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The Potential Utilization of Candlenut Shell Waste as Coarse Aggregate Replacement in Concrete

Parea Rusan Rangan[1], M. Tumpu[2] and Mansyur[3]

[1]Associate Professor, Civil Engineering Department, University of Christian Indonesia, Toraja, Indonesia
[2]Lecturer, Civil Engineering Department, Fajar University, Makassar Indonesia
[3]Lecturer, Civil Engineering Department, SembilanBelan November University, Kolaka,Indonesia
[1]pareausanrangan68@gmail.com*, [2]tumpumiswar@gmail.com,[3]mansyurusn14@gmail.com

Abstract:

Concrete is a mixture of cement, aggregate, water and additives. Concrete is a building material that is generally used in physical construction because it is easy to form and does not require expensive maintenance costs, compared to other materials. The development of science in the field of concrete technology, allows the use of candlenut shell as a substitute for some coarse aggregate in the concrete mixture, this is because the amount of material used in the concrete mixture, especially coarse aggregate, must be limited. This research uses candlenut shell as a comparison with normal concrete with a number of different variants of candlenut shell. This research is also to determine whether or not the candlenut shell is used as coarse aggregate in the concrete mixture. The method used in the mixed design of this research is SNI (Indonesian National Standard) and ASTM (American standard testing and materials) with a compressive strength of 20.75 MPa, a maximum coarse aggregate size of 20 mm and a cube-shaped test sample with a size of 15 cm x. 15 cm x 15 cm. As for the partial replacement variation of candlenut shells to coarse aggregates, namely the residue between 5.0%, 7.5%, 10.0%, 12.5%, 15.0%, 20.0% and 25.0%. Concrete compressive strength tests were carried out at the ages of 3, 7, 14 and 28 days. The results showed that the ratio of the compressive strength of normal concrete to that of concrete using candlenut shells experienced an increase in compressive strength. Where the compressive strength of the plan at the age of 28 days is 20.75 MPa, an increase of 27.29 MPa in normal concrete, while the concrete using candlenut shells has increased by 27.93 MPa at a variation of 10%.

Keywords: *Coconut coir waste, Porous asphalt, REAM spesification*

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I. INTRODUCTION

Concrete is a mixture of its constituent materials consisting of cement, coarse aggregate, fine aggregate, water with or without added ingredients. Quality concrete if the concrete has good mechanical and resistance properties. The most important mechanical property of concrete is compressive strength. This characteristic is closely related to other characteristics, in other words if the compressive strength is high then the other characteristics are also good.

The use of crushed stone and sand, which are taken from nature, should be limited, because their quantity and availability will be increasingly limited in line with the increasing development of development. To overcome this problem, a study was conducted to find alternative substitutes for aggregate in concrete mixtures with waste components which are usually only wasted without any effort to reuse them. The waste component is candlenut shell waste.

Candlenut shell is a new potential that can be developed and utilized even more. Of course it can increase the economic value of candlenut shell which is only known as a waste material from the candlenut plant. The use of candlenut shell can later be used again to a higher level. The use of candlenut shells has only been known only in traditional ways, for example as a substitute for firewood and as a mosquito coil. But in fact, the potential of candlenut shells can be utilized even more. Candlenut shell is one of the additives or substitutes for aggregate which has recently begun to be studied for its impact on the concrete mixture. The use of candlenut shell can be treated as a partial replacement for coarse or fine aggregate depending on the size of the candlenut shell grains used.

Today there are many power plants that use coal as fuel. The byproduct of burning coal is fly ash which is classified as a pollutant. In Indonesia, to reduce waste, a number of cement factories mix fly ash and waste containing pozzolans with Portland cement clinker to produce Composite Portland Cement [1, 2] with the aim of reducing energy consumption and reducing the use of non-renewable natural sources [3]. Composite Portland Cement can be categorized as CEM II according to European standard EN 197-1: 2000, in Indonesia it was only produced in 2005, however in Europe the market share for CEM II category cement has been more than 50%, bigger than Portland Cement Type 1 which is only around 35% [4].

However there are very limited information with regard to utilization on candlenut shell as replacement coarse aggregate in concrete. Based on aforementioned backgrounds, this research aimed to analyze the compressive strength of concrete using candlenut shell as replacement of coarse aggregate.

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II. MATERIALS AND METHOD

A. Physical Properties of Aggregate

Concrete is generally composed of three main constituent materials, namely cement, aggregate, and water. In general, concrete contains about 1% - 2% air content, cement paste (cement and water) around 25% - 40%, and aggregates (fine aggregate and coarse aggregate) around 60% - 75%, respectively. Table 1 and 2 show the physical properties of coarse and fine aggregates, respectively.

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B. Chemical Components of Candlenut Shell

Table 3 shows the chemical components of candlenut shell. Candlenut (AleuritesMoluccanaWilld), is a tree that is familiar to Indonesian society. Candlenut from the encyclopedia book comes from the Maluku Islands, and Malaysia. Candlenut plant (AleuritesMoluccana) belongs to the Euphorbiaceae family. The height of the plant can reach 40 meters and the diameter of the lower stems can 1.25 meters.

TABLE I Physical properties of coarse aggregate

No.	Examination	Test results	Unit
1	Water content	1.60	%
2	Sludge content	0.80	%
3	Volume weight (loose condition)	1.40	
	Volume weight (loose condition)	1.61	
4	Bulk specific gravity	2.42	-
	Saturated surface dry specific gravity	2.45	-
	Apparent specific gravity	2.50	-
5	Water absorption	1.40	%
6	Abrasion	26.25	%

TABLE II Physical properties of fine aggregate

No.	Examination	Test results	Unit
1	Water content	2.30	%
2	Sludge content	0.51	%
3	Volume weight (loose condition)	1.30	
	Volume weight (loose condition)	1.56	
4	Bulk specific gravity	2.05	-
	Saturated surface dry specific gravity	2.10	-
	Apparent specific gravity	2.15	-
5	Water absorption	2.15	%

TABLE III Chemical components of candlenut shell

No	Component	Content (%)
1	Holoselulosa (Holosellulose)	49.22
2	Pentosa (pentosan)	14.55
3	Lignin	54.46

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4	Ash	8.73

C. Physical and Chemical Properties of Portland Composite Cement (PCC)

Some of chemical compositions and physical properties of the PCC are shown in the Table 4 and Table 5, respectively. The component oxides and physical properties meet the requirement of SNI 15-7064-2004 (Indonesia Standard for Portland Composite Cement) [5].

TABLE III Chemical components of candlenut shell

TABLE IV Component oxide of PCC

No	Oxide	Unit	SNI 15-7064-2004 [5]	PCC
1	MgO	%	6.0 (max)	0.97
2	SO_3	%	4.0 (max)	2.16
3	Loss of Ignition	%	5.0 (max)	1.98

TABLEV Physical properties of PCC

No.	Physical properties	SNI 15-7064-2004 [5]	Unit	Cement used (PCC)
1	Air content of mortar	12 max.	%	11.5
2	Fineness/Blaine meter	280 min.	m^2/kg	382
3	Expansion	0.8 max.	%	-
4	Compressive strength			
	a. 3 days age	125 min.	kg/cm^2	185
	b. 7 days age	200 min.	kg/cm^2	263
	c. 28 days age	250 min.	kg/cm^2	410
5	Time of setting (vicat test)			
	a. Initial set	45 min.	minutes	132.5
	b. Final set	375 max.	minutes	198
6	False setting time	50 min.	minutes	-
7	Heat of hydration 7 days	-	cal/g	65
8	Normally consistency	-	%	24.15
9	Specific gravity, SG	-	-	3.13

D. Testing Method of Slump and Compressive Strength Test

The design slump and compressive strength were 10 ± 2 cm and 20.75 MPa, respectively. Slump test was done according to SNI 1972 [6]. The compressive strength and static modulus were tested with according to SNI 1974-2011 (Method of test for compressive strength of concrete) [7]. Cube-shaped test sample with a size of 15 cm x. 15 cm x 15 cm, respectively.

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III. RESULTS AND DISCUSSION

A. Slump Test

The result of the slump test can be seen in Figure 1. Fresh concrete had a slump value of 11 cm with met the slump design of 10 ± 2 cm. Visual observation showed that fresh paste made with and without candlenut shell and PCC can maintain the workability and homogeneity of mixture without seggregation and bleeding occured. The obtained value from the test results of without candlenut shell concrete slump test is 11 cm while with candlenut shell concrete is 10 cm, using of candlenut shell and PCC affects the value of concrete slump.

Fig 1:Slump test

B. Compressive Strength Test

The visual observation on the cube-shape specimens showed that the surface of hardened concrete was smooth without any honeycomb and large air voids. This result showed that fresh concrete consisted of coarse aggregate, fine aggregate, PCC and candlenut shell can be poured with maintaining mixture homogeneity led to a good achievement of compaction. Table 6 shows the average 3 specimens of compressive strength results of concrete with and without candlenut shell as replacement of coarse aggregate (5%, 7.5%,10%, 12.5%. 15%, 20% dan 25%). The compressive strength test was carried out at the age of 3, 7, 14 and 28 days.

From Table 6, it can be seen that on the 3 days the average compressive strength of without candlenut shell specimens was 11.30 MPa while the average compressive strength of test objects with candlenut shells is 5%, 7.5%, 10%, 12.5%, 15%, 20% and 25% were 10.07 MPa, 10.59 MPa, 9.67 MPa, 11.21 MPa, 10.22 MPa, 11.11 MPa and 10.78 MPa, respectively. While on the 7 days the average compressive strength of without candlenut shell specimens was 15.48

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MPa while the average compressive strength with candlenut shell is 5%, 7.5%, 10%, 12.5%, 15%, 20% and 25% were 15.97 MPa, 16.40 MPa, 16.84 MPa, 16.37 MPa, 16.07 MPa, 15.24 MPa and 14.07 MPa, respectively. On 14 days the average compressive strength of without candlenut shell specimens was 21.73 MPa, while the average compressive strength with candlenut shells is 5%, 7.5%, 10%, 12.5%, 15%, 20% and 25% were 21.92 MPa, 22.39 MPa, 23.13 MPa, 22.53 MPa, 22.37 MPa, 21.52 MPa and 18.71 MPa, respectively. On the 28 days the average compressive strength of with candlenut shell concrete was 27.29 MPa, while the average compressive strength with candlenut shells is 5%, 7.5%, 10%, 12.5%, 15%, 20% and 25 % of 25.89 MPa, 26.09 MPa, 27.93 MPa and 25.67 MPa, 23.78 MPa, 21.78 MPa and 19.33 MPa, respectively.

TABLEVICompressive strength with and without candlenut shell

Age of concrete (Days)	Candlenut shell as replacement of coarse aggregate (%)/compressive strength (MPa)							
	0	5	7.5	10	12.5	15	20	25
3	11.30	10.07	10.59	9.67	11.21	10.22	11.11	10.78
7	15.48	15.97	16.40	16.84	16.37	16.07	15.24	14.07
14	21.73	21.92	22.39	23.13	22.53	22.37	21.52	18.71
28	27.29	25.89	26.09	27.93	25.67	23.78	21.78	19.33

IV. CONCLUDING REMARKS

The slump test result showed that fresh concrete had a proper workability while the hardened specimen exhibited that the mixture can mantain its homogeneity during pouring into the mould and compaction process led to achieve a good compaction result without honeycombs and large void appeared on the surface of specimens. The results of the concrete compressive strength test using candlenut shells as a substitute for some coarse aggregate that have been carried out are obtained a maximum compressive strength of 27.93 MPa at 10% replacement variation, and normal concrete which has a compressive strength of 27.29 MPa, an increase of 0.39% at the age of 28 days with a compressive strength of 20 MPa plans. The increase in the compressive strength of concrete in the laboratory test results using candlenut shells, did not show too significant or too prominent results, thus indicating that candlenut shells were not suitable for use in concrete mixtures.

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