Value of Concrete Compressive Strength on 28 days with Variation of Candlenut Shell Applied to Plate on a Non-destructive Test Using Hammer Test

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Abstract. Concrete compressive strength is one of the parameters used to control the quality of a concrete. Concrete compressive strength testing method which is considered the highest level of reliability is a destructive test using a compressive testing machine. Testing requires quite high costs and a longer processing time. But sometimes testing must be done in the scene. Based on the case, a testing tool is needed to measure or determine the compressive strength of concrete without spoil, which is known as the non-destructive test. The tool commonly used for this test is the hammer test. The type of research is experimental. The purpose of this research is to get the compressive strength value of a concrete plate variation of 30% candlenut shells from the test results using a hammer test so as the results can be close to the results of testing using a compressive testing machine (destructive test). The research variable is the testing method (3 point of testing with angle 0°), the age of concrete plate curing, the method of curing (wet curing and dry curing). The number of samples of reinforced concrete slabs is 8 pieces measuring 50cm x 25 cm x 12cm. The research results are Compressive strength of concrete slabs of 30% candlenut shell variations using a Hammer test showed that the concrete strength reached 23-27 Mpa both in wet curing and dry curing or equivalent to the quality of K250 concrete at 28 days. The results also indicate higher values compared to normal concrete slabs.

1. Introduction
Many buildings are often found using reinforced concrete construction systems. Even some buildings have a long life like a monument or historic building. The more old of building, definitely, the strength of itself more decreases, for example the building with reinforced concrete construction. According to the theory, as we know the concrete reaches its maximum age at 28 days but more than it, the concrete is actually experiencing an increase in strength but not too significant. However, when the concrete reaches more than 50 years the strength of concrete will decrease. Concrete compressive strength is one of the parameters used to control the quality of a concrete. Concrete compressive strength testing method which is considered the highest level of reliability is a destructive test using a compressive testing machine. Testing requires quite high costs and a longer processing time. But sometimes testing must be done in the scene. Based on the case, a testing tool is needed to measure or determine the compressive strength of concrete without spoil, which is known as the non-destructive test. The tool commonly used for this test is the hammer test.
Based on the explanation, this article discusses about the purpose of research which is to get the compressive strength value of a concrete plate variation of 30% candlenut shells from the test results using a hammer test so as the results can be close to the results of testing using a compressive testing machine (destructive test).

2. Literature Review

According to [1], concrete can generally be divided into groups, namely: (a) Class I concrete. It is a class of concrete for non-structural works. For its implementation, this concrete does not require special expertise. Its quality control is limited to light supervision of the ingredients quality. As for the compressive strength, inspection is not required. Class I concrete is expressed as Bo; (b) Class II concrete. It is a class of concrete for general structural works. Its implementation requires sufficient expertise and must be carried out under the supervision of experts. Class II concrete is divided into B1, K125, K175, and K225 standard qualities. In the B1, quality control is only limited to the supervision of the ingredients quality. As for the compressive strength, inspection is not required. In the K125 and K175, there is a need to check the concrete compressive strength continuously from the results of the test specimens; (c) Class III concrete. It is a class of concrete for structural works higher than K225. Its implementation requires special expertise and must be carried out under the supervision of experts. It requires a concrete laboratory with complete equipment that is served by experts who can carry out continuous quality control of concrete.

Table 1. Concrete quality conversion from Kg/cm$^2$ to Mpa [2]

| CONCRETE QUALITY | CONCRETE QUALITY |
|------------------|------------------|
| K100             | fc 8,3 mpa       |
| K-150            | fc12.35 mpa      |
| K-175            | fc 14.53 mpa     |
| K-200            | fc 16.60 mpa     |
| K-250            | fc 20.75 mpa     |
| K-275            | fc 22.83 mpa     |
| K-300            | fc 24.90 mpa     |
| K-350            | fc 29.05 mpa     |
| K-400            | fc 33.20 mpa     |
| K-450            | fc 37.35 mpa     |
| K-500            | fc 41.50 mpa     |

Based on Table 1 above, the concrete quality is classified into three quality classes, namely class I concrete, class II concrete, and class III concrete. Class I concrete, which are K-100, K125, K-150, K-175, and K-200, are used for non-structural work; Class II concrete, which are K-225, K-250, and K-275, are used for structural works such as floors, roads, foundations, floors, columns, etc.; and Class III concrete, which are K-325, K-350, K-375, K450, and K-500, are special concrete, for example for bridge beams and floors, runways, etc.

Concrete Hammer Test or Schmidt Hammer Test is an easy and simple testing method for estimate the quality of concrete.
2.1. How to Use the Hammer Test
Because the principle of work and how to use the tool were very easy, it was used generally to estimate the quality of concrete, especially for finished building structures. Furthermore, the quick test process that hammer test have can testing whole part of building structure for identicating uniformity of concrete. For noted, the concrete hammer test just become initial indication for grade and its grade uniformity because the tool only read the hardness of concrete on the surface layer (+4 cm) [3].

![Diagram of concrete hammer-schmidt rebound hammer](image)

**Figure 1.** Principle of work concrete hammer-schmidt rebound hammer [4]

2.2. Advantages of the Hammer Test Method:
1. Cheap
2. Measurements can be made quickly
3. Easy to use
4. Do not damage the object

2.3. Disadvantages of the Hammer Test Method:
1. The test results are influenced by the surface flatness, concrete moisture, the properties and types of coarse aggregate, the degree of carbonization and the age of the concrete. Therefore it is important to remember that the concrete to be tested must be of the same type and condition.
2. It is difficult to calibrate the test results
3. The reliability level is low
4. Only provide information about concrete characteristics on the surface.

2.4. Collection Data:
1. Prepare a test schedule plan, prepare the equipment needed.
2. Finding data about the location of the construction detail, spatial layout and quality of construction materials during the building implementation.
3. Determine the test point.
   a. Test points for columns taken as many as 5 (five) points, each test point consisting of 8 (eight) firing points
   b. blocks are taken as many as 3 (three) test points each point consists of 5 (five) firing points
   c. floor plates taken as many as 5 (five) test points each consisting of 5 (five) firing points.
3. The Method
This research was conducted in several stages of work. It starts with the preparation of research tools and materials, material inspection, mixture planning, manufacturing of test specimens and testing of specimens. All work is carried out based on applicable regulations / standards with adjustments to existing laboratory conditions and facilities. The stages are as follows:
   a. Preparation of tools and materials
   b. Examination of material that aims to determine the characteristics of each concrete constituent material.
   c. Manufacture of test specimens consisting of: Material preparation and Printing of test specimens
   d. Test specimens using a hammer test on the test specimen plate
   e. Processing test results and drawing conclusions.

The research variable is the testing method (3 point of testing with angle 0°), the age of concrete plate curing, the method of curing (wet curing and dry curing). The number of samples of reinforced concrete slabs is 8 pieces measuring 50cm x 25 cm x 12cm.

![Figure 2. Type of hammer test that was used (CONTROL Model 58-C0181/N) [5]](image)

4. Result and Discussion
4.1. Previous Research
In 2018, previous research had been carried out on cylindrical specimens and produced a concept of concrete material products with candlenut shell waste as a gravel substitution and as an innovative building material for self-help housing construction where the resulting cylindrical concrete showed that a variation of candlenut shells of 30% had concrete compressive strength is stronger and achieves the concrete quality of K200-K225. Then, from the results of these data, it becomes the basis for consideration to make a 30% candlenut shell variation by applying it to specimens with the function as a plate structure system.
Figure 3. (a) Candle nut shell material; (b) Normal concrete slump (0%); (c) 30% Concrete variation slump

Figure 4. Printing on mold plates that have been made

Figure 5. Plates treatment with wet and dry curing methods
4.2. Variety
Based on Table 2, it can be seen that a concrete plate with a variation of candlenut shell has a lighter weight than a normal concrete variation of 0%. The difference in weight reaches 10-15%.

Table 2. Test object identification

| Test Object | Weight (Kg) | Length (Cm) | Width (cm) | Height (cm) |
|-------------|-------------|-------------|------------|-------------|
| D0-01       | 35.96       | 50          | 25         | 12          |
| D0-02       | 35.17       | 50          | 25         | 12          |
| W0-01       | 36.94       | 50          | 25         | 12          |
| W0-02       | 36.81       | 50          | 25         | 12          |
| D30-01      | 32.52       | 50          | 25         | 12          |
| D30-02      | 30.94       | 50          | 25         | 12          |
| W30-01      | 31.73       | 50          | 25         | 12          |
| W30-02      | 30.61       | 50          | 25         | 12          |

Table 3. Non-destructive concrete compressive strength test results by using Hammer Test

| Concrete Compressive Strength (average of 8 samples) | Mpa |
|-----------------------------------------------------|-----|
| D-1                                                |     |
| 0%                                                  | 18  |
| 30%                                                 | 36  |
| D-2                                                |     |
| 0%                                                  | 20  |
| 30%                                                 | 25  |
| W-1                                                |     |
| 0%                                                  | 35  |
| 30%                                                 | 36  |
| W-2                                                |     |
| 0%                                                  | 35  |
| 30%                                                 | 26  |

P1 25 10 22 24 24
P2 18 15 14 20
P3 28 10 15 24 24
Average Value 20.3 23.7 24.7 27.3

D = Dry Curing, W = Wet Curing, P = Point (Shoot Point)
Based on the results of the concrete plate testing in Table 2 and figure 6, it was found that the variation of 30% (candlenut shell variation) has a higher compressive strength value of the concrete compared to the concrete plate variation of 0% normal concrete, in the dry curing methods. Which is able to 23-27 Mpa equivalent to the quality K250-K300, while the variation of 0% has higher value in the wet curing and reaches 24 Mpa or equivalent to the quality K225-K250 (Table 1). Based on this, [1], concrete plates with a variation of 30% (both in the wet curing and dry curing) based on the class classification of concrete shows that the plates are included in class II concrete which is a class of concrete for general structural work and its implementation requires sufficient expertise.

Hammer test is not an alternative method for testing the compressive strength of concrete, but as an indicator to assess the quality of concrete [6] is correct. In reality, the hammer test is used to determine whether the test object has a uniform or precise quality. If it is found that there is no uniformity in the reading of the rebound number in the hammer test, core samples from test specimens are taken for laboratory testing regarding their suitability and quality testing or compressive strength [7].

5. Conclusion
Compressive strength of concrete slabs of 30% candlenut shell variations using a Hammer test showed that the concrete strength reached 23-27 Mpa both in wet curing and dry curing or equivalent to the quality of K250 concrete at 28 days. The results also indicate higher values compared to normal concrete slabs.

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