A SEISMIC DESIGN OF 3-STORY BUILDING USING JAPANESE “SUGI” CLT PANELS

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ABSTRACT: In this paper, the general process and results of the seismic design on a 3-story building with Japanese Sugi CLT construction based on the time history response analysis as the only legal structural design method in Japan at the present moment, are shown. As a result, it is recognized that the building has enough seismic performance for the regulation of seismic design in Japan.

KEYWORDS: Japanese “Sugi” CLT panels, Seismic design, Dynamic analysis

1 INTRODUCTION

In Japan, recently some research projects on CLT (Cross Laminated Timber) construction are conducted to establish the law on the design method of CLT buildings suited with the Japanese regulations of seismic design. However, at the present moment, building with CLT construction have to be structurally designed only under “Approval route” where seismic performance of objective building is verified through the time history response analysis to obtain the approval by the minister of MLIT, since the law concerned with practical structural design of CLT construction is not yet issued. In this paper, dealing a 3-story building shown in Figure 1 with Sugi (Japanese cedar) CLT panels as the objective, general process and results of the structural design under “Approval route”, based on the results of structural tests on the CLT panels and the connections that were carried out as a part of the projects above mentioned, are shown.

2 BUILDING FOR STRUCTURAL DESIGN

The objective building is box-shaped 3-story wall structure with CLT panels used for a company house. The shape of plan is rectangular of 8.0m x 12.5m. The height is 9.950m. The composition of the structure is as shown in Figure 2. The thickness of CLT panels is 150mm for vertical planes, 180mm for diaphragms including roof panels. Tension-bolts and screws with steel plates are applied each to tensile and shear connections.

3 PROCEDURE OF SEISMIC DESIGN

As mentioned below and shown in Figure 3, the seismic design was processed under the procedure according to the regulation of “Approval route”.

Step 1 (static analysis); For the load incremental analysis (“static analysis” in the followings), the structure was transformed into 3-dimensional model where CLT panels and connections were expressed each as the shell elements and the spring elements. The mechanical properties of these elements were set based on the test results.
Step 2 (dynamic analysis); For the time history response analysis (“dynamic analysis” in the followings), the structure was transformed into 3-mass model. The load-deformation properties of each story were set based on results of the static analysis. The seismic motions were amplified to make their maximum velocity 25kine for Level 1 and 50kine for Level 2 which corresponded each to moderate and large earthquake.

Step 3 (stress for Level 1, 2 motions); Stress of the shell elements and the spring elements from the static analysis when the maximum story drift angle was 1/200rad and 1/100rad were each regarded as the stress for Level 1, 2.

Step 4 (verification of story drift and stress); The maximum story drift angle from the dynamic analyses and stress of the elements from the static analysis were examined according to Table 1. The allowable stress and the ultimate strength were set based also on the test results.

4 RESULTS OF VERIFICATION

As shown in the right end of Figure 3, the maximum story drift angle from Level 1 motions was 1/213, and from Level 2 motions was 1/109 which satisfied the criteria above mentioned. The ratio of the maximum stress of the shell elements and the spring elements on 1/200rad deformation to the allowable stress was 0.86 or less, and the ratio of the maximum stress on 1/100rad deformation to the ultimate strength was 0.78 or less.

5 CONCLUSIONS

The general process and results of the seismic design on a 3-story building with Japanese Sugi CLT construction based on the time history response analysis as the only legal structural design method in Japan at the present moment, are shown. As a result, it was recognized that the building had enough seismic performance for the regulation of seismic design in Japan.