Designation: D 4341 – 03

Standard Test Method for Creep of Hard Rock Core Specimens in Uniaxial Compression at Ambient or Elevated Temperature[1]

This standard is issued under the fixed designation D 4341; 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 test method covers the creep behavior of intact cylindrical hard rock core specimens in uniaxial compression. It specifies the apparatus, instrumentation, and procedures for determining the strain as a function of time under sustained load. Hard rocks are those with maximum strain at failure of less than 2 %.

NOTE 1—Most hard brittle rocks fail in uniaxial compression at strain levels of less than 2 %.

1.2 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.2.1 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.

1.3 *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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4543 Practice for Preparing Rock Core Specimens and Determining Dimensional and Shape Tolerances

D 5079 Practices for Preserving and Transporting Rock Core Samples

D 6026 Practice for Using Significant Digits in Geotechnical Data

E 4 Practices for Force Verification of Testing Machines

3. Summary of Test Method

3.1 A section of rock core is cut to length and the ends are machined flat to produce a cylindrical test specimen. The specimen is placed in a loading frame and, if required, heated to the desired test temperature. Axial load is rapidly applied to the specimen and sustained. Deformation is monitored as a function of elapsed time.

4. Terminology

4.1 Refer to Terminology D 653 for specific definitions.

5. Significance and Use

5.1 There are many underground structures that are created for permanent or long-term use. Often, these structures are subjected to an approximately constant load. Creep tests provide quantitative parameters for the stability analysis of these structures.

5.2 The deformation and strength properties of rock cores measured in the laboratory usually do not accurately reflect large-scale *in situ* properties, because the latter are strongly influenced by joints, faults, inhomogeneities, weakness planes, and other factors. Therefore, laboratory values for intact specimens must be employed with proper judgment in engineering applications.

NOTE 2—Notwithstanding the statements on precision and bias contained in this test method; the precision of 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 D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

Current edition approved Nov. 10, 2003. Published February 2004. Originally approved in 1984. Last previous edition approved in 1998 as D 4341 – 93 (1998).

[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.

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

Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on many factors: Practice D 3740 provides a means of evaluating some of these factors.

6. Apparatus

6.1 *Loading Device*—The loading device shall be of sufficient capacity to apply load at a rate conforming to the requirements specified in 10.5 and shall be able to maintain the specified load within 2 %. It shall be verified at suitable time intervals in accordance with the procedures given in Practices E 4 and comply with the requirements prescribed in this test method.

NOTE 3—By definition, creep is the time-dependent deformation under constant stress. The loading device is specified to maintain constant axial load and, therefore, constant engineering stress. The true stress, however, decreases as the specimen deforms and the cross-sectional area increases. Because of the associated experimental ease, constant load testing is recommended. However, the procedure permits constant true-stress testing provided that the applied load is increased with specimen deformation so that true stress is constant within 2 %.

6.2 *Elevated-Temperature Enclosure*—The elevated temperature enclosure may be either an enclosure that fits in the loading apparatus or an external system encompassing the complete test apparatus. The enclosure may be equipped with humidity control for testing specimens in which the moisture content is to be controlled. For high temperatures, a system of heaters, insulation, and temperature measuring devices are normally required to maintain the specified temperature. Temperature shall be measured at three locations, with one sensor near the top, one at midheight, and one near the bottom of the specimen. The average specimen temperature based on the midheight sensor shall be maintained to within ±1°C of the required test temperature. The maximum temperature difference between the midheight sensor and either end sensor shall not exceed 3°C.

NOTE 4—An alternative to measuring the temperature at three locations along the specimen during the test is to determine the temperature distribution in a dummy specimen that has temperature sensors located in drill holes at a minimum of six positions: along both the centerline and specimen periphery at midheight and at each end of the specimen. The temperature controller set point shall be adjusted to obtain steady-state temperatures in the dummy specimen that meet the temperature requirements at each test temperature (the centerline temperature at midheight shall be within ±1°C of the required test temperature, and all other specimen temperatures shall not deviate from this temperature by more than 3°C). The relationship between controller set point and dummy specimen temperature can be used to determine the specimen temperature during testing, provided that the output of the temperature feedback sensor (or other fixed-location temperature sensor in the triaxial apparatus) is maintained constant within ±1°C of the required test temperature. The relationship between temperature controller set point and steady-state specimen temperature shall be verified periodically. The dummy specimen is used solely to determine the temperature distribution in a specimen in the elevated temperature closure; it is not to be used to determine creep behavior.

6.3 *Temperature Measuring Device*—Special limits-of-error thermocouples or platinum resistance thermometers (RTDs) having accuracies of at least ±1°C with a resolution of 0.1°C.

6.4 *Platens*—Two steel platens are used to transmit the axial load to the ends of the specimen. They shall have a hardness of not less than 58 HRC. One of the platens should be spherically seated and the other a plain rigid platen. The bearing faces shall not depart from a plane by more than 0.015 mm when the platens are new and shall be maintained within a permissible variation of 0.025 mm. The diameter of the spherical seat shall be at least as large as that of the test specimen but shall not exceed twice the diameter of the test specimen. The center of the sphere in the spherical seat shall coincide with that of the bearing face of the specimen. The spherical seat shall be properly lubricated to ensure free movement. The movable portion of the platen shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated and tilted through small angles in any direction. If a spherical seat is not used, the bearing faces of the platens shall be parallel to 0.0005 mm/mm of platen diameter. The platen diameter shall be at least as great as the specimen but shall not exceed the specimen diameter by more than 1.50 mm. This platen diameter shall be retained for a length of at least one-half the specimen diameter.

6.5 *Strain/Deformation Measuring Devices*—The strain/deformation measuring system shall measure the strain with a resolution of at least 25×10^{-6} strain and an accuracy within 2 % of the value of readings above 250×10^{-6} strain and accuracy and resolution within 5×10^{-6} for readings lower than 250×10^{-6} strain, including errors introduced by excitation and readout equipment. The system shall be free from noncharacterizable long-term instability (drift) that results in an apparent strain of 10^{-8} per second.

6.5.1 *Axial Strain Determination*—The axial deformations or strains may be determined from data obtained by electrical resistance strain gages, compressometers, linear variable differential transformers (LVDTs), or other suitable means. The design of the measuring device shall be such that the average of at least two axial strain measurements can be determined. Measuring positions shall be equally spaced around the circumference of the specimen close to midheight. The gage length over which the axial strains are determined shall be at least 10 grain diameters in magnitude.

6.5.2 *Lateral Strain Determination*—The lateral deformations or strains may be measured by any of the methods mentioned in 6.5.1. Either circumferential or diametric deformations (or strains) may be measured. A single transducer that wraps around the specimen can be used to measure the change in circumference. At least two diametric deformation sensors shall be used if diametric deformations are measured. These sensors shall be equally spaced around the circumference of the specimen close to midheight. The average deformation (or strain) from the diametric sensors shall be recorded.

NOTE 5—The use of strain gage adhesives requiring cure temperatures above 65°C is not allowed unless it is known that microfractures do not develop at the cure temperature.

7. Safety Precautions

7.1 Many rock types fail in a violent manner when loaded to failure in compression. A protective shield should be placed around the test specimen to prevent injury from flying rock fragments. Elevated temperatures increase the risks of electrical shorts, fire, and burns.