EXPERIMENTAL STUDY ON STATIC BENDING STRENGTH OF RC BEAMS REINFORCED BY CARBON FIBER

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1. Introduction

It have been reported that there are over 700,000 bridges in Japan for the time being and most of them was been built in the rapid growth of the Japanese economy period (1965-1980). The percentage of constructive bridges increases dramatically from 18% to 43% within 10 years, and this figure will be predicted to 67% next two decades. However, a number of bridges have been damaging and aging seriously due to its use nearly half a century. Therefore, the maintenance of bridges is an integral issue apparently, and one of good workability methods to repair and reinforcement bridges is study on static bending strength of RC beams reinforced by carbon fiber.

2. Materials and Outline of Experiment

The carbon fiber is produced from Nippon Steel Sumikin Materials Co., Ltd. The number of the carbon fiber strands is divided into two types (SR-48, SR-72). The material properties are presented in Table 1, the RC beam specimen shown in Fig. 1, and the specimens are shown in Table 2. SN (Static, Normal) specimen is not reinforced with carbon fiber strands, SR (Static, Reinforcement) specimen is reinforced with carbon fiber strands. The position of reinforcement with a length of 1500 mm was formed on the lower surface of the beam, and the carbon strands were bonded by epoxy resin to the slits. Compressive strength of concrete ranges from 32.27 to 39.14N/mm^2, which is 35.81N/mm^2 on average. The span length was set to 1600 mm, the position of load is put in the middle of beam. The strain was measured by strain gauge attached to the beam in advance, the displacement determined by the displacement meter, and the load was confirmed by the load cell.

Table 1 Material properties of reinforcing materials

Reinforcing material name	48 carbon fiber strands	72 carbon fiber strands
The number of strand	48	72
Cross section mm^2	44	66
Young modulus GPa	245	245
Fineness g/km	1650	1650
The number of filaments K	24	24

Table 2 Specimen data

Name of specimen	Type of reinforcement
SN-1	None
SN-2	None
SR48-1	48 carbon strands
SR48-2	48 carbon strands
SR72-1	72 carbon strands
SR72-2	72 carbon strands

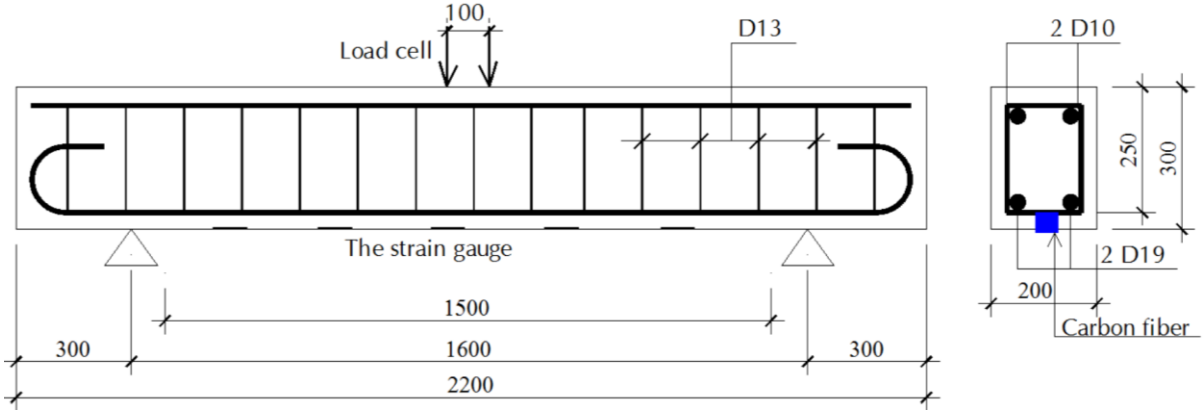

Fig.1 Beam specimen and measure items

3. Experimental Results and Discussion

The yield load and maximum load of the specimens are presented in Table 3, and the relationship between load and displacement is illustrated in Fig 2. Here, the yield load was taken in the elastic state of the load-displacement relation. The SN specimen that is not reinforced by the carbon fiber has a yield load of 134kN, and its maximum load of 151kN and 153kN. Whereas the load value of SR specimen reinforced with the carbon strands is higher, SR-48 nearly yield loads of 155kN, 160kN, maximum loads of 179kN, 188kN respectively, and SR-72 nearly yield load of 163kN, 165kN, maximum load of 190kN, 199kN respectively.

Table 3 Yield load and maximum load

Name of specimens	**Type of reinforcement**	**Yield load** (kN)	**Maximum load** (kN)
SN-1	None	134	153
SN-2	None	134	151
SR48-1	48 carbon strands	155 (155/134 =1.16)	179 (179/153 =1.17)
SR48-2	48 carbon strands	160 (160/134 =1.19)	188 (188/151 =1.25)
SR72-1	72 carbon strands	163 (163/134 =1.22)	190 (190/153 =1.24)
SR72-2	72 carbon strands	165 (165/134 =1.23)	199 (199/151 =1.32)

Many of the reinforced specimens finally ended due to peeling of the carbon fiber as shown in Fig 3. In addition, some of specimens have reached the ultimate state with a value smaller than the theoretical value because the theoretical value is considered at ultimate state in which the carbon fibers are not peeled off, the carbon fibers was peeled off from the beam in the experiment as well.

Moreover, it became clear from Fig. 2 that the structures have bearing capacity with the same load, even after entering the final state. This means that even if the carbon fiber reinforcement does not fulfill its role of reinforcement, ordinary beams can be also obtained the same effects

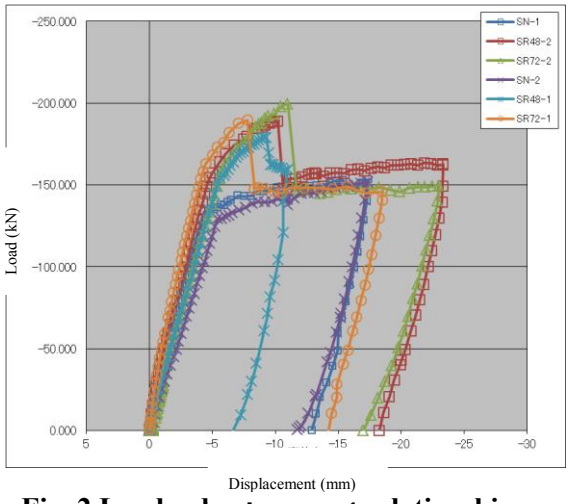

Fig. 2 Load – displacement relationship

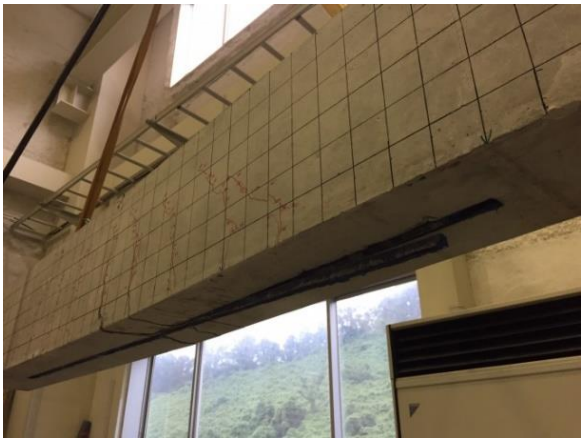

Fig. 3 Peeling status of reinforcing material SR48-1

4. Conclusion

(1) It became clear that the strand of carbon fiber is effective for the reinforcement to bending moment and it has a sufficient strength. More improvement of ultimate capacity of concrete structure is expected by the increase in the number of carbon fibers. In this study, difference in the number of carbon fibers between SN-48 and SN-72 specimens was about 10kN exceeded both the yield and maximum load.

(2) In addition, the static ultimate bending capacity of RC beams is likely to expect same strength after failure between the carbon fiber strand and concrete. As a result, it is understood that the reinforcement by carbon fiber strands lead to the improvement of such ability of RC beam.

We also are going to study the impact characteristics of this reinforcement from now on.