

Proper use of the Rebound Hammer Updated to reflect the changes to ASTM C805

The Rebound Hammer has been around since the late 1940's and today is a commonly used method for estimating the compressive strength of in-place concrete. Developed in 1948 by a Swiss engineer named Ernst Schmidt, the device measures the hardness of concrete surfaces using the rebound principle. The device is often referred to as a Swiss Hammer.

The Swiss Hammer, at times, is not used properly. This usually happens when someone attempts to solely use the rebound values obtained and the correlation chart provided by the equipment producer to determine the compressive strength of the concrete. The ASTM standard test method has been revised several times in recent years and the current revision of the document is ASTM C805-13, Standard Test Method for Rebound Number of Hardened Concrete.

How does it work?

ASTM C805, "Standard Test Method for Rebound Number of Hardened Concrete", summarizes the procedure as "A steel hammer impacts, with a predetermined amount of energy, a steel plunger in contact with a surface of concrete, and the distance that the hammer rebounds is measured."

The device consists of a plunger rod and an internal spring loaded steel hammer and a latching mechanism. When the extended plunger rod is pushed against a hard surface, the spring connecting the hammer is stretched and when pushed to an internal limit, the latch is released causing the energy stored in the stretched spring to propel the hammer against the plunger tip. The hammer strikes the shoulder of the plunger rod and rebounds a certain distance. There is a slide indicator on the outside of the unit that records the distance traveled during the rebound. This indication is known as the rebound number. By pressing the button on the side of the unit, the plunger is then locked in the retracted position and the rebound number (R-number) can be read from the graduated scale. A higher R-number indicates a greater hardness of the concrete surface.

The tests can be performed in horizontal, vertically upward, vertically downward or any intermediate angled positions in relation to the surface (Figs 1 and 2). The devices are furnished with correlation curves by the manufacturer. ASTM C805 now states that these references to the relationship between the rebound number and compressive strength provided by the manufacturer "*shall be used only to provide indications of relative concrete strength at different locations in a structure.*" To obtain greater accuracy of test results, it is

recommended that the user develop a correlation for the device on each concrete mixture design to be tested and at the intended test angle.



Figures 1 and 2 – Horizontal orientation of hammer during a measurement

What is the significance and use of this test?

ASTM C805 states that this method is applicable for the following uses:

- To assess the in-place uniformity of concrete
- To delineate regions in a structure of poor quality or deteriorated concrete
- To estimate in-place strength if a correlation is developed

This standard also states that to use the device to estimate in-place strength, a relationship between strength and rebound number needs to be established for the specific concrete mixture design(s) of interest. Different rebound hammers of the same design and manufacture may give rebound numbers differing from 1 to 3 units; therefore, when developing the strength to rebound number relationship, the operator should use the same device in all of the tests.

ASTM C805 states that the relationship must be established by correlating the rebound numbers obtained for a given area of concrete to the results of cores obtained from the corresponding locations. The reason stated for the required use of cores is that “The use of molded test specimens to develop a correlation may not provide a reliable relationship because the surface texture and depth of carbonation of molded specimens are not usually representative of the in-place concrete.”¹

ASTM C805 requires a minimum of two cores obtained from at least six locations with different rebound numbers. The test locations should be selected so that a wide range of rebound numbers is obtained. The ASTM standard also states that the locations where it is intended to estimate strength based on the correlation data shall have a similar surface texture and have been exposed to similar conditions as the locations used to develop the correlation data. ASTM C805 also provides a recommendation to reference ACI 228.1R for additional information on the proper development of correlation data.

ACI 228.1R-03 addresses the development of a strength relationship for both new construction and existing construction. For new construction, ACI states that at least 12 specimens should be cast and at each age a set of 10 rebound number readings should be obtained from each pair of cylinders. ACI further recommends that the specimens be held firmly in a compression machine under 500 psi pressure while the rebound numbers are obtained in preferably the same device orientation that will be used to measure the structure. For the evaluation of existing structures, ACI also recommends that six to nine different locations be identified and a minimum of two cores be taken at each place. ACI further recommends that the cores be wiped dry, stored in sealed plastic bags, and tested in accordance with ASTM C42 “Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete”. The data generated should then be correlated with the rebound numbers obtained at the core locations in the field. An example of a graphical representation of comparison data can be found in Fig. 3. ACI 228.1R-03 provides a very extensive discussion regarding interpretation of the test results.

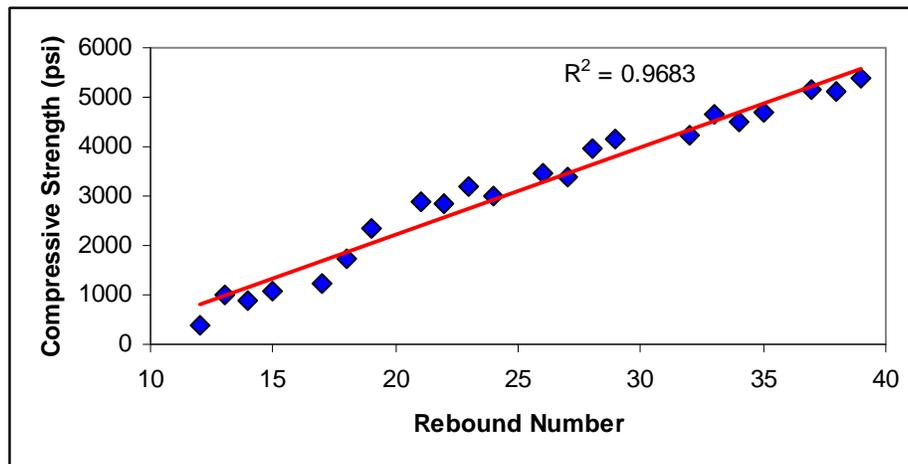


Fig. 3 – Example of a calibration chart for a rebound hammer

What factors affect the test results?



Surface Smoothness – The surface texture significantly affects the R-number obtained. Tests performed on a rough-textured finish will typically result in crushing of the surface paste, resulting in a lower number. Alternately, tests performed on the same concrete that has a hard, smooth texture will typically result in a higher R-number. Therefore, it is recommended that test areas with a rough surface be ground to a uniform smoothness. This can be achieved easily with a Carborundum stone or similar abrasive stone. The Guide to Nondestructive Testing of Concrete, September 1997 (FHWA-SA-97-105) published by the U.S. Department of Transportation Federal Highway Administration (herein referred to as the FHWA Guide) states: “Past research has also shown that troweled surfaces or surfaces formed by metal forms yield rebound numbers 5 to 25 percent higher than surfaces cast against wooden forms.”³

The FHWA Guide also states that troweled surfaces result in a higher scatter of results, hence lowering confidence in the estimated strengths. ASTM C805 states that when formed surfaces were ground, increases in rebound number of 2.1 for plywood formed surfaces and 0.4 for high-density plywood formed surfaces have been noted.

Age of Concrete – Concrete continues to develop strength with age due to cement hydration. This is the reason behind the development of data relating rebound numbers to the compressive strength of the concrete mixture or cores from the structure. Testing of concrete less than 3 days old or concrete with expected strengths less than 1000 psi is not recommended. This is because the R-numbers will be too low for an accurate reading, and the testing will be more destructive to the concrete surface.

Moisture Content – This has a profound effect on the test results. Dry concrete surfaces result in higher rebound numbers than wet surfaces. The FHWA Guide references a study where saturated surface-dry (SSD) specimens were left in a room at 70°F and air-dried. The specimens gained 3 units in 3 days and 5 units in 7 days. It is recommended that to achieve the most accurate results when the actual moisture condition is unknown, the surface of the cores should be pre-saturated with water for several hours prior to testing and use the correlation developed for SSD specimens.

Surface Carbonation – With greater amounts of surface carbonation, higher rebound numbers will be obtained. Rebound numbers of a carbonated surface can be as much as 50 percent higher than non-carbonated surfaces. Older concrete surfaces may have much deeper amounts of surface carbonation than younger concrete. ASTM states that the effects of moisture content and carbonation can be reduced by thoroughly wetting the surface for 24 hours before testing, and that where a thick layer of carbonation is present, it may be necessary to use a power grinder to remove the carbonated concrete to obtain more accurate data.

Aggregate, air voids, and steel reinforcement – The presence of materials in the immediate area where the plunger comes into contact with the concrete will have an obviously profound effect as well. If the test is performed over a hard aggregate particle or a section of steel reinforcement, the result may be an unusually high rebound number. ASTM C805 states that tests directly over reinforcing bars with cover less than 0.75 inches should not be conducted. The use of a pachometer or similar device is recommended for determining the location and cover in structurally reinforced concrete. Likewise, if the test is performed over a very soft aggregate particle or an air void, an unusually low rebound number may result. The FHWA guide reported that for equal compressive strengths, concrete made with crushed limestone resulted in rebound numbers approximately 7 units higher than concrete made with gravel, representing a difference of approximately 1000 psi compressive strength estimation.



Because of the factors mentioned above, ASTM C805 requires that for each test area, ten readings be obtained, with no two tests being closer to one another than one inch. Readings differing from the average of the ten readings by more than six units should be discarded. Also, if two readings differ from the average by six units or more, the operator should discard the entire set of readings and take ten new readings within the test area.

Temperature – Tests should not be performed on frozen concrete surfaces. Wet concrete at temperatures of 32°F or less may result in higher rebound numbers. Also, the temperature of the Swiss Hammer itself in extreme cold (0°F) may result in rebound numbers reduced by as much as two or three units¹.

Calibration of the Rebound Hammer – The device itself should be serviced and verified annually or whenever there is a reason to doubt proper performance. Verification of proper performance of the device includes the use of a test anvil. The required dimensions and steel hardness is listed in ASTM C805. Impacting the proper test anvil with a properly functioning device will typically result in rebound numbers of 80 ± 2 . If the device is believed to not be functioning properly, it is recommended to send it back to the manufacturer or experienced facility for repairs and re-verification.

How to interpret the test results?

There is an advantage in using the rebound hammer as a means of evaluating concrete to assess the in-place uniformity, to delineate regions in a structure of poor quality or deteriorated concrete, and to estimate in-place strength. The unit is easy to use and a large number of readings can be obtained in a relatively short amount of time. The method is for the most part non-destructive and typically more economical than other methods. However, with these advantages come disadvantages related to limitations on accuracy, and the need for proper calibration and correlation with cores for evaluation of an existing structure.

The rebound hammer can be a valuable tool for evaluating the uniformity of concrete in the field provided that the concrete is under the same conditions related to age, moisture content, surface carbonation, and temperature. It should not be used as a substitute for performing normal specified quality control procedures.

Of most importance is that the current version of ASTM C805 states *“This test method is not suitable as the basis for acceptance or rejection of concrete.”* As stated previously, when ASTM C805 is followed, it will provide an estimation of the in-place compressive strength; however, it is not a direct measurement, and the data obtained should not be used to accept or reject the concrete in place.

References:

1. ASTM C805-08, "Standard Test Method for Rebound Number of Hardened Concrete", American Society for Testing and Materials, West Conshohocken, PA
2. ACI 228.1 R-03, "In-Place Methods to Estimate Concrete Strength", American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094
3. U.S. Department of Transportation Federal Highway Administration, "Guide to Nondestructive Testing of Concrete", September 1997, Publication No. FHWA-SA-97-105, 400 Seventh Street, SW, Washington, DC 20590

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