Designation: D4320/D4320M – 09

Standard Practice for Laboratory Preparation of Chemically Grouted Soil Specimens for Obtaining Engineering Parameters[1]

This standard is issued under the fixed designation D4320/D4320M; 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 practice covers the laboratory preparation of chemically grouted soil specimens for use in laboratory tests to determine engineering parameters.

NOTE 1—This practice may not be applicable to grout mixtures with gel times shorter than the time required to saturate the specimen with grout.

1.2 The specimens are intended for both strength and modulus determination in unconfined and confined compression testing.

NOTE 2—Preparation methods for specimens to be used for other purposes are described in Test Methods D4219 and D5202.

1.3 This practice requires the injection of grout into soil specimens already fabricated to a desired density.

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

1.4.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy to which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.5 The values stated in either 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.

1.5.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The slug unit is not given, unless dynamic (F = ma) calculations are involved.

1.6 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.

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 and health practices and determine the applicability of regulatory requirements prior to use.*

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:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

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

D4219 Test Method for Unconfined Compressive Strength Index of Chemical-Grouted Soils (Withdrawn 2017)[3]

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D5202 Test Method for Determining Triaxial Compression Creep Strength of Chemically Grouted Soils

D6026 Practice for Using Significant Digits in Geotechnical Data

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.16 on Grouting.

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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] 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**

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of technical terms in this standard, refer to Terminology D653.

4. Significance and Use

4.1 The purpose of this practice is to prepare specimens of chemically grouted soils for testing in unconfined or triaxial compression.

NOTE 3—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 *Specimen Molds*—Molds are to be constructed so that they may be longitudinally split to allow the removal of grouted specimens without the use of a jacking force. They may be sized for the preparation of one or multiple specimens (Multiple specimen molds should be externally marked to indicate desired ends of individual specimens, as an aid in preparation). Molds shall produce specimens with a length-to-diameter ratio between two and three, (2.5 is recommended) and shall have a tolerance of ±0.25 mm [±0.01 in.] on the internal diameter. Molds will have top and bottom caps designed to prevent leakage of grout during pressure injection.

5.1.1 Satisfactory molds, similar to Fig. 1, may be made from an acrylic tube which has been split longitudinally into three pieces (Fig. 2), which allows for the mold to be assembled and disassembled using silicon rubber seals and hose clamps. Equally satisfactory molds can be made by splitting tubes longitudinally with one narrow slit (Fig. 3), which is closed by hose clamps around the tubes and will reopen when the clamps are loosened, thus releasing the specimens. Leakage may be prevented by covering the slit from the inside with tape. Satisfactory seals of end caps may be made by threading the tubing and cap or by external tie rods to hold the caps in place (Fig. 4).

5.2 *Grout Injection System*—A system composed of the following components (Fig. 5):

5.2.1 *Mixing Tank,* capable of being pressurized to 200 kPa [30.0 psi] without leaking and able to contain all of the grout volume to be injected in one grouting operation. The tank will have an internal mixing device (such as a paddle wheel) or be able to accommodate the use of a magnetic stirrer. The tank will be fitted with a regulated air-pressure source and pressure gauge readable to 2 kPa [0.2 psi] without interpretation.

NOTE 4—Alternatively, proportioning pump sets may be used. Such equipment may be of advantage when the grout gel times are too short for effective use of pressure-tank injection equipment.

5.2.2 *Tubing,* capable of transporting the grout from the mixing tank to the specimen mold or molds to be injected is required. A bleed valve located just before the mold injection inlet allows for air bubbles trapped in the grout lines to be removed before they move into the specimen.

5.3 *Balance*—A balance having a minimum capacity of 1000-g and meeting the requirements of Guide D4753 for a balance of 0.1 g readability.

5.4 *Miscellaneous Equipment*—Tools such as: spoons; tare dishes, etc., for handling and determining masses of soil and any dry grout components; graduate for measuring water and fluid grout components; tamping rod or vibrating tool or both for compaction of specimens to desired density; nylon window screen or similar inert screening having openings small enough to retain the soil to be grouted but otherwise as large as possible; disposable porous disks, if used; and scissors for cutting.

5.5 *Leveling Device*—A leveling plate attached to a rod of sufficient length such that the plate can be oriented perpendicular to the long axis of the mold at any height within the mold, capable of fitting inside the mold with approximately 6.0-mm [0.25 in.] clearance.

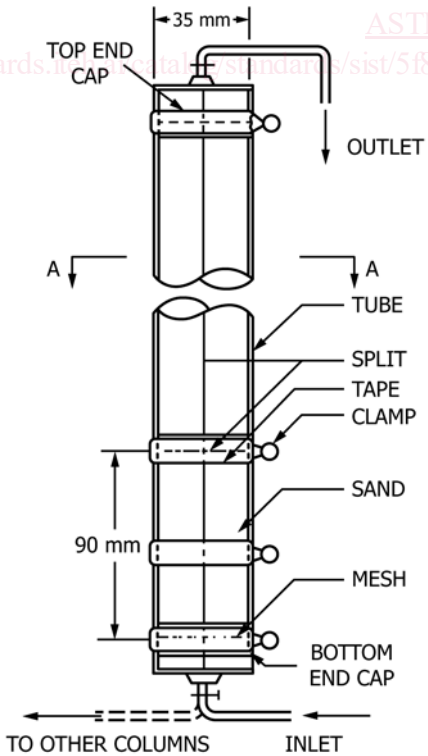

FIG. 1 Specimen Mold

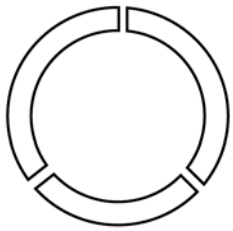

FIG. 2 Three piece multiple specimen mold

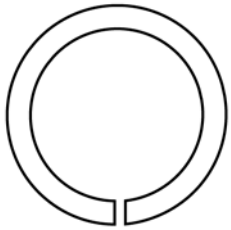

FIG. 3 Split tube multiple specimen mold

5.6 *Moist Room or Cabinet*—A moist room or cabinet capable of maintaining a temperature of 23.0 ± 1°C [73 ± 2ºF] and a relative humidity of not less than 96 % for moist curing specimens.

5.7 *Deviations,* from standard curing conditions are to be noted in the report.

6. Reagents and Water

6.1 Typical grout formulations include silicate-based, acrylamide and acrylate.

6.2 Tap water may be used whenever its composition is similar to site groundwater, or whenever it does not change grout characteristics from those obtained with deionized water. Deionized water may be used, when the use of tap water is questionable. Site groundwater or site supply water may also be used.

NOTE 5—It may be desirable to use deaired water to prevent air from coming out of solution during flow through the small voids of the sample.

7. Size of Specimens

7.1 Compression test specimens shall be right circular cylinders having a minimum diameter of 38 mm [1.5 in.]. The height shall be between two and three times the diameter (2.3 is recommended).

8. Molding Specimens

8.1 Either single or multiple specimen molds may be used.

8.2 *Formation of Soil Specimen*—The mold to be used is assembled (with the top cap removed) and held vertically in a stable fashion while the soil sample is prepared using the following procedure:

8.2.1 A small piece of screen made of inert material is placed over the grout inlet at the bottom of the mold to retain filter material.

NOTE 6—The term "inert" refers to a material which does not interact in any way with the components of the specific grout being used.

8.2.2 The lower portion of the mold is filled with a layer (approximately 12.5 to 25.4 mm [0.5 to 1 in.]) of coarse sand or pea gravel to serve as a filter to disperse grout over the entire area of the specimen.

8.2.3 Insert the leveling device and smooth the surface of the filter material perpendicular to the long axis of the mold. Remove the leveling device and insert a piece of inert screen, having a diameter no more than 2.5 mm [0.1 in.] smaller than the inside of the mold. Position the screen flat on the filter surface.

8.2.4 The soil to be grouted is placed in layers and compacted to the desired density.

8.2.4.1 Compaction may be done by tamping, tapping, or vibration. The method used shall be noted in the report. Satisfactory density control can be obtained by weighing sufficient soil to produce a 25-mm [1-in.] layer at the desired density and compacting this soil until a 25-mm [1-in.] layer thickness is obtained. If a multiple specimen mold is used, an inert screen shall be inserted at the interface between the specimens, as noted on the outside of the mold. When the top specimen is compacted and the inert screen is in place, construct the top filter as in 8.2.2 and assemble the top cap.

8.2.5 Alternatively, disposable inert porous discs may be placed on top and at the bottom of specimens prior to grouting, so that the samples will not require future capping. Discs shall have porosities equal to or greater than that of the ungrouted specimen and shall fit the specimen molds with a clearance of between 0.25 to 0.5 mm [0.01 to 0.02 in.]. When molds for multiple specimens are used, inert screens shall be used between adjacent top and bottom discs.

9. Grout Injection

9.1 Fill the grout injection tank with enough water to represent three times the volume of voids in the soil specimens, and pump this water through the specimens from the bottom to the top under a pressure of 35 kpa [5 psi] or less to enhance saturation. If this process takes less than 30 min, let the sample remain filled with water until 30 min has elapsed. Presaturation is not required for soils expected to be grouted above the groundwater table.

9.1.1 Water should be as described in 6.2.

9.2 Pour the predetermined quantities of the grout constituents into the empty injection tank and mix as required, but for less than 20 % of the gel time. Using a mixing propeller or a magnetic stirrer is permissible during the injection period for those grouts which would be similarly handled in the field.

9.3 Apply the air pressure to the injection tank not to exceed 70 kPa [10 psi] depending on grout viscosity and gelling time) and maintain constant during the pumping process. Injection should continue until the effluent shows that the water in the specimens has been replaced with grout. A specimen of this material shall be taken for a gel time check.

9.4 Leave specimens within the molds for at least long enough so that they can be removed without physical damage.

10. Curing Specimens

10.1 Leave the specimens in the molds when they are to be tested within about 16 h. After 16 h, the specimens may be removed from the mold provided that they have cured sufficiently to be undamaged by handling. For low concentration silicate-based grouts, this period may be as long as 48 h. For acrylamide and acrylate grouts, this period may be only a few minutes longer than the gel time. Specimens removed from molds shall be sealed in plastic or cured in a moist room, as specified in section 5.6 from the time of gelation until tested.