

## Multiplication Factor of Actual Compressive Strength Relative to the Predicted Compressive Strength Obtained from Hammer Test Results

Eka Juliafad<sup>1</sup> Wilis Ardilla<sup>2</sup>, Iskandar G. Rani<sup>3</sup>

<sup>1</sup> Faculty of Engineering, Universitas Negeri Padang

<sup>2</sup> Faculty of Engineering, Universitas Negeri Padang

<sup>3</sup> Faculty of Engineering, Universitas Negeri Padang

Correspondence: [ekajuliafad@ft.unp.ac.id](mailto:ekajuliafad@ft.unp.ac.id).

---

### Article Info

#### Article history:

Received March 16<sup>th</sup>, 2026

Revised March 17<sup>th</sup>, 2026

Accepted March 18<sup>th</sup>, 2026

---

#### Keyword:

Compressive Strength, Non-Destructive Test, Hammer Test, Concrete Quality

---

### ABSTRACT

Concrete is a composite material consisting of coarse aggregates, fine aggregates, water, and cement, with or without additional admixtures. In the construction of concrete structures, various problems are still frequently encountered, particularly when the implemented work does not meet the design specifications of the planned concrete strength. Therefore, it is necessary to evaluate the quality of concrete to determine whether it complies with the intended design strength. The compressive strength of concrete can be determined through two methods: destructive testing using a Compression Testing Machine (CTM) and non-destructive testing using a rebound hammer test. This study aims to determine the multiplication factor obtained from hammer test results in order to estimate the actual compressive strength of concrete. Additionally, the study compares the compressive strength values obtained from hammer test measurements with those obtained from compression testing. The research employed an experimental method using 60 normal concrete cube specimens. The results indicate that there is a significant difference between the actual compressive strength obtained from compression testing and the predicted compressive strength derived from the hammer test. The actual compressive strength values are higher by 23.35% compared to the vertical hammer test direction and 37.68% compared to the horizontal hammer test direction. The multiplication factor relating the actual compressive strength to the hammer test prediction is 1.3 for the vertical test direction (90<sup>o</sup>) and 1.6 for the horizontal test direction (180<sup>o</sup>).



© 2026 The Authors. Published by Cendekia Publikasi Indonesia. This is an open access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>)

---

## INTRODUCTION

Construction development in Indonesia has experienced significant growth in recent decades. Nearly 60% of construction activities in Indonesia utilize concrete as the primary building material. In Padang City, West Sumatra, more than 80% of the building population consists of reinforced concrete structures, which are predominantly low-rise buildings [1] [2]. The widespread use of concrete as a construction material is mainly attributed to the availability and accessibility of its constituent materials. However, concrete may experience strength degradation and structural defects due to several factors, including improper fresh concrete placement techniques and poor quality of raw materials used in the mixture [1] [3] [4].

Low-quality concrete is typically characterized by porous and honeycombed structures, which may lead to structural deterioration. Damage in concrete structures is commonly found in structural elements such as columns, ring beams, floor slabs, and other load-bearing components. In practice, concrete that appears visually strong in the field does not necessarily possess adequate structural quality. Therefore, it is essential to conduct concrete quality assessments to ensure that the material meets the required design specifications. Generally, the evaluation of concrete quality can be carried out using two approaches: destructive testing, performed using a Compression Testing Machine (CTM), and non-destructive testing, conducted using a rebound hammer test [5].

The compressive strength of concrete is one of the most important performance indicators of concrete structures. It represents the ability of concrete to withstand compressive loads and is widely used to determine the quality of a structural element. In general, the higher the desired structural capacity, the higher the required compressive strength of the concrete. Compressive strength can be defined as the maximum load per unit area that causes concrete to fail under compressive stress, which is measured using a compression testing machine [6]. Several factors may influence the compressive strength of concrete, including the type of cement, type of aggregate used, concrete age, and curing conditions.

The rebound hammer test is a widely used non-destructive testing (NDT) method because it is easy to operate and allows rapid evaluation of concrete quality. This method is commonly used to estimate the uniformity of concrete and to detect areas with potential variations in concrete quality [7]. According to ASTM C805 (2012), the concrete surface to be tested must have a minimum thickness of 100 mm and should be integrally connected with the structural element. The hammer test operates by applying a controlled impact load to the concrete surface through a plunger (steel rod). The resulting rebound value reflects the hardness of the concrete surface, which can then be converted into an estimated compressive strength using the calibration charts provided with the hammer test device, considering the angle of impact [8].

Several factors can influence the results of hammer test measurements. These include the characteristics of the concrete mixture, such as the type of cement, the type of aggregates, moisture conditions, and the surface characteristics of the tested concrete. The hammer test offers several advantages, including ease of use, rapid testing procedures, and the ability to evaluate concrete without causing damage to the structure. However, the method also has limitations, particularly in terms of lower reliability and the fact that the obtained information mainly represents the surface characteristics of the concrete rather than its internal properties [9].

The hammer test device consists of a steel hammer mechanism that strikes a plunger made of hardened steel, which comes into direct contact with the concrete surface. Various types and sizes of hammer test devices are available, allowing the test to be adapted to different structural conditions [8]. Proper knowledge of the testing procedure and adherence to established standards are essential when conducting hammer test measurements. The following section describes the standard procedures for using the hammer test device [6].

1. Position the tip of the hammer perpendicular to the concrete surface to be tested. Prior to testing, the surface of the concrete should be properly smoothed to ensure accurate measurement results.
2. If the tested surface is covered with plaster, it is not necessary to remove the plaster layer, as doing so could damage the structure. This approach is consistent with the non-destructive nature of the testing method.
3. Press the hammer firmly against the concrete surface until the maximum compression of the spring mechanism is reached. Once this limit is achieved, release the pressure so that the hammer rebounds. The rebound distance is measured on a scale ranging from 10 to 100, and the indicated value on the hammer scale represents the rebound number obtained during the test.
4. The rebound distance is influenced by the magnitude of the initial impact energy absorbed during the interaction between the hammer tip and the concrete surface. The greater the energy absorbed by the concrete, the smaller the rebound distance that will be recorded.
5. The impact points in the hammer test should be spaced approximately 2–3 cm apart, with a minimum of nine impact points for each testing area to ensure reliable measurement results.

## RESEARCH METHODS

The method used in this study was an experimental approach, in which tests were conducted on concrete specimens designed with a specified compressive strength. This research was carried out at the Materials and Soil Mechanics Laboratory, Faculty of Civil Engineering, *Universitas Negeri Padang*. The test specimens consisted of concrete cubes measuring 15 cm × 15 cm × 15 cm, with a total of 80 specimens. All specimens were first tested using the rebound hammer test to obtain the estimated compressive strength. Subsequently, the same cube specimens were tested using a Compression Testing Machine (CTM) to determine the actual compressive strength of the concrete. The stages of the research implementation are described as follows [10].

### 1. Provision of Research Materials

The materials used in this study included fine aggregate obtained from Pasaman (Padang Sawah), coarse aggregate sourced from South Solok, and Portland cement as the binding material.

### 2. Material Characterization Testing

Material characterization tests were conducted to determine the physical properties of the aggregates. These tests included silt content testing of fine and coarse aggregates, specific gravity testing of fine and coarse aggregates, bulk density testing of aggregates, abrasion resistance testing of coarse aggregates, and sieve analysis of both fine and coarse aggregates.

### 3. Preparation of Test Specimens

The test specimens consisted of 80 concrete cube samples, each measuring 15 cm × 15 cm × 15 cm.

### 4. Curing of Test Specimens

The curing process was carried out by immersing the concrete specimens in a curing tank filled with clean water until the concrete reached the age of 28 days. The purpose of curing is to maintain appropriate temperature and moisture conditions to ensure proper hydration and strength development of the concrete. The curing procedure followed the provisions specified in SNI 2493-2011.

### 5. Testing of Specimens

The compressive strength tests were conducted at the Civil Engineering Laboratory of *Universitas Negeri Padang* (UNP) using a Compression Testing Machine (CTM) to determine the actual compressive strength of the concrete specimens.

## RESULTS AND DISCUSSION

Based on the tests conducted, the following results were obtained.

### 1. Compressive Strength Test Using a Compression Testing Machine

The test to determine the actual compressive strength of concrete was carried out using a Compression Testing Machine (CTM). A total of 80 cube specimens were tested. The compressive strength test was conducted when the concrete reached an age of 28 days. The designed concrete strength for the cube specimens was K-250, which is equivalent to 20.75 MPa.

The compressive strength test was performed by placing the concrete cube specimen in the compression testing machine and applying a compressive load at a loading rate of 0.15–0.35 MPa per second until the specimen failed.

The compressive strength test produced data in the form of the maximum compressive load (P) recorded at the moment when the specimen fractured. The compressive strength obtained from this test represents the actual compressive strength of the concrete cube specimens. This value was then used as a reference to determine the percentage difference between the actual compressive strength and the estimated compressive strength obtained from the hammer test.

The actual compressive strength of concrete is defined as the maximum load per unit area that causes the concrete specimen to fail when subjected to a compressive force generated by the compression testing machine. The compressive strength of concrete can be calculated using the following equation:

$$F'c = \frac{P}{A}$$

Where:

Fc = Compressive Strength (Kg/cm<sup>2</sup>)

P = Applied Compressive Load (Kg)

A = Cross-sectional Area of the Cube Specimen (Cm<sup>2</sup>)

#### a. Compressive Strength of Control Concrete

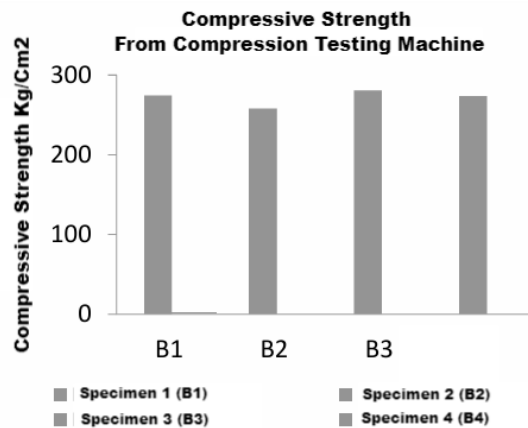
The compressive strength of the control concrete specimens, denoted as B1, B2, B3, and B4, represents the compressive strength obtained from the trial mix design according to the planned concrete strength.

Based on the test results, the compressive strength values obtained were 274.12 kg/cm<sup>2</sup> for specimen B1, 257.74 kg/cm<sup>2</sup> for specimen B2, 280.95 kg/cm<sup>2</sup> for specimen B3, and 273.74

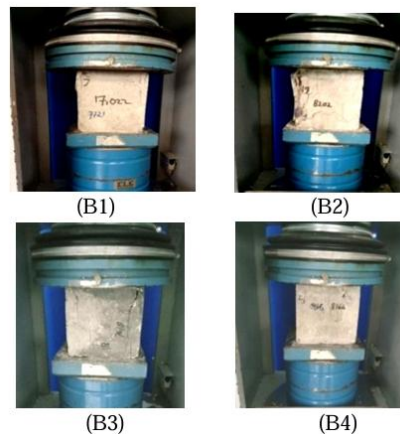
kg/cm<sup>2</sup> for specimen B4. These results indicate slight variations among the specimens, although the values remain close to the targeted design strength. Figure 1 presents the graphical representation of the compressive strength test results obtained using the Compression Testing Machine.

**Table 1. Compressive Strength from Strenght Test**

No	Sample	Area (Cm2)	Compressive Strength
1	B1	225	274.12
2	B2	225	257.74
3	B3	225	280.595
4	B4	225	273.725



**Figure 1. Graph of Concrete Compressive Strength Obtained from the Compression Testing Machine**



**Figure 2. Actual Compressive Strength Test Using a Compression Testing Machine for Specimens B1, B2, B3 and B4**

b. Estimated Compressive Strength of Concrete Cubes Using Hammer Test and Actual Compressive Strength

The hammer test was conducted on 60 concrete cube specimens using both vertical and horizontal testing directions. For each specimen, a total of 16 impact points were applied on one surface of the cube, with a spacing of 3 cm between impact points. After completing the hammer test measurements, the same 60 cube specimens were subjected to compressive strength testing using a Compression Testing Machine to determine their actual compressive strength values.

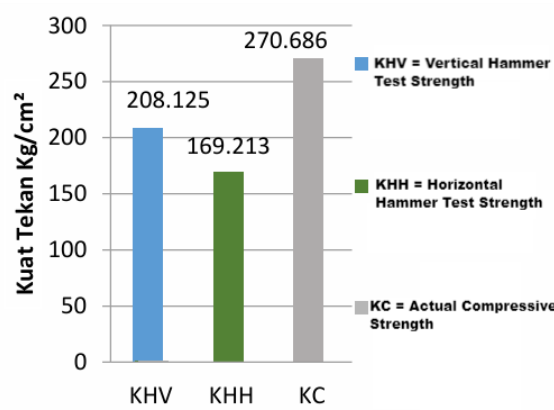
This procedure allowed a comparison between the estimated compressive strength obtained from the hammer test and the actual compressive strength obtained from the compression testing machine, which was subsequently used to determine the multiplication

(calibration) factor relating the hammer test prediction to the actual concrete compressive strength.

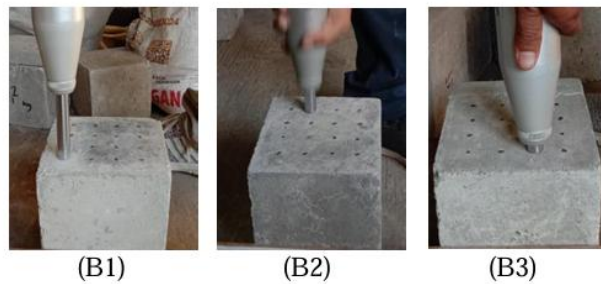
Based on the tests conducted, the estimated compressive strength obtained from the hammer test in the vertical direction was higher than that obtained in the horizontal direction. However, the actual compressive strength of the concrete obtained from the compression testing machine was higher than the estimated compressive strength derived from the hammer test. Figure 3 illustrates the compressive strength values obtained from the hammer test measurements.

**Table 2. Compressive Strength Estimated From the Hammer Test in The Vertical Direction**

Sample	Compressive Strength Kg/Cm <sup>2</sup>	Ratio	Multiplication Factor
KHV	F <sub>cv</sub> 208.125	0.77	1.3
KHH	F <sub>ch</sub> 169.213	0.63	1.6
KC	f <sub>ck</sub> 270.686	1	



**Figure 3. Actual Compressive Strength and Estimated Compressive Strength from the Hammer Test**



**Figure 4. Hammer Test Compressive Strength Evaluation**

The compressive strength results obtained using the compression testing machine showed differences when compared with the results obtained from the hammer test. The compression test produced higher compressive strength values than the hammer test results. The difference between the compression test and the hammer test in the vertical direction reached 23.35%, while in the horizontal direction the difference reached 37.68%.

These findings are consistent with the research conducted by Dharmawan (2016), which concluded that the hammer test cannot be considered an alternative method for determining the actual compressive strength of concrete. This conclusion is supported by the test results obtained in this study, which demonstrate that the hammer test mainly measures the surface hardness and uniformity of concrete, and does not provide information about the internal compressive strength of the concrete core [11].

In general conditions, compressive strength values obtained from the compression test tend to be higher than those obtained from the hammer test. Similar findings were also reported in previous

studies, where the compressive strength measured using the compression test was consistently higher than the values estimated from the hammer test [12].

Based on the test results, the ratio between the compressive strength obtained from the hammer test and the actual compressive strength was determined (Table 2). From this study, the actual compressive strength of concrete can be estimated using the predicted compressive strength obtained from the hammer test by applying a multiplication factor (Table 2). This multiplication factor is derived from the ratio between the actual compressive strength and the compressive strength estimated from the hammer test.

## CONCLUSION

Based on the analysis of the research results, it can be concluded that the compressive strength values obtained from the hammer test do not provide highly accurate estimations, whether the measurements are taken in the horizontal or vertical directions. The estimated compressive strength obtained from the hammer test is lower than the actual compressive strength of the concrete. This study also determined a multiplication (calibration) factor that can be used to convert the estimated compressive strength obtained from the hammer test into the actual compressive strength of concrete. The results indicate that the calibration factor is 1.3 for the vertical testing direction and 1.6 for the horizontal testing direction. However, the application of this multiplication factor is limited to normal concrete with crushed stone aggregates, tested using the hammer test with 16 impact points arranged in a grid spacing of 3 cm.

## REFERENCES

- [1] E. Juliafad, K. Meguro and H. Gokon, "Study On the Environmental System Towards the Development of Assessment Tools For Disaster Reduction of Reinforced Concrete Building Due to Future Mega-Earthquake in Padang City Indonesia," *Institute of Industrial Science the University of Tokyo*, 2017.
- [2] A. Komala and E. Juliafad, "Evaluasi Kuat Tekan Beton Eksisting Pada Bangunan Gedung B Sekolah Dasar Negeri 09 Pasaman," *Jurnal Applied Science in Civil Engineering*, vol. 3, no. 2, pp. 156-163, 2022.
- [3] E. Juliafad, I. G. Rani and F. Rifwan, "Concreting Workmanship in Indonesia Study Case: Padang City, West Sumatra, Indonesia," *International Journal On Advanced Science, Engineering And Information Technology*, vol. 9, no. 1, 2019.
- [4] E. Juliafad, K. Meguro and H. Gokon, "Study On The Characteristic of Concrete and Brick As Construction Material for Reinforced Concrete Buildings In Indonesia," *Institute of Industrial Science the University of Tokyo*, 2020.
- [5] E. Juliafad, *Investigasi Kerusakan Pada Bangunan Beton Bertulang*, Depok: Rajawali Pers, 2020.
- [6] S. 03-1974-1990, *Metode Pengujian Kuat Tekan Beton*, Jakarta: Balitbang PU, 1990.
- [7] American Society for Testing and Materials, *Test Methods for Rebound Number of Hardened Concrete*, West Conshohocken: ASTM International, 2004.
- [8] R. Setani, *Tinjauan Hasil Uji Mutu Beton Jembatan Dengan Alat (Test Ruseltreview of Concrete Brindge Quality Using Pundit)*, 2014.
- [9] E. H. Ulfa, "Perbandingan Hasil Uji UPV dan Schmidt Hammer Test," 2020.
- [10] R. Arwanto, "Respon Kuat Tekan Hammer Test dengan Compression Test pada Beton Normal dan Beton Pasca Bakar".