ABSTRACT: This paper shows the racking test results of CLT shear walls with different failure modes. The failure modes of shear walls were designed by using reliability analysis considering the failure of the hold down connections at the bottom end of shear wall and that of the joints connecting two CLT panels at the centre of the wall. It was shown that the design of joints with the yield capacity $P_y$ for the central joints SP and the ultimate capacity $P_u$ for the hold down connection HD (Mode III) determined well the precedence of HD failure without slips in SP and showed high capacity, while Modes I and II failure showed higher ductility than Mode III failure.

KEYWORDS: CLT shear walls, Failure mode, Reliability analysis, Yield load, Ultimate load

1 INTRODUCTION

In seismic design, the joints connecting CLT panels to the surrounding boundaries such as hold-down connections dominate the mechanical property of the structure. The determination procedure of the failure mechanism of CLT shear walls due to the failure of joints was presented in the 45th CIB-W18 meeting in Vaxjo1. It showed that the reliability based analysis based on the ultimate capacity of fasteners predicted quite well the failure process of shear walls when a rigid loading beam was applied. However, the failure process due to the failure of hold-down connectors was not very clear when the flexible loading beam was used. Therefore additional lateral loading tests were conducted by using flexible loading beam as shown in Fig.1 with different procedures to determine the failure mode. This new procedure based on the yield strength of shear plates and the ultimate capacity of hold-down connectors showed better determination of the failure mechanism of CLT shear walls without conspicuous slips between CLT panels.

2 BASIC THEORY

Assuming a shear wall including of two CLT wall panels connected each other with screwed shear plats (SP) and connected to the foundation with hold-down connectors (HD), the condition where the failure of SP precedes that of HD (Mode I) is:

$$Z_I = (TU + FV) - SU \geq 0 \quad \cdots (1)$$

the condition where the failure of HD precedes the failure of SP (Mode II) is:

$$Z_{II} = SU - TU - FV \geq 0 \quad \cdots (2)$$

and the condition where the failure of HD precedes the failure of SP without slips at the panel joints (Mode III) is:

$$Z_{III} = SY - TU - FV \geq 0 \quad \cdots (3)$$

where $Z_I$, $Z_{II}$, $Z_{III}$ = performance function in each failure mode, $TU$ : ultimate capacity of HD, $SU$, $SY$: ultimate and yield capacity of SP joints and $FV$: vertical force per panel. The average and standard deviation of HD and SP were obtained from the tensile and shear tests of HD and SP, and the number of screws used for SP was determined as shown in Table 1.

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Figure 1: Schematic diagram of specimen
3 LATERAL LOADING TEST OF CLT SHEAR WALLS

Reversed cyclic lateral loading tests were conducted with CLT shear walls. Specimens were designed to have the failure mechanism either by HD or SP. Vertical loads of 30kN in total were applied. The loading beam was separated at the centre of specimen to allow the free slips between two panels, and they were connected by two steel bar of 30x70mm at the centre of each panel.

Figure 2: Load-displacement relationship of specimens

Figure 3: Deformation of CLT panels in each specimen with the vertical loads of 30kN

4 RESULTS AND DISCUSSION

Figure 2 shows the example of load-displacement relation with the vertical load of 30kN, and Fig. 3 shows the deformation of panels. These results show that the design of joints with the yield capacity $P_y$ for SP joints and the ultimate capacity $P_u$ for HD joints (Mode III) determine well the precedence of HD failure without slips in SP and showed high capacity, while Modes I and II failure showed higher ductility than Mode III failure.

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