Test Procedure for

LABORATORY CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

TxDOT Designation: Tex-142-E

Effective Date: August 1999

1. SCOPE

1.1 This method is a system for classifying disturbed and undisturbed soils based on laboratory determination of liquid limit, plasticity index, and particle-size characteristics.

1.1.1 This method of soil classification is similar to the ASTM version of the Unified Soils Classification System (USCS). This classification system identifies three major soil groups: coarse-grained soils, fine-grained soils, and highly organic soils.

1.1.2 Based on visual observations and prescribed laboratory tests, a soil is assigned a group symbol(s) and names and thereby classified.

1.1.3 There are other parameters such as unconfined compressive strength, dry unit weight, and water content, which can be used in conjunction with this method to provide detailed description of undisturbed soil samplers.

1.2 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. DEFINITIONS

2.1 *Plasticity Chart*—A plasticity chart is used to differentiate the plasticity and organic characteristics of the fine-grained soils based on liquid limit (LL) and plasticity index (PI) of the soils.

2.2 *A-Line*—On the plasticity chart, A-line is a sloped line beginning at PI = 4 and LL = 25.5 with an equation of PI = 0.73 (LL-20).

2.3 *Clay*—Clay is a fine grained soil that can be made to exhibit plasticity (putty-like properties) within a range of water contents and that exhibits considerable strength when air dry.

2.4 *Silt*—Silt is soil passing the No. 200 (75 µm) sieve that is non-plastic or very slightly plastic and that exhibits little or no strength when air dry.

2.5 *Organic Clay*—Organic clay is a soil that would be classified as a clay except that its LL after oven drying (dry sample preparation) is less then 75% of its LL before oven drying (wet sample preparation).

2.6 *Organic Silt*—Organic silt is a soil that would be classified as a silt except that its LL after oven drying (dry sample preparation) is less then 75% of its LL before oven drying (wet sample preparation).

2.7 *Peat*—Peat is a soil composed of vegetable tissue in various stages of decomposition usually with a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

2.8 *Gravel*—Gravel consists of unconsolidated or loose detrital sediment (aggregate resulting from natural disintegration and abrasion of rock) with particle sizes passing the 3 in. (76.2 mm) sieve and retained on the No. 10 (2.00 mm) sieve.

2.9 *Sand*—Sand consists of fine aggregate particles that are retained on the No. 200 (75 µm) sieve, either as natural sand resulting from natural disintegration and abrasion of rock, or as manufactured sand, which is produced by the crushing of rock, gravel, slag, etc.

2.10 *Coefficient of Curvature, Cc*—Coefficient of Curvature is the ratio $(D_{30})^2 / (D_{10} \bullet D_{60})$, 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.

2.11 *Coefficient of Uniformity, Cu*—Coefficient of Uniformity is 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.

3. PREPARING SOIL FOR CLASSIFICATION

3.1 Before a sample can be classified according to this test method, determine the particle-size distribution of the minus 3 in. (75 mm) sieve and minus No. 4 (4.75 mm) sieve material and the soils constants (LL, PL & PI) of the minus No. 40 (425 µm) sieve material.

3.2 Use the following test methods to determine these parameters:

- Tex-110-E
- Tex-104-E
- Tex-105-E
- Tex-106-E.

3.2.1 Following are the criteria for assigning group symbols and group names using laboratory test results.

3.2.1.1 *Coarse-Grained Soil*—More than 50% by dry weight is retained on the No. 200 (75 µm) sieve.

Table 1—Gravels – More than 50% of Plus No. 200 (75 μm) Retained on the No. 4 (4.75 mm) Sieve

		Symbol	Group Name
Clean Gravel – less than 5% fines	Cu ≥ 4 & 1 ≤ Cc ≤ 3	GW	Well-graded gravel
	Cu < 4 &/or 1 > Cc > 3	GP	Poorly graded gravel
Gravel with fines – 5 to 12% clay fines	Cu ≥ 4 & 1 ≤ Cc ≤ 3	GW-GC	Well-graded gravel with clay
	Cu < 4 &/or 1 > Cc > 3	GP-GC	Poorly graded gravel with clay
Gravel with fines – 5 to 12% silt fines	Cu ≥ 4 & 1 ≤ Cc ≤ 3	GW-GM	Well-graded gravel with silt
	Cu < 4 &/or 1 > Cc > 3	GP-GM	Poorly graded gravel with silt
Gravel with more than 12% fines	Fines classified as CL or CH	GC	Clayey Gravel
	Fines classified as ML or MH	GM	Silty Gravel

Note: If gravel contains ≥ 15% sand, add "with sand" after group name. If fines are organic, add "with organic fines" after the group name.

Table 2—Sands – 50% or More of Plus No. 200 (75 μm) Passes the No. 4 (4.75mm) Sieve

		Symbol	Group Name
Clean Sands - less than 5% fines	Cu ≥ 6 & 1 ≤ Cc ≤ 3	SW	Well-graded sand
	Cu < 6 &/or 1 > Cc > 3	SP	Poorly graded sand
Sand with 5 to 12% clay fines	Cu ≥ 6 & 1 ≤ Cc ≤ 3	SW-SC	Well-graded sand with clay
	Cu < 6 &/or 1 > Cc > 3	SP-SC	Poorly graded sand with clay
Sand with 5 to 12% silt fines	Cu ≥ 6 & 1 ≤ Cc ≤ 3	SW-SM	Well-graded sand with silt
	Cu < 6 &/or 1 > Cc > 3	SP-SM	Poorly graded sand with silt
Sand with more than 12% fines	Fines classified as CL or CH	SC	Clayey Sand
	Fines classified as ML or MH	SM	Silty Sand

Note: If sand contains ≥ 15% gravel, add "with gravel" after group name. If fines are organic, add "with organic fines" after group name.

3.2.1.2 *Fine-Grained Soil*—50% or more passes the No. 200 (75 µm) sieve.

Table 3—Silts and Clays – Liquid Limit Less than 50% & Have Less than 15% Material Retained on No. 200 (75 µm) Sieve

		Symbol	Group Name
Inorganic	PI > 7 & plots on or above "A" line	CL	Lean Clay
	PI < 4 or plots below "A" line	ML	Silt
	4 < PI < 7 & plots on or above "A" line	CL-ML	Silty Clay
Organic - defined by (LL-oven dried)/(LL-not dried) <0.75	PI ≥ 4 & plots on or above "A" line	OL	Organic Clay
	PI < 4 or plots below "A" line		Organic Silt

Note: If soil contains 15 to 29% plus No. 200 (75 µm), add "with sand" or "with gravel" after group name, whichever is predominant. If soil contains 30% or more plus No. 200 (75 µm), predominantly sand, add "sandy" before group name. If soil contains 30% or more plus No. 200 (75 µm), predominantly gravel, add "gravelly" before group name.

Examples:

- (CL) lean clay w/sand; lean clay w/gravel; sandy lean clay; sandy lean clay w/gravel; gravelly lean clay; etc.
- (CL-ML) silty clay w/sand; silty clay w/gravel; sandy silty clay; sandy silty clay w/gravel; gravelly silty clay; etc.
- (ML) silt w/sand; silt w/gravel; sandy silt; sandy silt w/gravel; gravelly silt w/sand
- (OL) organic clay w/sand; organic clay w/gravel; sandy organic clay; sandy organic clay w/gravel; etc.
- (OL) organic silt w/sand; organic silt w/gravel; sandy organic silt; sandy organic silt w/gravel; etc.

Table 4—Silts and Clays – Liquid Limit of 50% or More & Have Less than 15% Material Retained on No. 200 (75 µm) Sieve

		Symbol	Group Name
Inorganic	PI plots on or above "A" line	CH	Fat Clay
	PI plots below "A" line	MH	Elastic Silt
Organic – defined by (LL-oven dried)/(LL-not dried)<0.75	PI plots on or above "A" line	OH	Organic Clay
	PI plots below "A" line	OH	Organic Silt

Note: If soil contains 15 to 29% plus No. 200 (75 µm), add "with sand" or "with gravel" after group name, whichever is predominant. If soil contains 30% or more plus No. 200 (75 µm), predominantly sand, add "sandy" before group name. If soil contains 30% or more plus No. 200 (75 µm), predominantly gravel, add "gravelly" before group name. (CH) fat clay w/sand; fat clay w/gravel; sandy fat clay; sandy fat clay w/gravel; gravelly fat clay; etc.

Examples:

- (MH) elastic silt w/sand; elastic silt w/gravel; sandy elastic silt; sandy elastic silt w/gravel; etc.
- (OH) organic clay w/sand; organic clay w/gravel; sandy organic clay; sandy organic clay w/gravel; etc.
- (OH) organic silt w/sand; organic silt w/gravel; sandy organic silt; sandy organic silt w/gravel; etc.

4. PROCEDURE

4.1 Determine the LL, PL, and PI of the soil in accordance with:

- Tex-104-E
- Tex-105-E
- Tex-106-E.

4.2 Determine the water content of the soil in accordance with Tex-103-E.

4.3 Determine the amount of material passing the No. 200 (75 µm) sieve in accordance with Tex-110-E for fine-grained soil, or Tex-401-A for coarse-grained soil.

4.4 Determine the particle size distribution of the materials retained on the No. 200 (75 µm) sieve in accordance with Tex-406-A decantation tests for concrete aggregates.

4.5 Use Figure 1, LL, PI, percent material passing the No. 200 (75 µm) sieve, and Cu and Cc, and classify the soil with group name and description with group symbol.

Note 1—Other than soil constants and particle size distribution, there are other engineering properties that can be measured in either the field or laboratory in conjunction with this classification system to provide a more complete description of the soil characteristics.

Note 2—In general, there is a close correlation among the soil classification and the engineering properties such as consistency, density, water content, and dry unit weight. When available, this information should be used in conjunction with soil classification to aid in the evaluation of the soil's significant properties for engineering use.

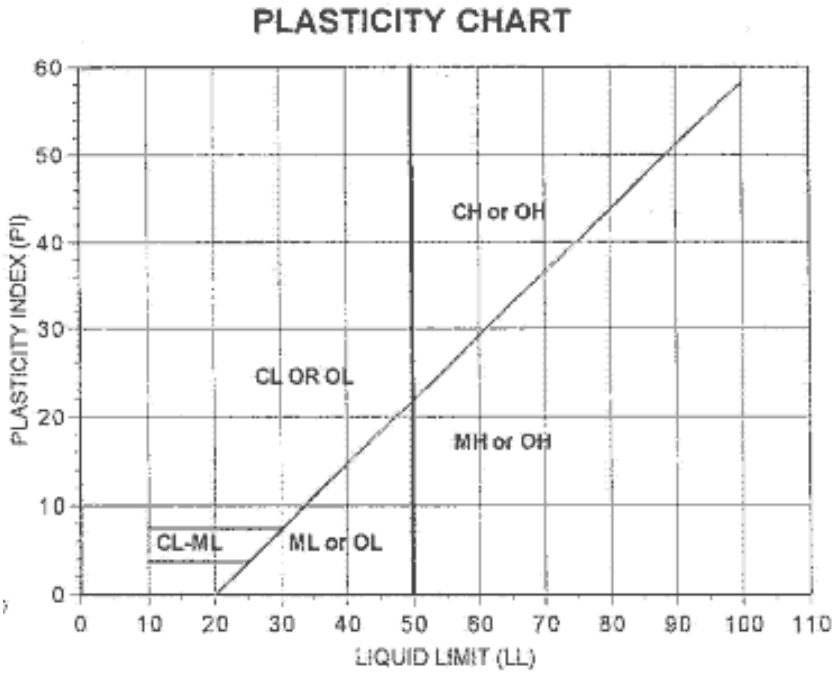

Figure 1—Plasticity Chart

5. CONSISTENCY

5.1 The consistency of a predominantly clay and/or silt is defined by its unconfined compressive (UC) strength when tested in the laboratory under the normal moisture condition in an undisturbed condition. Typically, one would find higher water content associated with lower unconfined compressive strength or softer material, and lower water content associated with a higher unconfined compressive strength or harder material.

5.2 Table 5 classifies soil by unconfined compressive strength.

Table 5—Soil Consistency

UC kg/cm2 (tsf)	Consistency
less than 0.25	Very Soft
0.25 to 0.5	Soft
0.5 to 1.0	Medium Stiff
1.0 to 2.0	Stiff
2.0 to 4.0	Very Stiff
greater than 4.0	Hard

6. DENSITY

6.1 Soil density as typically measured by the N-Value of in-situ Standard Penetration Test (SPT) or the Texas Cone Penetration Test (TCP) is an indication of the relative compactness and bearing capacity of a predominantly granular material such as sand, clayey sand, silty sand, and gravelly material. The water content of a granular material is mostly unimportant because the bearing strength is independent of water content, and the water content of a disturbed sample is not representative of the material.

6.2 Table 6 classifies soil by density.

Table 6—Soil Density

SPT N Value	TCP Blows/0.3 m (12 in.)	Density
less than 4	less than 8	Very Loose
4 to 10	8 to 20	Loose
10 to 30	20 to 60	Medium Dense
30 to 50	60 to 100	Dense
Greater than 50	greater than 100	Very Dense

7. DRY UNIT WEIGHT

7.1 Dry unit weight of the material usually increases with decreasing plasticity and/or increasing percentage of coarse-grained particles in the soils. One can usually find a higher than usual water content and lower dry unit weight in an organic material. The more plastic material such as clay has a greater propensity to hold water and therefore has a higher water content and lower dry unit weight.

7.2 Table 7 indicates the dry unit weight for soil types.

Table 7—Dry Unit Weight for Soil Types

Dry Unit Weight Kg/m3 (pcf)	Soil Type (Group Symbol)
0.77–1.03 (60–80)	Organic Clay (OH)
1.03–1.22 (80–95)	Clay (CH)
1.16–1.35 (90–105)	Clay (CL)
1.22–1.42 (95–110)	Sandy Clay (CL)
1.29–1.55 (100–120)	Clayey Sand (SC)