A STUDY ON THE MECHANICAL PROPERTIES OF STEEL FIBER REINFORCED WATER-PERMEABLE CONCRETE FOR PAVEMENT USING INDUSTRIAL BY-PRODUCTS

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1. Introduction

Recently, it has become difficult to collect aggregates for construction materials and to develop new quarries as the laws related to natural environment preservation have recently been toughened. So this study is being performed on recycling industrial by-products to attempt to reduce environmental problems and increase the effective use of resources. In Korea 16,810,000 tons of slag was generated in 2005, most of which was used as landfill or simply used in the base course or sub-base course of roads [1]. There are insufficient natural aggregate resources, technology that uses the slag as an aggregate for concrete in secondary products and road pavements needs to be developed in order to more efficiently use Korea's limited resources and ensure the protection of the environment [2].

Therefore, this study examines the applicability of slag aggregate and fly ash to water-permeable concrete for paving. It also investigates and analyzes the mechanical properties of the water-permeable concrete according to Water-Permeable Cement Concrete for Paving Standards (Compressive strength : 18MPa, Permeability coefficient : 0.01cm/sec, The Korea Housing Corporation) and Research Committee's Report on the Establishment of Design and Construction Method for Porous Concrete (Flexural strength : 4.5 MPa, Permeability coefficient : 0.01cm/sec, JCI) [3] [4].

2. Materials and Method

2.1 *Materials and Mix Proportion*

The cement used for this study was Ordinary Portland cement with a density of 3.14g/cm^3 and a blaine fineness of 3,200cm^2/g. Slag aggregate with a grain size of 5~13mm, manufactured by "D" company in Korea was used in this study. The fly ash was used to improve the strength and durability of the water-permeable concrete use. And hooked steel fibers made from stainless steel were used.

In order to analyze the physical and mechanical properties according to the mix proportions, the water-binder ratio and design void ratio were set. Also steel fiber was mixed in the concrete to increase its strength, durability and toughness.

Table1 Mixing proportions of water-permeable concrete

Mix No.	W/B (%)	Void (%)	Steel fiber (vol.%)	Slag aggregate (vol.%)	Fly ash (wt.%)
Plain-1	25	10	0	0	0
Plain-2			0.5	0	0
Series 1			0.75	0	0,5,10,20
Series 2				30	
Series 3				50	
Series 4				100	

2.2 *Experiment Method*

The permeability coefficient was measured in accordance with Testing Method for Permeability of Porous Concrete (JCI). The compressive strength test and the flexural strength test were taken in accordance with the KS F 2405 and KS F 2408. The abrasion resistance was measured in accordance with KS F 2508.

3. Experiment Results and Discussion

3.1 *Permeability Coefficient*

The permeability coefficient increased as the mixing ratio of the slag aggregate increased regardless of mixing fly ash. In addition, when fly ash was used at ratios of 5%, 10%, and 20%, the permeability coefficient of water-permeable concrete tended to diminish by approximately 1.95~9.85% according to the increase of the fly ash mixing ratio.

Fig. 1 Permeability coefficient according to the slag aggregate and fly ash content

3.2 *Strength Properties*

The compressive strength decreased by approximately 4.93%, 11.21%, and 21.07% compared with when the slag aggregate was mixed at 30%, 50%, 100%. As the fly ash mixing ratio increased, the compressive strength increased by 0.7~4.2%, 1.5~3.6%, and 0.1~6.4% compared with when the fly ash was not used. However, it was also observed that the rising rate of compressive strength decreased when the fly ash mixing ratio was greater than 10%.

The flexural strength was 4.85, 4.62, 4.48, and 4.42 MPa as the slag aggregate mixing ratio was increased, showing a tendency to decrease with an increase in the slag aggregate mixing ratio. However, it was observed that the flexural strength tended to become greater as the fly ash was mixed into the water-permeable concrete, meeting the required value of 4.5 MPa and greater, if more than 5% of the fly ash was mixed even when the slag aggregate was mixed at 50%. When the steel fiber was mixed by 0.5 vol.% and 0.75 vol.%, the flexural strength increased by 17.6% and 22.8%, respectively, compared with the plain mix.

Fig. 2 Strength according to the slag aggregate and fly ash content

3.3 *Abrasion Resistance*

As shown in Figure 3, as the slag aggregate mixing ratio increased to 30%, 50%, and 100%, the weight loss rate due to abrasion increased by 7.5~22.8%. As the fly ash mixing ratio increased to 5%, 10%, and 20%, the weight loss rate resulting from the abrasion tended to decrease by 1.5~2.9%, 3.8~5.6%, and 6.9~12.0%, respectively, compared with when the fly ash was not used. For the effect of the fly ash on the abrasion resistance, it was thought that the abrasion resistance improved because the toughness of the bonding material became greater as the quantity of bonding material was increased due to the difference in density between the cement and fly ash.

Fig. 3 Weight loss according to the slag aggregate and fly ash content

4. Conclusion

(1) The permeability coefficient of water-permeable concrete was 0.130~0.187cm/sec, which meets the Korean domestic and international requirement (greater than 0.01 cm/sec) for the permeability coefficient of water-permeable cement concrete.

(2) As mixing ratio of fly ash and slag aggregate increased, compressive and flexural strength of the water-permeable concrete increased. And these satisfy the values of 18 MPa (Korean domestic standards) and 4.5 MPa (JCI).

(3) From the above experiment results, it is thought that is possible to produce economic water-permeable concrete for paving that will simultaneously satisfy the permeability, specified strength, and durability standards, even if the fly ash and slag aggregate were mixed by approximately 10% and 50%, respectively.

5. Acknowledgment

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6. References

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