INFLUENCE OF PRE-DAMAGE IN RC BEAMS JACKETED WITH LARGE FACTURE STRAIN FIBER

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1. INTRODUCTION

Worldwide attention has emphasized more on the strengthening of shear deficient reinforced concrete (RC) beams by Fiber-Reinforced Polymers (FRPs) because they provide high corrosion resistance and long-term durability. However, conventional FRPs such as Carbon Fiber Reinforced Polymer (CFRP) and Aramid fibers are brittle because of their low fracture strains resulting in early rupture and loss of load carrying capacity (Anggawidjaja et al. 2009). This premature rupture leads to the development of the alternative FRP materials with high fracture strain, Polyethylene Terephthalate (PET) which enhances shear strength and ductility, while being more economical.

Most of the existing beams commonly suffered from the damage before strengthening. Hence, the effect of damage due to the pre-loading such as shear crack opening and reinforcement yielding should be investigated to ensure the ductility of those beams. Ueda et al. (2002) proved that the shear deformation is significantly influenced by the development of shear cracks and yielding of reinforcement. To address these effects, five RC beams with different degree of pre-damage were tested under a monotonic loading. The truss mechanism was connected with the Linear Variable Differential Transformers (LVDT) devices to measure the shear deformation precisely. This paper evaluates the degree of damage prior to strengthening and the effectiveness of strengthening damaged RC beams with PET jackets.

2. EXPERIMENTAL PROGRAM

To investigate the effect of pre-damaged degree, five RC beams with and without PET-jacketing identified as B1-B5 were conducted under a monotonic three-point bending load. All specimens were designed to be deficient in shear. Since the concrete is mixed in the same batch, the compressive strength of concrete showed an insignificant difference in each specimen. As a result, the authors used the average cylinder compressive strength of concrete as f'_c. The details of specimens are summarized in Table 1. The cross section and characteristics of specimens are also illustrated in Fig. 1.

Table 1 Details of specimens

Specimen	f'_c (MPa)	b (mm)	h (mm)	d (mm)	a/d	Fiber	p_{sc} *1 (%)	p_s *2 (%)	p_w *3 (%)	p_f *4 (%)	s *5 (mm)	Pre-damaged degree
B1	36.0	200	250	212	2.8	None	0.33	2.40	0.11	0.00	150	Failed
B2	36.0	200	250	212	2.8	PET	0.33	2.40	0.11	0.84	150	-
B3	36.0	200	250	212	2.8	PET	0.33	2.40	0.11	0.84	150	SC
B4	36.0	200	250	212	2.8	PET	0.33	2.40	0.11	0.84	150	SC/SY
B5	36.0	200	250	212	2.8	PET	0.33	2.40	0.11	0.84	150	SC/SY

*1 compression steel ratio, *2 tension reinforcement ratio, *3 steel tie ratio, *4 fiber ratio, *5 spacing of steel tie,
SC = Diagonal shear crack, SY = Yielding of shear reinforcement

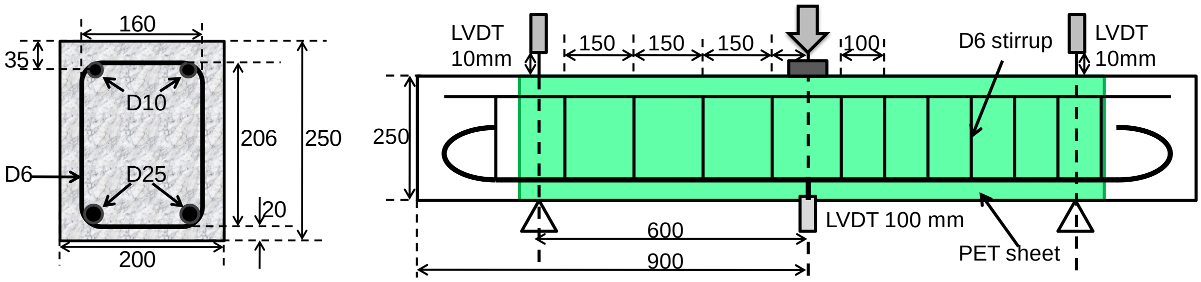

Fig.1 Cross section and characteristics of specimens

3. EXPERIMENTAL RESULTS

3.1. Shear capacity and failure modes

The crack pattern of controlled specimen (B1) is mainly governed by the diagonal shear crack as shown in Fig. 2. The specimen B1 was loaded until it failed in shear with the diagonal shear crack reaching the loading point and the ultimate load is 89.9 kN. To simulate the actual damage of an RC member during its service life, three beams (B3-B5) were preloaded before strengthening by PET fiber sheet whereas the beam, B2, is strengthened without the pre-damage. The degree of the pre-damage is separated into three stages based on the influences of shear crack, yielding of shear reinforcement and ultimate load. From the experimental observation, the PET-jacketed specimens showed the

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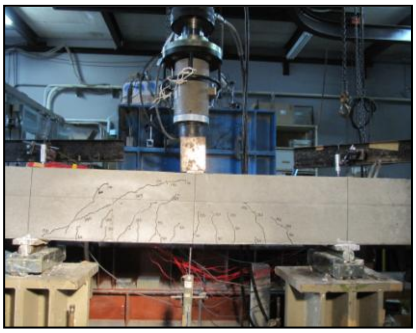


Fig.2 Crack pattern of B1

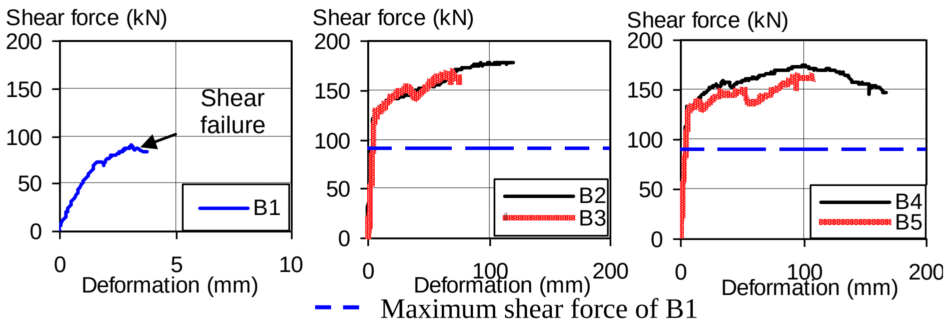


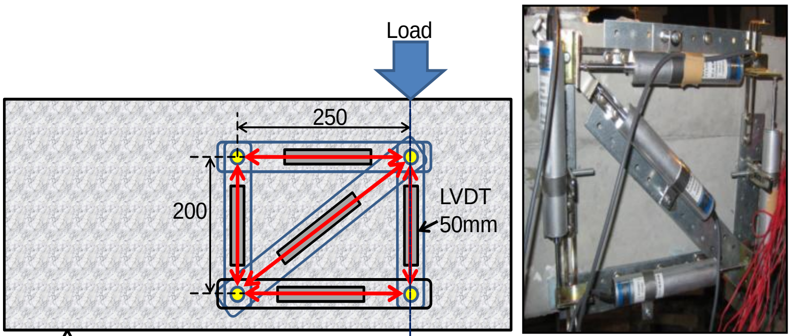
Fig.3 Shear force and deformation of B1-B5

enhancement of shear capacity and the failure mode shifted to be flexural failure. In addition, PET fiber did not show any breakage because of its high fracture strain. The relationship between applied shear force and central deflection of each specimen are shown in Fig. 3. At ultimate load, the total shear force of the pre-damaged beams (B3-B5) is insignificantly different from that of the undamaged beam (B2). It can be implied that the pre-damage does not affect the total shear force because the shear force provided by fiber sheet compensates the reduction of the shear force due to the pre-damage.

3.2. Shear deformation

To examine the influence of pre-damaged degree in the shear deformation, the truss system was set up with 200×250 mm in dimension as illustrated in Fig. 4(a). The Linear Variable Differential Transformers (LVDT) devices were connected with the truss system to measure the movement of each chord as shown in Fig. 4(b). Based on the method proposed by Massone and Wallace (2004), the results of shear deformation can be obtained.

Figure 5 shows the relationships between shear force and shear deformation of specimens B1-B5. Although the pre-existing damage lowered the initial stiffness of PET-jacketed specimens, the rate of stiffness degradation under large inelastic loading was lower than that of the corresponding control beam (B1).



a) Dimension of truss system b) LVDT devices

Fig.4 Truss mechanism

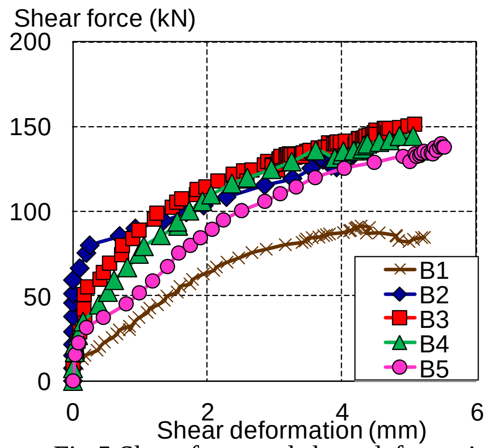


Fig.5 Shear force and shear deformation

4. CONCLUSIONS

This paper presents an investigation of shear deformation considering the effect of the pre-damaged degree. Experiments of five RC beams with and without PET-jacketing were conducted to examine the shear deformation in each damaged degree. The conclusion of this study is as follows:

1) The PET-jacketed specimens showed the enhancement of shear capacity and the failure mode shifted to be flexural failure. Moreover, PET fiber did not show any breakage because of its high fracture strain.
2) The pre-damaged degree does not affect the total shear force because the shear force provided by PET fiber sheet can compensate the reduction of the shear force due to the pre-damage.
3) Although the pre-existing damage lowered the initial stiffness of PET-jacketed specimens, the rate of stiffness degradation under large inelastic loading was lower than that of the corresponding normal beam.

REFERENCES

Anggawidjaja, D. and Ueda, T.: PET, High Fracturing Strain Fiber, for Concrete Structure Retrofitting: Shear Force and Deformation Enhancement: Experiments, Analysis and Model, VDM Verlag Dr. Müller, 2009, pp.1-64.

Massone, L. M., and Wallace, J. W.: Load-deformation responses of slender reinforced concrete walls, ACI Structural Journal, 101(1), 2004, pp 103-113.

Ueda, T., Sato, Y., Ito, T., and Nishizono, K.: Shear Deformation of Reinforced Concrete Beam. Journal of Materials, JSCE, 56(711), 2002, pp. 205-215.