Large X-Lam Floor and Roof Plates For Composite Construction

Ian SMITH
Professor
University of New Brunswick
Fredericton, NB, Canada
ismith@unb.ca

Ian Smith DSc, PhD, CEng, PEng, FIABSE, FIStructE, FIWSc was born and educated in England before moving to Canada in 1986.

Andi ASIZ
Research Associate
University of New Brunswick
Fredericton, NB, Canada
aasiz@unb.ca

Andi Asiz PhD, PEng originates from Indonesia and holds MSc and PhD degrees from Colorado State University and the University of Colorado, Boulder.

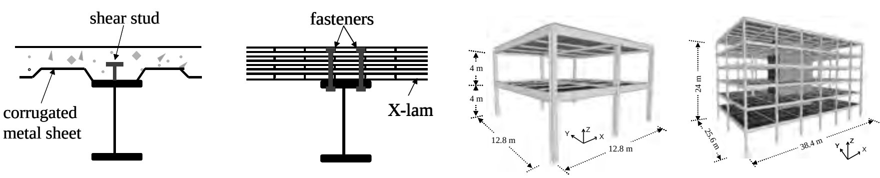
Summary

Focus is on using massive wood prefabricated Cross Laminated Timber (X-Lam) panels as slab elements in floors and roofs of composite steel framed buildings. Such panels are like giant sheets of plywood with thicknesses from about 75 mm to several hundred mm, with individual layers consisting of sawn lumber boards. Numerical case studies suggest that gravity deflections, sway deflections and stresses in the steel frame are much reduced using X-Lam slabs instead of conventional steel-concrete composite slabs in either low- or medium-rise buildings.

Keywords: Composite construction, concrete, connections, floors, roofs, steel, timber, X-Lam.

1. Introduction

Over the last decade X-Lam panels have become popular in Alpine Europe for construction of low- and medium-rise residential and commercial buildings. The approach taken is to create structural systems in which all of the walls and upper floors are made entirely from X-Lam panels that are fixed together with simple fasteners like long screws. It is rather like building with giant sheets of plywood. Although panels must be prefabricated in factories they are of low mass and can be easily transported to site and easily handled and erected once there. Here consideration is given to using X-Lam panels to construct floor and roof slabs within composite steel framed buildings. The vehicle is finite element method case studies of the performances of two-storey and six-storey buildings that incorporate X-Lam slabs elements (SRX systems) in lieu of conventional steel and concrete composite slabs (SRC systems) for loadings typical in Canada, Fig. 1. Analysis was performed using the SAP2000 software [1].



(a) SRC (steel-concrete) *(b) SXL (X-Lam)* *(c) case study 1* *(d)case study 2*

Fig. 1: Slab constructions and system arrangements for case studies

In the SRC systems floor and roof slabs consist of cast in place concrete poured over corrugated steel permanent forms, with the slabs connected to the steel frame beams via shear studs, Fig. 1a. Slab thicknesses are 150 mm for floors and 110 mm for roofs. In SXL systems the slabs consist

https://doi.org/10.2749/222137908796292380

of 1.6 m x 6.4 m prefabricated X-Lam panels connected to steel beams via mechanical fasteners, Fig. 1b. Abutting edges of panels interlock via as tongue and groove joints fastened using long wood screws, ensuring slab continuity. Slabs are 190 mm for floors and 112 mm for roofs. For the six-storey building the steel frame is supplemented by a building core constructed from reinforced concrete shear walls. Mechanical properties of X-Lam are from the literature [2,3].

2. Summary of case study results

It was found for both the two-storey and six-storey buildings that using X-Lam slabs lowers deformations, stress in the steel framework and modal periods, compared to matched SRC systems. This is irrespective of whether loads are gravitational forces or combinations of gravitational forces and ground motion. Assuming that either SRC or SXL systems respond as though slabs create rigid diaphragms is reasonable for normal design purposes.

Fig. 2: Case study 2: fundamental mode shape

The introduction of the shear walls to the 6-storey arrangement meant that it's dynamic response was unsymmetrical (torsional) irrespective of the nature of applied ground motions. Fig. 2 illustrates this based on the fundamental mode. Third and higher modal frequencies for either SRC or SXL systems tend to cluster, and therefore amplification of motion occurs at many locations. Largest levels of inter-storey drift occurred in mid-height of the building in both types of system, but in each case those were less than 1/600 of storey height. The most challenging issue with design of taller building with X-Lam slabs is connecting them to steel frameworks. Analyses found the largest slab connection demands occur at the 3rd floor level of the taller building, requiring use of 12 mm diameter screws spaced at 150 mm on centre. That peak demand was the consequence of high torsional accelerations in the system during design level earthquakes for the high seismic risk West coast of Canada.

3. Conclusions

It is highly feasible to substitute Cross Laminated Timber (X-Lam) slab elements in lieu of conventional steel-concrete slabs in composite steel framed buildings of low- or medium-rise. The X-Lam slabs create rigid diaphragms, and their light weight reduces demands on the steel frameworks and moderates building sway during potentially critical seismic events. The proposed construction method is not expected to be problematic from fire safety or building serviceability perspectives. Further refinement of construction details will be beneficial and is being addressed by the authors.

References

[1] COMPUTERS AND STRUCTURES INC., *Nonlinear Structural Analysis Program SAP2000 - Version 11*, CSI, Berkeley, CA, 2007, p. 450.

[2] BOGENSPERGER T., MOOSBRUGGER T., and SCHICKHOFER, G., "New Test Configuration for CLT-Wall-Elements Under Shear Load", Proceeding of the International Council for Research and Innovation in Building and Construction Working Commission W18 – Timber Structures, Meeting Forty, Bled, Slovenia, August 28-31, 2007, p. 13.