Technical Note 2

July 2013

IN-PLANE STIFFNESS OF CROSS-LAMINATED TIMBER FLOORS

KEYWORDS: Floor diaphragm; In-plane diaphragm stiffness: Cross laminated timber

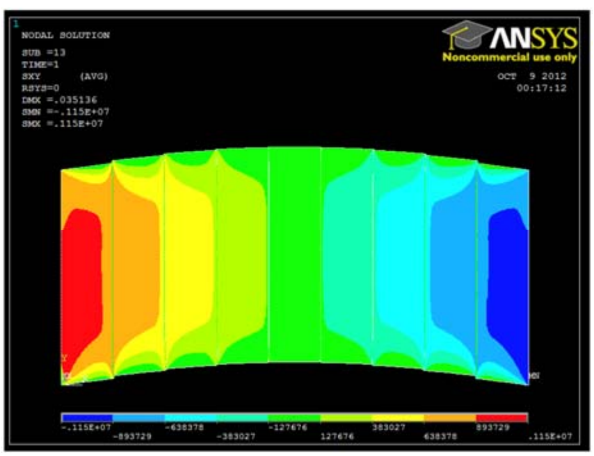
OVERVIEW OF PROJECT

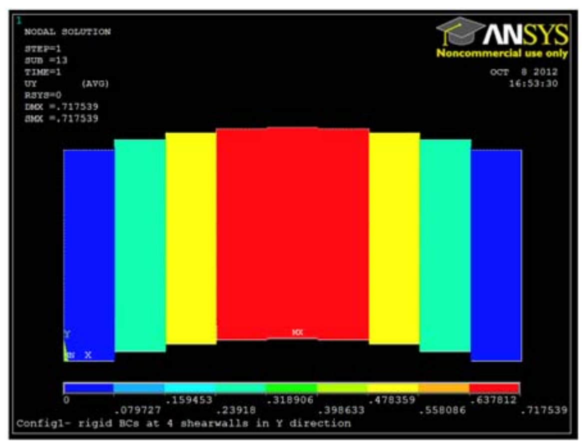
The objective in this project was to study the in-plane stiffness of CLT floor diaphragms. The in-plane stiffness is an important factor in determining the distribution of forces onto shear-walls for buildings subjected to lateral forces from wind or earthquakes. To determine the force in each shear wall it is common in current design practice to classify the diaphragm as either flexible or rigid. In engineering practice, some diaphragms are assumed to be rigid, including reinforced concrete floors, while others are assumed to be flexible, including light wood-frame floors. While CLT is a wood product, it is not clear that it should be categorized with wood-frame floors as being flexible. In fact, intuitively it may appear that the in-plane stiffness of thick CLT panels is closer to rigid than flexible.

The research approach adopted in this project recognized that the key source of flexibility in CLT diaphragms is the connection between the panels. Thus, test data for panel-to-panel connections were obtained and implemented in a detailed finite element model of the CLT floor diaphragm. Several configurations were analyzed, ranging from standalone panels to more complete building configurations.

KEY RESULTS

Selected results from this research project are presented.





The above two figures show plots from the finite element program ANSYS, which was utilized for modelling floor diaphragms in this project. The left figure shows the mode of deformation when the panel-to-panel connection (self-tapping screws) is stiff relative to the in-plane stiffness of the panels. Conversely, the right figure shows the more realistic mode of deformation, where most of the in-plane deformation takes place in the connections between the panels.

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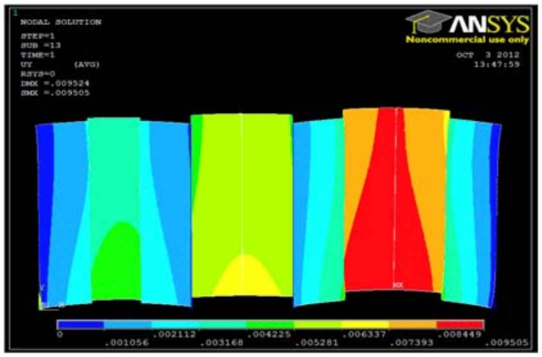
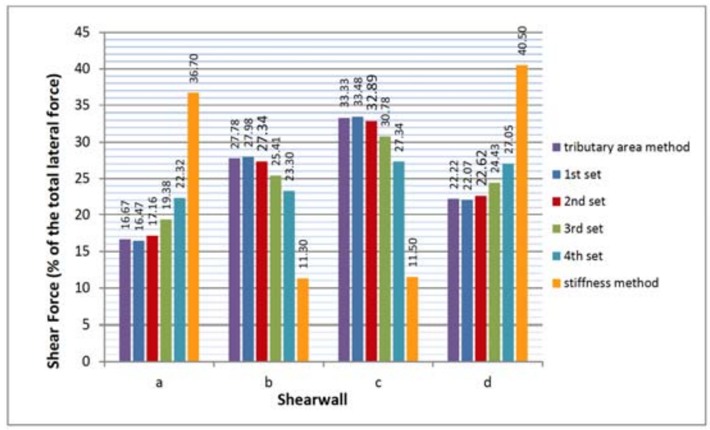
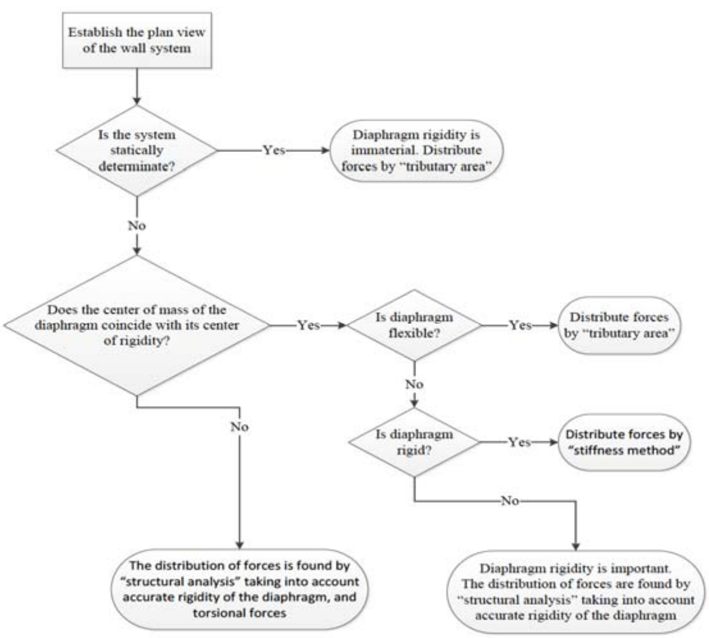


This figure shows the deformation mode for the CLT panels of an actual building plan. This building was analyzed with ANSYS, and shear wall forces and other results were examined. It is observed that a substantial portion of the overall deformation takes place in the panel-to-panel connections. The presence of shear wall also alters the deformation mode compared with the two figures above.

The figure on the right shows the percent distribution of forces in each of four shear walls, namely a, b, c and d, transferred from a floor diaphragm. The shear wall stiffness increases from the "1st set" to the "4th set". The results with a completely flexible diaphragm (purple column) and a completely rigid diaphragm (orange column) are also shown. Contrary to the intuitive belief, it is observed that the results are closer to the flexible diaphragm assumption than the rigid assumption because of the deformation in the connections.





The figure on the left shows a simple and tentative flow-chart that can be used by an engineer to approach the problem of how to determine forces onto the shear walls due to wind and earthquake demands.

THESIS

Ashtari, S. 2012. In-plane stiffness of cross laminated timber floors. MASc thesis. University of British Columbia, Vancouver, BC.