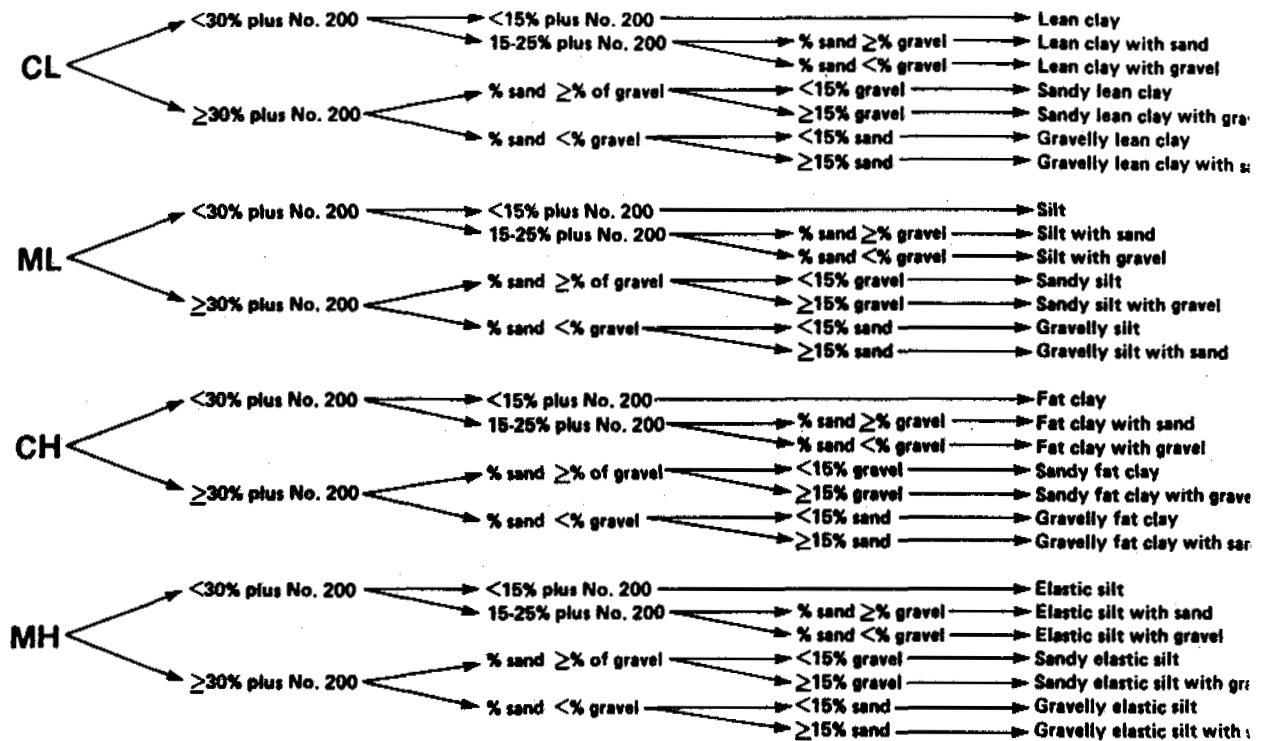
3.1.1.5 **organic silt**—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.1.6 **peat**—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.1.7 **sand**—particles of rock that will pass a No. 4

**GROUP SYMBOL**

**GROUP NAME**



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

(4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

*coarse*—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

*medium*—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

*fine*—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.1.8 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the “A” line (see Fig. 3 of Test Method D 2487).

**4. Summary of Practice**

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

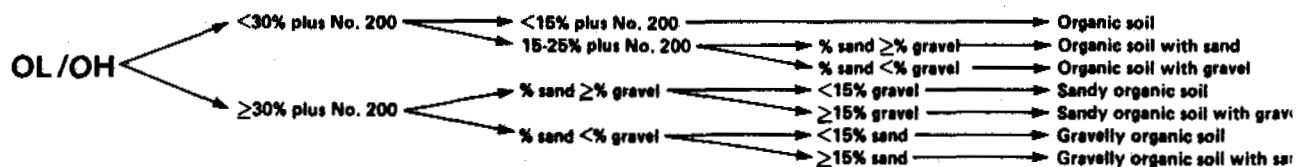
4.2 The soil can be given an identification by assigning group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it in a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

*Dual Symbol*—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines.

**GROUP SYMBOL**

**GROUP NAME**



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

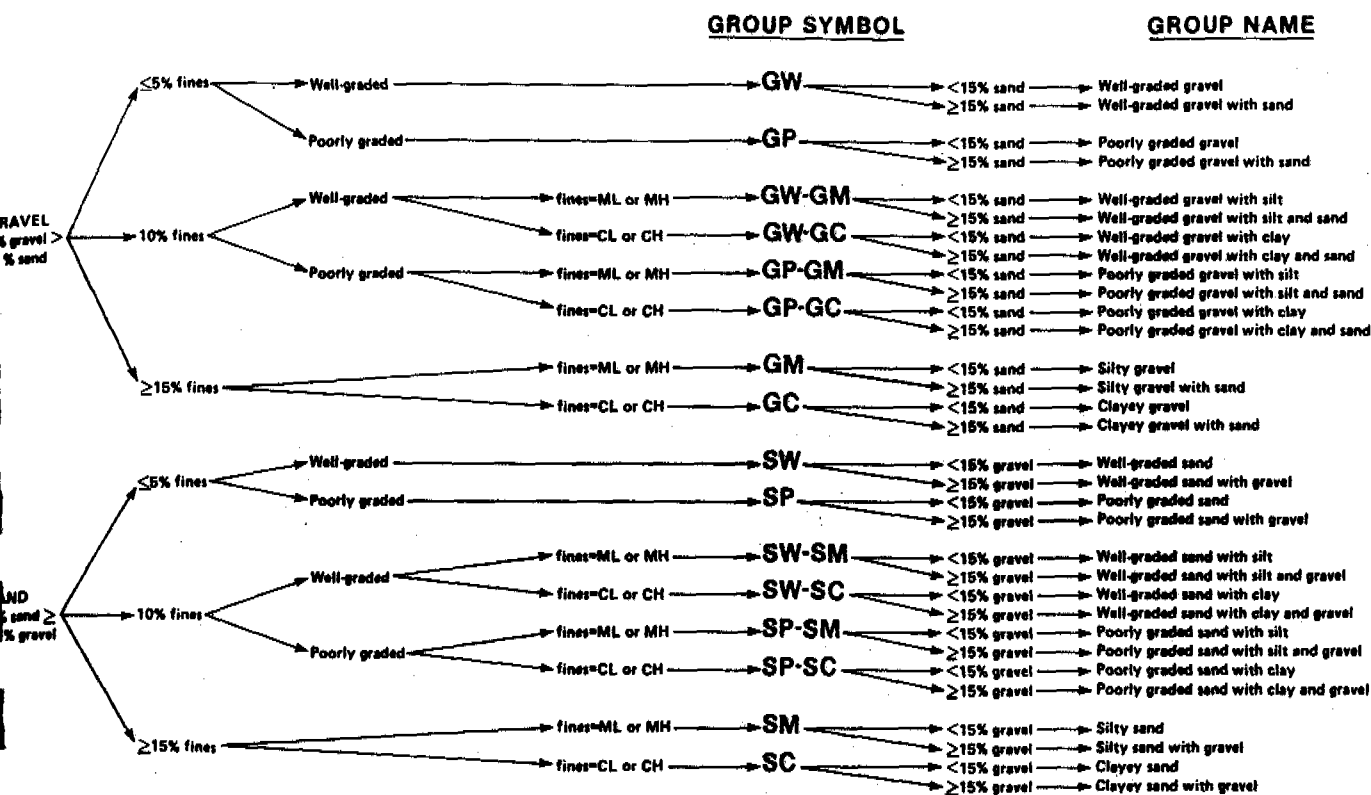


FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

**Borderline Symbol**—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol could be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see appendix X3).

## Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice could be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may be acquired systematically by comparing numerical laboratory test

results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

## 6. Apparatus

### 6.1 Required Apparatus:

#### 6.1.1 Pocket Knife or Small Spatula.

### 6.2 Useful Auxiliary Apparatus:

#### 6.2.1 Small Test Tube and Stopper (or jar with a lid).

#### 6.2.2 Small Hand Lens.

## 7. Reagents

7.1 **Purity of Water**—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 **Hydrochloric Acid**—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 N) to three parts water (This reagent is optional for use with this practice). See Section 8.

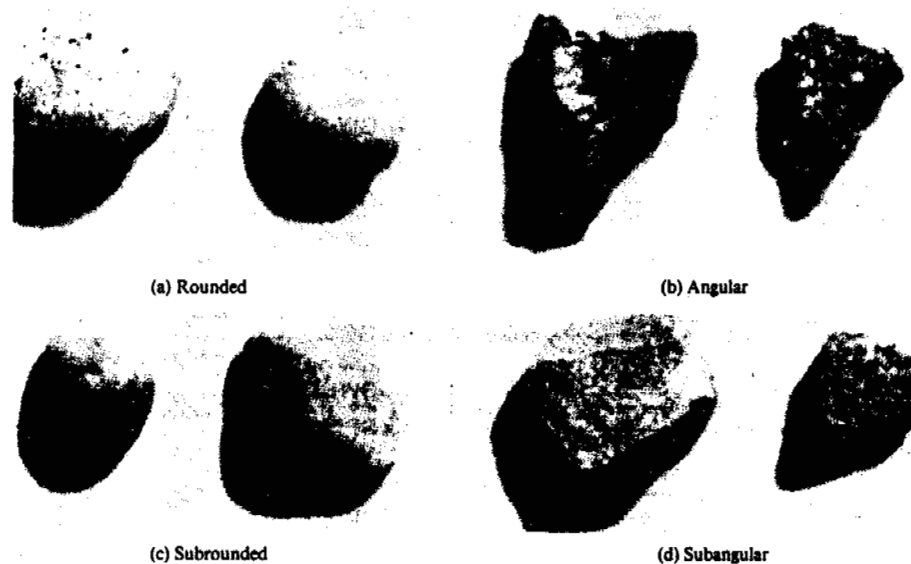


FIG. 3 Typical Angularity of Bulky Grains

## 8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

## 9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (3/8 in.)	200 g (0.5 lb)
19.0 mm (3/4 in.)	1.0 kg (2.2 lb)
38.1 mm (1 1/2 in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

## 10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given

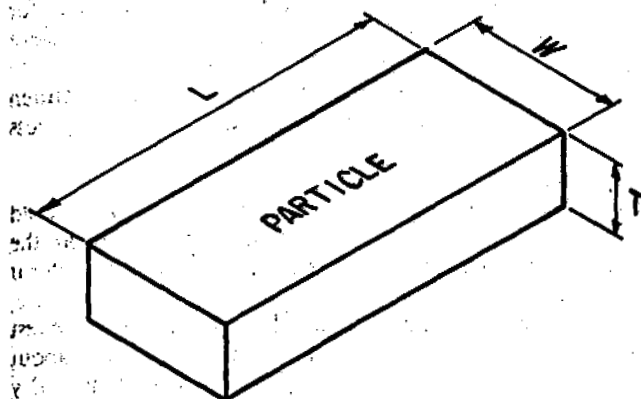
TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

## PARTICLE SHAPE

W = WIDTH  
T = THICKNESS  
L = LENGTH



FLAT:  $W/T > 3$

ELONGATED:  $L/W > 3$

FLAT AND ELONGATED:  
— meets both criteria

FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the criteria in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about 1/4 in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1 1/2 in. (will pass a 1 1/2-in. square opening but not a 3/4-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation.

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure



TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

### 11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

### 12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

### 13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more

fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

### 14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

#### 14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

#### 14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

tation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

### 11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

### 12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

### 13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more

fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

### 14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

#### 14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

#### 14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

#### 14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 Plasticity—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

#### 14.7 Identification of Inorganic Fine-Grained Soils:

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

#### 14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

#### 15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

## 16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 13—Example: *Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
  - Gravel—fine, coarse
  - Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong
- For intact samples:
  18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
  19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
  20. Cementation: weak, moderate, strong
  21. Local name
  22. Geologic interpretation
  23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification are given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in logs, forms, summary tables, reports, and the like, that the symbols and name are based on visual-manual procedures.

## 17. Precision and Bias

17.1 This practice provides qualitative information only; therefore, a precision and bias statement is not applicable.

## 18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

## APPENDIXES

## (Nonmandatory Information)

## X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

*In-Place Conditions*—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray;

in-place density 106 lb/ft<sup>3</sup>; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

## X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incorporated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to

100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

## X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two

possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the

percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-

grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay

ML/CL clayey silt

CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

#### X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size

present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

#### X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

## X6. RATIONALE

Changes in this version from the previous version, D 2488 - 90, include the addition of X5 on Abbreviated Soil

### Classification Symbols.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

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## **SECTION 2**

### **SAMPLING FROM A HAND-EXCAVATED TEST PIT**



## **2.0 SAMPLING FROM A HAND EXCAVATED TEST PIT**

### **2.1 GENERAL**

Proper sampling is as important as the intended testing. The test pit should be excavated to the desired depth and a sidewall should be neatly trimmed to expose a fresh face. The exposed face should be examined for changes in gradation and logged accordingly. The overall borrow site, test pit, and exposed test pit wall should be photographed. It is important to ensure there is an object in the photo that will provide a general scale.

### **2.2 REPRESENTATIVE SAMPLING COARSE GRAINED SOIL (GRAVEL AND SAND)**

Samples should be obtained from each different stratum in the deposit. Either individual or composite samples are obtained by excavating into the exposed face with a cut of uniform cross-section. The sample can either be readily collected while excavating or gathered on a polyethylene sheet or a suitable cloth sheet spread out at the base of the cut. The minimum cross-section dimension at the sampling location should be at least four times the dimension of the largest gravel size included in the soil.

Individual small samples taken from several locations in a uniform stratum can be combined and thoroughly mixed to form a representative bulk sample of the required volume. When taking individual samples, it is important to be certain that sufficient representative material is obtained from the stratum and to ensure that extraneous material is not included.

When taking a sample at a lower elevation in the test pit by inserting a board into the trench wall above the point of sampling will aid in preventing possible segregation and/or ensure extraneous material is not introduced.

### **2.3 REPRESENTATIVE SAMPLING COARSE-GRAINED SOIL (SAND)**

A sand stratum may be sampled as previously outlined in Section 2.2 or alternatively may be sampled by means of a sampling tube (approximately 25 mm in diameter and 1 metre in length). With a little practise, the tube will hold damp sand which is forced into it as the tube is inserted into the exposed face of the test pit. A series of insertions will provide the sample size required.

### **2.4 REPRESENTATIVE SAMPLING FINE-GRAINED SOILS (SILTS AND CLAYS)**

In general, the procedure as outlined for sampling of coarse-grained soils (sands and gravels) also apply for fine-grained soils. Fine-grained soils (silts and clays) are generally cohesive; a spade is usually the best tool for obtaining samples.

### **2.5 REDUCING FIELD SAMPLES OF COARSE-GRAINED SOILS TO TESTING SIZE**

Table 1 provides a general guideline as to the mass of sample required as obtained in the field and subsequently reduced for testing purposes.

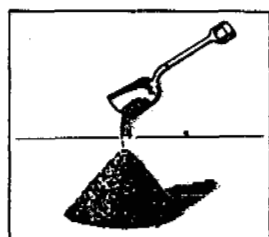
Quartering and splitting are the two most frequent methods used. If at all possible, all reduction of sample size should be done damp to prevent loss of the fines fractions.

The "quartering method" should be done on a clean surface. A tarpaulin/plastic sheet is convenient in that pulling up the edges simplifies the combining. The material is carefully shovelled into a cone in the centre of the tarp. The cone is slightly flattened on the top and is then divided into four equal portions and separated one from the other. Two of the opposite portions are discarded and, if necessary, the remains are again quartered. Figure 1 illustrates the "quartering method" procedure.

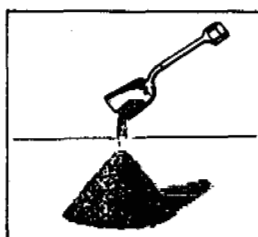
The splitting method (sometimes called riffing) is a mechanically aided process for dividing a sample into approximately equal portions. The sample is introduced into the top of the sample splitter in as uniform a manner as possible and one of the resultant "splits" is discarded. The remaining split is again introduced into the splitter until the sample size has been reduced to a size acceptable for testing. Figure 2 illustrates the mechanically aided splitting method.

**TABLE 1**  
**SAMPLE MASS REQUIREMENTS**

<b>Maximum Nominal Size (mm)</b>	<b>Approximate Minimum Mass of Field Sample (kg)</b>	<b>Approximate Minimum Mass of Moisture Content Sample (g)</b>	<b>Approximate Minimum Mass of Sieve Sample (g)</b>
5	10	500	500
10	15	1,000	1,000
25	50	1,500	5,000
50	100	3,000	10,000



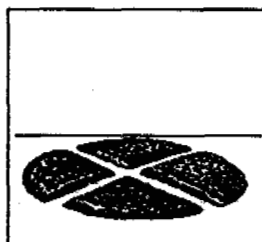
Cone Sample on Hard Clean Surface



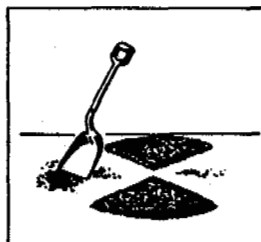
Mix by Forming New Cone



Quarter After Flattening Cone

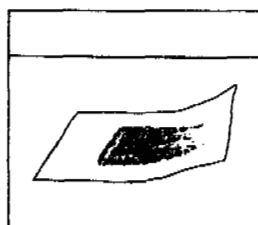


Sample Divided into Quarters

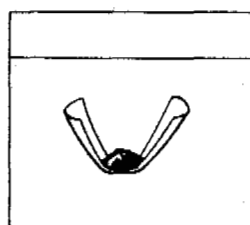


Retain Opposite Quarters  
Reject the Other Two Quarters

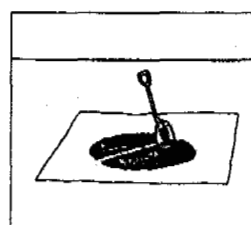
Quartering on a Hard, Clean Level Surface



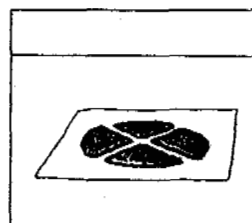
Mix by Rolling on Blanket



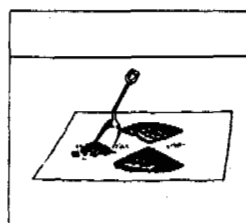
Form Cone after Mixing



Quarter After Flattening Cone



Sample Divided into Quarters

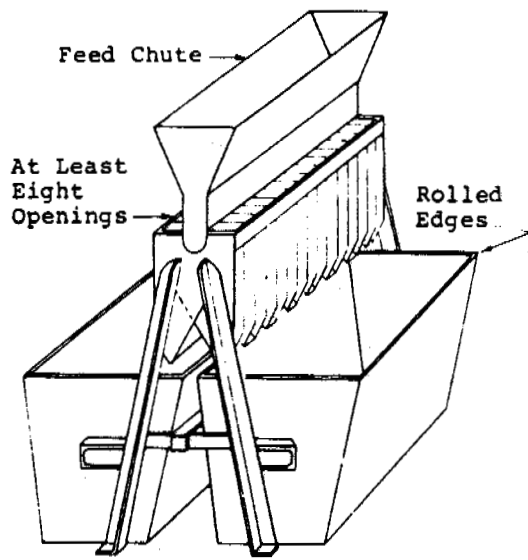


Retain Opposite Quarters  
Reject the Other Two Quarters

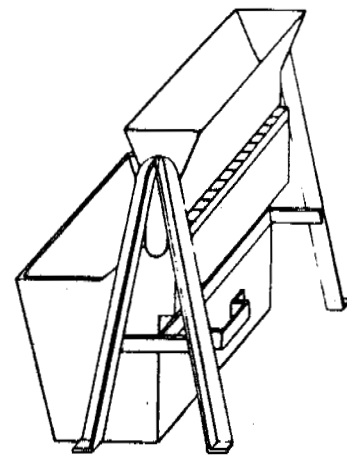
Quartering on a Canvas Blanket

FIGURE 1

REDUCING SAMPLE SIZE  
QUARTERING METHOD

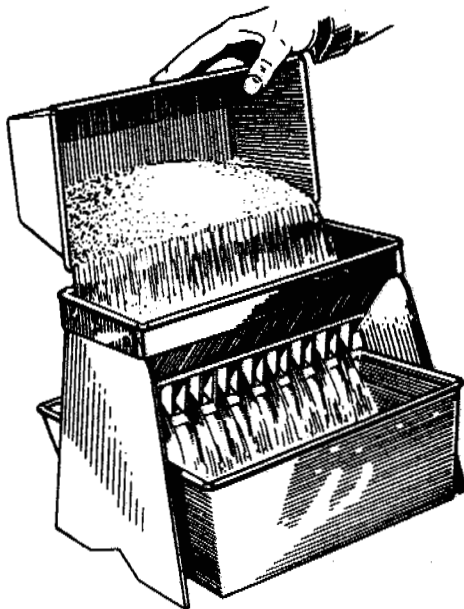


Riffle Sample Splitter

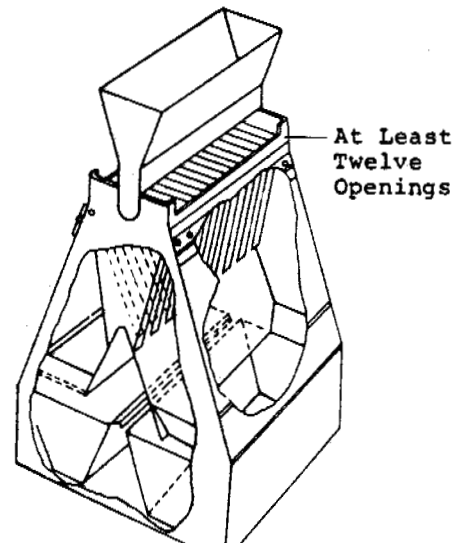


Riffle Bucket and  
Separate Feed Chute Stand

(a) Large Riffle Samplers for Coarse Aggregate



(b) Small Riffle Samplers for Fine Aggregate



NOTE—May be constructed as either closed or open type. Closed type is preferred.

## FIGURE 2

## REDUCING SAMPLE SIZE MECHANICAL METHOD





## Standard Practice for Sampling Aggregates<sup>1</sup>

This standard is issued under the fixed designation D 75; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This practice has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

<sup>e1</sup> NOTE—Editorial changes were made throughout in September 1992.

### 1. Scope\*

1.1 This practice covers sampling of coarse and fine aggregates for the following purposes:

- 1.1.1 Preliminary investigation of the potential source of supply,
- 1.1.2 Control of the product at the source of supply,
- 1.1.3 Control of the operations at the site of use, and
- 1.1.4 Acceptance or rejection of the materials.

NOTE 1—Sampling plans and acceptance and control tests vary with the type of construction in which the material is used. Attention is directed to Practices E 105 and D 3665.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 702 Practice for Reducing Field Samples of Aggregate to Testing Size<sup>2</sup>
- D 2234 Test Method for Collection of a Gross Sample of Coal<sup>3</sup>
- D 3665 Practice for Random Sampling of Construction Materials<sup>4</sup>
- E 105 Practice for Probability Sampling of Materials<sup>5</sup>
- E 122 Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process<sup>5</sup>
- E 141 Practice for Acceptance of Evidence Based on the Results of Probability Sampling<sup>5</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.30 on Methods of Sampling.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 05.05.

<sup>4</sup> Annual Book of ASTM Standards, Vol 04.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

### 3. Significance and Use

3.1 Sampling is equally as important as the testing, and the sampler shall use every precaution to obtain samples that will show the nature and condition of the materials which they represent.

3.2 Samples for preliminary investigation tests are obtained by the party responsible for development of the potential source (Note 2). Samples of materials for control of the production at the source or control of the work at the site of use are obtained by the manufacturer, contractor, or other parties responsible for accomplishing the work. Samples for tests to be used in acceptance or rejection decisions by the purchaser are obtained by the purchaser or his authorized representative.

NOTE 2—The preliminary investigation and sampling of potential aggregate sources and types occupies a very important place in determining the availability and suitability of the largest single constituent entering into the construction. It influences the type of construction from the standpoint of economics and governs the necessary material control to ensure durability of the resulting structure, from the aggregate standpoint. This investigation should be done only by a responsible trained and experienced person. For more comprehensive guidance, see the Appendix.

### 4. Securing Samples

4.1 *General*—Where practicable, samples to be tested for quality shall be obtained from the finished product. Samples from the finished product to be tested for abrasion loss shall not be subject to further crushing or manual reduction in particle size in preparation for the abrasion test unless the size of the finished product is such that it requires further reduction for testing purposes.

4.2 *Inspection*—The material shall be inspected to determine discernible variations. The seller shall provide suitable equipment needed for proper inspection and sampling.

#### 4.3 Procedure:

4.3.1 *Sampling from a Flowing Aggregate Stream (Bins or Belt Discharge)*—Select units to be sampled by a random method, such as Practice D 3665, from the production. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 4.4.2. Take each increment from the entire cross section of the material as it is being

\* A Summary of Changes section appears at the end of this practice.

TABLE 1 Size of Samples

Maximum Nominal Size of Aggregates <sup>A</sup>	Approximate Minimum Mass of Field Samples, lb (kg) <sup>B</sup>
<b>Fine Aggregate</b>	
No. 8 (2.36 mm)	25 (10)
No. 4 (4.75 mm)	25 (10)
<b>Coarse Aggregate</b>	
¾ in. (19.0 mm)	25 (10)
½ in. (12.5 mm)	35 (15)
¾ in. (19.0 mm)	55 (25)
1 in. (25.0 mm)	110 (50)
1½ in. (37.5 mm)	165 (75)
2 in. (50 mm)	220 (100)
2½ in. (63 mm)	275 (125)
3 in. (75 mm)	330 (150)
3½ in. (90 mm)	385 (175)

<sup>A</sup> For processed aggregate the nominal maximum size of particles is the largest sieve size listed in the applicable specification, upon which any material is permitted to be retained.

<sup>B</sup> For combined coarse and fine aggregates, (for example, base or subbase) minimum weight shall be coarse aggregate minimum plus 25 lb (10 kg).

discharged. It is usually necessary to have a special device constructed for use at each particular plant. This device consists of a pan of sufficient size to intercept the entire cross section of the discharge stream and hold the required quantity of material without overflowing. A set of rails may be necessary to support the pan as it is passed under the discharge stream. Insofar as is possible, keep bins continuously full or nearly full to reduce segregation.

**NOTE 3**—Sampling the initial discharge or the final few tons from a bin or conveyor belt increases the chances of obtaining segregated material and should be avoided.

**4.3.2 Sampling from the Conveyor Belt**—Select units to be sampled by a random method, such as Practice D 3665, from the production. Obtain at least three approximately equal increments, selected at random, from the unit being sampled and combine to form a field sample whose mass equals or exceeds the minimum recommended in 4.4.2. Stop the conveyor belt while the sample increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt in the aggregate stream on the belt, and space them such that the material contained between them will yield an increment of the required weight. Carefully scoop all material between the templates into a suitable container and collect the fines on the belt with a brush and dust pan and add to the container.

**4.3.3 Sampling from Stockpiles or Transportation Units**—Avoid sampling coarse aggregate or mixed coarse and fine aggregate from stockpiles or transportation units whenever possible, particularly when the sampling is done for the purpose of determining aggregate properties that may be dependent upon the grading of the sample. If circumstances make it necessary to obtain samples from a stockpile of coarse aggregate or a stockpile of combined coarse and fine aggregate, design a sampling plan for the specific case under consideration. This approach will allow the sampling agency to use a sampling plan that will give a confidence in results obtained therefrom that is agreed upon by all parties concerned to be acceptable for the particular situation. The sampling plan shall define the number of samples necessary to represent lots and sublots of specific sizes. General principles for sampling from stockpiles are applicable to sampling from trucks, rail cars, barges or other transportation units. For general guidance in sampling from stockpiles, see the Appendix.

**4.3.4 Sampling from Roadway (Bases and Subbases)**—Sample units selected by a random method, such as Practice D 3665, from the construction. Obtain at least three approximately equal increments, selected at random from the unit being sampled, and combine to form a field sample whose mass equals or exceeds the minimum recommended in 4.4.2. Take all increments from the roadway for the full depth of the material, taking care to exclude any underlying material. Clearly mark the specific areas from which each increment is to be removed: a metal template placed over the area is a definite aid in securing approximately equal increment weights.

#### 4.4 Number and Masses of Field Samples

**4.4.1** The number of field samples (obtained by one of the methods described in 4.3) required depends on the criticality of, and variation in, the properties to be measured. Designate each unit from which a field sample is to be obtained prior to sampling. The number of field samples from the production should be sufficient to give the desired confidence in test results.

**NOTE 4**—Guidance for determining the number of samples required to obtain the desired level of confidence in test results may be found in Test Method D 2234, Practice E 105, Practice E 122, and Practice E 141.

**4.4.2** The field sample masses cited are tentative. The masses must be predicated on the type and number of tests to which the material is to be subjected and sufficient material obtained to provide for the proper execution of these tests. Standard acceptance and control tests are covered by ASTM standards and specify the portion of the field sample required for each specific test. Generally speaking, the amounts specified in Table 1 will provide adequate material for routine grading and quality analysis. Extract test portions from the field sample according to Practice C 702 or as required by other applicable test methods.

#### 5. Shipping Samples

**5.1** Transport aggregates in bags or other containers so constructed as to preclude loss or contamination of any part of the sample, or damage to the contents from mishandling during shipment.

**5.2** Shipping containers for aggregate samples shall have suitable individual identification attached and enclosed so that field reporting, laboratory logging, and test reporting may be facilitated.

#### 6. Keywords

6.1 aggregates, exploration of potential sources; aggregates, number and sizes needed to estimate character; aggregates, sampling



## APPENDIXES

(Nonmandatory Information)

### X1. SAMPLING AGGREGATE FROM STOCKPILES OR TRANSPORTATION UNITS

#### X1.1 Scope

X1.1.1 In some situations it is mandatory to sample aggregates that have been stored in stockpiles or loaded into rail cars, barges, or trucks. In such cases the procedure should ensure that segregation does not introduce a serious bias in the results.

#### X1.2 Sampling from Stockpiles

X1.2.1 In sampling material from stockpiles it is very difficult to ensure unbiased samples, due to the segregation which often occurs when material is stockpiled, with coarser particles rolling to the outside base of the pile. For coarse or mixed coarse and fine aggregate, every effort should be made to enlist the services of power equipment to develop a separate, small sampling pile composed of materials drawn from various levels and locations in the main pile after which several increments may be combined to compose the field sample. If necessary to indicate the degree of variability existing within the main pile, separate samples should be drawn from separate areas of the pile.

X1.2.2 Where power equipment is not available, samples from stockpiles should be made up of at least three increments taken from the top third, at the mid-point, and at the bottom third of the volume of the pile. A board shoved vertically into the pile just above the sampling point aids in preventing further segregation. In sampling stockpiles of fine

aggregate the outer layer, which may have become segregated, should be removed and the sample taken from the material beneath. Sampling tubes approximately 1¼-in. (30-mm) min by 6 ft (2-m) min in length may be inserted into the pile at random locations to extract a minimum of five increments of material to form the sample.

#### X1.3 Sampling from Transportation Units

X1.3.1 In sampling coarse aggregates from railroad cars or barges, effort should be made to enlist the services of power equipment capable of exposing the material at various levels and random locations. Where power equipment is not available, a common procedure requires excavation of three or more trenches across the unit at points that will, from visual appearance, give a reasonable estimate of the characteristics of the load. The trench bottom should be approximately level, at least 1 ft (0.3 m) in width and in depth below the surface. A minimum of three increments from approximately equally spaced points along each trench should be taken by pushing a shovel downward into the material. Coarse aggregate in trucks should be sampled in essentially the same manner as for rail cars or barges, except for adjusting the number of increments according to the size of the truck. For fine aggregate in transportation units, sampling tubes as described in X1.2 may be used to extract an appropriate number of increments to form the sample.

### X2. EXPLORATION OF POTENTIAL AGGREGATE SOURCES

#### X2.1 Scope

X2.1.1 Sampling for evaluation of potential aggregate sources should be performed by a responsible trained and experienced person. Because of the wide variety of conditions under which sampling may have to be done it is not possible to describe detailed procedures applicable to all circumstances. This appendix is intended to provide general guidance and list more comprehensive references.

#### X2.2 Sampling Stone from Quarries or Ledges

X2.2.1 *Inspection*—The ledge or quarry face should be inspected to determine discernible variations or strata. Differences in color and structure should be recorded.

X2.2.2 *Sampling and Size of Sample*—Separate samples having a mass of at least 50 lb (approximately 25 kg) should be obtained from each discernible stratum. The sample should not include material weathered to such an extent that it is no longer suitable for the purpose intended. One or more pieces in each sample should be at least 6 by 6 by 4 in. (150 by 150 by 100 mm) in size with the bedding plane plainly marked, and this piece should be free of seams or fractures.

X2.2.3 *Record*—In addition to the general information

accompanying all samples the following information should accompany samples taken from ledges or quarry faces:

X2.2.3.1 Approximate quantity available. (If quantity is very large this may be recorded as practically unlimited.)

X2.2.3.2 Quantity and character of overburden.

X2.2.3.3 A detailed record showing boundaries and location of material represented by each sample.

NOTE X2.1—A sketch, plan, and elevation, showing the thickness and location of the different layers is recommended for this purpose.

#### X2.3 Sampling Roadside or Bank Run Sand and Gravel Deposits

X2.3.1 *Inspection*—Potential sources of bank run sand and gravel may include previously worked pits from which there is an exposed face or potential deposits discovered through air-photo interpretation, geophysical exploration, or other types of terrain investigation.

X2.3.2 *Sampling*—Samples should be so chosen from each different stratum in the deposit discernible to the sampler. An estimate of the quantity of the different materials should be made. If the deposit is worked as an open-face bank or pit, samples should be taken by channeling the face

vertically, bottom to top, so as to represent the materials proposed for use. Overburdened or disturbed material should not be included in the sample. Test holes should be excavated or drilled at numerous locations in the deposit to determine the quality of the material and the extent of the deposit beyond the exposed face, if any. The number and depth of test holes will depend upon the quantity of the material needed, topography of the area, nature of the deposit, character of the material, and potential value of the material in the deposit. If visual inspection indicates that there is considerable variation in the material, individual samples should be selected from the material in each well defined stratum. Each sample should be thoroughly mixed and quartered if necessary so that the field sample thus obtained will be at least 25 lb (12 kg) for sand and 75 lb (35

kg) if the deposit contains an appreciable amount of coarse aggregate.

**X2.3.3 Record**—In addition to the general information accompanying all samples the following information should accompany samples of bank run sand and gravel:

X2.3.3.1 Location of supply.

X2.3.3.2 Estimate of approximate quantity available.

X2.3.3.3 Quantity and character of overburden.

X2.3.3.4 Length of haul to proposed site of work.

X2.3.3.5 Character of haul (kind of road, maximum grades, etc.)

X2.3.3.6 Details as to extent and location of material represented by each sample.

**NOTE X2.2**—A sketch of plans and elevations, showing the thickness and location of different layers, is recommended for this purpose.

### X3. NUMBER AND SIZE OF INCREMENTS NEEDED TO ESTIMATE CHARACTER OF UNIT SAMPLED

#### X3.1 Scope

X3.1.1 This appendix presents the rationale used by the responsible committee in the development of this practice.

#### X3.2 Descriptions of Terms Specific to This Standard

X3.2.1 *field sample*—a quantity of the material to be tested of sufficient size to provide an acceptable estimate of the average quality of a unit.

X3.2.2 *lot*—a sizable isolated quantity of bulk material from a single source, assumed to have been produced by the same process (for example, a day's production or a specific mass or volume).

X3.2.3 *test portion*—a quantity of the material of sufficient size extracted from the larger field sample by a procedure designed to ensure accurate representation of the field sample, and thus of the unit sampled.

X3.2.4 *unit*—a batch or finite subdivision of a lot of bulk material (for example, a truck load or a specific area covered).

#### X3.3 Test Unit, Size, and Variability

X3.3.1 The unit to be represented by a single field sample should neither be so large as to mask the effects of significant variability within the unit nor be so small as to be affected by the inherent variability between small portions of any bulk material.

X3.3.2 A unit of bulk material composed of graded aggregate or aggregate mixtures might consist of a full truckload. If it were possible, the entire load might be tested; as a practical matter, a field sample is composed of three or more increments chosen at random from the material as it is loaded or unloaded from the truck. Research has shown that such a procedure permits an acceptable estimate to be made of the average gradation that might be measured from 15 or 20 increments from the truck.

X3.3.3 Significant variability with a lot of material, where it might exist, should be indicated by statistical measures, such as the standard deviation between units selected at random from within the lot.

### SUMMARY OF CHANGES

This section identifies the location of selected changes to this practice that have been incorporated since the last issue. For the convenience of the user, Committee D-4 has highlighted those changes that may impact the use of this

practice. This section may also include descriptions of the changes or reasons for the changes, or both.

(1) Appendix X3 was added.

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## Standard Practice for Reducing Field Samples of Aggregate to Testing Size<sup>1</sup>

This standard is issued under the fixed designation C 702; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This practice describes three methods for the reduction of field samples of aggregate to the appropriate size for testing employing techniques that are intended to minimize variations in measured characteristics between the test samples so selected and the field sample.

1.2 The values stated in acceptable metric units are to be regarded as the standard.

### 2. Referenced Documents

- 2.1 *ASTM Standards*:  
C 128 Test Method for Specific Gravity and Absorption of Fine Aggregate<sup>2</sup>  
D 75 Practice for Sampling Aggregates<sup>2</sup>

### 3. Significance and Use

3.1 Specifications for aggregates require sampling portions of the material for testing. Other factors being equal, larger samples will tend to be more representative of the total supply. This practice provides procedures for reducing the large sample obtained in the field to a convenient size for conducting a number of tests to describe the material and measure its quality in a manner that the smaller portion is most likely to be a representation of the field sample, and thus of the total supply. Failure to carefully follow the procedures in this practice could result in providing a nonrepresentative sample to be used in subsequent testing. The individual test methods provide for minimum amount of material to be tested.

3.2 Under certain circumstances, reduction in size of the field sample prior to testing is not recommended. Substantial differences between the selected test samples sometimes cannot be avoided, as for example, in the case of an aggregate having relatively few large size particles in the field sample. The laws of chance dictate that these few particles may be unequally distributed among the reduced size test samples. Similarly, if the test sample is being examined for certain contaminants occurring as a few discrete fragments in only small percentages, caution should be used in interpreting results from the reduced size test sample. Chance inclusion or exclusion of only one or two particles in the selected sample may importantly influence interpretation of the

characteristics of the field sample. In these cases, the entire field sample should be tested.

### 4. Selection of Method

4.1 *Fine Aggregates*—Field samples of fine aggregate that are drier than the saturated-surface-dry condition (Note 1) shall be reduced in size by a mechanical splitter according to Method A. Field samples having free moisture on the particle surfaces may be reduced in size by quartering according to Method B, or by treating as a miniature stockpile as described in Method C.

4.1.1 If the use of Method B or Method C is desired, and the field sample does not have free moisture on the particle surfaces, the sample may be moistened to achieve this condition, thoroughly mixed, and then the sample reduction performed.

4.1.2 If use of Method A is desired and the field sample has free moisture on the particle surfaces, the entire field sample may be dried to at least the surface-dry condition, using temperatures that do not exceed those specified for any of the tests contemplated, and then the sample reduction performed. Alternatively, if the moist field sample is very large, a preliminary split may be made using a mechanical splitter having wide chute openings 38 mm (1½ in.) or more to reduce the sample to not less than 5000 g. The portion so obtained is then dried, and reduction to test sample size is completed using Method A.

NOTE 1—The method of determining the saturated-surface-dry condition is described in Test Method C 128. As a quick approximation, if the fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated-surface-dry.

4.2 *Coarse Aggregates and Mixtures of Coarse and Fine Aggregates*—Reduce the sample using a mechanical splitter in accordance with Method A (preferred method) or by quartering in accordance with Method B. The miniature stockpile Method C is not permitted for coarse aggregates or mixtures of coarse and fine aggregates.

### 5. Sampling

5.1 The field sample of aggregate shall be taken in accordance with Practice D 75, or as required by individual test methods. When tests for sieve analysis only are contemplated, the size of field sample listed in Practice D 75 is usually adequate. When additional tests are to be conducted, the user shall satisfy himself that the initial size of the field sample is adequate to accomplish all intended tests.

#### METHOD A—MECHANICAL SPLITTER

### 6. Apparatus

6.1 *Sample Splitter*—Sample splitters shall have an even number of equal width chutes, but not less than a total of

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates. In this edition, 6.1 and Note 2 were revised and the section on precision was deleted.

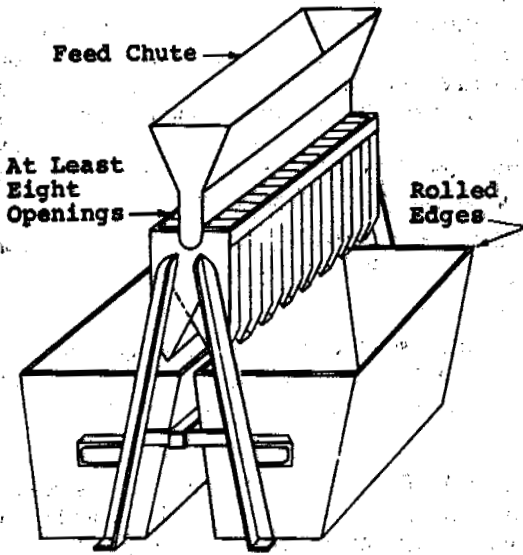
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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.02.

eight for coarse aggregate, or twelve for fine aggregate, which discharge alternately to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50 % larger than the largest particles in the sample to be split (Note 2). For dry fine aggregate in which the entire sample will pass the 9.5-mm (3/8-in.) sieve, a splitter having chutes 12.5 to 20 mm (1/2 to 3/4 in.) wide shall be used. The splitter shall be equipped with two receptacles to hold the two halves of the sample

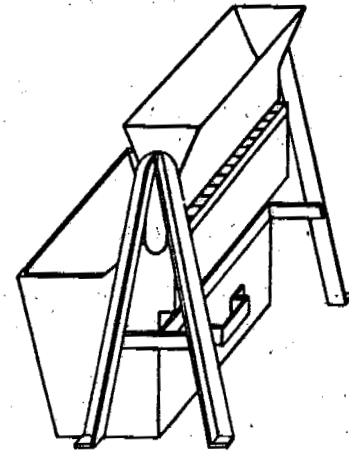
following splitting. It shall also be equipped with a hopper or straightedged pan which has a width equal to or slightly less than the over-all width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (Fig. 1).

NOTE 2—Mechanical splitters are commonly available in sizes adequate for coarse aggregate having the largest particle not over 37.5 mm (1 1/2 in.).

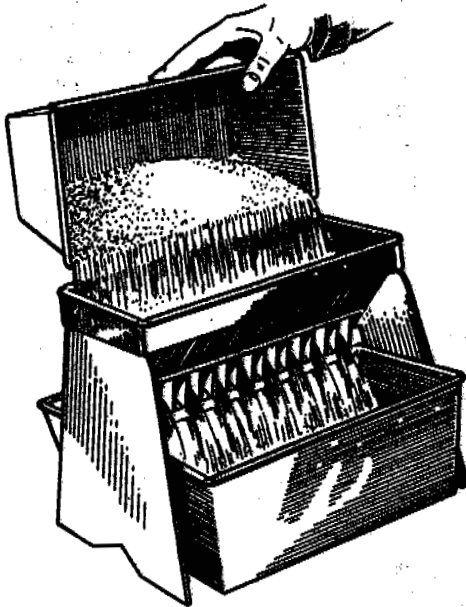


Riffle Sample Splitter

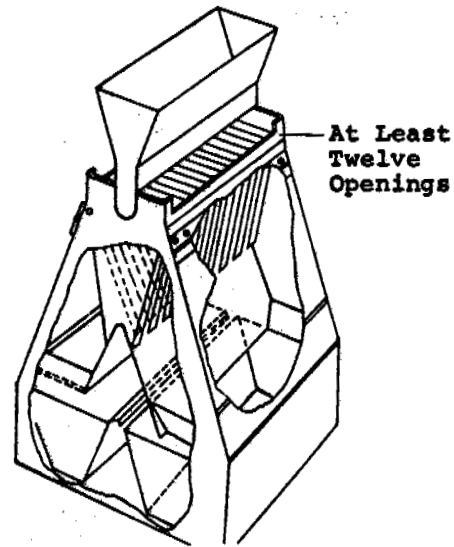
(a) Large Riffle Samplers for Coarse Aggregate



Riffle Bucket and Separate Feed Chute Stand



(b) Small Riffle Samplers for Fine Aggregate



NOTE—May be constructed as either closed or open type. Closed type is preferred.

FIG. 1 Sample Splitters (Riffles)

## 7. Procedure

7.1 Place the field sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced into the chutes, approximately equal amounts will flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the receptacles below. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The portion of the material collected in the other receptacle may be reserved for reduction in size for other tests.

### METHOD B—QUARTERING

## 8. Apparatus

8.1 Apparatus shall consist of a straight-edged scoop, shovel, or trowel; a broom or brush; and a canvas blanket approximately 2 by 2.5 m (6 by 8 ft).

## 9. Procedure

9.1 Use either the procedure described in 9.1.1 or 9.1.2 or a combination of both.

9.1.1 Place the field sample on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material thoroughly by turning the entire sample over three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately four to eight times the thickness. Divide the flattened mass into four equal quarters with a shovel or trowel and remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. Successively mix and quarter the remaining material until the sample is reduced to the desired size (Fig. 2).

9.1.2. As an alternative to the procedure described in 9.1.1, when the floor surface is uneven, the field sample may be placed on a canvas blanket and mixed with a shovel as described in 9.1.1, or by alternately lifting each corner of the canvas and pulling it over the sample toward the diagonally opposite corner causing the material to be rolled. Flatten the pile as described in 9.1.1. Divide the sample as described in 9.1.1, or if the surface beneath the blanket is uneven, insert a stick or pipe beneath the blanket and under the center of the pile, then lift both ends of the stick, dividing the sample into two equal parts. Remove the stick leaving a fold of the blanket between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four equal parts. Remove two diagonally opposite quarters, being careful to clean the fines from the blanket. Successively mix and quarter the remaining material until the sample is reduced to the desired size (Fig. 3).

### METHOD C—MINIATURE STOCKPILE SAMPLING (Damp Fine Aggregate Only)

## 10. Apparatus

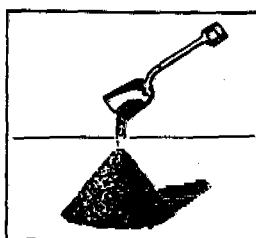
10.1 Apparatus shall consist of a straight-edged scoop, shovel, or trowel for mixing the aggregate, and either a small sampling thief, small scoop, or spoon for sampling.

## 11. Procedure

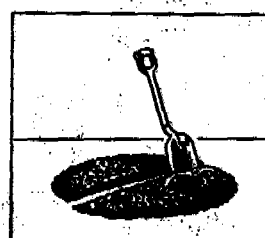
11.1 Place the field sample of damp fine aggregate on a hard clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material thoroughly by turning the entire sample over three times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one. If desired, the conical pile may be flattened to a uniform thickness and diameter by pressing down the apex with a shovel so that each quarter sector of the resulting pile will contain the material originally in it. Obtain a sample for each test by selecting at least five increments of material at random locations from the miniature stockpile, using any of the sampling devices described in 10.1.



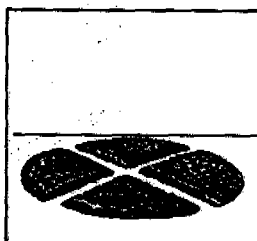
Cone Sample on Hard Clean Surface



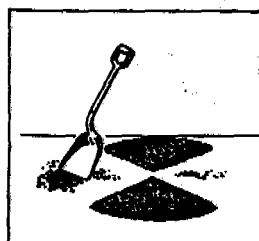
Mix by Forming New Cone



Quarter After Flattening Cone



Sample Divided into Quarters



Retain Opposite Quarters  
Reject the Other Two Quarters

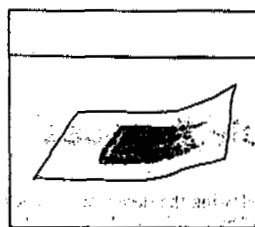
FIG. 2 Quartering on a Hard, Clean Level Surface

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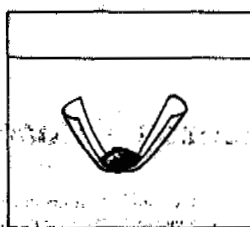
### STOCKPILE SAMPLING (Only)

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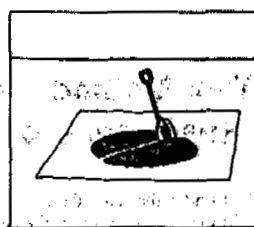
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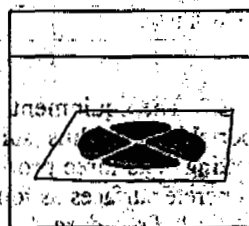
Mix by Rolling on Blanket



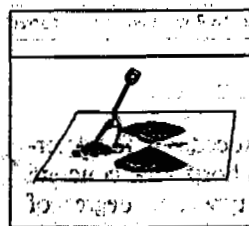
Form Cone after Mixing



Quarter After Flattening Cone



Sample Divided into Quarters



Retain Opposite Quarters  
Reject the Other Two  
Quarters

FIG. 3 Quartering on a Canvas Blanket

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

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**SECTION 3**  
**MOISTURE CONTENT DETERMINATION**



### 3.0 DETERMINING MOISTURE CONTENT OF SOILS

#### 3.1 OVEN DRYING METHOD

This is the standard method to be used where precise data is required. Degree of accuracy is dependent upon the size of the sample and the sensitivity of the scales or balances used for weighing.

#### 3.2 PROCEDURE

1. Weigh and record the mass of a suitable container (tare).
2. Select and place in the container a representative quantity of moist soil in the amount indicated:

Maximum Particle Size (mm)	Minimum Weight of Sample (grams)
5	500
12.5	1000
25.0	1500

3. Weight and record the wet mass of the sample and the container to an accuracy of 0.1 g for samples weighing 100 to 1000 g, and accurate to 1.0 g for samples weighing over 1000 g.
4. Dry sample in an oven at 105°C to 115°C for approximately 12 hours or overnight. Generally the larger the particle size the shorter the drying period required. Sands and gravels will dry in several hours while fine grained soils may require up to 24 hours. It is important to remember that dry samples will absorb moisture from wet samples placed in the oven together with the dry samples.
5. Cool sample and container to room temperature and weigh them together to determine dry mass.
6. Weight of water = wet mass - dry mass
7. Dry mass of soil = dry mass - container mass
8. Moisture content % = 
$$\frac{\text{Weight of Water}}{\text{Dry Mass of Soil}} \times 100$$

# MOISTURE CONTENT CALCULATION

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6
TARE WEIGHT (gm)	WET WEIGHT SOIL + TARE (gm)	DRY WEIGHT SOIL + TARE (gm)	WEIGHT OF MOISTURE (gm)	WEIGHT OF DRY SOIL (gm)	MOISTURE CONTENT (%)
25.00	1044.40	950.80	93.60	925.80	10.1
27.00	127.60	116.30	11.30	89.30	12.7
32.00	784.40	726.40	58.00	694.40	8.4
22.00	255.00	234.10	20.90	212.10	9.9
26.00	336.50	313.10	23.40	287.10	8.2
25.00	318.00	298.10	19.90	273.10	7.3

- COLUMN 1: Weight determined using appropriate scale
- COLUMN 2: Weight determined using appropriate scale
- COLUMN 3: Weight determined using appropriate scale
- COLUMN 4: Weight of Moisture=Column 2 - Column 3
- COLUMN 5: Weight of Dry Soil=Column 3 - Column 1
- COLUMN 6: Moisture Content=(Column 4 / Column 5) x 100





## Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock<sup>1</sup>

This standard is issued under the fixed designation D 2216; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the laboratory determination of the water (moisture) content of soil, rock, and similar materials by mass. For simplicity, the word "material" hereinafter also refers to either soil or rock, whichever is most applicable.

1.2 The water content of a material is defined by this standard as the ratio, expressed as a percentage, of the mass of "pore" or "free" water in a given mass of material to the mass of the solid material.

1.3 The term "solid particles" as used in geotechnical engineering is typically assumed to mean naturally occurring mineral particles of soil and rock that are not readily soluble in water. Therefore, the water content of materials containing extraneous matter (such as cement, and the like) may require special treatment or a qualified definition of water content. In addition, some organic materials may be decomposed by oven drying at the standard drying temperature for this method (110°C). Materials containing gypsum (calcium sulfate dihydrate or other compounds having significant amounts of hydrated water) may present a special problem as this material slowly dehydrates at the standard drying temperature (110°C) and at very low relative humidities, forming a compound (calcium sulfate hemihydrate) which is not normally present in natural materials except in some desert soils. In order to reduce the degree of dehydration of gypsum in those materials containing gypsum, or to reduce decomposition in highly organic soils, it may be desirable to dry these materials at 60°C or in a desiccator at room temperature. Thus, when a drying temperature is used which is different from the standard drying temperature as defined by this test method, the resulting water content may be different from standard water content determined at the standard drying temperature.

NOTE 1—Test Methods D 2974 provides an alternate procedure for determining water content of peat materials.

1.4 Materials containing water with substantial amounts of soluble solids (such as salt in the case of marine sediments) when tested by this method will give a mass of solids which includes the previously soluble solids. These materials require special treatment to remove or account for the presence of precipitated solids in the dry mass of the

specimen, or a qualified definition of water content must be used.

1.5 This test method requires several hours for proper drying of the water content specimen. Test Method D 4643 provides for drying of the test specimen in a microwave oven which is a shorter process.

1.6 This standard requires the drying of material in an oven at high temperatures. If the material being dried is contaminated with certain chemicals, health and safety hazards can exist. Therefore, this standard should not be used in determining the water content of contaminated soils unless adequate health and safety precautions are taken.

1.7 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>2</sup>
- D 2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils<sup>2</sup>
- D 4220 Practice for Preserving and Transporting Soil Samples<sup>2</sup>
- D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils<sup>2</sup>
- D 4643 Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method<sup>2</sup>
- D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing<sup>2</sup>
- E 145 Specification for Gravity-Convection And Forced-Ventilation Ovens<sup>3</sup>

### 3. Terminology

3.1 Refer to Terminology D 653 for standard definitions of terms.

#### 3.2 Description of Term Specific to This Standard:

3.2.1 *water content* (of a material)—the ratio of the mass of water contained in the pore spaces of soil or rock material, to the solid mass of particles in that material, expressed as a percentage.

<sup>1</sup> This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

Current edition approved June 15, 1992. Published August 1992. Originally published as D 2216 - 63 T. Last previous edition D 2216 - 90<sup>1</sup>.

<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>3</sup> Annual Book of ASTM Standards, Vol 14.02.

#### 4. Summary of Test Method

4.1 A test specimen is dried in an oven to a constant mass. The loss of mass due to drying is considered to be water. The water content is calculated using the mass of water and the mass of the dry specimen.

#### 5. Significance and Use

5.1 For many materials, the water content is one of the most significant index properties used in establishing a correlation between soil behavior and its properties.

5.2 The water content of a material is used in expressing the phase relationships of air, water, and solids in a given volume of material.

5.3 In fine-grained (cohesive) soils, the consistency of a given soil type depends on its water content. The water content of a soil, along with its liquid and plastic limits as determined by Test Method D 4318, is used to express its relative consistency or liquidity index.

#### 6. Apparatus

6.1 **Drying Oven**—thermostatically controlled, preferably of the forced-draft type, meeting the requirements of Specification E 145 and capable of maintaining a uniform temperature of  $110 \pm 5^\circ\text{C}$  throughout the drying chamber.

6.2 **Balances**—All balances must meet the requirements of Specification D 4753 and this Section. A Class GP1 balance of 0.01g readability is required for specimens having a mass of up to 200 g (excluding mass of specimen container) and a Class GP2 balance of 0.1g readability is required for specimens having a mass over 200 g.

6.3 **Specimen Containers**—Suitable containers made of material resistant to corrosion and change in mass upon repeated heating, cooling, exposure to materials of varying pH, and cleaning. Containers with close-fitting lids shall be used for testing specimens having a mass of less than about 200 g; while for specimens having a mass greater than about 200 g, containers without lids may be used. One container is needed for each water content determination.

NOTE 2—The purpose of close-fitting lids is to prevent loss of moisture from specimens before initial mass determination and to prevent absorption of moisture from the atmosphere following drying and before final mass determination.

6.4 **Desiccator**—A desiccator cabinet or large desiccator jar of suitable size containing silica gel or anhydrous calcium phosphate. It is preferable to use a desiccant which changes color to indicate it needs reconstitution. See Section 10.5.

NOTE 3—Anhydrous calcium sulfate is sold under the trade name Drierite.

6.5 **Container Handling Apparatus**, gloves, tongs, or suitable holder for moving and handling hot containers after drying.

6.6 **Miscellaneous**, knives, spatulas, scoops, quartering cloth, sample splitters, etc., as required.

#### 7. Samples

7.1 Samples shall be preserved and transported in accordance with Practice 4220 Groups B, C, or D soils. Keep the samples that are stored prior to testing in noncorrodible airtight containers at a temperature between approximately 3 and  $30^\circ\text{C}$  and in an area that prevents direct contact with

sunlight. Disturbed samples in jars or other containers shall be stored in such a way as to prevent or minimize moisture condensation on the insides of the containers.

7.2 The water content determination should be done as soon as practicable after sampling, especially if potentially corrodible containers (such as thin-walled steel tubes, paint cans, etc.) or plastic sample bags are used.

#### 8. Test Specimen

8.1 For water contents being determined in conjunction with another ASTM method, the specimen mass requirement stated in that method shall be used if one is provided. If no minimum specimen mass is provided in that method then the values given before shall apply.

8.2 The minimum mass of moist material selected to be representative of the total sample, if the total sample is not tested by this method, shall be in accordance with the following:

Maximum particle size (100 % passing)	Standard, Sieve Size	Recommended minimum mass of moist test specimen for water content reported to $\pm 0.1\%$	Recommended minimum mass of moist test specimen for water content reported to $\pm 1\%$
2 mm or less	No. 10	20 g	20 g*
4.75 mm	No. 4	100 g	20 g*
9.5 mm	3/8-in.	500 g	50 g
19.0 mm	3/4-in.	2.5 kg	250 g
37.5 mm	1 1/2-in.	10 kg	1 kg
75.0 mm	3-in.	50 kg	5 kg

NOTE—\*To be representative not less than 20 g shall be used.

8.2.1 If the total sample is used it does not have to meet the minimum mass requirements provided in the table above. The report shall indicate that the entire sample was used.

8.3 Using a test specimen smaller than the minimum indicated in 8.2 requires discretion, though it may be adequate for the purposes of the test. Any specimen used not meeting these requirements shall be noted in the report of results.

8.4 When working with a small (less than 200g) specimen containing a relatively large gravel particle, it is appropriate not to include this particle in the test specimen. However, any discarded material shall be described and noted in the report of the results.

8.5 For those samples consisting entirely of intact rock, the minimum specimen mass shall be 500 g. Representative portions of the sample may be broken into smaller particles, depending on the sample's size, the container and balance being used and to facilitate drying to constant mass, see Section 10.4.

#### 9. Test Specimen Selection

9.1 When the test specimen is a portion of a larger amount of material, the specimen must be selected to be representative of the water condition of the entire amount of material. The manner in which the test specimen is selected depends on the purpose and application of the test, type of material being tested, the water condition, and the type of sample (from another test, bag, block, and the likes.)

9.2 For disturbed samples such as trimmings, bag samples, and the like, obtain the test specimen by one of the

following methods (listed in order of preference):

9.2.1 If the material is such that it can be manipulated and handled without significant moisture loss, the material should be mixed and then reduced to the required size by quartering or splitting.

9.2.2 If the material is such that it cannot be thoroughly mixed and/or split, form a stockpile of the material, mixing as much as possible. Take at least five portions of material at random locations using a sampling tube, shovel, scoop, trowel, or similar device appropriate to the maximum particle size present in the material. Combine all the portions for the test specimen.

9.2.3 If the material or conditions are such that a stockpile cannot be formed, take as many portions of the material as possible at random locations that will best represent the moisture condition. Combine all the portions for the test specimen.

9.3 Intact samples such as block, tube, split barrel, and the like, obtain the test specimen by one of the following methods depending on the purpose and potential use of the sample.

9.3.1 Carefully trim at least 3 mm of material from the outer surface of the sample to see if material is layered and to remove material that is drier or wetter than the main portion of the sample. Then carefully trim at least 5 mm, or a thickness equal to the maximum particle size present, from the entire exposed surface or from the interval being tested.

9.3.2 Slice the sample in half. If material is layered see Section 9.3.3. Then carefully trim at least 5 mm, or a thickness equal to the maximum particle size present, from the exposed surface of one half, or from the interval being tested. Avoid any material on the edges that may be wetter or drier than the main portion of the sample.

NOTE 4—Migration of moisture in some cohesionless soils may require that the full section be sampled.

9.3.3 If a layered material (or more than one material type is encountered), select an average specimen, or individual specimens, or both. Specimens must be properly identified as to location, or what they represent, and appropriate remarks entered on data sheets.

## 10. Procedure

10.1 Determine and record the mass of the clean and dry specimen container (and its lid, if used).

10.2 Select representative test specimens in accordance with Section 9.

10.3 Place the moist test specimen in the container and, if used, set the lid securely in position. Determine the mass of the container and moist material using a balance (See 6.2) selected on the basis of the specimen mass. Record this value.

NOTE 5—To prevent mixing of specimens and yielding of incorrect results, all containers, and lids if used, should be numbered and the container numbers shall be recorded on the laboratory data sheets. The lid numbers should match the container numbers to eliminate confusion.

NOTE 6—To assist in the oven-drying of large test specimens, they should be placed in containers having a large surface area (such as pans) and the material broken up into smaller aggregations.

10.4 Remove the lid (if used) and place the container with moist material in the drying oven. Dry the material to a

constant mass. Maintain the drying oven at  $110 \pm 5^\circ\text{C}$  unless otherwise specified (see 1.3). The time required to obtain constant mass will vary depending on the type of material, size of specimen, oven type and capacity, and other factors. The influence of these factors generally can be established by good judgment, and experience with the materials being tested and the apparatus being used.

NOTE 7—In most cases, drying a test specimen overnight (about 12 to 16 h) is sufficient. In cases where there is doubt concerning the adequacy of drying, drying should be continued until the change in mass after two successive periods (greater than 1 h) of drying is an insignificant amount (less than about 0.1 %). Specimens of sand may often be dried to constant mass in a period of about 4 h, when a forced-draft oven is used.

NOTE 8—Since some dry materials may absorb moisture from moist specimens, dried specimens should be removed before placing moist specimens in the same oven. However, this would not be applicable if the previously dried specimens will remain in the drying oven for an additional time period of about 16 h.

10.5 After the material has dried to constant mass remove the container from the oven (and replace the lid if used). Allow the material and container to cool to room temperature or until the container can be handled comfortably with bare hands and the operation of the balance will not be affected by convection currents and/or its being heated. Determine the mass of the container and oven-dried material using the same balance as used in 10.3. Record this value. Tight fitting lids shall be used if it appears that the specimen is absorbing moisture from the air prior to determination of its dry mass.

NOTE 9—Cooling in a desiccator is acceptable in place of tight fitting lids since it greatly reduces absorption of moisture from the atmosphere during cooling especially for containers without tight fitting lids.

## 11. Calculation

11.1 Calculate the water content of the material as follows:

$$w = [(M_{cws} - M_{cs}) / (M_{cs} - M_c)] \times 100 = \frac{M_w}{M_s} \times 100$$

where:

$w$  = water content, %,  
 $M_{cws}$  = mass of container and wet specimen, g,  
 $M_{cs}$  = mass of container and oven dry specimen, g,  
 $M_c$  = mass of container, g,  
 $M_w$  = mass of water ( $M_w = M_{cws} - M_{cs}$ ), g, and  
 $M_s$  = mass of solid particles ( $M_s = M_{cs} - M_c$ ), g.

## 12. Report

12.1 The report (data sheet) shall include the following:

12.1.1 Identification of the sample (material) being tested, such as boring number, sample number, test number, container number etc.

12.1.2 Water content of the specimen to the nearest 1 % or 0.1 %, as appropriate based on the minimum sample used. If this method is used in concert with another method, the water content of the specimen should be reported to the value required by the test method for which the water content is being determined.

12.1.3 Indicate if test specimen had a mass less than the minimum indicated in 8.2.

12.1.4 Indicate if test specimen contained more than one material type (layered, etc.).

12.1.5 Indicate the method of drying if different from oven-drying at  $110 \pm 5^\circ\text{C}$ .

12.1.6 Indicate if any material (size and amount) was excluded from the test specimen.

### 13. Precision and Bias

13.1 *Statement on Bias*—There is no accepted reference value for this test method; therefore, bias cannot be determined.

#### 13.2 *Statements on Precision:*

13.2.1 *Single-Operator Precision*—The single-operator coefficient of variation has been found to be 2.7 percent.

Therefore, results of two properly conducted tests by the same operator with the same equipment should not be considered suspect unless they differ by more than 7.8 percent of their mean.

13.2.2 *Multilaboratory Precision*—The multilaboratory coefficient of variation has been found to be 5.0 percent. Therefore, results of two properly conducted tests by different operators using different equipment should not be considered suspect unless they differ by more than 14.0 percent of their mean.

### 14. Keywords

14.1 consistency; index property; laboratory; moisture analysis; moisture content; soil aggregate; water content

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**SECTION 4**  
**PARTICLE SIZE DISTRIBUTION ANALYSIS**  
**SIEVE METHOD**



## 4.0 PARTICLE SIZE DISTRIBUTION ANALYSIS SIEVE METHOD

### 4.1 SCOPE

This Test Method covers a procedure for the determination of the particle size distribution of fine and coarse aggregate, using sieves with square openings.

### 4.2 SAMPLES

Samples for sieve analysis shall be obtained from the materials to be tested by the use of a sample splitter or by a suitable method of quartering. Fine aggregate sampled by the quartering method shall be thoroughly mixed and in a moist condition. The sample for test shall be approximately of the mass desired and shall be the end result of the sampling method.

Samples of fine aggregate for sieve analysis shall have a mass, after drying, of approximately the amount indicated in Table 1.

TABLE 1  
DRY MASS OF SAMPLES

Nominal Maximum Size of Particle (mm)	Minimum Mass of Sample (g)
5	500
10	1,000
28	5,000
56	10,000

When accurate determinations of the total amount passing the 80  $\mu\text{m}$  sieve are required, the sample shall be tested in accordance with Test Method, "Amount of Material Finer than 80  $\mu\text{m}$  in Aggregate". The percentage finer than the 80  $\mu\text{m}$  sieve determined by this method, which entails washing the sample, shall be added to the percentage passing the 80  $\mu\text{m}$  sieve by dry sieving of the same sample. After the final drying operation the sample shall be dry sieved.

#### **4.3 PREPARATION OF SAMPLE**

Samples shall be dried to constant mass in an oven at a temperature of  $110 \pm 5^{\circ}\text{C}$ .

#### **4.4 PROCEDURE**

Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period.

The sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by a jarring action so as to keep the sample moving continuously over the surface of the sieve.

Continue sieving for a sufficient period and in such a manner that, after completion, not more than 1 percent by mass of the residue retained on any individual sieve will pass that sieve during 1 minute of continuous hand-sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and, with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one-sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the 5 mm sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 200 mm diameter sieves to verify the sufficiency of sieving.

Determine the mass of each size increment to the nearest 0.1 percent of the mass of the sample by using a suitable scale or balance.

#### **4.5 CALCULATION**

The calculations are in percentage retained on each screen and either accumulated for cumulative percent retained or subtracted from the total percentage coarser to yield the total percentage finer (percent passing).

The total mass of the entire sample is reduced by the amount retained on the coarsest sieve (or, 100 percent is reduced by the percentage retained on the coarsest sieve). This figure is then reduced by the amount retaining on the next finest sieve and so on down to the end.

To convert from percent passing to cumulative percent retained, subtract the percent passing each sieve from 100 percent.

To convert from cumulative percent retained to percent passing, subtract the percent passing each sieve from 100 percent.

**PARTICLE SIZE - ANALYSIS  
SIEVE METHOD**

Project:

Project No:

Sample Location

Zone

N

E

Elevation:

Date Sampled:

By:

Sample No:

Depth:

Sample Description

	Initial	Washed
Wet Wt & tare (g)	1950.00	
Dry Wt & tare (g)	1902.70	1860.00
tare mass (g)	690.50	690.50
Moisture mass (g)	47.30	
Dry mass (g)	1212.20	1169.50
% Moisture	3.90	

Hydrometer sample wt.

Plus No. 10 material    yes\_\_\_    no\_XX\_\_\_

**SIEVE ANALYSIS TEST**

	Retained	Passing	% Passing
6"		1212.20	100%
3"		1212.20	100%
2"		1212.20	100%
1 1/2"	99.40	1112.80	92%
1"	59.30	1053.50	87%
3/4"	44.00	1009.50	83%
1/2"	149.40	860.10	71%
3/8"	79.90	780.20	64%
No. 4	224.30	555.90	46%
No. 10	242.00	313.90	26%
No. 20	187.30	126.60	10%
No. 40	34.30	92.30	8%
No. 60	12.50	79.80	7%
No. 100	11.00	68.80	6%
No. 200	15.70	53.10	4%
Pan	12.20		

## PARTICLE - SIZE ANALYSIS OF SOILS

Project: \_\_\_\_\_

Project Number: \_\_\_\_\_

Date Tested: \_\_\_\_\_

Borehole Number: \_\_\_\_\_

Depth: \_\_\_\_\_

Soil Description: *GRAVEL (GP) NO SAND - trace silt*

Cu: *8.9*

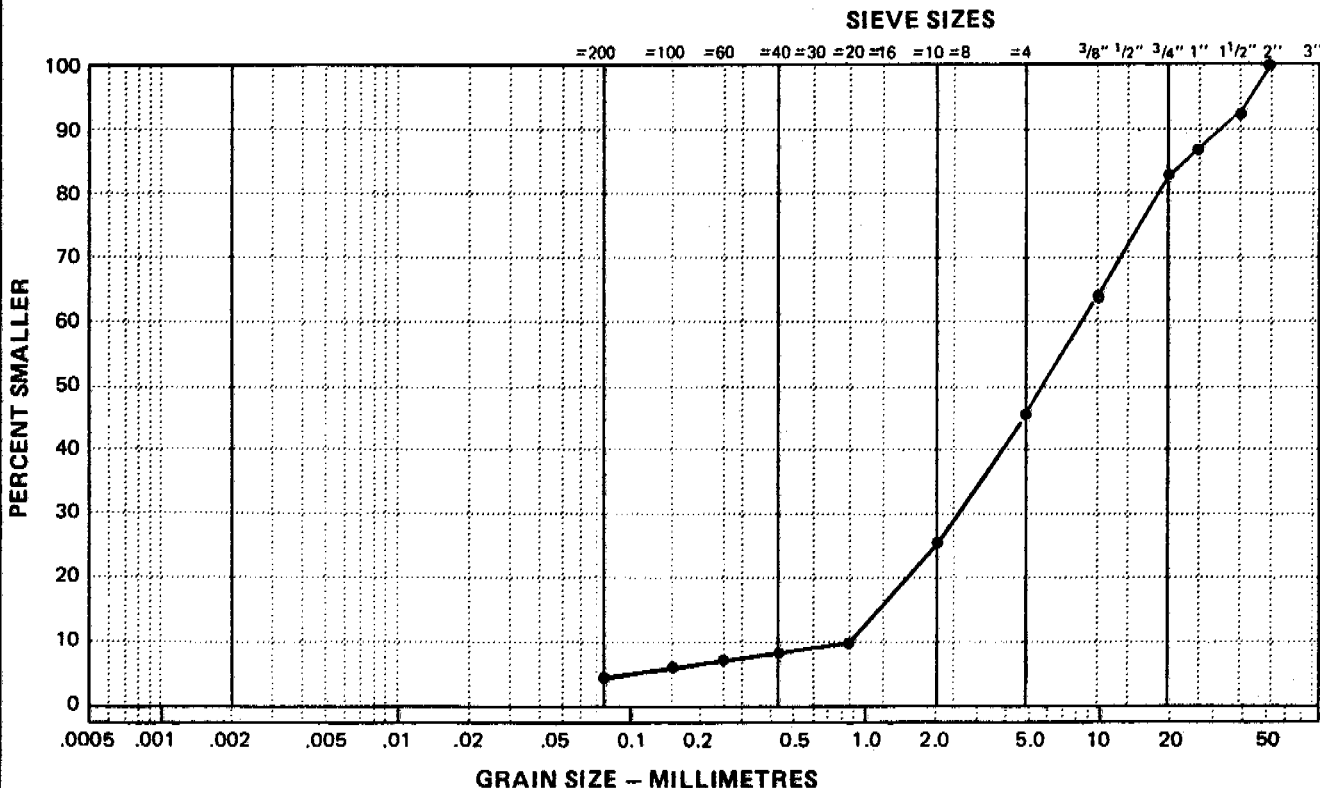
Cc: *0.9*

Natural Moisture Content: *3.9* %

Remarks: \_\_\_\_\_

SIEVE	PERCENTAGE PASSING
3"	
2"	100
1 1/2"	92
1"	87
3/4"	83
3/8"	64
No. 4	46
No. 10	26
No. 20	10
No. 40	8
No. 60	7
No. 100	6
No. 200	4

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



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## Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates<sup>1</sup>

This standard is issued under the fixed designation C 136; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

### 1. Scope

1.1 This test method covers the determination of the particle size distribution of fine and coarse aggregates by sieving.

1.2 Some specifications for aggregates which reference this method contain grading requirements including both coarse and fine fractions. Instructions are included for sieve analysis of such aggregates.

1.3 The values stated in acceptable metric units (SI units and units specifically approved in ASTM E 380 for use with SI units) are to be regarded as the standard. The values in parentheses are provided for information purposes only.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

C 117 Test Method for Materials Finer Than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing<sup>2</sup>

C 125 Terminology Relating to Concrete and Concrete Aggregates<sup>3</sup>

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials<sup>3</sup>

C 702 Practice for Reducing Field Samples of Aggregate to Testing Size<sup>3</sup>

D 75 Practice for Sampling Aggregates<sup>2</sup>

E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>4</sup>

E 380 Practice For Use of the International System of Units (SI) (the Modernized Metric System)<sup>5</sup>

#### 2.2 AASHTO Standard:

AASHTO No. T 27 Sieve Analysis of Fine and Coarse Aggregates<sup>6</sup>

### 3. Terminology

3.1 **Definitions**—For definitions of terms used in this standard, refer to Terminology C 125.

### 4. Summary of Test Method

4.1 A weighed sample of dry aggregate is separated through a series of sieves of progressively smaller openings for determination of particle size distribution.

### 5. Significance and Use

5.1 This test method is used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregates. The results are used to determine compliance of the particle size distribution with applicable specification requirements and to provide necessary data for control of the production of various aggregate products and mixtures containing aggregates. The data may also be useful in developing relationships concerning porosity and packing.

5.2 Accurate determination of material finer than the 75- $\mu$ m (No. 200) sieve cannot be achieved by use of this method alone. Test Method C 117 for material finer than 75- $\mu$ m sieve by washing should be employed.

### 6. Apparatus

6.1 **Balances**—Balances or scales used in testing fine and coarse aggregate shall have readability and accuracy as follows:

6.1.1 For fine aggregate, readable to 0.1 g and accurate to 0.1 g or 0.1 % of the test load, whichever is greater, at any point within the range of use.

6.1.2 For coarse aggregate, or mixtures of fine and coarse aggregate, readable and accurate to 0.5 g or 0.1 % of the test load, whichever is greater, at any point within the range of use.

6.2 **Sieves**—The sieves shall be mounted on substantial frames constructed in a manner that will prevent loss of material during sieving. The sieves shall conform to Specification E 11. Sieves with openings larger than 125 mm (5 in.) shall have a permissible variation in average opening of  $\pm 2$  % and shall have a nominal wire diameter of 8.0 mm (5/16 in.) or larger.

NOTE 1—It is recommended that sieves mounted in frames larger than standard 203-mm (8 in.) diameter frames be used for testing coarse aggregate.

6.3 **Mechanical Sieve Shaker**—A mechanical sieve shaker, if used, shall impart a vertical, or lateral and vertical, motion to the sieve, causing the particles thereon to bounce and turn so as to present different orientations to the sieving

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee C-9 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.20 on Normal Weight Aggregates.

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<sup>2</sup> Annual Book of ASTM Standards, Vols 04.02 and 04.03.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02. Excerpts in all volumes.

<sup>6</sup> Available from American Association of State Highway and Transportation Officials, 444 North Capitol St. N.W., Suite 225, Washington, DC 20001.

surface. The sieving action shall be such that the criterion for adequacy of sieving described in 8.4 is met in a reasonable time period.

NOTE 2—Use of a mechanical sieve shaker is recommended when the size of the sample is 20 kg or greater, and may be used for smaller samples, including fine aggregate. Excessive time (more than approximately 10 min) to achieve adequate sieving may result in degradation of the sample. The same mechanical sieve shaker may not be practical for all sizes of samples, since the large sieving area needed for practical sieving of a large nominal size coarse aggregate very likely could result in loss of a portion of the sample if used for a small sample of coarse aggregate or fine aggregate.

6.4 *Oven*—An oven of appropriate size capable of maintaining a uniform temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ).

## 7. Sampling

7.1 Sample the aggregate in accordance with Practice D 75. The weight of the field sample shall be the weight shown in Practice D 75 or four times the weight required in 7.4 and 7.5 (except as modified in 7.6), whichever is greater.

7.2 Thoroughly mix the sample and reduce it to an amount suitable for testing using the applicable procedures described in Practice C 702. The sample for test shall be approximately of the weight desired when dry and shall be the end result of the reduction. Reduction to an exact predetermined weight shall not be permitted.

NOTE 3—Where sieve analysis, including determination of material finer than the 75- $\mu\text{m}$  sieve, is the only testing proposed, the size of the sample may be reduced in the field to avoid shipping excessive quantities of extra material to the laboratory.

7.3 *Fine Aggregate*—The test sample of fine aggregate shall weigh, after drying, approximately the following amount:

Aggregate with at least 95 % passing a 2.36-mm (No. 8) sieve 100 g  
Aggregate with at least 85 % passing a 4.75-mm (No. 4) sieve 500 g  
and more than 5 % retained on a 2.36-mm (No. 8) sieve

7.4 *Coarse Aggregate*—The weight of the test sample of coarse aggregate shall conform with the following:

Nominal Maximum Size, Square Openings, mm (in.)	Minimum Weight of Test Sample, kg (lb)
9.5 (3/8)	1 (2)
12.5 (1/2)	2 (4)
19.0 (3/4)	5 (11)
25.0 (1)	10 (22)
37.5 (1 1/2)	15 (33)
50 (2)	20 (44)
63 (2 1/2)	35 (77)
75 (3)	60 (130)
90 (3 1/2)	100 (220)
100 (4)	150 (330)
112 (4 1/2)	200 (440)
125 (5)	300 (660)
150 (6)	500 (1100)

7.5 *Coarse and Fine Aggregate Mixtures*—The weight of the test sample of coarse and fine aggregate mixtures shall be the same as for coarse aggregate in 7.4.

7.6 The size of sample required for aggregates with large nominal maximum size is such as to preclude testing except with large mechanical sieve shakers. However, the intent of this method will be satisfied for samples of aggregate larger than 50 mm nominal maximum size if a smaller weight of sample is used, provided that the criterion for acceptance or rejection of the material is based on the average of results of several samples, such that the sample size used times the

number of samples averaged equals the minimum weight of sample shown in 7.4.

7.7 In the event that the amount of material finer than the 75- $\mu\text{m}$  (No. 200) sieve is to be determined by Test Method C 117, proceed as follows:

7.7.1 For aggregates with a nominal maximum size of 12.5 mm (1/2 in.) or less, use the same test sample for testing by Test Method C 117 and this method. First test the sample in accordance with Test Method C 117 through the final drying operation, then dry sieve the sample as stipulated in 8.2 through 8.7 of this method.

7.7.2 For aggregates with a nominal maximum size greater than 12.5 mm (1/2 in.), a single test sample may be used as described in 7.7.1, or separate test samples may be used for Test Method C 117 and this method.

7.7.3 Where the specifications require determination of the total amount of material finer than the 75- $\mu\text{m}$  sieve by washing and dry sieving, use the procedure described in 7.7.1.

## 8. Procedure

8.1 Dry the sample to constant weight at a temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ).

NOTE 4—For control purposes, particularly where rapid results are desired, it is generally not necessary to dry coarse aggregate for the sieve analysis test. The results are little affected by the moisture content unless: (1) the nominal maximum size is smaller than about 12.5 mm (1/2 in.); (2) the coarse aggregate contains appreciable material finer than 4.75 mm (No. 4); or (3) the coarse aggregate is highly absorptive (a lightweight aggregate, for example). Also, samples may be dried at the higher temperatures associated with the use of hot plates without affecting results, provided steam escapes without generating pressures sufficient to fracture the particles, and temperatures are not so great as to cause chemical breakdown of the aggregate.

8.2 Suitable sieve sizes shall be selected to furnish the information required by the specifications covering the material to be tested. The use of additional sieves may be desirable to provide other information, such as fineness modulus, or to regulate the amount of material on a sieve. Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve. Agitate the sieves by hand or by mechanical apparatus for a sufficient period, established by trial or checked by measurement on the actual test sample, to meet the criterion for adequacy or sieving described in 8.4.

8.3 Limit the quantity of material on a given sieve so that all particles have opportunity to reach sieve openings a number of times during the sieving operation. For sieves with openings smaller than 4.75-mm (No. 4), the weight retained on any sieve at the completion of the sieving operation shall not exceed  $6 \text{ kg/m}^2$  ( $4 \text{ g/in.}^2$ ) of sieving surface. For sieves with openings 4.75 mm (No. 4) and larger, the weight in  $\text{kg/m}^2$  of sieving surface shall not exceed the product of  $2.5 \times$  (sieve opening in mm). In no case shall the weight be so great as to cause permanent deformation of the sieve cloth.

NOTE 5—The  $6 \text{ kg/m}^2$  amounts to  $194 \text{ g}$  for the usual 203-mm (8 in.) diameter sieve. The amount of material retained on a sieve may be regulated by (1) the introduction of a sieve with larger openings immediately above the given sieve or (2) testing the sample in a number of increments.

8.4 Continue sieving for a sufficient period and in such



manner that, after completion, not more than 1 weight % of the residue on any individual sieve will pass that sieve during 1 min of continuous hand sieving performed as follows: Hold the individual sieve, provided with a snug-fitting pan and cover, in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one sixth of a revolution at intervals of about 25 strokes. In determining sufficiency of sieving for sizes larger than the 4.75-mm (No. 4) sieve, limit the material on the sieve to a single layer of particles. If the size of the mounted testing sieves makes the described sieving motion impractical, use 203-mm (8 in.) diameter sieves to verify the sufficiency of sieving.

8.5 In the case of coarse and fine aggregate mixtures, the portion of the sample finer than the 4.75-mm (No. 4) sieve may be distributed among two or more sets of sieves to prevent overloading of individual sieves.

8.5.1 Alternatively, the portion finer than the 4.75-mm (No. 4) sieve may be reduced in size using a mechanical splitter according to Practice C 702. If this procedure is followed, compute the weight of each size increment of the original sample as follows:

$$A = \frac{W_1}{W_2} \times B$$

where:

$A$  = weight of size increment on total sample basis,

$W_1$  = weight of fraction finer than 4.75-mm (No. 4) sieve in total sample,

$W_2$  = weight of reduced portion of material finer than 4.75-mm (No. 4) sieve actually sieved, and

$B$  = weight of size increment in reduced portion sieved.

8.6 Unless a mechanical sieve shaker is used, hand sieve particles larger than 75 mm (3 in.) by determining the smallest sieve opening through which each particle will pass. Start the test on the smallest sieve to be used. Rotate the particles, if necessary, in order to determine whether they will pass through a particular opening; however, do not force particles to pass through an opening.

8.7 Determine the weight of each size increment by weighing on a scale or balance conforming to the requirements specified in 5.1 to the nearest 0.1 % of the total original dry sample weight. The total weight of the material after sieving should check closely with original weight of sample placed on the sieves. If the amounts differ by more than 0.3 %, based on the original dry sample weight, the results should not be used for acceptance purposes.

8.8 If the sample has previously been tested by Test Method C 117, add the weight finer than the 75- $\mu$ m (No. 200) sieve determined by that method to the weight passing the 75- $\mu$ m (No. 200) sieve by dry sieving of the same sample in this method.

## 9. Calculation

9.1 Calculate percentages passing, total percentages retained, or percentages in various size fractions to the nearest 0.1 % on the basis of the total weight of the initial dry sample. If the same test sample was first tested by Test Method C 117, include the weight of material finer than the 75- $\mu$ m (No. 200) size by washing in the sieve analysis calculation; and use the total dry sample weight prior to washing in Test Method C 117 as the basis for calculating all the percentages.

9.2 Calculate the fineness modulus, when required, by adding the total percentages of material in the sample that is coarser than each of the following sieves (cumulative percentages retained), and dividing the sum by 100: 150- $\mu$ m (No. 100), 300- $\mu$ m (No. 50), 600- $\mu$ m (No. 30), 1.18-mm (No. 16), 2.36-mm (No. 8), 4.75-mm (No. 4), 9.5-mm (3/8-in.), 19.0-mm (3/4-in.), 37.5-mm (1 1/2-in.), and larger, increasing in the ratio of 2 to 1.

## 10. Report

10.1 Depending upon the form of the specifications for use of the material under test, the report shall include the following:

10.1.1 Total percentage of material passing each sieve, or

10.1.2 Total percentage of material retained on each sieve,

or

10.1.3 Percentage of material retained between consecutive sieves.

10.2 Report percentages to the nearest whole number, except if the percentage passing the 75- $\mu$ m (No. 200) sieve is less than 10 %, it shall be reported to the nearest 0.1 %.

10.3 Report the fineness modulus, when required, to the nearest 0.01.

## 11. Precision

11.1 The estimates of precision of this method listed in Table 1 are based on results from the AASHTO Materials Reference Laboratory Reference Sample Program, with testing conducted by this method and AASHTO Method T 27. While there are differences in the minimum weight of the test sample required for other nominal maximum sizes of aggregate, no differences entered into the testing to affect the determination of these precision indices. The data are based on the analyses of more than 100 paired test results from 40 to 100 laboratories. The values in the table are given for different ranges of percentage of aggregate passing one sieve and retained on the next finer sieve.

## 12. Keywords

12.1 aggregate; coarse aggregate; fine aggregate; gradation; grading; sieve analysis; size analysis

TABLE 1 Precision

	% of Size Fraction Between Consecutive Sieves	Coefficient of Variation (1S %), % <sup>a</sup>	Standard Deviation (1S), % <sup>a</sup>	Acceptable Range of Test Results	
				(D2S %) <sup>b</sup> % of Avg.	(D2S), % <sup>c</sup>
<b>Coarse Aggregates: <sup>c</sup></b>					
Single-Operator Precision	0 to 3	30 <sup>d</sup>		85 <sup>d</sup>	
	3 to 10		1.4 <sup>d</sup>		4.0 <sup>d</sup>
	10 to 20		0.95		2.7
Multilaboratory Precision	20 to 50	35 <sup>d</sup>	1.38	99 <sup>d</sup>	3.9
	0 to 3				
	3 to 10		1.06		3.0
	10 to 20		1.66		4.7
	20 to 30		2.01		5.7
	30 to 40		2.44		6.9
	40 to 50		3.18		9.0
<b>Fine Aggregates:</b>					
Single-Operator Precision	0 to 3		0.14		0.4
	3 to 10		0.43		1.2
	10 to 20		0.60		1.7
	20 to 30		0.64		1.8
	30 to 40		0.71		2.0
Multilaboratory Precision	40 to 50		0.21		0.6
	0 to 3		0.57		1.6
	3 to 10		0.95		2.7
	10 to 20		1.24		3.5
	20 to 30		1.41		4.0
	30 to 40				
	40 to 50				

<sup>a</sup> These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670.

<sup>b</sup> These numbers represent, respectively, the (1s %) and (d2s %) limits as described in Practice C 670.

<sup>c</sup> The precision estimates are based on coarse aggregates with nominal maximum size of 19.0 mm (¾ in.).

<sup>d</sup> These values are from precision indices first included in Method C 136 - 77. Other indices were developed in 1982 from more recent AASHTO Materials Reference Laboratory sample data, which did not provide sufficient information to revise the values so noted.

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**SECTION 5**  
**PARTICLE SIZE DISTRIBUTION ANALYSIS**  
**HYDROMETER METHOD**

## **5.0 PARTICLE SIZE ANALYSIS HYDROMETER METHOD**

The particle size analysis of a soil sample involves determining the percentage by weight of particles within the different size ranges. The particle size distribution of a coarse-grained soil can be determined by the method of sieving (described in Section 4.0).

The particle size distribution of a fine-grained soil or the fine-grained fraction of a coarse-grained soil can be determined by the method of sedimentation. The method is based on Stokes' law which governs the velocity at which spherical particles settle in suspension: the larger the particles the greater is the settling velocity and vice versa. The law does not apply to particles smaller than 0.0002 mm, the settlement of which is influenced by Brownian movement. The size of a particle is given as the diameter of a sphere which would settle at the same velocity as the particle. The soil sample is pretreated to remove any organic material, calcium compounds and soluble salts. The sample is then made up as a suspension in distilled water to which a deflocculating agent has been added to ensure that all particles settle individually. The suspension is placed in a sedimentation tube. From Stokes' law it is possible to calculate the time ("t") for particles of a certain size ("D") (the equivalent settling diameter) to settle a specified depth in the suspension. Measurements of the specific gravity of the suspension are taken at specified time intervals by means of a special hydrometer. The specific gravity is a function of the weight of soil particles in the suspension at the time of measurement.





## Standard Test Method for Particle-Size Analysis of Soils<sup>1</sup>

This standard is issued under the fixed designation D 422; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>1</sup> NOTE—Section 19 was added editorially in September 1990.

### 1. Scope

1.1 This test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75  $\mu\text{m}$  (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75  $\mu\text{m}$  is determined by a sedimentation process, using a hydrometer to secure the necessary data (Notes 1 and 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425- $\mu\text{m}$ ), or No. 200 (75- $\mu\text{m}$ ) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (1) a high-speed mechanical stirrer, and (2) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20- $\mu\text{m}$  size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20  $\mu\text{m}$ .

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants<sup>2</sup>
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>3</sup>
- E 100 Specification for ASTM Hydrometers<sup>4</sup>

### 3. Apparatus

3.1 **Balances**—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 **Stirring Apparatus**—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically oper-

ated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than 3/4 in. (19.0 mm) nor more than 1 1/2 in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup<sup>5</sup> (Note 3) conforming to the general details shown in Fig. 3 (Notes 4 and 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft<sup>3</sup>/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3.3 **Hydrometer**—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 **Sedimentation Cylinder**—A glass cylinder essentially 18 in. (457 mm) in height and 2 1/2 in. (63.5 mm) in diameter, and marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36  $\pm$  2 cm from the bottom on the inside.

3.5 **Thermometer**—A thermometer accurate to 1°F (0.5°C).

3.6 **Sieves**—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

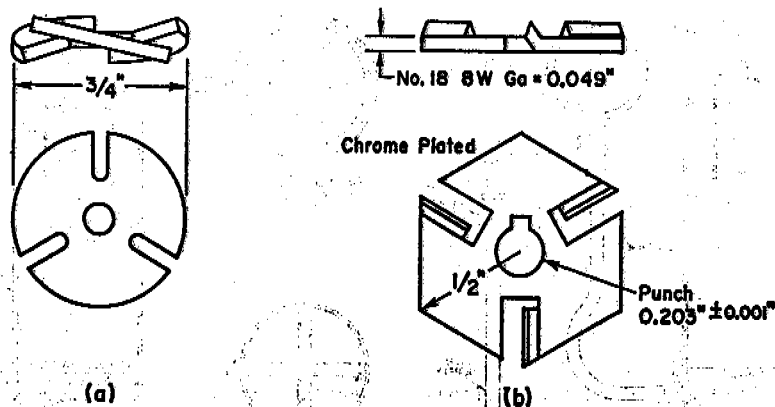
Current edition approved Nov. 21, 1963. Originally published 1935. Replaces D 422 - 62.

<sup>2</sup> Annual Book of ASTM Standards, Vol 04.08.

<sup>3</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 14.03.

<sup>5</sup> Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103. Order Adjunct No. 12-404220-00.



Metric Equivalents					
in.	0.001	0.049	0.203	1/2	3/4
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles

3-in. (75-mm)	No. 10 (2.00-mm)
2-in. (50-mm)	No. 20 (850-μm)
1 1/2-in. (37.5-mm)	No. 40 (425-μm)
1-in. (25.0-mm)	No. 60 (250-μm)
3/4-in. (19.0-mm)	No. 140 (106-μm)
1/2-in. (9.5-mm)	No. 200 (75-μm)
No. 4 (4.75-mm)	

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)	No. 16 (1.18-mm)
1 1/2-in. (37.5-mm)	No. 30 (600-μm)
3/4-in. (19.0-mm)	No. 50 (300-μm)
1/2-in. (9.5-mm)	No. 100 (150-μm)
No. 4 (4.75-mm)	No. 200 (75-μm)
No. 8 (2.36-mm)	

**3.7 Water Bath or Constant-Temperature Room**—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

**3.8 Beaker**—A beaker of 250-mL capacity.

**3.9 Timing Device**—A watch or clock with a second hand.

#### 4. Dispersing Agent

**4.1** A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7).

NOTE 7—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

**4.2** All water used shall be either distilled or demineralized water. The water for a hydrometer test shall

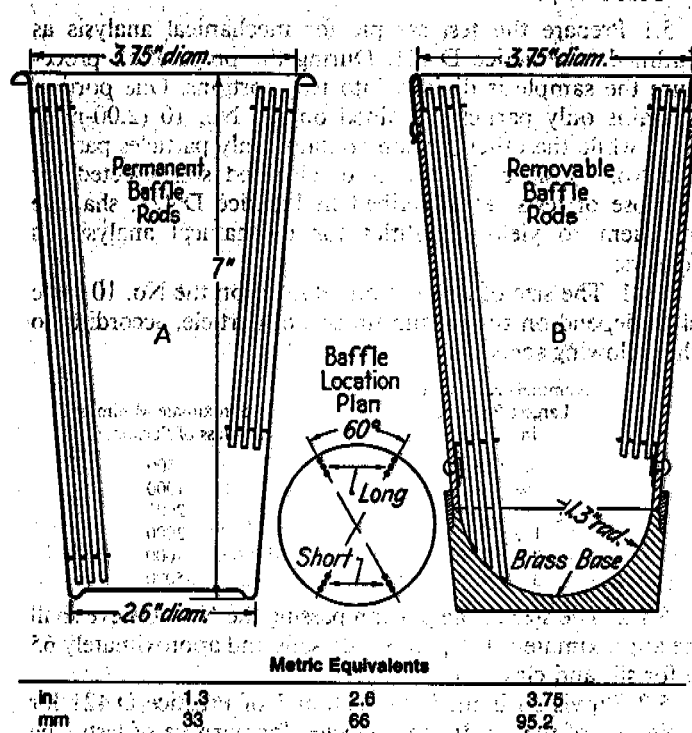


FIG. 2 Dispersion Cups of Apparatus

be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath; or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the hydrometer test is 68°F (20°C). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

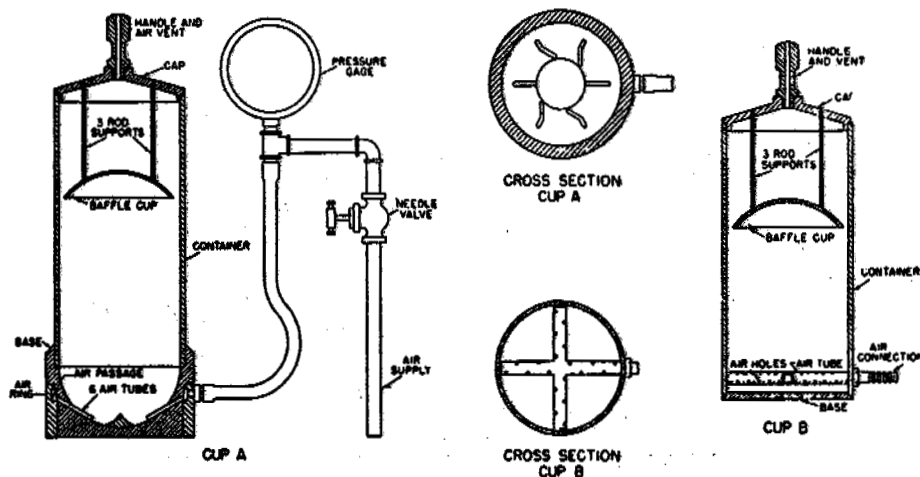


FIG. 3 Air-Jet Dispersion Cups of Apparatus B

## 5. Test Sample

5.1 Prepare the test sample for mechanical analysis as outlined in Practice D 421. During the preparation procedure the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No. 10 sieve. The mass of air-dried soil selected for purpose of tests, as prescribed in Practice D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
3/8 (9.5)	500
1/4 (19.0)	1000
1 (25.4)	2000
1 1/2 (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

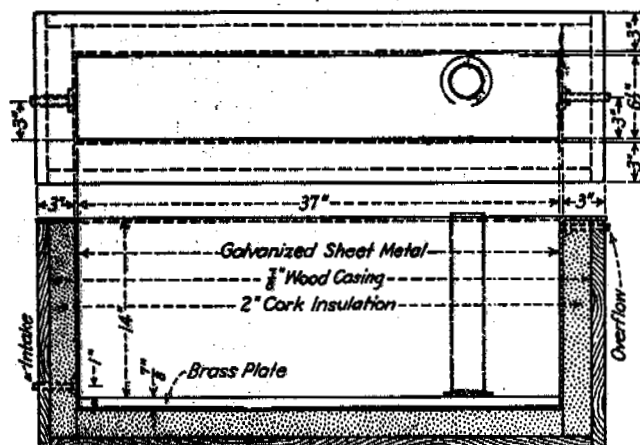
5.2 Provision is made in Section 5 of Practice D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

### SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

## 6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm),



Metric Equivalents						
in.	7/8	1	3	6 1/4	14	37
mm	22.2	25.4	76.2	158.2	356	940

FIG. 4 Insulated Water Bath

2-in. (50-mm), 1 1/2-in. (37.5-mm), 1-in. (25.0-mm), 3/4-in. (19.0-mm), 3/8-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.



## HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

### 7. Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hydrometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

### 8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at  $230 \pm 9^\circ\text{F}$  ( $110 \pm 5^\circ\text{C}$ ), and weigh again. Record the masses.

### 9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil - water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil - water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil - water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil - water slurry to the sedimentation cylinder.

### 10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil - water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns.

Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

## 11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75- $\mu$ m) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at  $230 \pm 9^\circ\text{F}$  ( $110 \pm 5^\circ\text{C}$ ) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

## CALCULATIONS AND REPORT

### 12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the  $\frac{3}{8}$ -in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the  $\frac{3}{8}$ -in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

### 13. Hygroscopic Moisture Correction Factor

13.1 The hygroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

### 14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10

TABLE 1 Values of Correction Factor,  $\alpha$ , for Different Specific Gravities of Soil Particles<sup>A</sup>

Specific Gravity	Correction Factor <sup>A</sup>
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

<sup>A</sup> For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

(2.00-mm) sieve, and multiplying the result by 100. This value is the weight  $W$  in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100$$

where:

$a$  = correction fraction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

$P$  = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

$R$  = hydrometer reading with composite correction applied (Section 7),

$W$  = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,

$G$  = specific gravity of the soil particles, and

$G_1$  = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for  $R$  is based on a value of one for  $G_1$ .

### 15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law:

$$D = \sqrt{[30\eta/980(G - G_1)] \times L/T}$$

where:

$D$  = diameter of particle, mm,

- $n$  = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),  
 $L$  = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (Table 2)),  
 $T$  = interval of time from beginning of sedimentation to the taking of the reading, min,  
 $G$  = specific gravity of soil particles, and  
 $G_1$  = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows:

$$D = K\sqrt{L/T}$$

where:

$K$  = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of  $K$  for a range of temperatures and specific gravities are given in Table 3. The value of  $K$  does not change for a series of readings constituting a test, while values of  $L$  and  $T$  do vary.

15.3 Values of  $D$  may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of  $L$  is divided by  $T$  using the  $A$ - and  $B$ -scales, the square root being indicated on the  $D$ -scale. Without ascertaining the value of the square root it may be multiplied by  $K$ , using either the  $C$ - or  $CI$ -scale.

## 16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves, in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100.

## 17. Graph

17.1 When the hydrometer analysis is performed, a graph

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes<sup>A</sup>

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

<sup>A</sup> Values of effective depth are calculated from the equation:

$$L = L_1 + \frac{1}{2} [L_2 - (V_B/A)]$$

where:

- $L$  = effective depth, cm,  
 $L_1$  = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,  
 $L_2$  = overall length of the hydrometer bulb, cm,  
 $V_B$  = volume of hydrometer bulb, cm<sup>3</sup>, and  
 $A$  = cross-sectional area of sedimentation cylinder, cm<sup>2</sup>

Values used in calculating the values in Table 2 are as follows:

For both hydrometers, 151H and 152H:

$L_2$  = 14.0 cm

$V_B$  = 67.0 cm<sup>3</sup>

$A$  = 27.8 cm<sup>2</sup>

For hydrometer 151H:

$L_1$  = 10.5 cm for a reading of 1.000

= 2.3 cm for a reading of 1.031

For hydrometer 152H:

$L_1$  = 10.5 cm for a reading of 0 g/litre

= 2.3 cm for a reading of 50 g/litre

of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.01323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01225	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

## 18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

- (1) Gravel, passing 3-in. and retained on No. 4 sieve ..... %  
 (2) Sand, passing No. 4 sieve and retained on No. 200 sieve ..... %  
 (a) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve ..... %  
 (b) Medium sand, passing No. 10 sieve and retained on No. 40 sieve ..... %  
 (c) Fine sand, passing No. 40 sieve and retained on No. 200 sieve ..... %  
 (3) Silt size, 0.074 to 0.005 mm ..... %  
 (4) Clay size, smaller than 0.005 mm ..... %  
 Colloids, smaller than 0.001 mm ..... %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

### SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	.....
2-in.	.....
1½-in.	.....
1-in.	.....
¾-in.	.....
½-in.	.....
No. 4 (4.75-mm)	.....
No. 10 (2.00-mm)	.....
No. 40 (425-µm)	.....
No. 200 (75-µm)	.....

### HYDROMETER ANALYSIS

0.074 mm	.....
0.005 mm	.....
0.001 mm	.....

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-µm) sieves may be substituted for No. 10 and No. 40 sieves.

## 19. Keywords

19.1 grain-size; hydrometer analysis; hygroscopic moisture; particle-size; sieve analysis

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## **SECTION 6**

### **LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS**





## Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils<sup>1</sup>

This standard is issued under the fixed designation D 4318; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the determination of the liquid limit, plastic limit, and the plasticity index of soils as defined in Section 3.

1.1.1 Two procedures for preparing test specimens are provided as follows: *Wet preparation procedure*, as described in 10.1. *Dry preparation procedure*, as described in 10.2. The procedure to be used shall be specified by the requesting authority. If no procedure is specified, use the wet preparation procedure.

1.1.2 Two methods for determining the liquid limit are provided as follows: *Method A*, Multipoint test as described in Sections 11 and 12. *Method B*, One-point test as described in Sections 14 and 15. The method to be used shall be specified by the requesting authority. If no method is specified, use Method A.

1.1.3 The plastic limit test procedure is described in Sections 16, 17, and 18. The plastic limit test is performed on material prepared for the liquid limit test.

1.1.4 The procedure for calculating the plasticity index is given in Section 19.

1.2 The liquid limit and plastic limit of soils (along with the shrinkage limit) are often collectively referred to as the Atterberg limits. These limits distinguished the boundaries of the several consistency states of plastic soils.

1.3 The multipoint liquid limit method is generally more precise than the one-point method. It is recommended that the multipoint method be used in cases where results may be subject to dispute, or where greater precision is required.

1.4 Because the one-point method requires the operator to judge when the test specimen is approximately at its liquid limit, it is particularly not recommended for use by inexperienced operators.

1.5 The correlations on which the calculations of the one-point method are based may not be valid for certain soils, such as organic soils or soils from a marine environment. It is strongly recommended that the liquid limit of these soils be determined by the multipoint method.

1.6 The liquid and plastic limits of many soils that have been allowed to dry before testing may be considerably different from values obtained on undried samples. If the liquid and plastic limits of soils are used to correlate or estimate the engineering behavior of soils in their natural moist state, samples should not be permitted to dry before testing unless data on dried samples are specifically desired.

1.7 The composition and concentration of soluble salts in a soil affect the values of the liquid and plastic limits as well as the water content values of soils (see Method D 2216). Special consideration should therefore be given to soils from a marine environment or other sources where high soluble salt concentrations may be present. The degree to which the salts present in these soils are diluted or concentrated must be given careful consideration.

1.8 Since the tests described herein are performed only on that portion of a soil which passes the 425- $\mu$ m (No. 40) sieve, the relative contribution of this portion of the soil to the properties of the sample as a whole must be considered when using these tests to evaluate properties of a soil.

1.9 The values stated in acceptable metric units are to be regarded as the standard. The values given in parentheses are for information only.

1.10 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:

- C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials<sup>2</sup>
- C 702 Methods for Reducing Field Samples of Aggregate to Testing Size<sup>3</sup>
- D 75 Practice for Sampling Aggregates<sup>2</sup>
- D 420 Practice for Investigating and Sampling Soil and Rock for Engineering Purposes<sup>2</sup>
- D 653 Terminology Relating to Soil, Rock, and Contained Fluids<sup>2</sup>
- D 1241 Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses<sup>2</sup>
- D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock<sup>2</sup>
- D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)<sup>2</sup>
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>2</sup>
- D 3282 Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes<sup>3</sup>
- D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing<sup>3</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 04.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 04.08.



# E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>2</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 The definitions of terms in this test method are in accordance with Terminology D 653.

### 3.2 Description of Terms Specific to This Standard:

3.2.1 *Atterberg limits*—Originally, six "limits of consistency" of fine-grained soils were defined by Albert Atterberg: the upper limit of viscous flow, the liquid limit, the sticky limit, the cohesion limit, the plastic limit, and the shrinkage limit. In current engineering usage, the term usually refers only to the liquid limit, plastic limit, and in some references, the shrinkage limit.

3.2.2 *consistency*—the relative ease with which a soil can be deformed.

3.2.3 *liquid limit (LL)*—the water content, in percent, of a soil at the arbitrarily defined boundary between the liquid and plastic states. This water content is defined as the water content at which a pat of soil placed in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2 in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of 2 shocks per second.

3.2.3.1 *Discussion*—The undrained shear strength of soil at the liquid limit is considered to be approximately 2 kPa (0.28 psi).

3.2.4 *plastic limit (PL)*—the water content, in percent, of a soil at the boundary between the plastic and brittle states. The water content at this boundary is the water content at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) in diameter threads without crumbling.

3.2.5 *plastic soil*—a soil which has a range of water content over which it exhibits plasticity and which will retain its shape on drying.

3.2.6 *plasticity index (PI)*—the range of water content over which a soil behaves plastically. Numerically, it is the difference between the liquid limit and the plastic limit.

3.2.7 *liquidity index*—the ratio, expressed as a percentage of (1) the natural water content of a soil minus its plastic limit, to (2) its plasticity index.

3.2.8 *activity number (A)*—the ratio of (1) the plasticity index of a soil to (2) the percent by weight of particles having an equivalent diameter smaller than 0.002 mm.

## 4. Summary of Test Method

4.1 The sample is processed to remove any material retained on a 425- $\mu$ m (No. 40) sieve. The liquid limit is determined by performing trials in which a portion of the sample is spread in a brass cup, divided in two by a grooving tool, and then allowed to flow together from the shocks caused by repeatedly dropping the cup in a standard mechanical device. The multipoint liquid limit, Method A, requires three or more trials over a range of water contents to be performed and the data from the trials plotted or calculated to make a relationship from which the liquid limit is determined. The one-point liquid limit, Method B, uses the data from two trials at one water content multiplied by a correction factor to determine the liquid limit.

4.2 The plastic limit is determined by alternately pressing together and rolling into a 3.2-mm (1/8-in.) diameter thread a small portion of plastic soil until its water content is reduced to a point at which the thread crumbles and can no longer be pressed together and rerolled. The water content of the soil at this point is reported as the plastic limit.

4.3 The plasticity index is calculated as the difference between the liquid limit and the plastic limit.

## 5. Significance and Use

5.1 This test method is used as an integral part of several engineering classification systems to characterize the fine-grained fractions of soils (see Test Method D 2487 and Practice D 3282) and to specify the fine-grained fraction of construction materials (see Specification D 1241). The liquid limit, plastic limit, and plasticity index of soils are also used extensively, either individually or together, with other soil properties to correlate with engineering behavior such as compressibility, permeability, compactibility, shrink-swell, and shear strength.

5.2 The liquid and plastic limits of a soil can be used with the natural water content of the soil to express its relative consistency or liquidity index and can be used with the percentage finer than 2- $\mu$ m size to determine its activity number.

5.3 These methods are sometimes used to evaluate the weathering characteristics of clay-shale materials. When subjected to repeated wetting and drying cycles, the liquid limits of these materials tend to increase. The amount of increase is considered to be a measure of a shale's susceptibility to weathering.

5.4 The liquid limit of a soil containing substantial amounts of organic matter decreases dramatically when the soil is oven-dried before testing. Comparison of the liquid limit of a sample before and after oven-drying can therefore be used as a qualitative measure of organic matter content of a soil.

## 6. Apparatus

6.1 *Liquid Limit Device*—A mechanical device consisting of a brass cup suspended from a carriage designed to control its drop onto a hard rubber base. Figure 1 shows the essential features and critical dimensions of the device. The device may be operated by either a hand crank or electric motor.

6.1.1 *Base*—A hard rubber base having a D Durometer hardness of 80 to 90, and a resilience such that an 8-mm (5/16-in.) diameter polished steel ball, when dropped from a height of 25 cm (9.84 in.) will have an average rebound of at least 80 % but no more than 90 %. Conduct resilience tests on the finished base with the feet attached. Details for measuring the resilience of the base are given in Appendix A.

6.1.2 *Rubber Feet*, supporting the base, designed to provide isolation of the base from the work surface, and having an A Durometer hardness no greater than 60 as measured on the finished feet attached to the base.

6.1.3 *Cup*, brass, with a weight, including cup hanger, of 185 to 215 g.

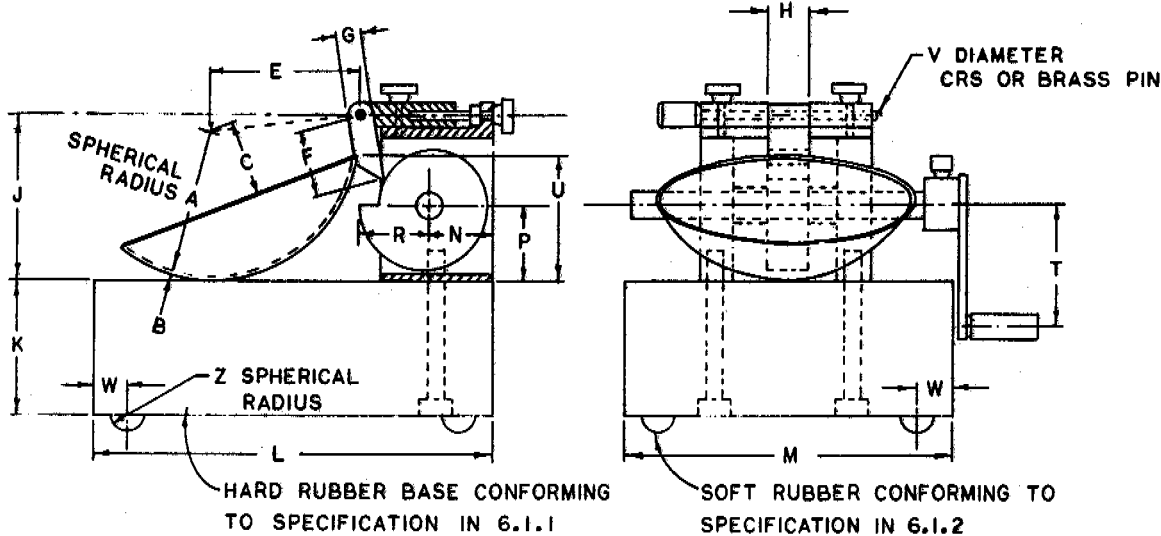
6.1.4 *Cam*—designed to raise the cup smoothly and continuously to its maximum height, over a distance of at least 180° of cam rotation, without developing an upward or downward velocity of the cup when the cam follower leaves



# DIMENSIONS

LETTER	A <sup>Δ</sup>	B <sup>Δ</sup>	C <sup>Δ</sup>	E <sup>Δ</sup>	F	G	H	J <sup>Δ</sup>	K <sup>Δ</sup>	L <sup>Δ</sup>	M <sup>Δ</sup>
MM	54 ± 0.5	2 ± 0.1	27 ± 0.5	56 ± 2.0	32	10	16	60 ± 1.0	50 ± 2.0	150 ± 2.0	125 ± 2.0
LETTER	N	P	R	T	U <sup>Δ</sup>	V	W	Z			
MM	24	28	24	45	47 ± 1.0	3.8	13	6.5			

<sup>Δ</sup> ESSENTIAL DIMENSIONS



CAM ANGLE DEGREES	CAM RADIUS
0	0.742 R
30	0.753 R
60	0.764 R
90	0.773 R
120	0.784 R
150	0.796 R
180	0.818 R
210	0.854 R
240	0.901 R
270	0.945 R
300	0.974 R
330	0.995 R
360	1.000 R

FIG. 1 Hand-Operated Liquid Limit Device

the cam. (The preferred cam motion is a uniformly accelerated lift curve.)

NOTE 1—The cam and follower design in Fig. 1 is for uniformly accelerated (parabolic) motion after contact and assures that the cup has no velocity at drop off. Other cam designs also provide this feature and may be used. However, if the cam-follower lift pattern is not known, zero velocity at drop off can be assured by carefully filing or machining the cam and follower so that the cup height remains constant over the last 20 to 45° of cam rotation.

6.1.5 *Carriage*, constructed in a way that allows convenient but secure adjustment of the height of drop of the cup to 10 mm (0.394 in.), and designed such that the cup and cup hanger assembly is only attached to the carriage by means of a removable pin.

6.1.6 *Motor Drive (Optional)*—As an alternative to the hand crank shown in Fig. 1, the device may be equipped with a motor to turn the cam. Such a motor must turn the cam at  $2 \pm 0.1$  revolutions per second and must be isolated from the rest of the device by rubber mounts or in some other way that prevents vibration from the motor being transmitted to the rest of the apparatus. It must be equipped with an ON-OFF switch and a means of conveniently positioning the cam for height of drop adjustments. The results obtained using a motor-driven device must not differ from those obtained using a manually operated device.

6.2 *Flat Grooving Tool*—A tool made of plastic or noncorroding-metal having the dimensions shown in Fig. 2. The design of the tool may vary as long as the essential dimensions are maintained. The tool may, but need not,

incorporate the gage for adjusting the height of drop of the liquid limit device.

NOTE 2—Prior to the adoption of this test method, a curved grooving tool was specified as part of the apparatus for performing the liquid limit test. The curved tool is not considered to be as accurate as the flat tool described in 6.2 since it does not control the depth of the soil in the liquid limit cup. However, there are some data which indicate that typically the liquid limit is slightly increased when the flat tool is used instead of the curved tool.

6.3 *Gage*—A metal gage block for adjusting the height of drop of the cup, having the dimensions shown in Fig. 3. The design of the tool may vary provided the gage will rest securely on the base without being susceptible to rocking, and the edge which contacts the cup during adjustment is straight, at least 10 mm ( $\frac{3}{8}$  in.) wide, and without bevel or radius.

6.4 *Containers*—Small corrosion-resistant containers with snug-fitting lids for water content specimens. Aluminum or stainless steel cans 2.5 cm (1 in.) high by 5 cm (2 in.) in diameter are appropriate.

6.5 *Balance*, conforming to Specification D 4753, Class GP1.

6.6 *Storage Container*—A container in which to store the prepared soil specimen that will not contaminate the specimen in any way, and will prevent moisture loss. A porcelain, glass, or plastic dish about 11.4 cm (4½ in.) in diameter and a plastic bag large enough to enclose the dish and be folded over is adequate.

6.7 *Ground Glass Plate*—A ground glass plate at least 30

# DIMENSIONS

LETTER	A <sup>Δ</sup>	B <sup>Δ</sup>	C <sup>Δ</sup>	D <sup>Δ</sup>	E <sup>Δ</sup>	F <sup>Δ</sup>
MM	2 ± 0.1	11 ± 0.2	40 ± 0.5	8 ± 0.1	50 ± 0.5	2 ± 0.1
LETTER	G	H	J	K <sup>Δ</sup>	L <sup>Δ</sup>	N
MM	10 MINIMUM	13	60	10 ± 0.05	60 DEG ± 1 DEG	20

<sup>Δ</sup> ESSENTIAL DIMENSIONS

<sup>□</sup> BACK AT LEAST 15 MM FROM TIP

NOTE: DIMENSION A SHOULD BE 1.9–2.0 AND DIMENSION D SHOULD BE 8.0–8.1 WHEN NEW TO ALLOW FOR ADEQUATE SERVICE LIFE

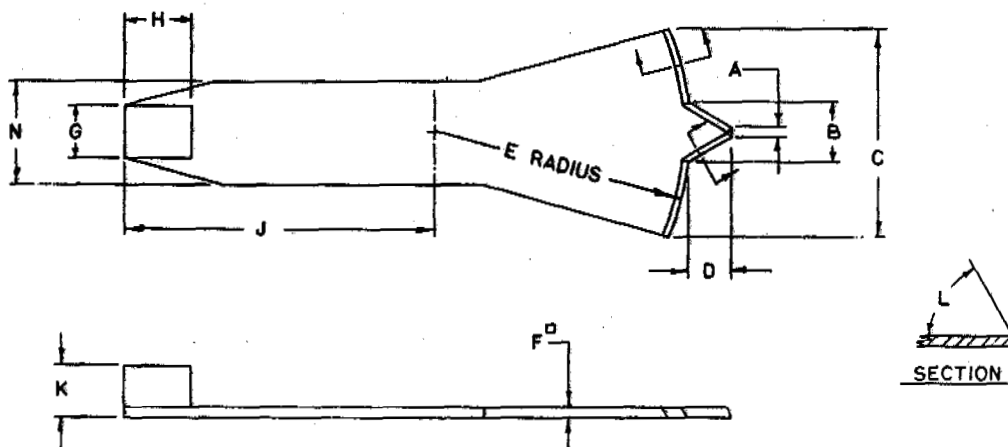
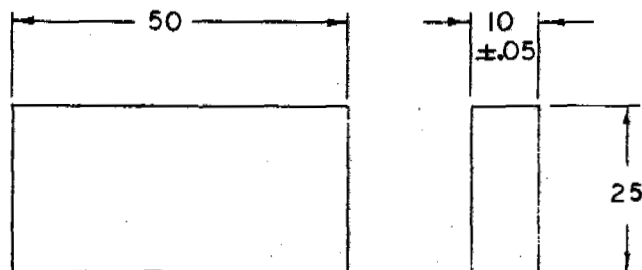


FIG. 2 Grooving Tool (Optional Height-of-Drop Gage Attached)



DIMENSIONS IN MILLIMETRES

FIG. 3 Height of Drop Gage

cm (12 in.) square by 1 cm (3/8 in.) thick for rolling plastic limit threads.

6.8 *Spatula*—A spatula or pill knife having a blade about 2 cm (3/4 in.) wide, and about 10 to 13 cm (3 to 4 in.) long.

6.9 *Sieve*—A 20.3-cm (8-in.) diameter, 425-μm (No. 40) sieve conforming to the requirements of Specification E 11 and having a rim at least 5 cm (2 in.) above the mesh. A 2-mm (No. 10) sieve meeting the same requirements may also be needed.

6.10 *Wash Bottle*, or similar container for adding controlled amounts of water to soil and washing fines from coarse particles.

6.11 *Drying Oven*, thermostatically controlled, preferably of the forced-draft type, capable of continuously maintaining a temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ) throughout the drying chamber.

6.12 *Washing Pan*, round, flat-bottomed, at least 7.6 cm (3 in.) deep, and slightly larger at the bottom than a 20.3-cm (8-in.) diameter sieve.

## 7. Reagents and Materials

7.1 *Purity of Water*—Where distilled water is referred to in this test method, either distilled or demineralized water may be used.

## 8. Sampling

8.1 Samples may be taken from any location that satisfies testing needs. However, Methods C 702, Practice D 75, and Practice D 420 should be used as guides for selecting and preserving samples from various types of sampling operations. Samples which will be prepared using the wet preparation procedure (10.1) must be kept at their natural water content prior to preparation.

8.2 Where sampling operations have preserved the natural stratification of a sample, the various strata must be kept separated and tests performed on the particular stratum of interest with as little contamination as possible from other strata. Where a mixture of materials will be used in construc-

tion, combine the various components in such proportions that the resultant sample represents the actual construction case.

8.3 Where data from this test method are to be used for correlation with other laboratory or field test data, use the same material as used for these tests where possible.

8.4 Obtain a representative portion from the total sample sufficient to provide 150 to 200 g of material passing the 425- $\mu$ m (No. 40) sieve. Free flowing samples may be reduced by the methods of quartering or splitting. Cohesive samples shall be mixed thoroughly in a pan with a spatula, or scoop and a representative portion scooped from the total mass by making one or more sweeps with a scoop through the mixed mass.

## 9. Calibration of Apparatus

### 9.1 Inspection of Wear:

9.1.1 *Liquid Limit Device*—Determine that the liquid limit device is clean and in good working order. Check the following specific points.

9.1.1.1 *Wear of Base*—The spot on the base where the cup makes contact should be worn no greater than 10 mm ( $\frac{3}{8}$  in.) in diameter. If the wear spot is greater than this, the base can be machined to remove the worn spot provided the resurfacing does not make the base thinner than specified in 6.1 and the other dimensional relationships are maintained.

9.1.1.2 *Wear of Cup*—Replace the cup when the grooving tool has worn a depression in the cup 0.1 mm (0.004 in.) deep or when the rim of the cup has been reduced to half its original thickness. Verify that the cup is firmly attached to the cup hanger.

9.1.1.3 *Wear of Cup Hanger*—Verify that the cup hanger pivot does not bind and is not worn to an extent that allows more than 3 mm ( $\frac{1}{8}$  in.) side-to-side movement of the lowest point on the rim.

9.1.1.4 *Wear of Cam*—The cam shall not be worn to an extent that the cup drops before the cup hanger (cam follower) loses contact with the cam.

9.1.2 *Grooving Tools*—Inspect grooving tools for wear on a frequent and regular basis. The rapidity of wear depends on the material from which the tool is made and the types of soils being tested. Soils containing a large proportion of sand particles may cause rapid wear of grooving tools; therefore, when testing these materials, tools should be inspected more frequently than for other soils.

NOTE 3—The width of the tip of grooving tools is conveniently checked using a pocket-sized measuring magnifier equipped with a millimetre scale. Magnifiers of this type are available from most laboratory supply companies. The depth of the tip of grooving tools can be checked using the depth measuring feature of vernier calipers.

9.2 *Adjustment of Height of Drop*—Adjust the height of drop of the cup so that the point on the cup that comes in contact with the base rises to a height of  $10 \pm 0.2$  mm. See Fig. 4 for proper location of the gage relative to the cup during adjustment.

NOTE 4—A convenient procedure for adjusting the height of drop is as follows: place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. The edge of the tape away from the cup hanger should bisect the spot on the cup that contacts the base. For new cups, placing a piece of carbon paper on the base and allowing the cup to drop several times will mark the contact spot. Attach the cup to the device and turn the crank until the cup is raised to its maximum height. Slide the height gage under the cup from the front, and observe whether the gage contacts the cup or the tape. (See Fig. 4.) If the tape and cup are both contacted, the height of drop is approximately correct. If not, adjust the cup until simultaneous contact is made. Check adjustment by turning the crank at 2 revolutions per second while holding the gage in position against the tape and cup. If a faint ringing or clicking sound is heard without the cup rising from the gage, the adjustment is correct. If no ringing is heard or if the cup rises from the gage, readjust the height of drop. If the cup rocks on the gage during this checking operation, the cam follower pivot is excessively worn and the worn parts should be replaced. Always remove tape after completion of adjustment operation.

## 10. Preparation of Test Specimens

10.1 *Wet Preparation*—Except where the dry method of specimen preparation is specified (10.2), prepare specimens for test as described in the following sections.

### 10.1.1 Samples Passing the 425- $\mu$ m (No. 40) Sieve:

10.1.1.1 When by visual and manual procedures it is determined that the sample has little or no material retained on a 425- $\mu$ m (No. 40) sieve, prepare a specimen of 150 to 200 g by mixing thoroughly with distilled or demineralized water on the glass plate using the spatula. If desired, soak the soil in a storage dish with a small amount of water to soften the soil before the start of mixing. Adjust the water content of the soil to bring it to a consistency that would require 25 to 35 blows of the liquid limit device to close the groove (Note 5).

10.1.1.2 If, during mixing, a small percentage of material is encountered that would be retained on a 425- $\mu$ m (No. 40)

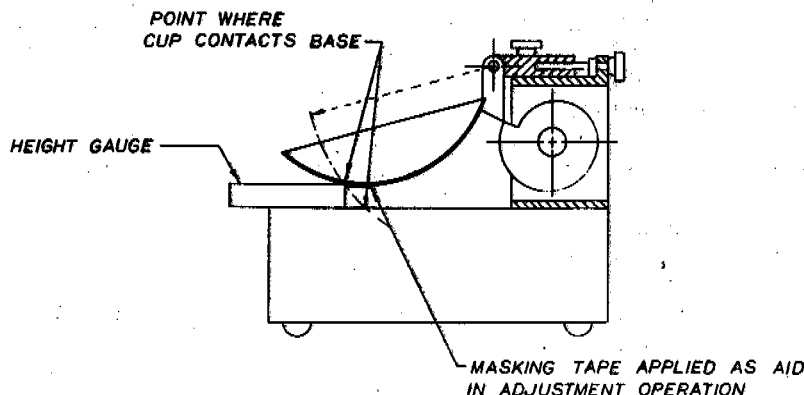


FIG. 4 Calibration for Height of Drop

sieve, remove these particles by hand (if possible). If it is impractical to remove the coarser material by hand, remove small percentages (less than about 15 %) of coarser material by working the specimen through a 425- $\mu$ m sieve using a piece of rubber sheeting, rubber stopper, or other convenient device provided the operation does not distort the sieve or degrade material that would be retained if the washing method described in 10.1.2 were used. If larger percentages of coarse material are encountered during mixing, or it is considered impractical to remove the coarser material by the methods just described, wash the sample as described in 10.1.2. When the coarse particles found during mixing are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425- $\mu$ m sieve, but remove by hand or by washing.

10.1.1.3 Place the mixed soil in the storage dish, cover to prevent loss of moisture, and allow to stand for at least 16 h (overnight). After the standing period and immediately before starting the test, thoroughly remix the soil.

NOTE 5—The time taken to adequately mix a soil will vary greatly, depending on the plasticity and initial water content. Initial mixing times of more than 30 min may be needed for stiff, fat clays.

10.1.2 *Samples Containing Material Retained on a 425- $\mu$ m (No. 40) Sieve:*

10.1.2.1 Select a sufficient quantity of soil at natural water content to provide 150 to 200 g of material passing the 425- $\mu$ m (No. 40) sieve. Place in a pan or dish and add sufficient water to cover the soil. Allow to soak until all lumps have softened and the fines no longer adhere to the surfaces of the coarse particles (Note 6).

NOTE 6—In some cases, the cations of salts present in tap water will exchange with the natural cations in the soil and significantly alter the test results if tap water is used in the soaking and washing operations. Unless it is known that such cations are not present in the tap water, distilled or demineralized water should be used. As a general rule, water containing more than 100 mg/L of dissolved solids should not be used for washing operations.

10.1.2.2 When the sample contains a large percentage of material retained on the 425- $\mu$ m (No. 40) sieve, perform the following washing operation in increments, washing no more than 0.5 kg (1 lb) of material at one time. Place the 425- $\mu$ m sieve in the bottom of the clean pan. Pour the soil-water mixture onto the sieve. If gravel or coarse sand particles are present, rinse as many of these as possible with small quantities of water from a wash bottle, and discard. Alternatively, pour the soil water mixture over a 2.00-mm (No. 10) sieve nested atop the 425- $\mu$ m sieve, rinse the fine material through and remove the 2.00-mm sieve. After washing and removing as much of the coarser material as possible, add sufficient water to the pan to bring the level to about 13 mm ( $\frac{1}{2}$  in.) above the surface of the 425- $\mu$ m sieve. Agitate the slurry by stirring with the fingers while raising and lowering the sieve in the pan and swirling the suspension so that fine material is washed from the coarser particles. Disaggregate fine soil lumps that have not slaked by gently rubbing them over the sieve with the fingertips. Complete the washing operation by raising the sieve above the water surface and rinsing the material retained with a small amount of clean water. Discard material retained on the 425- $\mu$ m sieve.

10.1.2.3 Reduce the water content of the material passing the 425  $\mu$ m (No. 40) sieve until it approaches the liquid

limit. Reduction of water content may be accomplished by one or a combination of the following methods: (a) exposing to air currents at room temperature, (b) exposing to warm air currents from a source such as an electric hair dryer, or (c) decanting clear water from surface of the suspension. During evaporation and cooling, stir the sample often enough to prevent overdrying of the fringes and soil pinnales on the surface of the mixture. For soil samples containing soluble salts, use a method of water reduction (a or b) that will not eliminate the soluble salts from the test specimen.

10.1.2.4 Thoroughly mix the material passing the 425- $\mu$ m sieve on the glass plate using the spatula. Adjust the water content of the mixture, if necessary, by adding small increments of distilled or demineralized water or by allowing the mixture to dry at room temperature while mixing on the glass plate. The soil should be at a water content that will result in closure of the groove in 25 to 35 blows. Put the mixed soil in the storage dish, cover to prevent loss of moisture, and allow to stand for at least 16 h. After the standing period and immediately before starting the test, thoroughly remix the soil.

10.2 *Dry Preparation:*

10.2.1 Select sufficient soil to provide 150 to 200 g of material passing the 425- $\mu$ m (No. 40) sieve after processing. Dry the sample at room temperature or in an oven at a temperature not exceeding 60°C until the soil clods will pulverize readily. Disaggregation is expedited if the sample is not allowed to completely dry. However, the soil should have a dry appearance when pulverized.

10.2.2 Pulverize the sample in a mortar with a rubber-tipped pestle or in some other way that does not cause breakdown of individual grains. When the coarse particles found during pulverization are concretions, shells, or other fragile particles, do not crush these particles to make them pass a 425- $\mu$ m (No. 40) sieve, but remove by hand or other suitable means, such as washing.

10.2.3 Separate the sample on a 425- $\mu$ m (No. 40) sieve, shaking the sieve by hand to assure thorough separation of the finer fraction. Return the material retained on the 425- $\mu$ m sieve to the pulverizing apparatus and repeat the pulverizing and sieving operations as many times as necessary to assure that all fine material has been disaggregated and material retained on the 425- $\mu$ m sieve consists only of individual sand or gravel grains.

10.2.4 Place material remaining on the 425- $\mu$ m (No. 40) sieve after the final pulverizing operations in a dish and soak in a small amount of water. Stir the soil water mixture and pour over a 425- $\mu$ m sieve, catching the water and any suspended fines in the washing pan. Pour this suspension into a dish containing the dry soil previously sieved through the 425- $\mu$ m sieve. Discard material retained on the 425- $\mu$ m sieve.

10.2.5 Proceed as described in 10.1.2.3 and 10.1.2.4.

## MULTIPOINT LIQUID LIMIT—METHOD A

### 11. Procedure

11.1 Place a portion of the prepared soil in the cup of the

liquid limit device at the point where the cup rests on the base, squeeze it down, and spread it into the cup to a depth of about 10 mm at its deepest point, tapering to form an approximately horizontal surface. Take care to eliminate air bubbles from the soil pat, but form the pat with as few strokes as possible. Keep the unused soil in the storage dish. Cover the storage dish with a wet towel (or use other means) to retain the moisture in the sample.

11.2 Form a groove in the soil pat by drawing the tool, beveled edge forward, through the soil on a line joining the highest point to the lowest point on the rim of the cup. When cutting the groove, hold the grooving tool against the surface of the cup and draw in an arc, maintaining the tool perpendicular to the surface of the cup throughout its movement. See Fig. 5. In soils where a groove cannot be made in one stroke without tearing the soil, cut the groove with several strokes of the grooving tool. Alternatively, cut the groove to slightly less than required dimensions with a spatula and use the grooving tool to bring the groove to final dimensions. Exercise extreme care to prevent sliding the soil pat relative to the surface of the cup.

11.3 Verify that no crumbs of soil are present on the base or the underside of the cup. Lift and drop the cup by turning the crank at a rate of 1.9 to 2.1 drops per second until the two halves of the soil pat come in contact at the bottom of the groove along a distance of 13 mm ( $\frac{1}{2}$  in.). See Fig. 6.

NOTE 7—Use of a scale is recommended to verify that the groove has closed 13 mm ( $\frac{1}{2}$  in.).

11.4 Verify that an air bubble has not caused premature closing of the groove by observing that both sides of the groove have flowed together with approximately the same shape. If a bubble has caused premature closing of the groove, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving operation and repeat 11.1 to 11.3. If the soil slides on the surface of the cup,

repeat 11.1 through 11.3 at a higher water content. If, after several trials at successively higher water contents, the soil pat continues to slide in the cup or if the number of blows required to close the groove is always less than 25, record that the liquid limit could not be determined, and report the soil as nonplastic without performing the plastic limit test.

11.5 Record the number of drops,  $N$ , required to close the groove. Remove a slice of soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, place in a weighed container, and cover.

11.6 Return the soil remaining in the cup to the storage dish. Wash and dry the cup and grooving tool and reattach the cup to the carriage in preparation for the next trial.

11.7 Remix the entire soil specimen in the storage dish adding distilled water to increase the water content of the soil and decrease the number of blows required to close the groove. Repeat 11.1 through 11.6 for at least two additional trials producing successively lower numbers of blows to close the groove. One of the trials shall be for a closure requiring 25 to 35 blows, one for closure between 20 and 30 blows, and one trial for a closure requiring 15 to 25 blows.

11.8 Determine the water content,  $W^n$ , of the soil specimen from each trial in accordance with Test Method D 2216. Initial weighings should be performed immediately after completion of the test. If the test is to be interrupted for more than about 15 minutes, the specimens already obtained should be weighed at the time of the interruption.

## 12. Calculation

12.1 Plot the relationship between the water content,  $W^n$ , and the corresponding number of drops,  $N$ , of the cup on a semilogarithmic graph with the water content as ordinates on the arithmetical scale, and the number of drops as abscissas

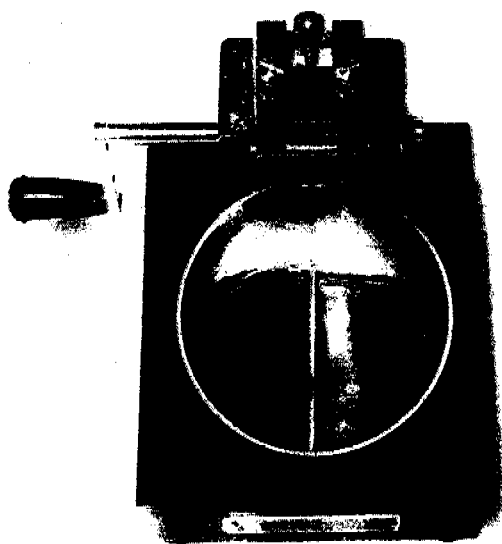


FIG. 5 Grooved Soil Pat in Liquid Limit Device

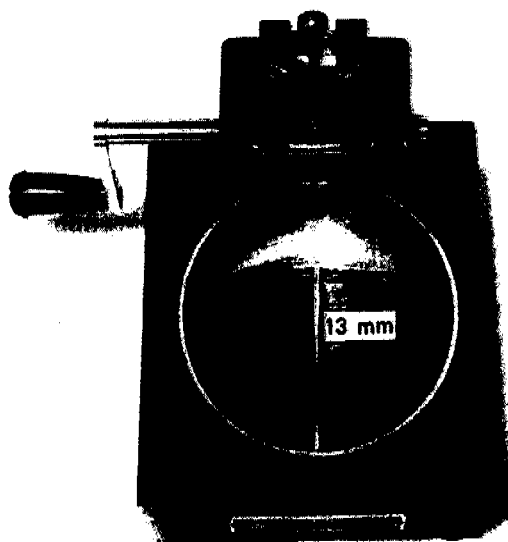


FIG. 6 Soil Pat After Groove Has Closed

on a logarithmic scale. Draw the best straight line through the three or more plotted points.

12.2 Take the water content corresponding to the intersection of the line with the 25-drop abscissa as the liquid limit of the soil. Computational methods may be substituted for the graphical method for fitting a straight line to the data and determining the liquid limit.

#### ONE-POINT LIQUID LIMIT—METHOD B

### 13. Preparation of Test Specimens

13.1 Prepare the specimen in the same manner in accordance with Section 10, except that at mixing, adjust the water content to a consistency requiring 20 to 30 drops of the liquid limit cup to close the groove.

### 14. Procedure

14.1 Proceed as described in 11.1 through 11.5 except that the number of blows required to close the groove shall be 20

to 30. If less than 20 or more than 30 blows are required, adjust the water content of the soil and repeat the procedure.

14.2 Immediately after removing a water content specimen as described in 11.5, reform the soil in the cup, adding a small amount of soil to make up for that lost in the grooving and water content sampling orientations. Repeat 11.2 through 11.5, and, if the second closing of the groove requires the same number of drops or no more than two drops difference, secure another water content specimen. Otherwise, remix the entire specimen and repeat.

NOTE 8—Excessive drying or inadequate mixing will cause the number of blows to vary.

14.3 Determine water contents of specimens in accordance with 11.8.

### 15. Calculation

15.1 Determine the liquid limit for each water content specimen using one of the following equations:

$$LL = W^n \left( \frac{N}{25} \right)^{0.121}$$

OR

$$LL = kW^n$$

where:

$N$  = number of blows causing closure of the groove at water content,

$W^n$  = water content, and

$k$  = factor given in Table 1.

The liquid limit is the average of the two trial liquid limit values.

15.2 If the difference between the two trial liquid limit values is greater than one percentage point, repeat the test.

TABLE 1 Factors for Obtaining Liquid Limit from Water Content and Number of Drops Causing Closure of Groove

N (Number of Drops)	k (Factor for Liquid Limit)
20	0.974
21	0.979
22	0.985
23	0.990
24	0.995
25	1.000
26	1.005
27	1.009
28	1.014
29	1.018
30	1.022

## PLASTIC LIMIT

## 16. Preparation of Test Specimen

16.1 Select a 20-g portion of soil from the material prepared for the liquid limit test, either after the second mixing before the test, or from the soil remaining after completion of the test. Reduce the water content of the soil to a consistency at which it can be rolled without sticking to the hands by spreading or mixing continuously on the glass plate or in the storage dish. The drying process may be accelerated by exposing the soil to the air current from an electric fan, or by blotting with paper that does not add any fiber to the soil, such as hard surface paper toweling or high wet-strength filter paper.

## 17. Procedure

17.1 From the 20-g mass, select a portion of 1.5 to 2.0 g. Form the test specimen into an ellipsoidal mass. Roll this mass between the palm or fingers and the ground-glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length (Note 9). The thread shall be further deformed on each stroke so that its diameter reaches 3.2 mm ( $\frac{1}{8}$  in.), taking no more than 2 min (Note 10). The amount of hand or finger pressure required will vary greatly, according to the soil. Fragile soils of low plasticity are best rolled under the outer edge of the palm or at the base of the thumb.

NOTE 9—A normal rate of rolling for most soils should be 80 to 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position. This rate of rolling may have to be decreased for very fragile soils.

NOTE 10—A 3.2-mm ( $\frac{1}{8}$ -in.) diameter rod or tube is useful for frequent comparison with the soil thread to ascertain when the thread has reached the proper diameter.

17.1.1 When the diameter of the thread becomes 3.2 mm, break the thread into several pieces. Squeeze the pieces

together, knead between the thumb and first finger of each hand, reform into an ellipsoidal mass, and reroll. Continue this alternate rolling to a thread 3.2 mm in diameter, gathering together, kneading and rerolling, until the thread crumbles under the pressure required for rolling and the soil can no longer be rolled into a 3.2-mm diameter thread (see Fig. 7). It has no significance if the thread breaks into threads of shorter length. Roll each of these shorter threads to 3.2 mm in diameter. The only requirement for continuing the test is that they are able to be reformed into an ellipsoidal mass and rolled out again. The operator shall at no time attempt to produce failure at exactly 3.2 mm diameter by allowing the thread to reach 3.2 mm, then reducing the rate of rolling or the hand pressure, or both, while continuing the rolling without further deformation until the thread falls apart. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal mass nearer to the required 3.2-mm final diameter. If crumbling occurs when the thread has a diameter greater than 3.2 mm, this shall be considered a satisfactory end point, provided the soil has been previously rolled into a thread 3.2 mm in diameter. Crumbling of the thread will manifest itself differently with the various types of soil. Some soils fall apart in numerous small aggregations of particles, others may form an outside tubular layer that starts splitting at both ends. The splitting progresses toward the middle, and finally, the thread falls apart in many small platy particles. Fat clay soils require much pressure to deform the thread, particularly as they approach the plastic limit. With these soils, the thread breaks into a series of barrel-shaped segments about 3.2 to 9.5 mm ( $\frac{1}{8}$  to  $\frac{3}{8}$  in.) in length.

17.2 Gather the portions of the crumbled thread together and place in a weighed container. Immediately cover the container.

17.3 Select another 1.5 to 2.0-g portion of soil from the

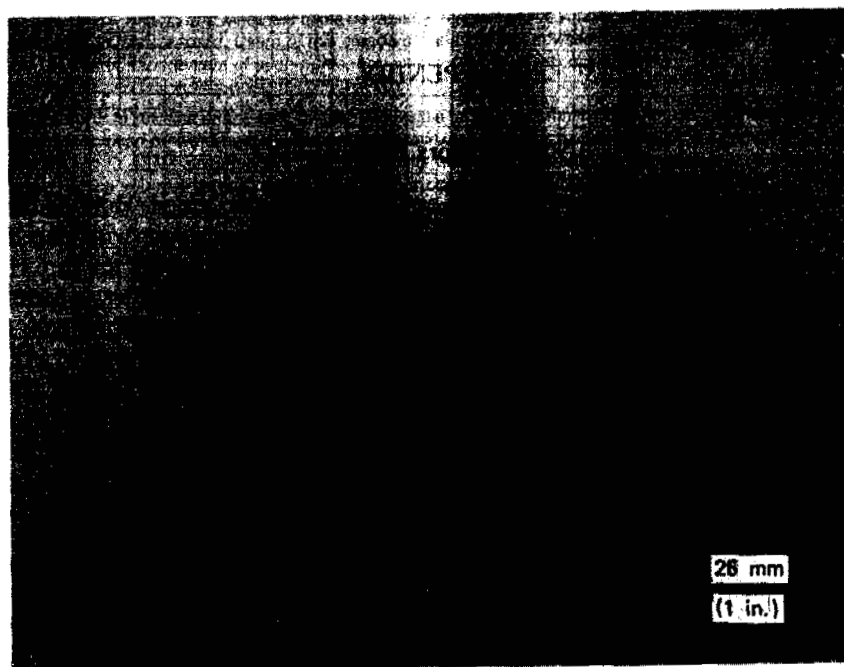


FIG. 7 Lean Clay Soil at the Plastic Limit



TABLE 2 Table of Precision Estimates<sup>a</sup>

Material and Type Index	Standard Deviation <sup>b</sup>	Acceptable Range of Two Results <sup>b</sup>
<i>Single-operator precision:</i>		
Liquid Limit	0.8	2.4
Plastic Limit	0.9	2.6
<i>Multilaboratory precision:</i>		
Liquid Limit	3.5	9.9
Plastic Limit	3.7	10.6

<sup>a</sup> The figures given in Column 2 are the standard deviations that have been found to be appropriate for the test results described in Column 1. The figures given in Column 3 are the limits that should not be exceeded by the difference between the two properly conducted tests.

<sup>b</sup> These numbers represent, respectively, the (1S) and (D2S) limits as described in Practice C 670.

original 20-g specimen and repeat the operations described in 17.1 and 17.2 until the container has at least 6 g of soil.

17.4 Repeat 17.1 through 17.3 to make another container holding at least 6 g of soil. Determine the water content of the soil contained in the containers in accordance with Test Method D 2216.

## 18. Calculation

18.1 Compute the average of the two water contents. Repeat the test if the difference between the two water contents is greater than the acceptable range for two results listed in Table 2 for single-operator precision. The plastic limit is the average of the two water contents.

## PLASTICITY INDEX

## 19. Calculation

19.1 Calculate the plasticity index as follows:

$$PI = LL - PL$$

where:

LL = liquid limit,

PL = plastic limit.

19.1.1 Both LL and PL are whole numbers. If either the liquid limit or plastic limit could not be determined, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP.

## 20. Report

20.1 Report the following information:

20.1.1 Sample identifying information,

20.1.2 Any special specimen selection process used, such as removal of sand lenses from undisturbed sample,

20.1.3 Report sample as air-dried if the sample was air-dried before or during preparation,

20.1.4 Liquid limit, plastic limit, and plasticity index to the nearest whole number, omitting the percent designation. If the liquid limit or plastic limit tests could not be performed, or if the plastic limit is equal to or greater than the liquid limit, report the soil as nonplastic, NP,

20.1.5 Estimate of the percentage of sample retained on the 425- $\mu$ m (No. 40) sieve, and

20.1.6 Procedure by which liquid limit was performed, if it differs from the multipoint method.

## 21. Precision and Bias

21.1 *Precision*—Criteria for judging the acceptability of liquid limit and plastic limit test results obtained by this test method on material are given in Table 2. The estimates of precision are based on the results of an interlaboratory study that included eleven laboratories performing the multipoint test (Method A) on three replicate samples of soil having a liquid limit of 64 and a plastic limit of 22.

21.2 *Bias*—There is no acceptable reference value for this test method; therefore, bias cannot be determined.

## 22. Keywords

22.1 activity; Atterberg limits; liquid limit; plasticity index; plastic limit

## APPENDIX

### (Nonmandatory Information)

X1.1 A device for measuring the resilience of liquid limit device bases is shown in Fig. X1.1. The device consists of a clear acrylic plastic tube and cap, a  $\frac{1}{16}$ -in. diameter steel ball, and a small bar magnet. The cylinder may be cemented to the cap or threaded as shown. The small bar magnet is held in the recess of the cap and the steel ball is fixed into the recess in the underside of the cap with the bar magnet. The cylinder is then turned upright and placed on the top surface

of the base to be tested. Holding the tube lightly against the liquid limit device base with one hand, release the ball by pulling the magnet out of the cap. Use the scale markings on the outside of the cylinder to determine the highest point reached by the bottom of the ball. Repeat the drop at least three times, placing the tester in a different location for each drop. Tests should be conducted at room temperature.



CLEAR PLASTIC (SUCH AS ACRYLIC)  
CAP AND TUBE

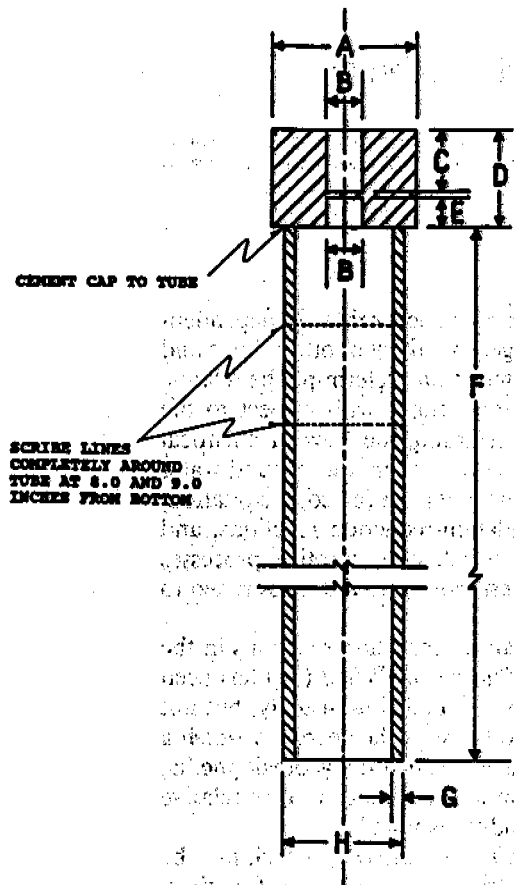


TABLE OF MEASUREMENTS

DIMENSION	DESCRIPTION	ENGLISH, in.	METRIC, mm
A	DIAM. OF CAP	1 1/2	38.10
B	DIAM. OF HOLE	3/8	9.52
C	DEPTH OF HOLE	10/16	15.88
D	HEIGHT OF CAP	1	25.40
E	DEPTH OF HOLE	5/16	7.94
F	LENGTH OF TUBE	10	254.00
G	WALL THICKNESS	1/8	3.18
H	O.D. OF TUBE	1 1/4	31.75

FIG. X1.1 Resilience Tester

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**SECTION 7**  
**TYPICAL FIELD FORMS**

## BORROW SOURCE DATA SHEET

Completed By:	Equipment Type:	Borrow Source No:
Date:	Contractor:	

### LOCATION

SITE NAME

SITE NUMBER

SITE LOCATION

U.T.M. Co-ords. Zone \_\_\_\_\_ E \_\_\_\_\_ N

(Indicate location of U.T.M. Co-ords. on attached site plan)

### SITE DESCRIPTION

Terrain Type:

Vegetation & Ground Cover:  
(type, density, dia., & ht.)

Surface Boulders:  
(size & % coverage)

Drainage:

Wildlife Sightings:  
(incl. nests, tracks, etc.)

Historical and Archeological:

### PHOTOGRAPHS (Roll/Frames)

Access:

Obliques:

Site:

Vegetation:

Ground Cover:

Misc.:

Pit Walls:

(Note: Include photos of pit walls on test hole logs).

### TEST HOLE LOGS

Attach logs to Data Sheet. Logs to include soil and ice description per Modified Unified Classification System and NRC Ice Classification System, ground water table, overburden thickness, photograph numbers, sample numbers and depths, and petrographic description.

### VOLUME CALCULATIONS & MISC.

## BORROW SOURCE DATA SHEET - SITE PLAN

i) North Arrow  
ii) Location of U.T.M. co-ords.  
iii) Landmarks, terrain features

iv) Pit/hole locations  
v) Areal extent of deposit  
vi) Gradient & direction of slope

# BORROW SOURCE DATA SHEET - SITE PLAN

i) North Arrow  
ii) Location of U.T.M. co-ords.  
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iv) Pit/hole locations  
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vi) Gradient & direction of slope

## TEST PIT LOG

CO-ORDINATES: N		E	
SURFACE ELEVATION (m):		DATUM:	
COMPLETION DEPTH (m):		WATER LEVEL (m):	

BORROW  
SOURCE  
NO.

DEPTH (metres)	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	Percentage of Cobbles and Boulders						SAMPLE INVENTORY	
			DIAMETER (mm)						Sample Interval (metres)	Represent. Interval (metres)
			< 75	75- 150	150- 225	225- 300	> 300			

START:	DATE EXCAVATED:
DOWNTIME:	METHOD:
FINISH:	LOGGED BY:

TEST  
PIT  
NO.

## OVERSIZE MATERIAL DETERMINATIONS

CO-ORDINATES: N		E	BORROW SOURCE NO.
SURFACE ELEVATION (m):		DATUM:	
COMPLETION DEPTH (m):		WATER LEVEL (m):	

[illegible]

START:	DATE EXCAVATED:	TEST PIT NO.
DOWNTIME:	METHOD:	
FINISH:	LOGGED BY:	

## PHOTOGRAPH INDEX

FILM TYPE

**ASA or DIN**

ROLL No.

[illegible]

## PHOTOGRAPH INDEX

FILM TYPE

**ASA or DIN**

ROLL No.

[illegible]



## SAMPLE INVENTORY

Project: \_\_\_\_\_ Borehole No.: \_\_\_\_\_

Project No.: \_\_\_\_\_ Completion Date: \_\_\_\_\_

[illegible]

**SHEET \_\_\_\_\_ OF \_\_\_\_\_**