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Standard Terminology Relating to Soil, Rock, and Contained Fluids[1]

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This standard has been approved for use by agencies of the Department of Defense.
These definitions were prepared jointly by the American Society of Civil Engineers and the American Society for Testing and Materials.

1. Scope*

1.1 These definitions apply to many terms found in the Terminology section of standards of ASTM Committee D18.

1.2 This terminology standard defines terms related to soil, rock, and contained fluids found in the various sections of standards under the jurisdiction of ASTM Committee D18.

1.3 Definitions of terms relating to frozen soils are contained in Terminology D7099.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C150 Specification for Portland Cement
D558 Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3(600 kN-m/m^3))
D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3(2,700 kN-m/m^3))
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D4043 Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques
D4044 Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers
D4050 Test Method for (Field Procedure) for Withdrawal and Injection Well Tests for Determining Hydraulic Properties of Aquifer Systems
D4104 Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)
D4105 Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Modified Theis Nonequilibrium Method
D4106 Test Method for (Analytical Procedure) for Determining Transmissivity and Storage Coefficient of Nonleaky Confined Aquifers by the Theis Nonequilibrium Method
D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4631 Test Method for Determining Transmissivity and Storativity of Low Permeability Rocks by In Situ Measurements Using Pressure Pulse Technique
D4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[3]
D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5092 Practice for Design and Installation of Ground Water Monitoring Wells
D5269 Test Method for Determining Transmissivity of Nonleaky Confined Aquifers by the Theis Recovery Method
D5270 Test Method for Determining Transmissivity and Storage Coefficient of Bounded, Nonleaky, Confined Aquifers
D5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

[1] This terminology is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.93 on Terminology for Soil, Rock and Contained Fluids.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

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

D5878 Guides for Using Rock-Mass Classification Systems for Engineering Purposes
D6312 Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs
D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
D7099 Terminology Relating to Frozen Soil and Rock
D7382 Test Methods for Determination of Maximum Dry Unit Weight and Water Content Range for Effective Compaction of Granular Soils Using a Vibrating Hammer

3. Significance and Use

3.1 Definitions in this standard are to be regarded as the correct ones for terms found in other ASTM standards of Committee D18. Certain terms may be found in more than one standard issued under the jurisdiction of this committee and many of these terms have been placed in this standard.

3.2 Terms that are defined in some textbooks may differ slightly from those in this terminology standard. Definitions in this terminology standard are to be regarded as correct for ASTM usage.

3.3 See Appendix X1 for References.

3.4 A number of the definitions include symbols. The symbols appear in italics immediately after the name of the term.

3.4.1 No significance should be placed on the order in which the symbols are presented where two or more are given for an individual term.

3.4.2 The symbols presented are examples; therefore, other symbols are acceptable.

3.4.3 See Appendix X2 for Symbols.

3.5 A number of definitions indicate the units of measurements in parentheses and which follow the symbol(s) if given. The applicable units are indicated by bold capital letters, as follows:

D—Dimensionless
F—Force, such as pound-force, ton-force, newton
L—Length, such as inch, foot, millimeter, and meter[4]
M—Mass, such as kilogram, gram
T—Time, such as second, minute

3.5.1 Positive exponents designate multiples in the numerator. Negative exponents designate multiples in the denominator. Degrees of angle are indicated as "degrees."

3.5.2 Expressing the units either in SI or the inch-pound system has been purposely omitted in order to leave the choice of the system and specific unit to the engineer and the particular application, for example:

FL^{-2}—may be expressed in pounds-force per square inch, kilopascals, tons per square foot, etc.

LT^{-1}—may be expressed in feet per minute, meters per second, etc.

3.6 Where synonymous terms are cross-referenced, the definition is usually included with the earlier term alphabetically. Where this is not the case, the later term is the more significant.

[4] In accordance with IEEE/ASTM SI 10, the alternate spelling for meter, liter, and deka, may be metre, litre, and deca.

3.7 Definitions marked with (ISRM) are included for the convenience of the user and were taken directly from the International Society for Rock Mechanics (see X1.3).

3.8 *Grouping of Definitions and Listing of Related Terms*—To aide users in finding terms, this terminology standard provides grouping of definitions and listing of related terms.

3.8.1 *Groupings*—Some of these groupings of definitions are *density*, *unit weight*, and *specific gravity*.

3.8.2 *Listings (see* Appendix X3*)*—The listing of related terms might be headed by such items as *aquifer*, *density*, *gradation*, *index*, *specific gravity*, and *unit weight*.

4. Terminology

AASHTO compaction—see **compaction test**.
"A" Horizon—see **horizon**.
abrasion—a rubbing and wearing away. (ISRM)
abrasion—the mechanical wearing, grinding, scraping or rubbing away (or down) of rock surfaces by friction or impact, or both.
abrasive—any rock, mineral, or other substance that, owing to its superior hardness, toughness, consistency, or other properties, is suitable for grinding, cutting, polishing, scouring, or similar use.
abrasiveness—the property of a material to remove matter when scratching and grinding another material. (ISRM)
absorbed water—*in soil and rock*, water held mechanically in a soil or rock mass and having physical properties not substantially different from ordinary water at the same temperature and pressure.

DISCUSSION—See **adsorbed water**.

absorption—the assimilation of fluids into interstices.
absorption loss—that part of transmitted energy (mechanical) lost due to dissipation or conversion into other forms (heat, etc.).
accelerator—*in grouting,* a material that increases the rate at which chemical reactions would otherwise occur.
activator—*in grouting,* a material that causes a catalyst to begin its function.
active earth pressure—see **earth pressure**.
active state of plastic equilibrium—see **plastic equilibrium**.
activity number (A)—*in cohesive soils,* the ratio of (1) the plasticity index of a soil to (2) the percent by mass of particles having an equivalent diameter smaller than 2 μm. **D4318**
additive—*in grouting,* any material other than the basic components of a grout system.
adhesion—*in soils,* shearing resistance between soil and another material under zero externally applied pressure.

	Symbol	Unit
Unit Adhesion	c_a	FL^{-2}
Total Adhesion	C_a	F or FL^{-1}

adhesion—shearing resistance between two unlike materials under zero externally applied pressure.
admixture—a material other than water, aggregates, or cementitious material, used as a grout ingredient for cement-based grouts.
adsorbed water—*in soil and rock,* water in a soil or rock mass

attracted to the particle surfaces by physiochemical forces, having properties that may differ from those of pore water at the same temperature and pressure due to altered molecular ar-rangement; adsorbed water does not include water that is chemically combined within the clay minerals.

DISCUSSION—See **absorbed water**.

adsorption—*in soils,* the attachment of water molecules or ions to the surfaces of soil particles.

advancing slope grouting—*in grouting,* a method of grouting by which the front of a mass of grout is caused to move horizontally by use of a suitable grout injection sequence.

aeolian deposits—wind-deposited material such as dune sands and loess deposits.

aggregate—*as a grouting material*, relatively inert granular mineral material, such as sand, gravel, slag, crushed stone, etc. "Fine aggregate" is material that will pass a No. 4 (6.4-mm) screen, "Coarse aggregate" is material that will not pass a No. 4 (6.4-mm) screen. Aggregate is mixed with a cementing agent (such as Portland cement and water) to form a grout material.

agitator tank—*in grouting/slurries,* a tank, usually vertical and with open top, with rotation paddles used to prevent segregation of grout after mixing.

air-space ratio, G_a **(D)**—ratio of: (*1*) volume of water that can be drained from a saturated soil or rock under the action of force of gravity, to (*2*) total volume of voids.

air-void ratio, G_v **(D)**—the ratio of: (*1*) the volume of air space, to (*2*) the total volume of voids in a soil or rock mass.

alkali aggregate reaction—*in grouting,* a chemical reaction between Na_2O and K_2O in the cement and certain silicate minerals in the cement and certain silicate minerals in the aggregate, which causes expansion resulting in weakening and cracking of Portland cement grout.

DISCUSSION—See **reactive aggregate**.

allowable bearing value (allowable soil pressure), q_a, p_a **(FL^{-2})**—the maximum pressure that can be permitted on foundation soil, giving consideration to all pertinent factors, with adequate safety against rupture of the soil mass or movement of the foundation of such magnitude that the structure is impaired.

allowable pile bearing load, Q_a, P_a **(F)**—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, the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.

amplification factor—ratio of dynamic to static displacement.

amorphous peat—see **sapric peat**.

angle of external friction (angle of wall 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 friction (angle of friction between solid bodies), ϕ_s **(degrees)**—angle whose tangent is the ratio between the maximum value of shear stress that resists slippage between two solid bodies at rest with respect to each other, and the normal stress across the contact surfaces.

angle of internal friction (angle of shear resistance), ϕ (degrees)—angle between the axis of normal stress and the tangent to the Mohr envelope at a point representing a given failure-stress condition for solid material.

angle of obliquity, α, β, ϕ, Ψ (degrees)—the angle between the direction of the resultant stress or force acting on a given plane and the normal to that plane.

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

DISCUSSION—For dry granular soils the effect of the height of slope is negligible; for cohesive soils the effect of height of slope is so great that the angle of repose is meaningless.

angle of shear resistance—see **angle of internal friction**.

angle of wall friction—see **angle of external friction**.

angular aggregate—aggregate, the particles of which possess well-defined edges formed at the intersection of roughly planar faces.

anisotropic mass—a mass having different properties in different directions at any given point.

anisotropy—having different properties in different directions. (ISRM)

annual space; annulus—*in borings,* the space between two concentric tubes or casings, or between the casing and the borehole wall.

DISCUSSION—This would include the space(s) between multiple strings of tubing/casings in a borehole installed either concentrically or multi-cased adjacent to each other. **D5092**

apparent cohesion—see **cohesion**.

aquiclude—*in groundwater,* a relatively impervious formation capable of absorbing water slowly but will not transmit it fast enough to furnish an appreciable supply for a well or spring.

aquifer—*in geohydrology/hydrogeology,* a geologic formation, group of formations, of part of a formation that is saturated and is capable of providing a significant quantity of water. **D5092**

aquifer, confined—see **confined aquifer**.

aquifer, unconfined—see **unconfined aquifer**.

aquitard—a confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed.

arching—the transfer of stress from a yielding part of a soil or rock mass to adjoining less-yielding or restrained parts of the mass.

area grouting—grouting a shallow zone in a particular area utilizing holes arranged in a pattern or grid.

DISCUSSION—This type of grouting is sometimes referred to as blanket or consolidation grouting.

area of influence of a well, α (L^2)—area surrounding a well within which the piezometric surface has been lowered when pumping has produced the maximum steady rate of flow.

area ratio of a sampling spoon, sampler, or sampling tube, A_r (D)—the area ratio is an indication of the volume of soil displaced by the sampling spoon (tube), calculated as follows:

$$A_r = [(D_e^2 - D_i^2/D_i^2] \times 100 \quad (1)$$

where:

D_e = maximum external diameter of the sampling spoon, and

D_i = minimum internal diameter of the sampling spoon at the cutting edge.

armor—the artificial surfacing of bed, banks, shore, or embankment to resist erosion or scour.

armor stone—(generally one ton to three tons in weight) stone resulting from blasting, cutting, or by other methods to obtain rock heavy enough to require handling two individual pieces by mechanical means.

articulating concrete block (ACB) revetment system , *n—in erosion control*, a matrix of interconnected concrete block units for erosion protection that are typically connected by geometric interlock, cables, ropes, geotextile, geogrids or combination thereof, and typically including a geotextile underlayment.

artifactual turbidity—*in monitoring wells*, particulate matter that is not naturally mobile in the groundwater system and that is produced in some way by the groundwater sampling process. May consist of particles introduced to the subsurface during drilling or well construction, sheared from the target monitoring zone during pumping or bailing the well, or produced by exposure of groundwater to atmospheric conditions. D5092

ash content—the percentage by dry weight of material remaining after an oven dry organic soil or peat is burned by a prescribed method.

assessment monitoring—*in groundwater,* an investigative monitoring program that is initiated after the presence of a contaminant in groundwater has been detected. The objective of this program is to determine the concentration of constituents that have contaminated the groundwater and to quantify the rate and extent of migration of these constituents. D5092

assessment monitoring program, *n—in geonvironmental programs*. groundwater monitoring that is intended to determine the nature and extent of a potential site impact following a verified statistically significant exceedance of the detection monitoring program. D6312

ASTM cement types—Portland cements meeting the requirements of Specifications C150. Cement types have slightly different formulations that result in various characteristics which address different construction conditions and different physical and chemical environments. They are as follows:

DISCUSSION—See **cement, API**.

Type I (Portland)—a general-purpose construction cement with no special properties. D5092

Type II (Portland)—a construction cement that is moderately resistant to sulfates and generates a lower head of hydration at a slower rate than Type I D5092

Type III (Portland: high early strength)—a construction cement that produces a high early strength. This cement reduces the curing time required when used in cold environments, and produces a higher head of hydration than Type I. D5092

Type IV (Portland)—a construction cement that produces a low head of hydration (lower than Types I and II) and develops strength at a slower rate. D5092

Type V (Portland)—a construction cement that is a high sulfate resistant formulation. Used when there is severe sulfate action from soils and groundwater.

attapulgite clay—a chain-lattice clay mineral. The term also applies to a group of clay materials that are lightweight, tough, matted, and fibrous.

attenuation—reduction of amplitude with time or distance.

Atterberg Limits—*in cohesive soils*, Originally, six "limits of consistency" of fine-grained soils were defined by Albert Atterberg: the upper limit of viscous flow, the liquid limit, the sticky limit, the cohesion limit, the plastic limit, and the shrinkage limit. In current engineering usage, the term usually refers only to the liquid limit, plastic limit, and in some references, the shrinkage limit. D4318

"B" horizon—see **horizon**.

average interstitial velocity—see **velocity, average interstitial**.

backpack grouting—the filling with grout of the annular space between a permanent tunnel lining and the surrounding formation.

DISCUSSION—Same as crown grouting and backfill grouting.

back-packing—any material (usually granular) that is used to fill the empty space between the lagging and the rock surface. (ISRM)

baffle—a pier, weir, sill, fence, wall, or mound built on the bed of a stream to parry, deflect, check, or regulate the flow or to float on the surface to dampen the wave action.

bailer—a hollow tubular receptacle used to facilitate withdrawal of fluid from a well or borehole. D5092

ballast—*in drilling,* materials used to provide stability to a buoyant object (such as casing within a borehole filled with water). D5092

barometric efficiency—*in hydraulic properties,* the ratio of the change in depth to water in a well to the inverse of water-level change in barometric pressure, expressed in length of water. D4043

base—*in grouting*, main component in a grout system.

base course (base)—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, minimizing frost action, etc.

base exchange—the physicochemical process whereby one species of ions adsorbed on soil particles is replaced by another species.

batch—*in grouting*, quantity of grout mixed at one time.

batch method—*in grouting*, a quantity of grout materials are mixed or catalyzed at one time prior to injection.

batch mixer—*in grouting*, a machine that mixes batches of grout, in contrast to a continuous mixer.

bearing capacity—see **ultimate bearing capacity**.

bearing capacity (of a pile), Q_p, P_p **(F)**—the load per pile required to produce a condition of failure.

bedding—applies to rocks resulting from consolidation of sediments and exhibiting surfaces of separation (bedding planes) between layers of the same or different materials, that is, shale, siltstone, sandstone, limestone, etc. (ISRM)

bedding—collective term signifying the existence of layers of beds. Planes or other surfaces dividing sedimentary rocks of the same or different lithology.

bedrock—the more or less continuous body of rock which underlies the overburden soils. (ISRM)

bedrock (ledge)—rock of relatively great thickness and extent in its native location.

bench—(*1*) the unexcavated rock having a nearly horizontal surface which remains after a top heading has been excavated, or (*2*) step in a slope; formed by a horizontal surface and a surface inclined at a steeper angle than that of the entire slope. (ISRM)

bending—process of deformation normal to the axis of an elongated structural member when a moment is applied normal to its long axis. (ISRM)

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.

biaxial compression—compression caused by the application of normal stresses in two perpendicular directions. (ISRM)

biaxial state of stress—state of stress in which one of the three principal stresses is zero. (ISRM)

binder (soil binder)—portion of soil passing No. 40 (425-µm) U.S. standard sieve,

binder—anything that causes cohesion in loosely assembled substances, such as clay or cement.

bit—any device that may be attached to or is an integral part of a drill string and is used as a cutting tool to bore into or penetrate rock or other materials.

blaine fineness—the fineness of powdered materials, such as cement and pozzolans, expressed as surface area usually in square centimetres per gram.

blanket grouting—a method in which relatively closely spaced shallow holes are drilled and grouted on a grid pattern over an area, for the purpose of making the upper portions of the bedrock stronger and less pervious.

blastibility—index value of the resistance of a rock formation to blasting. (ISRM)

blasting cap (detonator, initiator)—a small tube containing a flashing mixture for firing explosives. (ISRM)

bleeding—*in grouting*, the autogeneous flow of mixing water within, or its emergence from, newly placed grout caused by the settlement of the solid materials within the mass.

bleeding rate—*in grouting*, the rate at which water is released from grout by bleeding.

blocking—wood blocks placed between the excavated surface of a tunnel or shaft and the main bracing system. (ISRM)

blow-in—*in drilling,* the inflow of groundwater and unconsolidated material into a borehole or casing caused by differential hydraulic heads; that is, caused by the presence of a greater hydraulic head outside of a borehole/casing than inside. **D5092**

body force—a force such as gravity whose effect is distributed throughout a material body by direct action on each elementary part of the body independent of the others. (ISRM)

bog—a peat covered area with a high water table and a surface dominated by a carpet of mosses, chiefly sphagnum. It is generally nutrient poor and acidic. It may be treed or treeless.

bond strength—*in grouting*, resistance to separation of set grout from other materials with which it is in contact; a collective expression for all forces such as adhesion, friction, and longitudinal shear.

borehole—*in drilling*, a hole of circular cross-section made in soil or rock.

DISCUSSION—normally, a borehole is advanced using an auger, a drill, or casing with or without drilling fluid. **D4750**

borehole—an open or uncased subsurface hole, generally circular in plan view, created by drilling. **D5092**

borehole log—*in drilling,* the record of geologic units penetrated, drilling progress, depth, water level, sample recovery, volumes and types of materials used, and other significant facts regarding the drilling of an exploratory borehole or well. **D5092**

borehole television log—a borehole or well video record produced by lowering a television camera into the borehole or well. This record is useful in visually observing downhole conditions such as collapsed casing or a blocked screen.

bottom charge—concentrated explosive charge at the bottom of a blast hole. (ISRM)

boulder clay—a geological term used to designate glacial drift that has not been subjected to the sorting action of water and therefore contains particles from boulders to clay sizes.

boulders—a rock fragment, usually rounded by weathering or abrasion, with an average dimension of 12 in. (305 mm) or more.

breakwater stone—stone, generally three tons to twenty tons in weight, resulting from blasting, cutting, or other means to obtain rock heavy enough to require handling individual pieces by mechanical means.

bridge—*in drilling,* an obstruction within the annulus which may prevent circulation or proper emplacement of annular materials. **D5092**

buckling—a bulge, bend, bow, kink, or wavy condition produced in sheets, plates, columns, or beams by compressive stresses.

bulb of pressure—see **pressure bulb**.

bulk density, ρ—the mass of a quantity of a bulk solid divided by its total volume.

bulk solid—an assembly of solid particles handled in sufficient quantities that its characteristics can be described by the properties of the mass of particles rather than the characteristics of each individual particle. May also be referred to as granular material, particulate solid or powder. Examples are sugar, flour, ore, and coal.

bulkhead—a steep or vertical structure supporting natural or artificial embankment.

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.

bunker—synonym for **bin**, but sometimes understood as being a bin without any or only a samll vertical part at the top of the hopper.

buoyant unit weight (*submerged unit weight*)**—**see **unit weight**.

burden—*in an explosive blasting,* the distance between the charge and the free face of the material to be blasted.

burden—distance between charge and free surface in direction of throw. (ISRM)

*"C" Horizon***—**see **horizon**.

California bearing ratio, *CBR* (**D**)—the ratio of: (*1*) the force per unit area required to penetrate a soil mass with a 3-in.^{2}(19-cm)^2 circular piston (approximately 2-in. (51-mm) diameter) at the rate of 0.05 in. (1.3 mm)/min, to (*2*) that required for corresponding penetration of a standard material. The ratio is usually determined at 0.1-in. (2.5-mm) penetration, although other penetrations are sometimes used. Original California procedures required determination of the ratio at 0.1-in. intervals to 0.5 in. (12.7 mm). Corps of Engineers' procedures require determination of the ratio at 0.1 in. and 0.2 in. (5.1 mm). Where the ratio at 0.2 in. is consistently higher than at 0.1 in., the ratio at 0.2 in. is used.

camouflet—the underground cavity created by a fully contained explosive. (ISRM)

capillary action (capillarity)—the rise or movement of water in the interstices of a soil or rock due to capillary forces.

*capillary flow***—**see **capillary action**.

capillary fringe zone—the zone above the free water elevation in which water is held by capillary action.

capillary head, *h* (**L**)—the potential, expressed in head of water, that causes the water to flow by capillary action.

*capillary migration***—**see **capillary action**.

capillary rise (height of capillary rise), h_c (**L**)—the height above a free water elevation to which water will rise by capillary action.

capillary water—water subject to the influence of capillary action.

casing—*in drilling,* pipe, finished in sections with either threaded connections or bevelled edges to be field welded which is installed temporarily or permanently to counteract caving, to advance the borehole, or to isolate the zone being monitored, or combination thereof. **D5092**

casing, protective—*in drilling,* a section of larger diameter pipe that is emplaced over the upper end of a smaller diameter monitoring well riser or casing to provide structural protection to the well and restrict unauthorized access into the well. **D5092**

casing, surface—*in drilling,* pipe used to stabilize a borehole near the surface during the drilling of a borehole that may be left in place or removed once drilling is completed. **D5092**

catalyst—a material that causes chemical reactions to begin.

catalyst system—those materials that, in combination, cause chemical reactions to begin; catalyst systems normally consist of an initiator (catalyst) and an activator.

cation—an ion that moves, or would move toward a cathode; thus nearly always synonymous with positive ion.

*cation exchange***—**see **base exchange**.

cation exchange capacity (*CEC*)**,** *n—in soils,* is a pH dependent measure of the negative electrical charge present on the surfaces of soil minerals, particularly clay minerals, and on soil organic materials, especially humic compounds, capable of dynamically adsorbing positively charged ions (cations) and polar compounds.

DISCUSSION—The units for *CEC* are typically in milliequivalents per 100 grams of oven-dry soil (meq/100 g). The SI units for *CEC* are centimoles of charge per kilogram of oven-dry soil ($cmol_c$/kg).

caving; sloughing—*in drilling,* the inflow of unconsolidated material into a borehole which occurs when the borehole walls lose their cohesive strength. **D5092**

cavity—a natural underground opening that may be small or large.

cavity—underground opening created by a fully contained explosive. (ISRM)

cement factor—quantity of cement contained in a unit volume of concrete or grout, expressed as weight, or volume (specify which).

cement grout—a grout in which the primary cementing agent is Portland cement.

cement; Portland cement—commonly known as Portland cement. A mixture that consists of a calcareous argillaceous, or other silica-, alumina,- and iron-oxide bearing materials that is manufactured and formulated to produce various types which are defined in Specification C150. Portland cement is also considered a hydraulic cement because it must be mixed with water to form a cement-water paste that has the ability to harden and develop strength even if cured under water (see **ASTM cement types**). **D5092**

cementitious factor—quantity of cement and other cementitious materials contained in a unit volume of concrete or grout, expressed as weight or volume (specify which).

centralizer—*in drilling,* a device that assists in the centering of a casing or riser within a borehole or another casing. **D5092**

*centrifuge moisture equivalent***—**see **moisture equivalent**.

chamber—a large room excavated underground, for example, for a powerhouse, pump station, or for storage. (ISRM)

chamber blasting (coyotehole blasting)—a method of quarry blasting in which large explosive charges are confined in small tunnel chambers inside the quarry face. (ISRM)

chemical grout—any grouting material characterized by being a true solution; no particles in suspension. See also **particulate grout**.

chemical grout system—any mixture of materials used for grouting purposes in which all elements of the system are true solutions (no particles in suspension).

chip—crushed angular rock fragment of a size smaller than a few centimetres. (ISRM)

chisel—the steel cutting tool used in percussion drilling. (ISRM)

circuit grouting—a grouting method by which grout is circulated through a pipe extending to the bottom of the hole and back up the hole via the annular space outside the pipe. Then the excess grout is diverted back over a screen to the agitator tank by means of a packing gland at the top of the hole. The method is used where holes tend to cave and sloughing material might otherwise clog openings to be grouted.

circulation—*in drilling,* applies to the fluid rotary drilling method; drilling fluid movement from the mud pit, through the pump, hose and swivel, drill pipe, annular space in the hole and returning to the mud pit. **D5092**

classification, *n*—*in soil or rock*, a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use (*Regulations Governing ASTM Technical Committees*). **D5878**

clay (clay soil)—fine-grained soil or the fine-grained portion of soil that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. The term has been used to designate the percentage finer than 0.002 mm (0.005 mm in some cases), but it is strongly recommended that this usage be discontinued, since there is ample evidence from an engineering standpoint that the properties described in the above definition are many times more important.

clay size—that portion of the soil finer than 0.002 mm (0.005 mm in some cases) (see also **clay**).

clay soil—see **clay**.

cleavage—*in crystallography*, the splitting, or tendency to split, along planes determined by the crystal structure. *In petrology*, a tendency to cleave or split along definite, parallel, closely spaced planes. It is a secondary structure, commonly confined to bedded rocks.

cleavage—the tendency to cleave or split along definite parallel planes, which may be highly inclined to the bedding. It is a secondary structure and is ordinarily accompanied by at least some recrystallization of the rock. (ISRM)

cleavage planes—the parallel surfaces along which a rock or mineral cleaves or separates; the planes of least cohesion, usually parallel to a certain face of the mineral or crystal.

cleft water—water that exists in or circulates along the geological discontinuities in a rock mass.

closure—the opening is reduced in dimension to the extent that it cannot be used for its intended purpose. (ISRM)

closure—*in grouting*, closure refers to achieving the desired reduction in grout take by splitting the hole spacing. If closure is being achieved, there will be a progressive decrease in grout take as primary, secondary, tertiary, and quanternary holes are grouted.

cobble (cobblestone)—a rock fragment, usually rounded or semirounded, with an average dimension between 3 and 12 in. (75 and 305 mm).

coefficient of absolute viscosity—see **coefficient of viscosity**.

coefficient of active earth pressure—see **coefficient of earth pressure**.

coefficient of compressibility (coefficient of compression), α_v **(L^2F^{-1})**—the secant slope, for a given pressure increment, of the pressure-void ratio curve. Where a stress-strain curve is used, the slope of this curve is equal to $\alpha_v/(1 + e)$.

coefficient of consolidation, c_v **(L^2T^{-1})**—a coefficient utilized in the theory of consolidation, containing the physical constants of a soil affecting its rate of volume change.

$$c_v = k\,(1 + e)/\alpha_v \gamma_w \qquad (2)$$

where:

k = coefficient of permeability, LT^{-1},
e = void ratio, D,
α_v = coefficient of compressibility, L^2F^{-1}, and
γ_w = unit weight of water, FL^{-3}.

Discussion—In the literature published prior to 1935, the coefficient of consolidation, usually designated c, was defined by the equation:

$$c = k/\alpha_v \gamma_w\,(1 + e) \qquad (3)$$

This original definition of the coefficient of consolidation may be found in some more recent papers and care should be taken to avoid confusion.

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 friction (coefficient of friction between solid bodies), f **(D)**—the ratio between the maximum value of shear stress that resists slippage between two solid bodies with respect to each other, and the normal stress across the contact surfaces. The tangent of the angle of friction is ϕs.

coefficient of friction, f—a constant proportionality factor, μ, relating normal stress and the corresponding critical shear stress at which sliding starts between two surfaces: $T = \mu \cdot \sigma$. (ISRM)

coefficient of internal friction, μ (D)—the tangent of the angle of internal friction (angle of shear resistance) (see **internal friction**).

coefficient of permeability (permeability), k **(LT^{-1})**—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 shear resistance—see **coefficient of internal friction,** μ (D).

coefficient of subgrade reaction (modulus of subgrade reaction), k, k_s **(FL^{-3})**—ratio of: (*1*) load per unit area of horizontal surface of a mass of soil, to (*2*) corresponding settlement of the surface. It is determined as the slope of the

secant, drawn between the point corresponding to zero settlement and the point of 0.05-in. (1.3-mm) settlement, of a load-settlement curve obtained from a plate load test on a soil using a 30-in. (762-mm) or greater diameter loading plate. It is used in the design of concrete pavements by the Westergaard method.

coefficient of transmissibility—the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 ft (0.3 m) wide, under a unit hydraulic gradient.

coefficient of uniformity, C_u (D)—the ratio D_{60}/D_{10}, where D_{60} is the particle diameter corresponding to 60 % finer on the cumulative particle-size distribution curve, and D_{10} is the particle diameter corresponding to 10 % finer on the cumulative particle-size distribution curve.

coefficient of viscosity (coefficient of absolute viscosity), η (FTL^{-2})—the shearing force per unit area required to maintain a unit difference in velocity between two parallel layers of a fluid a unit distance apart.

coefficient of volume compressibility (modulus of volume change), m_v (L^2F^{-1})—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, or $a_v/(1 + e)$.

cohesion—shear resistance at zero normal stress (an equivalent term in rock mechanics is intrinsic shear strength). (ISRM)

cohesion, c (FL^{-2})—the portion of the shear strength of a soil indicated by the term c, in Coulomb's equation, $s = c + p \tan \phi$. See **intrinsic 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 that has little or no cohesion when submerged.

cohesive soil—a soil that when unconfined has considerable strength when air-dried and that has significant cohesion when submerged.

collar—*in grouting*, the surface opening of a borehole.

colloidal grout—*in grouting*, a grout in which the dispersed solid particles remain in suspension (colloids).

colloidal mixer—*in grouting*, a mixer designed to produce colloidal grout.

colloidal particles—particles that are so small that the surface activity has an appreciable influence on the properties of the aggregate.

combined Shewhart (CUSUM) control chart, *n*—*in groundwater data analysis*, a statistical method for intra-well comparisons that is sensitive to both immediate and gradual releases. **D6312**

communication—*in grouting*, subsurface movement of grout from an injection hole to another hole or opening.

compaction—the densification of a soil by means of mechanical manipulation.

compaction curve or Proctor curve, *n*—*in soils*, the curve showing the relationship between the dry density or dry unit weight and the molding water content of a soil using a standard test method. See **compaction test**.

compaction test, *n*—*in soils*, the determination of the dry density or dry unit weight versus molding water content relationship using a standard test method in fine grained or coarse grained soils; or the direct determination of the maximum dry density or maximum dry unit weight using a standard test method in coarse grained soils.

DISCUSSION—Some of the D18 test methods are D558 (standard effort compaction for soil-cement), D698 (standard effort compaction), D1557 (modified effort compaction), D4253 (vibrating table), and D7382 (vibrating hammer). The test method designation needs to be identified, such as "compaction test by D698" or "compaction test using D698." The usage of moisture-density test or Proctor test has been eliminated because test methods D4253 and D7382 are also considered compaction tests.

composite sieving, *v*—*in sieving*, the process of separating a large specimen on a designated separating sieve to obtain coarser and finer particle-size portions. The coarser portion is sieved using the coarser sieve set. The finer portion is subsampled to obtain a subspecimen of manageable size (mass) and this subspecimen is sieved using the finer sieve set. The results of both sieve sets (coarser and finer) are combined mathematically to determine the gradation of the large specimen. **D6913**

compressibility—property of a soil or rock pertaining to its susceptibility to decrease in volume when subjected to load.

compression curve—see **pressure-void ratio curve**.

compression index, C_c (D)—the slope of the linear portion of the pressure-void ratio curve on a semi-log plot.

compression wave (irrotational)—wave in which element of medium changes volume without rotation.

compressive strength (unconfined or uniaxial compressive strength), p_c, q_u, C_o (FL^{-2})—the load per unit area at which an unconfined cylindrical specimen of soil or rock will fail in a simple compression test. Commonly the failure load is the maximum that the specimen can withstand in the test.

compressive stress—normal stress tending to shorten the body in the direction in which it acts. (ISRM)

concentration factor, n (D)—a parameter used in modifying the Boussinesq equations to describe various distributions of vertical stress.

conceptual model—*in geohydrology/hydrogeology,* a simplified representation of the hydrogeologic setting and the response of the flow system to stress. **D4043**

conductance (specific)—a measure of the ability of the water to conduct an electric current at 77°F (25°C). It is related to the total concentration of ionizable solids in the water. It is inversely proportional to electrical resistance. **D5092**

cone of impression, *n*—a rise of the potentiometric surface in the approximate shape of a cone that develops around an injection well.

confined aquifer—*in geohydrology/hydrogeology,* an aquifer bounded above and below by confining beds and in which the static head is above the top of the aquifer. **D4050, D4104, D4105, D4106, D5269**

confining bed—*in geohydrology/hydrogeology,* a hydrogeologic unit of less permeable material bounding one or more aquifers. **D4043, D4050, D4104, D4105, D4106, D5269**

confining unit—*in geohydrology/hydrogeology,* a term that is synonymous with "aquiclude," "aquitard," and "aquifuge": defined as a body of relatively low permeable material stratigraphically adjacent to one or more aquifers. D5092

conjugate joints (faults)—two sets of joints (faults) that formed under the same stress conditions (usually shear pairs). (ISRM)

connate water, *n*—water entrapped in the voids of a sedimentary or extrusive igneous rock at the time of its deposition or emplacement.

consistency—the relative ease with which a soil can be deformed. D4318

consistency—*in grouting*, the relative mobility or ability of freshly mixed mortar or grout to flow; the usual measurements are slump for stiff mixtures and flow for more fluid grouts.

consistency index—see **relative consistency**.

consolidated-drained test (slow test)—a soil test in which essentially complete consolidation under the confining pressure is followed by additional axial (or shearing) stress applied in such a manner that even a fully saturated soil of low permeability can adapt itself completely (fully consolidate) to the changes in stress due to the additional axial (or shearing) stress.

consolidated-undrained test (consolidated quick test)—a soil test in which essentially complete consolidation under the vertical load (in a direct shear test) or under the confining pressure (in a triaxial test) is followed by a shear at constant water content.

consolidation *(grouping)*—the gradual reduction in volume of a soil mass resulting from an increase in compressive stress.

initial consolidation (initial compression)—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 (primary compression) (primary time effect)—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 (secondary compression) (secondary time effect)—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 curve—see **consolidation time curve.**

consolidation grouting—*in grouting,* injection of a fluid grout, usually sand and Portland cement, into a compressible soil mass in order to displace it and form a lenticular grout structure for support.

DISCUSSION—In rock, grouting is performed for the purpose of strengthening the rock mass by filling open fractures and thus eliminating a source of settlement.

consolidation ratio, U_s **(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 (time curve) (consolidation curve) (theoretical time curve)—a curve that shows the relation between: (*1*) the degree of consolidation, and (*2*) the elapsed time after the application of a given increment of load.

constant-head boundary—*in geohydrology/hydrogeology,* the conceptual representation of a natural feature such as a lake or river that effectively fully penetrates the aquifer and prevents water-level change in the aquifer at that location. D5270

constitutive equation—force deformation function for a particular material. (ISRM)

contact grouting—see **backpack grouting**.

contact pressure, p **(FL^{-2})**—the unit of pressure that acts at the surface of contact between a structure and the underlying soil or rock mass.

contaminant—*in soil, rock and groundwater,* an undesirable substance not normally present in water or soil. D5092 , D5088

continuous mixer—a mixer into which the ingredients of the mixture are fed without stopping, and from which the mixed product is discharged in a continuous stream.

contraction—linear strain associated with a decrease in length. (ISRM)

control rinse water—*in decontamination,* water used for equipment washing and rinsing having a known chemistry. D5088

control well—*in aquifer testing,* well by which the aquifer is stressed, for example, by pumping, injection, or change of head. D4043, D4044, D4104, D4105, D5269

controlled blasting—includes all forms of blasting designed to preserve the integrity of the remaining rocks, that is, smooth blasting or pre-splitting. (ISRM)

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.

convergence—generally refers to a shortening of the distance between the floor and roof of an opening, for example, in the bedded sedimentary rocks of the coal measures where the roof sags and the floor heaves. Can also apply to the convergence of the walls toward each other. (ISRM)

core—a cylindrical sample of hardened grout, concrete, rock, or grouted deposits, usually obtained by means of a core drill.

core drilling; diamond drilling—a rotary drilling technique, using diamonds in the cutting bit, that cuts out cylindrical rock samples. (ISRM)

core recovery—ratio of the length of core recovered to the length of hole drilled, usually expressed as a percentage.

cover—the perpendicular distance from any point in the roof of an underground opening to the ground surface. (ISRM)

cover—*in grouting*, the thickness of rock and soil material overlying the stage of the hole being grouted.

crack—a small fracture, that is, small with respect to the scale of the feature in which it occurs. (ISRM)

crater—excavation (generally of conical shape) generated by an explosive charge. (ISRM)

creep—slow movement of rock debris or soil usually imperceptible except to observations of long duration. Time-dependent strain or deformation, for example, continuing strain with sustained stress.

critical circle (critical surface)—the sliding surface assumed in a theoretical analysis of a soil mass for which the factor of safety is a minimum.

critical damping—the minimum viscous damping that will allow a displaced system to return to its initial position without oscillation.

critical frequency, f_c—frequency at which maximum or minimum amplitudes of excited waves occur.

critical height, H_c **(L)**—the maximum height at which a vertical or sloped bank of soil or rock will stand unsupported under a given set of conditions.

critical hydraulic gradient—see **hydraulic gradient**.

critical slope—the maximum angle with the horizontal at which a sloped bank of soil or rock of given height will stand unsupported.

critical surface—see **critical circle**.

critical void ratio, e_c **(D),** *n—in soil*, the void ratio above which the soil will exhibit contractive behavior at high shear strain and below which it will exhibit dilative behavior at high strain. See *critical density* under **density** grouping.

DISCUSSION—The critical density or critical void ratio (the two definitions are alternate and equivalent measures of soil packing) is an aspect of soil behavior that has now been known for some eighty years. The critical density/void ratio of a given material varies with effective confining stress and is affected by other factors. Some of those factors being the fabric of the material, stress history, type of loading, and duration of loading. "High strain" is associated with strain at and after peak strength conditions. The critical density/void ratio arises in the context of both liquefaction of cohesionless soil and in the fundamental modeling of soil constitutive behavior (including sands, silts, and clays). For the particular case of saturated soil subjected to undrained deformation, contractive behavior will cause a strength reduction because of the build up of excess pore water pressure during shear. In very loose soil, this pore pressure increase will often be so large as to cause brittle strength reduction with shear strain (liquefaction), For dense soil, dilative behavior will produce a strength gain whether drained (as an increase in the soils friction angle) or undrained (as an increase in shear strength). For constitutive modeling, the variation of critical void ratio with mean effective stress is often referred to as a critical state locus (CSL) and in this form appears widely in modern models of soil behavior (including the Modified Cam Clay model found in most commercial finite element programs as the default 'advanced' soil model).

crown—also roof or back, that is, the highest point of the cross section. *In tunnel linings*, the term is used to designate either the arched roof above spring lines or all of the lining except the floor or invert. (ISRM)

cryology—the study of the properties of snow, ice, and frozen ground.

cumulative material retained (cumulative retained material or cumulative mass retained), *n—in sieving*, the mass of material retained on an individual sieve plus the masses of material retained on all the coarser sieves in a given stack/set of sieves. **D6913**

cumulative percent retained, *n—in sieving*, the ratio of cumulative material retained on a given sieve to the mass of the specimen, expressed in percent. **D6913**

cure—*in grouting*, the change in properties of a grout with time.

cure time—*in grouting*, the interval between combining all grout ingredients or the formation of a gel and substantial development of its potential properties.

curtain grouting—injection of grout into a sub-surface formation in such a way as to create a barrier of grouted material transverse to the direction of the anticipated water flow.

cuttings—small-sized rock fragments produced by a rock drill. (ISRM)

d-10 or D_{10}—*in soils,* the diameter of a soil particle (preferably in millimetres) at which 10 % by weight (dry) of the particles of a particular sample are finer. Synonymous with the effective size or effective grain size. **D5092**

d-60 or D_{60}—*in soils,* the diameter of a soil particle (preferably in millimetres) at which 60 % by weight (dry) of the particles of a particular sample are finer. **D5092**

damping—reduction in the amplitude of vibration of a body or system due to dissipation of energy internally or by radiation. (ISRM)

damping ratio—for a system with viscous damping, the ratio of actual damping coefficient to the critical damping coefficient.

decay time—the interval of time required for a pulse to decay from its maximum value to some specified fraction of that value. (ISRM)

decomposition—for peats and organic soils, see **humification**.

decontamination—*in apparatus,* the process of removing or reducing to a known level undesirable physical or chemical constituents, or both, from a sampling apparatus to maximize the representativeness of physical or chemical analyses proposed for a given sample. **D5088**

decoupling—the ratio of the radius of the blasthole to the radius of the charge. In general, a reducing of the strain wave amplitude by increasing the spacing between charge and blasthole wall. (ISRM)

deflocculating agent (deflocculant) (dispersing agent)—an agent that prevents fine soil particles in suspension from coalescing to form flocs.

deformability—*in grouting*, a measure of the elasticity of the grout to distort in the interstitial spaces as the sediments move.

deformation—change in shape or size.

deformation—a change in the shape or size of a solid body. (ISRM)

deformation resolution (deformation sensitivity), R_d **(L)**—ratio of the smallest subdivision of the indicating scale of a deformation-measuring device to the sensitivity of the device.

degradable, *adj—in erosion control,* decomposes under biological, chemical processes, or ultraviolet stresses associated with typical application environments.

degree-days—the difference between the average temperature each day and 32°F (0°C). In common usage degree-days are positive for daily average temperatures above 32°F and negative for those below 32°F (see **freezing index**).

degree of consolidation (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.

degrees-of-freedom—the minimum number of independent coordinates required in a mechanical system to define completely the positions of all parts of the system at any instant of time. In general, it is equal to the number of independent displacements that are possible.

degree of saturation—see **percent saturation**.

degree of saturation—the extent or degree to which the voids in rock contain fluid (water, gas, or oil). Usually expressed in percent related to total void or pore space. (ISRM)

degree of sensitivity —see **sensitivity**.

delay—time interval (fraction of a second) between detonation of explosive charges. (ISRM)

density *(grouping)*—See **unit weight** and **specific gravity** groupings.

DISCUSSION—In soil and rock the term density requires the inclusion of an adjective to define its specific application, such as dry, bulk, submerged, and maximum. The adjectives "dry," "total," "wet," "moist," etc. do not modify the noun density, but the state of the soil or rock, or both, along with its voids. However; in some professions, such as Soil Science and Geology, the usage of the adjective ″bulk″ pertains to the volume of the soil/rock instead of its state. Acceptable SI units are kg/m^3, g/cm^3 or Mg/m^3. Acceptable inch-pound units are slugs/ft^3 or lbm/ft^3(only use lbm if force units are not included in that standard). See 3.4.2 for usage of symbols in definitions.

Density is a key element in the phase relations, phase relationships, or mass-volume relationships of soil/rock. If dissolved solids, such as salt, are present in the pore fluid, then modifications to these relationships are required.

In all density definitions, mass is determined in air without any corrections for buoyancy in air and the unit total volume applies to the unit volume including both solids and voids. The density of water is a function of temperature; therefore, reference temperature should be given, such as water density (20°C). However, this reference temperature is typically omitted and assumed to be 20°C.

For definitions involving rock and aggregates, it is common practice, especially in the concrete industry, to include the terms absolute and apparent. In this case, absolute refers to mass-volume relations without any voids (solids volume) while apparent refers to the mass-volume relations with voids (unit total volume). Surface dry means all water on the rock's surface is removed, usually by light blotting. In definitions containing "surface dry," the omission of "surface dry" is typical when using that term; such as, apparent bulk (surface dry) density becomes apparent bulk density. For highly porous rock, specialized surface dry techniques might be required to model specific applications. The saturation of rock or aggregate is typically accomplished by submerging in water with or with out a vacuum for a prescribed period of time.

It is acceptable practice to change the density adjective to a noun, such as dry density to density of dry soil or rock, apparent saturated density to apparent density of saturated rock or aggregate, or solids density to density of soil solids or particles.

NOTE 1—The most general density terms are presented first, such as density, dry density, saturated density, and total density followed by the special application terms in alphabetical order.

density, ρ **(ML^{-3})**, *n*—the mass per unit volume. See **density** discussion.

dry density, ρ_d **(ML^{-3})**, *n*—the mass of dry soil or rock per unit total volume. See **density** discussion.

DISCUSSION—In some professions, such as Soil Science and Geology, the term "bulk density" usually has the same meaning as "dry density." See **density** discussion.

saturated density, ρ_{sat} **(ML^{-3})**, *n*—the mass of saturated soil or rock per unit total volume. See **density** discussion.

total, moist, wet or bulk density, ρ_t **(ML^{-3})**, *n*—the total mass of partially saturated or saturated soil or rock per unit total volume.

DISCUSSION—Throughout D18 standards either the adjective of total, moist, wet or bulk is used to represent this density condition. The order of preference is as presented; however, any one of these adjectives is acceptable. In some professions, such as Soil Science and Geology, the term "bulk density" usually has the same meaning as "dry density." See **density** discussion and *dry density* definition.

absolute solids density, ρ_r **(ML^{-3})**, *n—in rock or aggregate*, the mass of the mineral constituents present in rock or aggregate per unit volume of the mineral without any voids.

DISCUSSION—It is usually measured by pulverizing the rock or aggregate to silt size or finer, so there are not any voids in the rock or aggregate, then measuring their overall dry mass and volume. A D18 test method is D854. See **density** discussion.

apparent bulk (surface dry) density, $\rho_{r,t}$ **(ML^{-3})**, *n—in rock or aggregate*, the mass of partially saturated rock or aggregate with its surface(s) blotted dry per unit total volume.

DISCUSSION—The replacement of "bulk" with total, moist or wet is common. This definition could apply to saturated conditions; however, it is preferable to replace bulk with saturated. See **density** discussion and *apparent saturated (surface dry) density*.

apparent dry bulk density, $\rho_{r,d}$ **(ML^{-3})**, *n—in rock or aggregate*, the dry mass of rock or aggregate per unit total volume. See **density** discussion.

apparent saturated (surface dry) density, $\rho_{r,sat}$ **(ML^{-3})**, *n—in rock or aggregate*, the mass of saturated rock or aggregate with its surface(s) blotted dry per unit total volume. See **density** discussion.

buoyant or submerged density (@ temp), $\rho_{sub,(@temp)}$, $\rho_{b,(@temp)}$ **(ML^{-3})**, *n*—the difference between the saturated density of soil or rock and the density of water (at 20°C or project specific temperature).

DISCUSSION—The buoyant/submerged density times acceleration of gravity is used to calculate effective stress verses depth, providing hydrostatic conditions are applicable. See **density** discussion.

critical density, ρ^c **(ML^{-3})**, *n—in soil*, the dry density below which the soil will exhibit contractive behavior at high shear strain and above which it will exhibit dilative behavior at high strain. See **critical void ratio**.

DISCUSSION—The critical density or critical void ratio is an aspect of soil behavior that has now been known since the 1930s and these two definitions are alternate and equivalent measures of soil packing. The critical density/void ratio of a given material varies with effective confining stress and is affected by other factors. Some of those factors being the fabric of the material, stress history, type of loading, and

duration of loading. "High strain" is associated with strain at and after peak strength conditions. The critical density/void ratio arises in the context of both liquefaction of cohesionless soil and in the fundamental modeling of soil constitutive behavior (including sands, silts, and clays). For the particular case of saturated soil subjected to undrained deformation, contractive behavior will cause a strength reduction because of the build up of excess pore water pressure during shear. In very loose soil, this pore pressure increase will often be so large as to cause brittle strength reduction with shear 2 of 4 strain (liquefaction), For dense soil, dilative behavior will produce a strength gain whether drained (as an increase in the soils friction angle) or undrained (as an increase in shear strength). For constitutive modeling, the variation of critical void ratio with mean effective stress is often referred to as a critical state locus (*CSL*) and in this form appears widely in modern models of soil behavior (including the *Modified Cam Clay* model found in most commercial finite element programs as the default "advanced" soil model).

maximum dry density (Std.#), (Std.#)-$\rho^{d,max}$ **(ML^{-3})**—*in soils*, the densest state (represented as a dry condition) of a soil determined using the standard test method indicated.

DISCUSSION—The term "maximum" or "densest state" does not mean an absolute value, but a test value determined by a standard test method (compaction test) developed to evaluate the subject property. Some of these D18 test methods are D558 (standard effort compaction for soil-cement), D698 (standard effort compaction), D1557 (modified effort compaction), D4253 (vibrating table), and D7382 (vibrating hammer). The test method used to determine the maximum density needs to be identified since the value typically depends on the test method. In the above symbol presentation, "Std.#" is an abbreviation for the ASTM designation number associated with the applicable test method; an example might be "D698-$\rho^{d,max}$= 1750 kg/m^3 or maximum dry density (D 698D698) equals 1750 kg/m^3." See **density** discussion.

minimum dry density (Std.#), (Std.#)-$\rho^{d,min}$ **(ML^{-3})**—*in soils*, the loosest state (represented as a dry condition) of a soil determined using the standard test method indicated.

DISCUSSION—The term "minimum" or "loosest state" does not mean an absolute value, but a test value determined by a standard test method associated with that subject property. A D18 test method is D4254. The standard test method should be identified. In the above symbol presentation, "Std.#" is an abbreviation for the ASTM designation number associated with the applicable test method; an example might be "D4254-$\rho^{d,min}$= 1430 kg/m^3 or minimum dry density (D4254) equals 1430 kg/m^3." See **density** discussion and *maximum dry density*.

relative density, D_r, R_d (D), n—in cohesionless soils, a relationship describing the void ratio/density of a soil sample/specimen relative to the loosest and densest states for that soil, and usually expressed as a percentage. It is defined by either of the following two equations:

(a) by void ratio:

$$D_r = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

where:

D_r = relative density in %,
e_{max} = void ratio in loosest state, from minimum dry density (Std#),
e = any given void ratio (typically an in-situ test value or that of a test specimen, and
e_{min} = void ratio in densest state, from maximum dry density (Std#).

(b) by dry density:

$$D_r = \frac{\rho_{d,max}}{\rho_d} \times \frac{\rho_{d,max} - \rho_d}{\rho_{d,max} - \rho_{d,min}} \times 100$$

where:

$\rho_{d,max}$ = maximum dry density (Std#) in kg/m^3,
ρ_d = any given dry density (typically an in-situ test value or that of a test specimen in kg/m^3, and
$\rho_{d,min}$ = minimum dry density (Std#) in kg/m^3.

DISCUSSION—The numerical value of the relative density is the same whether performing the calculation based on void ratio or density. The terms "loosest," "densest," "maximum," or "minimum" does not mean an absolute value, but a test value determined by a standard test method associated with that subject property. Therefore, the test methods should be identified. In the above symbol presentation, "Std.#" is an abbreviation for the ASTM Designation number associated with the applicable Test Method. The usage of unit weight applies to Equation (b) if density is replaced by unit weight. See **density** discussion and definitions for **void ratio** and *maximum dry density*, and *minimum dry density* under **density** grouping.

solids or particle density, ρ_s **(ML^{-3})**, *n*—the mass of dry solids (particles) of soil per unit volume of solids without any voids. See **density** discussion and definition for *absolute solids density*.

water density (@ temp), $\rho_{w,(@\ temp)}$ **(ML^{-3})**, *n*—the mass of water per unit volume at a given temperature. See **density** discussion.

depth of flow, *n—in hydraulics,* the distance from the channel thalweg to the water surface, measure normal to the direction of flow, for a given discharge.

designated separating sieve, *n—in composite sieving*, the sieve selected to separate the specimen into coarser and finer portions for composite sieving. **D6913**

design discharge, *n—in erosion control,* the volumetric quantity of water flow within a channel which is typically used in determining required channel dimensions and suitable lining materials for ensuring adequate channel capacity and stability.

DISCUSSION—The discharge associated with a specified frequency of recurrence, for example, an n-year flood. The n-year flood event has a probability of 1/n being equaled or exceeded in any given year.

detection monitoring—*in geoenvironmental programs,* a program of monitoring for the express purpose of determining whether or not there has been a contaminant release to groundwater. **D5092**

detection limit, *DL*, *n—in data analyses*, the true concentration at which there is a specified level of confidence (for example, 99 % confidence) that the analyte is present in the sample . **D6312**

detection monitoring program, *n—in geoenvironmental programs*, groundwater monitoring that is intended to detect a potential impact from a facility by testing for statistically significant changes in geochemistry in a downgradient monitoring well relative to background levels. **D6312**

detonation—an extremely rapid and violent chemical reaction causing the production of a large volume of gas. (ISRM)

deviator stress, $\Delta\sigma$ (FL^{-2})—the difference between the major and minor principal stresses in a triaxial test.

deviator of stress (strain)—the stress (strain) tensor obtained