INTERNATIONAL

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# Standard Test ~~Method~~Methods for Determining the Effect of Freeze-Thaw on Hydraulic Conductivity of Compacted or Intact Soil Specimens Using a Flexible Wall Permeameter[1]

This standard is issued under the fixed designation D6035/D6035M; 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.

## 1. Scope*

1.1 ~~This~~These test ~~method covers~~methods cover laboratory measurement of the effect of freeze-thaw on the hydraulic conductivity of compacted or intact soil specimens using Test Method D5084 and a flexible wall permeameter to determine hydraulic conductivity. ~~This~~These test ~~method does~~methods do not provide steps to perform sampling of, or testing of, in situ soils that have already been subjected to freeze-thaw conditions. Test Method A uses a specimen for each hydraulic conductivity determination that is subjected to freeze/thaw while Test Method B uses one specimen for the entire test method (that is, the same specimen is used for each hydraulic conductivity).

1.2 ~~This~~These test ~~method~~methods may be used with intact specimens (block or thin-walled) or laboratory compacted specimens and shall be used for soils that have an initial hydraulic conductivity less than or equal to 1E-5 m/s [3.94 E-4 in./s] (1E-3 cm/s) (Note 1).

NOTE 1—The maximum initial hydraulic conductivity is given as 1 E-5 m/s [3.94 E-4 in./s]. This should also apply to the final hydraulic conductivity. It is expected that if the initial hydraulic conductivity is 1 E-5 m/s (3.94 E-4 in./s), then the final hydraulic conductivity will not change (increase) significantly (that is, greater than 1 E-5 m/s) (3.94 E-4 in./s).

1.3 Soil specimens tested using this test method can be subjected to three-dimensional freeze-thaw (herein referred to as 3-d) or one-dimensional freeze-thaw (herein referred to as 1-d). (For a discussion of one-dimensional freezing versus three-dimensional freezing, refer to Zimmie and LaPlante or ~~Othman.~~Othman, et al.[2,3])

1.4 Soil specimens tested using this test method can be tested in a closed system (that is, no access to an external supply of water during freezing) or an open system.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.



1.5.1 The procedures used to specify how data are collected/recorded and calculated in the standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of the test methods ro consider significant digits used in analysis methods for engineering data.

1.6 *Units*—The values stated in SI units or inch-pound units (presented in brackets) are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Reporting of test results in units other than SI shall not be regarded as ~~conconformance~~nonconformance with this test method.

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

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[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.19 on Frozen Soils and Rock.
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[2] Zimmie, T. F., and La Plante, C., "The Effect of Freeze/Thaw Cycles on the Permeability of a Fine-Grained Soil," *Hazardous and Industrial Wastes, Proceedings of the Twenty-Second Mid-Atlantic Industrial Waste Conference*, Joseph P. Martin, Shi-Chieh Cheng, and Mary Ann Susavidge, eds., Drexel University, 1990, pp. 580–593.

[3] Othman, M. A., Benson, C. H., Chamberlain, E. J., and Zimmie, T. F., "Laboratory Testing to Evaluate Changes in Hydraulic Conductivity of Compacted Clays Caused by Freeze-Thaw: State-of-the-Art," *Hydraulic Conductivity and Waste Contaminant Transport in Soils, ASTM STP 1142*, David E. Daniel, and Stephen J. Trautwein, eds., American Society for Testing and Materials, Conshohocken, PA, pp. 227–254.

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

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[4]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

~~D1587~~D1587/D1587M Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

~~D4220~~D4220/D4220M Practices for Preserving and Transporting Soil Samples

D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

D6026 Practice for Using Significant Digits in Geotechnical Data

## 3. Terminology

~~3.1 *Definitions*—For common definitions of other terms in this standard, see Terminology D653, including *hydraulic conductivity*.~~

3.1 *Definitions:*

3.1.1 For definitions of common technical terms used in this standard, see Terminology D653, including *hydraulic conductivity*.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *freeze-thaw cycle, n*—a loop from room temperature to the ambient temperature of the freezing cabinet, and back to room temperature.

3.2.2 *freezing, closed system, n*—freezing that occurs under conditions that preclude the gain or loss of any water in the system.

3.2.3 *freezing, open system, n*—freezing that occurs under conditions that allow the gain or loss of water in the system by movement of pore water from or to an external source to growing ice lenses.



## 4. Significance and Use

4.1 This test method identifies the changes in hydraulic conductivity as a result of freeze-thaw on natural soils only.

4.2 It is the user's responsibility when using this test method to determine the appropriate water content of the laboratory-compacted specimens (that is, dry, wet, or at optimum water content) (Note 2).



NOTE 2—It is common practice to construct clay liners and covers at optimum or greater than optimum water content. Specimens compacted dry of optimum water content typically do not contain larger pore sizes as a result of freeze-thaw because the effects of freeze-thaw are minimized by the lack of water in the sample. Therefore, the effect of freeze-thaw on the hydraulic conductivity is minimal, or the hydraulic conductivity may increase slightly.[3]

4.3 The requestor must provide information regarding the effective stresses to be applied during testing, especially for determining the final hydraulic conductivity. Using high effective stresses (that is, 35 kPa [5 psi] as allowed by Test Method D5084) can decrease an already increased hydraulic conductivity resulting in lower final hydraulic conductivity values. The long-term effect of freeze-thaw on the hydraulic conductivity of compacted soils is unknown. The increased hydraulic conductivity caused by freeze-thaw may be temporary. For example, the overburden pressure imparted by the waste placed on a soil liner in a landfill after being subjected to freeze-thaw may reduce the size of the cracks and pores that cause the increase in hydraulic conductivity. It is not known if the pressure would overcome the macroscopically increased hydraulic conductivity sufficiently to return the soil to its original hydraulic conductivity (prior to freeze-thaw). For cases such as landfill covers, where the overburden pressure is low, the increase in hydraulic conductivity due to freeze-thaw will likely be permanent. Thus, the requestor must take the application of the test method into account when establishing the effective stress.

4.4 The ~~specimen~~specimen(s) shall be frozen to −15°C [5°F] unless the requestor specifically dictates otherwise. It has been documented ~~in the literature~~ by Othman, et al[3] that the initial (that is, 0 to −15°C [32°F to 5°F]) freezing condition causes the most significant effects in hydraulic conductivity. Freezing rate and ultimate temperature should mimic the field conditions. It has been shown that superfreezing (that is, freezing the specimen at very cold temperatures and very short time periods) produces erroneous results.

4.5 The thawed specimen temperature and thaw rate shall mimic field conditions. Thawing specimens in an oven (that is, overheating) will produce erroneous results.

[4] 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.