

Effect of Using Bagasse Ash and Glass Powder on Concrete Compressive Strength

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Abstract

Bagasse ash is a waste from the sugar factory industry which has silica content and grain size is relatively the same as cement. Glass powder is made from industrial glass and household waste, has a silica content and grain size is relatively same as sand. The use of both wastes as concrete substitutes is expected to reduce environmental pollution and exploitation of natural resources. This study aims to determine the effect of bagasse ash as a cement substitution and glass powder as sand substitution in a concrete mixture on the compressive strength. This study uses a mixture of bagasse ash 2.5%, 5%, and 7.5% by weight of cement, and the glass powder is 5%, 10%, and 15% by weight of sand. Compressive strength testing on days 7 and 28. The results of this study are the higher percentage of substitution materials, workability will decrease. Compressive strength testing shows that all variations have resulted under normal concrete. The highest compressive strength is obtained from variation A with a mixture of 2.5% bagasse ash + 5% glass powder that is 24.50 MPa. Variation of the mixture with bagasse ash of 2.5% has a higher compressive strength than other variations on day 28.

Keywords: Environmentally Friendly Materials, Bagasse Ash, Glass Powder, Concrete, Compressive Strength of concrete

1. Introduction

Concrete is a construction material made of cement, aggregate, and water. Cement is one of the concrete material made from limestone, silica and others. Limestone is obtained by mining on limestone mountains, and over time it will damaged the environment. Cement industries is the main source of CO₂ emissions. Every year more than 4 billion tons of cement are produced and contribute as much as 8% of CO₂ in the world [3]. An increase in the amount of CO₂ give an affect for environment. One of them is green house effect, which is increasing air temperature on earth.

Concrete mixtures other than cement are sand and stone. Sand and stone can be obtained in the river. Sand and stone mining activities continuously will cause environmental damage such as a decrease in groundwater due to river water levels are declining. The use of industrial waste is a good alternative for mixing concrete.

Bagasse ash is a sugar factory industrial waste which has silica content and relatively small grain size such as cement particles so it is expected to be able to fill pore holes in concrete and result in increased compressive strength of concrete [5]. While the glass powder comes from glass industry and households waste which have a high silica content and the same grain size as sand. If the wastes are just thrown away and not recycled it will cause environmental pollution.

Previous research has been carried out on the use of bagasse ash and glass powder on concrete partially, this research will attempt to mix bagasse ash as a mixture of partial cement, and glass powder as a mixture of partially fine aggregate (sand). This research is expected to determine the effect of bagasse ash substituted with cement and glass powder substituted with sand on the compressive strength of concrete.

2. Methodology

This research used experimental method by mixing and dependent and independent variables. The independent variables in this study were bagasse ash (x_1) and glass powder (x_2), while the dependent variable was concrete compressive strength (y). Both are mixed in a concrete mixture with bagasse ash 2.5%, 5%, and 7.5% by weight of cement, and glass powder 5%, 10%, and 15% by weight of sand.

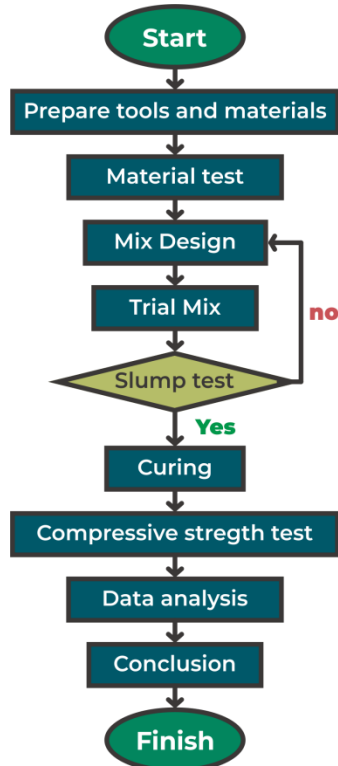


Figure 1. Flow Chart

Source: Data in research, 2019

The first steps are preparing the tools and materials needed. After that, test the material in appropriate with the testing standards. If the materials used have met the requirements, the next step is the mix design calculation. After the mix design is complete, the next step is to mix the materials. At the trial mix a slump test is required to determine the workability of fresh concrete. If the slump test meets the requirements, the concrete can be poured in a mold and wait until it is dry or ± 24 hours so the mold can be opened. This research uses concrete molds measuring 15 x 15 x 15 cm. The next step is the curing process by soaking in a tub of water until a predetermined day. The day before the compressive strength test, the concrete must be removed from the tub and dried first. Compressive strength testing is carried out on the 7th and 28th days of concrete. After all stages of testing is done, the final stage is to analyze and summarize the results of tests performed.

2. Methodology

- The bagasse ash used in this study was bagasse ash from the Madukismo sugar factory, Bantul.
- The cement used in this study is PPC type 1 cement from the Dynamix.
- The water used in this study came from the UMB Civil Engineering Laboratory.
- The sand used in this study is the sand from Bangka.
- The gravel used in this study is the sand from Bogor.

Table 1. Materials requirement of 1m³ concrete

Materials	Kg/m ³
Portland Cement	366
Water	205
Sand	618
Gravel	1149

Source: Data in research, 2019

The study was conducted with 9 variations of the mixture plus normal concrete as a controller. Each variation there are 3 samples per day. So, the total of all variations plus normal concrete is 60 samples. Here are the material requirements for a 15x15x15 cm cube mold :

Table 2. Materials requirement of 15x15x15 cube mold

VARIATIONS		PC	SAND	GRAVEL	WATER	BAGASSE ASH	GLASS POWDER
BAGASSE	GLASS	(kg)	(kg)	(kg)	(Ltr)	(kg)	(kg)
0%	0%	1.483	2.505	4.651	0.830	0.000	0.000
2.5%	5%	1.446	2.379	4.651	0.830	0.037	0.125
2.5%	10%	1.446	2.254	4.651	0.830	0.037	0.250
2.5%	15%	1.446	2.129	4.651	0.830	0.037	0.376
5%	5%	1.408	2.379	4.651	0.830	0.074	0.125
5%	10%	1.408	2.254	4.651	0.830	0.074	0.250
5%	15%	1.408	2.129	4.651	0.830	0.074	0.376
7.5%	5%	1.371	2.379	4.651	0.830	0.111	0.125
7.5%	10%	1.371	2.254	4.651	0.830	0.111	0.250
7.5%	15%	1.371	2.129	4.651	0.830	0.111	0.376

Source: Data in research, 2019

Place and time of research

Place : Structure and Material Laboratory Civil Engineering Study Program, Faculty of Engineering, Mercu Buana University Bekasi Campus D.

Time : September 2019 to January 2020.

3. Results and Discussion

Sieve Analysis of Bagasse Ash



Figure 1. Bagasse Ash

Source: Data in research, 2019

Sieve analysis on Bagasse ash aims to determine the grading of bagasse ash. Bagasse ash grain size should be equal to the size of grains of cement that passes through the sieve number 100. Here are the results of bagasse ash sieve analysis :

Table 3. Sieve analysis of bagasse ash

Sieve	Weight of Retained (gram)	Cumulative Weight of Retained (gram)	Percentage	
			Retained	Pass
No. 4	0.00	0.00	0.00	100.00
No. 8	0.00	0.00	0.00	100.00
No. 10	0.00	0.00	0.00	100.00
No. 12	0.00	0.00	0.00	100.00
No. 20	0.00	0.00	0.00	100.00
No. 40	18.00	18.00	3.60	96.40
No. 80	80.00	98.00	19.60	80.40
No. 100	32.00	130.00	26.00	74.00
No. 200	140.00	270.00	54.00	46.00
PAN	230.0	500.0	100.00	0.00

Source: Data in research, 2019

Sieve Analysis of Glass Powder



Figure 2. Glass Powder

Source: Data in research, 2019

Sieve analysis on glass powder aims to determine the grading of glass powder. Glass powder grain size should be equal to the size of grains of sand that passes through the sieve number 4. Here are the results of glass powder sieve analysis :

Table 3. Sieve analysis of bagasse ash

Sieve	Weight of Retained (gram)	Cumulative Weight of Retained (gram)	Percentage	
			Retained	Pass
9.52 (3/8")	-	-	0.00	100.00
No. 4	40	40.00	2.00	98.00
No. 8	720.00	760.00	38.00	62.00
No. 10	160.00	920.00	46.00	54.00
No. 12	150.00	1070.00	53.50	46.50
No. 20	430.00	1500.00	75.00	25.00
No. 40	260.00	1760.00	88.00	12.00
No. 80	150.00	1910.00	95.50	4.50
No. 100	30.00	1940.00	97.00	3.00
No. 200	40.0	1980.00	99.00	1.00
PAN	20.0	2000.0	100.00	0.00

Source: Data in research, 2019

Slump test (Workability)

Slump test is needed to determine the workability of the fresh concrete. The higher value of the slump of the concrete is thinner and easier to work, and if the lower, the concrete is difficult to work. In this study the planned slump value is 10 ± 2 cm.

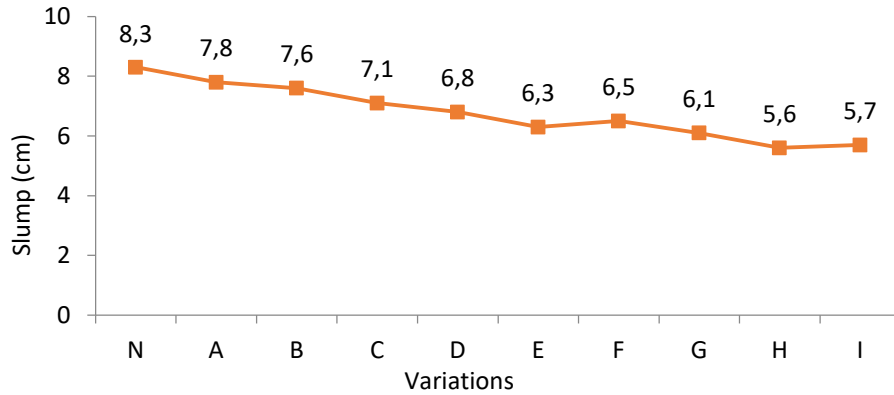


Figure 3. Slump test result
Source: Data in research, 2019

From the test results above, it can be seen that in this study the more the amount of ash and glass powder mixed, get the lower slump value. This can be seen from the graph of slump which is getting lower.

Compressive Strength Test

Compressive strength testing is done by using a compression testing machine with 6 concrete samples for each variation (3 samples on day 7, 3 other samples on day 28).

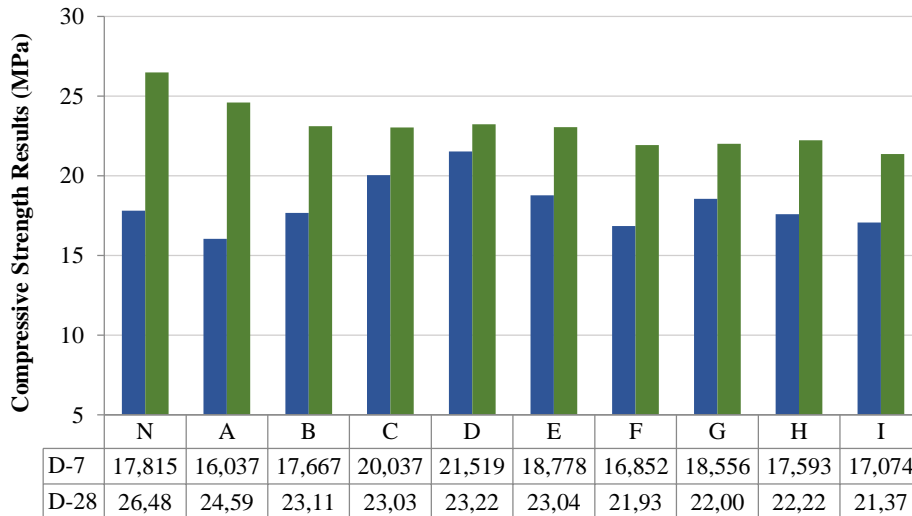


Figure 4. Histogram of compressive strength results
Source: Data in research, 2019

From the histogram, it can be seen that the highest compressive strength results on all variations on day 7 is variation D with a mixture of 5% bagasse ash + 5% glass powder with compressive strength of 21.52 MPa. Whereas on the 28th day the compressive strength of all variations that have been mixed with substitution material is under normal concrete that is 26.67 Mpa. For substituted concrete on the 28th day the highest compressive strength get from concrete A variation with a mixture of 2.5% bagasse ash + 10% glass powder with compressive strength of 24.50 MPa. On day 28 concrete with 2.5% bagasse ash mixture variation has the highest compressive strength than other variations of the mixture. These variations are variation A with a variation of a mixture of 2.5% bagasse ash + 5% glass powder get a compressive strength of 24.50 MPa, variation B with a variation of a mixture of 2.5% bagasse ash + 10% glass powder get a 23.11 MPa, a variation C with a mixture of 2.5% bagasse ash + 15% glass powder get a 23.03 MPa.

4. Conclusion

1. From testing 9 variations of the concrete mixture it can be seen that the highest compressive strength results on day 28 is 24.50 MPa, obtained from variation A with a mixture of 2.5% bagasse ash and 5% glass powder.
2. On the 28th day the compressive strength of all variations that have been mixed with substitution material is under normal concrete.
3. On day 28 concrete with 2.5% bagasse ash mixture variation has the highest compressive strength than other variations of the mixture.
4. From the results of compressive strength testing, on the 28th day all variations of the mixture get compressive strength values above 20 MPa and below 35 MPa (K250 - K400), so that in this study all variations included in the category of concrete with medium quality / category II and can be used as structural material in a construction such as reinforced concrete such as columns and beams, reinforced culverts, etc [2].
5. Concrete that has been mixed with substitution material gets a slump value below the normal concrete, the more substitution material is added the lower the value of concrete slowness / worse.

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Biographies

Syafwandi is a professor who works as an Institution of Higher Education Services in region IV West Java and Banten. Prof. Syafwandi has taken his undergraduate education at the University of Indonesia in 1984. Then continued his postgraduate or master's program at the Bandung Institute of Technology in 1988. Prof. Syafwandi has also taken his doctorate at Jakarta State University.

Latif Sulistyawan is a student from Mercu Buana University in Bekasi with a civil engineering study program. Before majoring in civil engineering, at the previous level namely Vocational High School, had taken engineering school with a major in architectural engineering at a favorite school in Yogyakarta namely Vocational High School 2 Depok, Sleman. The author graduated from the 2016 Vocational High School and then immediately entered Mercu Buana University in 2016 as well. During college, the writer was active in various campus events such as Civil Expo, Seminars, Training, etc. He was the chair of the autocad training committee in 2017 and 2018. In addition, the author was a teaching assistant in the subject of soil mechanics 2.