OZONE TREATED CARBON FIBER FOR REINFORCING CONCRETE

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Introduction

Although much attention has been given to the surface treatment of carbon fiber for reinforcing polymer, little attention has been given to that for reinforcing concrete. Even without surface treatment, short isotropic-pitch-based carbon fibers are effective for increasing the tensile strength, tensile ductility, flexural strength and flexural toughness, and for decreasing the drying shrinkage of concrete [1]. Our recent work has shown that ozone treatment of carbon fiber is effective for increasing the shear bond strength between carbon fiber and cement paste [2] and for increasing the tensile strength, modulus and ductility of cement paste beyond the values attained by using untreated carbon fibers [3]. The ozone treatment is more effective than treatments using H_2O_2, NaOH, nitric acid or acetic acid [2]. This work is directed at elucidating the origin of the ozone treatment effect. This origin was found to be associated with the improved wetting of the fiber by water.

Experimental

The carbon fibers were isotropic pitch based and unsized, as obtained from Ashland Petroleum Co. (Ashland, Kentucky). The fiber properties are shown in Table 1. As-received and ozone treated fibers were used. The ozone treatment involved exposure of the fibers to O_3 gas (0.3 vol.%, in air) for 10 min at 160°C. Prior to O_3 exposure, the fibers had been dried at 110°C in air for 1 h.

The dynamic contact angle between carbon fiber and deionized water was measured using the Sigma 70 tensiometer of KSV Instruments (Monroe, CT). The tensiometric method (micro-Wilhemy technique) was used. The immersion depth was up to 3 mm and the stage with a beaker of water was moved up (advancing) and down (receeding) at a constant speed of 3 mm/min. Five samples of each type were tested.

Results and Discussion

The advancing and receding contact angles for the first three cycles of advancing (increasing immersion depth) and receding (decreasing immersion depth) are shown in Table 2 for each of the two types of fibers described above. Both angles are decreased to zero by the ozone treatment of the fiber. The

Table 1 Properties of carbon fibers

Filament diameter	10 μm
Tensile strength	1500 MPa*
Tensile modulus	48 GPa
Elongation at break	1.4%
Electrical resistivity	3.0×10^{-3} Ω.cm
Specific gravity	1.6 $g.cm^{-3}$
Carbon content	98 wt.%

* Measured in this work. The manufacturer's value is 690 MPa.

Table 2 Contact angle (degrees, ±0.1) between carbon fiber and water

	Untreated		Treated	
	Advancing	Receding	Advancing	Receding
1st cycle	86.1	30.2	0	0
2nd cycle	84.9	28.5	0	0
3rd cycle	83.2	28.3	0	0
Average	84.7	29.0	0	0

improved wetting is presumably due to the oxygen-containing functional groups on the fiber surface resulting from the ozone treatment. As cement paste is a hydraulic mix, the improved wetting of the fiber by water means improved wetting of the fiber by the cement paste.

Conclusion

The treatment of isotropic-pitch-based carbon fiber with ozone increases the bond strength between fiber and cement paste, thereby increasing the tensile strength, modulus and ductility of carbon fiber reinforced cement paste. This effect is due to the improved wetting of carbon fiber, as shown by decrease in the contact angle between fiber and water to zero.

Acknowledgement

This work was supported in part by National Science Foundation.

References

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