

Fabrication of Fiber-Reinforced Cementitious Composite with Recycled Carbon Fiber

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1. INTRODUCTION

Fiber-reinforced cementitious composite (FRCC) is mixed with discrete fibers. The fibers bridge between cracks and transmit tensile forces. Therefore, cracking and its propagation are inhabited. As a result, FRCC shows higher tensile performance than that of conventional concrete. Virgin fibers or optimally processed fibers are usually used for FRCC. On the other hand, the use of recycled materials is recently focused on for the purpose of the reduction of environmental impact and creation of the new materials with added value. The development of FRCC with recycled fibers has possibility to provide one proposal for this issue.

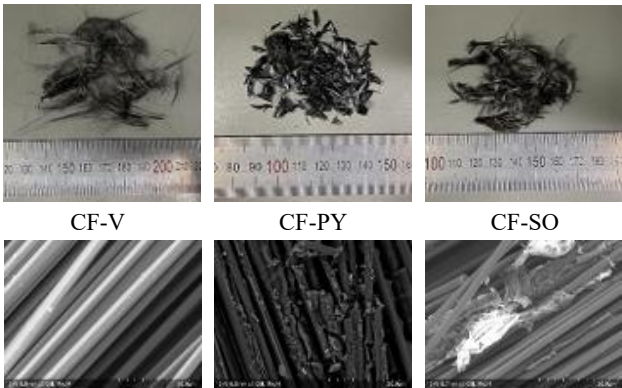
Carbon fiber (CF) is one of the most commonly used fibers as fiber-reinforced plastic (FRP). CF has a higher elastic modulus and tensile strength than other fibers. FRCC with CF can be expected to significantly improve tensile performance of FRCC. In order to ensure the use of FRCC with recycled CF practical, it is necessary to accumulate the fabrication know-how and clarify its mechanical performance. However, there are only a few studies on FRCC with recycled CF. Sasaki et al. reported that FRCC with CF showed the low compressive and bending strength [1]. In addition, the conditions of recycled fibers vary depending on the recycling methods. The dispersion of recycled fibers in cementitious composite is also unclear.

This study aims to fabricate FRCC with recycled CF and investigate the fundamental properties of hardened FRCC through compression and bending test. The dispersion of CF in FRCC is also observed by scanning electron microscope (SEM).

2. EXPERIMENT OVERVIEW

2.1 Tested recycled CF

The pyrolysis (CF-PY) and the solvolysis (CF-SO) are major methods for recycling CF [2]. In this study, CF recycled by these two methods are used. Virgin fiber (CF-V) is also used for comparison with recycled fibers. Fig.1 shows fibers by ordinary photograph and SEM. In CF-V, individual fibers are dispersed. In CF-PY and CF-SO,



CF-V(SEM x1000) CF-PY(SEM x1000) CF-SO(SEM x1000)

Fig.1 Photo of used fiber

Table 1 Mix proportion of FRCC

Specimen	Unit weight (kg/m³)					
	W	C	S	FA	CF	Ad
N	380	678	484	291	-	6
CF-V-0.5%					9	
CF-PY-2%					36	
CF-SO-0.5%					9	

W : Water C : High early strength Portland cement
S : Silica Sand No. 7 FA : Fly ash type II CF : Carbon fiber
Ad : High range water reducing admixture

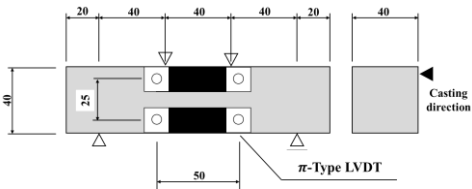


Fig.2 Four-point bending test

Table 2 Average compressive strength and elastic modulus

Specimen	Compressive strength (MPa)	Elastic modulus (GPa)
N	44.9	16.0
CF-V-0.5%	48.1	17.2
CF-PY-2%	46.4	17.2
CF-SO-0.5%	52.0	17.1

fibers are not dispersed due to residual resin. The fibers cut in 10mm length are used for fabrication of FRCC in the case of CF-V and CF-SO.

2.2 Compression and bending test of FRCC

Table 1 shows the mix proportion of FRCC. The specimen "N"

Keywords FRCC, Recycled carbon fiber, Bending strength, Bending toughness, Dispersion

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indicates mortar without fiber. The other specimens' identifications correspond to FRCC using each type of CF. The fiber volume fraction was set to 0.5% in the case of CF-V and CF-SO, and 2% in CF-PY.

The uniaxial compression test and four-point bending test are carried out by $\phi 50 \times 100$ mm cylinder and $40 \times 40 \times 160$ mm rectangle test pieces, respectively. In the bending test, axial deformations are measured to calculate the curvature as shown in Fig.2.

3. TEST RESULTS

3.1 Compression test

Table 2 shows a list of average compressive strength and elastic modulus. The average compressive strength and elastic modulus of the four types of specimens are similar. The type of fibers has little effect on the compressive properties.

3.2 Bending test

Fig.3 shows a typical example of test pieces after bending test. In all test pieces, one crack took place and failed by opening the crack. In CF-V-0.5% and CF-SO-0.5%, the fibers bridging the crack were observed.

Fig.4 shows the bending moment-curvature curves. In CF-PY-2%, the bending moment increases linearly to the peak. Then the bending moment decreases rapidly. In CF-V-0.5% and CF-SO-0.5%, the bending moment gradually increases after cracking to the peak showing deflection hardening property. After the peak, the bending moment decreases rapidly.

Table 3 shows the list of average maximum bending moment. The average maximum bending moment of CF-PY-2% is 0.332 times that of CF-V-0.5%. The average maximum bending moment of CF-SO-0.5% is 0.645 times that of CF-V-0.5%. It is recognized that bridging effect of fibers improves the bending strength and toughness in case of CF-V-0.5% and CF-SO-0.5%.

4. OVSERVATION OF FIBER IN FRCC

Fractured cross-sections of test pieces after bending test were observed by SEM to observe the dispersion of fibers as shown Fig.5. In CF-PY-2%, most of the fibers are not dispersed even in FRCC. In CF-V-0.5%, the packs of 2~4 fibers are scattered at intervals of 300~500 μ m. In CF-SO-0.5%, packs of 3~4 fibers are scattered at intervals of 300~600 μ m. These scattered fibers are observed over the entire cross-section.

5. CONCLUTIONS

(1) Fiber type has little effect on compressive properties.



CF-V-0.5%

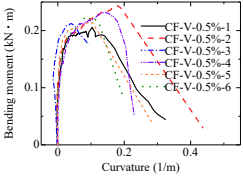


CF-PY-2%

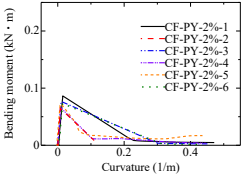


CF-SO-0.5%

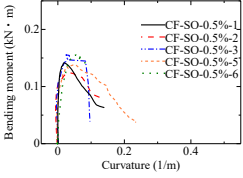
Fig.3 Bending specimen after bending test



CF-V-0.5%



CF-PY-2%

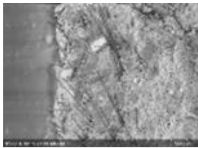


CF-SO-0.5%

Fig.4 Bending moment-curvature curve

Table 3 Average maximum bending moment

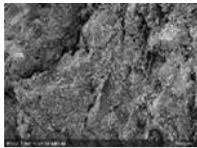
Specimen	Bending moment (kN · m)
CF-V-0.5%	0.220
CF-PY-2%	0.073
CF-SO-0.5%	0.142



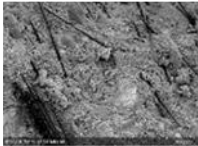
CF-V (x100)



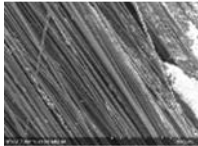
CF-PY (x100)



CF-SO (x100)



CF-V (x150)



CF-PY (x180)



CF-SO (x150)

Fig.5 Photo of fractured cross-section

(2) Improvements in bending strength and toughness were observed in FRCC using recycled fiber by the solvolysis method.

ACKNOWLEDGEMENTS

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[2]株式会社ミライ化成, 再生炭素繊維事業のご紹介, https://www.miraikasei.com/pdf/sale_carbon.pdf(2023/03/16 閲覧)