SOIL MECHANICS -- LEVEL I

MODULE 1

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 1

REFERENCES

REFERENCES

1. Glossary, Symbols, Abbreviations, and Conversion Factors, Soil Mechanics Note No. 6, Soil Conservation Service, U.S. Dept. of Agriculture, March, 1976.

2. Method for Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures, D 2216-80. Annual Book of Standards, Section 4, Volume 04-08, American Society of Testing and Materials, Philadelphia, PA, 1984.

3, Method for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants, D 421-38. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

4. Method for Particle-Size Analysis of Soils, D 422-63. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

5. Method for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants, D 2217-66. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

6. Recommended Practice for Description of Soils (Visual-Manual Procedure). D 2488-84. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

7. Specification for ASTM Hydrometers, E 100. Annual Book of Standards, Volume 14.02, American Society of Testing and Materials, Philadephia, PA, 1984.

8. Specification for Wire Cloth Sieves for Testing Purposes, E 11. Annual Book of Standards, Volume 14.02, American Society of Testing and Materials, Philadelphia, PA, 1984

9. Terms and Symbols Relating to Soil and Rock Mechanics, D 653-83. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

10. Test Method for Classification of Soils for Engineering Purposes. D 2487-83. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

11. Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, D 4318-83. Annual Book of Standards, Section 4, Volume 04.08, American Society of Testing and Materials, Philadelphia, PA, 1984.

SOIL MECHANICS -- LEVEL I

MODULE 1

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 2

GLOSSARY

GLOSSARY

APPENDIX 1

(A "D" in parenthesis after the term means that it is dimensionless)

"A" line -- The line on the plasticity chart that divides plastic and slightly plastic or nonplastic--plastic being above the line and slightly plastic or nonplastic below. It is defined by the equation: PI = 0.73 (LL-20).

Atterberg limits -- A general term denoting liquid limit, plastic limit and shrinkage limit.

Boulder -- A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 12 in. (300 mm) or more.

Clay -- Fine-grained soil or the fine grained portion of soil that exhibits (1) plasticity (putty-like properties) within a range of water contents and (2) considerable strength when air-dry.

Clean soil -- A soil that has less than 5 percent finer than the No. 200 sieve size.

Coarse-grained soil -- The minus 3-in. (75 mm) fraction of a soil having a gradation such that more than 50 percent by dry weight is retained on a No. 200 (75 mm) sieve.

Cobble -- A rock fragment, usually rounded or subrounded, with a minimum dimension ranging between 3 in. (75 mm) and 12 in. (300 mm).

Coefficient of curvature, Cc (D) -- A coefficient used in evaluating the grading characteristics of coarse-grained soils. It is calculated from the expression $(D_{30})^2/(D_{10} x D_{60})$ where D_{10}, D_{30}, and D_{60} are the particle diameters corresponding to 10, 30, and 60 percent finer on the grain size distribution curve.

Coefficient of uniformity, Cu (D) -- A coefficient used in evaluating the grading characteristics of coarse-grained soils. It is calculated from the expression: D_{60}/D_{10} where D_{10} and D_{60} are the particle diameters corresponding to 10 and 60 percent finer on the grain size distribution curve.

Consistency -- The relative ease with which a soil can be deformed.

D_5, D_{10} .... D_{85} size (mm or in.) -- The particle diameter corresponding to the 5, 10 .... 85 percent finer by dry weight on the grain size distribution curve.

Dilatancy test -- A test used to indicate the presence of significant amounts of rock flour, silt, or very fine sand in a fine-grained soil. It consists of shaking a pat of wet soil, having a consistency of thick paste, in the palm of the hand; observing the surface for a glossy or livery appearance; squeezing the pat; and observing if a rapid apparent drying and subsequent cracking of the soil occurs.

Dirty soil -- A soil that has more than 12% percent finer than the No. 200 sieve size.

Dry strength test -- A visual-manual test performed on the fraction of a soil finer than the No. 40 (425-mm) sieve for the purpose of evaluating crushing characteristics; used as an aid to field classification of soil.

Fined-grained soil -- The minus 3-in. (75 mm) fraction of a soil having a gradation such that 50 percent or more by dry weight passes a No. 200 (75-mm) sieve.

Fines -- Portion of a soil finer than a NO. 200 (75-mm) U.S. standard sieve.

Gap - graded -- A soil that has a range of particle sizes missing from its gradation.

Gradation -- (grain-size distribution) -- Distribution of grain sizes present in a given soil.

Gravel -- Rounded or semirounded particles of rock that will pass a 3-in. (75 mm) and be retained on a No. 4 (4.75 mm) U.S. standard sieve.

Group name -- A descriptive term used to provide additional information to the USCS symbol. It usually consists of a primary descriptive term and an appropriate modifier based on its sand and/or gravel content. (Clayey gravel with sand is an example).

Liquid limit, LL (D) -- (a) The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.
(b) The water content at which a pat of soil, cut by a grove of standard dimensions, will flow together for a distance of 1/2 in. under the impact of 25 blows in a standard liquid limit apparatus.

Nonplastic, NP -- A term applied to a soil that exhibits no plasticity, or PI = 0.

Organic soils -- Soils that usually have a pungent odor when moist and warm. They usually are dark brown to gray to black in color, and have a liquid limit value that is significantly affected by oven-drying of the soil prior to testing.

Peat -- A highly organic soil composed primarily of vegetable tissue in various states of decomposition. It usually has a strong odor, a dark brown to black color, and a texture ranging from fibrous to amorphous.

Plasticity -- The property of a soil which allows it to be deformed beyond the point of recovery without cracking or appreciable volume change.

Plasticity index, PI (D) -- Numerical difference between the liquid limit and the plastic limit.

Plastic limit, PL (D) -- (a) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil.

(b) Water content at which a soil being dried will just begin to crumble when rolled into a thread approximately 1/8 in. (0.32 mm) in diameter.

Plastic soil -- A soil that exhibits plasticity.

Plastic state -- The range of consistency within which a soil exhibits plastic properties.

Poorly graded soil -- A soil that contains a narrow range of particle sizes or one that has a range of particle sizes missing from its gradation.

Ribbon test -- A field test where a pat of soil near the plastic limit is squeezed between the thumb and forefinger to form a ribbon. The strength of the ribbon is then evaluated.

Sand -- Particles of rock that will pass the No. 4 (4.75 mm) sieve and be retained on the No. 200 (75-mm) U.S. standard sieve.

Coarse sand -- Sand passing the No. 4 sieve and retained on the No. 10 (2.0 mm) sieve.

Medium sand -- Sand passing the No. 10 sieve and retained on the No. 40 (425-mm) sieve.

Fine sand -- Sand passing the No. 40 sieve and retained on the No. 200 sieve.

Shrinkage limit, SL (D) -- The maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass.

Shine test -- A field test used in the USCS where a moist pat of soil is rubbed with a smooth object and the surface shine evaluated.

Silt -- Material passing the No. 200 (75-mm) U.S. standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

Sieve -- A testing device with wire meshes on the bottom. Finer particles of a soil of various sizes are passed through a sieve to separate them from coarser ones.

Toughness test -- A visual-manual test performed on the fraction of a soil finer than the No. 40 (425-mm) sieve for the purpose of evaluating consistency near the plastic limit; used as an aid in the field classification of soil.

Water content, w (D) -- The ratio, expressed as a percentage of: (1) the weight of water in a given soil mass to (2) the weight of solid particles.

Well-graded soil -- A soil that contains a broad range of particle sizes and about equal amounts of each.

Table of Contents

U. S. Department of Agriculture
Soil Conservation Service
Engineering Division

March, 1976

Soil Mechanics Note No. 6: Glossary, Symbols, Abbreviations, and Conversion Factors

I. Purpose

This Note is a guide to standardizing terms, symbols, abbreviations, and units in SCS geotechnical engineering reports, papers, notes, and handbook materials.

II. General

The ASTM and the ASCE have collaborated in the development of contents of ASTM Designation D653, "Terms and Symbols Relating to Soil and Rock Mechanics". As much as possible, terms and symbols from that designation have been incorporated in this Note. Other terms and symbols have been added.

Specific units of measurement, rather than general units, are presented in the Glossary in both the U.S. and the metric systems.

III. References

The principal references that were reviewed prior to compiling this Note are listed below. Many others, including SCS soil mechanics forms and training materials, were reviewed also.

a. "Terms and Symbols Relating to Soil and Rock Mechanics", ASTM D653-67, Annual Book of ASTM Standards, Part 19, 1974.

b. Soil Mechanics, Foundations, and Earth Structures, NAVFAC DM-7, Department of the Navy, March 1971.

c. Earth Manual, Bureau of Reclamation, USDI, 1st Edition (Rev.), 1963.

d. Cedergren, H. R., Seepage, Drainage, and Flow Nets, Wiley, 1967.

e. Terzaghi, K. and Peck, R. B., Soil Mechanics in Engineering Practice, 2nd Edition, Wiley, 1967.

f. SCS National Engineering Handbook, various sections.

This Note prepared by Donald M. Sundberg, under direction of David C. Ralston, with comments by EWP Unit and SML engineers.

g. Resource Conservation Glossary, Soil Conservation Society of America, 1970.

h. Diagnosis and Improvement of Saline and Alkali Soils, Agriculture Handbook No. 60, USDA, 1954.

i. Soil Survey Manual, Agriculture Handbook No. 18, USDA, 1951.

j. Glossary of Geology, American Geological Institute, Washington, D.C., 1972.

U. S. Department of Agriculture
Soil Conservation Service
Engineering Division

Soil Mechanics Note No. 6

Glossary, Symbols, Abbreviations, and Conversion Factors

March, 1976

SOIL MECHANICS -- LEVEL I

MODULE 1

APPENDIX 3

SOIL MECHANICS NOTE NO. 6

(GLOSSARY, SYMBOLS, ABBREVIATIONS, AND CONVERSION FACTORS)

Part A. Glossary

"A" horizon -- See horizon.

Absorbed water -- Water held mechanically in a soil mass and having physical properties not substantially different from ordinary water at the same temperature and pressure.

Active earth pressure -- See earth pressure.

Activity index of clay, a_c (D)* -- The ratio of: (1) plasticity index to (2) percent of the total sample smaller than 0.002 mm. by dry weight.

Adsorbed water -- Water in a soil mass, held by physicochemical forces, having physical properties substantially different from absorbed water or chemically combined water, at the same temperature and pressure.

Aeolian deposits -- Wind-deposited material such as dune sands and loess.

Aggregate -- A material composed of sand and/or gravel, usually having a known range of particle sizes.

A-line -- The line on Casagrande's plasticity chart that divides clays and silts--clays being above the line and silts below. It is defined by the equation: $PI = 0.73 (LL - 20)$.

Allowable bearing value, q_a (kg/cm^2 or ksf) -- The maximum pressure that can be permitted on foundation soil, giving consideration to all pertinent factors, with adequate safety against (1) rupture of the soil mass or (2) foundation movement of such magnitude that the structure is impaired.

Allowable pile bearing load, Q_a (kg or lb) -- The maximum load that can be permitted on a pile with adequate safety against movement of such magnitude that the structure is endangered.

Alluvium -- Soil which has been transported in suspension by flowing water and subsequently deposited by sedimentation.

Angle of external friction, δ (degrees) -- Angle between the abscissa and the tangent of the curve representing the relationship of shearing resistance to normal stress acting between soil and surface of another material.

Angle of internal friction, ϕ, $\bar{\phi}$ (degrees) -- Angle between the abscissa and the tangent of the curve representing the relationship of shearing resistance to normal stress acting within a soil.

Angle of repose, α (degrees) -- Angle between the horizontal and the maximum slope that a granular soil assumes through natural processes.

Anisotropic mass -- A mass having different properties in different directions at any given point.

Apparent cohesion -- See cohesion.

Apparent specific gravity -- See specific gravity.

Aquifer -- A water-bearing stratum or formation that provides a ground water reservoir.

Arching -- The transfer of stress from a yielding part of a soil mass to adjoining less-yielding or restrained parts of the mass.

Area of influence of a well, a_w (m^2 or sq ft) -- Area surrounding a well within which the piezometric surface has been lowered when pumping has produced the maximum steady rate of flow.

Atterberg limits -- A general term denoting liquid limit, plastic limit and shrinkage limit.

"B" horizon -- See horizon.

Base course -- A layer of specified or selected material of planned thickness constructed on the subgrade or subbase for the purpose of serving one or more functions such as distributing load, providing drainage, and minimizing frost action.

Base material -- In filter design, any material (embankment, backfill, foundation, or other filter material) through which water moves into a drainage system.

Bearing capacity -- Allowable bearing value.

Bearing capacity of a pile, Q_p (kg or lb) -- The load per pile required to produce a condition of failure.

Bedding material -- A layer or zone of material placed on the base or foundation to bed the designed structure. The bedding may distribute the applied load, fill the interface voids, or provide a transition in intergranular void size.

Bedrock -- The more or less solid, hard, and undisturbed rock in place.

Bentonitic clay -- A clay with a high content of the mineral montmorillonite, usually characterized by high swelling on wetting.

Berm -- A shelf that breaks the continuity of a slope.

Binder -- Portion of soil passing No. 40 (425-μm) U.S. standard sieve.

Blind well -- A relief well that consists solely of either drain material or drain and filter materials.

Blow count, N (blows/ft) -- See standard penetration test.

Borrow -- Soil or other material planned for removal, or removed, for use as a construction material.

Boulder -- A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 12 in. (300 mm) or more.

Boulder clay -- A geological term used to designate glacial drift that has not been subjected to the sorting action of water and contains particles from boulders to clay sizes.

Bulking -- The increase in volume of a material due to manipulation. Rock bulks upon being excavated; damp sand bulks if loosely deposited, as by dumping, because the apparent cohesion prevents movement of the soil particles to form a reduced volume.

Bulk specific gravity -- See specific gravity.

"C" horizon -- See horizon.

Capillary action -- The rise or movement of water in the interstices of a soil due to capillary forces.

Capillary flow -- The movement of water by capillary action.

Capillary fringe zone -- The zone in a soil mass above the free water elevation in which water is held by capillary action.

Capillary head, h (m or ft) -- The potential, expressed in height of water column, that causes water to flow by capillary action.

Capillary rise, h_c (m or ft) -- The height above a free water elevation to which water will rise by capillary action.

Capillary stress -- See stress.

Capillary water -- See soil water.

Cation exchange -- The physicochemical process whereby one species of cation adsorbed on soil particles is replaced by another species.

Cation exchange capacity, CEC (meq/100 g) -- The total exchangeable cations that a soil can adsorb from a solution of specified concentration and pH.

Centrifuge moisture equivalent -- See moisture equivalent.

Clay -- Fine-grained soil or the fine-grained portion of soil that exhibits (1) plasticity (putty-like properties) within a range of moisture contents and (2) considerable strength when air-dry.

Clay minerals -- Groups of extremely small solid substances, primarily crystalline, that are the chief constituents of clays and largely determine their engineering properties.

Clay size -- That portion of the soil finer than 0.002 mm (0.005 mm in some cases).

Coarse-grained soil -- The minus 3-in. (75 mm) fraction of a soil having a gradation such that more than 50 percent by dry weight is retained on a No. 200 (75-μm) sieve.

Cobble -- A rock fragment, usually rounded or subrounded, with a minimum dimension ranging between 3 in. (75 mm) and 12 in. (300 mm).

Coefficient of active earth pressure -- See coefficient of earth pressure.

Coefficient of compressibility, a_v (cm^2/g or sq ft/lb) -- The secant slope, for a given pressure increment, of the void ratio-pressure curve; it is calculated as: $a_v = \Delta e/\Delta p$. Where a stress-strain curve is used, $a_v = \frac{\Delta \epsilon}{\Delta p}(1 + e_o)$.

Coefficient of consolidation, c_v (cm^2/sec or sq ft/day) -- A coefficient utilized in the theory of consolidation, containing the physical constants of a soil affecting its rate of volume change.

$$c_v = \frac{k\ (1 + e)}{a_v \gamma_w}$$

where:

k = coefficient of permeability (cm/s or fpd),
e = void ratio (D),
a_v = coefficient of compressibility (cm^2/g or sq ft/lb), and
γ_w = unit weight of water (g/cm^3 or pcf)

Coefficient of curvature, C_z (D) -- A coefficient used in evaluating the grading characteristics of coarse-grained soils. It is calculated from the expression: $(D_{30})^2/(D_{10} \times D_{60})$ where D_{10}, D_{30}, and D_{60} are the particle diameters corresponding to 10, 30, and 60 percent finer on the gradation curve.

Coefficient of earth pressure, K (D) -- The principal stress ratio at a point in a soil mass.

Coefficient of earth pressure, active, K_a (D) -- The minimum ratio of: (1) the minor principal stress to (2) the major principal stress. This is applicable where the soil has yielded sufficiently to develop a lower limiting value of the minor principal stress.

Coefficient of earth pressure, at rest, K_o (D) -- The ratio of: (1) the minor principal stress to (2) the major principal stress. This is applicable where the soil mass is in its natural state without having been permitted to yield or without having been compressed.

Coefficient of earth pressure, passive, K_p (D) -- The maximum ratio of: (1) the major principal stress to (2) the minor principal stress. This is applicable where the soil has been compressed sufficiently to develop an upper limiting value of the major principal stress.

Coefficient of internal friction -- The tangent of the angle of internal friction (see internal friction).

Coefficient of permeability, k (cm/s or fpd) -- The rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions (usually 20° C).

Coefficient of pore pressure -- See pore pressure coefficients.

Coefficient of secondary consolidation, C_α (D) -- The slope of the final portion of the consolidation-time curve on a semi-log plot.

Coefficient of uniformity, C_u (D) -- A coefficient used in evaluating the grading characteristics of coarse-grained soils. It is calculated from the expression: D_{60}/D_{10} where D_{10} and D_{60} are the particle diameters corresponding to 10 and 60 percent finer on the gradation curve.

Coefficient of volume compressibility, m_v (cm^2/g or sq ft/lb) -- The compression of a soil layer per unit of original thickness due to a given unit increase in pressure. It is numerically equal to the coefficient of compressibility divided by one plus the original void ratio, i.e. $m_v = a_v/(1 + e_o)$.

Cohesion, c (kg/cm^2 or ksf) -- The portion of the shear strength of a soil indicated by the term c in Coulomb's equation: $s = c + \bar{\sigma} \tan \phi$; also referred to as no-load shear strength.

Apparent cohesion -- Cohesion in granular soils due to capillary forces.

Cohesionless soil -- A soil that, when unconfined, has little or no strength when air-dried and has little or no cohesion when submerged.

Cohesive soil -- A soil that, when unconfined, has considerable strength when air-dried and has significant cohesion when submerged.

Collapsible soil -- A soil that undergoes reorientation of particles and reduction in volume under constant load when the moisture content is increased. The term is most applicable to in-situ soil having a loose particle arrangement and a moisture content considerably less than saturation.

Colloidal particles -- Soil particles that are so small that the surface activity has an appreciable influence on the properties of the aggregate.

Colluvium -- A heterogeneous soil near the base of strong slopes that has been moved by gravity, frost action, creep, or local wash.

Compaction -- The densification of a soil by means of mechanical manipulation.

Compaction curve -- The curve showing the relationship between the dry unit weight (density) and the moisture content of a soil for a given compactive effort.

Compaction test -- A compacting procedure whereby a soil at a known moisture content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting unit weight determined. The procedure is repeated for various moisture contents sufficient to establish a relation between moisture content and unit weight.

Modified compaction test -- One of the compaction procedures outlined in ASTM D-1557; the method used should be specified.

Standard compaction test -- One of the compaction procedures outlined in ASTM D-698; the method used should be specified.

Compressibility -- Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

Compression index, C_c (D) -- The slope of the linear portion of the void ratio-pressure curve on a semi-log plot during compression, i.e. $C_c = \frac{\Delta e}{\Delta \log p}$.

Concentration factor, n (D) -- A parameter used in modifying the Boussinesq equations to describe various distributions of vertical stress.

Cone penetration test -- A quasi-static procedure for field testing whereby a standard cone-shaped steel point, often with a friction sleeve, is pushed at a steady, slow rate into soil or soft rock. The resulting data provide a basis for estimating some engineering properties of the soil or rock penetrated.

Consistency -- The relative ease with which a soil can be deformed.

Consolidated-drained test, CD -- A soil shearing test in which essentially complete consolidation under the confining pressure is followed by additional axial (or shearing) stress applied in a manner, and with drainage, that prevents a build-up of pore water pressures during the shearing process.

Consolidated-undrained test, CU or $\overline{CU}$ -- A soil shearing test in which essentially complete consolidation under the confining pressure is followed by additional axial (or shearing) stress applied while the soil is kept at constant moisture content, i.e. drainage is not permitted.

Consolidation -- The gradual reduction in volume of a soil mass resulting from an increase in compressive stress.

Initial consolidation -- A comparatively sudden reduction in volume of a soil mass under an applied load due principally to expulsion and compression of gas in the soil voids preceding primary consolidation.

Primary consolidation -- The reduction in volume of a soil mass caused by the application of a sustained load to the mass and due principally to a squeezing out of water from the void spaces of the mass and accompanied by a transfer of the load from the soil water to the soil solids.

Secondary consolidation -- The reduction in volume of a soil mass caused by the application of a sustained load to the mass and due principally to the adjustment of the internal structure of the soil mass after most of the load has been transferred from the soil water to the soil solids.

Consolidation ratio, U_z (D) -- The ratio of: (1) the amount of consolidation at a given distance from a drainage surface and at a given time to (2) the total amount of consolidation obtainable at that point under a given stress increment.

Consolidation test -- A test in which the specimen is laterally confined in a ring and is compressed between porous plates.

Consolidation-time curve -- A curve that shows the relation between: (1) percent consolidation and (2) the elapsed time after the application of a given increment of load.

Contact pressure, p (kg/cm^2 or ksf) -- The unit of pressure that acts at the surface of contact between a structure and the underlying soil mass.

Controlled-strain test -- A test in which the load is so applied that a controlled rate of strain results.

Controlled-stress test -- A test in which the stress to which a specimen is subjected is applied at a controlled rate.

Core -- The relatively impervious portion of a zoned earth embankment that serves as a barrier to water movement through the embankment; is usually located in the central portion of the embankment.
Creep -- Slow movement of rock debris or soil, usually imperceptible except to observations of long duration.
Critical density -- The unit weight of a saturated non-plastic material below which it will lose strength and above which it will gain strength when subjected to rapid deformation.
Critical height, H_c (m or ft) -- The maximum height at which a vertical or sloped bank of soil will stand unsupported under a given set of conditions.
Critical hydraulic gradient -- See hydraulic gradient.
Critical surface -- The sliding surface assumed in a theoretical analysis of a soil mass for which the factor of safety is a minimum.
Critical void ratio -- See void ratio.
Crumb test -- An index test for identification of dispersive clay soils.

D_5, D_{10} .... D_{85} size (mm or in.) -- The particle diameter corresponding to the 5, 10 .... 85 percent finer by dry weight on the gradation curve.
Deformation -- Change in shape.
Density -- See unit weight.
Desiccation -- The process of shrinkage or consolidation of fine-grained soil caused by drying.
Deviator stress, $\sigma_1 - \sigma_3$, (kg/cm^2 or ksf) -- The difference between the major and minor principal stresses in a triaxial test.
Dilatancy -- The expansion of soils when subject to shearing deformation.
Dilatancy test -- See shaking test.
Direct shear test -- A shear test in which soil under an applied normal load is stressed to failure by moving one section of the soil container (shear box) relative to the other section.
Discharge hydraulic gradient -- See hydraulic gradient.
Dispersing agent -- A chemical additive that prevents fine soil particles in suspension from coalescing to form flocs.
Dispersive clay soil -- A soil that (1) has a high percentage of sodium in the pore water salts and (2) is susceptible to rapid colloidal erosion from concentrated flow through cracks or openings in the soil.
Drain material -- Sand, gravel, or rock that has specific gradation limits for required permeability and internal stability.
Drawdown (m or ft) -- Vertical distance the water surface or the ground water elevation is lowered.
Dry strength test -- A visual-manual test performed on the fraction of a soil finer than the No. 40 (425-μm) sieve for the purpose of evaluating crushing characteristics; used as an aid to field classification and identification of soil.
Dry unit weight -- See unit weight.

Earth pressure -- The pressure or force exerted by soil on any boundary.

	Symbol	Unit
Pressure............	p	kg/cm^2 or ksf
Force...............	P	kg or lb

Active earth pressure, P_a, p_a -- The minimum value of earth pressure. This condition exists when a soil mass is permitted to yield sufficiently to cause its internal shearing resistance along a potential failure surface to be completely mobilized.

Earth pressure at rest, P_o, p_o -- The value of earth pressure when the soil mass is in its natural state without having been permitted to yield or without having been compressed.

Passive earth pressure, P_p, p_p -- The maximum value of earth pressure. This condition exists when a soil mass is compressed sufficiently to cause its internal shearing resistance along a potential failure surface to be completely mobilized.

Effective force, $\overline{P}$ (kg or lb) -- The force transmitted through a soil mass by intergranular pressures.

Effective porosity, n_e (D) -- The ratio of: (1) the volume of the voids of a soil mass that can be drained by gravity to (2) the total volume of the mass.

Effective size, D_{10} (mm or in.) -- Particle diameter corresponding to 10 percent finer on the grain-size curve.

Effective stress -- See stress.

Effective unit weight -- See unit weight.

Elasticity -- The property of a soil by which it (1) resists deformation and (2) recovers all or part of its original form upon removal of the load-causing deformation.

Elastic state of equilibrium -- State of stress within a soil mass when the internal resistance of the mass is not fully mobilized.

Engineering properties tests -- A term applied to laboratory tests that provide engineering properties of soils, e.g. permeability, compressibility, and shear strength.

Equipotential line -- Line in a flow net which represents equal piezometric elevations. The sum of pressure head and elevation head is equal at all points along the line.

Equivalent fluid -- A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil. This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.

Equivalent size, D (mm or in.) -- The diameter of a hypothetical sphere composed of material having the same specific gravity as that of the actual soil particle and of such size that it will settle in a given liquid at the same terminal velocity as the actual soil particle.

Excess hydrostatic pressure -- See hydrostatic pressure.

Exchangeable sodium percentage, ESP (D) -- A measure of the amount of exchangeable sodium relative to the other exchangeable cations in the soil. It is calculated by the formula:

$$ESP = \frac{\text{exchangeable sodium}}{\text{cation exchange capacity}} \times 100$$

where terms are expressed in meq/100 g of soil.

Factor of safety

Stability, F_s (D) -- The ratio of: (1) available shear strength to (2) mobilized shear strength.

Uplift or heave, F_h (D) -- The ratio of: (1) resisting effect [illegible] pressure to (2) applied uplift pressure.

Field moisture equivalent -- See moisture equivalent.
Fill -- Man-placed deposits of soils or waste materials.
Fill matrix -- The portion of fill material finer than the maximum particle size used in the specified compaction test method.
Filter -- A layer or combination of layers of pervious materials designed and installed in such a manner as to provide drainage, yet prevent the movement of soil particles due to flowing water.
Fine-grained soil -- The minus 3-in. (75 mm) fraction of a soil having a gradation such that 50 percent or more by dry weight passes a No. 200 (75-μm) sieve.
Fines -- Portion of a soil finer than a No. 200 (75-μm) U.S. standard sieve.
Floc -- Loose, open-structured mass formed in a suspension by the aggregation of minute particles.
Flocculation -- The process of forming flocs.
Flocculent structure -- See soil structure.
Flow channel -- The portion of a flow net bounded by two adjacent flow lines.
Flow curve -- The locus of points obtained from a standard liquid limit test and plotted on a graph representing moisture content as ordinate on an arithmetic scale and the number of flows as abscissa on a logarithmic scale.
Flow line -- The path that a particle of water follows in its course of seepage under laminar flow conditions.
Flow net -- A graphical representation of flow lines and equipotential lines used in the study of seepage phenomena.
Flow net square -- See square.
Flow slide -- The failure of a sloped bank of soil in which the movement of the soil mass does not take place along a well-defined surface of sliding.
Footing -- Portion of the foundation of a structure that transmits loads directly to the soil.
Foundation -- (a) Upper part of the earth mass carrying the load of the embankment, or (b) lower part of a structure that transmits the load to the soil.
Free water surface -- See ground water elevation.
Frost action -- Freezing and thawing of moisture in materials and the resultant effects on these materials and on structures of which they are a part or with which they are in contact.
Frost boil -- (a) Softening of soil occurring during a thawing period due to the liberation of water from ice lenses or layers.

(b) The hole formed in flexible pavements by the extrusion of soft soil and melt waters under the action of wheel loads.

(c) Breaking of a highway or airfield pavement under traffic and the ejection of subgrade soil in a soft and soupy condition caused by the melting of ice lenses formed by frost action.
Frost heave -- The raising of a surface due to the accumulation of ice in the underlying soil.

General shear failure -- See shear failure.
Glacial till -- Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.
Gradation (grain-size distribution) -- Distribution of grain sizes present in a given soil.

Gravel -- Rounded or semirounded particles of rock that will pass a 3-in. (75 mm) and be retained on a No. 4 (4.75 mm) U.S. standard sieve.

Coarse gravel -- Gravel passing 3-in. sieve (75 mm) and retained on 3/4-in. (19 mm) sieve.

Fine gravel -- Gravel passing 3/4-in. (19 mm) sieve and retained on No. 4 (4.75 mm) sieve.

Gravitational water (Ground water) -- See soil water.

Ground water elevation -- Elevation at which the pressure in water is equal to the atmospheric pressure.

Heave -- Upward movement of soil caused by expansion or displacement resulting from phenomena such as: moisture absorption, removal of overburden, driving of piles, and frost action.

Homogeneous mass -- A mass that exhibits essentially the same physical properties at every point throughout the mass.

Honeycomb structure -- See soil structure.

Horizon -- A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture, or by chemical composition, including content of organic matter, or degree of acidity or alkalinity.

"A" horizon -- The uppermost layer of a soil profile from which inorganic colloids and other soluble materials have been leached. Usually contains remnants of organic life.

"B" horizon -- The layer of a soil profile in which material leached from the overlying "A" horizon is accumulated.

"C" horizon -- Undisturbed parent material from which the overlying soil profile has been developed.

Humus -- A brown or black material formed by the partial decomposition of vegetable or animal matter; the organic portion of soil.

Hydraulic gradient, i (D) -- The loss of hydraulic head per unit distance of flow, $\frac{dh}{dL}$.

Critical hydraulic gradient, i_c (D) -- Hydraulic gradient at which the intergranular pressure in a mass of cohesionless soil is reduced to zero by the upward flow of water.

Discharge hydraulic gradient, i_d (D) -- Hydraulic gradient approaching a discharge face parallel to the flow lines.

Hydrostatic pressure, u_o (kg/cm^2 or ksf) -- The pressure in a liquid under static conditions; the product of the unit weight of the liquid and the piezometric head.

Excess hydrostatic pressure, u (kg/cm^2 or ksf) -- The pressure that exists in pore water in excess of the hydrostatic pressure.

Hygroscopic capacity, w_c (D) -- Ratio of: (1) the weight of water absorbed by a dry soil in a saturated atmosphere at a given temperature to (2) the weight of the oven-dried soil.

Hygroscopic moisture content, w_h (D) -- The moisture content of an air-dried soil.

Hygroscopic water -- See soil water.

Index tests -- A term applied to laboratory classification and other tests that do not directly measure engineering properties.

Influence factor, I (D) -- A factor (dependent on configuration of load, load distribution, and other considerations) which, when multiplied by the stress intensity of a loaded surface area, provides an estimate of the vertical stress at a point in a soil mass.
Initial consolidation -- See consolidation.
Initial void ratio -- See void ratio.
Intergranular pressure -- See effective stress under stress.
Intermediate principal plane -- See principal plane.
Intermediate principal stress -- See stress.
Internal friction -- (kg/cm^2 or ksf) -- The portion of the shearing strength of a soil indicated by the terms $\overline{\sigma} \tan \phi$ in Coulomb's equation $s = c + \overline{\sigma} \tan \phi$. It is usually considered to be due to the interlocking of the soil grains and the resistance to sliding between the grains.
Isochrone -- A curve showing the distribution of the excess hydrostatic pressure at a given time during a process of consolidation.
Isotropic mass -- A mass having the same property (or properties) in all directions.

Lacustrine deposit -- Material deposited in a fresh water lake and later exposed, either by a lowered water level or by uplifted land.
Laminar flow -- Flow in which head loss is directly proportional to velocity.
Landslide -- The failure of a sloped bank of soil in which the movement of the soil mass takes place along a surface of sliding.
Leaching -- The removal of colloids and soluble minerals and salts from parent material or rock by percolating water.
Linear expansion, L_E (D) -- The increase in one dimension of a soil mass, expressed as a percentage of that dimension at the shrinkage limit, when the moisture content is increased from the shrinkage limit to any given moisture content.
Linear shrinkage, L_S (D) -- Decrease in one dimension of a soil mass, expressed as a percentage of the original dimension, when the moisture content is reduced from a given value to the shrinkage limit.
Liquefaction -- The sudden large decrease of the shearing resistance of a cohesionless soil. It is caused by a collapse of the structure by shock or other type of strain and is associated with a sudden but temporary increase of the pore fluid pressure. It involves a temporary transformation of the material into a fluid mass.
Liquid limit, LL (D) -- (a) The moisture content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.

(b) The moisture content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of $\frac{1}{2}$ in. under the impact of 25 blows in a standard liquid limit apparatus.
Liquidity index, LI (D) -- The ratio of: (1) the natural moisture content of a soil minus its plastic limit to (2) its plasticity index.
Local shear failure -- See shear failure.
Loess -- A uniform aeolian deposit of silty material having an open structure and relatively high cohesion at natural moisture content due to cementation by clay or calcareous material at grain contacts. A characteristic of loess deposits is that they can stand with nearly vertical slopes.

Major principal plane -- See principal plane.

Major principal stress -- See stress.
Mass density, γ_t (g/cm^3 or pcf) -- Dry unit weight of total soil mass.
Maximum dry unit weight -- See unit weight.
Maximum preconsolidation pressure -- See preconsolidation pressure.
Maximum principal effective stress ratio, $\frac{\bar{\sigma}_1}{\bar{\sigma}_3}$ (D) -- The ratio of: (1) the major effective principal stress to (2) the minor effective principal stress from a triaxial shear test.
Mechanical analysis -- The process of determining gradation by sieving and hydrometer analyses.
Milliequivalent, meq -- The weight in one thousandth of a gram of an ion or compound that combines with or replaces one gram of hydrogen.
Minor principal plane -- See principal plane.
Minor principal stress -- See stress.
Modified compaction test -- See compaction test.
Modulus of elasticity, E (kg/cm^2 or ksf) -- The ratio of stress to strain for a material that deforms in accordance with Hooke's Law (elastic). Numerically equal to the slope of the stress-strain curve.

Initial tangent modulus, E_i (kg/cm^2 or ksf) -- The slope of the stress-strain curve at the start of the test.

Secant modulus, E_s (kg/cm^2 or ksf) -- The slope of the line connecting two points on the stress-strain curve.

Secant modulus at failure, E_f (kg/cm^2 or ksf) -- The slope of the line between the origin and point of failure on the stress-strain curve.

Modulus of shear deformation, G (kg/cm^2 or ksf) -- A modulus used in evaluating various states of stress and strain.

$$G = \frac{E}{2\ (1 + \mu)}$$

where E = modulus of elasticity (kg/cm^2 or ksf)
μ = Poisson's ratio (D)

Mohr circle -- A graphical representation of the stresses acting on the various planes at a given point.
Mohr envelope -- The envelope of a series of Mohr circles representing stress conditions at failure for a given material. According to Mohr's rupture hypothesis, a rupture envelope is the locus of points, the co-ordinates of which represent the combinations of normal and shearing stresses that will cause a given material to fail.
Moisture content, w (D) -- The ratio, expressed as a percentage, of: (1) the weight of water in a given soil mass to (2) the weight of solid particles.
Moisture equivalent:

Centrifuge moisture equivalent, CME (D) -- The moisture content of a soil after it has been saturated with water and then subjected for one hour to a force equal to 1000 times that of gravity.

Field moisture equivalent, FME (D) -- The minimum moisture content, expressed as a percentage of the weight of the oven-dried soil, at which a drop of water placed on a smoothed surface of the soil will not immediately be absorbed by the soil but will spread out over the surface and give it a shiny appearance.

Morphology, soil -- The constitution of a soil, including the texture, structure, consistency, color and other physical, chemical, and biological properties of the various soil horizons that make up a soil profile.

Muck -- An organic soil of very soft consistency.

Mud -- A mixture of soil and water in a fluid or soft, plastic state.

Muskeg -- Level, practically treeless areas supporting dense growth consisting primarily of grasses. The surface of the soil is covered with a layer of partially decayed grass and grass roots which is usually wet and soft when not frozen.

Neutral stress -- See stress.

Normal stress -- See stress.

Normally consolidated soil -- A soil deposit that has never been subjected to an effective pressure greater than the existing overburden pressure.

Non-plastic, NP -- A term applied to a soil that exhibits no plasticity.

Observation well -- A cased or uncased hole in which the ground water surface is measured. May not reflect pressure head in a specific soil layer or at a point as does a piezometer.

Optimum moisture content, w_o (D) -- The moisture content at which a soil can be compacted to the maximum dry unit weight by a given compactive effort.

Organic clay -- A clay with a high organic content.

Organic silt -- A silt with a high organic content.

Organic soil -- Soil with a high organic content. In general, organic soils are very compressible and have poor load-sustaining properties.

Overconsolidated soil -- A soil deposit that has been subjected to an effective pressure greater than the present effective overburden pressure.

Overconsolidation ratio, OCR (D) -- The ratio of: (1) the maximum past effective pressure to (2) either the computed effective vertical pressure on the sample in the field or the consolidating chamber pressure at the start of a triaxial shear test. Thus, for a normally consolidated soil, OCR = 1.

Oversize fraction, P (D) -- The portion of a soil in terms of dry weight that is larger than (1) the maximum particle size in the test specimen (e.g., usually plus No. 4 (4.75 mm) or 3/4-inch (19 mm) particles in the compaction test) or (2) the maximum particle size in the sample submitted to the testing facility.

Parent material -- Material from which a pedological soil has been derived.

Passive earth pressure -- See earth pressure.

Path of percolation -- The path that water follows along the surface of contact between the foundation soil and the base of a dam or other structure.

Peat -- An organic soil or material with readily identifiable plant remains. It holds a large quantity of water, is spongy, and is generally brown.

Pedological soil survey -- The areal mapping or delineating of soil based on its physical, chemical, and organic content occurring within approximately the surface six feet (2 m) of the earth's crust. Delineations are based on the classification system established for the U.S. by the Soil Conservation Service.

Penetration resistance, p_r (kg/cm^2 or ksf) -- The unit load required to produce a penetration into fine-grained soil of at least 3 inches at a rate of 1/2 inch per second by use of a soil penetrometer with attached needle having a flat end of known area.

Penetration resistance curve -- The curve showing the relationship between: (1) the penetration resistance and (2) the moisture content.

Percent compaction -- The ratio, expressed as a percentage, of: (1) dry unit weight of a soil to (2) maximum dry unit weight obtained in a compaction test.

Percent consolidation, U (D) -- The ratio, expressed as a percentage, of: (1) the amount of consolidation at a given time within a soil mass to (2) the total amount of consolidation obtainable under a given stress condition.

Percent dispersion (D) -- The ratio, expressed as a percentage, of: (1) percent naturally dispersed 0.005 mm soil particles as determined by the laboratory dispersion test to (2) percent total 0.005 mm soil particles as determined by the laboratory hydrometer test.

Percent saturation, S (D) -- The ratio, expressed as a percentage, of: (1) the volume of water in a given soil mass to (2) the total volume of the voids.

Perched water table -- A water table usually of limited area maintained above the normal free water elevation by the presence of an intervening relatively impervious confining stratum.

Permafrost -- Perennially frozen soil.

Permeability -- The property of a porous medium that allows water to flow through it.

pH (D) -- The negative logarithm of the effective hydrogen ion concentration -- an index of the acidity or alkalinity of a soil.

Phreatic line -- The free water surface of the zone of seepage.

Piezometer -- An instrument for measuring water pressure at a point.

Piezometric head, h_p (m or ft) -- The hydrostatic water pressure at a point. The head is expressed in height to which a water column will rise or lower in a tube exposed to atmospheric pressure.

Piezometric surface -- The trace of a line connecting a series of points of piezometric head.

Pile -- Relatively slender structural element which is driven or otherwise inserted into the soil, usually for the purpose of providing vertical or lateral support. A pile transfers the foundation load to a more competent stratum at a lower elevation.

Pinhole test -- A laboratory test for identifying dispersive clay soil wherein distilled water is discharged through a standard-sized hole in a compacted specimen.

Piping -- The movement of soil particles by seepage leading to the development of tunnels.

Plastic deformation -- The deformation of a plastic material beyond the point of recovery, accompanied by continuing deformation with no further increase in stress.

Plastic equilibrium -- State of stress within a soil mass, or a portion thereof, which has been deformed to such an extent that its ultimate shearing resistance is mobilized.

Active state of plastic equilibrium -- Plastic equilibrium obtained by expansion of a mass.

Passive state of plastic equilibrium -- Plastic equilibrium obtained by compression of a mass.

Plasticity -- The property of a soil which allows it to be deformed beyond the point of recovery without cracking or appreciable volume change.
Plasticity index, PI (D) -- Numerical difference between the liquid limit and the plastic limit.
Plastic limit, PL (D) -- (a) The moisture content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil.

(b) Moisture content at which a soil being dried will just begin to crumble when rolled into a thread approximately 1/8 in. (0.32 mm) in diameter.

Plastic soil -- A soil that exhibits plasticity.
Plastic state -- The range of consistency within which a soil exhibits plastic properties.
Poisson's ratio, μ (D) -- The ratio of: (1) lateral strain to (2) axial strain in a material when under axial compression.
Pore pressure coefficients (Skempton):

Pore pressure coefficient, $\overline{A}$ (D) -- In an undrained soil, the ratio of: (1) the change in pore water pressure produced by the stress difference to (2) the stress difference itself.

$$\overline{A} = \frac{\Delta u}{\Delta (\sigma_1 - \sigma_3)}$$

Pore pressure coefficient, B (D) -- In an undrained triaxial shear test, the ratio of: (1) the change in pore water pressure caused by a change in all-round (chamber) pressure to (2) the change in all-round pressure itself.

$$B = \frac{\Delta u}{\Delta \sigma_3}$$

Pore water pressure -- See neutral stress under stress.
Porosity, n (D) -- The ratio, expressed as a percentage, of: (1) the volume of voids of a given soil mass to (2) the total volume of the soil mass.
Positive cutoff -- A barrier of impervious material extending downward to an essentially impervious lower boundary to intercept completely the path of subsurface seepage.
Potential drop, Δh (m or ft) -- The difference in piezometric head between two equipotential lines.
Preconsolidation pressure, p_c (kg/cm^2 or ksf) -- The most probable effective pressure to which a soil has been subjected.

Maximum preconsolidation pressure, $p_{c(max)}$ (kg/cm^2 or ksf) -- The maximum preconsolidation pressure as inferred from a void ratio-pressure (log scale) curve using Casagrande's procedure.

Minimum preconsolidation pressure, $p_{c(min)}$ (kg/cm^2 or ksf) -- The least probable preconsolidation pressure as inferred from a consolidation test at the intersection of (1) a horizontal line through the initial void ratio and (2) a projection of the straight-line portion of the void ratio-pressure (log scale) curve.

Pressure, p (kg/cm^2 or ksf) -- The load divided by the area over which it acts.

Effective pressure, $\overline{p}$ (kg/cm^2 or ksf) -- The load per unit area which is transmitted from grain to grain in a soil mass. The total pressure minus the effect of uplift, i.e. $\overline{p} = \overline{P}/A$.

Pressure bulb -- The zone in a loaded soil mass bounded by an arbitrarily selected isobar of stress.

Primary consolidation -- See consolidation.
Principal plane -- Each of three mutually perpendicular planes through a point in a soil mass on which the shearing stress is zero.

Intermediate principal plane -- The plane normal to the direction of the intermediate principal stress.

Major principal plane -- The plane normal to the direction of the major principal stress.

Minor principal plane -- The plane normal to the direction of the minor principal stress.

Principal stress -- See stress.
Progressive failure -- Failure in which the ultimate shearing resistance is progressively mobilized along the failure surface.

Quick condition -- Condition in which water is flowing upwards with sufficient velocity to reduce significantly the bearing capacity of the soil through a decrease in intergranular pressure.

Radius of influence of a well (m or ft) -- Distance from the center of the well to the closest point at which the piezometric surface is not lowered when pumping has produced the maximum steady rate of flow.
Rebound -- The increase in void ratio due to elastic rebound when a compressive load on a soil or rock mass is reduced.
Recompression -- The decrease in void ratio when a soil, that has been loaded and the load is subsequently reduced, is again subjected to an increase in compressive stress.
Recompression index, C_r (D) -- The slope of the recompression portion of the void ratio-pressure (log scale) curve.
Relative density, D_r (D) -- The ratio, expressed as a percentage, of: (1) the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio to (2) the difference between its void ratios in the loosest and the densest states.
Remolded soil -- Soil that has had its natural structure modified by manipulation.
Residual soil -- Soil derived in place by weathering of the underlying material.
Rock -- Natural solid mineral matter occurring in large masses or fragments.
Rock flour -- Generally unweathered, non-plastic silt and clay size particles produced by the grinding action of glaciers.

Sand -- Particles of rock that will pass the No. 4 (4.75 mm) sieve and be retained on the No. 200 (75-μm) U.S. standard sieve.

Coarse sand -- Sand passing the No. 4 sieve and retained on the No. 10 (2.0 mm) sieve.

Medium sand -- Sand passing the No. 10 sieve and retained on the No. 40 (425-μm) sieve.

Fine sand -- Sand passing the No. 40 sieve and retained on the No. 200 sieve.

Sand boil -- The ejection of sand and water resulting from piping.
Saturated unit weight -- See unit weight.
Sealing test -- A laboratory test made for the purpose of determining the type and the quantity of additives (chemicals, bentonite, etc.) to mix with a soil and/or the percent compaction to reduce permeability to acceptable limits.
Secondary consolidation -- See consolidation.

Seepage -- The slow movement of gravitational water through soil or rock.

Seepage force, J (kg or lb) -- The force transmitted to the soil grains by seepage.

Seepage pressure, p_s (kg/cm^2 or ksf) -- The seepage force per unit area of soil mass.

Seepage velocity -- See velocity.

Seismic force -- An inertial force that is added in stability analyses in an attempt to account for earthquake effects.

Sensitivity -- The effect of remolding on the consistency of a cohesive soil.

Sensitivity ratio, S_t (D) -- The ratio of: (1) the unconfined compressive strength of an undisturbed specimen of soil to (2) the unconfined compressive strength of a specimen of the same soil after remolding at the same moisture content.

Settlement, S (m or ft) -- The displacement of a structure due to the compression and deformation of the underlying soil.

Shaking test -- A test used to indicate the presence of significant amounts of rock flour, silt, or very fine sand in a fine-grained soil. It consists of shaking a pat of wet soil, having a consistency of thick paste, in the palm of the hand; observing the surface for a glossy or livery appearance; squeezing the pat; and observing if a rapid apparent drying and subsequent cracking of the soil occurs.

Shape factor, $ (D) -- A characteristic of a flow net which is independent of the permeability and the total head loss; the ratio N_f/N_d.

Shear failure -- Failure in which movement caused by shearing stresses in a soil mass is of sufficient magnitude to destroy or cause serious distress to a structure.

General shear failure -- Failure in which the ultimate strength of the soil is mobilized along the entire potential surface of sliding before the structure supported by the soil is impaired by excessive movement.

Local shear failure -- Failure in which the ultimate shearing strength of the soil is mobilized only locally along the potential surface of sliding at the time the structure supported by the soil is impaired by excessive movement.

Shear strength, s (kg/cm^2 or ksf) -- The resistance of a soil to shearing stresses.

Shear stress -- See stress.

Shell -- The outer portion of a zoned embankment that provides structural support for the core and seepage control. The material contained in the shell is permeable enough that shear strength is not affected by moisture content.

Shrinkage index, SI (D) -- The numerical difference between the plastic and the shrinkage limits.

Shrinkage limit, SL (D) -- The maximum moisture content at which a reduction in moisture content will not cause a decrease in volume of the soil mass.

Shrinkage ratio, R (D) -- The ratio of: (1) a given volume change, expressed as a percentage of the dry volume, to (2) the corresponding change in moisture content above the shrinkage limit, expressed as a percentage of the weight of the oven-dried soil.

Silt -- Material passing the No. 200 (75-μm) U.S. standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

Silt size -- That portion of the soil finer than 0.075 mm and coarser than 0.002 mm.

Single-grained structure -- See soil structure.

Skin friction, f (kg/cm^2 or ksf) -- The frictional resistance developed between soil and a structure.

Slaking -- The process of breaking up or sloughing when soil or rock is immersed in water.

Slickensides -- Surfaces within a soil or rock mass that have been smoothed and striated by shear movements on these surfaces.

Sodium adsorption ratio, SAR (D) -- The ratio of: (1) sodium cations to (2) the square root of one half of the sum of calcium and magnesium cations where all terms refer to the concentrations of the designated soluble cations expressed in meq/liter. It may be expressed by the formula:

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

Soil -- Sediments or other unconsolidated accumulations of solid particles produced by the physical disintegration and chemical decomposition of rocks and which may or may not contain organic matter.

Soil-forming factors -- Factors, such as parent material, climate, vegetation, topography, and time involved in the transformation of an original geologic deposit into a soil profile.

Soil mechanics -- The application of the laws and the principles of mechanics and hydraulics to engineering problems dealing with soil as an engineering material.

Soil physics -- The organized body of knowledge concerned with the physical characteristics of soil and the methods employed in their determinations.

Soil profile -- Vertical section of a soil showing the nature and sequence of the various layers as developed by deposition or weathering, or both.

Soil stabilization -- Chemical and/or mechanical treatment to increase or maintain the stability of a mass of soil or otherwise to improve its engineering properties.

Soil structure -- The arrangement and the state of aggregation of soil particles in a soil mass.

Flocculent structure -- An arrangement composed of flocs of soil particles instead of individual soil particles.

Honeycomb structure -- An arrangement of soil particles having a comparatively loose, stable structure resembling a honeycomb.

Single-grained structure -- An arrangement of soil particles in which they act individually.

Soil suspension -- Dilute mixture of soil and water.

Soil water -- The water contained in a soil mass. It may exist under pressures ranging from positive to negative.

Hygroscopic water -- The water adsorbed on the surface of soil particles as a thin film that (1) has properties substantially different from ordinary water and (2) is removed by oven drying but not by air drying.

Capillary water -- The water that (1) is under tension in a soil mass and (2) will move with a change in capillary stress.

Gravitational water -- Water that is free to move through a saturated soil mass under the influence of gravity.

Soluble salt content (D) -- The ratio, expressed as a percentage, of: (1) the weight of soluble salts in a soil mass to (2) the weight of the dry soil.

Soluble sodium percentage, SSP (D) -- The ratio, expressed as a percentage, of: (1) sodium in a saturation extract to (2) the sum of calcium, magnesium, sodium, and potassium, all expressed in meq/liter. It may be calculated by the formula:

$$SSP = \frac{Na}{Ca + Mg + Na + K} \times 100$$

Specific gravity:

Specific gravity of solids, G_s (D) -- Ratio of: (1) the weight in air of a given volume of soil solids at a stated temperature to (2) the weight in air of an equal volume of distilled water at a stated temperature.

Apparent specific gravity, G_a (D) -- Ratio of: (1) the weight in air of a given volume of the impermeable portion of a permeable material (that is, the solid matter including its impermeable pores or voids) at a stated temperature to (2) the weight in air of an equal volume of distilled water at a stated temperature.

Bulk specific gravity, G_m (D) -- Ratio of: (1) the weight in air of a given volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to (2) the weight in air of an equal volume of distilled water at a stated temperature.

Square -- Any curvilinear figure in a flow net that has four sides and the same dimensions in the two primary directions. Also, any figure that can be sub-divided into three squares and a remaining figure similar in shape to the original is called a square.

Standard compaction test -- See compaction test.

Standard penetration test, SPT -- A field procedure in which a 140-lb (63.5 kg) hammer falling a distance of 30 in. (0.76 m) is used to drive a standard split-barrel sampler into the soil. Data are recorded as blows to drive the sampler one foot (ASTM D-1586).

Strain, ϵ (D) -- The change in length per unit of length in a given direction.

Stress, σ (kg/cm^2 or ksf) --The force per unit area acting within the soil mass.

Capillary stress, u_c (kg/cm^2 or ksf) -- The pore water pressure less than atmospheric values produced by surface tension of pore water acting on the meniscus formed in void spaces between soil particles.

Effective stress, $\overline{\sigma}$ (kg/cm^2 or ksf) -- The average normal force per unit area transmitted from grain to grain of a soil mass. It is the stress that is effective in mobilizing internal friction.

Neutral stress, u_w (kg/cm^2 or ksf) -- Stress transmitted through the pore water (water filling the voids of the soil).

Normal stress, σ (kg/cm^2 or ksf) -- The stress component normal to a given plane.

Principal stress, σ_1, σ_2, σ_3 (kg/cm^2 or ksf) -- Stresses acting normal to three mutually perpendicular planes intersecting at a point in a body, on which the shearing stress is zero.

Major principal stress, σ_1 (kg/cm^2 or ksf) -- The largest (with regard to sign) principal stress.

Minor principal stress, σ_3 (kg/cm or ksf) -- The smallest (with regard to sign) principal stress.

Intermediate principal stress, σ_2 (kg/cm^2 or ksf) -- The principal stress whose value is neither the largest nor the smallest (with regard to sign) of the three.

Shear stress, τ (kg/cm^2 or ksf) -- The stress component tangential to a given plane.

Total stress, σ (kg/cm^2 or ksf) -- The total force per unit area acting within a mass of soil. It is the sum of the neutral and the effective stresses.

Stress path -- A continuous representation of successive states of stress in a triaxial shear test formed by a line or curve connecting a series of stress points.

Subgrade -- The soil prepared and compacted to support a structure or a pavement system.

Submerged unit weight -- See unit weight.

Subsoil -- (a) Soil below a subgrade or fill or (b) the B horizon of soils with distinct profiles.

Superficial velocity -- See velocity.

Swell -- The increase in volume and moisture content of a soil that occurs in the presence of free water when pressure is reduced.

Talus -- Rock fragments mixed with soil at the foot of a natural slope from which they have been separated and moved by the force of gravity.

Thixotropy -- The property of a material that enables it to stiffen in a relatively short time on standing, but upon agitation or manipulation to change to a very soft consistency or to a fluid of high viscosity, the process being completely reversible.

Time curve -- See consolidation-time curve.

Time factor, T (D) -- Dimensionless factor, utilized in the theory of one-dimensional consolidation, containing the physical constants of a soil stratum influencing its time-rate of consolidation, expressed as follows:

$$T = \frac{k(1 + e)t}{(a_v)(\gamma_w)(H^2)} = \frac{(c_v)(t)}{H^2}$$

where:

k = coefficient of permeability (cm/s or fpd)
e = void ratio (dimensionless)
t = elapsed time that the stratum has been consolidated (s or day)
a_v = coefficient of compressibility (cm^2/g or sq ft/lb)
γ_w = unit weight of water (g/cm^3 or pcf)
H = thickness of stratum drained on one side only. If stratum is drained on both sides, its thickness equals 2H (cm or ft)
c_v = coefficient of consolidation (cm^2/s or sq ft/day)

Topsoil -- Surface soil, usually containing organic matter.

Total stress -- See stress.

Toughness test -- A visual-manual test performed on the fraction of a soil finer than the No. 40 (425-μm) sieve for the purpose of evaluating consistency near the plastic limit; used as an aid in the field classification and identification of soil.

Transformed flow net -- A flow net whose boundaries have been properly modified (transformed) so that a net consisting of curvilinear squares can be constructed to represent flow conditions in an anisotropic porous medium.

Transition zone -- A relatively thin zone or layer between two adjacent zones or layers of differing permeability. A transition zone provides for seepage between the adjacent layers without movement of soil particles. The gradation of the transition zone may or may not meet filter requirements.

Triaxial shear test -- A test in which a cylindrical specimen of soil encased in an impervious membrane is subjected to a confining pressure and then loaded axially to failure.

Turbulent flow -- That type of flow in which (1) any water particle may move in any direction with respect to any other particle and (2) the head loss is approximately proportional to the second power of the velocity.

Ultimate bearing capacity, q_{ult} (kg/cm^2 or ksf) -- The average load per unit of area required to produce failure by rupture of a supporting soil mass.

Unconfined compressive strength, q_u (kg/cm^2 or ksf) -- The load per unit of area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test.

Unconsolidated - undrained test, UU -- A soil shearing test in which the moisture content of the test specimen remains practically unchanged during the application of the confining pressure and the additional axial (or shearing) force.

Underconsolidated soil -- A deposit that is not fully consolidated under the existing overburden pressure.

Undisturbed sample -- A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

Unit weight, γ (g/cm^3 or pcf) -- Weight per unit volume.

Dry unit weight, γ_d (g/cm^3 or pcf) -- The weight of soil solids per unit of total volume of soil mass.

Effective unit weight, γ_e (g/cm^3 or pcf) -- The unit weight of a soil which, when multiplied by the height of the overlying column of soil, yields the effective pressure due to the weight of the overburden.

Maximum dry unit weight, γ_{max} (g/cm^3 or pcf) -- The dry unit weight defined by the peak of a compaction curve.

Saturated unit weight, γ_{sat} (g/cm^3 or pcf) -- The wet unit weight of a soil mass when saturated.

Submerged unit weight, γ_{sub} (g/cm^3 or pcf) -- The weight of the solids in air minus the weight of water displaced by the solids per unit of volume of soil mass; the saturated unit weight minus the unit weight of water.

Unit weight of water, γ_w (g/cm^3 or pcf) -- The weight per unit volume of water; nominally equal to 1 g/cm^3 or 62.4 pcf.

Wet unit weight, γ_m (g/cm^3 or pcf) -- The weight (solids plus water) per unit of total volume of soil mass, irrespective of the degree of saturation.

Uplift -- The upward water pressure on a structure.

	Symbol	Unit
Unit symbol............	u	kg/cm^2 or ksf
Total symbol...........	U	kg or lb

Vane shear test -- An in-place shear test in which a rod with thin radial vanes at the end is forced into the soil and the resistance to rotation of the rod is determined.

Varved clay -- Alternating thin layers of silt (or fine sand) and clay formed by variations in sedimentation during the various seasons of the year, often exhibiting contrasting colors when partially dried.

Velocity:

Seepage velocity, v_s (cm/s or fpd) -- The rate of discharge of seepage water through a porous medium per unit area of void space perpendicular to the direction of flow. ($v_s \approx v/n$)

Superficial (discharge) velocity, v (cm/s or fpd) -- Rate of discharge of water through a porous medium per unit of total area perpendicular to the direction of flow.

Virgin compression curve -- Straight line portion of a void ratio-pressure curve when plotted on semi-log paper with pressure on the log scale.

Void -- Space in a soil mass not occupied by solid mineral matter. This space may be occupied by air, water, or other gases or liquids.

Void ratio, e (D) -- The ratio of: (1) the volume of void space to (2) the volume of solid particles in a given soil mass.

Critical void ratio, e_c (D) -- The void ratio corresponding to the critical density.

Initial void ratio, e_o (D) -- The void ratio at the beginning of a test or in-situ prior to loading.

Void ratio-pressure curve -- A curve representing the relationship between effective pressure and void ratio of a soil as obtained from a consolidation test. The curve has a characteristic shape when plotted on semi-log paper with pressure on the log scale.

Volumetric shrinkage, V_s (D) -- The decrease in volume, expressed as a percentage of the soil mass when dried, of a soil mass when the moisture content is reduced from a given percentage to the shrinkage limit.

Water table -- See ground water elevation.

Wet unit weight -- See unit weight.

Zero air voids curve -- The curve showing unit weight as a function of moisture content when saturated. Sometimes called the 100 percent saturation curve.

Zoned embankment -- An earth dam embankment zoned by the systematic distribution of soil types according to their strength and permeability characteristics, usually with a central impervious core and shells of greater permeability.

Part B. Symbols

Symbol	Designation
a	spacing of relief wells; distance along downstream slope of earth dam from breakout point of top flow line to toe
a_c	activity index of clay
a_o	horizontal distance between toe of dam or drain and vertex of basic parabola (Casagrande's phreatic line criteria)
a_v	coefficient of compressibility
a_w	area of influence of a well
A	area
$\overline{A}$	pore pressure coefficient (Skempton)
A_s	area of soil solids in section
A_v	area of voids in section
Å	angstrom unit
b	horizontal projection of a slope
B	breadth of foundation; pore pressure coefficient (Skempton)
B_o	point of intersection of basic parabola and water surface (Casagrande's phreatic line criteria)
c	unit cohesion
$\overline{c}$	effective unit cohesion
c_e	unit cohesion of embankment material
c_f	unit cohesion of foundation material
c_v	coefficient of consolidation
C_c	compression index
C_r	recompression index
C_u	coefficient of uniformity
C_w	Lane's weighted creep ratio
C_z	coefficient of curvature
c/b	ratio of: (1) horizontal distance from top of downstream slope to upstream edge of drain to (2) horizontal projection of downstream slope
CBR	California bearing ratio
CD	consolidated-drained (shear test or shear strength)
CEC	cation exchange capacity
CME	centrifuge moisture equivalent
CU	consolidated-undrained (shear test or shear strength)
$\overline{\text{CU}}$	consolidated-undrained shear test with pore pressure measured or shear strength based on measured pore pressure
C_α	coefficient of secondary consolidation
d	depth from ground surface to center of compressible stratum; thickness of aquifer
d'	adjusted depth for arching in clean sand or gravel stratum
D	diameter; equivalent size (diameter); depth of embedment beneath ground surface (e.g., a footing)
D_r	relative density
D_{10}	effective size (effective diameter)

D_z	particle diameter where z is a numerical subscript corresponding to 15, 30, etc. percent finer by dry weight
DD	effective drawdown in well
e	void ratio; base of natural (or Naperian) logarithms
e_c	critical void ratio
e_o	initial or original void ratio
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
E	modulus of elasticity; energy head
E_i	initial tangent modulus
E_f	secant modulus at failure
E_s	secant modulus
ESP	exchangeable sodium percentage
f	skin friction (coefficient of friction between soil and structure)
F	total frictional resistance
F_h	factor of safety against failure by heaving
F_s	factor of safety against failure in shear
FME	field moisture equivalent
g	acceleration due to gravity
G	modulus of shear deformation
G_a	apparent specific gravity
G_m	bulk specific gravity
G_s	specific gravity of solids
h	hydraulic head; capillary head
Δh	difference in head; potential drop
h_b	head loss through upstream blanket
h_c	critical head for failure by piping; capillary rise
h_e	elevation head
h_m	head under surface stratum at a point midway between relief wells
h_o	effective head under surface stratum (blanket) at downstream toe of dam
h_p	pressure head; piezometric head
h_v	velocity head
h_w	head under surface stratum at relief well; head measured in an observation well
H	height of dam or slope; thickness of compressible stratum
H_c	critical height
H_f	thickness of field stratum
H_ℓ	thickness of laboratory specimen

H_t	depth of tension crack
H_u	thickness of stratum at U degree of consolidation
H_{50}	thickness of stratum at 50% consolidation
i	hydraulic gradient
i_c	critical hydraulic gradient
i_d	discharge (or exit) hydraulic gradient
I	influence factor
J	seepage force
k	coefficient of permeability
k'	average coefficient of permeability of anisotropic soils
k_b	vertical permeability of blanket material
k_f	lateral permeability of aquifer
k_h	horizontal permeability
k_v	vertical permeability
K_a	coefficient of active earth pressure
K_o	coefficient of earth pressure at rest
K_p	coefficient of passive earth pressure
L, ℓ	length; distance
L_a	length of arc
L_c	length of chord
L_E	linear expansion
L_S	linear shrinkage
L_o	distance from toe of embankment to exposed aquifer
L_1	effective length of upstream blanket
L_2	total length of base of embankment
L_3	effective length of downstream blanket
LI	liquidity index
LL	liquid limit
m	horizontal distance from upstream toe of dam to intersection of reservoir water surface and embankment
m_v	coefficient of volume compressibility
M	moment
n	porosity; concentration factor (Boussinesq)
n_e	effective porosity
N	number of blows/foot (standard penetration test); force normal to failure surface
N_c, N_q, N_γ	bearing capacity factors
N_d	number of equipotential drops (flow net)
N_f	number of flow channels (flow net)
NP	non-plastic
OCR	overconsolidation ratio

p	pressure; unit earth pressure; unit normal pressure; contact pressure
p_a	unit active earth pressure
p_c	preconsolidation pressure
$p_{c(max)}$	maximum preconsolidation pressure
$p_{c(min)}$	minimum preconsolidation pressure
$\overline{p}_o$	present effective overburden pressure
p_o	unit at rest earth pressure
p_p	unit passive earth pressure
p_r	penetration resistance
p_s	seepage pressure
$\overline{p}$	effective pressure (intergranular pressure)
pH	index of acidity or alkalinity of a soil
P	total load or force; oversize fraction
$\overline{P}$	effective load or force (P - U)
P_a	total active earth pressure
P_o	total earth pressure at rest
P_p	total passive earth pressure
Δp	change in unit vertical pressure at a point in a foundation due to an embankment, a surcharge load, or an excavation; incremental load per unit area
PI	plasticity index
PL	plastic limit
P_m	pressure relief midway between wells
P_w	pressure relief at wells
q	rate of flow
q_a	allowable unit bearing value
q_{ult}	ultimate bearing capacity
q_u	unconfined compressive strength
Q	quantity of flow
Q_a	allowable pile bearing load
Q_p	ultimate bearing capacity of a pile
Q_w	total discharge of a relief well
r	radius
r_e	effective radius of well
r_m	radius of meniscus
R	resultant force; shrinkage ratio
s	shear strength
S	percent saturation; total consolidation; settlement
S_t	sensitivity ratio
S_u	consolidation per foot of compressible stratum
SAR	sodium absorption ratio
SI	shrinkage index; International System of Units
SL	shrinkage limit
SPT	standard penetration test
SSP	soluble sodium percentage

t	time
t_f	field time (consolidation)
t_ℓ	laboratory time (consolidation)
t_U	time at U degree of consolidation
T	force tangent to failure surface; temperature; time factor
T_s	surface tension
TSS	total soluble salts
u	excess unit hydrostatic pressure; unit uplift pressure
Δu	pore pressure difference
u_c	capillary stress
u_f	increment of pore water pressure developed during shear
u_o	hydrostatic pressure
u_w	neutral stress
U	percent consolidation; total uplift pressure; degree of pore pressure dissipation
U_z	consolidation ratio where z is a numerical subscript used to designate percent of consolidation
USCS	unified soil classification symbol (or system)
UU	unconsolidated-undrained (shear test or shear strength)
v	velocity; superficial velocity
v_e	exit velocity
v_s	seepage velocity
V	total volume of soil mass; volume
V_a	volume of air in soil mass
V_s	volume of solid component of soil in soil mass; volumetric shrinkage
V_v	volume of voids in soil mass
V_w	volume of water in soil mass
w	moisture content of total material; bottom width of trench
w_c	hygroscopic capacity
w_g	moisture content of oversize material (usually plus No. 4 fraction)
w_h	hygroscopic moisture content
w_n	natural moisture content
w_o	optimum moisture content for a given compactive effort
w_{sat}	moisture content at saturation
w_s	moisture content of soil matrix (usually minus No. 4 fraction)
W	total weight of soil mass; top width of dam; depth of penetration of relief wells into aquifer; weight
W_a	weight of air in soil mass (usually $W_a = 0$)
W_s	weight of solids in soil mass
W_w	weight of water in soil mass
WL	ground water elevation (at a given date)
x	Cartesian coordinate (abscissa or horizontal)

y	Cartesian coordinate (ordinate or vertical)
y_o	ordinate of basic parabola at toe of dam or at drain
z	ratio of length to height of a slope; depth to a point or plane
Z	thickness of blanket in blanket-aquifer situation
α	angle of repose; angle of discharge face (from horizontal); angle of flow line with boundary at exit between materials of different permeabilities (in flow net); contact or wetting angle
β	angle of slope to horizontal; angle of flow line with boundary at entrance between materials of different permeabilities (in flow net)
γ	unit weight (density)
γ_d	dry unit weight of solid component of soil mass
γ_{ds}	dry unit weight of soil matrix fraction
γ_e	effective unit weight
γ_g	bulk dry unit weight of oversize material (usually plus No. 4 fraction)
γ_m	wet unit weight of soil mass
γ_{max}	maximum dry unit weight for a given compactive effort
γ_{sat}	saturated unit weight of soil mass
γ_{sub}	submerged unit weight of solid component of soil mass
γ_t	theoretical dry unit weight of total material (matrix and oversize material); mass dry unit weight
γ_w	unit weight of water
Δ	increment
δ	angle of external friction
ϵ	strain
θ	angle between sloping surface and horizontal (slope = cot θ)
μ	Poisson's ratio; micron (0.001 mm)
π	pi = 3.1416
σ	stress; normal stress; total stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
$\bar{\sigma}$	effective stress
τ	shear stress
τ_f	shear stress at failure
ϕ	angle of internal friction
$\bar{\phi}$	effective angle of internal friction
ϕ_e	angle of internal friction of embankment soil
ϕ_f	angle of internal friction of foundation soil
χ	fraction of the area over which pore water pressure acts
\$	shape factor (flow net)

Part C. Abbreviations

The following abbreviations should be used only when the meaning is unquestionably clear. When in doubt, the word should be spelled out. Do not use periods after abbreviations except for inch, longitudinal, and number.

Term	Abbreviation
absolute	abs
acre(s)	acre(s)
acre-foot (acre-feet)	acre-ft
approximate	approx
atmosphere	atm
average	avg
Celsius (Centigrade)	C
centerline	¢
center to center	c to c
centimeter(s)	cm
centimeters per second	cm/s
circular	cir
coefficient	coef
column	col
constant	const
cubic	cu
cubic centimeter(s)	cm^3
cubic feet per day	cfd
cubic feet per minute	cfm
cubic feet per second	cfs
cubic foot (cubic feet)	cu ft
cubic inch(es)	cu in.
cubic meter(s)	m^3
cubic yard(s)	cu yd
cycles per minute	cpm
cycles per second	cps
cylinder, cylindrical	cyl
degree(s)	deg
diameter	diam
elevation	el

Term	Abbreviation
engineer	engr
equation	eq
equivalent	equiv
Fahrenheit	F
feet per day	fpd
feet per minute	fpm
feet per second	fps
foot (feet)	ft
foot-pound(s)	ft-lb
foot-pounds per cubic foot	ft-lb/cu ft
gallon(s)	gal
gallons per minute	gpm
gallons per second	gps
gram(s)	g
grams per cubic centimeter	g/cm^3
head	head
hour(s)	hr
inch(es)	in.
inside diameter	ID
kilogram(s)	kg
kilograms per square centimeter	kg/cm^2
kilometer(s)	km
kip(s)	kip(s)
kips per square foot	ksf
lateral	lat
liter(s)	ℓ
logarithm (base 10)	log
logarithm (natural)	ln
longitudinal	long.
maximum	max
meter(s)	m
micron	μm
miles per hour	mph
milliequivalent	meq
milligram(s)	mg

Term	Abbreviations
milliliter(s)	ml
millimeter(s)	mm
million gallons per day	mgd
minimum	min
minute	min
modified	mod
number	no.
ounce(s)	oz
outside diameter	OD
parts per million	ppm
perforation(s)	perf
pound(s)	lb
pounds per cubic foot	pcf
pounds per square foot	psf
pounds per square inch	psi
radian	rad
radius	r
revolutions per minute	rpm
revolutions per second	rps
second(s)	s
specific gravity	sp gr
square centimeter(s)	cm^2
square foot (square feet)	sq ft
square inch(es)	sq in.
square meters	m^2
square mile(s)	sq mi
standard	std
temperature	temp
ton(s)	ton(s)
tons per square foot	tsf
total soluble salts	tss
volume	vol
weight	wt
yard(s)	yd
year(s)	yr

Part D. Common Units and Conversion Factors

1. Units for common usage in SCS soil mechanics.

Length	:	m or ft
Grain (particle) size	:	mm or in.
Area	:	m^2 or sq ft
Volume	:	cm^3 or cu in.
		m^3 or cu ft
Weight/force	:	kg or lb
Time	:	s or day
Pressure/stress	:	kg/cm^2 or ksf
Unit weight (density)	:	g/cm^3 or pcf
Permeability/velocity	:	cm/s or fpd
Coefficients	:	cm^2/g or sq ft/lb (a_V and m_V)
		cm^2/s or sq ft/day (c_V)

2. Conversion factors.

Length	:	1 in.	=	25.40 mm
		"	=	2.540 cm
		"	=	2.540×10^{-2} m
		1 ft	=	30.48 cm
		"	=	3.048×10^{-1} m
		1 micron	=	1×10^{-3} mm
		1 m	=	39.37 in.
		"	=	3.28 ft
Area	:	1 sq in.	=	6.452 cm^2
		1 sq ft	=	9.29×10^{2} cm^2
		"	=	9.29×10^{-2} m^2
		1 cm^2	=	1.55×10^{-1} sq in.
		1 m^2	=	10.76 sq ft
Volume	:	1 cu in.	=	16.387 cm^3
		1 cu ft	=	2.832×10^{-2} m^3
		1 cm^3	=	1 ml
		"	=	6.10×10^{-2} cu in.
		1 m^3	=	35.31 cu ft

Weight	:	1 lb	= 453.6 g
		"	= 4.536×10^{-1} kg
		1 kip	= 1×10^{3} lb
		"	= 4.536×10^{2} kg
		1 kg	= 2.2046 lb
		"	= 2.2046×10^{-3} kips
Time	:	1 day	= 8.6400×10^{4} s
		1 s	= 1.157×10^{-5} day
Pressure	:	1 psi	= 7.03×10^{-2} kg/cm^2
		1 psf	= 4.88×10^{-4} kg/cm^2
		1 ksf	= 4.88×10^{-1} kg/cm^2
		1 kg/cm^2	= 2.048×10^{3} psf
		"	= 2.048 ksf
Unit weight (density)	:	1 pcf	= 1.602×10^{-2} g/cm^3
		1 g/cm^3	= 62.4 pcf
Permeability	:	1 fps	= 30.48 cm/s
		1 fpd	= 3.53×10^{-4} cm/s
		1 cm/s	= 2.835×10^{3} fpd
Compressibility Coefficients (a_v, m_v)	:	1 sq ft/lb	= 2.048 cm^2/g
		1 cm^2/g	= 4.88×10^{-1} sq ft/lb
Coefficient of Consolidation (c_v)	:	1 sq ft/day	= 1.075×10^{-2} cm^2/s
		1 sq in./min	= 1.075×10^{-1} cm^2/s
		1 cm^2/s	= 93.0 sq ft/day
		"	= 9.30 sq in./min
Angle	:	1 deg	= 1.745×10^{-2} rad
		1 rad	= 57.30 deg

SOIL MECHANICS -- LEVEL I

MODULE I

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 4

NARRATION AND SLIDE DESCRIPTION

PART A - TERMS AND DEFINITIONS

UNIFIED SOIL CLASSIFICATION Part A (1)	This module describes the use of both laboratory data and field procedures to classify soils by the Unified Soil Classification System. The name of this system is often shortened to USCS.
Slide of World Globe (2)	The Unified Soil Classification System was developed to assist in the grouping of soils based on their predicted engineering behavioral characteristics. The USCS is used for classifying soils for engineering works in most countrie throughout the world.
Slide divided into 4 parts showing farm pond, pipe inlet, terrace, & dam. (3)	The Soil Conservation Service uses this system when classifying soils for most engineering related purposes such as farm ponds, pipe inlets, terraces, and dams.
Slide of Cover of the Published Soil Survey for the District of Columbia. (4)	The USCS is also a vital part of the National Cooperative Soil Survey, such as this one for the Distrct of Columbia, our nation's capitol.
Part A - Terms and Definitions Part B - Lab Data and classification Part C - Field procedures and classifications (5)	This module consists of three basic parts: Part A contains the terms and definitions necessary to use the USCS. Part B explains the use of laboratory data to classify soils in this system. Part C contains field procedures for identifying and classifying soils using the USCS without laboratory data.
PART A TERMS & DEFINITIONS (6)	At the completion of Part A you will be able to complete the following objectives:

PART A -- OBJECTIVES
1. Memorize definitions of terms
2. Define consistency states.
3. Describe how the four basic soil properties of the USCS are obtained in the laboratory.
(7)

Objective Number One:
Given a list of terms, state conceptually from memory all definitions necessary to classify soils in the Unified Soil Classification System.

PART A -- OBJECTIVES
1. Memorize definitions and terminology.
2. Define consistency states.
3. Describe how the four basic soil properties of the USCS are obtained in the laboratory.
(8)

Objective Number Two:
Define from memory the four states of consistency of a soil.

PART A -- OBJECTIVES
1. Memorize definitions and terminology.
2. Define consistency states.
3. Describe how the four basic soil properties of the USCS are obtained in the laboratory.
(9)

Objective Number Three:
Describe how each of the four basic soil properties needed to use the Unified Soil Classification System are determined in the laboratory. These objectives are also listed in your Study Guide, Part A, Activity 1.

PART A
TERMS
AND
DEFINITIONS
(10)

To use the Unified Soil Classification System, you must be familiar with the meaning of several terms. Part A of this module defines these terms. It also covers the laboratory test procedures for obtaining the soil data used in classifying soils by the Unified Soil Classification System. The definitions and terms in this module conform to the American Society of Testing and Materials Standard D 653.

SOIL PROPERTIES
1. Gradation
2. Plasticity Characteristics
3. Water-holding Characteristics
4. Organic Characteristics
(11)

The four basic soil properties which may be measured by laboratory tests and are used for classifying soils by the Unified Soil Classification System are:

1. Gradation
2. Plasticity characteristics
3. Water-holding characteristics
4. Organic Characteristics

1. Gradation
   a. Percent gravel
   b. Percent sand
   c. Percent fines
(12)

Most soils consist of a mixture of different sizes of particles. Laboratory tests and field estimates are used to determine what sizes of particles are present in a soil sample and how much of each size particle is present. This determination is referred to as grain size distribution analysis of a soil, the mechanical analysis, or gradation.

GRAIN SIZE DISTRIBUTION ANALYSIS = Sieve Analysis + Hydrometer Analysis
(13)

Data from the sieve and hydrometer analyses tests are combined to determine what particle sizes are present in a soil sample This data also determines the amount of each particle size that exists in a soil sample.

(Slide of nested set of sieves, scale, soil sample)
(14)

In a sieve analysis, a soil sample is processed to remove foreign matter and break down any clods. The sample is weighed and processed through a nested set of of sieves. The sieves are progressively finer from top to bottom.

(Slide of 3-inch sieve)
(15)

Sieves are labeled in two ways. Sieves for the larger particles are labeled as the length of the side of the square opening in the sieve. This is the 3-inch sieve.

Slide of illustration showing dimension of 3-inch sieve.
(16)

A 3-inch sieve has openings that are exactly 3 inches by 3 inches. Commonly used sieves for gravel size particles are listed in your Study Guide, Part A, Activity 2. Turn to this activity and review before proceeding. Press the pause button to stop the tape. When you have finished, release the pause button to start the tape.

Slide of Number 4 sieve (17)	For the Finer particle sizes, sieves are labled using a sieve number.
Slide of illustration showing numbering system of smaller sieves, No. 4. (18)	The sieve number is the number of openings per lineal inch. Openings are measured from the centers of the wires in the sieve. A Number 4 sieve has 4 equal openings per lineal inch.
(Illustration of No. 4 sieve) (19)	The actual opening in the sieve depends on the thickness of wire used in construction of the sieve. The opening in a Number 4 sieve is 0.187 inches, or 4.76 millimeters.
Slide of #200 sieve (20)	Sieves are constructed with very small openings for measuring very small particle sizes. The smallest sieve commonly used is the Number 200 sieve, which has an opening of 0.074 millimeters. Small sieves clog quickly during use. Sieves smaller than the Number 200 are seldom used because of the clogging problem.
Slide of assortment of sand sieves. (21)	Sieve sizes commonly used for sands are listed in your Study Guide, Part A, Activity 3. Press the pause button to stop the tape. When you have finished this activity, release the pause button to start the tape.
Putting soil in a sieve slide of gravel sieves. (22)	To continue with the sieve analysis procedure, the soil sample to be tested is placed in the top of a set of sieves.
Slide of Gilson sieves gravel (23)	The sieves are then positioned in a mechanical shaker. The soil samples are shaken for at least 10 minutes to completely sort the sample. Testing standards for sieve analysis are listed in the American Society for Testing and and Materials(ASTM), Section 4, Volume 04.08.

Sketch of a set of sieves with samples caught on on sieves.
(24)

The weight of soil particles retained on each sieve is measured. This weight is converted into a percentage of the total sample weight. Usually a portion of the sample will be caught in the pan beneath the finest sieve. All percentages are determined on a dry weight rather than a volume basis.

Activity 4
(25)

The results of the sieve analysis may be presented in tabular form, as shown in Activity 4, Part A of the Study Guide. Press the pause button to stop the tape. When you have finished reviewing this material, release the pause button to start the tape.

Percent retained on each sieve is converted to percent finer for each sieve for practical uses.
(26)

Usually the data is expressed as the percentage of the total sample that is finer than each sieve size, rather than the percentage retained. The percentage finer is commonly referred to as the percent passing. The arithmetic process for converting the percent retained on each sieve into a percent finer for each sieve is illustrated in Part A, Activity 5, of your Study Guide. Please press pause to stop the tape. When you have completed this activity release the pause button to start the tape.

Hydrometer analysis to determine very small particle sizes.
(27)

As you remember, sieves with very small openings tend to clog easily. Therefore, a hydrometer analysis is commonly used to determine the amounts and sizes of very small particles finer than No. 200 sieve.

[Slide of hydrometer/soil/sample/hydrometer jar (on table)]
(28)

In the hydrometer analysis, a portion of the soil sample finer than the Number 10 sieve is mixed with distilled water and a chemical dispersant in a 1000 milliliter graduated cylinder. This chemical dispersant and agitation are used to completely break up any clumps of soil particles.

Slide of shaking cylinder with soil, water, & dispersing agent.
(29)

The soil is thoroughly mixed in the cylinder with water and and the dispersant by shaking for at least one minute. The cylinder is set on a table or other flat surface and a timer is started.

Slide of technician inserting a hydrometer in a cylinder.
(30)

A hydrometer is inserted into the cylinder and readings are taken at predetermined time intervals. The hydrometer measures the specific gravity of the soil-water suspension. As particles settle out of suspension with time, the specific gravity of the suspension changes.

Stoke's Law for Free-falling spheres in suspension.
(31)

These specific gravities may be converted to equivalent particle sizes by using formulas such as Stoke's Law. Using this formula, you can determine the length of time different sizes of particles take to settle out of suspension. For instance, sand size particles will settle out of suspension in less than about 30 seconds.

Particle Size mm	% Finer
.074	---
.05	---
.02	---
.005	---
.002	---

(32)

You may determine from hydrometer readings taken at selected times what percent of the total sample has settled out. A tabulation showing the percent finer for selected sizes of particles can be developed.

Grain Size Distribution Analysis = Gravel Sieve+ Sand Sieve+ Hydrometer Analysis
(33)

Combining results of a sieve analysis and a hydrometer analysis gives a complete grain size distribution. Press the pause button and study the example of a completed grain size distribution analysis located in Part A, Activity 6 of your Study Guide. When you have completed this activity, release the pause button to start the tape.

Slide of SCS-353
Sieve number
%
F
i
n
3
r

Particle size mm(LOG)
(34)

A graphical representation of the gradation data is frequently prepared. The graph uses a horizontal log scale with grain size prepared. The graph uses a horizontal log scale with grain size in millimeters across the bottom and corresponding sieves across the top. The vertical axis is the percent of the total sample finer than the sieve or particle size being plotted. To gain practice and understanding of this process, use the data shown on Part A, Activity 7 in your Study Guide to plot a grain size distribution curve for an example soil. Press the pause button to stop the tape. When you have finished release the pause button to start the tape.

2. Plasticity Characteristics 3. Water-Holding Characteristics (35)	The next two soil properties measured in the laboratory that are used to classify soils in the Unified Soil Classification System will now be discussed together, plasticity and water-holding characteristics.
(Slide of ball of modeling clay being squeezed) (36)	Plasticity is the property of a soil that allows it to be deformed beyond the point of recovery without crumbling, cracking, or undergoing appreciable volume change. This property may be visualized by imagining a piece of modeling clay which can be reshaped into many configurations by finger pressure. The clay holds its shape after remolding and does not crack or fall apart. It has plasticity.
(Slide of moist sand in hand being squeezed). (37)	Some soils cannot be reshaped or remolded, no matter what their water content. Two examples are clean sands and some silts. These soils are nonplastic. Only the portion of a sample finer than the Number 40 sieve is tested to evaluate plasticity.
Consistency (38)	Consistency is the relative ease with which a soil can be deformed and is dependent on its water content.
Consistency Diagram Solid Semi - Plas. Liq. State solid water content (39)	Soils have four states of consistency. These are (1) liquid (2) plastic (3) semi-solid and (4) solid. Consistency varies with the water content of the soil.
Definitions of Water Content, w $= \frac{\text{Wet wt - Dry wt} \times 100}{\text{Dry weight of soil}}$ $= \frac{\text{Weight water}}{\text{Dry weight of soil}} \times 100$ (40)	The water content of a soil is the weight of water in the soil divided by the dry weight of soil solids, expressed as a percentage.

(Slide of moisture can, scale, oven)

(41)

To determine the water content of a soil sample, the moist soil is weighed. It is then placed in an oven regulated to a constant temperature of 110° centigrade, and dried 24 hours or until a constant weight is obtained. The dry soil is then weighed. These values are then used to calculate the water content. For a better understanding of water content, complete Part A, Activity 8 in the Study Guide. Press the pause button to stop the tape. When you have completed this activity, release the pause button to start the tape.

Liquid State of Consistency.

Liquid
(42)

At high water contents, soils have flow characteristics. They are very soft and are in a liquid state of consistency. This occurs at some unique water content and all higher water contents for a particular soil.

Plastic State of Consistency.

Plastic
(43)

At somewhat lower water contents, a soil and water mixture will not have flow characteristics, but will exhibit plasticity characteristics. It can be remolded and shaped without crumbling or cracking. This could occur over a range of water contents. In this range, a soil is in the plastic state of consistency.

Semi-Solid State of Consistency.

Semi-solid

(44)

Soils will lose their plasticity characteristics at certain lower water contents. They will crack or crumble when an attempt is made to remold them. The soil will continue to shrink in volume if permitted to dry further, however. This is the semi-solid state of consistency.

Solid

(45)

At some point, additional drying of a soil mass ceases to cause additional shrinkage. Below this water content, soils are in the solid state of consistency. Press the pause button and carefully study Activity 9 in your Study Guide on Plasticity and Consistency.
When you have finished, release the pause button to start the tape.

Laboratory Tests to Define Boundaries Between Consistency States.

Liquid Limit
Plastic Limit
Shrinkage Limit
(46)

A series of laboratory tests devised by a Swedish scientist named Atterberg are used to define the water contents at which soils change from one state of consistency to another. The three tests are:
(1) liquid limit test (2) plastic limit test, and (3) shrinkage limit test.

Liquid Limit, LL (47)

The water content that serves as the boundary between the liquid state and the plastic state of consistency is called the liquid limit. The liquid limit is generally denoted by LL. At water contents higher than the liquid limit, soils are in the liquid liquid state of consistency.

Slide of Liquid Limit Device (48)

This testing apparatus is called a liquid limit device. It is used in the laboratory to determine the liquid limit of soils.

Slide of pat of soil in LL cup with groove cut (49)

Soil is mixed with water and placed in the cup of the liquid limit device. A groove of standard dimensions is cut in the soil pat. -
Only the portion of a soil sample finer than the Number 40 sieve is used in this test.

LL Defined as water content at which 25 Blows closes groove for ½ inch (50)

The liquid limit is the water content determined when exactly 25 drops (or blows as they are commonly called), of the cup on the base will cause the groove to close for a distance of ½ inch.

Slide of Liquid Limit Device with Groove closed. (51)

The test is usually performed at several water contents with the number of blows to close the groove determined for each water content. At water contents above the liquid limit, the groove will close with fewer than 25 blows. At water contents below the liquid limit, more than 25 blows will be necessary to close the groove.

Blows
log
N=25

W%, water content.
(52)

A curve is developed by plotting the number of blows versus water content, and the liquid limit interpolated as the water content at 25 blows. The plot consists of a logarithmic scale used for the number of blows, N, and an arithmetic scale for water content W in per cent.

Range of Liquid Limit values

16 400+
(53)

Liquid limit water contents less than 16 percent cannot be accurately and reliably measured. Soils with liquid limit values less than 16 percent are nonplastic. Liquid limit water contents may exceed 100 per cent. Some soils have liquid limit water contents of over 400 per cent.

Part A Activity 10 (54)	Activity 10 of your Study Guide summarizes information on the liquid limit definition and test procedure. Press the pause butto to stop the tape and review this material. When you have completed this activity start the tape.
Plastic Limit, PL (55)	The plastic limit is the water content that serves as the boundary between the plastic and semi-solid states of consistency of a a soil. The plastic limit test is used to determine this water content. The plastic limit is generally abbreviated as PL.
Slide of Plastic Limit Test Being Performed (56)	The plastic limit is the water content at which a 1/8 inch diamete thread of soil begins to crack or crumble when rolled on a glass plate. At higher water contents, the thread will not crumble or crack. If a thread 1/8 inch in diameter cannot be formed at any water content, the soil is nonplastic.
Plasticity Index Plastic Liquid Limit Limit Plasticity Index PL PI LL (57)	Plasticity Index, or PI, is the numerical difference between the liquid limit and the plastic limit water contents. It identifies the range of water contents over which a soil has plastic behavior.
Review and Complete Part A Activity 11 (58)	Activity 11 of your Study Guide has detailed information on the plastic limit test and plasticity index. Press pause and review this activity. When you have completed this activity release the pause button to start the tape.
Shrinkage Limit, SL (59)	The third Atterberg limit test determines the shrinkage limit, SL. The shrinkage limit defines the water content separating the semi-solid and solid states of consistency. It is the water content below which additional drying of a soil sample provides no further shrinkage.
Slide of Shrinkage Limit Test being run. (60)	This test has fewer uses than the other Atterberg limit tests and is seldom performed by soil mechanics laboratories. The determination of the shrinkage limit is not necessary to classify a soil in the USCS. However, this brief discussion will help you in the understanding the total behavoir of a soil with respect to its water content. Please review and complete Activity 12, Part A of the Study Guide. Press the pause button to stop the tape. When you have completed this activity release the pause button to start the tape.

4. Organic Characteristics a. Odor b. Color c. LL affected by oven drying (61)	The fourth and last soil property evaluated in the laboratory is the organic characteristic. Organic soils usually are identified by their pungent odor when moist and warm. They usually are dark brown to gray to black in color, and have a liquid limit value that is significantly affected by oven-drying of the soil prior to testing.
Compare liquid limits of airdried and ovendried soil. (62)	The only acceptable criteria in the USCS for evaluating organic soils is to compare the liquid limit obtained from a soil sample that has been oven-dried to that of a sample that has been air-dried.
Criteria for Organic Soils $\frac{\text{LL oven-dried}}{\text{LL air-dried}} > 0.75$ (63)	If the ratio of the oven-dried liquid limit to the air-dried liquid limit is less than 0.75, the soil is organic in the USCS.
Remember? (64)	Before proceeding, let's review the four soil properties that must be evaluated to classify a soil in the Unified Soil Classification System.
1. Gradation 2. Plasticity Characteristics 3. Water holding Characteristics 4. Organic Characteristics (65)	These four properties are: (1) Gradation (2) Plasticity characteristics (3) Water-holding characteristics (4) Organic characteristics
PART A OBJECTIVES?? (66)	Do you recall the objectives of Part A of this module?
Part A -- Objectives 1. List definitions and terminology. (67)	Objective 1 was to list certain definitions associated with soil properties needed to classify a soil in the USCS.

PART A -- OBJECTIVES
1. List definitions and terminology.
2. Define consistency states.
(68)

Objective 2 was to be able to define the four consistency states of a soil and water mixture.

PART A --OBJECTIVES
1. List definitions and terminology
2. Define consistency states.
3. Describe how the four basic soil properties of the USCS are obtained in the laboratory.
(69)

Objective 3 was to be able to describe how the four basic soil properties used in classifying soils in the USCS are determined in the laboratory.

Part A Activity 13
(70)

Before continuing with Part B of this module, complete Part A, Activity 13 in your Study Guide.
You may also want to take time to review Part A before proceeding to Part B. Press the pause button and complete Activity 13. When you are ready continue to Part B.

SOIL MECHANICS -- LEVEL I

MODULE 1

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 5

NARRATIVE AND SLIDE DESCRIPTION

(Part B)

SOIL MECHANICS -- LEVEL I

MODULE 1

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 5

NARRATION AND SLIDES FOR

PART B - USING LABORATORY DATA

PART B
Unified Soil
Classification
System Using
Laboratory Data
Unified Soil
(1)

Now that you know the terms and definitions used to describe and determine some basic soil properties, you will learn how to use the data to classify soils in the Classification System. The criteria given in this module is based on the American Society of Testing and and Materials Standard D2487 which was significantly revised in 1983.

PART B --
Objectives
(2)

At the completion of Part B of this module, you will be able able to meet the following objectives:

Objectives:
1. Identify two
essential charts
(3)

Objective Number 1 - Identify the two essential charts and briefly describe how they are used to classify soils in the Unified Soil Classification System using laboratory data.

Objectives:
1. Identify two
essential charts
2. Classify Soils
(4)

Objective Number 2 - Correctly classify all 25 classes of soil in the USCS using the flow chart, plasticity chart, and given laboratory data. These objectives are also given in your Study Guide, Part B, Activity 1.

USCS is appli-
cable only to
particles finer
than 3 inches.
COBBLES...3"-12"
BOULDERS > 12"
(5)

The USCS is based only on the portion of a soil sample finer than 3 inches. If a soil has larger particles, the amounts and sizes are determined and reported as auxiliary information. Larger particles are classified as cobbles - 3 inches to 12 inches in size, and boulders - greater than 12 inches in size.

Three Categories
GRAVELS
SANDS
FINES
(6)

The Unified System has three broad categories of soil particle sizes. Gravels are particles finer than 3 inches but larger than the Number 4 sieve. Sands are finer than the Number 4 sieve but larger than the Number 200 sieve. Fines are particles smaller than the Number 200 sieve.

3"
Coarse
Gravels 3/4"
Fine No.4
(7)

Gravels may be subdivided into coarse and fine gravels.

Sands: NO.4 / Coarse / No.10 / Medium / No.40 / Fine / No.200 (8)	Sands are subdivided into coarse, medium, and fine sands Part B - Activity 2 of your Study Guide shows the particle size definitions used in the Unified System. It also compares the particle size categories with those used in other classification systems.
Part B Activity 2 (9)	Press the pause button and review Part B, Activity 2 before continuing. When you have completed this activity release the pause button to start the tape.
<u>Fine-Grained Soils</u> or ..Organic or Inorganic ..Plasticity ..Water-holding characteristics (10)	Fine-grained soils are classified on the basis of their organic, plasticity, and water holding characteristics. Each of these characteristics will be discussed in detail.
Flow Chart (11)	The basic tool you will use to classify soils in the Unified System is the Flow Chart shown in Part B, Activity 3 in your Study Guide. You should press the pause button and locate this chart. It is extremely important that this information be reviewed before continuing. When you are ready, release the pause button to continue.
Use of Flow Chart (12)	The Flow Chart is used by beginning at the top of the chart and branching downwards, with decisions based on laboratory data and calculations made as required.
Slide of Flow Chart with fine-grained/coarse-decision blocks highlighted (13)	The first decision in the Flow Chart is to determine whether the soil you are classifying is a <u>fine-grained</u> or a <u>coarse-grained</u> soil. Fine-grained soils have 50 percent or more finer than the Number 200 sieve. Coarse-grained soils have less than 50 percent finer than the Number 200 sieve.

Slide of Flow
Chart with fine
grained decision
block high-lighted.
(14)

You should now be at this point on the Flow Chart. The fine-grained soils will be discussed first.

Organic
or
Inorganic
(15)

Fine-grained soils may be either organic or inorganic.

Slide of Flow
Chart with organic
decision block
highlighted.
(16)

You should be at this point on the Flow Chart.

ORGANIC SOILS
...Odor
...Color
...Liquid Limit
Change
(17)

Organic soils are identified by their pungent odor when moist and warm. They are usually dark brown, grayish to black in color. Organic soils also have a liquid limit value that is significantly affected by oven-drying of the soil prior to testing.

CRITERIA FOR
ORGANIC SOILS
$\frac{\text{LL oven-dried}}{\text{LL air-dried}}$ 0.75
(18)

When organic soils are suspected on the basis of odor, color, or other charteristics, two liquid limit tests are performed. One is performed on a sample that has been air-dried before preparation for the test. The second liquid limit test is performed on a sample which has been oven-dried at 110 degrees centigrade overnight. If the ratio of the oven-dried sample's liquid limit to the air-dried sample's liquid limit is less than 0.75, the soil is organic.

Organic Soils
LL 50 LL 50
OL OH
(19)

The two classes of organic soils in the Unified System are OL and OH. OL soils have air-dried liquid limit values less than 50%. OH soils have air-dried liquid limit values equal to or greater than 50%.
Press the pause button and complete Part B, Activity 4 in your Study Guide. When you have completed this activity release the pause button to start the tape.

Peat (PT) (20)	Another classification of highly organic soil that is recognized in the Unified Soil Classification System is PEAT. Peat is soil composed primarily of vegetable tissue in various stages of decomposition. It usually has a strong organic odor and a dark-brown to black color. PEAT has a spongy consistency and a fibrous texture. Peat will usually have very small amounts of mineral soil. The Unified symbol for peat is PT.
Slide of Flow Chart with inorganic decision block highlighted (21)	Inorganic fine-grained soils and their classification will now be covered. You should be at this location on the flow chart.
Inorganic Fine-grained Soils (22)	Inorganic fine-grained soils have 50 percent or more finer then No. 200 sieve and are classified on the basis of of plasticity and liquid limit.
PLASTICITY CHART (23)	The Plasticity Chart is a basic tool used to classify inorganic soils. Press the pause button and locate this chart in your Study Guide, Part B, Activity 5 before continuing. When you are ready, release the pause button to continue.
FINE-GRAINED Inorganic Soil Classifications CL CH ML MH CL-ML (24)	There are five classes of fine-grained, inorganic soils in The Unified System. Using the soil's liquid limit and plasticity index values and plotting these on the plasticity chart determines the soil's classification. The CL-ML zone of the plasticity chart includes PI values of 4 to 7 inclusive.
Liquid Limit Criteria for Classification 50 = L=Low LL 50 = H=High (25)	A major division on the Plasticity Chart is the liquid limit value of 50%. Soils with liquid limits equal to or greater than 50% are said to have a high liquid limit, LL and have the symbol H. Soil with liquid limit values less than 50% have a low liquid limit and have the symbol, L.

A-Line M On or Below (26)	The A-line shown on the plasticity chart separates plastic C soils and nonplastic or slightly plastic soils. For a Above given value of liquid limit, soils plotting on or above the A-line are plastic and have the symbol, C and soils plotting below the A-line are slightly plastic or nonplastic nonplastic and have the symbol M.
U-line = PI Line (27)	Another line of interest on the plasticity chart is the U-line. Based on many tests, liquid limit and plasticity LL index values from correctly performed tests never plot above this line. It may be referred to as the unrealistic line. If a soil's liquid limit and plasticity index plot above this line, test results should be verified. The uppermost slanted line is the liquid limit equals plasticity index line. No soil can plot above this line.
GROUP NAMES (28)	Descriptive information for fine-grained soils must be given in addition to a Unified Soil Classification symbol. The group name contains other information based on the amounts of sand or gravel in the sample. It includes a primary descriptive term with an appropriate modifier. Activity 6 in your Study Guide covers the Group Names for the fine-grained soils in the Unified System, including organic soils. Press the pause button and carefully review this information before continuing. Release the pause button to start the tape.
Complete Activity 7 in the Study Guide (29)	Part B, Activity 7 in your Study Guide has several problems illustrating classification of fine-grained soils using both the symbols and the group names. Press the pause button to stop the tape. When you have completed Part B, Activity 7, release the pause button to start the tape.
Coarse-grained Soils (30)	The next division of soils to be discussed is the coarse-grained soils. These are soils with less than 50 percent finer than the number 200 sieve. Press the pause button and locate the flow chart, Activity 3 in your Study Guide before continuing.
Slide of Flow Chart with coarse-grained decision block highlighted. (31)	You should be at this point on your flow chart.

Coarse-grained Dual Dirty Clean (32)	The three subdivisions of coarse-grained soils are: CLEAN - coarse-grained soils with less than 5 percent fines DUAL - coarse-grained soils with 5 to 12 percent fines DIRTY - coarse-grained soils with more than 12 percent fines
Slide of flow chart with highlight on clean coarse-grain decision block. (33)	The first group of coarse-grained soils to be studied is the clean, coarse-grained group. These soils have less than 5% finer than the Number 200 sieve. You should be at this position on the flow chart.
SAND OR GRAVEL (34)	The next step is to determine the percentages of gravel and sand in the soil sample from the data given. Then determine which size is predominant. That is, is there more gravel or sand present?
% G =% finer than 3" minus % finer than No.4. % S = % finer than No. 4 minus % finer than No. 200. (35)	The percent of gravel in the sample is the percent finer than the 3-inch sieve minus the percent finer than the number 4 sieve.The percent sand is the percent finer than the number 4 sieve minus the percent finer than the number 200 sieve.
Slide of Flow Chart with sand or gravel decision blocks highlighted (36)	You should be at this point on the Flow Chart.
Slide of Flow Chart with gravel block highlighted (37)	If gravel is predominant, the symbol G is used.

Slide of Flow Chart with sand block highlighted (38)	If sand is predominant, the symbol S is used. If the percent of sand and gravel in the soil sample are equal, then the symbol S is used. Press the pause button and complete Part B Part B, Activity 8, in your Study Guide. When you have completed this activity, release the pause button to continue.
Well - graded or poorly graded (39)	The next step in the classification of clean sands or gravel is to determine whether the soil is well-graded or poorly graded.
Slide of flow chart with block high-lighted showing poorly graded or well-graded decision for clean sands (40)	You should be at this point on the Flow Chart for clean sands or
Slide of flow chart with block high-lighted showing poorly graded or well-graded decision for clean sands. (41)	at this point for clean gravels.
Definition of "Well-graded" (42)	Well-graded sands or gravels have a wide range of particle sizes and about equal amounts of each.
Well-graded Example (43)	A grain-size distribution curve for a well-graded sand or gravel would have a rather flat slope and be gently curved upwards.
Poorly graded particle definition (44)	Poorly graded sands or gravels have a narrow range of sizes, or have a range of particle sizes missing from their gradation.

Poorly graded Example (45)

One type of grain-size distribution curve for a poorly graded sand or gravel would be rather steep, reflecting a narrow range of particle sizes present.

Gap-graded (46)

Another type of poorly graded sand or gravel is called gap-graded. A range of particle sizes is missing from the total gradation.

Coefficient of Uniformity, Cu (47)

A coefficient may be calculated from a grain-size distribution curve which partly determines whether a soil is well-graded. This coefficient is the coefficient of uniformity and has the abbreviation, Capital Cee, Small U.

Definition of Cu

$$Cu = \frac{D_{60}}{D_{10}}$$

(48)

The coefficient of uniformity is the ratio of the Dee-Sub Sixty size to the Dee-Sub-Ten size of the sample. The larger this value, the flatter is a sample s grain size distribution curve.

Definition of D_{60} (49)

The Dee-Sub-Sixty size of a soil is the particle size, expressed in millimeters, of which 60 percent of the soil is finer than that size particle. It is determined from a plotted grain size distribution curve by reading horizontally from the 60 percent finer coordinate to the grain-size curve. Then move downward from this point and read the grain size in millimeters on the scale at the bottom of the graph.

Definition D_{10} (50)

The Dee-Sub-Ten size of the soil is the particle size, expressed in millimeters, at which 10 percent of the soil is finer. It is determined from a plotted grain-size distribution curve. Read horizontally from the 10 percent finer coordinate to the curve. Then read vertically downward to the grain-size in millimeters on the scale at the bottom of the graph. Press the pause button, and complete Part B, Activity 9 of the Study Guide. When you have finished this activity, release the pause button to start the tape.

Coefficient of
curvature
Cc
(51)

A second coefficient is also needed to determine whether a soil is well-graded or poorly graded. This is the coefficient of curvature and is calculated from data obtained from a grain size distribution curve . It is abbreviated as Capital Cee, Small Cee.

Coefficient of
curvature

$$Cc = \frac{(D_{30})^2}{(D_{10} X D_{60})}$$

(52)

The coefficient of curvature is the square of the Dee-Sub-Thirty size, expressed in millimeters, divided by the product of the Dee-Sub-Sixty and Dee-Sub-Ten sizes, both expressed in millimeters. The Dee-Sub-Thirty size is obtained in a similar method as the Dee-Sub-Sixty and Dee-Sub-Ten sizes. Press the pause button and complete Part B, Activity 10, in your Study Guide. When you have finished this activity, release the pause button to start the tape.

Criteria for
Well-graded
sands and
gravels
(53)

Both of these coefficients must fall within a prescribed range in order for a sand or gravel to be well-graded. If either of the coefficients is not within the prescribed range, then the soil is poorly graded.

Permissible Range
of Coefficients
for well-graded
between
soils

	Sands	Gravel
Cu	6	4
Cc	1-3	1-3

(54)

For a sand to be well-graded, the coefficient of uniformity must be greater than 6 and the coefficient of curvature 1 and 3. For a gravel to be well-graded, the coefficient of uniformity must be greater than 4 and the coefficient of curvature between 1 and 3. The criteria is shown on the flow chart.

W = Well-graded
Poorly graded
(55)

The symbol, capital W, is used for well-graded and the symbol, capital P, is used for poorly graded.

GP - Clean
gravel
GW - Clean, well
graded gravel
SP - Clean,
poorly graded
sand
Sw - Clean, well-
graded sand
(56)

This completes the classification process for clean, coarse-grained soils. The 4 possible classes are:

GP - poorly graded, clean gravel
GW - well - graded, clean gravel
SP - poorly graded, clean sand, and
SW - well-graded, clean sand

Press the pause button to stop the tape and Complete Part B, Activity 11 in the Study Guide.

Study Activity 12 in the study Guide and then Complete Activity 13 (57)	To illustrate the complete classification process for these type soils, refer to Activity 12 for an example of a well-graded gravel,GW. Then complete Part B, Activity 13. When you have finished these activities release the pause button to start the tape.
GROUP NAME (58)	In addition to the symbol for clean sands and gravels, a group name is also given. The group name consists of a primary descriptive term plus the appropriate modifier.
STUDY ACTIVITY 14 (59)	Study the list of primary descriptive terms and modifiers and the criteria for their use in Part B, Activity 14 in the the Study Guide. Stop the tape and review these modifiers. When you are ready release the pause button to start the tape.
Slide of flow chart with dirty coarse-grained soil decision point highlighted (60)	Dirty coarse-grained soils will be discussed next. Press the pause button and locate your flow chart. You should be at this location on the flow chart.
DIRTY, COARSE-GRAINED SOILS (61)	Dirty coarse-grained soils have enough fines to influence the engineering behavior characteristics. This effect is more important than whether the soil is well-graded or poorly graded. To classify dirty, coarse-grained soils, you must evaluate both the Atterberg limits of the minus Number 40 fraction and the sand and/or gravel content.
Slide with sand and gravel decision block highlighted (62)	In classifying dirty coarse-grained soils, the first step is to determine which is predominant, sand or gravel. This determination is the same as you made with the clean coarse-grained soils. The percent gravel is equal to the percent finer than the 3-inch sieve minus percent finer than the No. 4 sieve. The percent sand is equal to the percent finer than No. 4 sieve minus the percent finer than the No. 200 sieve.

Slide with Atterberg limit decision block on flow chart highlighted under dirty sand and dirty gravel (63)	Once you have determined whether sand or gravel predominates, you must determine whether the Atterberg limits plot on or above the A-line, below the A-line, or in the hatched area of the plasticity chart. Press the pause button and locate the plasticity chart, Activity 5, Part B.
DIRTY SANDS AND GRAVELS SM SC-SM SC GM GC-GM GC (64)	There are six possible classes of dirty, coarse-grain soils. SM, SC-SM, SC GM, GC-GM, and GC
GROUP NAMES FOR DIRTY SANDS AND GRAVELS (65)	In addition to the symbols for dirty sands and gravels, the group name must be given. This group name consists of a primary descriptive term and the appropriate modifier. Review these criteria in Part B, Activity 15 of your Study Guide. Then complete, Part B, Activity 16. Release the pause button to start the tape when you're ready.
Dual coarse-grained soils (66)	The last group of coarse-grained soils to be discussed in the Unified Classification System is the dual classification group. Press the pause button and locate the flow chart.
Slide of flow chart with dual decision block highlighted. chart (67)	The dual classification group of coarse grained soils have between 5 percent and 12 percent finer than the Number 200 sieve, inclusive. This is the beginning point on the flow for classifying these soils.
Gradation and plasticity characteristics needed to classify dual, plasticity coarse-grained soils. (68)	The engineering behavior of the dual classified group of coarse-grained soils is affected by both gradation characteristics of the coarser particles and by the characteristics of the finer particles. The classification of this group involves determination both of whether the soil is well-graded or poorly graded and whether the fines plot above or below the A-line on the plasticity chart. Both gradation and plasticity affect the engineering behavior of these soils.

Three steps in classifying dual, coarse-grained soils 1. Sand or Gravel 2. Well-graded or poorly graded 3. Above or below A-line? (69)	The process of classifying dual coarse-grained soils is shown in detail on your flow chart. Press the pause button and carefully review these steps on the flow chart, Part B, Activity 3, before continuing. When you are ready, release the pause button to start the tape.
Review Activity 17 Complete Activity 18 (70)	Review the example of a dual-classified soil shown in Part B Activity 17 of your Study Guide. Then, with the given data, complete the classification of the soil shown in Activity 18. Press the pause button to stop the tape. When you have completed these activities release the pause button to continue.
GROUP NAMES FOR DUAL-CLASSIFIED SANDS AND GRAVELS (71)	In addition to the symbols for dual-classified sands and gravels, the group name must be given.
CRITERIA FOR GROUP NAMES FOR DUAL-CLASSIFIED SANDS AND GRAVELS (72)	Part B, Activity 19, summarizes the Unified Classification Symbols and group names for the eight possible dual, coarse-grained soils. Press the pause button and review this information. Release the pause button to continue when you have completed reviewing this information.
Complete Activity 20 (73)	Part B, Activity 20, has review questions on terminology and procedures in the use of laboratory data to classify soils by the Unified Soil Classification System. You should be able to answer all questions completely and accurately before proceeding. Stop the tape and complete this activity. If you are having any problems at this point, review the previous activites. When you are ready, start the tape.
Complete Activity 21 in the Study Guide (74)	Classify the 23 soils shown in Activity 21 using the information given to your previously. Good Luck!

Part B - Objectives
1. Identify and describe the use of flow chart and plasticity chart
2. Correctly classsify soils into one of 25
(75)

Did you get most of the classifications right? Of course you did. However, to make sure your original objectives in Part B of this module have been reached, let's take another look at them. You are now able to

1. Use the flow chart and plasticity chart.
2. Correctly classify soils in the USCS using laboratory data.

Proceed to Part C
(76)

Congratulations! You are now ready to proceed to Part C of this module.

SOIL MECHANICS - LEVEL 1

MODULE 1

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX 6

PART C USING FIELD PROCEDURES

PART C
Unified Soil Classification Using Field Procedures
(1)

Part C involves the use of field procedures to classify soils in the Unified Soil Classification System.

OBJECTIVES
(2)

At the completion of Part C, you will be able to meet the following objectives.

OBJECTIVES
1. Identify and describe use of flow chart.
(3)

Objective number one:
Identify the flow chart and describe how it is used to classify soils in the USCS using field procedures.

OBJECTIVES
1. Identify and describe use of flow chart procedures.
2. Describe field test procedures.
(4)

Objective number two:
Describe from a list each of the important field tests used in classifying soils by the Unified System.

OBJECTIVES
1. Identify and describe use of flow chart procedures.
2. Describe field test procedures.
3. Classify unknown soils.
(5)

Objective number three:
Correctly classify all 14 field classes using the flow chart
and field procedures on a set of soil samples. These objectives are also listed in your Study Guide, Part C, Activity 1.

Introduction
(6)

In Part C, you will learn the procedures and the various field tests used to classify soils in the field when you do not have access to laboratory data or testing equipment.

Review Activity 2 in the Study Guide Part C (7)	A reference used in the field classification procedure is the flow chart shown in your Study Guide, Part C, Activity 2. Press the pause button and review the information on the chart. When you have finished, release the pause button to start the tape.
Flow Chart Use (8)	The flow chart for field identification is arranged so that you proceed from left to right on the chart. After you make evaluations of the soil being classified, you arrive at the classification symbol on the right side of the chart.
Fine-grained or Coarse-grained (9)	The first step in field identification is the same as the first step in laboratory identification. You must determine whether the soil has 50 percent or more finer than the Number 200 sieve, or if it has less than 50 percent finer than the Number 200 sieve. Remember that the Unified System is based only on the portion of a soil finer than 3 inches.
Slide of smoothed coarse-grained, pile of sand and gravel mixture. (10)	To determine whether a soil is fine-grained or spread the soil on a flat surface and visually estimate by weight the amounts of particles larger than the Number 200 sieve and the amounts finer than the Number 200 sieve. The Number 200 sieve size particles (0.074 mm.) are the smallest individual grains that can be seen with the human eye. Remember that one gravel size particle may weigh as much as a considerable volume of finer particles.
Slide of texturing soil by hand. (11)	If it is not readily apparent whether coarse-grained sands or fines predominate, it may be necessary to take a small amount of the soil and mix it with water and rub it between your thumb and index finger. If you can detect a gritty feeling, there will usually be more than 50 percent of particles larger than the Number 200 sieve. Written procedures for determining grain size and gradation are described in Activity 3 of the Study Guide. Review this activity before proceeding.
Fine-grained soil (12)	If a soil is judged to be fine-grained, several tests are used to determine the liquid limit and plasticity characteristics. The following steps detail these tests. They are usually performed in the sequence presented.

Slide of liquid limit Test with water being added with squeeze bottle (13)	The liquid limit test is performed by placing a tablespoon of air-dried soil passing the number 40 sieve in the palm of your hand. A No. 40 sieve would be a useful reference tool to help judge the sizes of particles that need to be removed. A No. 40 sieve opening is about 0.5 mm.
Slide of liquid limit test being performed - water penetration being assessed (14)	Several observations may be helpful in deciding whether the soil being tested has a high liquid limit (over 50 percent water content) or a low liquid limit (less than 50 percent water content). The speed with which the water penetrates the pile of soil in your hand reflects the water holding characteristics of the soil. Usually, high liquid limit soils will retain the water and it will be slow to penetrate the soil pat. Low liquid limit soils will be penetrated more readily by the wetting front of the water as it is added.
Comparison with known samples. (15)	Another observation that is used to evaluate liquid limit is based on comparison of soils with known liquid limit values and developing an experience base. In the field exercise associated with Part C, you will have an opportunity to perform this test on soils with known liquid limit values and develop some expertise. Liquid limit evaluation procedures are given in Activity 4 of your Study Guide. Press the pause button to stop the tape and review this information. When you are finished release the pause button to start the tape.
Evaluation of plasticity charac- teristics (16)	The remaining field identification procedures are for determining the plasticity characteristics of the soil. If the liquid limit determination is made correctly, then the identification of the soils plasticity characteristics, that is whether it plots above or below the A-line, will determine the USCS symbol.
Dilatency Test (17)	The dilatency test is performed at the same water content as the liquid limit. Therefore, it is usually expedient to use the same pat of soil that was used in the liquid limit field test. No free water should be visible on the surface of the soil pat when running the dilatency test.

Slide showing the dilatency test - one hand being hit against the other. (18)	The dilatency test is performed by vigorously shaking your hand horizontally, striking the hand with the soil pat against the other hand several times.
Slide showing close-up of a soil pat with a glossy surface. (19)	A dilatent reaction occurs when the soil pat attains a glossy surface appearance,
	and
Slide showing glossy surface pat being squeezed. (20)	When the glossy appearance can be made to disappear when the pat is squeezed. High dilatency reactions are typical of soils with low plasticity. Press the pause button and review Part C, Activity 5, of your Study Guide. When you are ready, realease the pause button to start the tape.
Toughness test & Plasticity Evaluation (21)	The next step in the field identification procedure for fine-grained soils is to add dry soil to the moist pat you have remaining from the dilatency test. Continue to dry the soil pat until you have reached the plastic state of consistency. Dry soil should be added slowly and mixed thoroughly. Determine whether you are approaching the plastic limit by occasionally rolling out a 1/8-inch diameter thread, on a smooth surface. If you can readily roll out a thread, you are still above the plastic limit. Continue to dry the soil by kneading, manipulation, and rolling until a 1/8-inch thread begins to crack or crumble.
Slide of thread being rolled (22)	Some soils cannot be formed into a thread at any water content. This is typical of low plasticity classifications such as ML soils. The next step when you have reached the plastic limit water content is to assess the toughness of the thread formed. Evaluate whether the thread can be lumped into a ball. Evaluate the fragility of the thread.

High plasticity soils usually have high toughness. (23)	[Soils with high toughness are typical of high plasticity soils such as CL and CH, but occasionally, MH soils may have moderately high toughness as well.] Press the pause button and review the toughness test procedures and guidance on evaluation of the test results along with some helpful suggestions contained in Part C, Activity 6 in your Study Guide. Release the Pause Button to start the tape when you are ready to begin.
Ribbon Test (24)	A supplemental test that can be performed at the same water content as the toughness test is the ribbon test. In this test, the moist soil pat is squeezed between the thumb and side of the index finger, forcing a ribbon of soil between the digits.
Slide of ribbon test (25)	The strength of the ribbon is evaluated once it has been formed. The Unified soil classes with high plasticity will form a strong ribbon, while the soils with no or limited plasticity will not form a ribbon, or it will be quite weak. A discussion of the ribbon test procedures, evaluations, and possible ratings are given in Part C, Activity 7 of your Study Guide. Press the pause button to stop the tape. Review this activity. Release the pause button to start the tape.
Shine test (26)	Another test which may be performed at the same water content is the shine test.
Slide of shine test being performed. (27)	The shine test is performed by creating a smooth surface on the soil pat with a knife blade or your fingernail. The shininess of the surface created is evaluated.
Slide of shine test with a shiny surface appearance (28)	Typically, plastic soils will have a shiny appearance, and nonplastic or slightly plastic soils will have a dull shine or have no shine at all.

Slide of a test on micaceous soil. (29)	You should be cautious not to mistake any shininess caused by by the presence of mica flakes. In fact, soils containing appreciable amounts of mica will almost always have plasticity indices that plot below the A-line. The shine test procedures, possible ratings and cautions are listed in detail in Activity 8 of the Study Guide. Stop at this time and go to Part C, Activity 8.
Dry strength test (30)	The dry strength test is performed on a pat of soil which has been allowed to air dry completely.
Slide of dry strength test being run. (31)	The dry pat of soil is crushed with finger pressure and the the dry strength evaluated. Plastic soils usually have a high dry crushing strength, while silts or nonplastic soils have low dry crushing strength. Detailed test procedures, possible ratings, and cautions are given in Part C, Activity 9 of your Study Guide. Press the Pause Button and locate this activity. When you have studied this material release the pause button to continue.
Odor Test (32)	Organic soils are usually identified by their organic odor, color, and sometimes a fibrous texture. Press the pause button and carefully review the characteristics of the 2 organic soil classifications (OL and OH) and of the Peat (PT) classification in Part C, Activity 10 and in the Flow Chart in Part C, Activity 2 of the Study Guide. It is important that you review both parts before you continue.
Coarse-grained soils (33)	That completes the steps for classifying fine-grained soils. The classification of coarse-grained soils will now be discussed.
Coarse-grained soils (34)	Once you have determined that a soil is coarse-grained by either visual inspection or by textural evaluation using your fingers, the next step is to decide whether the soil is predominately a sand or a gravel. You should be at this position on the flow chart.

Sand or Gravel (35)	Visually inspect the soil sample which has been spread on a flat surface. Determine whether more or less than half of the coarse fraction is larger than 1/4 inch. For field procedures, 1/4 inch may be used to approximate the number 4 sieve size. A pocket ruler or scale is useful for this purpose.
Slide of mixture sand and gravel (36)	You will gain experience in this evaluation by comparing known gradations of soils in the field exercise portion of this module. By examining soils with known gradations, you will be able to develop an experience base.
Slide showing sand and gravel mixture with gravel predominating. (37)	This is a coarse-grained soil with gravel predominating.
Slide showing sand and gravel mixture with sand predominating. (38)	This is a coarse-grained soil with the sand-size particles predominating.
Slide of flow chart with clean/dirty decision blocks (39)	The next step in the flow chart is to determine whether the coarse-grained soil is clean or dirty.
CLEAN OR DIRTY (40)	Ordinarily, using field procedures, it is not possible to identify dual classifications of coarse-grained soils. Therefore, only "clean" or "dirty" classifications are used.

Slide of dirt staom on hand. (41)	To determine whether a coarse-grained soil is clean or dirty, wet a sample of the soil in your palm, then brush off the coarser materials. Dirty samples will leave a stain on your palm. This can often be observed best by allowing the material left in your palm to dry. A powdery residue left on your palm is evidence of sufficient fines in the sample to classify as a dirty sand or gravel.
Slide of soil in beaker of water. (42)	A supplemental test which may be useful in this determination is to drop a small amount of the sample in a beaker of clear water. Observe the formation of a cloud in the water. Dirty coarse-grained soils will usually have an observable cloud after about 30 seconds while clean soils will not.
Slide of flow chart with well-graded/ poorly graded decision blocks highlighted (43)	If a soil is judged to be a clean coarse-grained material the next step in your chart is to evaluate whether the sample is well-graded or poorly graded. You should now be at this point on the Flow Chart.
Well-graded Poorly graded (44)	Determination of a soil's gradation characteristics is made visually in the field. A well-graded coarse-grained soil has a wide range of particle sizes and about equal amounts of each size particle. Poorly graded materials have a narrow range of particle sizes, or some particle sizes in the range are missing.
Slide of well-graded gravel. (45)	This is a well-graded gravel. Note the wide range of particle sizes present and the equal distribution of these particle sizes.
Slide of poorly graded gravel (46)	This is a poorly graded gravel. It has a concentration of large size gravels and small size gravels, but there are no intermediate size gravels in the sample. This type of poorly graded soil is sometimes referred to as gap-graded or skip-graded.

Slide of poorly graded sand (47)	This is a poorly graded sand. The soil has nearly all one size of particle. Remember, the full range of particle sizes for both sand and gravel is quite large. The entire range of particle sizes must be represented in the soil to be well-graded.
CLEAN, COARSE-GRAINED SW SP GW GP (48)	Part C, Activity 11 in your Study Guide summarizes the procedures for evaluating clean coarse-grained soils. At this time review only the section on clean soils. After you have reviewed this section of Activity 11, refer to the Flow Chart in Activity 2 and note the 4 possible field classifications of clean, coarse-grained soils, GW, GP, SW, and SP. Press the Pause button and study this information. When you are ready, release the pause button to start the tape.
Slide of flow chart with dirty sand/gravel highlighted. (49)	The next group of soils to be discussed are the dirty coarse-grained soils. Once you have determined that the coarse-grained soil being classified is dirty, you must determine whether the fines in the soil are plastic or nonplastic.
Slide of number 40 sieve. (50)	A Number 40 sieve is useful for manually removing coarse sand and gravel from the soil before attempting to evaluate the plasticity of the fines. The evaluation of plasticity must be based on the portion of the soil finer than the Number 40 sieve.
Slide of flow chart with nonplastic/ plastic decision blocks, and the plasticity characteristics blocks highlighted. (51)	The evaluation of plasticity of the fines in a dirty coarse-grained soil uses the same field test procedures as those used for evaluating the plasticity of fine-grained soils. The toughness test is the most important.

Note that in the flow chart it is not necessary to evaluate the liquid limit. Classification of dirty coarse-grained soils depends only on whether the fines plot above or below the A-line.

Dirty, Coarse-grained soil (52)

Press the pause button and study Activity 11. Also carefully review the 4 possible field classification of dirty, coarse-grained soils, GM, GC, SM, and SC, as shown on the Remember the last time you reviewed Activity 11, it was for clean coarse-grained soils. This time review the dirty coarse-grained soils.

Log information for fine-grained soils (53)

A complete description of a soil should accompany the field classification symbol when using field procedures in the Unified Classification System. Part C, Activity 12, of the Study Guide shows an example of descriptive terms used in classifying fine-grained soils. Press the pause button and carefully study this Activity. When you are ready release the pause button to start the tape.

Log information for coarse-grained soils (54)

Part C, Activity 13, contains an example of an excellent description of a coarse-grained soil. It also shows the typical information that should be provided when describing a coarse-grained soil in a field log. Press the pause button and carefully review this information. Release the Pause button to continue when you are ready.

Borderline and dual classi- fication (55)

Sometimes you may not be able to clearly place a soil within a single classification. Activity 14 of the Study Guide covers use of these borderline classifications and the situations where they are permitted. Press the pause button and study this information.

OBJECTIVES
1. Identify and describe use of flow chart.
2. Describe field test procedures.
3. Classify unknown soils.
(56)

Before you actually practice classifying soils using the field procedures just presented, lets review the objectives of Part C of this module.

1. Identify and describe flow chart procedures.
2. Describe the field test procedures, and
3. Classify unknown soils correctly.

Activity 15 contains several questions that will enable you to determine if you are ready to classify some unknown soils. Stop and complete this Activity at this time. When you have finished restart the tape.

Practice field test procedures on soils from your local (57)

Now, you have met the first two objectives. Before you are given the information and soils to work on Objective 3, you should practice field classifying of several soils in your local area. Concentrate on the various field procedures to determine clean or dirty, well-graded or poorly graded, and to evaluate plasticity and liquid limit.

ACTIVITY 16 & ACTIVITY 17 (58)

Note that the Study Guide contains two additional activities, 16 and 17. You should notify your supervisor that you are now ready to work on these two activities. The completion of these two activities will require about four to six hours and will generally be given by a designated trainer, usually in small groups. Your supervisor will notify you of the date, time, and location of this training. Be sure to take your Study Guide to the training location as you will need it for reference. Data sheets to be used are included in the Study Guide. Until you are notified of the time for this additional training, continue practicing on soils from your local area.

Continue to Module 2 (59)

Your training facilitator will dicuss Activity 17 with you in detail and answer any questions on field classification. While you are waiting for the in-state training sessions, you may want to continue on to Module 2, Qualitative Engineering Behavior.