Application of unresin and unshaped continuous carbon fibers to concrete structures as reinforcement materials

○ Djamaluddin RUDY, Members, Kyushu University
Takayuki NAGAHAMA, Members, Kyushu University
Yuichi KOBAYASHI, Members, Kyushu University
Toshiaki OHTA, Members, Kyushu University

1. INTRODUCTION

Corrosion by chloride ions of steel reinforcement embedded in concrete is recognized to be the main cause of concrete deterioration. Currently, some uncorrosive materials such as carbon fibers have been emerged as a promising material for enhancing the corrosion resistance of reinforced concrete structures. In particular, carbon fibers offer some great potential for use in reinforced concrete structure under corrosive condition. The advantages of carbon fibers include high tensile strength and stiffness to weight ratio, resistance to chemical attack and ease handling. This paper presents the flexural behavior of the concrete beam reinforced by uncorrosive unresin continuous carbon fibers as a substitute for steel reinforcement.

2. SPECIMENS

The tested reinforced concrete beams are divided into two types according the concrete strength. Type I and Type II have concrete strength of 35 Mpa and 60 MPa, respectively (Table 2). The simply supported beams have span length of 1400 mm and are subjected to two equal loads placed symmetrically at the center of the beams, as shown in Fig.2. The used carbon fiber (Figure 1) has 24 sub strands per one strand, and 3000 micro fibers per sub strand and its properties are presented in Table 1.

Table 1 Properties of continuous carbon fibers

Type of CF	E_{CF} (GPa)	f_t (GPa)	A (mm^2)	Density (g/cm^3)
24x3000	230	3.53	2.65	1.76

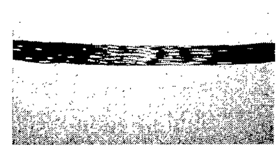

Figure 1 Carbon fiber

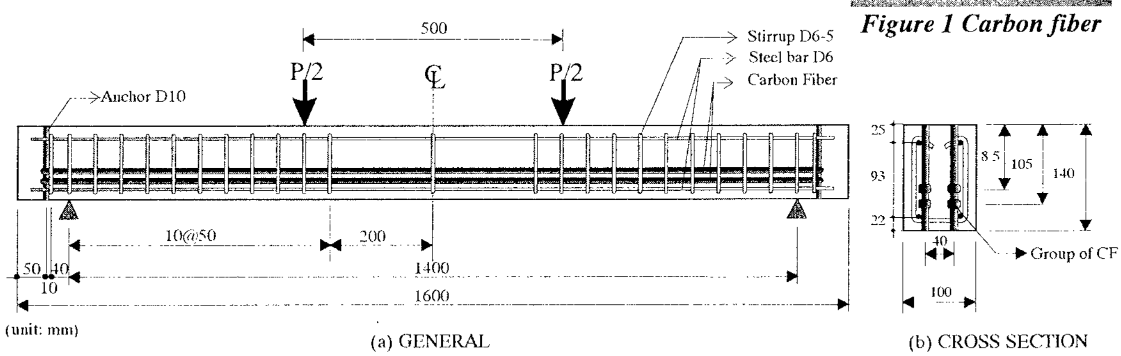

Figure 2 Dimension of test specimen

Key word: unresin continuous carbon fiber, flexural behavior, reinforcement ratio.
Kyushu University, Civil Dept, Fukuoka-shi, Hakozaki, Phone: (092)641-3131(8677), Fax:(092)642-3306

3. TEST RESULTS AND DISCUSSION

The experimental results are summarized in Table 3. As shown in Table 3, the effect of reinforcement ratio on Type I shows that the peak load decreases about 7.7% by increasing reinforcement ratio from 0.89 to 1.12. This phenomenon is not found in specimens Type II that has higher concrete strength than Type I in which the peak load increases about 12.6% by increasing reinforcement ratio from 0.89 to 1.12 and increases 7.6 % by increasing reinforcement ratio from 1.12 to 1.34. Furthermore, the effect of concrete strength indicates that the peak load increases about 1.40% by increasing concrete strength from 36.0 Mpa to 56.8 MPa for reinforcement ratio 0.89% and increases about 23.9% by increasing concrete strength from 36.0 Mpa to 51.2 MPa for reinforcement ratio 1.12%.

Firstly, crushing of concrete around the position of the applied load occurred. Once the concrete has crushed, the deflection increases with decrease in load. In this stage, the load falls approximately about 50% of the peak load, and then the deflection still propagates with little decrease in load, as shown in Fig.3. This stage is called as the second stage of beam capacity. As shown in Table 3, the decreasing of load from peak load to second stage load for Type I are 39.8%, 35.1%, for A and B, respectively and for Type II are 40.6%, 41.2%, 48.3%, 50.7% for C, D, E1 and E2, respectively. In this stage, the compression stress is transferred to the remain cracked part of concrete that forms concrete blocks.

Table 2 Test specimens

Types (MPa)	Specimen name	Number of strand*	Reinforcement ratio (%)
I (f'c=35)	A	8	0.89
	B	10	1.12
II (f'c=60)	C	8	0.89
	D	10	1.12
	E	12	1.34

*) per group

Table 3 Summary of experimental result

Types	Specimen name	f'c MPa	Peak load		Post peak (second capacity)	
			Load (kN)	Deflection (mm)	Load (kN)	Deflection (mm)
I	A	36.0	35.2	18.0	21.2	28.1
	B	36.0	32.5	15.6	21.1	24.5
II	C	56.8	35.7	21.0	21.2	25.7
	D	51.2	40.2	20.4	23.7	30.4
	E1	51.2	42.7	17.0	22.1	29.1
	E2	58.8	43.8	19.5	21.6	31.2

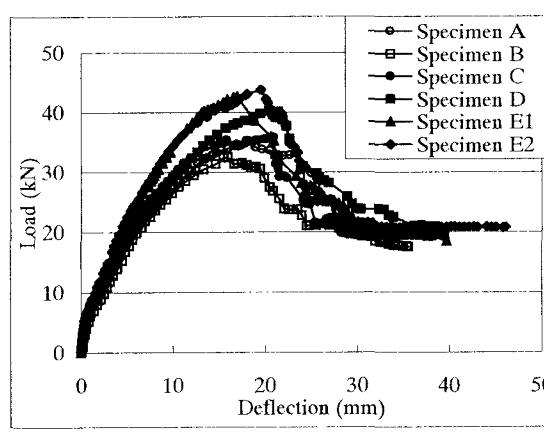

Figure 3 Load-Deflection curves

4. CONCLUSION

Carbon fibers are available to substitute steel as flexural reinforcement in the concrete beam. The high concrete strength should be used for concrete beam reinforced with continuous carbon fibers. Generally, the concrete beam reinforced by unresin continuous carbon fibers has a typical flexural behavior, even after peak load is reached. After peak load, the load-deflection curve falls approximately 50% of peak load and then the deflection still propagates at almost same load level till the complete failure of the beam.