ABSTRACTS (MASTER THESIS)

Compressive fracture behavior of CLT wall panel under horizontal loading

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Introduction

As a way to open up new possibilities for wood buildings with low environmental impact, Cross-laminated timber (CLT) that can effectively utilize low-quality materials and enable a reasonable wall structure has attracted attention, and mid-rise building technology is under development. In the shaking table experiment of the 5 story CLT building, a compression failure was caused at around the hole for fasteners at the bottom of the wall panel of first floor, and it became a criterion for seismic performance. This study aimed to verify this phenomenon which is considered as one of design criteria.

Methods

In order to reproduce a compression failure at the bottom of wall panel, a static horizontal loading test of a 5-layer 5-ply CLT wall panel with length 1,000 mm × height 2,700 mm × thickness 150 mm was conducted. Also, the presence or absence of hole for tensile bolt connector was set as parameter. In the loading method, pulling side cyclic loading was applied controlled by apparent displacement based on stroke displacement of the actuator. The lift-up displacement due to the locking of the panel was restrained by tie-rods, HD hardware so as to cause a collapse at panel leg. Simultaneously, the numerical analysis by elasto-plastic finite element model was carried out for the model of specimen. In the FE analysis, the influence of the restraint condition and the vertical force of the top of the specimen was confirmed.

Results and discussion

In the fracture behavior, after the crack was observed near the hole, the outermost lamina was deflected out of plane and collapsed by local buckling, which was similar to the destructive behavior of shaking table experiment. The load-displacement relationship showed elastic load increase up to deformation of 1/30 rad, followed by no clear load reduction until 1/20 rad with high deformability. The specimens with holes showed about 20% lower ultimate strength in comparison of the specimens with and without holes. It was thought that the vicinity of the hole collapsed prior to the crush of the contact surface at the bottom of the panel. From the stress distribution of the specimen measured by the strain gauge, the internal stress flow was observed that occurred from the position of the tie rod at the top of the specimen toward the leg compression side. So it was concluded that the resistance mechanism of the compression struts was formed by tie rods bearing the large tension force. Results of FE analysis were in good agreement with experimental results. In order to confirm the influence of constrained conditions, a model only tie rods works as constraint hardware was analyzed. As a result, it was found that the contribution of the hold-down fastener to the horizontal resistance is smaller than that of the tie rod. In order to simulate the actual shaking table experiment condition, in which the tensile restraint conditions are different from wall test, we performed advanced FE analysis with applying the vertical constant load of 0 to 2,000 kN as the parameter. The results are shown in Fig. 1. Up to vertical load condition of 1,500 kN, the higher the vertical load, the more the lifting is restrained which resulted in the higher yield load. However, in condition of 2,000 kN, both rigidity and yield load became smaller compared with that of 1,500 kN. Based on this result, it was confirmed that the crushing of the leg in the shaking table experiment was caused by the influence of the fluctuating axial force due to the horizontal force.

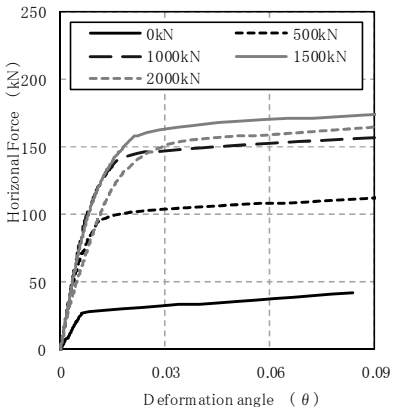

Figure 1. Relation between load and deformation angle.