Concrete Compressive Strength Study with *Anadara granosa* Shell Waste as a Replacement for Part of Cement

Hendramawat Aski Safarizki
Department of Civil Engineering, Faculty of Engineering, Universitas Veteran Bangun Nusantara Sukoharjo, Indonesia, Jl. Letjend S. Humardani No 1, Bendosari, Sukoharjo, Indonesia

hendra.mawat@gmail.com

Abstract. Concrete is the main component of construction materials in Indonesia. Concrete composition materials consist of cement, sand, gravel, and water. Cement production in Indonesia in fact often causes polemic in the community. The community often complains of environmental pollution resulting in the cement production process. Shellfish from various mollusks like that are available abundantly along the coastal areas in Indonesia. Blood clam (*Anadara granosa*) is one of the many shells found in Indonesian waters and is consumed by many people because of its high protein content. Shells are part of the clam that cannot be consumed so they only accumulate into household waste. Seashell waste can be an environmental problem if not handled properly. The conch shell contains lime, silicate and alumina. The aim of this study was to determine the effect of the *Anadara granosa* shell as a substitute for a portion of cement in the manufacture of normal concrete. Stages of research conducted in the form of making normal concrete without any added material, making concrete with *Anadara granosa* shell as a partial replacement for cement, and testing the compressive strength of normal concrete samples. The optimum level of *Anadara granosa* shell waste as a substitute material for a portion of normal mixed concrete cement is 3% of the weight of cement used. The optimum compressive strength of concrete with Blood Shells waste as a substitute for some cement is at 30.62 MPa. The effect of *Anadara granosa* shell as a partial cement substitute in making normal concrete can reduce the compressive strength along with the addition of *Anadara granosa* shell as a partial cement substitute.

***Keywords**: blood shells, cement, compressive strength, concrete*

1. Introduction

Concrete is the main construction material in Indonesia. Concrete composition materials consist of cement, sand, gravel, and water. Cement production in Indonesia in fact often causes polemics due to environmental pollution generated in the cement production process. Shells from various mollusks such as oysters, pearl oysters, blood oysters and green oysters are available in abundance along the coast in Indonesia. Blood clam (*Anadara granosa*) is one of the many shells found in Indonesia and is widely consumed by the community because of its high protein content. Statistics of the Ministry of Maritime Affairs and Fisheries in 2011 showed the volume of shellfish production in Indonesia, for the types of Blood Shells, Green Clams, Oysters, Scallops, Pearls, Mussels, Mussels, Abalone, and others, reaching 54,801 tons. The shellfish production target in 2015 is 233,700 tons and expected to grow 32.60% per year until 2019. The number of shells that are abundant will be proportional to the amount of shell waste [1]. *Anadara granosa* have a thick and bulging body, has parts that resemble ribs in the shell. Blood-red flesh. It lives on the bottom of coastal waters with sandy mud substrate and relatively low salinity.

Shells are an inedible part and only left to pile up into household waste. Shellfish shell waste can be an environmental problem if not handled properly. The conch shell contains lime, silicate and alumina. The composition of the compounds contained in the largest blood shells are CaCO3 of 97.13% and CaO of 54.24% [2]. Shellfish waste powder gives effect to the volume weight of the concrete. The lightest volume weight occurs in a concrete variation of 20% at 14 days [3].

The use of a combination of Bagasse Ash and Shellfish Ash as cement substitution shows the results that concrete with a combination of Bagasse Ash and Shellfish Ash has a higher compressive strength than normal concrete [4], [5], [6]. The addition of rice husk ash and shells as a substitute for a portion of fine aggregate can increase the compressive strength of concrete. From the test results it was found that the addition of rice husks and shell ash to bamboo fiber concrete will increase the tensile strength of concrete [7]. Shellfish powder can increase the compressive strength of concrete with added ingredients and can reduce compressive strength of concrete complement [8], [9], [10].

The use of shells with variations in cement demand shows the results in variations of 3% and 5% compressive strength of concrete will increase. It can be concluded that the optimum proportion of shells is 3% of the total cement demand [11].

The research carried out in the form of making a normal concrete mix design with Blood Shells as a partial replacement material for cement. Then the test is carried out to determine the compressive strength of the mixed design that has been made.

2. Methods

The study was conducted at the Construction Materials Technology Laboratory, Civil Engineering Department, Universitas Veteran Bangun Nusantara Sukoharjo. Stages of research carried out include:

1. Making normal concrete without any added material.
   Making a concrete mix design normally with fc '20 MPa then proceed with making normal concrete samples of three test cylinders measuring 15 cm in diameter and 30 cm high. Normal concrete without any added material is made as a comparison with concrete using the *Anadara granosa* as a partial replacement for cement.
2. Making concrete with *Anadara granosa* shell as a partial replacement for cement.
   As the main objective of the study, concrete with *Anadara granosa* shell was made as a partial replacement for cement. Preparation begins with the preparation of a concrete mix design with *Anadara granosa* as a partial replacement for cement. The cement material in the normal concrete mix design reduced and replaced with *Anadara granosa* waste.
3. Compressive strength testing of normal concrete and concrete samples with *Anadara granosa* as a partial replacement for cement.
   Concrete sample testing was carried out with a concrete compressive strength test instrument at the Construction Materials Technology Laboratory, Civil Engineering Department, Universitas Veteran Bangun Nusantara Sukoharjo. Tests carried out at 28 days concrete age.

Data on the compressive strength test results of normal concrete and compressive strength samples with *Anadara granosa* as a substitute for a portion of cement are recorded on the observation sheet then an analysis of the results of the tests is carried out to find out several things as follows:

a. Effect of *Anadara granosa* shells as a partial replacement material for cement in the manufacture of normal concrete.
b. Optimum levels of *Anadara granosa* waste in normal concrete mix.
c. The optimum compressive strength of concrete with *Anadara granosa* waste shells as a substitute for a portion of cement.

The implementation of research refers to the research procedure diagram as shown in Figure 1.

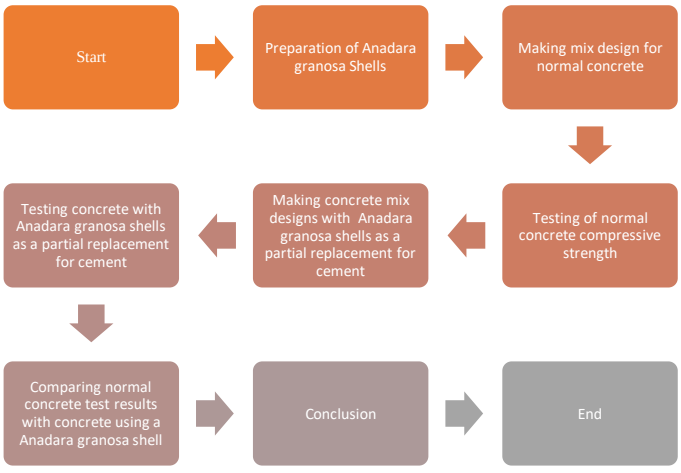

Figure 1. Research procedure diagram

3. Results and Discussion

3.1. Examination of added ingredients of Anadara granosa shell powder

Examination of added ingredients of *Anadara granosa* shell powder carried out through several stages as follows:

1. Cleaning the *Anadara granosa* shell
2. The destruction of *Anadara granosa* shell into powder
3. Separation of *Anadara granosa* shell powder gradation size
4. The last stage is testing the density of added material from *Anadara granosa* powder. Table 1 shown the density test result of added material from *Anadara granosa* powder.

Table 1. Density test result of *Anadara granosa* shell powder

No	Variable	Result
1	Relative density (Sd)	2,33
2	Relative density (SSD) (Ss)	2,48
3	Apparent relative density (Sa)	2,75
4	Water Absobsion	6,5 %

In this study, shell waste powder was substituted with cement using a ratio of the weight of cement in the mixture. The level of Anadara granosa shell waste powder used was at 3%, 5%, and & 7% of the weight of cement in the concrete mixture. The *Anadara granosa* shell powder used was weighed according to the mix design, as shown in Figure 2 before being mixed in the concrete.

Figure 2. Weighing the *Anadara granosa* shell powder

3.2. Mix Design

Concrete mix design is made so that the desired compressive strength target can be achieved. The basis for preparing the mix design is a fine and coarse aggregate testing chart. Cement needs are determined by a comparison of cement water factors and maximum cement demand. Sand and gravel requirements are determined using grading zone graphs from the results of specific gravity measurements. In this study, *Anadara granosa* shell powder was substituted with cement by using a ratio of cement weight in the mixture. Mix design can be seen in Table 2. Concrete mix design with *Anadara granosa* shell waste as a partial replacement for cement. The process of mixing concrete materials is made with a value according to the results of the mix design. The process of making concrete is shown in Figure 3 and Figure 4.

Tabel 2. Concrete mix designs using *Anadara granosa* shell waste as a partial replacement for cement.

Sample	***Anadara granosa* shell waste content**	**Volume (m^3)**	**Material requirements**				
			Water (ltr)	Cement (kg)	Fine agregat (kg)	Coarse agregat (kg)	Shell powder (kg)
BN	0 %	0,016	3,02	5,487	9,225	21,528	0
BS 3	3 %	0,016	3,02	5,322	9,225	21,528	0,165
BS 5	5 %	0,016	3,02	5,213	9,225	21,528	0,274
BS 7	7 %	0,016	3,02	5,103	9,225	21,528	0,384

Figure 3. The process of making concrete with the substitution of *Anadara granosa* powder as a substitute for cement

Figure 4. The process of making concrete cylinder samples with *Anadara granosa* shell powder as a substitute for cement

3.3. Compressive strength test with Anadara granosa shell powder as a substitute for cement

Anadara granosa shell powder is added by reducing the amount of cement in the mixture. *Anadara granosa* shell powder was added at levels 3%, 5% and 7%. When the concrete sample is 28 days old as shown in Figure 5, a compressive strength test is performed using the Compression Testing Machine (CTM). The testing process as shown in Figure 6. Recapitulation of compressive strength test results as shown in Table 3 and graphs in Figure 7 The compressive strength test results showed that the optimum compressive strength value of concrete with *Anadara granosa* powder as a substitute for cement was at the level of 3% of shell powder.

Figure 5. Concrete cylinder samples with the substitution of *Anadara granosa* powder instead of cement

Figure 6. The process of compressive strength testing of concrete with the substitution of *Andara granosa* powder instead of cement

Table 3. Concrete compressive strength test with *Anadara granosa* powder substitution as a substitute for cement

NO	Anadara granosa shell powder content	Sample	Compressive Strength (Mpa)	Average compressive strength (Mpa)
1	0%	BN-1	32,43	31,03
2	0%	BN-2	28,99	
3	0%	BN-3	31,69	
4	3%	BS3-1	31,20	30,62

5	3%	BS3-2	32,18	
6	3%	BS3-3	28,50	
7	5%	BS5-1	23,09	23,99
8	5%	BS5-2	24,57	
9	5%	BS5-3	24,32	
10	7%	BS7-1	23,83	23,50
11	7%	BS7-2	23,83	
12	7%	BS7-3	22,85	

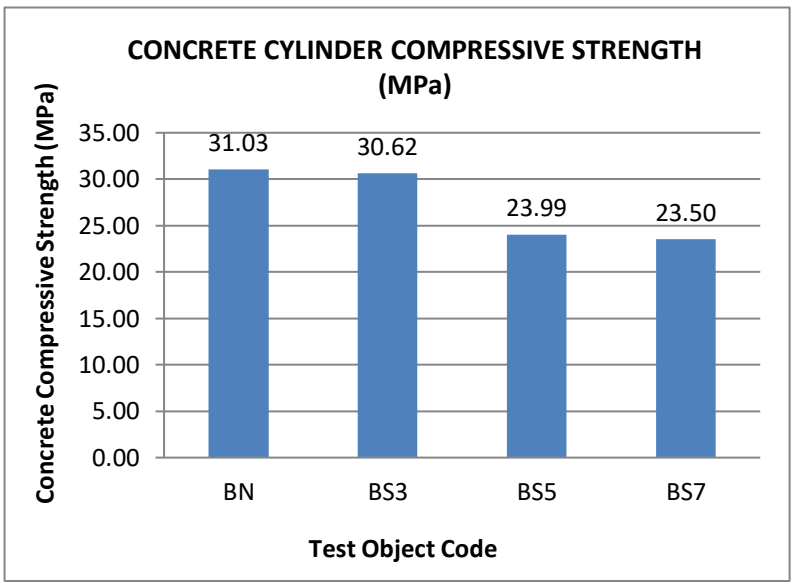

Figure 7. Graph of concrete compressive strength test results with *Anadara granosa* powder as a substitute for cement

The compressive strength value of concrete with the substitution of *Anadara granosa* powder as a substitute for cement appears to have decreased along with increasing levels of shell powder used.

4. Conclusion and Recommendation

The addition of *Anadara granosa* shell as a substitute for part of cement in the manufacture of normal concrete can reduce the compressive strength of concrete. The optimum level of *Anadara granosa* shell waste as a substitute material for a portion of normal concrete mixture cement is at 3% of the volume of cement used. The optimum compressive strength value of concrete with *Anadara granosa* shell waste as a substitute for part of cement is at 30,62 MPa. This research needs to be continued continuously, to get the grain size of *Anadara granosa's* shell waste as a partial replacement for cement in the concrete mixture. The pre-treatment process for *Andara granosa* shell waste is used in concrete mixtures. A more detailed study needs to be done to find out the proportion of *Anadara granosa* shell waste as a substitute for a portion of cement in the concrete mixture.

Acknowledgements

Authors would like to thank to Universitas Veteran Bangun Nusantara Sukoharjo who gave permission to carry out testing in the structure and material laboratory.

References

[1] Sawiji A, Perdanawati RA. Pemetaan Pemanfaatan Limbah Kerang dengan Pendekatan Masyarakat Berbasis Aset (Studi Kasus: Desa Nambangan Cumpat, Surabaya). Mar J 2017;03:10–9.

[2] Lertwattanaruk P, Makul N, Siripattarapravat C. Utilization of ground waste seashells in cement mortars for masonry and plastering. J Environ Manage 2012;111:133–41. https://doi.org/10.1016/j.jenvman.2012.06.032.

[3] Liemawan AE, Tavio, Raka IGP. Pemanfaatan Limbah Kerang Hijau (Perna Viridis L .) sebagai Bahan Campuran

Kadar Optimum Agregat Halus pada Beton Mix Design dengan Metode Substitusi. J Tek ITS 2015;4:128–33.

[4] Irawan SR. Dan Abu Kulit Kerang Sebagai Substitusi Semen Pada Campuran Beton Mutu K225. J Tek Sipil Dan Lingkung 2014;2:510–5.

[5] Putra MA. Pemanfaatan Kombinasi Limbah Abu Ampas Tebu dan Abu Kulit Kerang Sebagai Substitusi Semen pada Campuran Beton Mutu K225 dengan NaCl Sebagai Rendaman. J Tek Sipil Dan Lingkung 2014;2:413–7.

[6] Safrin Zuraidah, La Ode Adi S, Budi Hastono S. Limbah Cangkang Kerang sebagai Subtitusi Agregat Kasar pada Campuran Beton. J Chem Inf Model 2015;1:21–8. https://doi.org/10.1007/978-1-4614-7990-1.

[7] Wahyuni AS, Supriani F, Elhusna, Gunawan A. The performance of concrete with rice husk ash, sea shell ash and bamboo fibre addition. Procedia Eng., 2014, p. 473–8. https://doi.org/10.1016/j.proeng.2014.12.207.

[8] Andika R, Safarizki HA. Pemanfaatan Limbah Cangkang Kerang Darah (Anadara granosa) sebagai Bahan Tambah dan Komplemen Terhadap Kuat Tekan Beton Normal. J Media Komun Dunia Ilmu Sipil 2019;1:1–6.

[9] Olivia M, Oktaviani R, Ismeddiyanto. Properties of Concrete Containing Ground Waste Cockle and Clam Seashells. Procedia Eng., 2017, p. 658–63. https://doi.org/10.1016/j.proeng.2017.01.404.

[10] Eziefula UG, Ezeh JC, Eziefula BI. Properties of seashell aggregate concrete: A review. Constr Build Mater 2018. https://doi.org/10.1016/j.conbuildmat.2018.10.096.

[11] Siswanto R, Suyoso H, Hayu GA. Pengaruh Penggunaan Pasir Pantai Sebagai Agregat Halus dan Cangkang Kerang sebagai Subtitusi Parsial Semen terhadap Kuat Tekan Beton. J Rekayasa Sipil Dan Lingkung 2017;1:192. https://doi.org/10.19184/jrsl.v1i02.6895.