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Characteristics Of Compressive Strength According To The Content Of Fine Aggregate Replacement Beads

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ABSTRACT

Recently, concrete industry is concentrating on researches regarding on alternative aggregates to solve the two major problems of depletion of natural resources and environmental pollutions. In this study, the potential use of glass, plastic, and steel beads as an aggregates substitute was reviewed, and the compressive strength and fracture mode of concrete according to the material substitution ratio (0%, 5%, 15%, 30%, and 50%) was investigated through experimental tests. Each material seems to have optimal mixing ratios that give maximum compressive strength, and although it was slightly different depending on each mixing ratio, in general, the compressive strength decreased in the order of steel, glass, and plastic .

INTRODUCTION

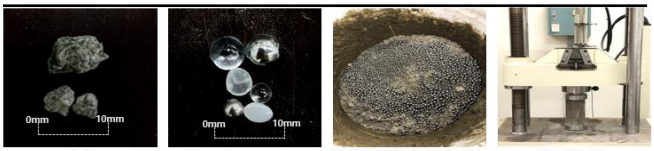
Since its first use, concrete has been widely used all over the world compared to other materials due to its economical and durable advantages. However, the amount of aggregate, the main material of concrete, is limited because it is a natural resource. In addition, a large amount of carbon dioxide is emitted during the manufacturing process, which is the main culprit of environmental pollution. Existing studies have confirmed the suitability of aggregates when properly mixing waste glass and waste plastics, but it is difficult to generalize because the waste recycling process is different from each individual waste. Therefore, in this study, the strength of concrete according to the replacement rate of glass, plastic, and steel, which replaces the existing concrete aggregate, was tested and used for future research on alternative aggregate.

EXPERIMENT AND METHOD

The size of the concrete specimen was manufactured in a cylindrical form of 100mm × 200 mm, demolded 1 day after casting, and cured in a water tank with a water temperature of 20±2 °C. Compressive strength was measured through a UTM tester. The maximum size of thick aggregate and fine aggregate replacement beads is 10mm and 5mm, respectively, in accordance with the cylinder size and the size of the fine aggregate classification criteria. Two identical specimens were prepared for each mixing ratio(0%, 5%, 15%, 30%, 50%) with reference to the previous study.

Table. 1 Standard Mix Ratio (kg/㎥)

	Cement	Water	Coarse Aggregates	Fine Aggregates
PLAIN	384	179	1039	695



(a) Aggregates used in specimen (b) Mixed with Steel Beads (c) UTM Test

Fig. 1 Image of Specimen and Experiment

RESULTS

Table. 2 Compressive Strength(MPa)

Specimen	Compressive Strength(MPa)		Average (MPa)	Standard Deviation	Number
PLAIN	28.5	22.2	25.35	3.47	2
GBA5	23.9	21.5	22.7	1.29	
GBA15	23.9	22.5	23.2	0.75	
GBA30	23.1	20.2	21.65	1.57	
GBA50	23.5	21	22.25	1.36	
PBA5	22.4	20.2	21.3	1.17	
PBA15	22.5	19.6	21.05	1.65	
PBA30	20.5	19.7	20.1	0.46	
PBA50	19.7	18.7	19.2	0.55	
SBA5	29.3	27.3	28.3	1	
SBA15	26.8	26.2	26.5	0.3	
SBA30	27.3	25.8	26.5	0.7	
SBA50	24.9	22.3	23.6	1.3	

*GBA (Glass Beads Aggregate), PBA (Plastic Beads Aggregate, SBA (Steel Beads Aggregate)

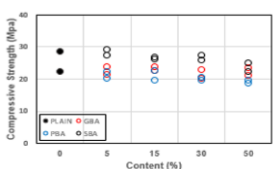


Fig. 2 Compressive Strength by Mix Ratio

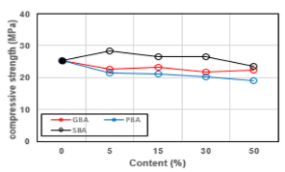


Fig. 3 Average of Compressive Strength

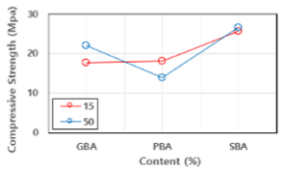
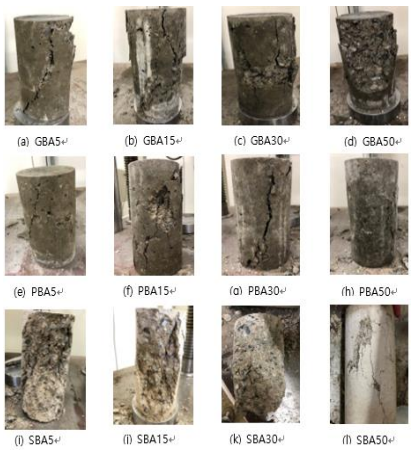


Fig. 4 Compressive Strength by Material

- For glass beads, the decrease in compressive strength was the smallest as the replacement ratio increased, and the strength decreased by 12.3% at the 50% replacement ratio. In the case of plastic beads, the compressive strength continued to decrease as the replacement ratio increased, and the average compressive strength decreased by 24.3% at the 50% replacement ratio.
- Unlike the GBA and PBA experimental test, the steel beads specimen showed a tendency to increase in compressive strength up to a replacement ratio of 30%, and the strength decreased by only 6.9% even at a 50% replacement ratio.

FAILURE MODE



In a specimen with a mixing ratios of 15% and 30%, it was completely split and destroyed. In addition, the PBA50 and SBA50 specimens exhibited a phenomenon in which the outer surface fell off rather than split.

In the case of plastic, it was found that the surface was smooth and the adhesion to the cement paste was very low, so that it was split and the inner beads fell at the same time.

Fig. 5 Failure Mode of Specimen

CONCLUSION

- When glass beads are used as a substitute for fine aggregates, the decrease in compressive strength of concrete is the lowest among the three substitutes, which is thought to be due to their similar material properties.
- In case of plastic beads specimen, the decrease in compressive strength was the largest, which is due to the lower strength and density of plastic material itself. Similar results were also obtained in recent experiments by many other researchers.
- Steel bead specimens appear to increase in strength due to their higher density. However, their strength decreases with the replacement ratio because beads are all hollow sphere.

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