

IN-PLANE STIFFNESS OF CROSS-LAMINATED TIMBER FLOORS

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ABSTRACT: This study investigates the in-plane behaviour of CLT floor diaphragms and lateral load distribution within buildings containing CLT floors. It is common in practice to assume floor diaphragms as either completely flexible or rigid. Based on the assumption for the flexibility of floor diaphragm, the lateral load is then distributed to the attached shearwalls according to simplified hand calculations methods. However, as a relatively new product to North American wood industry, it is not clear whether CLT floors falls under these two distinct categories, and also if the simplified lateral load distribution methods are applicable for CLT assemblies. As part of the NSERC Strategic network “NewBuildS” projects to investigate the characteristics of CLT panels produced in North America, this study has resulted in key findings regarding the in-plane behaviour of CLT panels.

This was achieved through developing detailed 2D finite element models of CLT panels and a generic smeared model of CLT panel-to-panel connections in ANSYS. UBC in-house test data was utilized to calibrate the generic panel-to-panel connection to examine the behaviour of CLT panels connected with a special type of self-tapping wood screws as a floor diaphragm. The most influential parameters affecting the in-plane behaviour of CLT floors and lateral load distribution within CLT buildings were then identified by means of parametric study. The studied parameters are categorized in the following two groups: (1) material properties, including mechanical properties of CLT panels, parameters defining the non-linear response of CLT panel-to-panel connections, and stiffness of the attached shearwalls; (2) geometrical parameters, including floor diaphragm configuration, number of connected CLT panels, and dimensions of the panels.

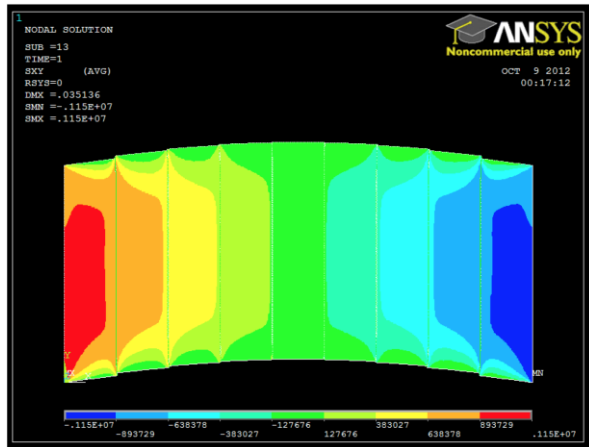
It was found that, the in-plane stiffness and thus the in-plane behaviour of CTL floors are primarily dependent on the properties of the panel-to-panel connections and shear modulus of elasticity of CLT panels. In fact, most of the in-plane deformation of CLT floors occurs in panel-to-panel connections, if these connections are less stiff than the panels (Figure 1). Moreover, whether CLT floors should be assumed rigid or flexible is dependent predominantly on the relative stiffness of the CLT floor diaphragm and the attached shearwall system, i.e. shearwalls and shearwall-to-floor connections. In addition, the numerical results of ANSYS analyses for lateral load distribution were compared with simplified hand calculation methods, for various cases. It was found that, contrary to intuition, the actual lateral load distributions in most of the studied cases were closer to the results of flexible diaphragm assumption, rather than rigid diaphragm assumption (Figure 2).

KEYWORDS: Cross-laminated timber, In-plane Stiffness, Floor diaphragm, ANSYS

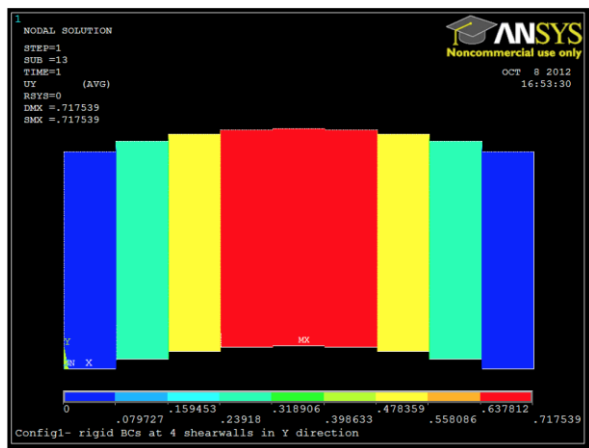
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(a)



(b)

Figure 1: Example of CLT floor models in ANSYS (a) with stiff panel-to-panel connections, (b) with more flexible panel-to-panel connections, under uniform in-plane load

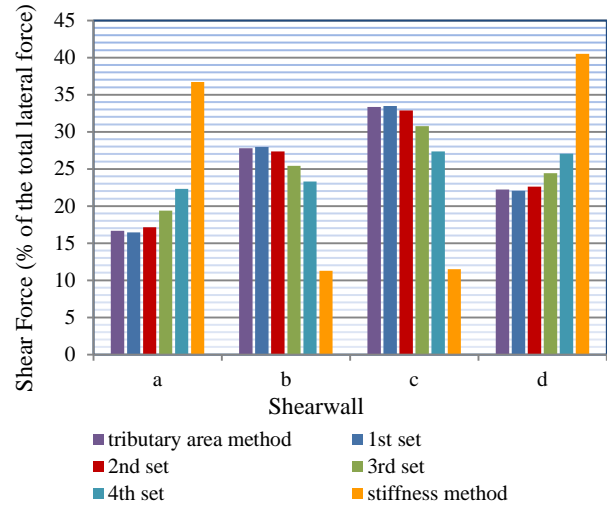


Figure 2: Example of comparing the lateral load distribution from ANSYS analyses for different cases, with hand calculation results for flexible diaphragm (purple column) and rigid diaphragm (orange column)

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