R & D for Standardization of CLT Panel Construction in Japan

Building Research Institute *Contact: Takahiro TSUCHIMOTO, Ph.D., tutti@kenken.go.jp*

1. Introduction

The Act for Wood Use Promotion in Public Buildings of Japan was established at 2010. The CLT panel construction are considered as a choice to promote the wood utilization. In this paper, the research and development for the standardization and the recent case studies of CLT panel construction in Japan.

2. Background

Almost of trees in Japan were cut (Photo 1) in order to substitute the fossil fuel under the World War II. So, we don't have little wood to recover the damage by the war. After that, many trees were planted on all of bare mountains. Recently, the planted trees has grown up enough to be used as building components. So, we have to use the domestic wood and the Act for Wood Use Promotion was established.

The cross laminated timber (CLT) could be manufactured in Japan recent several years. In high seismic Japan, it is necessary for CLT panel construction to be safe under the strong ground motion. So, we have to develop the seismic design methods of CLT construction.

3. Initial studies

In 2011 fiscal year, the experimental studies on material strength and joint capacity were conducted, as shown in Fig. 1. As a result, the tensile bolt was chosen as a prototype of the specification of CLT joint because of strength, ductility and workability of assembling the joints.

Next, the lateral load tests on the structural elements as shown in Fig. 2 were conducted. Based on the performance of the tensile bolt and structural elements, the full-sized 3-story building as shown in Photo 3 was designed and tested on the shaking table. As a results, the rocking behaviors of panels as shown in Fig. 3 were obtained and the failure properties has never grasped.

Photo 1. Bare mountains after World War 2.

Photo 2. Mountains covered with planted trees.

Photo 3. Full-sized 3-story shaking table test.

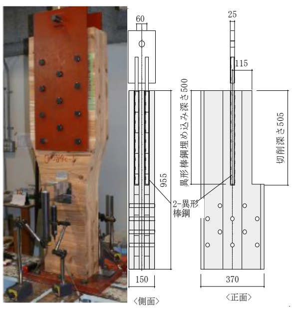

Fig. 1. Joint test of tensile bolt.

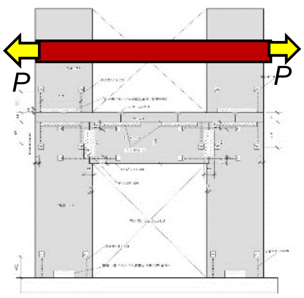

Fig. 2. Structural element under lateral load tests.

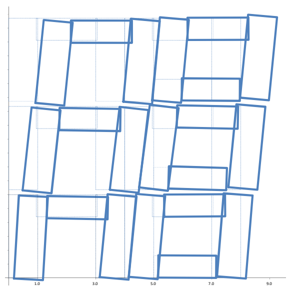

Fig. 3. Diagram of rocking behavior of panel.

Then, the static lateral load test for the full-sized 3-story building with the same specification to the former. As a result, the failure mode of (a) failure of floor panels, (b) that in joint, (c) compression at washer perpendicular to grain and (d) failure of whole wall were grasped, as shown in Fig. 4.

Fig. 4. Failure modes under the static load to full-sized 3-story building.

4. Recent studies

In FY2014, the suitability of structural analysis model (Fig.5) was verified of the results of shaking table tests on full-sized 5- and 3-story CLT building, as shown Photo 4 (a) and (b), respectively. The 5-story speci-men employed the narrow panel construction (Photo 5) with the tensile bolts and targeted the middle-rise building. The 3-story specimen employed the wide panel construction (Photo 6) with the wood screws and targeted the low-rise house construction.

In FY2015, in order to establish the general seismic design method, 3 full-sized 3-story specimen (Table1) were subjected to shaking table tests. The focus of these tests were on the development of the seismic method which may secure the safety under the extremely rarely occurred earthquake without special calculation with higher skills. As a result, the failure positions, as shown Photo 7 and timings were agreed with stress-concentrated position and the timing estimated by the analysis. In the design methods that tolerate cracks in the corner, the behavior after cracks is considered to shift to the same behavior of the narrow panel structures.

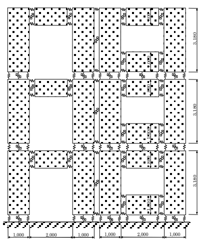

Fig. 5. Finite strip element model.

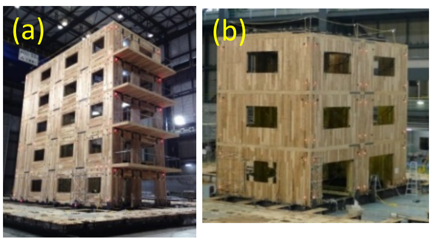

Photo 4. Full-sized (a) 5- and (b) 3-story shaking table test.

Photo 5. Narrow panel construction.

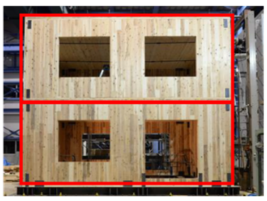

Photo 6. Wide panel construction.

Table 1. Descriptions of tested building E, D and C.

	Building E	Building D	Building C
Structure	Narrow Panel	Wide Panel 1	Wide Panel 2
No. of stories	3		
Height	8.7 m		
Plane size	6 m × 10 m		
Wall panel	90 mm width, 3-ply 3-layer		
Floor panel	210 mm width, 7-ply 7-layer		
Joint at wall bottom	Steel plate screwed joint		

Photo 7. Failure position of building E, D and C.

5. Conclusion

Based on the parametric studies with analytical model corresponding to the test results, the amplification or ductility factor which secured the safety under the extremely rarely occurred earthquake were derived. These factors and some other studies made the notification for the structural design of CLT panel construction under the Building Standard Law of Japan were established in 2016.