Designation: D5873 – 14

Standard Test Method for Determination of Rock Hardness by Rebound Hammer Method[1]

This standard is issued under the fixed designation D5873; 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 testing apparatus, sampling, test specimen preparation, and testing procedures for determining the rebound hardness number of rock material using a spring-driven steel hammer, referred to variously as a rebound hammer, impact test hammer, or concrete test hammer.

1.2 This test method is best suited for rock material with uniaxial compressive strengths ranging between approximately 1 and 100 MPa. Test Method D7012 provides more information on compressive strength of rock.

1.3 The portable testing apparatus may be used in the laboratory or field to provide a means of rapid assessment of rock hardness or to serve as an indicator of rock hardness.

1.4 Rebound hammers are available from their original manufacturers in several different energy ranges. For a given plunger tip diameter and radius of curvature, the impact energy of the rebound hammer determines its range of applicability. Accordingly, this limitation should be kept in mind when selecting a hammer type. Earlier recommendations for rock mechanics applications were only for hammers with an impact energy of 0.735 N·m, especially on smaller core samples and weaker rocks (see also Brown 1981[2]). This test method applies only to hammers with an impact energy not to exceed 0.735 N·m. Hammers with energies above 0.735 N·m tend to break the rock and are not recommended.

1.5 Rocks exhibiting vesicular texture may be beyond the scope of this test. Care should be taken when testing such rocks and conglomerates as the rebound values will vary between testing a large piece of aggregate versus softer matrix of the conglomerate.

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

1.6.1 The procedures used to specify how data are collected/recorded or calculated, in this 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, purpose for 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 analytical methods for engineering design.

1.7 For determining the rebound number of concrete, see Test Method C805/C805M.

1.8 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *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:*[3]

C805/C805M Test Method for Rebound Number of Hardened Concrete

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

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

D4543 Practices for Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional and Shape Tolerances

[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 Feb. 1, 2014. Published February 2014. Originally approved in 1995. Last previous edition approved in 2013 as D5873 – 13. DOI: 10.1520/D5873-14.

[2] Brown, E. T., ed., *Suggested Methods: Rock Characterization, Testing, and Monitoring*, International Society of Rock Mechanics (ISRM): Pergamon Press, London, 1981.

[3] 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**

D4879 Guide for Geotechnical Mapping of Large Underground Openings in Rock
D6026 Practice for Using Significant Digits in Geotechnical Data
D7012 Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

3. Terminology

3.1 *Definitions*—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 *rebound hammer*—a portable, spring loaded, steel hammer used to classify the hardness of rock in the field or laboratory.

3.2.2 *rebound hardness number, H_R*—a dimensionless number representing empirically determined, relative hardness of rock material or other hard substance by use of a rebound hammer.

3.2.3 *rebound number*—a dimensionless reading or value based on the absorption of part of the stored elastic energy of the spring through plastic deformation of the rock surface and mechanical waves propagating through the stone while the remaining elastic energy causes the actual rebound of the hammer.

3.2.3.1 *Discussion*—The rebound distance traveled by the spring loaded steel mass, expressed as a percentage of the initial extension of the spring, is called the *rebound number*. **Kolaiti and Papadopoulos (1993)**[4]

4. Significance and Use

4.1 The rebound hardness method provides a means for rapid classification of the hardness of rock during site characterization for engineering, design, and construction purposes, geotechnical mapping of large underground openings in rock, see Guide D4879, or reporting the physical description of rock core, see Practice D4543.

4.2 The rebound hardness number, H_R, can serve in a variety of engineering applications that require characterization of rock material. These applications include, for examples, the prediction of penetration rates for tunnel boring machines, determination of rock quality for construction purposes, grouping of test specimens, and prediction of hydraulic erodibility of rock.

4.3 This test method is of limited use on very soft rock or very hard rock, which is defined as having uniaxial compressive strengths less than approximately 1 MPa or greater than 100 MPa.

4.4 The results of this test method are not intended for conversion to strength data suitable for design.

NOTE 1—Several types of rebound hammers are commercially available to accommodate testing of various sizes and types of rock. For the same rock or material, rebound numbers obtained from different hammers are not comparable.

NOTE 2—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 and sampling. 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. Interferences

5.1 Rock at 0° C or less may exhibit very high rebound values.

5.2 Temperature of the rebound hammer itself may affect the rebound number. The hammer and materials to be tested should be at the same temperature.

5.3 For readings to be compared, the direction of impact must be the same.

5.4 Different instruments of the same nominal design may give rebound numbers differing from one to three units and therefore, tests should be made with the same instrument in order to compare results. If more than one instrument is to be used, a sufficient number of tests must be made on typical rock surfaces to determine the magnitude of the differences to be expected in the readings of different instruments.

5.5 Rocks exhibiting vesicular texture may be beyond the scope of this test. The open texture may continue throughout the entire specimen and no practical amount of abrasive stone application will produce a consistent test surface. The honeycombed nature of the material may readily fail giving a falsely low hardness value.

6. Apparatus

6.1 *Rebound Hammer*—A device consisting of a spring-loaded steel hammer with a predetermined amount of energy that, when released, strikes a metal plunger in contact with the rock core or natural surface. Fig. 1 is an example of a typical rebound hammer. Fig. 2 is an example of the rebound hammer against a rock core specimen that is held in a metal anvil in contact with, and supported by, a solid surface. The hammer must travel with a fixed and reproducible speed. The rebound distance of the hammer from the top of the steel plunger is measured through the use of a mechanical slider or electronic display and is taken as an empirical measure of rock hardness.

6.2 *Core Holder*—A steel V-block or steel cradle with a semi-circular machined slot with a minimum mass of 20 kg to which specimens are securely held with some type of clamping device. See Note 4 for more information on test holders. Rock core specimens must be firmly seated in the base for the test. The slot in the test cradle shall be the same radius as the core to be tested. A guide may be attached to the core holder to keep the rebound hammer perpendicular to the surface of the test specimen. Fig. 2 shows this positioning.

NOTE 3—Instruments are available that will store the rebound numbers, which can then be transferred to a computer for analysis.

NOTE 4—An evaluation is made of three different holders for hammer tests on rock core in the laboratory, including steel angle, V-block, and semi-circular groove holders. The differences are small, but it is shown

[4] Kolaiti E., and Papadopoulos Z., *Evaluation of Schmidt Rebound Hammer Testing: A Critical Approach*, Bulletin of the International Association of Engineering Geology, 1993.

FIG. 1 Typical Rebound Hammer with Correction Graph for Non-Vertical Use and Rebound Scale on the Side of the Body for Manual Readings

FIG. 2 Example of a Rebound Hammer Against a Rock Core Specimen in the Core Holder (the Clamp for Holding the Specimen is Not Shown)

that the V-block holder gives consistently higher rebound hardness values. It is also easier and more economical to build since you do not need a different size semi-circular grooved holder for each core size. These qualities indicate the V-block holder would be a better selection for conventional use.

6.3 *Verification Anvil*—A verification block or cylinder, as shown in Fig. 3, is used to determine the current value of the rebound hammer against the value supplied by the manufacturer. The size of the verification anvil should match the size needed for the type of rebound hammer being used and made of tool steel with an impact area hardened as hard as the plunger tip, which is typically Brinell 500 or Rockwell HRC 52. An instrument guide is provided to center the rebound hammer over the impact area to keep the instrument perpendicular to the surface.

6.4 *Abrasive Stone*—A medium-grained texture silicon carbide or equivalent material to grind smooth the surface stone of the test area if it is heavily textured. A hand operated abrasive stone, as seen in Fig. 4, may be used to achieve the desired smoothness. In addition, an abrasive stone attached to a power tool may also be used.

7. Sampling

7.1 Samples can be drill core, NX or larger, rock blocks, or in situ rock surfaces, such as tunnel walls.

7.2 Samples shall be of sufficient size and quantity to produce the required specimens and cover the rock material of interest.

7.3 Samples shall be representative of the rock to be studied. Test in situ rock surfaces or obtain samples by direct sampling of rock that correlate with the subsurface rock units of interest. Test specimens may be drill core or blocks of rock material from outcrops. Avoid sampling and testing rock material weakened by weathering, discontinuities, alteration, excavation damage, or is otherwise not representative of the rock material of interest. If relevant to the test program, record the orientation of block samples.

7.4 The rebound hammer is generally unsuitable for very soft or very hard rock; therefore, conduct simple field tests to quickly assess the suitability for use of the rebound hammer For example, a very soft rock will scratch with a fingernail and peel with a pocketknife and an intact specimen of very hard rock breaks only by repeated, heavy blows with a geological hammer and cannot be scratched with a common 20d steel nail.

FIG. 3 Verification Anvil with Instrument Guide

FIG. 4 Abrasive Stone

8. Specimen Preparation

8.1 Drill core specimens shall be NX or larger core and at least 15 cm in length. Block specimens shall have edge lengths of at least 15 cm. Rock surfaces tested in place, including natural outcrops or prepared surfaces, such as tunnel walls or floors, shall have smooth, flat test areas at least 15 cm in diameter.

8.2 For a block or core specimen, determine its length by taking the average of four lengths measured at four equally spaced points on the circumference and record to the nearest 5 mm.

8.3 For a block or core specimen, determine its diameter by taking the average of two diameters measured at right angles to each other approximately midway along the length of the specimen and record to the nearest 5 mm.

8.4 Record or document the moisture condition of the block or core specimen(s). Depending on the requirements of the test program, the qualitative condition can be reported, such as air-dried or in situ moisture, or a more exact method can be used such as Test Method D2216.

8.5 The test surface of all specimens, either in the laboratory or in the field, shall be smooth to the touch or free of joints, fractures, or other obvious localized discontinuities to a depth of at least 6 cm. In situ rock shall be flat and free of surface grit over the area covered by the plunger. If the surface of the test area is heavily textured, grind it smooth with the abrasive stone described in 6.4.

9. Calibration

9.1 Calibration of the hammer is essential to maintain its standard rebound values before and after field investigations and to make sure accurate test results are obtained. Rebound hammers shall be serviced and calibrated once every 12 months and whenever there is reason to question their proper operation.

NOTE 5—Different manufacturers recommend checking the calibration values after a specified number of rebound tests.

9.2 Prior to each testing sequence, verify the calibration of the hammer using a verification test anvil.

9.2.1 In instances where the core holder is used for tests, place the verification anvil in the core holder and obtain ten rebound hammer readings on the anvil.

9.2.2 Operation of the rebound hammer is satisfactory if the verification readings fall within the range provided by the manufacturer. If the verification readings fall outside this range, the instrument must be cleaned, adjusted, or returned to the manufacturer for correction.

9.3 Calculate the correction factor (CF) by dividing the manufacturer's standard hardness value for the anvil by the average of the ten readings taken on the anvil.

NOTE 6—If the instrument reads lower than the manufacturer's standard hardness value, the correction factor will be greater than unity. If the readings are higher, the correction factor will be less than unity.

10. Procedure

10.1 Prior to conducting the tests, make sure the hammer is at the same temperature as the test specimens by exposing the hammer to the same environmental conditions as the specimens for at least 2 hours.

10.2 Check the calibration value prior to testing as described in Section 9.

10.3 Other than in the in situ test, place the steel base or block specimen on a flat, level surface that provides firm, rigid support, such as a concrete floor.

10.4 Securely clamp rock core specimens in a steel cradle with a semi circular machined slot of the same radius as the core, or firmly seated into a steel V-block. Securely clamp rock block specimens to the rigid support in such a manner as to prevent vibration and movement of the specimen during the test.

10.5 *Orientation of the Rebound Hammer:*

10.5.1 For tests conducted on specimens in the laboratory, orient the instrument within 5° of vertical with the bottom of the plunger at right angles to and in firm contact with the surface of the test specimen. A guide may be used to make sure the rebound hammer is positioned for optimum performance. Position the hammer not less than one diameter from the edge of the specimen.

10.5.2 For tests conducted in situ on a rock mass, the rebound hammer can be used at any desired orientation provided the plunger strikes perpendicular to the surface tested and the orientation recorded. Correction curves shall be supplied by the manufacturer and shall be used when the orientation of the hammer is not vertical. The manufacturer shall keep a record of test data used as the basis for applicable correction factors.

10.6 Zero the readout. Compress the hammer spring by gradually depressing the plunger until the hammer is triggered and impact and rebound occurs. If necessary, press the button on the side of the hammer to lock the plunger in the retracted position, which also holds the reading.

10.7 Read and record the height of the plunger rebound to the nearest whole number, as measured on an arbitrary scale of 10 to 100 divisions located on the side of the hammer or as electronically displayed, before restoring the plunger to its original extension. Repeat steps 10.2 through 10.6 at ten representative locations on the specimen. Test locations shall be separated by at least the diameter of the plunger and only one test may be taken at any one point.

10.8 If a specimen breaks during rebound testing, energy is absorbed during breakage and, consequently, the rebound reading will be lower than had it not broken. Any individual impact test that causes cracking or any other visible failure shall cause that test and the specimen to be rejected.

11. Calculation

11.1 Calculate the average of the ten readings obtained for each specimen to the nearest whole number. Discard readings differing from the average by more than seven units.

11.2 Calculate the H_R by multiplying the remaining readings by the CF, as explained in 9.3 and record the results to the nearest whole number.

11.2.1 From the remaining readings, calculate the average, mode, range, and median H_R for the specimen.

11.3 For tests conducted in situ on a rock mass or at an inclined position, the rebound hammer results must be corrected to a horizontal or vertical position using the correction curves provided by the manufacturer.

12. Report: Test Data Sheet(s)/Form(s)

12.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s) as given below, is covered in 1.6 and Practice D6026.

12.2 Record as a minimum the following information/data:

12.2.1 Source of samples, including geographic location; boring number, depth, orientation, and stationing; and rock type as provided or as available,

12.2.2 Weathering and alteration condition of samples, particularly when sampling a surface outcrop as provided or as available,

12.2.3 Type of specimen (core, block, or in situ); size and shape of specimen; and, if block type, whether cut or blasted,

12.2.4 Date of sampling, date of testing, and name or initials of person(s) performing the test,

12.2.5 Storage conditions of samples (for example, exposure to temperature extremes, air drying, and moisture changes) if known, as provided, or as available,

12.2.6 Moisture content in % or in qualitative terms,

12.2.7 Type and model number of hammer,

12.2.8 Calibration and verification data,

12.2.9 Orientation of the plunger axis during the test,

12.2.10 Method of securing the specimen (for example, V-block, or clamps),

12.2.11 Number of tests conducted,

12.2.12 Temperature of site or laboratory at time of test,

12.2.13 The individual and average rebound readings, the correction factor, and the rebound hardness number, H_R as obtained in 11.2, and

12.2.14 Photographs of the specimens, as necessary.

13. Precision and Bias

13.1 *Precision*—Test data on precision is not presented due to the nature of rock materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

13.1.1 Subcommittee D18.12 is seeking any data from the users of this test method that might be used to make a limited statement on precision.

13.2 *Bias*—There is no accepted standard value for this test method, therefore bias cannot be determined.

14. Keywords

14.1 core; hardness; impact hammer; rebound hammer; rebound number; rock mass; unconfined compressive strength

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D5873 – 13) that may impact the use of this standard. (Approved Feb. 1, 2014.)

(1) Revised Sections 1, 6, 12, and 13.
(2) Added new term 'rebound number' to Section 3.
(3) Removed Fig. 3 and renumbered figures accordingly.

Committee D18 has identified the location of selected changes to this standard since the last issue (D5873 – 05) that may impact the use of this standard. (Approved July 1, 2013.)

(1) Added 1.4, 1.6, 1.7, 4.2, Section 5, 6.2, 7.2, 8.1, 9.1, 10.1, 10.2, 11.2, 11.2.1, 11.3, 12.2.6, 12.2.8, and 12.2.14.
(2) Revised 1.2, 3.2.1, 3.2.2, 4.1, 4.3, Note 1, 6.1, 6.3, 6.4, 7.1, 7.3, 7.4, 8.4, 9.2, 9.2.1, 9.2.2, 9.3, 10.3, 10.4, 10.5, 10.5.1, 10.5.2, 10.6, 10.7, 11.1, 12.2, 12.2.4, 12.2.10, and 13.1.
(3) Added the Kolaiti and Papadopoulos (1993) reference, Notes 3-5, and Figs. 1-4.
(4) Revised Section 2 to remove 'D420' and add D2216 and C805/C805M.
(5) Retitled Section 12.
(6) Revised Section 14 to remove 'rock' and add 'impact hammer,' 'rebound hammer,' and 'rebound number.'