Value of concrete compressive strength with variation of candlenut shell applied to plate on a non-destructive test using UPV

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Abstract. Concrete began to use substitute materials to reduce the brittle nature. Substitution material is material that can replace concrete material both coarse aggregate, fine aggregate, and cement with other materials, such as Portland cement with steel slag, broken stone (coarse aggregate) with pumice and other stones. One of the benefits of the concrete material substitution method is that it can use organic waste. Organic waste can be in the form of residual production or usage, one of which is the candlenut shell which is a waste of candlenut. The candlenut shell is a new potential that can be developed and utilized even greater. Of course, it can increase the economic value of the candlenut shell which has only been known as a waste material from the candlenut. The composition of the candlenut shells are CaO, SiO2, Al2O3, MgO, H2O, Fe2O3. When all reacts, there will be residual SiO2 that has not yet reacted to form a silica derivative reaction with CSH-2 gel resulting in a denser CSH-3 gel, which will increase the cement paste and aggregate. The purpose of this discussion is to determine the compressive strength value of candlenut shell concrete at 0% and 30% variation on the plates using Ultrasonic Pulse Velocity (UPV) at 28 days. The method used is experimental by testing samples / specimens in the form of reinforced plate size of 50cmx25cmx12cm with wet curing and dry curing methods with a variation in age of 28 days. Concrete compressive strength testing is done using UPV tools. The results of this discussion are the compressive strength of 30% candlenut shell variations on the application of the plate shows that the quality of the concrete produced in the wet curing reaches 18 MPa or equivalent to the quality of the K 225 concrete and the dry curing is only 14 MPa or equivalent to the quality of K175, while the variation Candlenut shells 0% (normal concrete) reach 28 MPa on wet curing and 24 MPa on dry curing. This shows that the plate with a variation of 30% candlenut shells are still able to achieve concrete quality II for use in structural work.

1. Introduction
Concere is the main material used in a building construction. Concrete is widely used because of its advantages, namely it can be easily formed in accordance with construction needs, it is able to carry heavy load, it is resistant to high temperatures, and its maintenance cost is small or easy to maintain.

In its development, concrete began to use substitution material to reduce its brittle nature. Substitution material is a material that can replace concrete material either coarse aggregate, fine aggregate, or cement
with other materials, namely Portland cement with steel slag, split stone (coarse aggregate) with pumice rock and others. One of the benefits of the concrete material substitution method is that it can use an organic waste. Organic waste can be a result of production and usage residues, such as candlenut shells produced from candlenut waste.

Candlenut shell is a new potential that can be developed and be utilized even more. Of course, this can increase the economic value of candlenut shell which has only been known as a waste material from candlenut. In the Kemirie area of Parepare City, South Sulawesi Province, the utilization of candlenut shell waste is not optimal yet. However, the reality shows that the potential of the candlenut shell can be utilized even greater. The composition of the candlenut shells are CaO, SiO₂, Al₂O₃, MgO, H₂O, Fe₂O₃. When all react, there will be a residual SiO₂ that has not yet reacted and form a silica derivative reaction with CSH-2 gel which results in a denser CSH-3 gel that will increase the cement paste and aggregate. Based on the explanation above, it is very appropriate to say that the candlenut shells, which have been used as waste, can be used as substitutes in concrete mixtures. Based on the description, the problem in this discussion is about the concrete's compressive strength value with a variety of candlenut shells to the concrete slabs application in a non-destructive manner by using UPV.

2. Literature review
According to Mulyono (2005) [1], concrete can generally be divided into groups, namely: 11 - Concrete based on concrete class and quality that are: (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.

| Concrete Quality K (kg/cm²) | Concrete Quality fc (Mpa) |
|---------------------------|--------------------------|
| K100                      | fc 8.3 mpa               |
| K-150                     | fc 12.35 mpa             |
| K-175                     | fc 14.53 mpa             |
| K-200                     | fc 16.60 mpa             |
| K-225                     | fc 18.68 mpa             |
| K-250                     | fc 20.75 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.

According to ASTM C 494 / C494M - 05a, the type of chemical additive can be divided into seven types, namely:
1. Water reducing admixtures
2. Retarding admixtures
3. Accelerating admixtures
4. Water reducing and retarding admixtures
5. Water reducing and accelerating admixtures
6. Water reducing and high range admixtures
7. Water reducing, high range and retarding admixtures

The compressive strength of concrete is obtained from a concrete compression test which is adjusted to the hardening time of the concrete. In the regulation, the concrete compression test can be carried out for 28 days.

Crushing compressive strength of individual is the ability of the test object to withstand the compressive force or the maximum ability of the test specimen in resisting the force which causes destruction. The concrete compressive strength is influenced by several factors including:
- Type and quality of cement
- Type and surface texture of aggregate
- Treatment
- Temperature

Ultrasonic Pulse Velocity (UPV) is a method used to measure the conductivity of ultrasonic pulses that pass through a concrete [3] as seen in:

| Concrete Quality K (kg/cm2) | Concrete Quality fc (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              |

Source: SNI 03-2847-2002 [2].
The UPV test is used to indirectly test the concrete compressive strength through measuring the propagation speed of longitudinal electronic waves on concrete media. The implementation can be done in three ways, namely: (1) direct, (2) semi-direct, and (3) indirect. The way the test works is by giving longitudinal wave vibrations through electro-acoustic transducer through coupling fluid which is in the form of fat or a type of cellulose paste, which is applied to the concrete surface before the test begins. When the waves propagate through different media, fat and concrete, on the boundary of fat and concrete will occur the reflection of waves that propagate in the form of shear and longitudinal waves. Shear waves propagate perpendicular to the trajectory and longitudinal waves propagate parallel to the trajectory. Longitudinal wave is the first to reach the receiving transducer. By transducer, this wave is converted into an electronic wave signal that can be detected by the receiver transducer so that the wave travel time can be measured. The Travel time needed to propagate waves on the concrete path along L can be measured so that the wave velocity can be searched by the formula [4].

3. The method

The method used in this test is measuring the compressive strength value of concrete in a non-destructive manner by using UPV tools. The test specimen is a 50cm x 25 cm x 12cm reinforced plate with reinforcement dimensions of 8mm 2 layers. The treatments performed on the sample are wet and dry curing methods. Concrete is compressed tested at 28 days with a sample size of 3 pieces per variation and per treatment. The variety of candlenut shells used is 0% and 30% of the total coarse aggregate. Testing by using Ultrasonic Pulse Velocity (UPV) is a non-destructive test. The testing result with UPV is wave velocity (m / s) which will then be converted to compressive strength (MPa) using the following graph;

![Figure 1](image)

**Figure 1.** The figure above is an empirical relationship between the velocity of the UPV results with the concrete's compressive strength from the compressive test (crushing) results. Source: hesa.co.id.
Figure 2. Testing by using UPV which shows the wave speed (m/s).

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) Candlenut 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. Result of the compressive strength test of a candlenut shell concrete plate 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 UPV.

| 28-days variation | Concrete Compressive Strength (average of three samples) | Dry Curing | Wet Curing |
|-------------------|-------------------------------------------------------|------------|------------|
|                   |                                                       | 0%         | 0%         |
|                   |                                                       | m/s Mpa    | m/s Mpa    |
| Length of 50cm    |                                                       | 2793 24    | 967 10     |
| Length of 25cm    |                                                       | 2790 24    | 846 10     |
|                   |                                                       | 2986 25    | 1480 15    |
|                   |                                                       | 3180 28    | 1248 14    |
| Average Value     |                                                       | 2937 25    | 1135 12    |
|                   |                                                       | 3188 28    | 1873 18    |
Based on the results of the concrete plate testing in Table 3, it was found that the variation of 0% (normal concrete) still has a higher compressive strength value of the concrete compared to the concrete plate variation of 30%, both in the wet curing and dry curing treatment methods, and their difference reached ± 30%. However, the concrete plate with a variation of 30% shows the strength of the concrete with the wet curing method is able to reach 18 Mpa or equivalent to the quality of K200-225 concrete (Table 1) and the dry curing treatment reaches the strength of 12 Mpa concrete which is equivalent to the quality of K150-175 (Table 1). Based on this, according to Mulyono (2004) [5], concrete plates with a variation of 30% 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 and must be carried out under supervision experts.

5. Conclusion
Concrete plates with a variation of 30% indicate that the strength of the concrete using the wet curing method is able to reach 18 Mpa or equivalent to the quality of K200-225 concrete and it includes the classification of class II concrete which is a class of concrete for general structural works.

Reference
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