

ABSTRACTS (PH D THESIS)

Evaluation of Structural Performance of CLT Joint

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Introduction

Cross Laminated Timber (CLT) is the structural timber panel for buildings. In the 90's, that is developed in Europe, and expected as a new material for the structural wall panel and/or floor in Japan. We chose the dowel type joint as the connectors to fix wall. The major benefits expected for CLT dowel type joints are the small dependence of load carrying capacity on angular orientation, and large deformation ability due to the prevention of failures along the laminae axis. The load carrying capacity of dowel type joints were evaluated by experiments, yield theory [1], and numerical to contribute to establish a design method of the joints.

Non-linear Behavior of Single CLT Drift Pin Joint

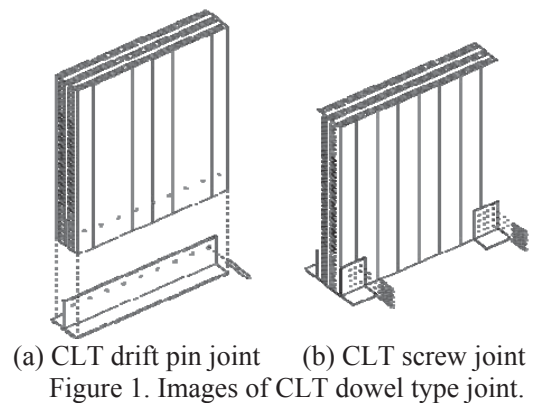
Image of dowel type leg joints with the CLT panel were shown in Fig.1 (a)(b). Usually, the dependence on angular orientation evaluated by Hankinson's experimental equation [3] and behavior of bar on the timber expressed by Winkler's foundation model [2]. Therefore, we predict the load-deformation relationships of CLT drift pin joints using FEM analysis based on these two theories, and that were verified by experiments (Fig.2 (a)(b)).

Tensile test of single drift pin joint was performed for the verification. The test parameter was determined to the laminae axis orientation against the load direction (0° , 45° , and 90°) for clarity the variation of the load-deformation relationships. Those relationships were measured by setups shown in Figure 2(a). The small dependences of structural performance of drift pin on angular orientation were verified [4]. Also, the horizontal structural performance of CLT shear wall with drift pin joint was verified by FEM analysis and experiments [5].

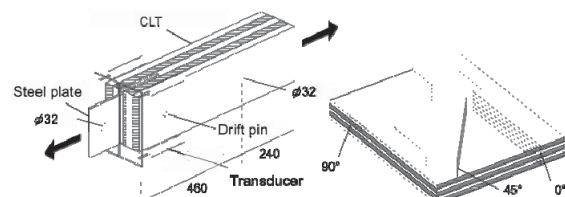
Failure Behavior of Single CLT Drift Pin Joint

Figure 4, 5 and 6 show the test parameters for the consideration of the failure factor around the connection, failure figure and an example of the test result; relationship between failure load and effective shear area.

Sprit or shear failures along the axis direction of each lamina were expected on the test parameters figure 4, however, actual failures were shear failure around the border of layers and rolling shear and/or tensile failure of the perpendicular layers.



(a) CLT drift pin joint (b) CLT screw joint
Figure 1. Images of CLT dowel type joint.



(a) Tensile test of single joint (b) Specimens
Figure 2. Experiment setup.

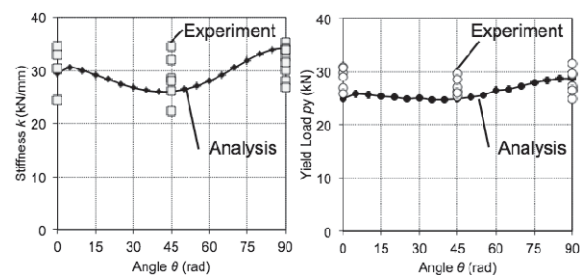


Figure 3. Effect of loading angle against the tensile performance of drift pin joint.

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The failures around the pin were not observed on the connection that has largest effective shear area ($e_1 e_2 = 7 * 7 d^2$). The maximum load and deformation were compared with logarithm of effective shear area. Logarithm was taken for the consideration of stress concentration around the hole.

Deference between Single CLT Screw Joint and Single CLT Drift Pin Joint

Same as CLT drift pin joint, CLT screw joint shown in figure 1(b) also was performed tensile test of single joint. The increase in the resistance load after the yielding by withdrawal resistance was observed on tensile test of single CLT screw joint. On the other hand, the joint has weakness against cyclic loading targeted in the positive and negative direction. Brittle failure arise from the material property of the screw was the caused of this phenomenon.

Conclusion

The merits of CLT dowel type joint are; (a) The small dependence on angular orientation caused of the cross lamination (b) The large ductility caused of the prevention of failures along the axis direction of each lamina. CLT screw joint resists against the tensile load by not only bending of the fastener but also withdrawal of the fastener.

Acknowledgements

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References

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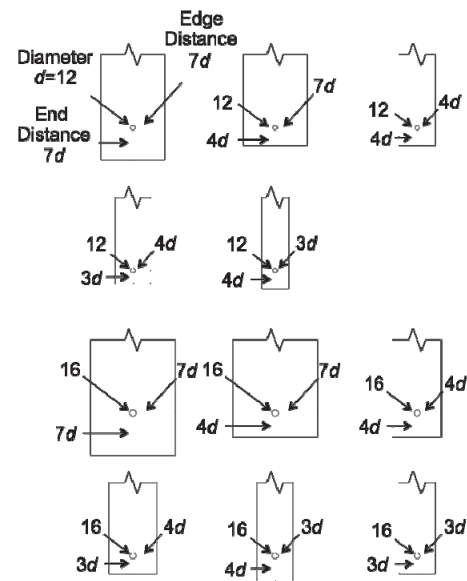


Figure 4. Test Parameters

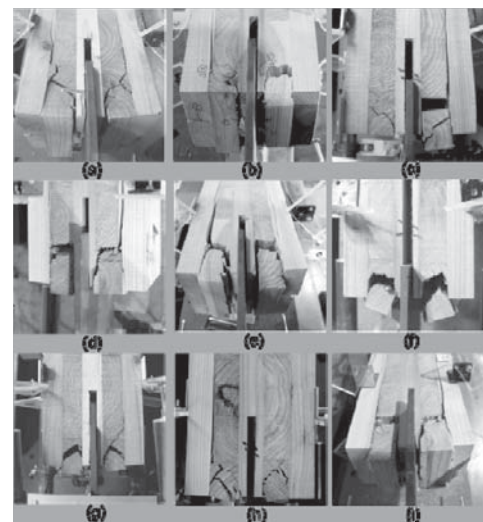


Figure 5. Shear failure on the border of the laminae.

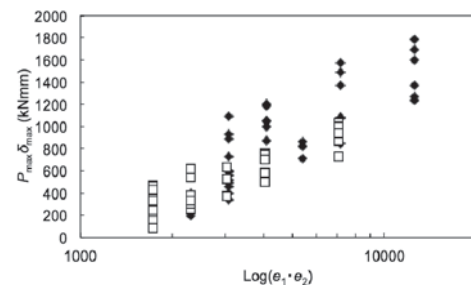


Figure 6. Maximum Load ($P_{\max}$), Deformation ($\delta_{\max}$) – Effective Shear Area ($e_1 \cdot e_2$) Relationships of Drift Pinned Joint. Legends: $\square$: Drift pin diameter $d = 12$, $\blacklozenge$: Drift pin diameter $d = 16$.