Investigation on the repair effects of sprayed PVA fiber-reinforced mortar

Korea Institute of Construction Technology　KSCE　○ Koh, Kyung-Taek,　Ryu, Gum-Sung
Korea Institute of Construction Technology　KSCE　Kim, Sung-Wook,　Kang, Su-Tae

1. Introduction

Various fiber-reinforced mortars including large quantities of PVA or steel fiber have been developed recently and studies to find applications in diverse domains are currently conducted actively. Regard to economical efficiency, high toughness fiber- reinforced mortar becomes competitive when applied as repair material with small quantities rather than the casting of large volume for the main body of structures in field.

The authors have developed a wet spraying technique using PVA fiber-reinforced ductile mortar and attempt to exploit it for rehabilitation. Differently from previous polymer-type or epoxy-type restorative materials, the coefficient of thermal expansion and the elastic modulus of the sprayed fiber-reinforced ductile mortar are similar to those of concrete, which allows it to behave similarly to the concrete members.

However, poor attention has been devoted by the Korean researchers to examine systematically the extent of the improvement brought by such fiber-reinforced ductile mortar compared to existing restorative materials and techniques. Therefore, this study investigates the repair effects of the sprayed PVA fiber-reinforced mortar through estimating strength, shrinkage, change of mechanical properties before and after freezing and thawing cycles in order to secure its stability for use on field.

2. Experimental program

The properties of the repair materials adopted for the tests are summarized in Table 1. A value of 0.2 for the water to mortar ratio (W/M) has been set for all the repair materials. The sprayed PVA fiber-reinforced mortar is characterized by the admixing of 1.2% (by volume) of PVA fiber to the mortar composed by cement, fly-ash and CSA-type expansion agents. The same tests have also been performed on the existing product R using natural cellulose fiber in the mortar composed with polymer and the existing product C without fiber in order to allow comparison with the sprayed fiber-reinforced mortar.

Compression, tension, bond and impact tests have been conducted in order to examine the strength characteristics of the sprayed fiber- reinforced mortar.

Table 1 Properties of the tested repair materials

Type	Components of mortar	Fiber	Main Purpose
Sprayed PVA fiber-reinforced mortar	Inorganic materials	PVA fiber	Repair / reinforcement
Product R	3 component-type polymer resin	Natural cellulose fiber	Crack and spalling repair, filling
Product C	SBR-type polymer	No fiber	Rust proof /restoring

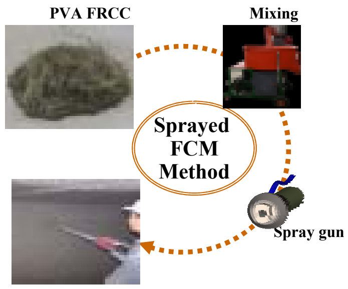

Fig. 1 Scheme of sprayed PVA fiber reinforced mortar method

The strength test was performed after water curing and at definite age. Plastic shrinkage, autogenous shrinkage and drying shrinkage tests were executed. And also confined drying shrinkage test was performed to evaluate the crack control performance. The change of mechanical properties has been examined by means of freezing-thawing cycle tests. The resistance to freezing and thawing cycles was examined according to ASTM C 666-B and the corresponding relative dynamic modulus of elasticity was evaluated. The flexural strength and bond strength were measured before and after the freezing and thawing test.

3. Experimental results and observations

Fig. 2 plots the compressive strength according to the type of repair material. The sprayed fiber-reinforced mortar exhibits higher strength than existing repair materials with a remarkable strength. This is due to the high strength of the repair mortar itself and to the use of PVA fiber, which increases significantly the tensile strength.

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Address : 2311, Daehwa-Dong, Ilsanseo-Gu, Goyang-Si, Gyeonggi-Do, 411-712, Republic of Korea, Tel : 82-31-9100-537

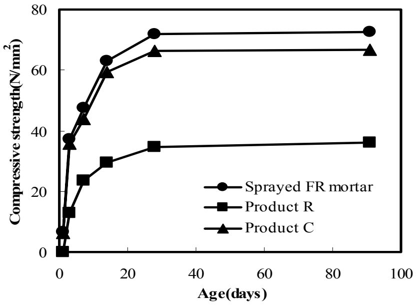

Fig. 2 Results of compressive strength

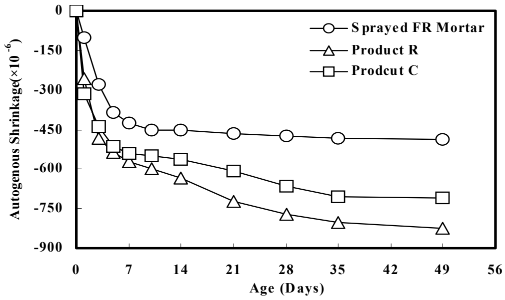

Fig. 4 Results of autogenous shrinkage

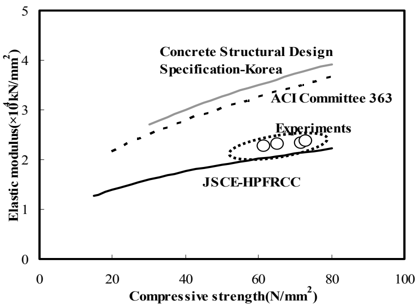

Fig. 3 Comparison of the elastic modulus of the sprayed fiber-reinforced mortar

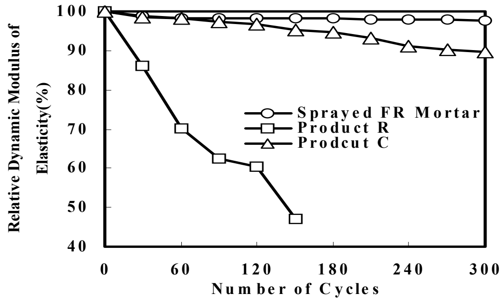

Fig. 5 Results of relative dynamic modulus of elasticity

Fig. 3 compares the elastic modulus of the sprayed fiber-reinforced mortar with those obtained by former predictive formula. The modulus is slightly larger than that obtained through the formula proposed in the design and construction guidelines of high-performance fiber reinforced cementitious composites (HPFRCC) of the JSCE under the same strength. The elastic modulus of HPFRCC in these guidelines is corresponding to 1/2-2/3 of ordinary concrete. On the other hand, considering the fact that repair is unnecessary for high strength structures and assuming that structures requiring repair are generally using concrete with strength below 30MPa, it can be said that the elastic modulus of the sprayed fiber-reinforced mortar is similar to that of concrete structures requiring repair.

Fig. 4 summarizes the results of the drying shrinkage test. The autogenous shrinkage strains developed by the sprayed fiber-reinforced mortar appear to be smaller respectively by about 30~40% and 20% compared to those of existing repair materials. The small shrinkage developed in the sprayed fiber-reinforced mortar is due to the use of shrinkage reducing agents and CSA-type expansion agents as well as the admixing of PVA fiber.

Fig. 5 plots the results of the relative dynamic modulus of elasticity. The product R decreased 60% for the relative dynamic modulus of elasticity at failure after 120 freezing-thawing cycles. On the other hand, the sprayed fiber-reinforced mortar and the product C presented remarkable relative dynamic modulus of elasticity exceeding 80% even after 300 cycles corresponding to the completion of freezing-thawing.

Fig. 6 plots the changes of the flexural strength before and after the freezing-thawing test. Even if the existing products satisfied the criteria of KS F 4042 before the test, their flexural strength appeared to drop below 6MPa after the completion of the test. However, the sprayed fiber-reinforced mortar presented insignificant variation of the flexural strength before and after the freezing-thawing test, and satisfied thus the KS standards.

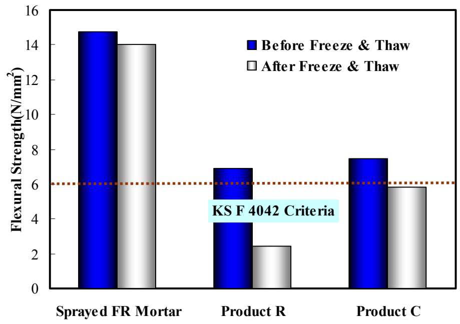

Fig. 6 Changes of the flexural strength before and after freezing-thawing test

4. Conclusions

The sprayed PVA fiber reinforced mortar exhibited strength properties, shrinkage and crack control performance, durability significantly superior to the existing polymer type repair materials. Therefore, applying on the repair method using sprayed PVA fiber reinforced mortar, the repaired concrete structures can be increased to service life.

References

1. JSCE Concrete Committee, "Evaluation and using of high performance fiber reinforced cementitious composites", Concrete Engineering Series 64, JSCE, 2005.