Fibrous Brucite and Polypropylene Hybrid Fibers Reinforced Concrete

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Introduction

To improve the ductility and to increase the toughness of the concrete, Fibrous Brucite (FB) and Polypropylene (PP) Hybrid Fibers are introduced to the ingredients of the concrete. Effects of FB-PP hybrid fibers to slumps, compressive strengths, and flexural strengths, splitting tensile strengths, bending fatigue life as well as freezing and thawing resistance of concrete were investigated. The results indicate that proper addition of FB-PP hybrid fibers is advantageous over single FB or PP fibers in improving the mechanical properties of concrete.

Experimental

Raw materials

$42.5^{\#}$ ordinary silicate cement, UNF-NA type high efficiency superplasticizer, river sand with fineness modulus 3.0, and 5.0 to 31.5 mm continuous particle size gravel were used. The Fibrous Brucite (FB) fibers are the naturally produced short fibers from Han Zhong Brucite Mine. They are in white gray fibrous morphology with a density of about $2.46 g.cm^{-3}$[2-3], fiber length 0.2 - 5.0mm and diameter 0.002 - 0.016 mm. The average aspect ratio is about 75. The fiber length of Polypropylene (PP) is 12-19mm with tensile strength 560 to 570MPa, elastic modulus 3.5GPa, and fiber diameter about 100 μm.

Methods

The fibers, tap water and the water reducer were put into a mortar mixer and agitated for 3 minutes to form a fiber-slurry. The cement, sand and gravel were mixed in another concrete mixer, then the fiber-slurry prepared were added in it, mixed for 3 minutes. The slumps of the new blended concrete were measured. Then the materials were molded, and cured at standard conditions. The mechanical strengths, the bending fatigue life, and the frost resistance of the samples were tested according to the corresponding Standard Test Method. In all tests, fibers were added to the ingredients in the volume percentages of the concrete.

Results and discussion

Effects of the FB-PP fiber ratios

To get the reasonable collocation of FB and PP fibers, experiments were conducted at the condition of 0.5vol% total fiber dosage of FB and PP. The mass ratio of concrete is cement: sand: gravel: water: water reducer = 1: 1.69: 3.14: 0.46: 0.008. The results are shown in Fig.1, Fig.2 and Fig. 3. In the Figures, the abscissa displays the PP-FB volume dosage.

Fig. 1 is the result of different FB-PP volume to the slumps of the concrete. From Fig.1 it can be seen that with the PP fiber content increase, the slumps of the concrete decline rapidly.

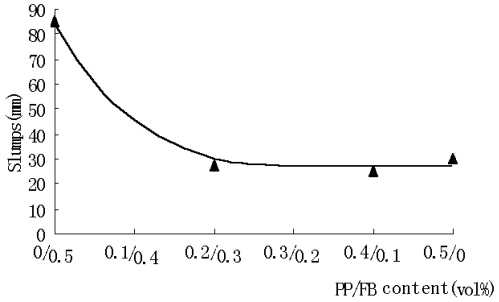

Fig.1 Influence of PP/FB content to concrete slumps

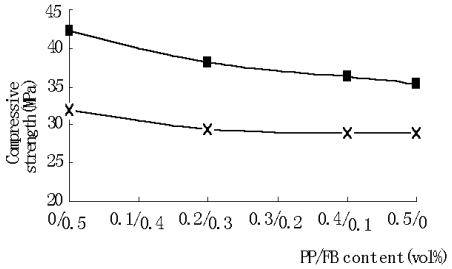

Fig.2 Effects of PP/FB content to compressive strength of concrete, ×-7d; ■-28d。

The effect of different PP:FB volume ratios to the 7d and 28d compressive strengths of the concrete can be seen in Fig. 2. It is clear from Fig.2 that both the 7d and 28d compressive strengths get monotonous down with the PP content increase. At the 0 dosage of the PP fibers (which means that the 0.5vol% amount of FB fibers), the concrete has the highest compressive strengths.

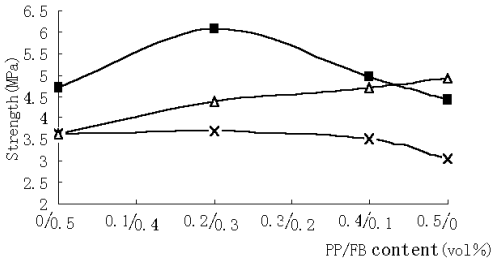

Fig. 3 Effects of PP/FB content to flexural and splitting tensile strengths of concrete, ×-7d flexural; ■-28d flexural; △-28d splitting tensile.

Fig. 3 shows the effects of different PP:FB volume ratios to the 7d, 28d flexural strengths and the 28d splitting tensile strengths of the concrete. From Fig.3, the splitting tensile strengths of the concrete go straight up with the PP dosage increase. It also indicates that the concrete reinforced with FB-PP hybrid fibers has the higher 28d flexural strengths than that either with the single FB fibers or with the single PP fibers. The optimum volume ratio of PP to FB fibers to flexural strength is about PP: FB = 0.2vol%: 0.3vol% at the condition of total fibers dosage of 0.5vol%.

Bending fatigue life test of FB and PP concrete

To study the influence of FB and PP fibers on the Bending fatigue life of concrete, tests were conducted after 90 days at the condition of fiber dosage of 0.5vol%. The mass ratio of cement: sand: gravel: water: water reducer is 1: 1.43:2.66:0.31:0.008. Fig. 4 shows the relations of average fatigue life to fatigue stress value.

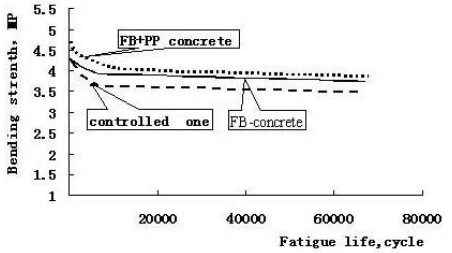

Fig. 4 Relationship between bending fatigue life and bending stress

From Fig.4, at the same bending stresses, fiber reinforced concrete has longer fatigue life than the controlled one. At the same fatigue life，and FB+PP hybrid fibers are superior to single PP fibers.

Effect of FB and PP fibers on the freezing-thawing properties of the concrete

Freezing and thawing tests were conducted at the condition of mass ratio of cement: sand: gravel: water: water reducer = 1：1.68：2.74：0.36：0.08. The results of the freezing and thawing comparison test of the concrete mass loss rate are shown in Fig.5.

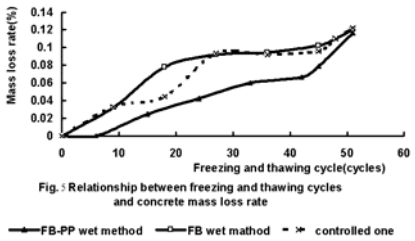

Fig. 5 Relationship between freezing and thawing cycles and concrete mass loss rate

From Fig.5, the mass loss rates of all the concrete samples are increased with the increase of freezing and thawing cycles. Before 50 cycles, the mass loss rate of FB fiber concrete is almost the same as that of the controlled one, while that of FB-PP hybrid fiber concrete is apparently lower than the two. During 40-45 cycles, the mass loss rates of the three samples accelerate together. At 50 freezing and thawing cycles, they reach to the same value.

Conclusions

The FB-PP hybrid fibers can increase the flexural strengths of the concrete remarkably, better than the single FB or PP fibers. At the condition of 0.5vol% total fiber dosage, the optimum ratio of fibers for flexural strengths of concrete is about 0.2vol% PP versus 0.3vol% FB.FB fibers and FB-PP hybrid fibers can prolong the bending fatigue life of the concrete. FB fiber or FB-PP hybrid fibers can also improve the frost resistance of the concrete.

Acknowledgments

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