Mechanical Behaviour of Laminated Carbon Fibre Grid with a Large Cross-sectional Area in New Strengthening Method

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Summary

A new strengthening method of an existing bridge pier by using carbon fibre grid and polymer cement mortar was developed. Carbon fibre grid with a large cross-sectional area will be needed for a strengthening of an existing bridge pier. Therefore, it is necessary to clarify the mechanical behaviour of both laminated plates of carbon fibre grid with a large cross-sectional area and a reinforced concrete member strengthened by the new method. From the test results, it is cleared that bending theory may be used to the reinforced concrete member strengthened by using laminated plates of carbon fibre grid and polymer cement mortar.

Keywords: carbon fibre grid; strengthening; retrofit; polymer cement mortar; dry spray system.

1. Introduction

A new strengthening method of existing bridge piers by using carbon fibre grid (hereafter, CFG) and polymer cement mortar (hereafter, PCM) was developed [1]. In the new strengthening method, anchored longitudinal re-bars are mounted only in the plastic hinge zone in the column bottom and CFG plates are set up around the existing column as the whole, and PCM is sprayed directly over the re-bars and the CFG plates by dry spray system. By the way, carbon fibre grid with a considerable amount of cross-sectional area will be needed for a strengthening of an existing bridge pier under certain conditions. Therefore, in the strengthening by the new method, two or three CFG plates will be laminated. However, little is known about the mechanical behaviour of laminated CFG plates with a large cross-sectional area. Accordingly, it is necessary to clarify the mechanical behaviour of both laminated CFG plates with a large cross-sectional area and a reinforced concrete member strengthened by the new method.

2. Experiments

The specimens are summarized in Table 1. The experimental variable is an amount of the cross-sectional area of the CFG. The cross-sectional area of the one tendon is 65.0 mm^2 or 100.0 mm^2 for the CFG of CR13 or CR16, respectively. The tensile strength or Young's modulus of CR13 is 1,506 N/mm^2 or 103.2 kN/mm^2, and 1,728 N/mm^2 or 114.8 kN/mm^2 for CR16. The compressive strength of the existing concrete or the sprayed PCM at testing the beams was 41.3 N/mm^2 or 78.3 N/mm^2, respectively. The re-bar of SD345 was used for compressive and lateral re-bars. The re-bar of SD295A was used for tension re-bar. A four-point static loading test was carried out for the beam specimens; 300 mm height, 300 mm width, 3,500 mm length, with three layers of the CFG plates strengthened by the new method.

Table 1: Specimen

Specimen	CFG	Cross section of CFG (mm^2)	Grid pitch (mm)	Sprayed PCM (mm)	Cover of PCM (mm)
C13-3	CR13	65.0*9	100	57	15
C16-3	CR16	100.0*9	100	63	15

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3. Results and Discussion

Figure 1 shows the distributions of the strains in the cross section at the flexural span of specimen C13-3, for example. The strains of the laminated CFG plates in the cross section in the reinforced concrete member strengthened by the new method are proportional to the distance from the neutral axis of the member. This fact suggests that it is possible to apply bending theory to the strengthening design by the new method.

The comparison of the calculated result by bending theory [2] to the test results in the relationship between the flexural moment and the average curvature are shown in Figure 2 for specimen C13-3. The calculated maximum flexural moments were significantly different from the test results because of difference of the failure mode. In the calculation, flexural failure is assumed, but shear failure was occurred in the experiment. However, the calculated results coincided with the test results except for near the final stages. Therefore, bending theory may be used to the reinforced concrete member strengthened by using laminated CFG plates with a large cross-sectional area and polymer cement mortar.

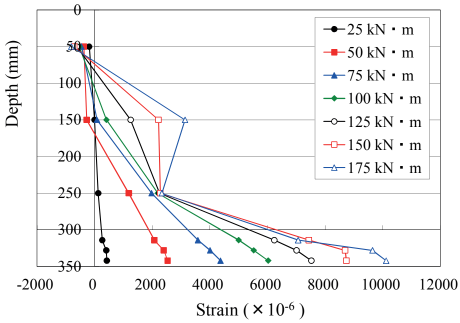

Fig. 1: Distribution of strains in cross section at flexural span (C13-3)

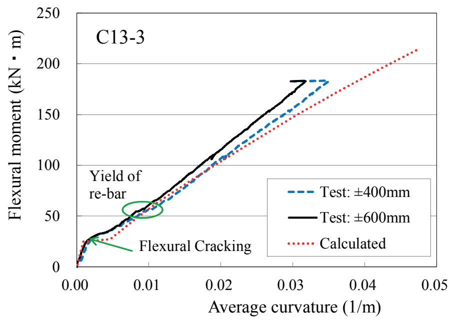

Fig. 2: Relationships between flexural moment and average curvature (C13-3)

4. Conclusions

This study clearly shows the followings.

(1) The laminated plates of carbon fibre grid behaved in one body with the existing reinforced concrete member under flexural condition till the ultimate stage.
(2) The failure mode of the specimens was shear-bond failure with the splitting of the existing concrete and/or the delamination of the carbon fibre grid after the shear cracks reached around the interface of the existing concrete and the polymer cement mortar, and/or the interface of the polymer cement mortar and the carbon fibre grid.
(3) The strains of the laminated plates of carbon fibre grid in the flexural span of the beam specimen matched with the calculated results by bending theory.
(4) The strains of the laminated plates of carbon fibre grid in the reinforced concrete member strengthened by the new method are proportional to the distance from the neutral axis of the member.
(5) The relation between the flexural moment and the average curvature in the test result coincided with that of the calculated result by bending theory.

References

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