Influence of Notch on Bending and Tensile Characteristics of FRCC

Regular Member ○Yu MU*
Regular Member Toshiyuki KANAKUBO**

Bending test Uniaxial tension test Aramid
Polypropylene Bridging stress Notch

1. INTRODUCTION

Fiber-reinforced cementitious composites (FRCCs) are a group of cement composites with the mixture of short fibers to increase their ductility and strength by the effect of fiber bridging after first cracking. Though the bending test and uniaxial tension test are usually carried out to characterize their performance, both notched specimens and un-notched specimens have been used for these test. The objective of this study is to make clear the influence of the notch on bending and tensile performance of FRCC by the bending test and uniaxial tension test.

2. BENDING TEST

Aramid and polypropylene (PP) fibers (Fig. 1) were used with 1% volume fraction for all experiments. The characteristics of the fibers are listed in Table 1. The mix proportion for base mortar is shown in Table 2. The compressive properties are listed in Table. 3.

2.1 Three-point bending test with notch

The notched beam specimens with 100mm square section (Fig. 2) specified in JCI-S-002-2003 were used. The notch was cut in the middle of specimen with a depth of 30mm. One LVDT was set to measure the load point deflection (LPD).

2.2 Four-point bending test without notch

The four-point bending test (Fig. 3) based on JCI-S-003-2007 was carried out. Three LVDTs were set to measure the load point deflections (D1, D2) and the deflection at the center of the specimen.

2.3 Bending stress vs. rotation angle

For three-point bending test specimen, the rotation angle is defined as load point deflection (LPD) divided by half of span (150mm). In case of four-point bending test specimen, the rotation angle is defined as the average of load point deflections (D1, D2) divided by shear span (100mm). In order to compare the difference of specimens with or without notch, the bending stress is also defined as bending moment at the load point divided by section modulus. The relationships of bending stress and rotation angle for aramid and PP specimens are shown in Fig. 4. In case of Aramid specimens, the load was increased significantly after first cracking to maximum for both types of

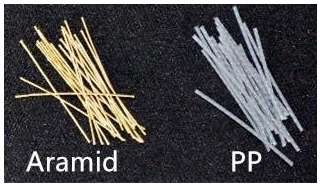

Fig. 1 Used fibers

Table 1 Characteristics of used fiber

Fiber	Density (g/cm^3)	Length (mm)	Diame-ter (mm)	Tensile Strength (MPa)	Elastic Modulus (GPa)
Aramid	1.39	30	0.5	3432	73
PP	0.91	30	0.7	580	4.9

Table 2 Mix proportion of base mortar

Water cement ratio	Unit weight (kg/m^3)			
	W	C	S	FA
0.56	380	678	484	291

Table 3 Compressive properties

Fiber	Compressive Strength (MPa)	Elastic Modulus (GPa)
Aramid	51.3	17.7
PP	51.5	17.2

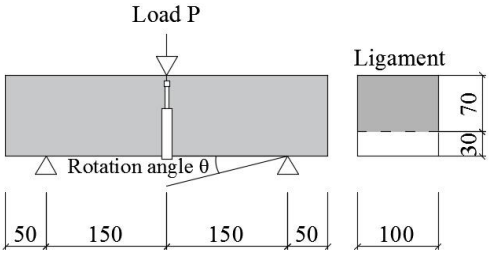

Fig. 2 Three-point bending test

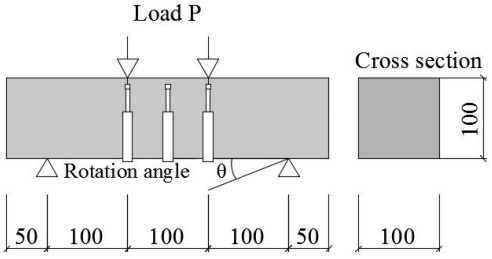

Fig. 3 Four-point bending test

bending test. For PP specimens, the load dropped after the maximum load and increased gradually again showing second peak load. The average of bending stresses at the maximum load after the sudden drop of the load (second peak) is 4.37MPa and 5.48MPa for Aramid three-point and four-point specimen. The bending stress of PP specimen at second peak is 2.13MPa and 2.44MPa.

3. UNIAXIAL TENSION TEST

3.1 Specimens with and without notch

The uniaxial tension test was conducted for same FRCCs with bending test specimens. The specimens are divided into two series, i.e., without notch or with notch. The method of the uniaxial tension test is same one performed in the previous study[1]. The dimensions of the specimen and cross section of notch are shown in Fig. 5 and Fig. 6. The test region of cross section are 50mm × 50mm and 40mm × 40mm for the specimens without and with notch, respectively. The total length of the specimen is 510mm. Pin-fix ends were adopted at the boundaries to minimize possible effects of external moment. Tensile load and deformation in the test region were obtained directly from the experiment.

3.2 Tensile stress vs. crack with or axial deformation

Tensile stress is calculated by considering the different section area of two types of specimens. Tensile stress versus crack width (with notch specimen) or axial deformation (without notch specimen) are shown in Fig. 7. The tensile behavior after first cracking differs by types of fiber. Except the PP specimen without notch, the tensile stress showed a significant drop after first cracking. Due to the fiber bridging effect, the tensile stress increased until to the second peak and then decreased gradually. For the Aramid specimen without notch, multiple cracks were observed after first cracking which leads to the several increase and decrease of tensile stress. In case of the PP specimen without notch, the second peaks could not be measured due to sudden opening over 1mm crack width. The average tensile stress of Aramid specimen with and without notch at second peak is 3.02MPa and 3.31MPa, of that for PP specimen is 1.61MPa and 1.33MPa, respectively.

4. CONCLUSIONS

The notch on bending test specimen nor uniaxial tension test specimen does not largely affect the peak stress after first cracking in case of FRCCs tested in this study.

REFERENCES

1)Kanakubo, T., Miyaguchi, M. and Asano, K. (2016) “Influence of Fiber Orientation on Bridging Performance of Polyvinyl Alcohol Fiber - Reinforced Cementitious Composite”, ACI Materials Journal, Vol.133, No.2, pp.131- 141.

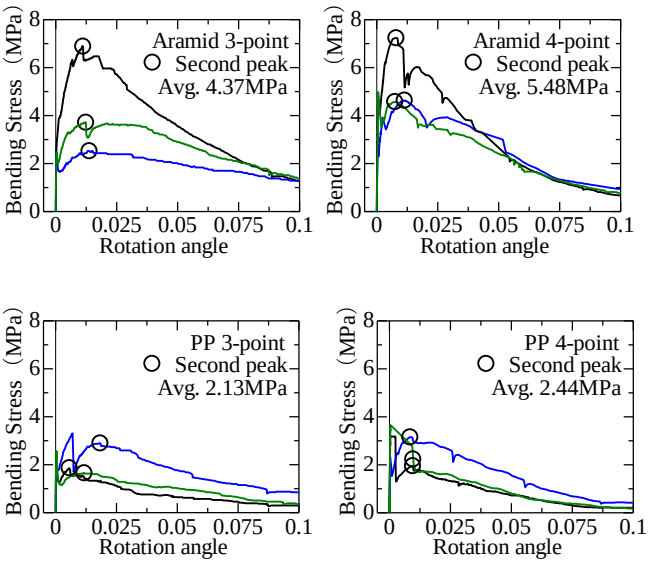

Fig.4 Bending stress – rotation angle curve

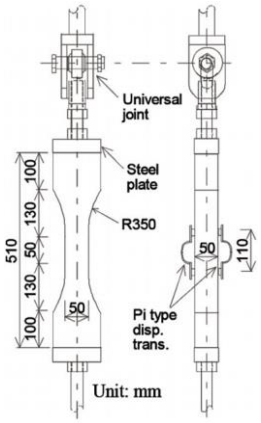

Fig. 5 Tension test specimen

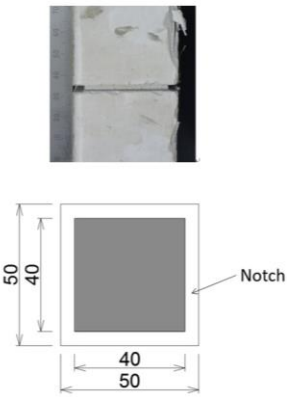

Fig. 6 Cross-section

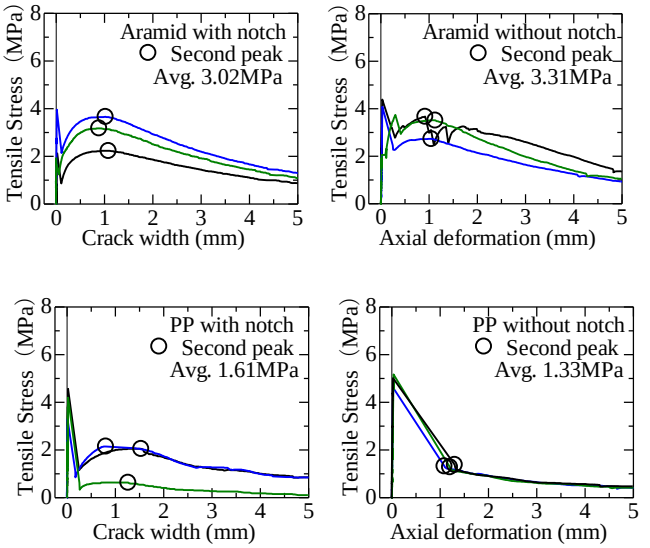

Fig. 7 Tensile stress – crack with or axial deformation curve

* 筑波大学大学院博士後期課程・修士(工学)
**筑波大学システム情報系教授・博士(工学)
*Doctoral Program in GSSIE, University of Tsukuba, M. Eng.
**Professor, FEIS, University of Tsukuba, Dr. Eng