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The Effect of *Anadara Granosa* Shell Waste as a Filler and a Coarse Aggregate Subtitution on the Mechanical Properties of Normal Concrete

Afiandra R. Pratomo, W. T. Wahyuningtyas, Dwi Nurtanto, N. M. Utami
Department of Civil Engineering, Faculty of Engineering, Universitas Jember

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ABSTRACT: *The amount of stone mining as a natural resource is decrease, innovation for concrete needed to making a concrete. Anadara granosa shell waste can be used as an alternative material that can be optimally utilized to make concrete. Anadara granosa shell waste itself contains calcium which can be used as a concrete mixture. It is possible that the waste shells can be used as a substitute for gravel in concrete and as a cement filler. To analyze the effect of Anadara granosa shell waste in concrete, a cylindrical specimen was made with a diameter of 15 cm and a height of 30 cm. Mechanical tests on normal concrete include compressive strength, modulus of elasticity and split tensile strength. The percentage of gravel substitute is 0%, 1.5%, 2%, 3%, 3.5% of the weight of the gravel and the percentage of cement filler is 0%, 1%, 3%, 6%, 9% of the weight of cement. The compressive strength of the concrete plan is 30 MPa. The result of this research is that when the Anadara granosa shell waste is used at the ideal percentage, the concrete will experience an increase in the concrete's mechanical properties. The percentage of gravel substitute is 1.5% by weight of gravel and cement filler is 1% of cement weight, resulting in compressive strength of 37.37 MPa, modulus of elasticity of 28720.44 and split tensile strength of 2.95 MPa where these results exceed compressive strength. Normal concrete and the compressive strength of a predetermined plan. If the percentage of shellfish waste is greater, the mechanical properties of the resulting concrete will decrease. The results show that the mechanical properties of concrete are interrelated where the higher the compressive strength, the higher the modulus of elasticity and tensile strength.*

KEYWORDS: concrete, shell waste, mechanical properties, compressive strength, filler

INTRODUCTION

The rapid development of the era demands massive infrastructure development and the use of concrete is still the prima donna as the main material for building structures. According to Suharwanto (2005), the increasing need for concrete constituent materials triggers rock mining because one of the constituent concrete materials is coarse aggregate, where the enormous demand results in large-scale mining being carried out the decreasing number of natural resources available for concreting purposes. Concrete is a mixture of fine aggregate, coarse aggregate, cement and water. In Indonesia, many additives are used and the benefits of additional materials need to be proven by using materials that are often used in the field. The added material can modify the concrete characteristics, for example, to increase the compressive strength of the concrete, modulus of elasticity, and split tensile strength.

According to DKP (2005), shellfish have a higher percentage of shells than clam meat, about 70% shellfish and 30% meat. Shellfish is a waste that can increase economic value. The yield per hectare per year can reach 200 to 300 tons of the whole shellfish or around 60 to 100 tons of shellfish (Siregar, 2009 in Annur 2013). According to the Ministry of Marine Affairs and Fisheries (2012), shellfish production with several types of shells, namely green clams, Anadara granosas, pearl clams, scallops, and mussels is 54,801 tons. Clamshell powder gets good results and shell powder as an alternative adsorbent that is environmentally friendly because the shells consist of compounds, namely 7.88% SiO_2, 1.25% Al_2O_3, 0.03% Fe_2O_3, 66.70% CaO and 22. 28% MgO (Maryam, 2006, in Afranita et al., 2014). With CaO content in the shells, it is expected to increase the compressive strength of normal concrete. Starting from the above problems, a study was carried out "the effect of shellfish waste as a filler and coarse aggregate substitution on the mechanical properties of normal concrete".

LITERATURE

According to SNI 2847: 2013, concrete is the result of a mixture of Portland cement or other hydraulic cement, sand (fine aggregate), gravel (coarse aggregate), and water, with or without added materials (admixture). Increasing the concrete's age, the concrete will be stronger and reach design strength (f'c) at the age of 28 days. Concrete was chosen as the main structure type because it has good compressive strength and is suitable for Indonesia.

A. Fine aggregate

According to SNI 03-2834-2000, fine aggregate is natural sand due to the natural disintegration of rock or sand produced by a stone crusher.

B. Coarse aggregate

Coarse aggregate is gravel due to natural disintegration from rock or in the form of crushed stone obtained from the stone crusher industry and has a grain size between 5 mm - 40 mm (SNI 03-2834-2000). Coarse aggregate comes from natural materials in the form of hard mineral grains. Coarse aggregate is an important material to fill the volume of concrete, which is about 50% -80%.

C. *Anadara granosa*

Anadara granosa is a popular type of shellfish in Indonesia. The Anadara granosa has two shells attached. The ribs on the shell stick out and number about 19 to 23 ribs. Anadara granosas spawn throughout the year, with the peak occurring in August / September (Vitalis et al., 2016). *Anadara granosa* have a thicker shell so that they can be considered as an added material for concrete.

Table 1 Chemical content of *Anadara granosa*

Component	Content (% Weight)
Cao	66,70
SiO_2	7,88
Fe_2O_3	0,03
MgO	22,28
Al_2O_3	1,25

D. Concrete testing

1. Compressive Strength

Compressive strength in concrete is obtained from the load formula listed on the compressive test machine divided by the test object's surface area. The formula is in mathematical form as follows:

$$fc ^\wedge ' = F / A$$

2. Modulus of Elasticity

The modulus of elasticity is the slope of the elastic region's stress curve because the slope has a unit of stress divided by strain (Gere and Timoshenko, 1997). In SNI 03-2847-2019, the modulus of elasticity is the ratio of tensile or compressive stress to the strain carried out in the laboratory. The following is the formula for determining the modulus of normal concrete elasticity:

$$Ee = 4700\sqrt{(fc ')}$$

3. Tensile Strength

The indirect concrete tensile strength of the cylindrical concrete specimen is obtained from the compressive strength loading results on the test object. In the split tensile strength test, the cylindrical specimen is placed horizontally and parallel to the testing machine's pressure table surface (SNI 2491-2014). The split tensile strength formula in concrete is as follows:

$$fc ^\wedge 't = 2P / (\pi.l.d)$$

E. Previous Research

Clamshell as a filler by Supriani (2013), the percentage of variation in the addition of 2.5%, 5%, and 10% of shell ash, which may be an added material to accelerate the concrete's initial life. The test results obtained that the addition of ash by 5% gave a greater value for the compressive strength of concrete than normal concrete at the age of 3 days.

Rejeki and Karolina's research, (2013) said that the substitution of shell ash for cement was 0%, 5%, 10%, 15%, 20%. The slump test has increased due to the effect of absorption on the shells. The compressive strength results decreased by 89.18%, 74.09%, 67.87%, 64.92% from normal concrete. The results of split tensile strength are 95.96%, 92.3%, 81.7%, 75.8% of normal concrete.

Annur's research (2013) states that the addition of coarse aggregate using shells in the concrete mixture is 0%, 17%, 31%, 44%, 55% of the weight of coarse aggregate with FAS 0.42 has decreased the mechanical properties of concrete.

In previous research on coarse aggregate substitution by Zuraidah et al. (2017), the percentage variation in substitution was 0%, 1.25%, 2.5%, 3.75%, 5% of the weight of coarse aggregate with a nominal size of 38 to 5 mm and the results compressive strength reaches the lowest up to 16.608 MPa at a variation percentage of 1.25% to 5%.

METHODOLOGY

A. *Anadara granosa* Shell

This study requires shell powder as a filler and shell fragments as a substitute for coarse aggregate. To obtain materials, it is carried out:

1. *Anadara granosa* Shell Powder
    - Drying the shells for one day
    - The crushing of clamshells into powder using a sling machine
    - The powder of the shells is sieved by sieve number 200
    - Shell Shrapnel
    - Drying the shells for one day
    - Destruction of clamshells by pounding
2. The result of the shells' collision passes through sieve number 3/4 and *is* stuck in sieve number 3/8 and 4 to get a maximum size of 10mm.

B. Test Object

This study uses quality fc '30 MPa. The test object is planned using a size of 15x30cm.

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Table 2 Calculation of the number of concrete specimens for compressive strength

Samples Code	*Anadara granosa*		Total Samples (age)			Total
	Filler	Subtitution Coarse Agregate	7 days	14 days	28 days	
CK 1 T	0%	0%	3	3	3	9
CK 2 T	1%	1,5%	3	3	3	9
CK 3 T	3%	2%	3	3	3	9
CK 4 T	6%	3%	3	3	3	9
CK 5 T	9%	3,5%	3	3	3	9
Total						45

Table 3 Calculation of the number of concrete specimens for split tensile strength

Samples Code	*Anadara granosa*		Total (age)
	Filler	Subtitution Coarse Agregate	28 days
CK 1 TB	0%	0%	3
CK 2 TB	1%	1,5%	3
CK 3 TB	3%	2%	3
CK 4 TB	6%	3%	3
CK 5 TB	9%	3,5%	3
Total			15

RESULT

The research results on the effect of *Anadara granosa* shell waste as a filler and coarse aggregate substitution on the mechanical properties of normal concrete were obtained from testing in the Civil Engineering Laboratory, University of Jember.

A. Sand

Sand testing to obtain sand data that will be used for normal concrete mix purposes.

Table 4 Sand material testing

No.	Type of testing	Result	Specification
1	Sieve Analysis	Zona 2	Zona 2
2	Volume Weight	1,54 g/cm3	> 1,20 g/cm3
3	Specific gravity	2,78 g/cm3	1,60-3,20 g/cm3
4	Humidity	2,31%	1-5%
5	Water infiltration	2,60%	1-4%

B. Gravel

Gravel test to obtain gravel data that will be used for normal concrete mix purposes.

Table 5 Gravel material testing

No.	Type of testing	Result	Specification
1	Sieve Analysis	Max 10 mm	Max 10 mm
2	Volume Weight	1,38 g/cm3	1,2-3,8 g/cm3
3	Specific gravity	2,73 g/cm3	1,6-3,2 g/cm3
4	Humidity	0,11%	0-3%
5	Water infiltration	1,90%	< 4%

C. *Anadara granosa*

Treatment of the shells before being tested is carried out in the sun for one day to remove the unpleasant odor from the shells.

Table 6 *Anadara granosa* material testing

No.	Type of testing	Result	Specification
1	Sieve Analysis	Max 10 mm	Max 10 mm
2	Powder Volume Weight	1,54 g/cm3	

D. Slump Test

The slump value test aims to determine the level of workability in a certain value.

Table 7 Slump result

Code	Slump (cm)
CK1T	10
CK2T	9
CK3T	9,5
CK4T	11
CK5T	11

E. Compressive Strength

The process before the concrete compressive strength test is carried out concrete treatment according to SNI 2493-2011 concerning the procedures for making and treating concrete specimens in the laboratory. The specimens were immersed in water with room temperature ranging from 200C to 300C. According to SNI 03-2847-2002, concerning procedures for calculating concrete structures for buildings, the concrete treatment process is immersed for 7 days.

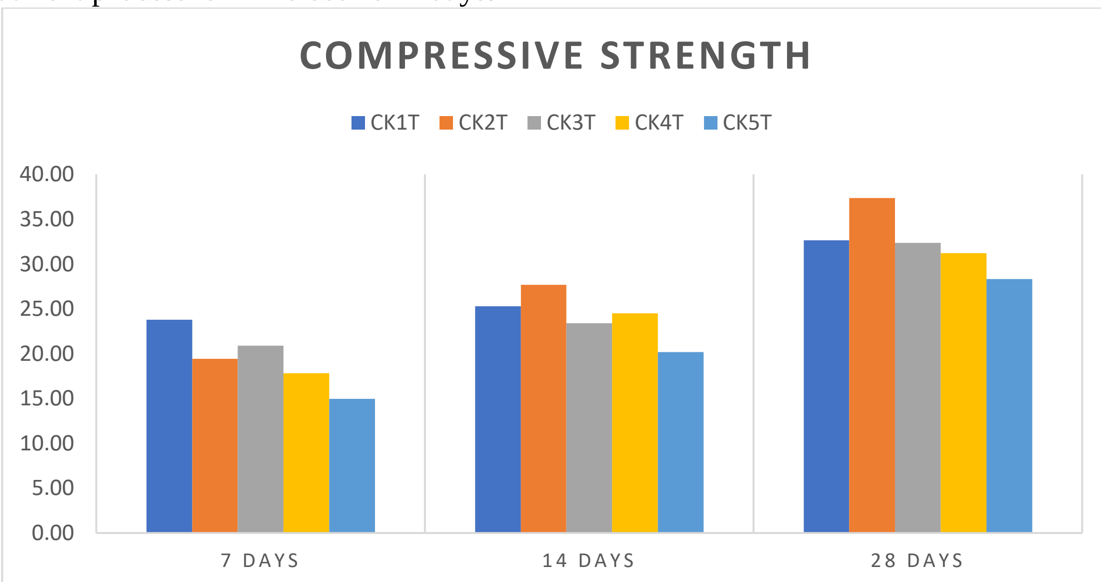

Figure 1 Compressive strength result

Based on the graphic image above, the compressive strength of normal concrete with *Anadara granosa* shells as a filler and coarse aggregate substitution occurs at 28 days CK2T concrete is 14.45% of normal concrete, then CK3T concrete has decreased by 0.87% of normal concrete. In CK4T concrete decreased by 4.05% from normal concrete and in CK5T concrete decreased by 13.38% from normal concrete. As a result, the compressive strength of concrete with excessive use can cause the concrete to become brittle because of the high hydration. According to Zuraidah (2017), the more shells used, the more impact on the decrease in concrete's compressive strength. It is recommended to use shellfish waste with a composition of 1.25% to 5% of the coarse aggregate need to achieve optimum compressive strength.

F. Modulus of Elasticity

According to Rifky (2011) the modulus of elasticity shows the ability to withstand stress under strain conditions. The results of the modulus of elasticity are obtained from the formula that refers to SNI 03-2847-2019.

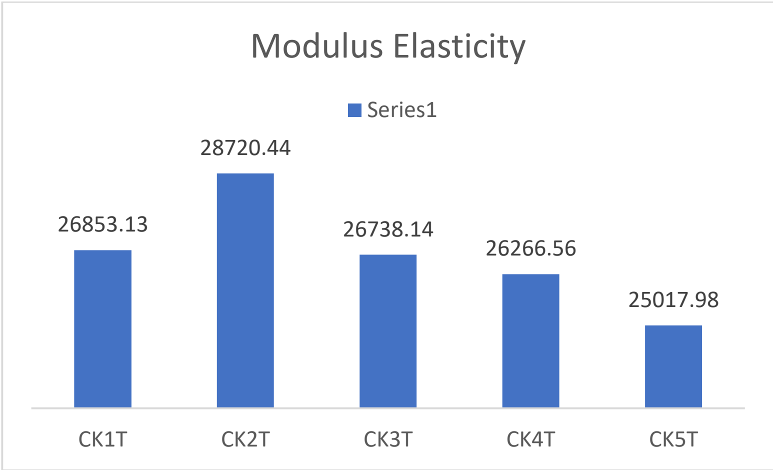

Figure 2 Modulus of elasticity result

From the results above, the modulus of elasticity results using the reference formula from SNI 03-2847-2019 on concrete so that the modulus of elasticity in concrete is affected by the compressive strength obtained by the concrete. These results indicate that the greater the mixture of *Anadara granosa* shells waste as a filler and coarse aggregate substitution, the smaller the modulus of elasticity obtained in the concrete. According to Annur (2013), from the test results data with a variable percentage of shellfish waste 0%, 17%, 31%, 44%, 55%, there is a decrease in the modulus of elasticity of concrete, this proves that the more waste shells used can reduce the modulus of elasticity.

G. Tensile Strength

The split tensile strength was performed at 28 days of concrete. The compressive strength test of concrete was carried out at the Civil Engineering Laboratory of the University of Jember using a compressive test tool.

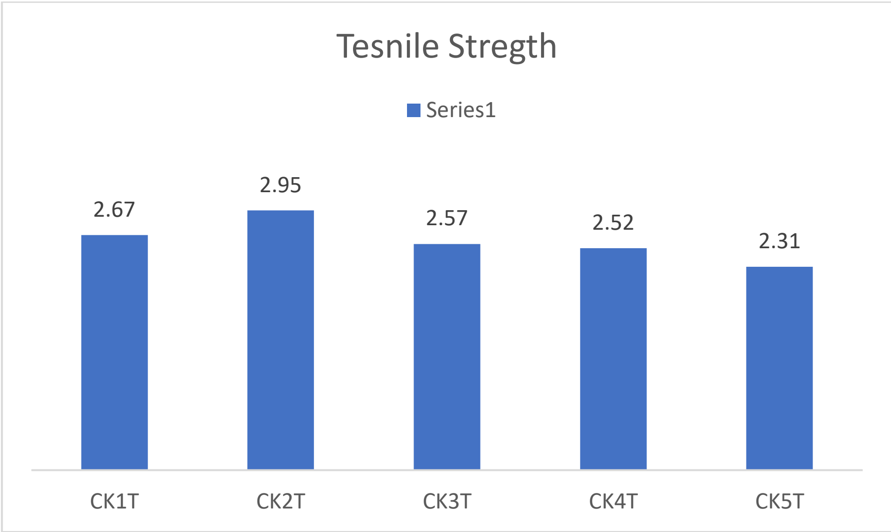

Figure 3 Tensile strength result

This results in the concrete having high workability and decreasing the split tensile strength. According to Rezeki (2013), researching the substitution of shell ash with a percentage of 0%, 5%, 10%, 15% and 20% in terms of compressive strength and split tensile strength, it was found that an increase in slump affects the decrease in compressive strength and split tensile strength. According to Annur (2013), the results obtained with a percentage of 0%, 17%, 31%, 44% and 55% of the coarse aggregate weight can reduce the mechanical properties of concrete.

DISCUSSION

A. Compressive Strength

The increase in compressive strength in CK2T concrete is due to the hydration process of the concrete achieving optimum results where the percentage of shellfish powder used works optimally. As well as the optimum use of shellfish waste which supports the compressive strength of the concrete. If the use of powder and substitution of coarse aggregate with excessive shellfish waste is also not good for the compressive strength of the concrete because the resulting compressive strength will experience a decrease in the compressive strength of the concrete. The high hydration process occurs because the CaO content in blood clam shells is 66.70%, meanwhile based on the opinion of Neville (2002) the CaO content in portland cement is in the amount of 60% to 65%. In the results, the compressive strength of concrete with excessive use can cause the concrete to become brittle because of the high hydration.

B. Modulus of Elasticity

In the modulus of elasticity of concrete with a mixture of shells, the greater the percentage of the mixture, the lower the modulus of elasticity of the concrete. This is due to the low stress received by the concrete and the resulting high strain. The modulus of elasticity of concrete depends on the concrete mix factor, but a frequent relationship is considered with the strength of the concrete.

C. Tensile Strength

The concrete's tensile strength value with the added material of *Anadara granosa* shells waste and *Anadara granosa* shell powder decreased. The high CaO content causes the concrete to experience high hydration, where the effect of high hydration is that the concrete will be brittle. Concrete with a mixed percentage of shellfish waste has a high slump value.

Implication to Research and Practice

This research can reduce the abundant shellfish waste in Indonesia and improve the existing ecosystem. Shell waste can also be used on concrete with a quality of 30 MPa where the concrete can achieve high compressive strength when using the optimum percentage of shellfish waste. impact on construction can reduce the mining of rock as a gravel which can reduce its availability in nature.

CONCLUSION

Increasing compressive strength when viewed from 7 days to the age of 28 days. At the age of 28, there is a difference in compressive strength, which is influenced by the addition of a mixture of *Anadara granosa* shells waste. Concrete with the addition of clamshell waste increased at 28 days of CK2T concrete by 14.45% of normal concrete, then CK3T concrete decreased 0.87% from normal concrete, CK4T concrete decreased by 4.05% from normal concrete, and CK5T concrete decreased by 13.38% from normal concrete. The use of optimum *Anadara granosa* shell waste will support the compressive strength of the concrete. A high hydration process occurs, which results in a decrease in compressive strength.

The modulus of elasticity using the reference formula from SNI 03-2847-2019, the results obtained in CK2T concrete increased by 6.95% from normal concrete, CK3T concrete decreased by 2.04% from normal concrete, CK4T decreased by 2.10% from normal concrete, and CK5T concrete decreased by 6.83% from normal concrete. This is due to the low stress received by the concrete and the resulting high strain.

The concrete's tensile strength at the age of 28 days with the added material *of Anadara granosa* shells waste and *Anadara granosa* shell powder decreases. The percentage of increase in CK2T concrete was 10.49% from normal concrete, CK3T concrete decreased by 3.75%, CK4T concrete decreased by 5.62%, and CK5T decreased by 13.48%.

Recommends

Based on the research results, it is necessary to increase the age of 90 days in the test to determine the effect of the mixture of *Anadara granosa* shells waste in a longer period of time. In this study, additional chemicals can reduce water use because the shells are difficult to absorb water. The basin in the shell waste can be filled with mortar. Further research is needed in the use of shellfish waste as a substitute for coarse aggregate. It is necessary to control one of the ingredients added by *Anadara granosa* shells waste as a filler and a substitute for coarse aggregate.

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