Experimental Study of Mortar Compressive Strength with Anadara Granosa Powder as a Substitute for Partial Use of Cement

A Sandjaya¹, Tavio², dan D Christianto¹

¹ Bachelor of Civil Engineering Study Program, Universitas Tarumanagara, Tomang, Grogol Petamburan, West Jakarta, Indonesia
² Bachelor of Civil Engineering Study Program, Institut Teknologi Sepuluh Nopember, Keputih, Sukolilo, Surabaya, Indonesia

* arifs@ft.untar.ac.id

Abstract. Making cement produces carbon dioxide (CO₂) gas which results in the greenhouse effect. To reduce the use of cement, alternative materials are examined. One of the raw materials for making cement is limestone. Limestone is a sedimentary rock mainly composed of calcium carbonate. Blood clams (Anadara Granosa) are tried to replace cement because they have a high calcium carbonate mineral composition. Blood clams are crushed into powder and filtered using No.325 filter. Cement is replaced by weight by 5%, 10%, 15%, and 20%. Mortar specimens in the form of cubes with a size of 5 cm. Mortar compressive strength test was carried out at 7 and 28 days. Anadara Granosa powder reacts very weakly with water and increases the initial compressive strength of the mortar. The results of Anadara Granosa mortar compressive strength test at 7 days were higher than normal mortar. The most efficient composition is indicated by cement replacement of 20%.

1. Introduction

Cement is an industrial product with limestone as the main ingredient and clay or other substitute materials. The raw material is burned until it melts to form a clinker, which is then crushed and added to a certain amount of gypsum. 7% of the production of carbon dioxide (CO₂) emissions in nature comes from cement production and every 1 ton reduction in cement production results in a reduction of 1 ton of CO₂ gas emissions [1]. Because of this, research was carried out to reduce the use of cement so that cement production needs were reduced.

Egg shells contain high calcium which can be used to replace cement. Eggshell powder is filtered using a 90 μm filter. Eggshell powder can replace cement up to 10% in the concrete mixture, more than that the compressive strength and tensile will decrease. Another additive that can increase the concrete mixture with eggshell is fly ash [2].

Limestone is a sedimentary rock mainly composed of calcium carbonate in the form of calcite minerals. The main source of calcite is marine organisms. The mineral composition of blood clams (Anadara Granosa) of West Coast of Peninsular Malaysia is calcium carbonate (CaC) more than...
98.7% and about 1.3% of composition are comprise of Magnesium (Mg), Sodium (Na), Phosphorus (P), Iron (Fe), Copper (Cu), Nickel (Ni), Beron (B), Zinc (Zn), and Silicon (Si) [3].

Research using Anadara Granosa ash as a substitute for Ordinary Portland Cement (OPC) of 4% by weight in concrete mixture showed that the resulting compressive strength was lower than normal concrete at 28 days, with curing ordinary water or brine for 7, 28, and 91 day [4].

Research using sea shells as a substitute for fine aggregates shows higher results of compressive, tensile and bending tests. The composition of the sea shell mixture is used as a substitute for fine aggregates of 20%, 40%, 60%, and 80%. From the results of the experiments, the optimum size of the fine aggregate substitute is 80%. When fine aggregates are replaced 100%, there is a decrease again [5].

Limestone should not be considered as a totally unreacted material when placed in a high pH environment with portland cement [6].

2. Research methods
Mixed plan based on SNI 03-6825-2002 Testing Methods of Compressive Strength of Portland Cement Mortar for Civil Works [7]. By using the weight of cement as a reference, the ratio of water to cement (W/C) is 0.48 and the ratio of sand to cement is 2.75. Cement used is Ordinary Portland Cement (OPC) type 1 and silica sand.

Two types of mixture are made, first is the weight of water maintained even though the weight of the cement decreases when replaced with Anadara Granosa powder and second is the weight of water adjusted to (W/C) with reduced weight of cement used when replaced with Anadara Granosa powder.

Anadara Granosa is obtained from seafood waste. Anadara Granosa is cleaned, dried (Figure 1), and crushed into powder. Then the powder is filtered using filter No. 325. The powder that passed the No. filter. 325 (<43 μm) was used instead of cement (Figure 2). The weight of cement replaced with Anadara Granosa powder is 5%, 10%, 15%, and 20% which is adjusted to the limits in EN-197-1 CEM II / A-M [8] where the composition of inorganic ingredients is 6-20%. Anadara Granosa does not go through the combustion process so it does not produce CO₂ emissions.

![Anadara Granosa which has been cleaned and dried.](image)

The mortar mixture is made into 5 cm cubes. Normal specimens (0%) and cement reduction test specimens as much as 20% each made 6 cubes were used as a comparison. The mixture of the first and second specimens for each composition was 6 cubes. The total specimens were 60 cubes. Test specimens were cured for 7 and 28 days.
Compressive strength test was carried out using ADR 3000 ELE machine with a maximum compressive capacity of 3000 KN made in England.

Figure 2. Anadara Granosa powder that passes the No. 325 filter.

3. Experimental results
The results of compressive strength of normal test specimens are shown in Table 1. The average compressive strength for 0% at 7 days is 71.6 kN or 28.64 MPa and at 28 days is 108.7 kN or 43.48 MPa. The average compressive strength for (-20%) at 7 days is 58.1 kN or 23.24 MPa and at 28 days is 80.5 kN or 32.2 MPa.

Table 1. Compressive Strength Test Results for Test Specimens Normal.

|       | 0%  |       |       | -20% |       |
|-------|-----|-------|-------|------|-------|
|       | 7 days | 28 days | 7 days | 28 days |
| Weight (gram) | Force (kN) | Weight (gram) | Force (kN) | Weight (gram) | Force (kN) |
| 263.3 | 69.8 | 265.4 | 108.2 | 243.6 | 60.2 |
| 260.6 | 68.3 | 265.5 | 112.3 | 242.8 | 55.8 |
| 270.1 | 76.8 | 257.4 | 105.7 | 245.0 | 58.4 |

The compressive strength of the test specimen for mixture 1 is shown in Tables 2 and Table 3. The average compressive strength at 7 days is 47.4 kN or 18.96 MPa for 5%, 42.3 kN or 16.92 MPa for 10%, 38.4 kN or 15.36 MPa for 15%, and 33.8 kN or 13.52 MPa for 20%. The average compressive strength at 28 days is 83.8 kN or 33.52 MPa for 5%, 76.9 kN or 30.76 MPa for 10%, 73.2 kN or 29.28 MPa for 15%, and 70.2 kN or 28.08 MPa for 20%.

Table 2. Test Results for Compressive Strength Test for Mixture 1 at 7 Days.

|       | 5%  |       |       | 10%  |       |       | 15%  |       |       | 20%  |       |
|-------|-----|-------|-------|------|-------|-------|------|-------|-------|------|-------|
|       | 7 days | 28 days | 7 days | 28 days | 7 days | 28 days | 7 days | 28 days | 7 days | 28 days |
| Weight (gram) | Force (kN) | Weight (gram) | Force (kN) | Weight (gram) | Force (kN) | Weight (gram) | Force (kN) | Weight (gram) | Force (kN) |
| 252.5 | 47.6 | 257.3 | 40.3 | 252.5 | 37.8 | 256.3 | 35.2 |
| 251.4 | 47.8 | 253.2 | 41.5 | 254.1 | 38.8 | 252.8 | 30.8 |
| 252.4 | 46.7 | 255.1 | 45.2 | 252.0 | 38.5 | 250.5 | 35.4 |
The compressive strength of the test specimens for mixture 2 is shown in Tables 4 and Table 5. The
average compressive strength at 7 days is 69.1 kN or 27.64 MPa for 5%, 67.8 kN or 27.12 MPa for 10%
, 66.9 kN or 26.76 MPa for 15%, and 64.0 kN or 25.6 MPa for 20%. The average compressive
strength at 28 days is 93.9 kN or 37.56 MPa for 5%, 88.7 kN or 35.48 MPa for 10%, 85.5 kN or 34.2
MPa for 15%, and 82.6 kN or 33.04 MPa for 20%.

4. Discussion

The results of the compressive strength of normal specimens at 7 days were higher than those of
mixture 1, but lower than the mixture 2. While the results of compressive strength at 28 days, only
mixture 2 with a composition of 20% higher. The compressive strength test results from the test
specimens for mixture 1 were lower than the mixture 2. Comparison can be seen in Figure 3 for the
test at 7 days and Figure 4 for the test at 28 days.

Anadara Granosa powder will change color to gray if soaked in water for a long time.
5. Conclusion

In this study, the results of the compressive strength test of mixtures 1 and 2 showed that Anadara Granosa powder without burning did not react well with water. The results of the compressive strength tests of normal and mixed 2, Anadara Granosa powder were able to replace cement and be efficient at a composition of 20%. Anadara Granosa powder also increases the initial compressive strength of the mortar.

![Graph Test Results Compressive Strength at 7 Days.](image1)

**Figure 3.** Graph Test Results Compressive Strength at 7 Days.

![Graph Test Results Compressive Strength at 28 Days.](image2)

**Figure 4.** Graph Test Results Compressive Strength at 28 Days.
Reference
[1] Malhotra V M 1999 Making Concrete Greener with Fly Ash Concrete International 21 (5) pp 61-66
[2] Yerramala A 2014 Properties of Concrete with Eggshell Powder as Cement Replacement The Indian Concrete Journal October pp 94-102
[3] Awang-Hazmi A J, Zuki A B Z, Noordin M M, Jalila A, dan Norimah Y 2007 Mineral Composition of the Cockle (Anadara Granosa) Shells of West Coast of Peninsular Malaysia and It’s Potensial as Biomaterial for Use in Bone Repair Medwell Journals Journal of Animal and Veterinary Advances 6 (5) pp 591-594
[4] Tarisa E, Olivia M, dan Kamaldi A 2016 Durabilitas Beton Bubuk Kulit Kerang Di Lingkungan Air Laut Jom FTEKNIK 3 (2) pp 1-6
[5] Mohanalakshmi M, Indhu S, Hema P, dan Prabba V C 2017 Developing Concrete Using Sea Shell as a Fine Aggregate International Journal for Innovative Research in Science and Technology 3 Issue 10 pp 282-286
[6] Paris J M dan Ferraro C C 2018 Evaluation of Particle Effects in Portland Cement Systems Journal of Materials in Civil Engineering 30 Issue 9 September
[7] Badan Standarisasi Nasional 2002 Metode Pengujian Kekuatan Tekan Mortar Semen Portland untuk Pekerjaan Sipil SNI 03-6825-2002 (Indonesia)
[8] European Standard 2000 Cement – Part 1: Composition, specification and conformity criteria for common cements EN 197-1 (Europe)