The Next Generation of Sustainable Buildings
Seismic assessment of an innovative hybrid mass timber structure

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Background

The construction of conventional buildings is characterized by the substantial use of concrete. The production and transportation processes of concrete are major sources of carbon emissions and energy consumption. In contrast, wood is carbon-neutral and renewable due to its inherent biomass nature. Therefore, adopting bio-based wood products, in conjunction with advanced timber construction techniques, can help the current building industry shift towards a more sustainable construction environment.

Objectives

This research intends to examine a hybrid timber structure's ability to sustain earthquake ground motions. Specific objectives include:

- ➢ developing a numerical model of the hybrid floor and reproducing the experimental result;
- ➢ carrying out nonlinear dynamic analysis and evaluating the structure performance in a probabilistic basis;
- ➢ setting up a comparative model to analyze differences in the seismic response from the proposed system.

Hybrid construction system

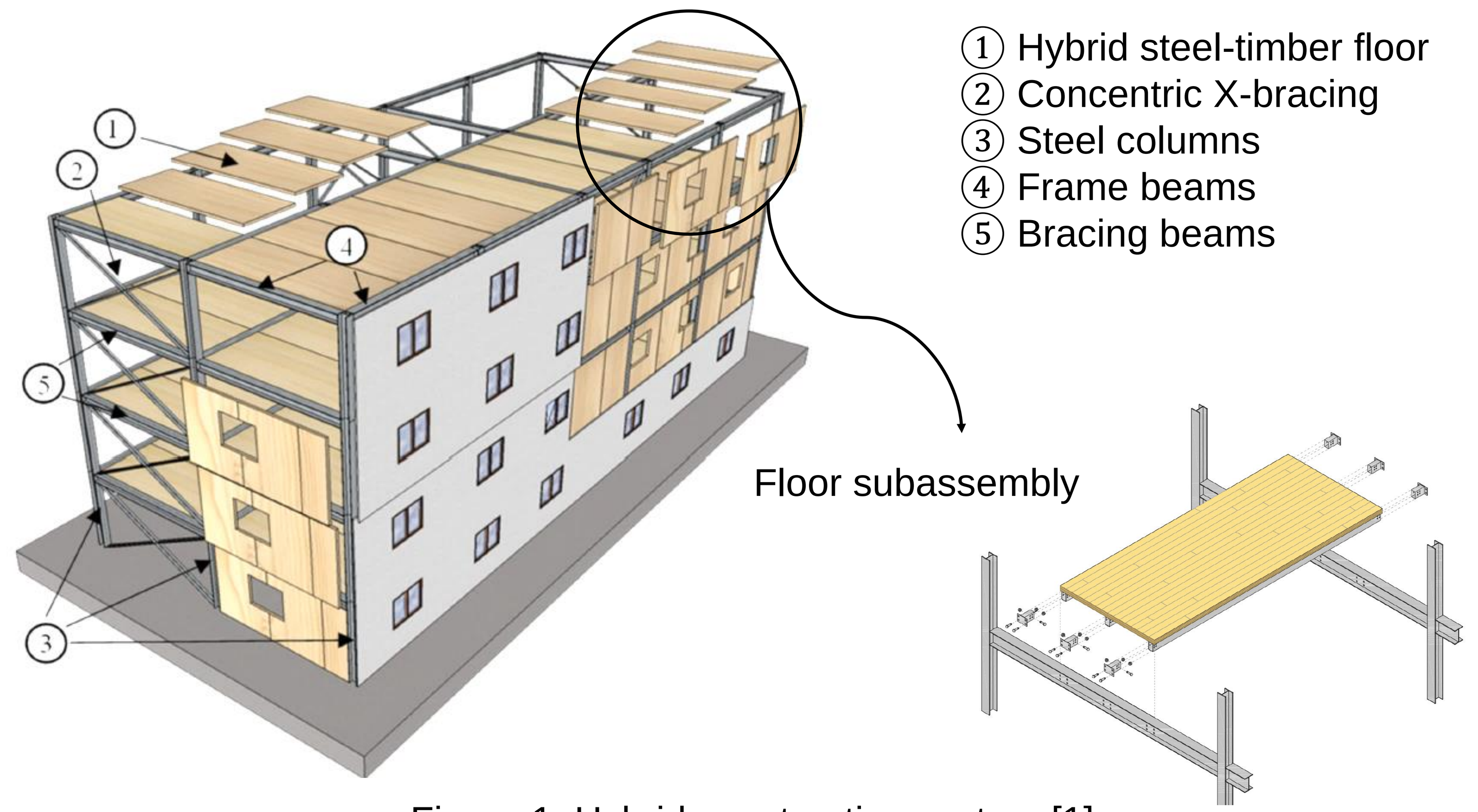


Figure 1. Hybrid construction system [1]

Methods

The methodology mainly includes the development of a representative and reliable numerical model and the subsequent nonlinear dynamic simulation. The following flow chart summarizes the main steps.

1. Diaphragm modelling
- Develop a finite element model of the floor diaphragm

2. Model validation
- Calibrate model under the same loading conditions
- Find optimal parameters to reproduce the test result

3. Archetype building modelling
- Design archetype building with assumed R factors
- Build a comparative model with rigid floors

4. Nonlinear analysis
- Subject the model to selected earthquake records
- Scale each record to increasing intensities to conduct the incremental dynamic analysis (IDA)
- Record roof drift and earthquake intensity, S_a, to plot the IDA curve (Figure 2)

5. Performance evaluation
- Summarize collapse points from the IDA curve and develop the fragility function (Figure 3)
- Plot fragility curve and find the median intensity $\hat{S}_{CT}$
- Evaluate structure's performance based on the collapse margin ratio, as computed by:

$$CMR = \frac{\hat{S}_{CT}}{S_{MT}};\ S_{MT}\text{: maximum intensity}$$

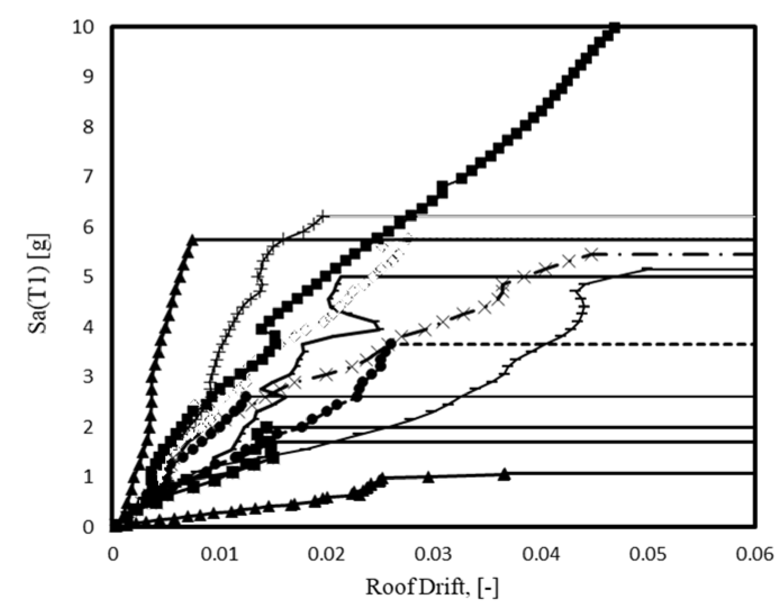


Figure 2. IDA curve for ground motion records

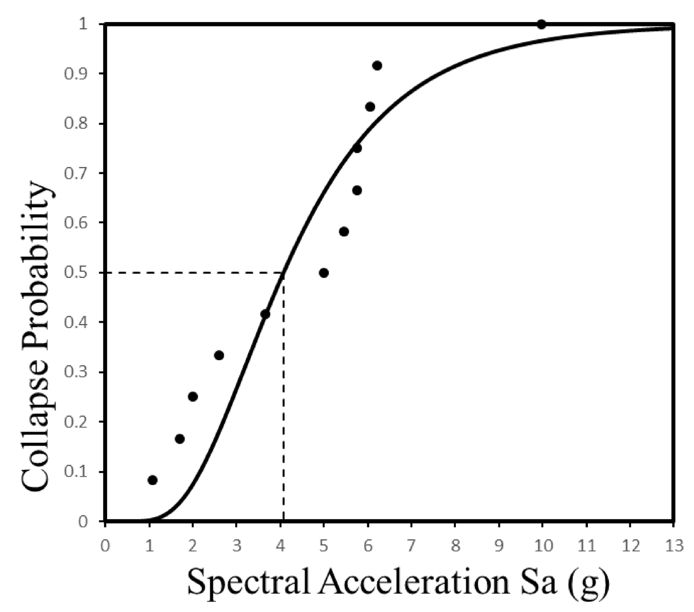
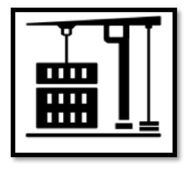


Figure 3. Collapse fragility curve

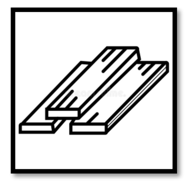
Expected results

Based on the simulation results, this work will evaluate the acceptance of the seismic performance of the hybrid mass timber structure, and subsequently propose a simplified design approach, while accounting for the actual in-plane flexibility of cross-laminated timber floors. Considering different shareholders, this research will:


- ➢ give engineers and practitioners a better understanding of the hybrid building's structural response under earthquake ground motions;



- ➢ provide reference for the building code committee and enables the design community to adopt this solution with less difficulties;



- ➢ support the wood product industry by boosting the lumber demand from the building sector.

Acknowledgement

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References

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