The effect of clamshells partial substitution of coarse aggregates on the mechanical properties of shellfish concrete (Berang)

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Abstract. This study analyzed the effect of blood clamshell substitution (Anadara granosa) on the mechanical properties of concrete, namely compressive strength and flexural strength, using clamshell material originating from the Bungkutoko island region, Abeli District and Toronipa coastal area Soropia District, Konawe Regency, Southeast Sulawesi Province. In this study, the concrete was made using blood clamshell (Anadara granosa) waste as a substitute for coarse aggregates. As a control, normal concrete was made using natural materials, namely the Moramo split and Pohara sand. The results show that partial substitution of coarse aggregates using blood clamshell concentrations of 15%, 25%, and 50% reduced the compressive strength of concrete by 11.00%, 16.20%, and 30.62% when compared to the control, respectively. Meanwhile, the respective concrete bending strength also decreased by 7.33%, 13.83%, and 32.53%. The compressive strength testing of 28 days-concrete with the shellfish compositions of 15% and 25% showed the values of 25.35 MPa and 23.87 MPa, respectively, which can be categorized as a medium-quality concrete (structural concrete). Meanwhile, the 50% shell composition had a compressive strength of 19.895 MPa, which can be categorized as a low-quality concrete (non-structural concrete).

1. Introduction
Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregates, coarse aggregates, and water or without added material to form a solid mass [1]. From these constituent materials, concrete is made to be strong and durable. It encourages studies on concrete modification, particularly in the material constituent of the concrete, while still considering the concrete’s strength and durability. Nowadays, the material requirements for concrete mixtures continue to increase along with the rapid development of infrastructure, where most of the construction materials are made of concrete. Alternative aggregate substitutes in the concrete mix either partially or as substitutes are developed to obtain new materials as part of the aggregate or as a substitute. One of the aggregate concrete mixture substitutes in the form of waste is blood clamshells (Anadara granosa) waste, which can be combined with standard aggregates. This study aimed to provide a solution in solving environmental problems by reducing the blood clam waste and developing cheaper concrete construction.

The previous study examined the effect of shellfish powder addition to the compressive strength of concrete by using coarse aggregates of Palu and fine aggregates of Mahakam sand [2]. The results show that the addition of shellfish powder to a certain level in the concrete mixture resulted in an
increase in compressive strength, optimum content of added shell powder shells reached 5.8% with compressive strength of 22.84 MPa, which was increased by 7.57% compared to the normal concrete compressive strength.

In this study, the concrete was made using blood clamshell (*Anadara granosa*) waste as a substitute for coarse aggregates. The purpose of this study was to determine the effect of partial substitution of coarse aggregates using blood clamshells on the mechanical properties of the concrete, namely compressive strength and bending strength. As a control, normal concrete was made using natural materials, namely the Moramo split and Pohara sand.

2. **Materials and method**

As a fine aggregate, this study used sand originating from the Pohara River, Konawe Regency, Southeast Sulawesi Province, while the coarse aggregate was split originating from Moramo Village, Moramo District, South Konawe Regency. Blood clams (*Anadara granosa*), which were used as coarse aggregate substitutes, were shellfish waste originating from the area of Bungkutoko Island, Abeli District, and the coastal area of Toronipa, Soropia District, Konawe Regency, Southeast Sulawesi Province. Figure 1 shows the shape and size of the blood clamshell waste, where the shapes and sizes physically resemble coarse aggregates.

![Figure 1. Blood clamshell (*Adanara granosa*) waste](image)

This study began with the preparation of blood clams, cement, and water as well as normal aggregate samples of split and sand. Then, the properties of the aggregate characteristics used were tested based on the relevant SNI method. The concrete mixture was divided into four compositions. The first composition was a normal concrete test with a composition of 100% normal aggregate (Moramo split and Pohara Sand) as the control. Meanwhile, the second, third, and fourth compositions concrete mixture substituted 15%, 25%, and 50% of coarse aggregates (Moramo split), respectively, with blood clamshells added with the fine aggregate (Pohara sand) [3,4].

Coarse and fine aggregate materials and shells used as substitutes for a portion of coarse aggregates were tested using the relevant SNI method. Meanwhile, the mix of 25 MPa concrete design quality with a water-cement ratio of 0.5 was made using the DOE (Development of Environment) method specifically for the control sample to obtain a ratio of aggregate mixture volume. Then, the volume ratio obtained was used as a basis for mixing coarse aggregate substitution material using a blood clamshell by assigning a slump test value of 6-10 cm, while the water-cement ratio values were varied.

The testing of concrete mechanical properties consisted of compressive strength and load bending strength testing. The compressive strength testing refers to SNI 1974: 1990 is regarding the method of testing of concrete with cylindrical specimens while the load was bending strength testing referred to SNI 03-4154-1996 [5,6]. The compressive strength and bending strength testing of the concrete were carried out for 28 days, with a total of 12 samples for each test.
Figure 2. Making the concrete cylinder test sample [7,8]

Figure 3. Concrete beam test specimen for bending strength test, (a). The normal concrete test specimen, (b). Specimens with blood clamshells coarse aggregate substitutions [9].

For the bending strength test, each variation of shell concentration use used three flexible beams [10]. The substitution position of the concrete shells was in the bottom layer (4.5 cm) at the base of the test specimen the appearance of the beam as shown in figure 2 and figure 3.

3. Results and discussion

3.1. Aggregate material testing results
Test results on the aggregates used in the concrete mixture are presents in table 1.

3.2. Test results for mechanical properties of concrete
Tests on the mechanical properties of concrete, namely compressive strength and bending strength of concrete after 28 days, are presents in figures 4 and 5. The results show that the use of blood clamshell waste as a partial substitution of coarse aggregates in concrete mixtures decreased the compressive strength and bending strength compared to the concrete that used normal aggregates (split and natural sand). It is by studies conducted by other researchers [11-14].

Partial substitution of coarse aggregates using blood clams with concentrations of 15%, 25%, and 50% reduced the compressive strength of concrete by 11.00%, 16.20%, and 30.62% compared to the control, respectively. Meanwhile, the respective concrete bending strength also decreased by 7.33%, 13.83%, and 32.53%.
### Table 1. Material testing results

| No. | Type            | Unit   | Sand | Split | Clamshells |
|-----|-----------------|--------|------|-------|------------|
| 1.  | Abrasion        | (%)    | -    | 31.37 | -          |
| 2.  | Unit weight     | gr/cm³ | 1.54 | 1.25  | 1.01       |
| 3.  | Clay content    | (%)    | 0.4  | 0.51  | 0.12       |
| 4.  | Bulk specific gravity |     | 2.66 | 2.64  | 2.4        |
| 5.  | SSD specific gravity |     | 2.67 | 2.66  | 2.41       |
| 6.  | Absorption      | (%)    | 0.51 | 0.38  | 0.33       |
| 7.  | Water content   | (%)    | 1.48 | 0.15  | 0.31       |

**Figure 4.** The relation between clamshells concentration and concrete’s compressive strength.

**Figure 5.** The relation between clamshells concentration and concrete’s bending strength.
3.3. Discussion

The results show that the use of blood clams (*Anadara granosa*) as a partial substitution of coarse aggregates reduced the compressive strength and bending strength of concrete. It can be influenced by several factors, including low absorption of shells, the roughness of shellfish surface, flat shells aggregate, and the slippery surface of the shells. These factors make the shells to be less resistance to friction, and they also create skid resistance (slip) on the surface when given certain stress. Furthermore, the unit weight and the specific gravity of shellfish were much lower than normal aggregates.

4. Conclusion

The use of blood clams (*Anadara granosa*) as a partial substitution of coarse aggregates reduced the compressive strength and bending strength of concrete. The compressive strength testing of 28 days-concrete with the shellfish compositions of 15% and 25% showed the values of 25.35 MPa and 23.87 MPa, respectively, which can be categorized as a medium-quality concrete (structural concrete). Meanwhile, the 50% shell composition had a compressive strength of 19.895 MPa, which can be categorized as a low-quality concrete (non-structural concrete).

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