Designation: D 6032 – 02

Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core[1]

This standard is issued under the fixed designation D 6032; 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 determination of the rock quality designation (RQD) as a standard parameter in drill core logging.

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 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units are approximate.

1.4 *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:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

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[2]

D 5079 Practices for Preserving and Transporting Rock Core Samples[2]

D 6026 Practice for Using Significant Digits in Geotechnical Data[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

3. Terminology

3.1 For terminology used in this test method, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core run*—in the most basic usage, the length of the interval measured from the depth each core sample was started to the depth at which drilling stopped and the sample was recovered from the core barrel. If required, the core run can also be defined to cover a specific length or lithology in the core samples.

3.2.2 *drill break*—any mechanical or man-made break in the core that is not natural occurring.

3.2.3 *intact core*—any segment of core between two open, natural discontinuities.

3.2.4 *rock quality designation (RQD)*—a modified core recovery percentage in which all pieces of sound core over 100 mm are counted as recovery.

3.2.5 *sound core*—any core which is fresh to moderately weather and which has sufficient strength to resist hand breakage.

4. Summary of Test Method

4.1 The RQD denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run, as shown in Fig. 1. Rock mechanics judgement may be necessary to determine if a piece of core qualifies as being intact and sound.

5. Significance and Use

5.1 The RQD was first introduced in the mid 1960's to provide a simple and inexpensive general indication of rock mass quality to predict tunneling conditions and support requirements. The recording of RQD has since become virtually standard practice in drill core logging for a wide variety of geotechnical investigations.

5.2 The RQD values provide a basis for making preliminary design decisions involving estimation of required depths of

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

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

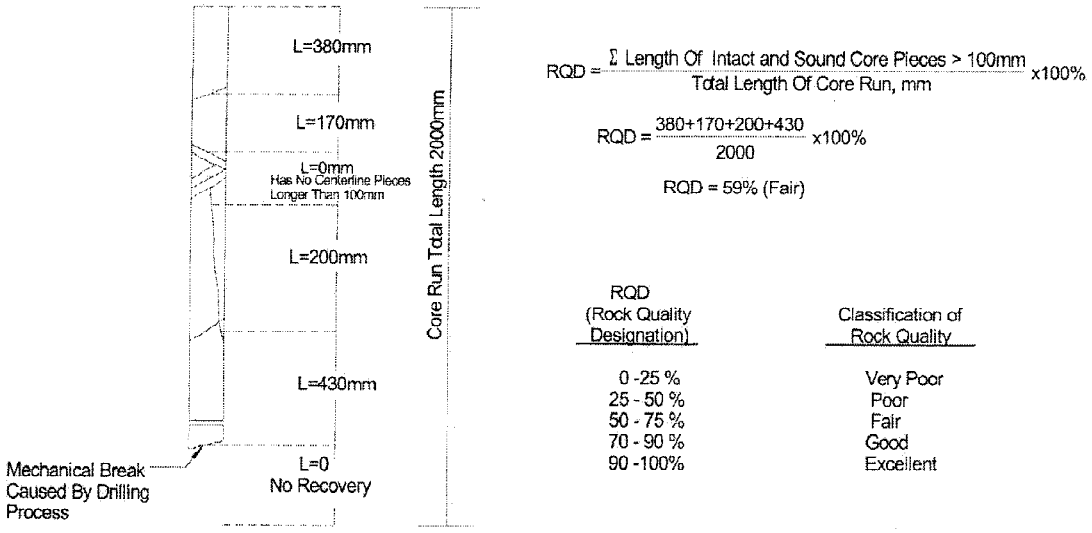

FIG. 1 RQD Logging Center Line Method[5]

excavation for foundations of structures. The RQD values also can serve to identify potential problems related to bearing capacity, settlement, erosion, or sliding in rock foundations. The RQD can provide an indication of rock quality in quarries for concrete aggregate, rockfill, or large riprap.

5.3 The RQD has been widely used as a warning indicator of low-quality rock zones that may need greater scrutiny or require additional borings or other investigational work.

5.4 The RQD is a basic component of many rock mass classification systems for engineering purposes.

5.5 Used alone, RQD is not sufficient to provide an adequate description of rock mass quality. The RQD does not account for joint orientation, tightness, continuity, and gouge material. The RQD must be used in combination with other geological and geotechnical input.

5.6 The RQD is sensitive to the orientation of joint sets with respect to the orientation of the core. That is, a joint set parallel to the core axis will not intersect the core, unless the drill hole happens to run along the joint. A joint set perpendicular to the core axis will intersect the core axis at intervals equal to the joint spacing. For intermediate orientations, the spacing of joint intersections with the core will be a cosine function of angle between joints and the core axis.

5.7 Core sizes from BQ to PQ with core diameters of 36.5 mm (1.44 in.) and 85 mm (3.35 in.), respectively, are normally acceptable for measuring RQD as long as proper drilling techniques are used that do not cause excess core breakage or poor recovery, or both. The NX-size (54.7 mm [2.16 in.]) and NQ-size (47.5 mm [1.87 in.]) are the optimal core sizes for measuring RQD. The RQD is also useful for large core diameters provided the core diameter is clearly stated. The RQD calculated for core smaller than BQ may not be representative of the true quality of the rock mass.

NOTE 1—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 D 3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Procedure

6.1 Drilling of the rock core should be done in accordance with Practice D 2113. It is important that proper drilling techniques and equipment are used to minimize core breakage or poor core recovery, or both.

6.2 There are several ways to define a core run for calculating RQD. Three of these are: (*1*) a core run is equal to a drill run; (*2*) a change in formation or rock type could constitute an end of a core run; and (*3*) a core run can be a selected zone of concern. In determining a core run it is important to be consistent throughout a drill hole and to document how the core run was defined.

6.3 Retrieval, preservation, transportation, storage, and cataloging of the rock core should be done in accordance with Practices D 5079. The RQD should be logged on site when the core is retrieved because some rocks can disintegrate, due to poor curatorial handling, slaking, desiccation, stress relief, or swelling, with time. For these rocks it is recommended that the RQD be measured again after 24 h to assist in determining durability.

6.4 Close visual examination of core pieces is required for assessing the type of fracture (that is, natural or drill break). Pieces of core that are moderately or intensely weathered, contain numerous pores, or are friable, or combination thereof, should not be included in the summation of pieces greater than 100 mm (4 in.) for the determination of the RQD. Any rejected piece of core is still included as part of the total length of core run and should be noted in the report.

6.5 Measure all core piece lengths that are intact and greater than 100 mm (4 in.) to the nearest 1 mm (0.04 in.) and record

on a RQD data sheet (Fig. 2). Measure such pieces along the centerline of the core as illustrated in Fig. 1[5]

NOTE 2—Centerline measurements ensure that the RQD value resulting from the measurements is not dependent on the core diameter. Centerline measurements also avoid unduly penalizing resulting RQD values for cases where fractures parallel the core axis. Any other method used for accounting for fractures parallel to the core axis, while not advocated by this test method and in the literature, must be clearly stated.[6,7]

6.6 Only those pieces of rock formed by natural fractures (that is, joints, shear zones, bedding planes, or cleavage planes that result in surfaces of separation) shall be considered for RQD purposes. The core pieces on either side of core breaks caused by the drilling process shall be fitted together and counted as one piece. Drilling breaks are usually evident by rough fresh surfaces. In some cases it may be difficult to differentiate between natural fractures and drilling breaks. When in doubt, count a fracture as a natural fracture. If for some reason there is not 100 % core recovery for a drill run, the length of core left in the borehole should be taken into account by adding it to the run in which it was cored rather than the run in which it was retrieved.

6.7 Record the top and bottom depths of each core run.

6.8 Sketch core features such as natural fractures, drilling breaks, lost core, highly weathered pieces, and so forth (see Fig. 1).

6.9 Include remarks concerning judgement decisions such as whether a break in a core is a natural fracture or a drilling break or why a piece of core longer than 100 mm (4 in.) was not considered to be intact.

6.10 Record the sum of intact core pieces longer than 100 mm (4 in.) long, and calculate the RQD value for the core run being evaluated.

6.11 Indicate the rock quality description for the core run using the rock quality table in Fig. 1.

7. Calculation

7.1 Calculate as a percentage, the RQD of a core run as follows:

$$\text{RQD} = \frac{[\Sigma\text{length of intact and sound pieces} > 100\text{ mm (4 in.)}]\times 100\ \%}{\text{total core run length, mm}} \quad (1)$$

In accordance with Practice D 6026, record the result to the nearest one percent.

8. Report

8.1 A typical report may include the following:

8.1.1 Source of sample including project name, location, and, if known, storage environment. The location may be specified in terms of borehole number and depth of core runs from the collar of the hole.

8.1.2 Description of drilling equipment, method, personnel, and hole orientation.

8.1.3 Physical description of core runs including diameter, rock type and location and orientation of discontinuities, such as, apparent weakness planes, bedding planes, schistosity, and large inclusions or inhomogeneities, if any.

8.1.4 Date of RQD calculations and sketches and/or photographs of core runs.

8.1.5 General indication of any conditions, observations, and assumptions relevant to the RQD values or calculations.

8.1.6 Include a table of RQD values and/or copies of any RQD data forms or sketches.

8.1.7 Report the rock quality classification for the core run using the table in Fig. 1.

9. Precision and Bias

9.1 *Precision*—A round-robin study of the RQD index of cores of four selected types of sedimentary rock (anhydrite/calcite, calcareous shale, limestone, and anhydrite) with four replications per rock type was conducted in accordance with Practice E 691 by eight experienced participants.[8] The repeatability and reproducibility statistics reported in Table 1 refer to within-participant and between-participant precision, respectively. The probability is approximately 95 % that two results obtained by the same participant on the same material will not differ by more than the repeatability limit *r*. Likewise, the probability is approximately 95 % that two results obtained by different participants on the same material will not differ by more than the reproducibility limit *R*. The precision statistics are calculated from the following equation:

$$r = 2(\sqrt{2})s_r \quad (2)$$

where s_r = repeatability standard deviation, and

$$R = 2(\sqrt{2})s_R \quad (3)$$

where s_R = reproducibility standard deviation.

NOTE 3—Some combinations of the means and *r* and *K* can result in KQD limits that exceed 100 % because the RQD values have been assumed to be normally distributed which may not reflect the actual underlying distribution of the RQD values.

9.2 *Bias*—There is no accepted reference value for this test method; therefore, bias cannot be determined.

10. Keywords

10.1 classification; index; logging; quality; rock; rock core

[5] Deere, D. U., and Deere, D. W., "The Rock Quality Designation (RQD) After Twenty Years," *Rock Classification Systems for Engineering Purposes, ASTM STP 984*, 1988, pp. 91–101.

[6] Deere, D. U., and Deere, D. W., " Rock Quality Designation (RQD) Index in Practice," *Contract Report G1–89–1*, Department of the Army Corps of Engineers, 1989.

[7] Bieniawski, Z.T., "Exploration for Rock Engineering" *Proceeding of the Symposium on Exploration for Rock Engineering*,November 1976, Johannesburg, A.A., Balkema, Rotterdam.

[8] Pincus, H. J., and Clift, S. J., *Interlaboratory Testing Program for Rock Properties: Repeatability and Reproducibility of RQD Values for Selected Sedimentary Rocks*, PCN: 33-000011-38, ASTM Institute of Standards Research, 1994.

RQD DATA SHEET			
Project:			Date:
Core Box I.D. no.:		Recorder(s):	
Total Length of Core Run, mm (in):		Checker(s):	
Core Diameter, mm (in):		Date Checked:	
Depth, m (ft)	Sketch or Photographic Image of Core	Length of Each Sound Piece of Core > 100 mm (4-inch)	Remarks
• Lengths of Sound Pieces of Core > 100 mm (4-in):			
RQD (%) = • Lengths of Sound Pieces of Core > 100 mm (4-in) * 100% / Total Length of Core Run, mm (in)			
RQD (%) =		Rock Classification:	
Page ____ of ____			

FIG. 2 RQD Data Sheet

TABLE 1 RQD Index of Cores of Sedimentary Rock

Material (Rock Type)	Mean RQD, $\bar{x}$, %	Repeatability, r, % [A]	Reproducibility, R, % [A]
Anhydrite/calcite	86	28	28
Calcareous shale	60	32	40
Limestone	92	14	14
Anhydrite	86	20	20

[A] The numbers in the *r* and *R* columns are not to be taken as percentages of the means, but are applied as plus or minus terms to the respective means.

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1996) that may impact the use of this standard.

(1) Added to Section 1 required statement about significant figures and Practice D 6026.
(2) Added Terminology D 653, Practices D 3740, and D 6026
(3) Added Terminology Section , and renumbered subsequent sections.
(4) Added Note 1 in Significance and Use Section, referencing Practice D 3740, and renumbered subsequent notes.
(5) In Section 4.1 defined method as applicable to drill holes in any orientation and added the word "sound" between "intact rock". Changed "Engineering judgement" to Rock mechanics judgement" so that both the engineering and geological considerations were included.
(6) In Calculation Section, added the sentence: "In accordance with Practice D 6026, record the result to the nearest one percent.
(7) In Calculation Section, Note 2, corrected typographical error in a symbol and the abbreviation for RQD. Took out confusing discussion of vertical fractures since it pertains to any fracture that parallels the core axis and added references used to support this section.
(8) In Section 6.1 added words "and equipment" with "proper drilling techniques."
(9) In Section 6.3 added the influence of curatorial handling.
(10) Added Report Section and renumbered accordingly.
(11) Figure 1 — Added "Centerline Method" to title, added "intact and sound" to the formula and changed "Description of Rock Quality" to "Rock Quality Classification."
(12) Figure 2 — Fixed heading to include more relevant background data, added the words "intact and sound" to the formula, changed meters to millimeters, and added place to put the rock quality classification.