Shear Performance of Concrete Beams Internally Reinforced with PBO Mesh

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Summary

In this study, the new innovation of internal shear reinforcement by using FRP mesh as a substitute for conventional stirrups was introduced. The substitution was expected to overcome the corrosion problem due to the prolonged utilization of steel stirrups. The six concrete beams were tested under the four-point bending load. One un-reinforced specimen (REF) was selected as a control beam and five specimens were reinforced with the internal PBO mesh varying in the number of mesh layers (N_f) and the total width of internal mesh in the shear span (L_f). The results from the test revealed that the increase in the number of mesh layer significantly improved the shear performance of the beams. On the other hand, an enlargement of the mesh width surprisingly diminished shear resisting performance of the internal mesh due to the presence of horizontal crack at the area where concrete and PBO mesh were attaching.

Keywords: PBO mesh; internal reinforcement; shear improvement; FRP mesh; shear capacity.

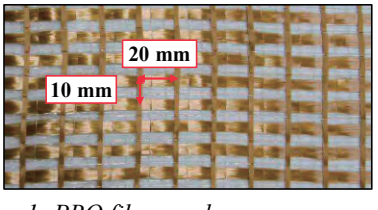

Fig. 1: PBO fiber mesh

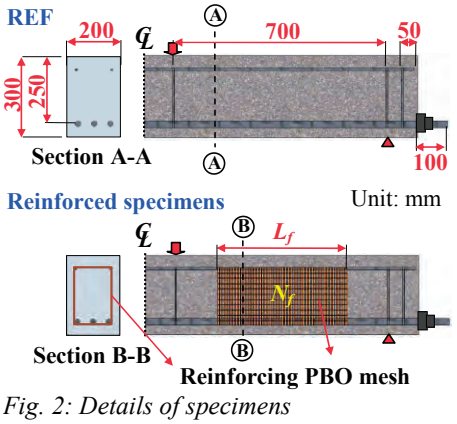

Fig. 2: Details of specimens

1. Introduction

To avoid a shear failure of concrete members, a new alternative shear improvement by using FRP mesh as a substitute for conventional stirrups was introduced. One of newly developed FRP meshes called PBO mesh as shown in *Fig. 1* has been adopted to reinforce concrete beams internally. The mechanical properties of the PBO fibers are very attractive since the elastic modulus of 270 kN/mm^2 and the tensile strength of 5800 N/mm^2 can be obtained if compared with the other types of structural fibers [1].

The new shear reinforcing method was expected to overcome the weak point of the utilization of stirrups due to the corrosion and extend the durability of the reinforcing FRP materials if compared with the externally bonded FRP system. The parameters were the number of mesh layers (N_f) and the width of internal mesh in the shear span (L_f) as shown in *Fig 2*. Shear capacities, load-displacement relationships were presented.

2. Experimental results and discussion

Figure 3 presents the relationships between the applied load and the mid-span displacement. For all reinforced specimens except N1-280, after the diagonal crack was observed, the loads still increased because of the internal mesh until the horizontal crack happened. It can be observed that the presence of horizontal crack greatly impacted the shear performance of the reinforced specimens and this became the failure mode of N1-700 as can be seen in *Fig. 4*.

Table 1: Summary of experimental results

Specimen designation	Mechanical properties of concrete		V (kN)	V_c (kN)	V_f (kN)
	f'_c (N/mm^2)	E_c (kN/mm^2)			
REF	41.2	30.0	77.8	77.8	-
N1-700	40.3	31.5	115.8	77.2	38.6
N2-700	33.8	28.3	134.3	72.8	61.5
N3-700	38.9	29.4	166.4	76.3	90.1
N1-280	34.0	27.6	141.5	73.0	68.5
N3-280	34.2	27.7	172.8	73.1	99.7

f'_c = compressive strength of concrete; E_c = Young's modulus of concrete; V = total shear capacity; V_c = shear carried by concrete, V_f = shear carried by internal PBO mesh

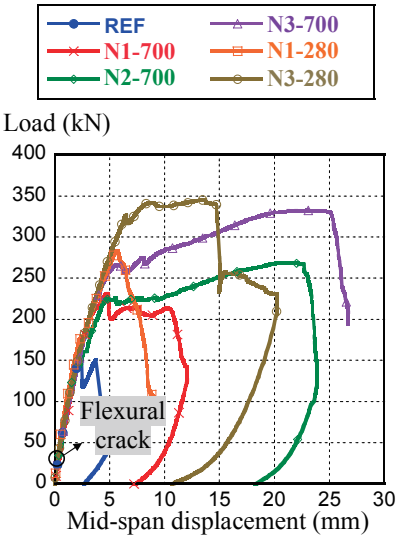

Fig. 3: Load-displacement curves

The results from *Table 1* show that the total shear capacity (V) and the shear carried by PBO mesh (V_f) increased with a larger number of PBO mesh layers. The total shear capacities of N1-700, N2-700 and N3-700 were higher than that of the REF beam about 48.8%, 72.6% and 113.9%, respectively. Similarly, the shears carried by PBO mesh of N2-700 and N3-700 were higher than that of N1-700 about 59.3% and 133.4%, respectively. Moreover, the comparison of the shear performance between N1-280 and N3-280 also showed that the total shear capacity and the shear carried by PBO mesh of N3-280 were higher than N1-280 about 22.1% and 45.5%, respectively.

Fig. 4: Crack patterns of N1-700

The effect of width of the internal PBO mesh in the shear span on the shear performance of the reinforced specimens reveals that, with the same amount of mesh layers, the shear performance of the shorter internal PBO mesh was better than the longer internal PBO mesh because of the presence of horizontal crack due to the weak bond between the reinforcing PBO mesh and the nearby concrete.

3. Conclusions

The new alternative shear reinforcement by the internal PBO mesh was proved to enhance the shear performance of concrete beam. With the same width of internal reinforcing mesh, the total shear capacity was increased as an increase of number of PBO mesh layers. On the other hand, because of the weak bond between the internal reinforcing mesh and nearby concrete, the larger of the mesh width could induce the horizontal crack resulting in the lower of the shear performance.

4. References

[1] RUREDIL S.P.A., "X Mesh Gold – Technical data sheet", S. Donato Milanese, Milan, 2006.