

Flagcrete: Fly Ash and Fine Powder Glass as a Sustainable Aggregate and Binding Agent in Concrete Hollow Blocks (CHB)

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ABSTRACT

Environmental issues such as waste management have existed for many years, where humans continue to explore waste reduction methods for sustainability. This study aims to discover a way to reuse consumer glass waste and fly ash, wastes from coal power plants, by testing its effectiveness as an alternative aggregate and binding agent for the production of hollow blocks. Hollow blocks were made from concrete mixture composed of cement, aggregates, and water. The mixture was put in a hollow block machine, where it was molded and compressed into a hollow block. It was then cured for 7 days. The coarse aggregate of each sample was replaced with powdered glass by 20%, 30%, 40% and 100% by weight, while the cement of all samples was replaced with fly ash by 20% of its weight. It was found that as the glass waste increased, the compressive strength of the hollow block also increased. Results show that the 100% glass waste for coarse aggregate had the lowest compressive strength with an average of 739 psi, and did not meet the required compressive strength for commercial use. The hollow block with 20% glass and 20% fly ash achieved the greatest compressive strength compared to the rest of the treatments except for the commercial hollow block (POSITIVE CONTROL). The results for the water absorption capacity show that all the samples are comparable with each other except for the TREATMENT 1 (20% glass and 20% fly ash).

Keywords: Aggregate, Concrete Masonry Unit, Flagcrete, Fly ash, Powder Glass

INTRODUCTION

A hollow block is a type of concrete block made using molds and is essential for constructing concrete walls of infrastructures. Fly ash is a residue from the combustion of pulverized coal and it can act as a pozzolanic material. The result of replacing a part of the cement with fly ash is that the concrete will increase in density. 20% fly ash is the optimum percentage to be used which meets the standards for load-bearing and non-load-bearing concrete masonry units [7]. There are different types of glass waste: container glass, flat glass, and demolition waste [8]. However, this study will use powdered clear container glass [3].

Waste glass is considered to be a major portion of municipal solid waste (MSW) due to its inability to degrade and it is impossible to regain energy from glass. It is reported that in the year 2014, the estimated global production of container glass was 77×10^6 t (77 million tons) [4]. Powdered glass can be used as a substitute for fine aggregates in making concrete because it was used as aggregates for mortars, the paste that is used for plastering building blocks, and it was found that there was no reaction detected in fine particle size, making it also feasible for making concrete [3]. It was discovered that the most effective replacement of aggregates by weight is 10%, 20%, 30%, and 40%. In this study, the researcher replaced the aggregate with powdered glass by 20%, 30%, 40%, and 100% of its weight [5].

Compressive strength is used to identify the strength of each hollow block; it is measured by breaking a concrete specimen in a compression-testing machine. It is computed from the failure load divided by the cross-sectional area withstanding the load and reported in units of pound-force per square inch (psi). The goal of this study is to discover the effectiveness of fine glass waste as an alternative aggregate and fly ash as an alternative binding agent for the fabrication of concrete hollow blocks. This study will contribute to improving and maintaining the sustainability of the environment through recycling used container glass and fly ash from coal power plant [6].

Because of the recycled materials, the product will reduce in cost compared to the commercial hollow blocks which will benefit the entrepreneurs, builders, and the concrete construction industry. This study also aims to produce hollow blocks with recycled materials that can withstand stress like earthquakes and typhoons.

A. Methods and Experimental Details

Concrete Production

In making the hollow blocks, 20%, 30%, 40%, and 100% of the weight of coarse aggregate (gravel) was replaced with powdered glass waste while 20% of the weight of the cement was replaced with fly ash. The dry components which were cement, fly ash, powdered glass, fine and coarse aggregates, were premixed, then water was added. Once it was mixed thoroughly, this concrete mixture was compressed and molded using a hollow block molding machine. The molded concrete was left to dry and cure for 28 days

Figure 1. Production of Sample Hollow Blocks



Compressive Strength Test

After the 28-day curing period, the samples were sent to Megatesting Center GenSan for the examination of compressive strength. A hollow block was placed on a machine and pressed until it showed cracks and breakage, to determine the compressive strength of each sample. Three replicates of each sample were made: 20%, 30%, 40%, 100% glass waste respectively, wherein all of which has 20% fly ash.

Figure 2. Compressive Strength Testing



Water Absorption Capacity Testing

The samples were brought to the J-Trade Construction and Concrete Products to test the water absorption capacity of each. Three replicates of each sample were tested out including the 500psi positive control samples, having a total of 15 hollow blocks to be tested. The replicates were submerged in water for 24 hours to get the results of the water capacity load.

Figure 3. Water Absorption Testing



RESULTS AND DISCUSSION

Compressive Strength Test

Table 1 presents the results of the compressive strength test. Results show that not all samples passed the required compressive strength for commercial use and were stronger than an ordinary 500 psi commercial hollow block. The hollow block with 100% glass and 20% fly ash (TREATMENT 4) showed the lowest average compressive strength and doesn't pass the required compressive strength for commercial use, while the normal hollow block (POSITIVE CONTROL) has the highest compressive strength exceeding the average by 408 psi. Hence, the POSITIVE CONTROL showed the highest observed compressive strength.

TABLE 1 Results of Compressive Strength Test

Sample	Unit	Compressive Strength
Positive Control	#1	801
	#2	1095
	#3	961
TREATMENT 1 (20% glass, 20% fly ash)	#1	961
	#2	694
	#3	1068
TREATMENT 2 (30% glass, 20% fly ash)	#1	988
	#2	908
	#3	534
TREATMENT 3 (40% glass, 20% fly ash)	#1	454

	#2	614
	#3	507
TREATMENT 4 (100% glass, 20% fly ash)	#1	534
	#2	400
	#3	481

Water Absorption Capacity

The table presents the mean and standard deviation of the average of each type of hollow block. The mean of the commercial type hollow block (POSITIVE CONTROL) without intervention was 10.0000 and has a standard deviation of 0.00000. The hollow block with 20% glass (TREATMENT 1) has a mean of 6.6667 and a standard deviation of 2.88675. The 30% glass (TREATMENT 2) has a mean of 10.0000 and a standard deviation of 0.00000. The 40% glass (TREATMENT 3) has a mean of 10.0000 and a standard deviation of 0.00000. The 100% glass (TREATMENT 4) has a mean of 10.0000 and a standard deviation of 0.00000. The total mean of all samples was 9.3333 and the standard deviation was 1.75933. All of the samples had the highest observed water absorption.

Table 2 Results of Water Absorption Test

	Treatments	N	Mean	Std. Deviation
Water Absorption	T1	3	6.6667	2.88675
	T2	3	10.0000	.00000
	T3	3	10.0000	.00000
	T4	3	10.0000	.00000
	PC	3	10.0000	.00000
	Total	15	9.3333	1.75933

Cost-benefit Analysis

The table on the screen shows that the substitution of fly ash to the cement and crushed glass waste to the aggregate affects the costing of each hollow block depending on its ratio. The FLAGCRETE 4 or the 100% glass has the lowest cost per piece with a difference of PHP 2.07 compared with the commercial hollow block.

Table 3 Results of Cost-benefit Analysis

Type of Hollow Block	Total Cost Per Piece (PHP)
Commercial	9.61
FLAGCRETE 1	8.20
FLAGCRETE 2	8.13
FLAGCRETE 3	8.03
FLAGCRETE 4	7.54

CONCLUSION

The results of this research show that powdered glass waste and fly ash can be effective as an alternative aggregate and binding agent for making hollow blocks. However, it is observed that the hollow blocks without the powdered glass and fly ash as alternative components showed greater compressive strength compared to treatments with alternative components, which implies that each treatment passed the targeted compressive strength of a hollow block except the treatment with 100% powdered glass and 20% fly ash. It is also observed that all samples except for the TREATMENT 1 (20% glass and 20% fly ash) showed comparable water absorption capacity. Therefore, powdered glass and fly ash as alternative aggregate and binding agents are feasible in making hollow blocks and have a great chance to be accepted for commercial use.

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REFERENCES

1. A.L.A. Fraay, J. B. (1989, January 23). The Reaction of Fly Ash in Concrete. A Critical Examination. *Cement and Concrete Research*, 19(2), 235-246. Retrieved 2020
2. Anna W. Larsen, H. M. (2009). Recycling of Glass: Accounting of Greenhouse Gases and Global Warming Contributions. *Waste Management & Research*. doi: <https://doi.org/10.1177/0734242X09342148>
3. Bearing capacity. (2019, August 16). Retrieved March 11, 2021, from <https://www.iadc-dredging.com/subject/dredging-terminology/bearing-capacity/>
4. Bhople, A. (2021, March 11). What is coarse aggregate: Requirements of good coarse aggregates: Uses of coarse aggregates: Classification of the aggregates. Retrieved March 12, 2021, from <https://civiljungle.com/coarse-aggregate/>
5. Binding agent. (2020, November 16). Retrieved March 11, 2021, from https://www.designingbuildings.co.uk/wiki/Binding_agent
6. Britannica, T. Editors of Encyclopaedia (2020, October 15). Recycling. *Encyclopedia Britannica*. <https://www.britannica.com/science/recycling>
7. Fraay, A.L.A., Bijen, J.M. and de Haan, Y.M. (1989) The Reaction of Fly Ash in Concrete a Critical Examination. *Cement and Concrete Research*, 19, 235-246. [https://doi.org/10.1016/0008-8846\(89\)90088-4](https://doi.org/10.1016/0008-8846(89)90088-4)
8. Larsen, A.W., Vrgoc, M., Lieberknecht, P. & Christensen, T.H. (2009). Diesel consumption in waste collection and transport and its environmental significance. *Waste Management & Research*. DOI: 10.1177/0734242X08097636.
9. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw-Hill Education.
10. Mindess, S., Young, J. F., & Darwin, D. (2003). *Concrete* (2nd ed.). Prentice Hall.
11. Neville, A. M. (2011). *Properties of concrete* (5th ed.). Pearson Education Limited.
12. Shi, C., Wu, Y., Riefler, C., & Wang, H. (2005). Characteristics and pozzolanic reactivity of glass powders. *Cement and Concrete Research*, 35(5), 987–993. <https://doi.org/10.1016/j.cemconres.2004.05.015>
13. Siddique, R. (2008). *Waste materials and by-products in concrete*. Springer.
14. Thomas, M. (2013). *Supplementary cementing materials in concrete*. CRC Press.