# BEHAVIOR OF MEMBERS WITH FRP JACKETING WITH BUCKLING OF REINFORCEMENT AND CONFINEMENT EFFECT

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## 1. INTRODUCTION

During the serious seismic events, most of reinforced concrete (RC) members suffered from the buckling of longitudinal reinforcement leading to the catastrophic failure. To improve performance of those RC members, strengthening of RC members by Fiber Reinforced Polymer (FRP) is one of the promising methods because FRP-jacketed members have been proved to be able to meet two demands: higher shear capacity and improved ductility. In addition the advantages of using FRP sheet are high strength-to-weight ratio, high resistance to corrosion and easy handling and installation.
Conventional fibers such as Carbon and Aramid FRP sheets have been used in common. However those FRP sheets have low fracture strain which may lead to early breakage of FRP sheet. Therefore, Polyethylene Terephthalate (PET) jacketing, whose fracture strain is high, has been developed by Dai et al (2011). This paper presents the investigation of buckling effect and the application of PET fiber with high fracture strain.

## 2. EXPERIMENTAL PROGRAM

A compression test was performed using a new experimental method in order to observe the behavior of FRP-jacketed RC members with buckling of reinforcement. As shown in Fig. 1(a), a steel plate restrains the vertical displacement meanwhile a steel diaphragm controls the buckling in horizontal direction. As Teflon sheet was placed between specimen's surface and the steel diaphragm, the vertical friction can be ignored. In addition, three types of reinforcing bar—Straight, B1 and B2—were prepared in order to investigate the effect of boundary conditions as shown in Fig. 1(b). The straight bar represents the normal specimen while B1 and B2 represent a hinged-hinged and fixed-end boundaries. Two strain gauges were attached on the outer and inner surface of rebar. The dimension of specimen and the location of strain gauges are shown in Fig. 1(c). As shown in Table 1, the details of six specimens in prismatic shape were chosen with parameters of PET jacketing and type of reinforcement.

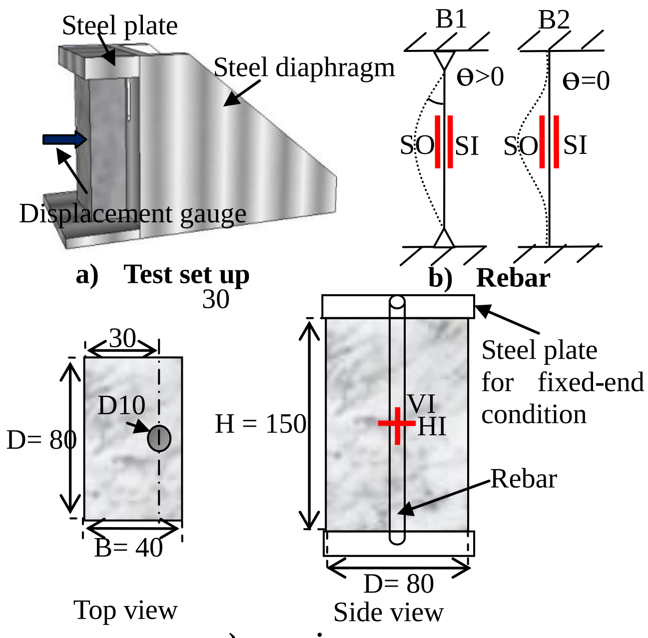


**Fig.1 Test setup, type of rebar and specimen**

**Table 1 Details of specimens**

| Specimen | B (mm) | D (mm) | H (mm) | Fiber | Steel Type |
|---|---|---|---|---|---|
| A150 | 40 | 80 | 150 | - | - |
| AU1-150 | 40 | 80 | 150 | - | Straight |
| AU2-150 | 40 | 80 | 150 | PET | Straight |
| A1B1-150 | 40 | 80 | 150 | - | B1 |
| A2B2-150 | 40 | 80 | 150 | - | B2 |
| A3B2-150 | 40 | 80 | 150 | PET | B2 |

## 3. RESULTS AND DISCUSSIONS

The summary of peak load and failure modes of all specimens is shown in Table. 2. The crack patterns and specimens at ultimate state are shown in Fig. 2. When comparing specimens with and without PET sheets, the relationship between AU150 and AU2-150 or A2B2-150 and A3B2-150, the peak load of specimen with PET sheets is approximately twice higher than that of specimen without PET jacketing. In addition, specimens with PET jacketing did not ruptured at

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ultimate state as shown in Fig. 2. This indicates that PET sheets enhanced the confinement of the core concrete so they significantly increase the peak load capacity.

**Table 2 Peak load and failure modes**

| Specimen | $P_{max}$ (kN) | Failure modes |
|---|---|---|
| A150 | 68.6 | Diagonal cracking |
| AU1-150 | 71.5 | Diagonal cracking |
| AU2-150 | 139.4 | Concrete：Compression failure<br>PET：No rupture |
| A1B1-150 | 63.7 | Diagonal cracking |
| A2B2-150 | 53.9 | Splitting |
| A3B2-150 | 106.7 | Concrete：Compression failure<br>PET：No rupture |

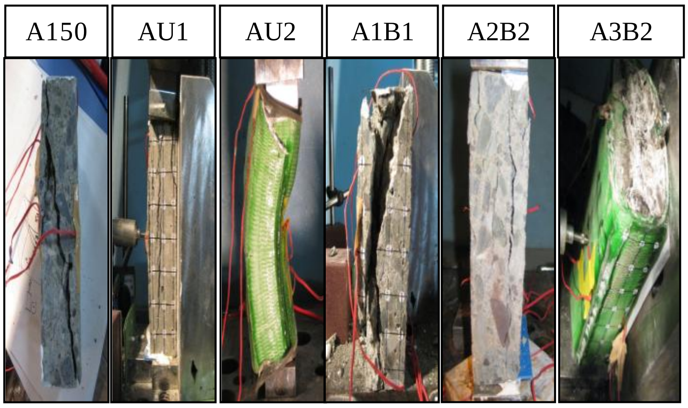


**Fig. 2 Crack patterns and specimens at ultimate**

Fig.3 shows a relationship between the load and vertical strain of specimens with and without PET jacketing. The strain of the AU2-150 increased more than that of AU1-150 as the load increased until the ultimate state. This indicates that PET sheets provided higher ductility and improved the confinement of the core concrete.

Fig.4 shows a relationship between the load and strain of rebar for the different boundary conditions. When comparing specimen A1B1-150 with the hinged-hinged condition to A2B2-150 with the fixed-end condition, the strain of specimen A1B1-150 increased more than that of specimen A2B2-150 at the ultimate state. Because the rotation induced at the B1-rebar's boundary leaded to the increase of lateral deformation of rebar after buckling, it resulted in a higher bending strain in the cross section of rebar. Another key observation is the buckling of rebar which was evident in the change of strain development. After the rebar buckled, the inner and outer strain of rebar showed different strain's mechanism—compression and tension.

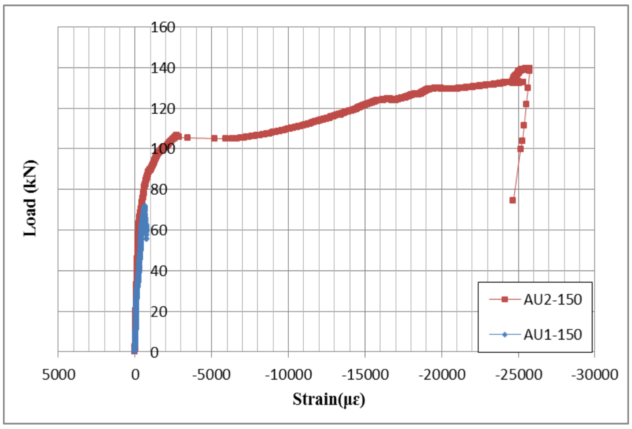


**Fig. 3 Load-Surface strain Curve**

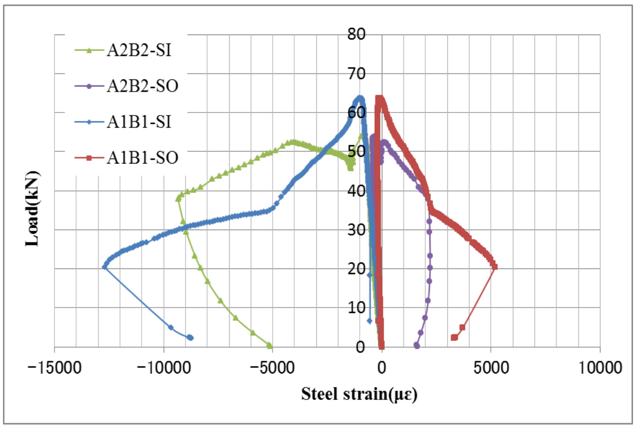


**Fig. 4 Load-steel strain Curve**

## 4. CONCLUSIONS

1) PET fiber sheet with high fracture strain did not break at the ultimate state and it also provided high effective confinement to the core concrete.
2) Difference in the boundary conditions can affect the development of strain in rebar. In the fixed-end condition, the strain of rebar shows smaller value than that of the hinged-hinged condition. This is because the rotation induced at the hinged-hinged boundary leads to the increase of lateral deformation of rebar after buckling, which results in a higher bending strain in the cross section of rebar.
3) The proposed test set up condition is able to show the buckling effect in strain of rebar. Therefore, it can be concluded that the proposed test set up is applicable.

## REFERENCES

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