



Designation: D6032/D6032M – 17

Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core¹

This standard is issued under the fixed designation D6032/D6032M; 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 of a core sample in addition to the commonly obtained core recovery value (Practice D2113); however there may be some variations between different disciplines, such as mining and civil projects.

1.2 This standard does not cover any RQD determinations made by other borehole methods (such as acoustic or optical televiewer) and which may not give the same data or results as on the actual core sample(s).

1.3 There are many drilling and lithologic variations that could affect the RQD results. This standard provides examples of many common and some unusual situations that the user of this standard needs to understand to use this standard and cannot expect it to be all inclusive for all drilling and logging scenarios. The intent is to provide a baseline of examples for the user to take ownership and watch for similar, additional or unique geological and procedural issues in their specific drilling programs.

1.4 This standard uses the original calculation methods by D.U. Deere to determine an RQD value and does not cover other calculation or analysis methods; such as Monte Carlo.

1.5 The RQD in this test method only denotes the percentage of intact and sound rock in a core interval, defined by the test program, and only of the rock mass in the direction of the drill hole axis, at a specific location. A core interval is typically a core run but can be a lithological unit or any other interval of core sample relevant to the project.

1.6 RQD was originally introduced for use with conventional drilling of N-size core with diameter of 54.7 mm (2.155 in.). However, this test method covers all types of core barrels and core sizes from BQ to PQ, which are normally acceptable for measuring determining RQD as long as proper drilling

techniques are used that do not cause excess core breakage or poor recovery, or both. See 6.3 for more information on this issue.

1.7 Only the RQD classification which correlates with the common tunneling classification that was presented by Deere^{2,3} is covered in this test method. Other classification systems are not covered specifically but are mentioned in general and if used shall not be regarded as nonconformance with this standard.

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

1.8.1 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.

1.9 The values stated in either SI units or inch-pound units [rational values are given 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. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.10 *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.*

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the*

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 March 1, 2017. Published April 2017. Originally approved in 1996. Last previous edition approved in 2008 as D6032 – 08. DOI: 10.1520/D6032_D6032M-17.

² 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.

³ 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.

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

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:⁴

- 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
- D5079** Practices for Preserving and Transporting Rock Core Samples (Withdrawn 2017)⁵
- D5878** Guides for Using Rock-Mass Classification Systems for Engineering Purposes
- D6026** Practice for Using Significant Digits in Geotechnical Data
- E691** Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions:

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *artificial core run*, *n*—run lengths, or intervals, created when logging the core to identify different zones or patterns of RQD in the rock mass.

3.2.2 *centerline method*, *n*—length of core sample measured along the centerline (core axis); see **Appendix X1**.

3.2.3 *core discing*, *n*—in rock mechanics, a phenomenon in which the drilled core breaks into disks with uniform spacing and shape due to the transient stress changes, and stress release during drilling.

3.2.4 *core recovery*, *n*—in rock drilling, the ratio of length of core sample recovered, both weathered and unweathered, to the length drilled, and expressed as a percent.

3.2.4.1 *Discussion*—Some literature is using a term called “total core recovery” to replace this definition. The added term “total” is an attempt to promote other types of core recovery definitions, one of which is “solid core recovery” and which is discussed in this standard and shown in the appendix to be technically flawed and should be discouraged. Therefore, it was decided to stay with a definition that is already recognized and has been used for many years in the drilling industry.

3.2.5 *core run*, *n*—in rock drilling, in the most basic usage, the length of the interval measured from the depth at which drilling to obtain a core sample was started to the depth at

which drilling stopped and the core barrel was retrieved to recover the cored sample.

3.2.5.1 *Discussion*—If required, the core run used to calculate the RQD can also be defined to cover a specific interval or lithology in the core samples. The length of the core run may not be equal to the length of the core sample retrieved if there is any core loss or void(s) in the coring interval or if a stub of core is left at the bottom of the drill hole. Any core sample or stub left at the bottom of the core run must be accounted for in a consistent manner in the drill logs and RQD calculations.

3.2.6 *discontinuity*, *n*—in geomechanics, a general term denoting any separation in a rock mass having zero or low tensile strength and is the collective term for most types of joints, fractures, weak bedding planes, weak schistosity planes, weakness zones, and shears.

3.2.7 *drill break*, *n*—in drilling, any mechanical or man-made break in the core that was not naturally occurring.

3.2.8 *fully circular method*, *n*—in geomechanics, measurement of the core length only where the core has a full circular cross section along the core axis. See **Appendix X1**.

3.2.9 *intact core*, *n*—in geomechanics, any segment of core between two open/unbonded, natural or mechanical discontinuities.

3.2.10 *rock quality designation (RQD)*, *n*—in geomechanics, a modified core recovery in which the ratio of length of core recovered to the total length drilled is modified such that only the length of the pieces of sound core that are equal to or greater than 100 mm [4 in.] in length, as measured along the core axis, are counted towards the length of core recovered, and this ratio is expressed as a percent.

3.2.11 *sound core*, *n*—in rock drilling, any core that is unweathered to moderately weathered and has sufficient strength to resist hand breakage.

3.2.11.1 *Discussion*—Most engineers and geologist understand what unweathered means but there is no one standard or definitions for “moderately weathered” or “resist hand breakage” and varies in the literature. However, most drillers and persons logging core usually have a good idea what either one means and would not be abused or would follow standard operating procedures used by their company. In general, hand breakage means something that cannot be indented with a finger nail and crumbles under firm blows with sharp end of a geological pick. Moderately weathered can vary in the literature. ISRM definitions for weathering were used for this standard.

3.2.12 *moderately weathered*, *n*—in geology, less than half of the rock material is decomposed and/or disintegrated to a soil; fresh or discolored rock is present either as a continuous framework or as core stones.

3.2.13 *tip to tip method*, *n*—in geomechanics, measurement of the core length as the distance between the highest point of the piece of the core along the borehole. See Appendix.

3.2.13.1 *Discussion*—This definition is only provide because it is used in the standard for discussions on why this measurement method is not used or approved by this standard and does not infer that the method is valid or applicable for RQD measurements

⁴ 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.

⁵ The last approved version of this historical standard is referenced on www.astm.org.



4. Summary of Test Method

4.1 The RQD denotes the percentage of intact and sound rock retrieved from a borehole orientated in any direction. All pieces of intact and sound rock core equal to or greater than 100 mm [4 in.] long are identified and recorded. The pieces are measured along the core axis (centerline method).

NOTE 1—The original paper by Deere states “over four inches” and many references vary between “over 4 inches” to “equal to or greater than 4 inches”. This issue was posed to the D18.12 membership and the consensus was that the way it is typically been used in the field, equal to or greater than 100-mm [4 in.] is how it should be worded in this standard. References like Wikipedia do not always have the best information either and should not be assumed to be correct much less a consensus on this issue.

4.2 Pieces of core that are moderately or intensely weathered, contain numerous pores, or are friable, or any combination thereof, should not be included in the summation of pieces for the determination of the RQD. Where the core is known or believed to have been broken by handling or by the drilling process, the broken pieces (including core discing) are fitted together and counted as one piece and the pieces are fitted together, marked as a mechanical break (both on the cores and on the logs) and counted as one piece.

4.3 All the sections of core that meet the greater than or equal to 100-mm [4 inches] and soundness criteria are summed and then divided by the total length of the core run or interval of interest (see 4.3.1), as shown in Fig. 1, to give the value of RQD as a percent. Rock mechanics judgment may be necessary to determine if a piece of core qualifies as being intact and sound.

4.3.1 If required, the RQD may be determined for intervals other than a given core run. For example, determining the RQD for a given rock unit, rock type, a running value, or weighted average.

4.4 The RQD value is then used for classification of the rock quality based upon a rating system, such as the one in Deere’s original paper and shown in Fig. 1 and is usually the default system to use. Some other classification system might be used, if required, at the drill site or later on in the data analysis process.

5. Significance and Use

5.1 The RQD was first introduced in the mid 1960s 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 explorations.

5.2 The use of RQD values has been expanded to provide a basis for making preliminary design and constructability decisions involving excavation for foundations of structures, or tunnels, open pits, and many other applications. 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 issues involving 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. This includes rocks with certain time-dependent qualities that by determining the RQD again after 24 h, under well-controlled conditions, can assist in determining durability.

5.4 The RQD is a basic component of many rock mass classification systems, such as rock mass rating (RMR) and Q-System, for engineering purposes. See D5878 and ^{2,3}.

5.5 When needed, drill holes in different directions can be used to determine the RQD in three dimensions.

5.6 The concept of RQD can be used on any rock outcrop or excavation surface using line surveys as well. However, this topic is not covered by this standard.

NOTE 2—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.

6. Interferences

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

6.2 The RQD is sensitive to the orientation of joint sets or other open or weak discontinuities with respect to the orientation of the core axis.⁶ For example, a joint set parallel to the core axis may not, if at all, intersect the core sample, unless the drill hole axis happens to run along the joint plane. 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 discontinuity intersections with the core will be a cosine function of angle between joints and the core axis.

6.3 The N-size are the optimal core barrel size for determining RQD. The RQD is also useful for larger 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. Larger sizes are preferred; and the smaller BQ and BWX sizes should be discouraged and; when used, should be identified with a disclaimer.

6.4 The RQD values obtained can be sensitive to the type of drill equipment and techniques that are used. Double or triple, split tube, core barrels are preferred over single tube barrels. Use of single tube core barrels will have additional issues to consider when making RQD determinations. Therefore, it is important to note what type of drill equipment and techniques were used as well as the personnel involved. Also, if conventional drilling is used, rather than, wire line drilling, then the

⁶ Arild Palmstrom, Ph.D., Norconsult as, Norway, Measurements of and Correlations between Block Size and Rock Quality Designation (RQD), Published in *Tunnels and Underground Space Technology*, 20 (2005), 362-377

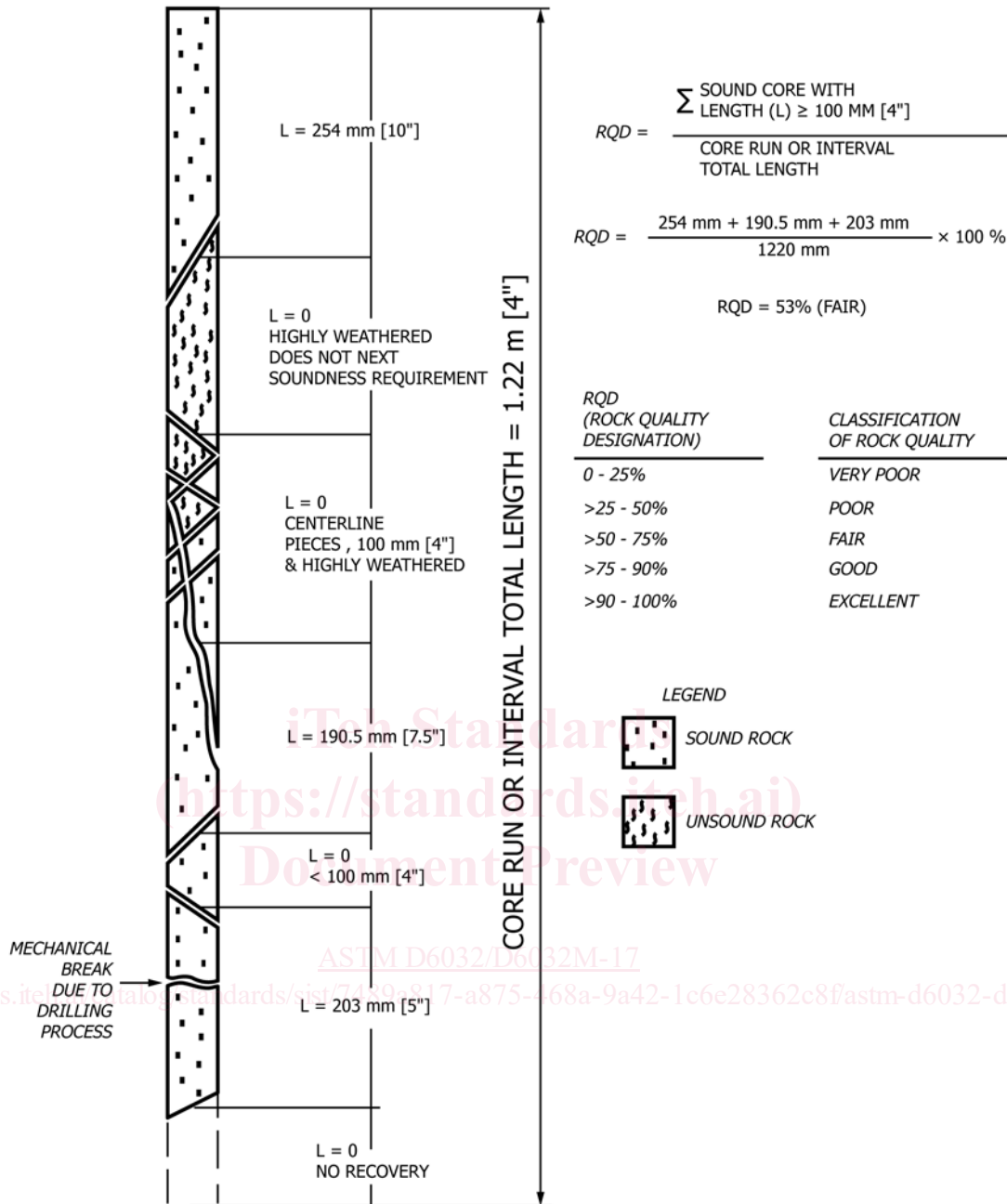


FIG. 1 Example of How RQD Data is Collected for a Core Run or Interval, and Calculated, Using the Centerline Method, and Then Classified. The rock quality classification shown is what was originally proposed by Deere^{2,3}. Other rock quality classifications may be used.

potential for material to cave in the hole is greater. This can alter the RQD results and must be anticipated and handled appropriately.

6.5 Measurement of the length of the core pieces by any other method than the centerline method can produce erroneous results (see Appendix X1). Training and of logging personnel is therefore critical and be given consistent advice or training. This means that training and feedback must be given early during the drilling program when the core is still available or with the core photos.

6.6 The RQD index is sensitive to the length of the core run. For example, a 300-mm [11.8-in.] wide, highly fractured zone within a massive rock would result in RQD values of 90 %, 80 %, and 40 % for respective core run lengths of 3 m [12.9 ft], 1.5 m [4.9 ft], and 0.5 m [1.6 ft]. Thus, the shorter the run length, the greater the sensitivity of the RQD and the lower its value (becoming equal to zero for a 300 mm [11.8 in.] core run encompassing the fractured zone).

6.7 Drill core samples can disc in certain stress conditions. Therefore, the RQD values can be effected by the stresses the