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Effect of Use of Substituted Oil Palm Shell Boiler Ash on Cement and Substituted Glass Powder on Fine Aggregate on Concrete Compressive Strength

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Abstract

This research aims to determine the effect of palm shell boiler ash substituted in cement and glass powder substituted on fine aggregate in concrete mixes on compressive strength and slump values and to determine the usefulness of the concrete. This research used an experimental method with 9 variations of substitution materials, a total of 60 samples of cube-shaped test specimens measuring 15cmx15cmx15cm. The variation of Oil palm shell boiler substitution used is 0%, 6%, 8%, and 10%, and for glass powder substitution variation is 0%, 5%, 10%, and 15%. From the results of the compressive strength test conducted on the 7th day, the substitution of 8% Oil palm shell boiler Ash and 10% glass powder or variation E received the highest compressive strength result of 19,593 MPaWhile on the 28th day, substitution of 6% oil palm shell boiler ash and 5% glass powder or variation A received the highest compressive strength yield of 22,630 MPa.
Keywords: Oil Palm Shell Boiler Ash, Glass Powder, Concrete, Compressive Strength, Slump.

1. Introduction

Nowadays, the development of Indonesia is growing rapidly. Almost every region of Indonesia there is development, whether it is building or infrastructure development. In the construction work also does not escape the use of concrete with predefined quality. Concrete consists of a mixture of portland cement or other hydraulic cement, fine aggregate, coarse aggregate and water with or without additives, forming a solid, strong, and stable mass [7].

According to the Chatham House research institute, cement is a source of about 8% of the world's carbon dioxide (CO2) emissions which affect the greenhouse effect. A total of 0.83 tons of CO2 are issued per tonne of cement products with a clinker factor of 80%. The emission consisted of CO2 emissions from coal burning as much as 0.28 tonnes, from calcination of 0.45 tonnes and from the power plant to as many as 0.1 tonnes [1].

Other concrete mix materials are aggregates consisting of coarse aggregates and fine aggregates. The rough aggregate used is the stone rupture or gravel and the fine aggregate used is sand and obtained by mining and of course the negative impact on the environment. In connection with the negative impact of the mining process it is necessary to do solutions and innovations that can reduce the use of concrete mixed materials. The innovation of concrete mixed materials that are currently used are often environmentally friendly materials such as waste use.

Based on data from the Directorate General of Plantations in 2018, the total area of oil palm plantations in Indonesia is 14.3 million hectares, with an average growth of land area reaching 10.31% every year. The data does not rule out the possibility that palm oil waste will overflow as well. Oil palm shell boiler ash is ash produced from the remains of combustion from boiler furnaces with a temperature of 500-700 ^{0}C. According to research conducted by [3] , oil palm shell boiler ash has a silica (SiO2) content of 58.02%. When the silica content is added with a mixture of concrete, the silica content will react with free lime Ca (OH) 2 which is a weak element in the concrete to the new CSH gel. CSH gel is the main element that influences the strength of cement paste and the strength of concrete.

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Figure 1. Oil palm shell boiler ash
Source: Research data, 2020

Table 1. Chemical elements of oil palm shell boiler ash

Chemical elements	Percentage (%)
Silika Dioksida (SiO_2)	58,02
Aluminium Oksida (Al_2O_3)	8,7
Besi Oksida (Fe_2O_3)	2,6
Kalsium Oksida (CaO)	12,65
Magnesium Oksida (MgO)	4,23

Source: Hutahean, 2007

In addition to the plantation sector, activities in the industrial sector also do not escape producing waste. One of them is in the glass processing industry which produces waste from broken glass. Glass is a material made by dry silica with a basic oxide. Roughness of glass gives concrete resistance to abrasion that can only be achieved by a small amount of natural aggregate stone. Glass has special properties compared to other ceramics.

Figure 2. Glass powder
Source: Research data, 2020

Table 2. Chemical Content in Glass Powder

Chemical Content	*Clear Glass*	*Amber Glass*	*Green Glass*	*Pyrex Glass*	*Fused Silica*
$Si0_2$	73,2 - 73,5	71,0 – 72,4	71,27	81	99,87
Al_2O_3	1,7 - 1,9	1,7 – 1,8	2,22	2	-
$Na_2O + K_2O$	13,6 - 14,1	13,8 – 14,4	13,06	4	-
CaO + MgO	10,7 – 10,8	11,6	12,17	-	-
Chemical Content	*Clear Glass*	*Amber Glass*	*Green Glass*	*Pyrex Glass*	*Fused Silica*
Fe_2O_3	0,04 – 0,05	0,3	0,599	3,72	-
Cr_2O_3	-	0,01	0,43	12,0 – 13,0	-

Source: Setiawan, 2006

2. Methodology

The research method used is to use an experimental method by doing substitution or mixing material of cement from the oil palm shell boiler ash and substitution of fine aggregate from glass powder in concrete mixtures with different composition variations to obtain data and results. The independent variable (X) in this research is the oil palm shell boiler ash (X1) and glass powder (X2) while the dependent variable (Y) is the concrete compressive strength (Y). The percentage of substitution of oil palm shell boiler ash is 6%, 8%, and 10% by weight of cement. While the percentage of substitution of glass powder is 5%, 10%, and 15% of the weight of sand. This research made 9 variations of substitution materials with a total of 60 samples of cube-shaped test specimens measuring 15cm x 15cm x 15cm.

Table 3. Variations in Material Substitution

Variation of oil palm shell boiler ash (%)		Variation of Glass powder (%)	Number of Samples (7 and 28 days)
		5	6
6	+	10	6
		15	6
		5	6
8	+	10	6
		15	6
		5	6
10	+	10	6
		15	6
Total Sample + 6 Normal			60

Source: Research data, 2020

This research begins by preparing the tools and materials to be used. The equipment used in the laboratory is confirmed to be in good condition and has been calibrated. Furthermore, testing the materials in the laboratory and continuing the mix design process using Microsoft Excel software with calculations referring to SNI 03-2834-2000. Then do a trial mix and slump test. If the value of slump test has been planned, then proceed with the preparation of the test with the printed material using a cube size 15 cm x 15 cm x 15cm. After the age of concrete 24 hours then the concrete is removed from the mold and then followed by a curring by soaking a concrete sample into the tub containing water until the age of the specified concrete is 7 and 28 days before the test is carried out ompressive strength test. After the planned life of concrete arrived, then concrete removed from the tub and then carried out a strong test press and obtained the data of the strong result, then obtained the result for analysis so that the conclusion obtained.

In this research the materials used as a constituent in the concrete mixture are as follows:

a. The cement used is type 1 PPC (Pozollan Portland Cement) Cement Dynamix brand.
b. Split used in this study is Bogor broken stone.
c. Fine aggregate used in this study is bangka sand
d. The water used in this study came from the Civil Engineering Laboratotium of Mercu Buana University, Cibubur.

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e. The oil palm shell boiler ash used in this study is a waste from the palm oil processing of PT. Asia Sawit Lestari, Batanghari, Jambi.
f. The glass powder used in this research is a glass processing waste from the company PT. Aneka Kreasi Glassindo, Cawang, East Jakarta.

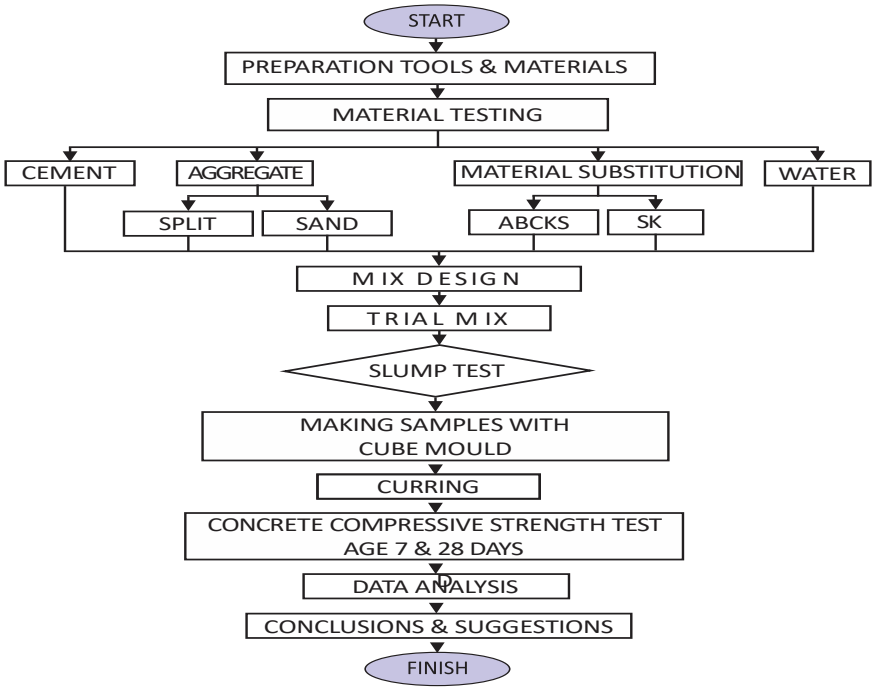

Figure 3. Research flow chart
Source: Research data, 2020

Table 4. Material requirements for 1 m^3

Material	Cement	Fine Aggregate	Split	Water
Requirements (m^3)	394	661	1079	205

Source: Research data, 2020

Table 5. Material Requirements for 60 Samples

No	Material	Requirements (kg)
1	Cement	95,8
2	Fine Aggregate	160,74
3	Split	262,26
4	Water	49,8
	Total	568,62

Source: Research data, 2020

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Table 6. Comparison of material requirements for each variation

	Variations		Cement	Fine Aggregate	Split	Water	Oil Palm Shell Boiler Ash	Glass Powder	Sample
	% Oil Palm Shell Boiler Ash	% Glass Powder	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	(Kg)	
N	0	0	1,597	2,679	4,371	0,830	0	0	6
A	0,06	0,05	1,501	2,545	4,371	0,830	0,096	0,134	6
B	0,06	0,1	1,501	2,411	4,371	0,830	0,096	0,268	6
C	0,06	0,15	1,501	2,277	4,371	0,830	0,096	0,402	6
D	0,08	0,05	1,469	2,545	4,371	0,830	0,128	0,134	6
E	0,08	0,1	1,469	2,411	4,371	0,830	0,128	0,268	6
F	0,08	0,15	1,469	2,277	4,371	0,830	0,128	0,402	6
G	0,1	0,05	1,437	2,545	4,371	0,830	0,160	0,134	6
H	0,1	0,1	1,437	2,411	4,371	0,830	0,160	0,268	6
I	0,1	0,15	1,437	2,277	4,371	0,830	0,160	0,402	6
				W/C	0,52		Total Sample		60

Source: Research data, 2020

3. Result And Discussion

a. Slump Testing

Table 7. Slump Test Results

CODE	SLUMP (CM)
N	9
A	8,5
B	8,3
C	7,9
D	7,7
E	7,7
F	7,4
G	7
H	6,9
I	6,5

Source: Research data, 2020

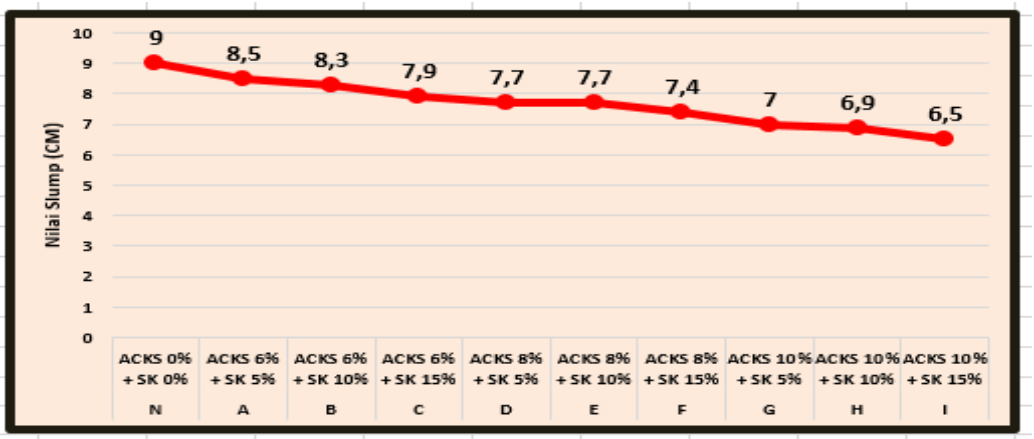

Figure 3. Graph of Slump Value
Source: Research data, 2020

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Based on the test results, it can be seen that by mixing the boiler ash of palm oil shells and glass powder causes the slump value to decrease compared to the normal concrete mixture.

b. Concrete Compressive Strength Testing

The compressive strength test in this study uses a 15x15x15 cm concrete cube, and each has 6 samples of test specimens and the average value will be taken.

Table 8. Combined Compressive Strength Test Results of All Mixed Variations

CODE	7 DAYS (MPa)	28 DAYS (MPa)
N	21,889	28,259
A	18,185	22,630
B	15,667	21,111
C	15,000	19,370
D	17,444	19,444
E	19,593	20,778
F	18,222	19,000
G	17,111	19,222
H	17,815	18,370
I	15,148	17,259

Source: Research data, 2020

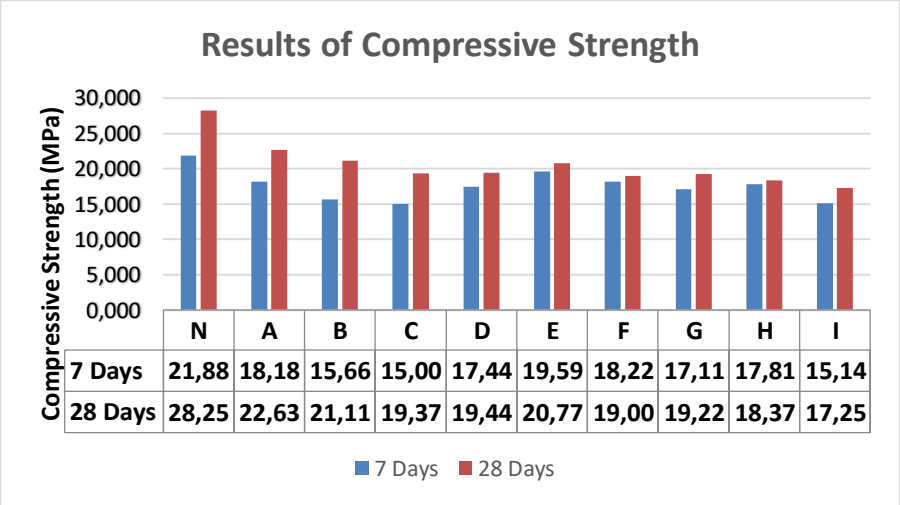

Figure 4. Histogram of Concrete Compressive Strength Results
Source: Research data, 2020

The results of the graph above show that at the age of 7 days concrete substitution of 8% oil palm shell boiler ash and glass powder 10% or variation E gets the highest compressive strength results of 19,593 MPa. While at the age of 28 days the substitution of oil palm shell boiler ash 6% and glass powder 5% or variation A got the highest compressive strength results of 22,630 MPa.

4. Conclusion

Based on the data analysis and discussion of this study related to the effect of the use of oil palm shell boiler ash substituted to cement and glass powder substituted with fine aggregate on the compressive strength value of concrete, the following conclusions are obtained:

1. Based on the results of the research, the use of oil palm shell boiler ash substituted with cement and glass powder substituted with fine aggregate has an influence on the compressive strength value of concrete. Average compressive strength results for normal concrete or without a mixture of oil palm shell boiler ash and glass powder at the age of 7 days and 28 days respectively amounted to 21,889 MPa and 28,259 MPa, whereas for concrete compressive strength results with oil palm shell boiler ash substitution and glass powder have compressive strength values below the normal concrete compressive strength.

2. Based on the results of research on the substituted concrete, it was found that concrete with a mixture of 8% of the oil palm shell boiler ash and 10% glass powder or variation E had the highest compressive strength on the 7th day of 19,593 MPa. Meanwhile, concrete with a mixture of oil palm shell boiler ash by 6% and glass powder by 5% or variation A received the highest compressive strength on the 28th day of 22,630 MPa.
3. Based on the results of the research, the use of oil palm shell boiler ash that are rearranged against cement and glass powders that are subtited against fine aggregates have an influence on the number of slump values. The number of slump in normal concrete is 9.5 cm, while the number of the slump in concrete with the subtitles of the oil palm shell boiler ash and glass powder is below the number of normal concrete slump value.
4. Based on the results of the research, the concrete that has been in the substituted with the oil palm shell boiler ash that are closed against the cement and glass powders that are substituted against the fine aggregate can be applied to the column and beam Simple building such as residential house or 2-storey building with the quality and mixture variation that has been calculated before.

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Biographies

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