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Shear strength of composite beams with steel angle-fabricated truss

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ABSTRACT

We investigated the cutting resistance of composite beams made of prefabricated concrete and steel angle frames. In order to verify the shear strength, composite beams and ordinary reinforced concrete beams were tested under static load of 4 points. Test variables are pre-fabricated concrete, reinforcement angle and abutment. The cut resistance of the test was greater than the current design code due to the contributions of the steel members of the band. A modification of the current design equation has been proposed to improve the accuracy of force predictions. As a result of the test, fracture failure was observed at the interface between steel angle and concrete angle. Therefore, the resistance of the interface must be carefully considered in design.

1. INTRODUCTION

The precast concrete (PC) structure has advantages such as minimization of field work, shortening of construction air through modularization method, and production of constant quality member, and thus application to construction site is expanding. However, the PC structure has problems such as an increase in manufacturing cost due to the transportation of heavy members, a problem of stability of the assembly at the time of construction, and difficulty in securing of members in the field due to excessive weight of concrete in the long span structure. Therefore, lightweight prefabricated steel-concrete composite members are being developed to overcome these drawbacks.
Table 1 shows the various composite beam shapes of existing researchers. Kim (2002) conducted flexural tests to investigate the strength enhancement and adhesion failure caused by the composite behavior between the steel and concrete in the composite beams embedded in the H-beams in the reinforced concrete members. In addition, an exposed composite sheet has been developed to bend the steel material into a U-shape to simultaneously perform a function of a tensile material and a concrete form.

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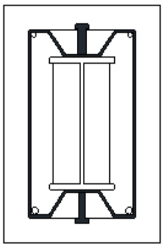
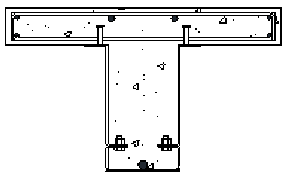
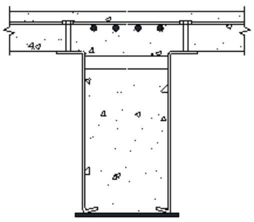
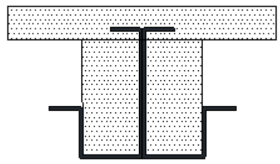
Kim (2012) developed a new U-shaped hybrid composite beam and evaluated its flexural performance. Lee (2016) conducted a study on the flexural performance evaluation and design of concrete filled U type hybrid beam using 570MPa high strength steel called TSC. Heo (2007) tested the performance of composite beams that bend and reinforce the concrete by bending the steel into lower U-shape and middle T-shape.

	Kim (2002)	Kim (2012)	Lee (2016)	Heo (2007)
Steel-Concrete composite section				

* More details are presented in reference papers

2. SHEAR STREHNGTH EQUATION (DESIGN CODES & WENG (2001))

2.1 Design codes

AISC360-10 [5] defines the nominal shear strength (Eq. (1)) as the sum of the shear strength of the steel and the shear strength of the shear reinforcement for the vertical shear strength of the composite beam,
Eq. (2) shows that the vertical shear strength of reinforced concrete beams is the sum of the shear strength of concrete and shear strength of shear reinforcement.

$$V_{n,AISC} = V_{steel} + V_{stirrup} \tag{1}$$

$$V_{n,ACI} = V_{conc} + V_{stirrup} \tag{2}$$

2.2 Weng (2001)

Weng (2001) conducted shear and flexural tests on SRC members embedded in H-shaped concrete, and evaluated the shear strength of embedded composite members. In this study, shear failure occurred before the flexural strength of the beam was exerted by the decrease of the horizontal shear resistance area of the concrete due to the use of the steel, and the shear splitting failure strength related to the bond strength between the steel and concrete was considered .

3. Test program & Results

3.1 Test program

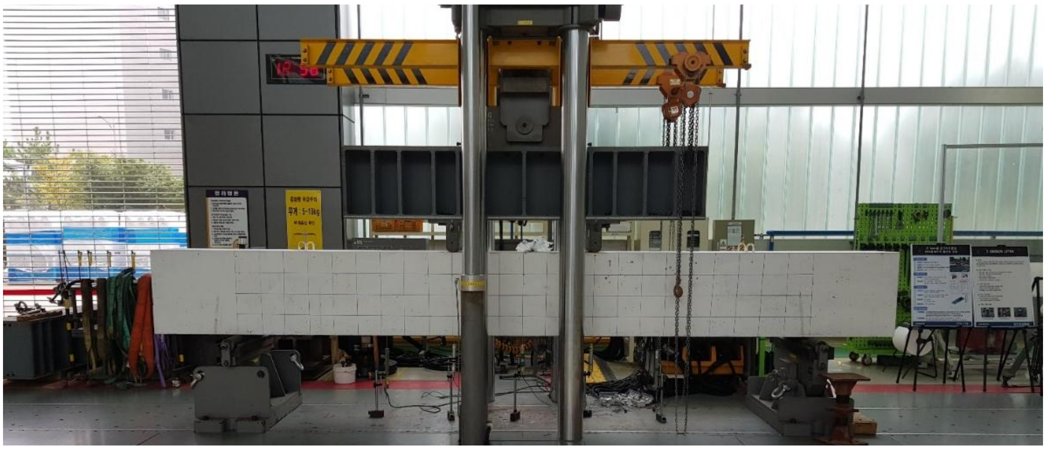


Fig. 1 Test setup for four points static loading

Fig. 1 shows the setup of the experiment and the location of the instrument installation. The total length of the specimen is 7200mm, the length between the supports is 4,200mm, the shear span is 1,800mm and the distance between the load points is 1,200mm. Therefore, the shear span ratio (a / h) = 1800/700 = 2.6. The section of the specimen is 500mm x 700mm. Also, the angle truss was assembled and buried inside the specimen. The point was simple support at both ends. The test was performed by forging using 3,000 kN capacity UTM.

3.2 Test results

Fig. 2 Test results of specimen S3 and S4

Fig. 2 shows the fracture photographs after the end of the experiment of S3 and S4. As shear test specimens S3 and S4, initial flexural cracks occurred, and the flexural cracks increased with increasing load, and they spread toward the fulcrum at the center. Bending cracks also develop into diagonal cracks. The developed diagonal cracks induce the stretching of the inner angle truss and shear reinforcement and resist the shear force. At the end, shear cleavage fracture and diagonal tensile fracture occurred as a mixed fracture.

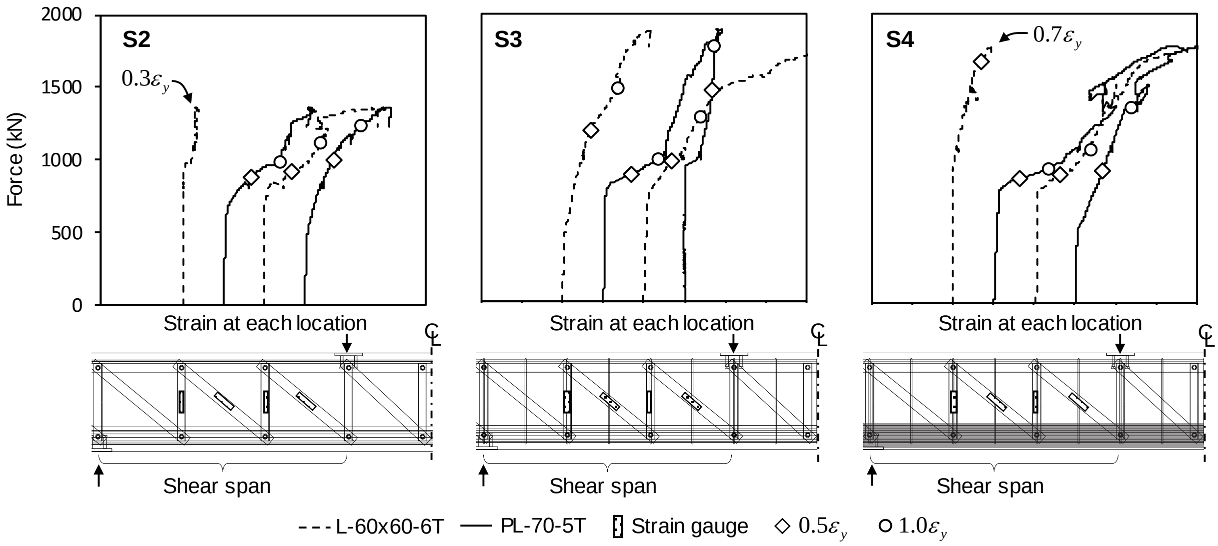


Fig. 3 Strain gauge of web truss

Fig. 3 shows the steel strain gage values attached to the web truss. The x-axis represents the spatial position of the strain gage, and the y-axis represents the experimental load of the specimen. Since all gauges exhibited a positive value of gauge behavior, no negative sign was given.
Also, the diamond marks indicate the yield strain and the circle mark indicates the yield strain.

3. CONCLUSIONS

To evaluate the shear strength of angle composite beams, five specimens were designed and tested with 4 point static load.
The conclusions obtained from the experiment are summarized as follows.

- The shear strength of angle composite beams showed higher experimental strength than AISC and AIC.

- We believe that the reason for this high strength is due to the truss angle buried in the inside.

- The reason for this is that the web trusses in the interior resist the diagonal tensile failure of the concrete while applying tensile resistance in the same manner as the shear reinforcement, as shown in Fig.3

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