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Standard Practice for Description of Frozen Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 4083; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 Note—Keywords were added in January 1994. Section 1.4 was added editorially in January 1999.

1. Scope

1.1 This practice presents a procedure for the description of frozen soils based on visual examination and simple manual tests.

1.2 It is intended to be used in conjunction with Test Method D 2487 and Practice D 2488, which describe and classify soils, but do not cover their frozen state.

1.3 This procedure is based on "Guide to Field Description of Permafrost for Engineering Purposes," National Research Council of Canada, 1963, and MIL-STD-619.

1.4 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 420 Guide for Investigating and Sampling Soil and Rock[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

2.2 *Military Standard:*

MIL-STD-619 Unified Soil Classification System for Roads, Airfields, Embankments and Foundations[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of the soil components of a frozen soil mass, that is, boulders, cobbles, gravel, sand, fines (silt and clay), and organic soils and peat shall be in accordance with Terminology D 653.

3.1.2 The following terms are used in conjunction with the description of frozen ground areas (Fig. 1):[4]

3.1.2.1 *annual frost zone (active layer)*—the top layer of ground subject to annual freezing and thawing.

3.1.2.2 *frost table*—the frozen surface, usually irregular, that represents the level, to which thawing of seasonally frozen ground has penetrated. See Fig. 1.

3.1.2.3 *frozen zone*—a range of depth within which the soil is frozen. The frozen zone may be bounded both top and bottom by unfrozen soil, or at the top by the ground surface.

3.1.2.4 *ground ice*—a body of more or less clear ice within frozen ground.

3.1.2.5 *ice wedge*—a wedge-shaped mass in permafrost, usually associated with fissures in polygons.

3.1.2.6 *icing*—a surface ice mass formed by freezing of successive sheets of water.

3.1.2.7 *permafrost*—the thermal condition in soil or rock, wherein the materials have existed at a temperature below 0°C (32°F) continuously for a number of years. Pore fluids or ice may or may not be present.

3.1.2.8 *permafrost table*—the surface that represents the upper limit of permafrost.

3.1.2.9 *polygons (polygonal ground)*—more or less regular-sized surface patterns created by thermal contraction of the ground. Two types are common: (*a*) those with depressed centers and (*b*) those with raised centers.

3.1.2.10 *residual thaw zone*—a layer of unfrozen ground between the permafrost and the annual frost zone. This layer

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rockand is the direct responsibility of Subcommittee D18.19 on Frozen Soils and Rock.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120.

[4] For more complete lists of generally accepted terms used in the description of frozen ground see: Hennion, F., "Frost and Permafrost Definitions," *Bulletin 111*, Highway Research Board, Washington, DC 1955; and Brown, R. J. E., and Kupsch, W. D., "Permafrost Terminology," *Technical Memorandum No. 111*, National Research Council of Canada, 1974.

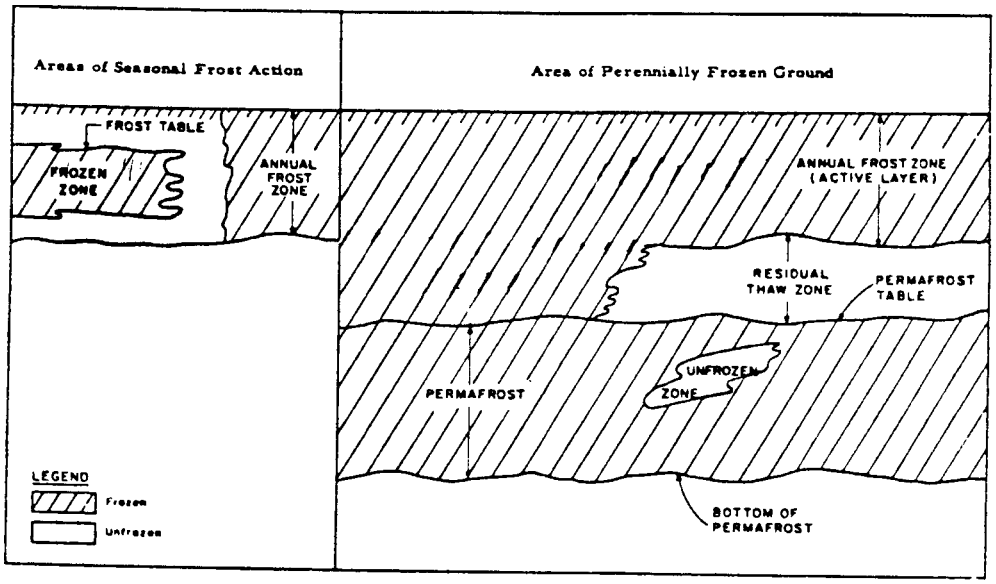


FIG. 1 Illustration of Frozen Soil Terminology

does not exist where annual frost extends to permafrost.

3.1.3 The following terms are used to describe the characteristics of the frozen earth:

3.1.3.1 *candled ice*—ice that has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

3.1.3.2 *clear ice*—ice that is transparent and contains only a moderate number of air bubbles.

3.1.3.3 *cloudy ice*—ice that is translucent or relatively opaque due to the content of air or for other reasons, but which is essentially sound and nonpervious.

3.1.3.4 *excess ice*—ice in excess of the fraction that would be retained as water in the soil voids after thawing.

3.1.3.5 *friable*—a condition under which the material is easily broken up under light to moderate pressure.

3.1.3.6 *granular ice*—ice that is composed of coarse, more or less equidimensional, crystals weakly bonded together.

3.1.3.7 *ice coatings on particles*—discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

3.1.3.8 *ice crystal*—a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.

3.1.3.9 *ice lenses*—lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss, and commonly in repeated layers.

3.1.3.10 *ice segregation*—the growth of ice within soil in excess of the amount that may be produced by the in-place conversion of the original void moisture to ice. Ice segregation occurs most often as distinct lenses, layers, veins, and masses, commonly, but not always, oriented normal to the direction of heat flow.

3.1.3.11 *poorly bonded*—a condition in which the soil particles are weakly held together by the ice so that the frozen soil has poor resistance to chipping and breaking.

3.1.3.12 *porous ice*—ice that contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.

3.1.3.13 *thaw stable*—the characteristic of frozen soils that, upon thawing, do not show loss of strength in comparison to normal, long-time thawed values nor produce detrimental settlement.

3.1.3.14 *thaw unstable*—the characteristic of frozen soils that, upon thawing, show significant loss of strength in comparison to normal, long-time thawed values or produce significant settlement, or both, as a direct result of the melting of excess ice in the soil.

3.1.3.15 *well bonded*—a condition in which the soil particles are strongly held together by the ice so that the frozen soil possesses relatively high resistance to chipping or breaking.

4. Significance and Use

4.1 This practice is intended primarily for use by geotechnical engineers and technicians and geologists in the field, where the soil profile or samples from it may be observed in a relatively undisturbed (frozen) state.

4.2 It may also be used in the laboratory to describe the condition of relatively undisturbed soil samples that have been maintained in a frozen condition following their acquisition in the field.

4.3 The practice is not intended to be used in describing unfrozen soils or disturbed samples of frozen soil.

5. Apparatus

5.1 *Required Apparatus*:

5.1.1 Pocket knife or small spatula.

5.1.2 Low-power magnifying hand lens.

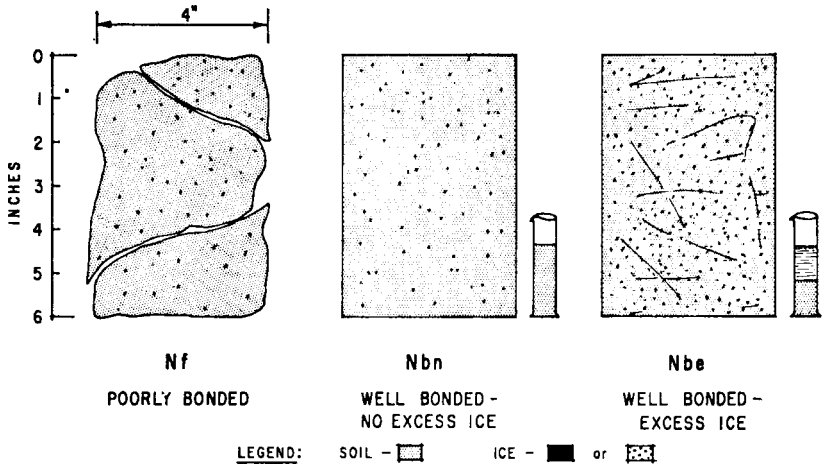
5.1.3 Pint-size graduated jars.

5.2 *Useful Auxiliary Apparatus*:

5.2.1 Camera.

5.2.2 Small bottle of dilute hydrochloric acid.

5.2.3 Small test tube and stopper.



NOTE 1—Frozen soils in the *N* group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the *V* group.

NOTE 2—When visual methods may be inadequate, a simple field test to aid evaluation of volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of total volume.

Group Symbol	Subgroup			Field Identification
	Description	Symbol		
	Poorly bonded or friable	N_f		
N	No excess ice Well-bonded	N_b	N_{bn}	Identify by visual examination. To determine presence of excess ice, use procedure under Note 2 and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation; medium, low. Note presence of crystals or of ice coatings around larger particles.
	Excess ice		N_{be}	

FIG. 2 Description of Frozen Soils—Ice Not Visible

5.2.4 Munsell Soil Color Chart or Rock Color Chart, or both.

5.2.5 Thermometer.

6. General Procedure for Identification

6.1 The system for describing and classifying frozen soil is based on an identification procedure which involves three steps designated as Parts I, II, and III. Part I consists of a description of the soil phase, Part II consists of the addition of soil characteristics resulting from the frozen state, and Part III consists of a description of the important ice strata associated with the soil.

NOTE 1—In addition to the description of the soil profile at a given site, it is normally advantageous to describe the local terrain features. Particularly useful are descriptions of the type of vegetation cover, depth and type of snow cover, local relief and drainage conditions, and depth of thaw. One or more photos of the area also can be very helpful. The terminology given in 3.1.2 should be used to describe any special conditions which can be recognized. To these should be added any available information on the depth of thaw as estimated from borings and test pits at the site.

7. Part I, Description of the Soil Phase[5]

7.1 The soil phase, whether thawed or frozen, is first described in accordance with Practice D 2488.

8. Part II, Description of the Frozen Soil

8.1 Frozen soils in which ice is *not visible to the unaided eye* are designated by the symbol *N* and are divided into two main subgroups as shown in Fig. 2.

8.1.1 *Poorly bonded or friable* material in which segregated ice is not visible to the unaided eye is designated by the symbol N_f. This condition exists when the degree of saturation is low.

8.1.2 *Well-bonded* frozen soil in which the ice cements the material into a hard solid mass, but in which segregated ice is not visible to the unaided eye is designated by the symbol N_b. It may further be described on the basis of detailed examination and assigned to one of two subtypes. See Fig. 2.

8.1.2.1 If no excess ice is present as indicated by the absence of segregation even under magnified viewing, the material is designated by the symbol N_{bn}.

8.1.2.2 If *excess ice* is present, but is so *uniformly distributed* that it is not easily apparent to the unaided eye, the material is designated by the symbol N_{be}. This condition may occur in very fine silty sands or coarse silts and can be verified by placing some frozen soil in a graduated jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of the total volume. See Fig. 2.

8.2 Frozen soils in which *significant segregated ice is visible* to the unaided eye, but individual ice masses or layers are *less than 1 in.* (25 mm) in thickness are designated by the symbol *V*. These are divided into five subgroups as shown in Fig. 3.

8.2.1 The symbol V_x designates those frozen soils which contain *individual ice crystals* or inclusions. See Fig. 3.

8.2.2 The symbol V_c designates those frozen soils in which the *ice occurs as coatings* on particles.

[5] When the surface soils are mostly organic (peat) a more complete description can be achieved through use of the "Guide to a Field Description of Muskeg," I. C. McFarlane, in *Special Procedures for Testing Soil and Rock for Engineering Purposes*, 5th Ed., *ASTM STP 479*, 1970.