A STUDY ON SELECTION OF THE MIX PROPORTIONS OF ULTRA-HIGH STRENGTH STEEL FIBER-REINFORCED CEMENTITIOUS COMPOSITES

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1. Introduction

Recently, numerous fiber-reinforced cementitious composites have been developed. Especially, ultra-high strength steel fiber-reinforced cementitious composites (ultra-high strength SFRCC) presenting compressive strength superior to 100MPa have been elaborated and are receiving keen interest. Despite of its outstanding performances, the active implementation of ultra-high strength SFRCC is still timid. This situation can be explained by numerous factors but the most determining one is the limited information concerning the mix proportions of ultra-high strength SFRCC which obstructs its economical production. In addition, even if it seems advisable to exploit materials being produced in the neighborhood of the construction field for its viable production, researches investigating systematically the effects of such materials on the characteristics of ultra-high strength SFRCC remains poorly initiated.

Therefore, this study aims the development of ultra-high strength SFRCC that can reach a target compressive strength of 180MPa through the analysis of the effects of the components of the matrix on the strength characteristics.

2. Experimental program

2.1 Materials and mix proportion

The materials used in the study are cement (OPC, density 3.14g/cm^3), silica fume(fineness 240,000cm^2/g, density 2.10g/cm^3), sand(A: density 2.62g/cm^3, mean diameter 0.3-0.5mm, B: density 2.62g/cm^3, mean diameter 0.17-0.3mm), filling powder(A: mean diameter 100μm, B: mean diameter 10μm), superplasticizer(polycarboxylic ether), steel fiber (L13mm×D0.2mm). Table 1 summarizes the mix proportions of ultra-high strength SFRCC.

Table 1 Mix proportion of ultra-high strength SFRCC (by weight)

OPC	W/B	SF	S	F	SP	STF
1	0.16 ~0.24	0 ~0.35	1 ~1.3	0 ~0.3	0.016	0.2

2.2 Test method

Six specimens for compression test purpose have been manufactured using a 50×50×50mm mold and the compressive strength is the mean value of the 6 specimens. The treatment of the specimens processed by the execution of wet-curing during 1 day under temperature of 20℃ and relative humidity of 65%, followed by stripping, then water curing at high temperature of 90±2℃ during 4 days to finish with curing under relative humidity of 65% and temperature of 20℃ during 2 days. The compressive strength was measured after the process.

3. Test results and examination

Fig. 1 illustrates the effect of the content of silica fume on the compressive strength. The maximum strength is observed for a silica fume content of 0.25, and, for larger ratios, the strength decreases to reach an adequate content of silica fume between 0.2~0.3.

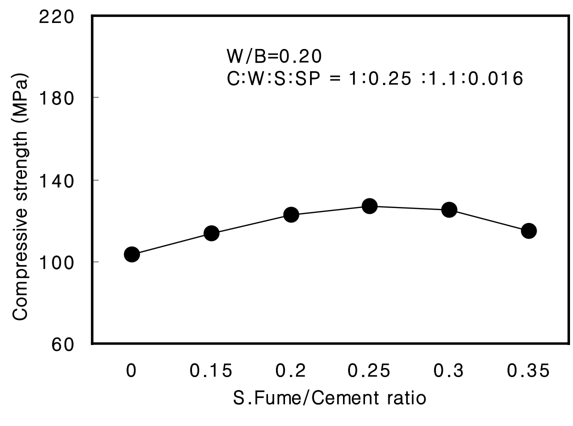

Fig.1 Compressive strength according to content of silica fume

Fig. 2 show the effects of the aggregates on the strength of ultra-high strength SFRCC. The largest strength is observed for an aggregate to cement ratio of 1.1. The most favorable strength increase is obtained for a composition of 70% of aggregate A and 30% of aggregate B.

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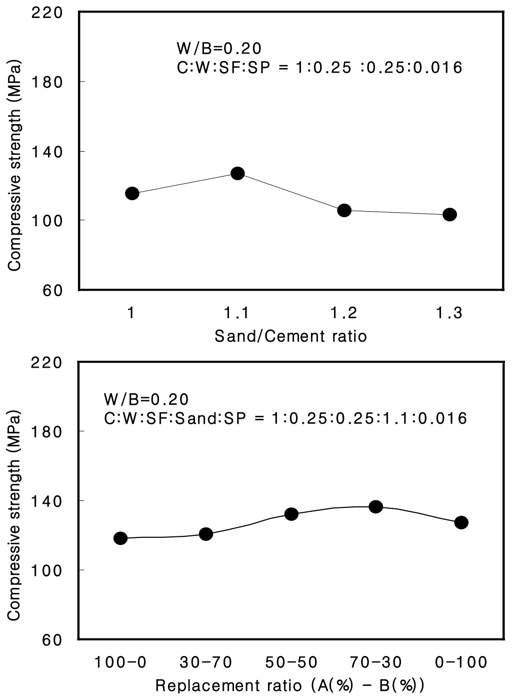

Fig. 2 Effects of aggregates on the strength

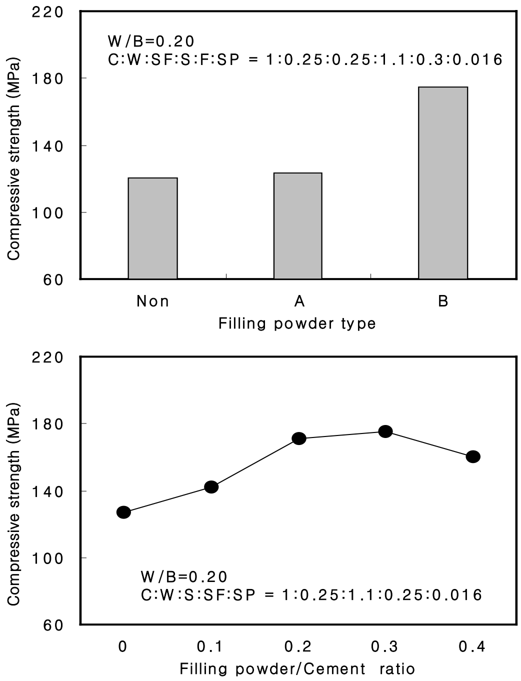

Fig.3 Effects of filling powder on the strength

Fig. 3 illustrates the effects of the mixture ratios and type of filling powder on the strength. Filling powder A with particle size of 100μm is seen to have nearly no effect on the increase of strength while filling powder B with particle size of 10μm is seen to produce an increment of about 55MPa (31%) to the strength compared to “Non” specimen, which does not use filling powder.

According to these results, it can be stated that the most effective particle size of filling powder, which increases strength through its role as filler at the interface between cement and aggregate, should run around 10μm. In addition, it can be seen that the adequate filling powder to cement ratio of 0.3 is the adequate value since it produces the largest compressive strength.

Fig. 4 presents the strengths resulting from the use of steel fiber. Tests reveal that the introduction of steel fiber increases the strength by about 13% regardless of the W/C ratio. Especially, a compressive strength of 200MPa is measured when steel fiber is mixed in the case of W/C ratio of 0.2. This means that the active exploitation of materials made in Korea can be done to produce ultra-high strength SFRCC.

Fig. 5 illustrates an example of mix proportion for ultra-high strength SFRCC that can reach compressive strength of 180MPa using materials made in Korea.

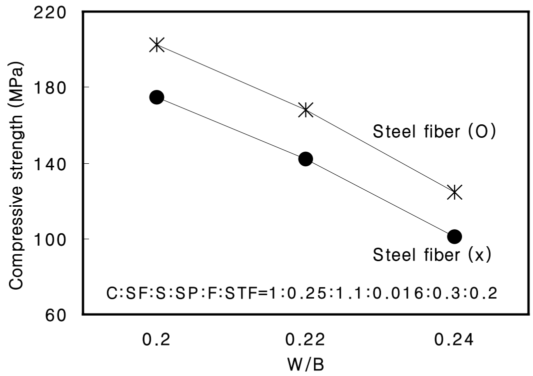

Fig. 4 Compressive strength according to the use of steel fiber

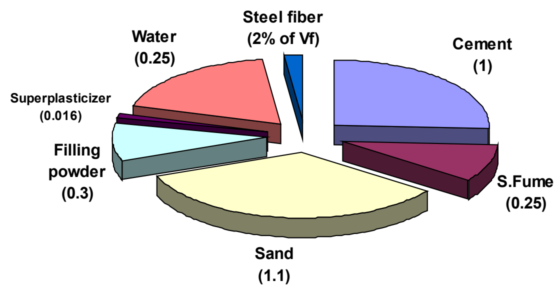

Fig. 5 Example of mixing proportion for ultra-high strength SFRCC

4. Conclusion

This study proposed the adequate mix proportion of ultra-high strength SFRCC that is able to secure a compressive strength of 180MPa by exploiting an appropriate combination of silica fume, quartz sand smaller than 0.5mm, filling powder and steel fiber.

Reference

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