



Designation: D5202/D5202M – 16

Standard Test Method for Determining Triaxial Compression Creep Strength of Chemically Grouted Soils¹

This standard is issued under the fixed designation D5202/D5202M; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This test method covers the determination of long-term strength and deformation of a cylindrical specimen of either a (undisturbed) field sample or laboratory-fabricated chemical grouted soil when it is sheared undrained in compression under a constant sustained load.

NOTE 1—The voids of chemical grouted soils are most often substantially filled with grout. Thus, pore pressures are unlikely to develop. This test method is not applicable to partially grouted soils in which substantial pore pressures may develop. If pore pressures must be measured, reference is made to Test Method D4767 for equipment and procedures.

1.2 This test method provides data useful in determining strength and deformation properties of chemical grouted soils subjected to sustained loads. Mohr strength envelopes may also be determined.

1.3 The determination of strength envelopes and the development of relationships to aid in interpreting and evaluating test results are left to the engineer or office requesting the test.

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

1.5 The values stated in either SI or inch-pound units shall be regarded separately as standard. The values in each system may not be exact equivalents, therefore, each system must be used independently of the other, without combining values in any way.

1.6 *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 limitations prior to use.*

1.7 *This test method 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.

1.8 *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

- D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)³
- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
- D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
- 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
- D4320 Practice for Laboratory Preparation of Chemically Grouted Soil Specimens for Obtaining Design Strength Parameters
- D4767 Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

¹ This test method 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

D6026 Practice for Using Significant Digits in Geotechnical Data**3. Terminology**

3.1 For common definitions of terms used in this test method, refer to Terminology **D653**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *failure*—in creep studies, the stress condition at a predefined excessive (15 to 20 %) strain, or at strain level leading to fracture.

4. Significance and Use

4.1 Data from these tests may be used for structural and geomechanical design purposes. Adequate safety factors, based on engineering judgment must be determined by the user.

NOTE 2—Sampling procedures for in-situ specimens have a major influence on test results. Specimens carefully trimmed in the laboratory from large block samples taken in the field have the least chance of fracturing prior to testing. Sample preparation methods of laboratory-fabricated specimens also have a major influence on test results. Specimens should be fabricated in accordance with Test Method **D4320**.

NOTE 3—The quality of the result produced by this test method 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, and inspection. Users of this test method 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 The requirements for equipment needed to perform satisfactory tests are given in the following sections:

5.2 *Axial Loading Device*—The axial compression device may be a dead weight system, a pneumatic or hydraulic load cell, or any other device capable of applying and maintaining desired constant loads to the accuracy prescribed for the load-measuring device.

5.3 *Axial Load-Measuring Device*—The axial load-measuring device may be a load ring, electronic load cell, hydraulic load cell, or any other load-measuring device capable of the accuracy prescribed in this subsection and may be part of the axial loading device. The axial load-measuring device shall be capable of measuring the axial load to an accuracy of within ± 1 % of the axial load at failure. If the load-measuring device is located inside the triaxial chamber it shall be insensitive to horizontal forces and to the magnitude of the chamber pressure.

5.4 *Triaxial Compression Chamber*—The triaxial chamber shall consist of a headplate and a baseplate separated by a cylinder. The size of the cylinder should be enough to yield a minimum annular clearance of 12 mm ($\frac{1}{2}$ in.) with the untested specimen. The cylinder may be constructed of any material capable of withstanding the applied pressures. It is desirable to use a transparent material or have a cylinder provided with viewing ports so the behavior of the specimen may be observed. The headplate shall have a vent valve such that air can be forced out of the chamber as it is filled. The baseplate shall have an inlet through which the chamber fluid (usually

water) is supplied to the chamber, and appropriate connections for the specimen base.

5.5 *Axial Load Piston*—The piston passing through the top of the chamber and its seal must be designed so the variation in the axial load due to friction does not exceed 0.1 % of the axial load at failure and so there is negligible lateral bending of the piston during loading. Alternatively, the apparatus may be calibrated, and a correction for friction may be made.

NOTE 4—The use of two linear ball bushings to guide the piston is recommended to minimize friction and maintain alignment.

NOTE 5—A minimum piston diameter of $\frac{1}{8}$ the specimen diameter has been used successfully in many laboratories to minimize lateral bending.

5.6 *Pressure Control Devices*—The chamber pressure control devices shall be capable of applying and controlling pressures to within ± 2 kPa (0.25 psi) for pressures less than 200 kPa (28 psi) and to within ± 1 % for pressures greater than 200 kPa (28 psi). The device may consist of pneumatic pressure regulators or any other device capable of applying and controlling pressures to the required tolerances.

5.7 *Pressure-Measurement Devices*—The chamber pressure measuring devices shall be capable of measuring pressures to the tolerances given in **5.6**. They may consist of Bourdon gauges, pressures manometers, electronic pressure transducers, or any other device capable of measuring to the stated tolerances.

5.8 *Deformation Indicator*—The vertical deformation of the specimen is usually determined from the travel of the piston acting on top of the specimen. The piston travel shall be measured with an accuracy of at least ± 0.2 % of the initial specimen height. The deformation indicator shall have a travel range of at least 20 % of the initial height of the specimen and may be a dial indicator, linear variable differential transformer (LVDT), extensometer, or other measuring device meeting the requirements for accuracy and range. Alternatively, the vertical deformation of the specimen can be measured from the top surface of the specimen cap.

5.9 *Specimen Cap and Base*—The specimen cap and base shall be constructed of a rigid, noncorrosive, impermeable material, and shall have a circular plane surface of contact with the specimen and a circular cross section. The weight of the specimen cap shall be less than 0.5 % of the applied axial load at failure or less than 50 g (0.1 lb). The diameter of the cap and base shall be equal to the initial diameter of the specimen. The specimen base shall be connected to the triaxial compression chamber to prevent lateral motion or tilting, and the specimen cap shall be designed to receive the piston such that eccentricity of the piston-to-cap contact relative to the vertical axis of the specimen does not exceed 0.13 cm (0.05 in.). The end of the piston and specimen cap contact area shall be designed so that tilting of the specimen cap during the test is minimal. The cylindrical surface of the specimen base and cap that contacts the membrane to form a seal shall be smooth and free of scratches.

5.10 *Rubber Membrane*—The rubber membrane used to encase the specimen shall provide reliable protection against leakage. To check a membrane for leakage, the membrane shall



be placed around a cylindrical form, sealed at both ends with rubber O-rings, subjected to a small air pressure on the inside, and immersed in water. If air bubbles appear from any point on the membrane, it shall be rejected. To offer minimum restraint to the specimen, the unstretched diameter of the membrane shall be between 90 and 95 % of the specimen diameter. The membrane thickness shall not exceed 1 % of the diameter of the specimen. The membrane shall be sealed to the specimen cap and base with rubber O-rings with an unstressed inside diameter between 75 and 85 % of the diameter of the cap and base, or by other means that will provide a positive seal. An equation for correcting deviator stress (principal stress difference) for the effect of the stiffness of the membrane is given in 11.3.

5.11 *Specimen-Size Measurement Devices*—Devices used to determine the height and diameter of the specimen shall measure the respective dimensions to within ± 0.1 % of the total dimension and be constructed such that their use will not disturb the specimen.

NOTE 6—Circumferential measuring tapes are recommended over calipers for determining the diameter.

5.12 *Recorders*—Specimen behavior may be recorded manually or by electronic digital or analog recorders. If electronic recorders are used, it shall be necessary to calibrate the measuring devices through the recorder using known input standards.

5.13 *Weighing Device*—The specimen weighing device shall be able to determine the mass of the specimen to an accuracy of within ± 0.05 % of the total mass of the specimen.

5.14 *Testing Environment*—Perform the test in an environment where temperature fluctuations are less than $\pm 4^\circ\text{C}$ ($\pm 7.2^\circ\text{F}$) and there is no direct contact with sunlight.

5.15 *Miscellaneous Apparatus*—Specimen trimming and carving tools including a wire saw, steel straightedge, miter box and vertical trimming lathe, may be needed for field samples. Apparatus for preparing laboratory specimens is detailed in Test Method D4320. Membranes and O-ring expander, water content cans, and data sheets shall be provided as required.

6. Safety Hazards

6.1 Tubing composed of glass or other brittle materials may explode/shatter when under pressure, especially air. Therefore, such tubing should be enclosed. Establish allowable working pressures and make sure they are not exceeded.

7. Test Specimen Preparation

7.1 Fabricate specimens as described in Test Method D4320, or carefully trim from samples taken in the field.

7.2 *Specimen Size*—Specimens shall be cylindrical and have a minimum diameter of 3.3 cm (1.3 in.). The height-to-diameter ratio shall be between 2.0 and 3.0. The largest particle size shall be smaller than $\frac{1}{10}$ the specimen diameter. If, after completion of a test, it is found based on visual observation that oversize particles are present, indicate this information in the report of test data (see Section 12).

NOTE 7—If oversize particles are found in the specimen after testing, a particle-size analysis performed in accordance with Method D422 may be performed to confirm the visual observation and the results provided with the test report (see Section 12).

7.3 *Specimen Measurement*—Measure height of specimens at 120° intervals. Diameter shall be measured at three places. Immediately record weight after specimen fabrication/trimming.

8. Specimen Mounting

8.1 *Preparations*—Before mounting the specimen in the triaxial chamber, make the following preparations:

8.1.1 If deemed necessary, check the rubber membrane for leaks (see 5.10).

8.1.2 Place the membrane on the membrane expander or, if it is to be rolled onto the specimen, roll the membrane on the cap or base.

8.1.3 Attach the pressure-control and pressure measurement system to the chamber base.

8.1.4 Place the rubber membrane around the specimen and seal it at the cap and base with two rubber O-rings or other positive seal at each end. A thin coating of silicon grease on the vertical surfaces of the cap and base will aid in sealing the membrane.

8.1.5 Check the alignment of the specimen and the specimen cap. If there is any eccentricity, realign the specimen and cap.

9. Procedure

9.1 After assembling the triaxial chamber, perform the following operations:

9.1.1 Bring the axial load piston into contact with the specimen cap several times to permit proper seating and alignment of the piston with the cap. During this procedure, take care not to apply an axial load to the specimen exceeding 0.5 % of the estimated axial load at failure. When the piston is brought into contact with the cap the final time, record the reading on the deformation indicator and lock the piston in place.

9.1.2 Fill the chamber with the chamber fluid, and apply the chamber pressure.

NOTE 8—The chamber pressure for any one series of tests should be a fixed percentage of the applied axial stress. The actual value used may be selected from the range of anticipated lateral pressure values in the field.

9.2 *Shear*—During shear, keep constant both the chamber pressure and the applied axial load. Prior to axial loading and the initiation of shear, perform the following steps:

9.2.1 Place the chamber in position in the axial loading device. Be careful to align the axial loading device, the axial load-measuring device, and the triaxial chamber to prevent the application of a lateral force to the piston during shear.

9.2.2 During this procedure, care should be taken not to apply an axial load to the specimen exceeding 0.5 % of the estimated axial load at failure. If the axial load-measuring device is located outside of the triaxial chamber, the chamber pressure will produce an upward force on the piston that will react against the axial loading device. In this case, start shear with the piston slightly above the specimen cap, and before the piston comes in contact with the specimen cap, either measure