Designation: D8359 – 20

Standard Test Method for Determining the In Situ Rock Deformation Modulus and Other Associated Rock Properties Using a Flexible Volumetric Dilatometer[1]

This standard is issued under the fixed designation D8359; 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 establishes the guidelines, requirements, procedure, and analyses for determining the in situ deformation modulus of a rock mass and other ancillary data using a flexible volumetric dilatometer in an NX drill hole (Fig. 1). Cyclic, creep, and unloading cycles are not covered in detail in this standard but may be added in the future or with a separate test standard, practice, or guide.

NOTE 1—Other rock mass deformability tests are radial jack tests, flat jack tests, flexible plate tests, and borehole jack tests.

1.2 This test method applies mainly to a commercially available flexible, volumetric dilatometer for an NX-sized (75.7-mm (2.98-in.)) borehole that is inflated and deflated hydraulically in the borehole. However, the test method could apply to other dilatometers, including pneumatically inflated, or for different borehole sizes as well as covered under the British Standards Institute EN ISO 22476-5.

1.3 *Purpose, Application, Range of Uses, and Limitations:*

1.3.1 This designation is described in the context of obtaining data for the design, construction, or maintenance of structures on or in rock. This method can be conducted in any orientation but is usually conducted in a vertical or horizontal borehole as dictated by the design consideration.

1.3.2 The test has no depth limits other than those imposed by the limitations of the test equipment, drill hole quality, testing personnel, and equipment to drill the holes and position the testing assembly.

1.3.3 Since this is a volumetric test, only the average deformation is obtained around the borehole. If the rock properties, for any reason, including the in situ stress field or fracture density, are significantly anisotropic, then this device cannot detect that difference.

1.3.4 A large expansion of the probe in a test zone can occur due to either an oversized drill hole, weathering, lithology, or discontinuities. As a result, the maximum pressure and expansion of the dilatometer would be limited. For example, for one particular dilatometer to avoid damaging the membrane in a preferred N size, 75.7 mm (2.98 in.) boreholes, the maximum working pressure of 30,000 kPa might be possible. In contrast, at 82.5 mm, the maximum working pressure would drop to only 20,680 kPa. Furthermore, regardless of if it an oversized drill hole or a low modulus test interval, the maximum diameter (inflated) of only 85.5 mm is allowed.

1.3.5 The radial displacements of the borehole walls during pressurization are calculated from the total volume change of the dilatometer. As such, the test results from a volumetric dilatometer indicates only the averaged value of the modulus of deformation.

1.3.6 The volumetric dilatometer test does not provide the anisotropic properties of the rock mass because it measures the average deformation and not the deformation in specific directions. However, by conducting dilatometer tests in boreholes oriented in different directions or taking impression packer data in any test intervals that had developed a hydraulic type fracture, some aspects of the in situ anisotropic conditions could be obtained.

1.4 *Units*—The values stated in SI units are to be regarded as standard. The values given in parentheses are provided for information only and are not considered standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

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

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 or 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, a purpose for

[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

Current edition approved Nov. 1, 2020. Published December 2020. DOI: 10.1520/D8359-20.

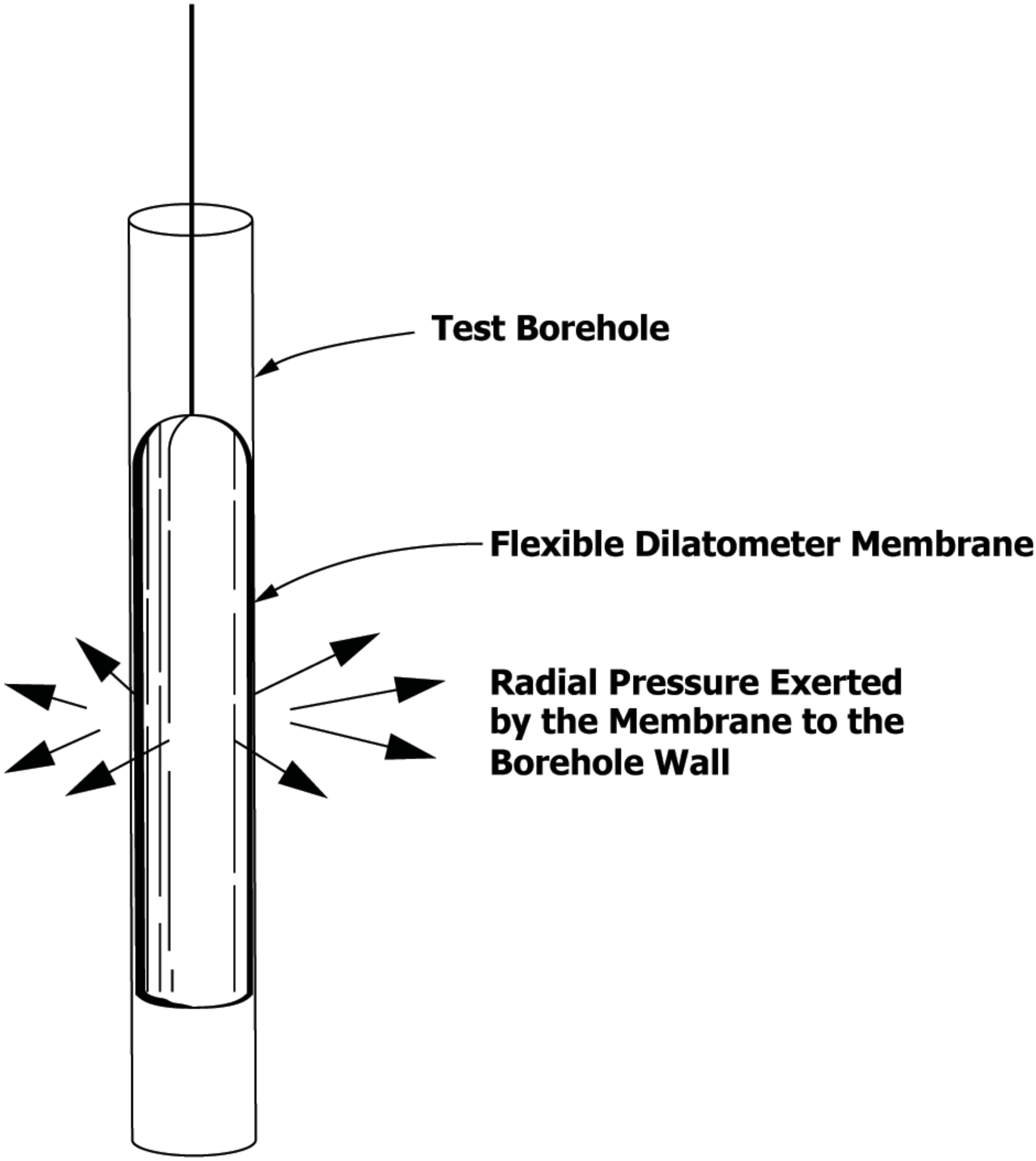

FIG. 1 General Depiction of a Flexible Dilatometer in a Borehole

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 this standard to consider significant digits used in analysis methods for engineering design.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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

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

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

D4645 Test Method for Determination of In-Situ Stress in Rock Using Hydraulic Fracturing Method (Withdrawn 2017)[3]

D4719 Test Methods for Prebored Pressuremeter Testing in Soils

D6026 Practice for Using Significant Digits in Geotechnical Data

D6032/D6032M Test Method for Determining Rock Quality Designation (RQD) of Rock Core

3. Terminology

3.1 *Definitions:*

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

3.1.2 *material certifications, n*—certifies a material's chemical and, in some cases, physical properties and states a product made of metal is in compliance with specific standards of international standards organizations such as ANSI, ASME, and alike, and bears the heat number from the cast from which the material was created.

3.1.2.1 *Discussion*—Also, known as a Material Test Report (MTR).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *borehole wall contact, n*—during the expansion of the dilatometer the pressure and volume at which the dilatable membrane contacts the borehole wall.

3.2.2 *correction factor "a", n*—sum of the intrinsic volumetric expansion of the dilatometer system and expansion of the thick-walled metallic calibration tube during pressurization.

3.2.3 *pressure correction factor (P_c), n*—a correction for the stiffness of the membrane at corresponding volume, determined from a pressure calibration at atmospheric pressure.

3.2.4 *volume correction factor (V_c), n*—the intrinsic volumetric expansion of the probe, and the hydraulic module, which is the small difference between the injected volume and the actual volume increase caused by the deformation of the rock tested.

4. Summary of Test Method

4.1 A borehole, specified by the engineer and that meets the test equipment specification criteria, is drilled at one or more locations and to the depths for which test data is needed and following Practice D2113, including the collection of any ancillary data such as RQD (D6032/D6032M) or test samples. If the borehole requires support, cementing, grouting, or casing, proper methods are employed as needed, including the use of interval or staged drilling and testing, to obtain satisfactory borehole intervals in the rock mass for testing.

4.2 Caliper logs of the borehole diameter and, if possible, a visual inspection using an optical or acoustic televiewer of the borehole are run to assure the selected test interval is suitable for testing.

4.3 The rock cores and any other pertinent data are examined to determine which intervals of the borehole to targeted that are within the objectives of the testing program.

4.4 A calibrated flexible dilatometer is connected to electrical and hydraulic cables for the readout and hydraulic equipment at the surface and inserted into a borehole. The membrane section of the dilatometer is placed at the targeted test interval in the borehole and secured from moving. A seating pressure is applied to the dilatometer and then allowed time to stabilize to the temperature in the borehole.

4.5 The dilatometer is expanded, by increasing the hydraulic pressure in predetermined steps, and the applied pressures and corresponding volume changes recorded. Depending on the geology in the test interval, the application of the pressure may be modified or repeated to obtain data for unloading, creep as well as tensile strength, and in situ stress if possible.

4.6 From the recorded volume and pressure values, calculate the in situ modulus of deformation of the rock mass. Any variations in the loading sequence or additional data collected for a test interval for any other rock mechanics properties would be recorded and calculated as well.

4.7 After testing a section of the borehole, the dilatometer is completely deflated and moved to the next test interval or removed from the borehole if all testing was completed or if the borehole conditions require sequential drilling and testing.

5. Significance and Use

5.1 The dilatometer test is usually performed in vertical boreholes. It can be used in inclined or horizontal holes, but the probe would drag along the borehole wall.

5.2 Deformation modulus of rock, creep characteristics, rebound, and permanent set data is obtained and is useful for engineering designs.

5.3 The rock mass discontinuities, in situ stresses, and the genesis, crystallography, texture, fabric, and other factors may cause the rock mass to behave as an anisotropic, inhomogeneous, discontinuous medium that laboratory size tests may not be able to measure that the dilatometer may be able to measure.

5.4 Determination of rock mass deformability yields a critical parameter in the design of foundations of dams, support of underground excavations, piers, caissons, and stability of rock slopes.

[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.