第V部門
短繊維補強コンクリート（材料）
2023年9月15日(金) 15:10 〜 16:30 V-8 (広島大 東広島キャンパス総合科学部講義棟 Ｋ２０９)

[V-751] Fabrication of Fiber-Reinforced Cementitious Composite with Recycled Carbon Fiber

Fabrication of Fiber-Reinforced Cementitious Composite with Recycled Carbon Fiber

*佐々木 秀人[1]、李 思聡[1]、金久保 利之[1] （1. 筑波大学）
*Hideto Sasaki[1], Sicong Li[1], Toshiyuki Kanakubo[1] （1. University of Tsukuba）

キーワード：FRCC、リサイクル炭素繊維、曲げ強度、曲げ靭性、分散性
FRCC, Recycled carbon fiber, Bending strength, Bending toughness, Dispersion

昨今の環境負荷の低減といった課題に対する一つの提案として，リサイクル繊維を用いた繊維補強セメント複合材料(FRCC)の開発が挙げられる．本研究では，リサイクル炭素繊維を用いた FRCCの作製及び基本性能の調査を目的とし，圧縮試験及び曲げ試験を実施した．圧縮試験の結果より，繊維の種類が圧縮性状に与える影響は少ないことが確認された．曲げ試験の結果より，溶媒法によるリサイクル炭素繊維を用いた FRCCで繊維の架橋効果が確認された．また，走査電子顕微鏡(SEM)を用いた破壊断面の観察により，溶媒法によるリサイクル炭素繊維は十分に分散することが明らかとなった．

The development of fiber-reinforced cementitious composite (FRCC) with recycled fibers provides one proposal for the reduction of environmental impact. This study aims to fabricate FRCC with recycled CF and investigate its fundamental properties through compression and bending test. From the compression test results, it is clarified that type of fibers little influence the compressive properties. From the bending test results, bridging effect is confirmed in the FRCC with CF by the solvolysis. It is observed by scanning electron microscope (SEM) that CF by the solvolysis is dispersed.

Fabrication of Fiber-Reinforced Cementitious Composite with Recycled Carbon Fiber

筑波大学　学生会員　○Hideto Sasaki
筑波大学大学院　学生会員　Sicong Li
筑波大学　正会員　Toshiyuki Kanakubo

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, 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.

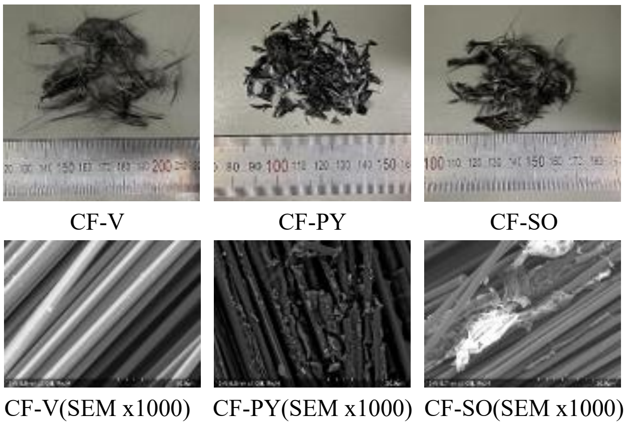

Fig.1 Photo of used fiber

Table 1 Mix proportion of FRCC

Specimen	Unit weight (kg/m^3)					
	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

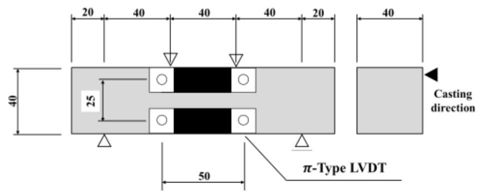

Fig.2 Four-point bending test

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

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
Adress　〒305-8573 茨城県つくば市天王台 1-1-1 筑波大学 TEL 029-853-5045

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 ϕ50x100mm cylinder and 40x40x160mm 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%.

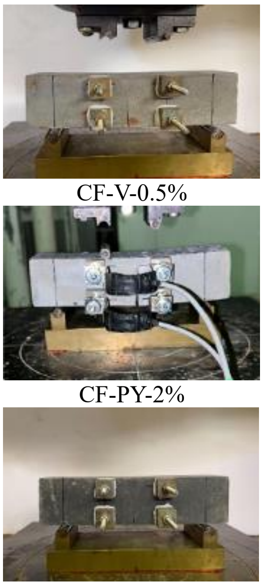

Fig.3 Bending specimen after bending test

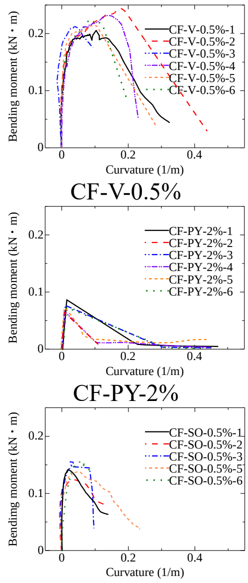

Fig.4 Bending moment-curvature curve

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

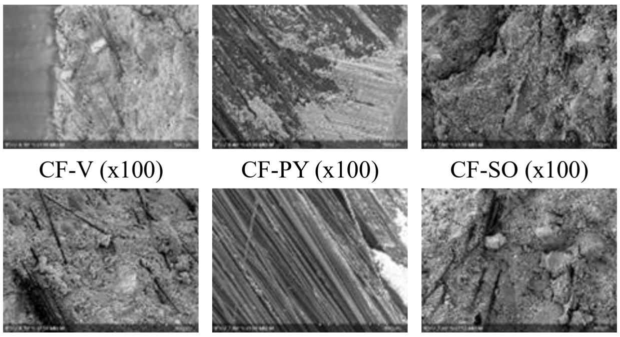

Fig.5 Photo of fractured cross-section

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 300~500μm. In CF-SO-0.5%, packs of 3~4 fibers are scattered at intervals of 300~600μm. These scattered fibers are observed over the entire cross-section.

5. CONCLUTIONS

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

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

ACKNOWLEGEMENTS

The recycled carbon fibers were provided from MIRAI KASEI INC. and Toray Industries, Inc.

REFERENCES

[1]佐々木隆ほか, 超臨界水処理による炭素繊維補強樹脂材料のリサイクルに関する研究, コンクリート工学年次論文集, Vol.28,No.1,pp.1553-1558,2006

[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)