國震中心台南實驗室開幕啟用研究合作專家學者論壇

NCREE Tainan Laboratory Grand Opening Forum

Multi-Hazard Test Facility for Built Infrastructure Protection and Resilience

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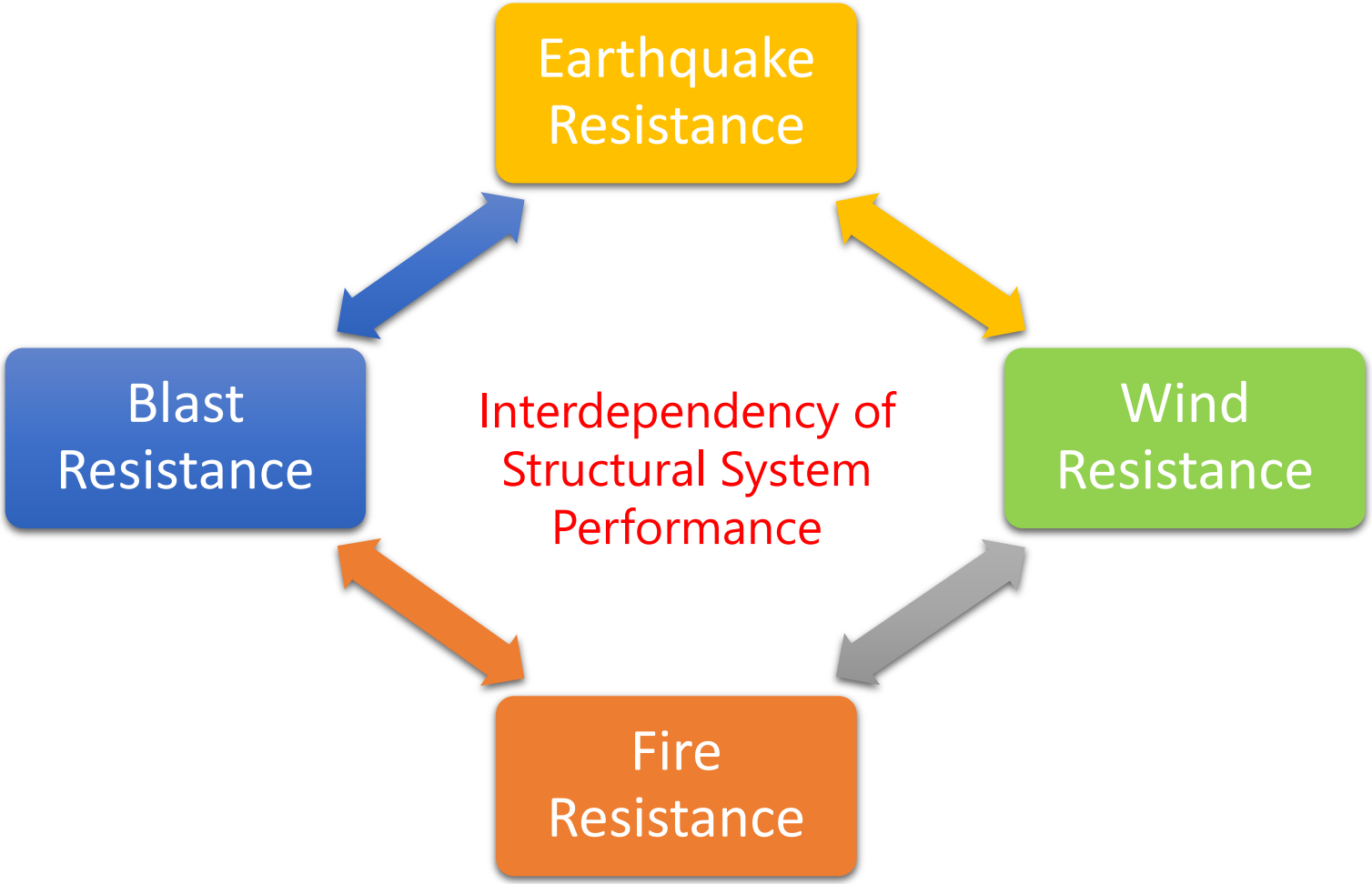
Carleton University
Ottawa, Canada

Designing for Hazards *Earthquake, wind, blast, fire, snow et*

- Silo Approach

Design for Hazards

- *Design for one hazard effects the performance of the others*
- *e.g. earthquake and wind*
- *e.g. earthquake and blast resistance*



Experimental Research Facilities for Multi-Hazards

Interaction Effects of structural systems against EQ, Wind, Blast, Fire etc.

Combination Effects

- *Fire following earthquake*
- *Blast following earthquake*

- *Earthquake after fire*

"Seismic resistance of building exposed to fire in the past"

Distributed Multi-Hazard Experimental Research Facilities

- Shared use resources
- Distributed multi-site hybrid simulation links
- Multi-hazard combinations

Carleton U Structure Lab

- EQ simulators
- Mobile shake table
- RTHS
- Climate change chamber

Carleton U Fire Lab

- PDHS
- Atrium & tunnel burn hall /funrnace

Distributed hybrid simulation links

U Ottawa Structure Lab

- EQ simulators
- Shock tube
- High axial load
- PDHS
- Wind chamber

NRC Fire Lab

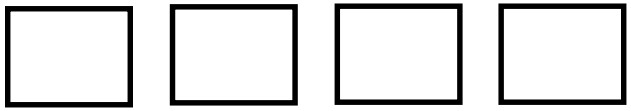
- PDHS
- Column, wall, floor slab furnaces

Earthquake Simulation System

MDOF's

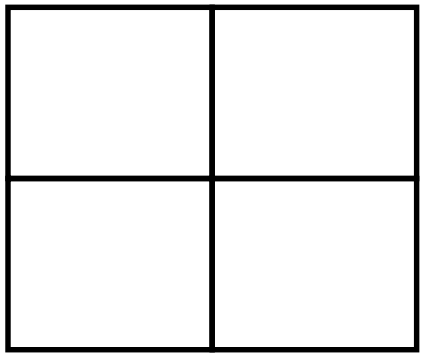
Mobile and reconfigurable

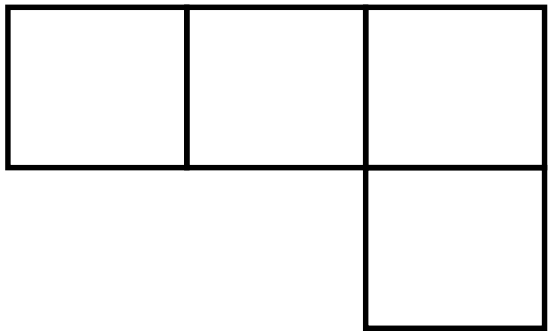
Flexible and Versatile

Use separately as multi-unit system 

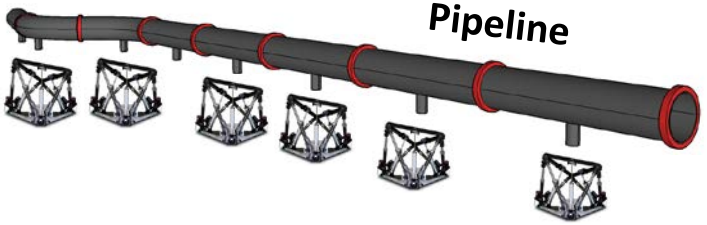
Combine to form a larger a single-unit system with higher payload capacity

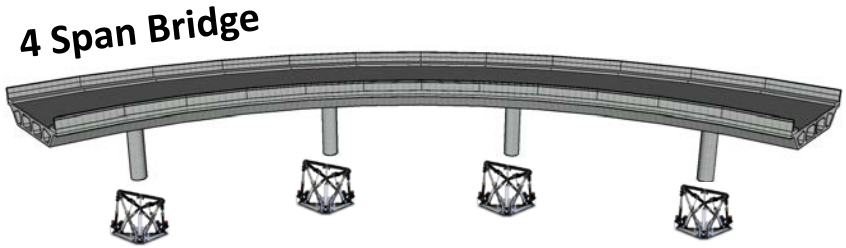
4x capacity



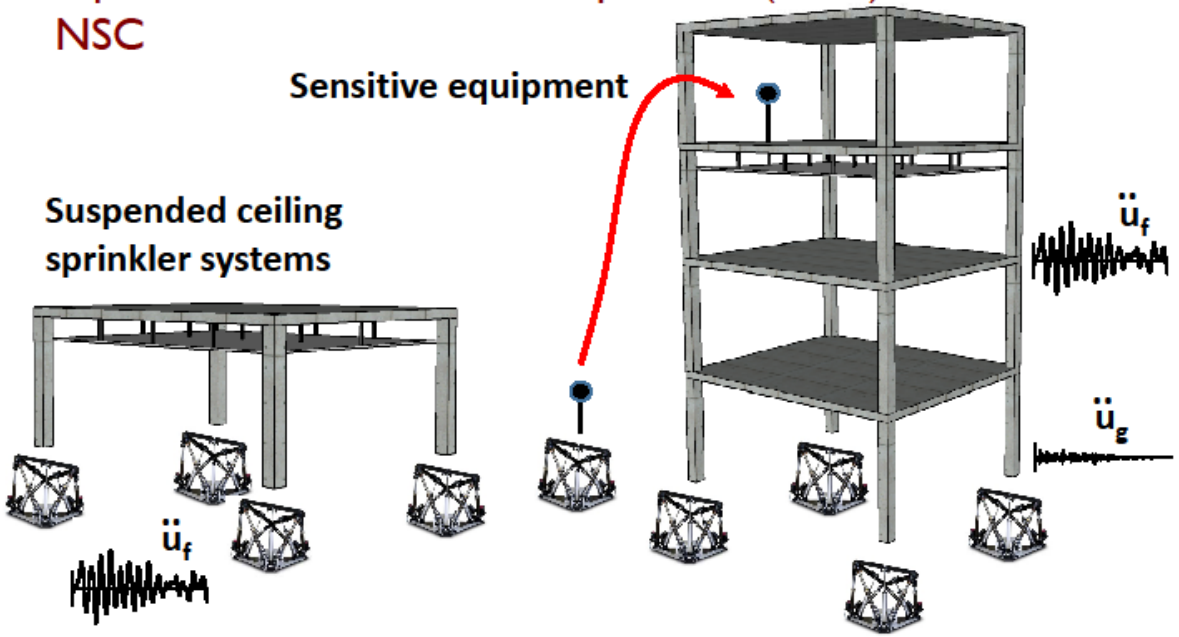


Mobile reconfigurable shake table system

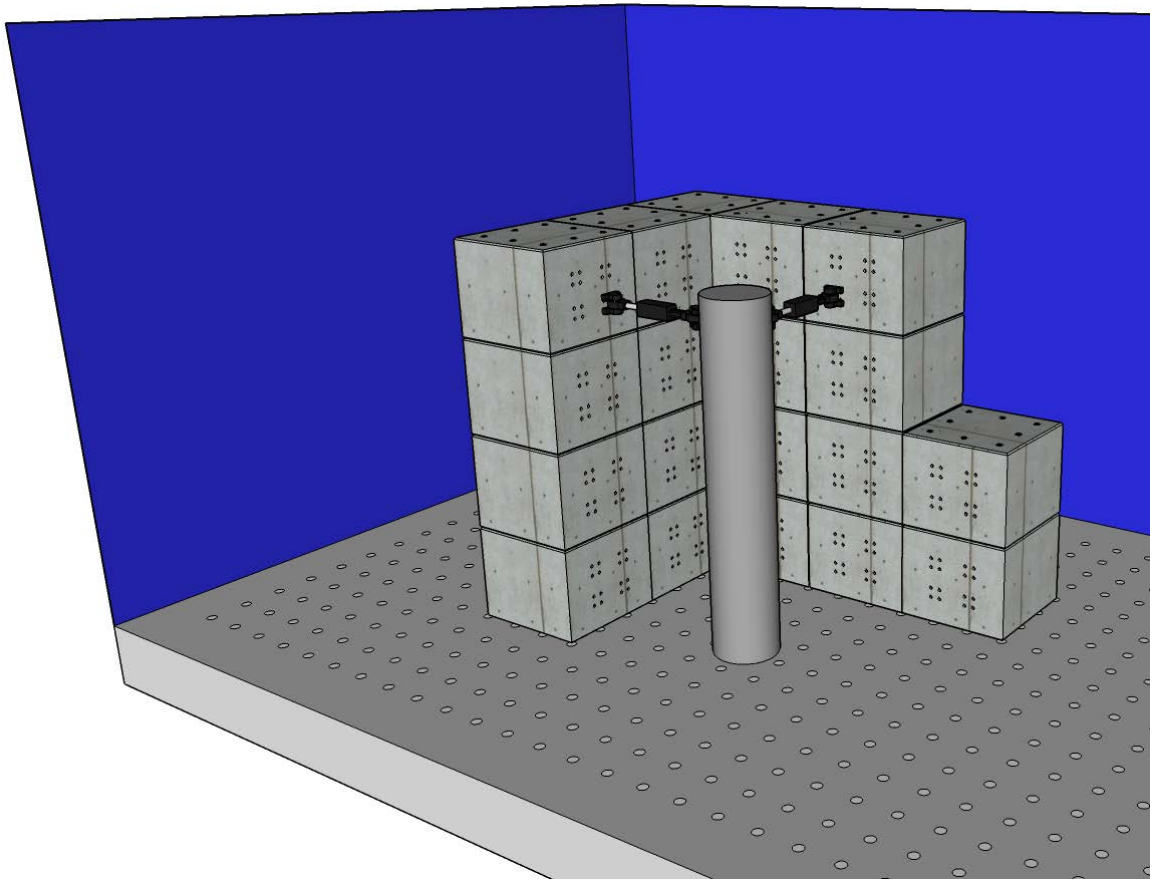


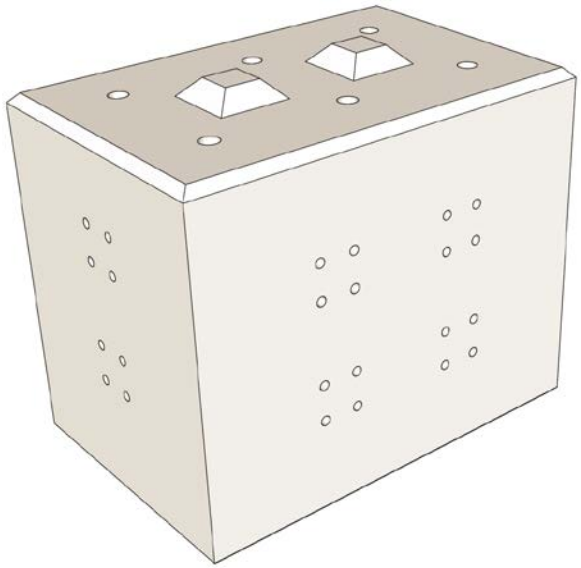


Seismic Design and Performance of Operational/Functional Components (OFC) or NSC



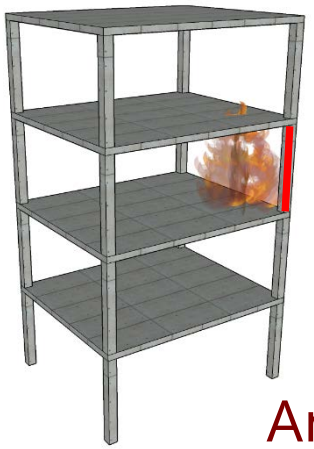
Reconfigurable Block Strong Wall (CU)





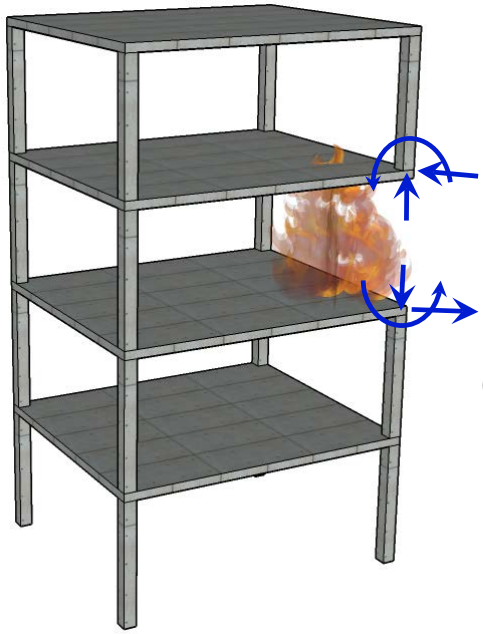
Provides maneuverability and flexibility in structural testing

Ideal for the application of lateral loads on test



Hybrid Fire Testing

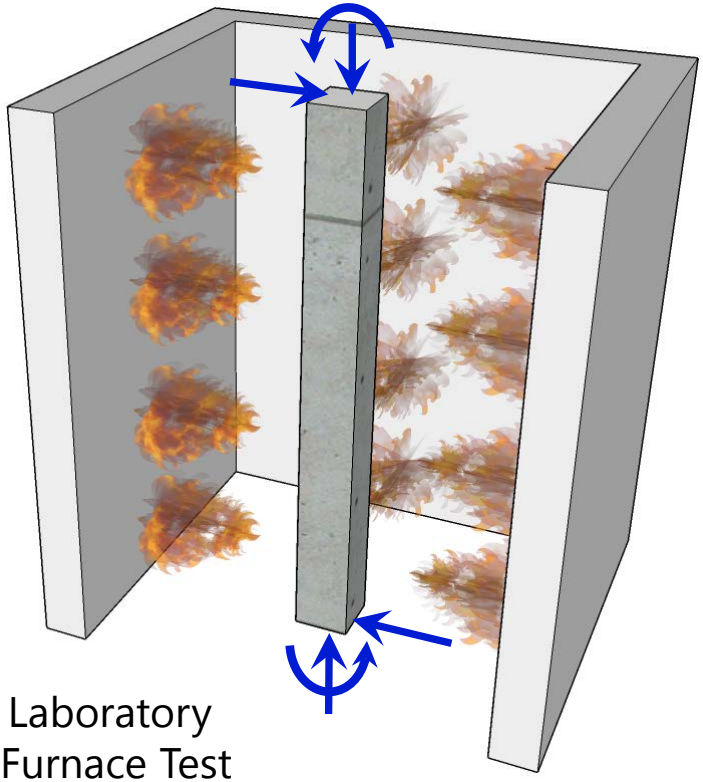
Analytical Substructure



Modelled Numerically

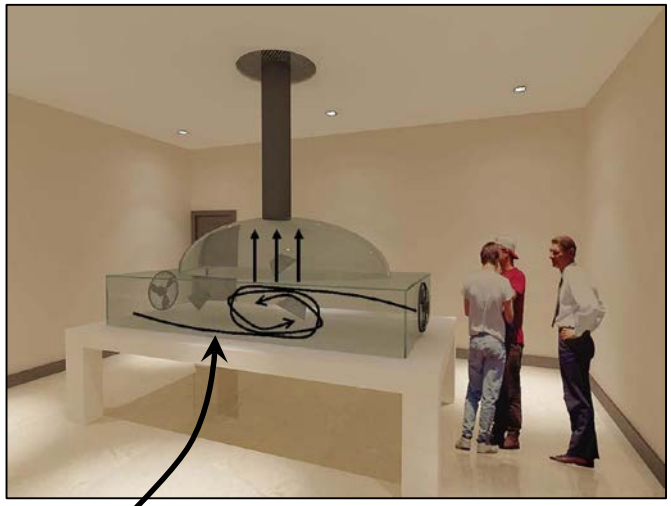
Network Communication

Physical Substructure

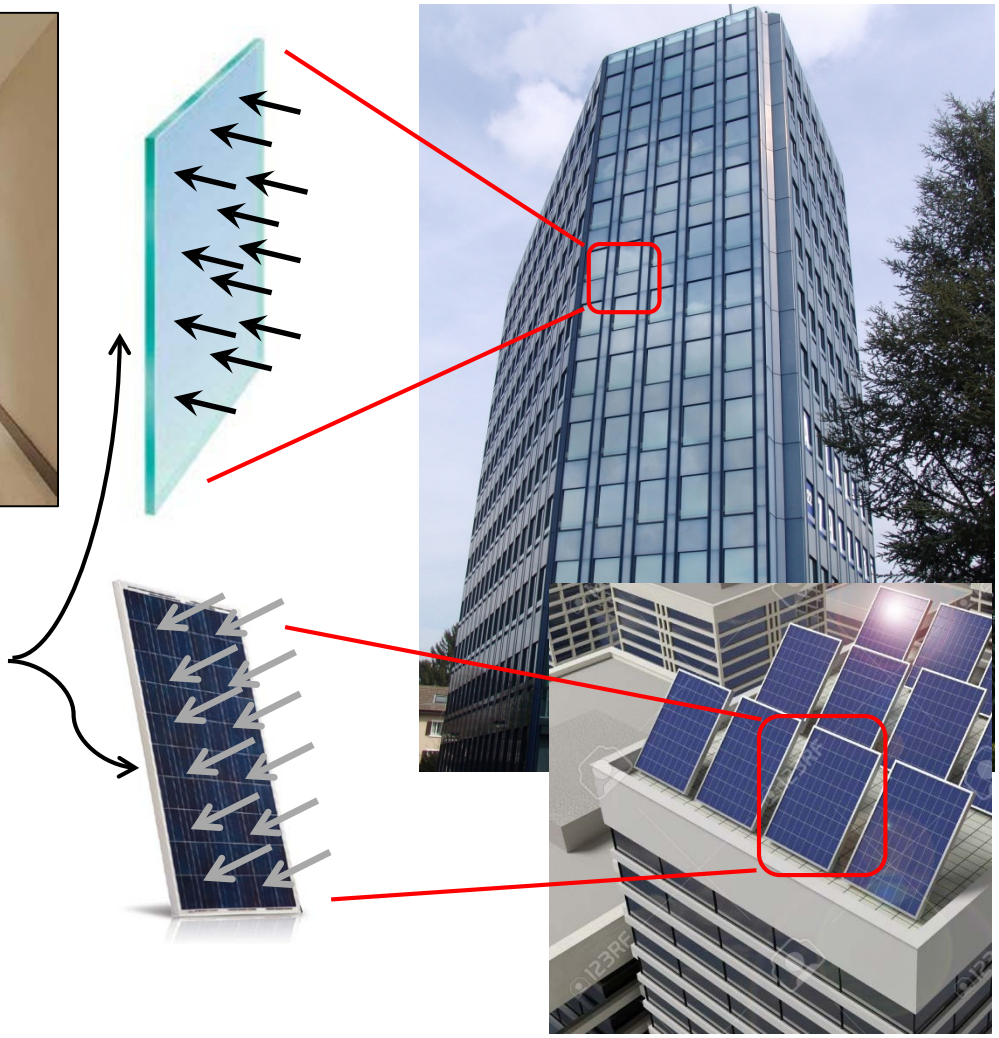


Laboratory Furnace Test

UOttawa Wind Pressure Simulation Chamber



Simulated wind pressure



Hybrid wind pressure distribution testing of exterior building façade (OSC/NSC) components or solar

Upgrade of UOttawa CFI Blast Lab

Blast load simulation shock tube

New ultra high speed 3D video system and load cells for capturing continuous 3D strain and motion data

Realistic post-blast assessments of Infrastructure subjected to
- Other hazards, including fire (caused by blast)
- Progressive collapse

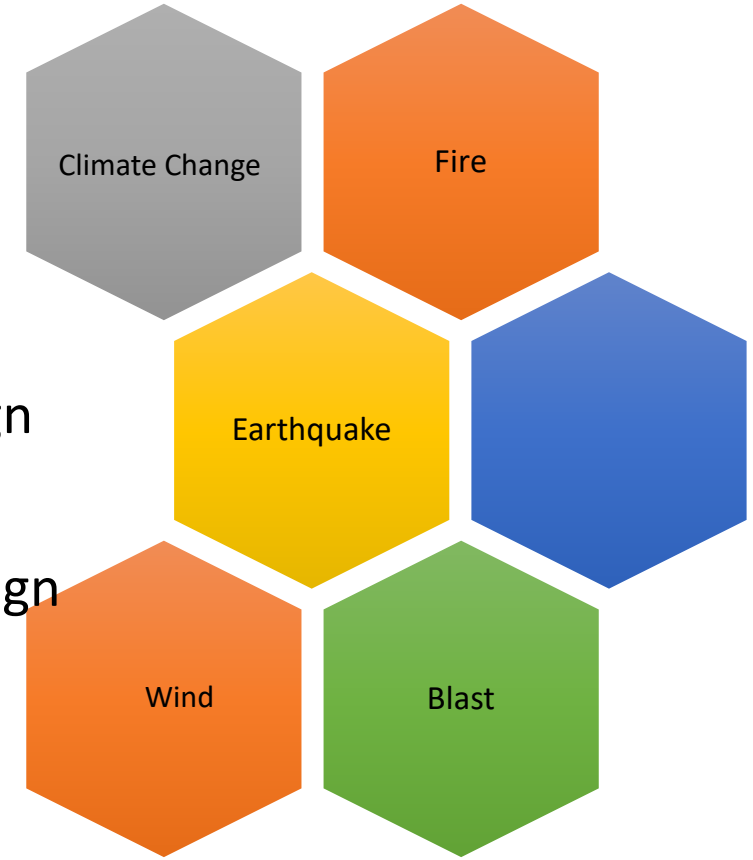
Evaluation of the residual capacity and safety of blast-damaged infrastructure

New Multi-Hazard Test Platform (2015-2018?)

Able to test complex system performance subject to multi-hazard scenarios by hybrid simulation of both

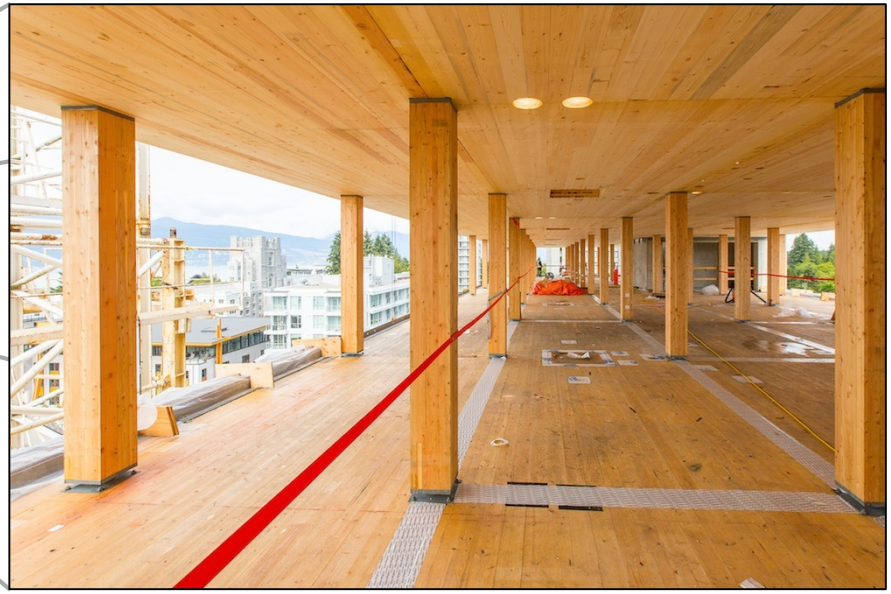
- Individual hazard effects, or
- Combinations of multiple hazard effects

- Adapt experimental hybrid simulation techniques developed in earthquake engineering to other hazards
- Able to assess system performance
- 2015 Canadian Highway Bridge Design Code has moved towards performance based design
- Experimental facilities would help towards achieving the goal of performance based design
- Development of hybrid simulation techniques should go hand-in-hand with reliable numerical simulation methods



Rise of Heavy Timber Buildings

UBC Brock Commons -18 Storey Wood Structure



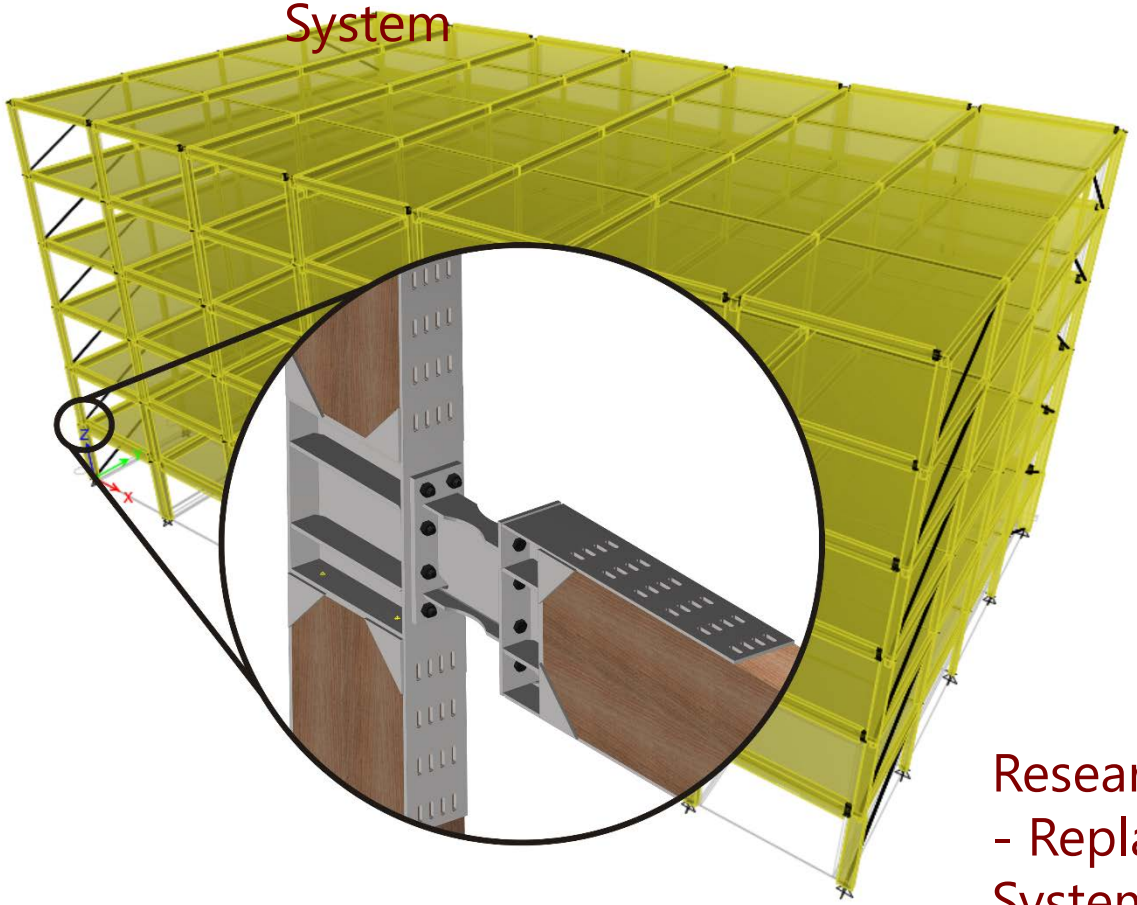
10 Storey, Melbourne

14 Storey, Norway

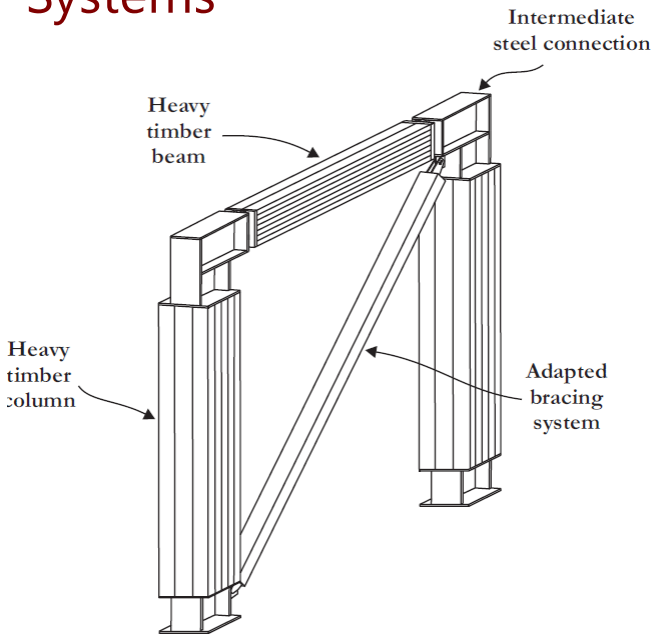
Carleton Hybrid Timber Systems

Ryan Gohlich, Colin Gilbert and Dr. Jeffrey Erochko

Replaceable Link System

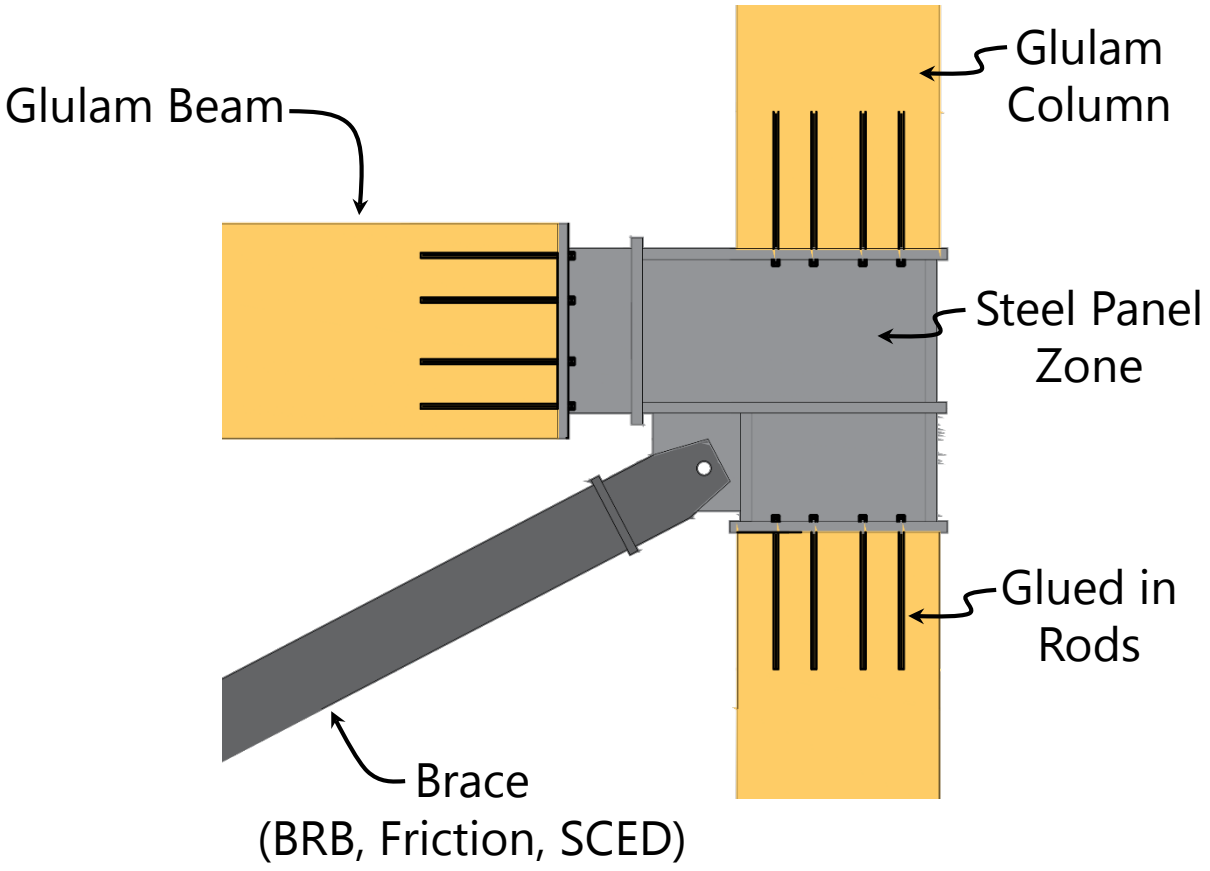


Advanced Bracing Systems



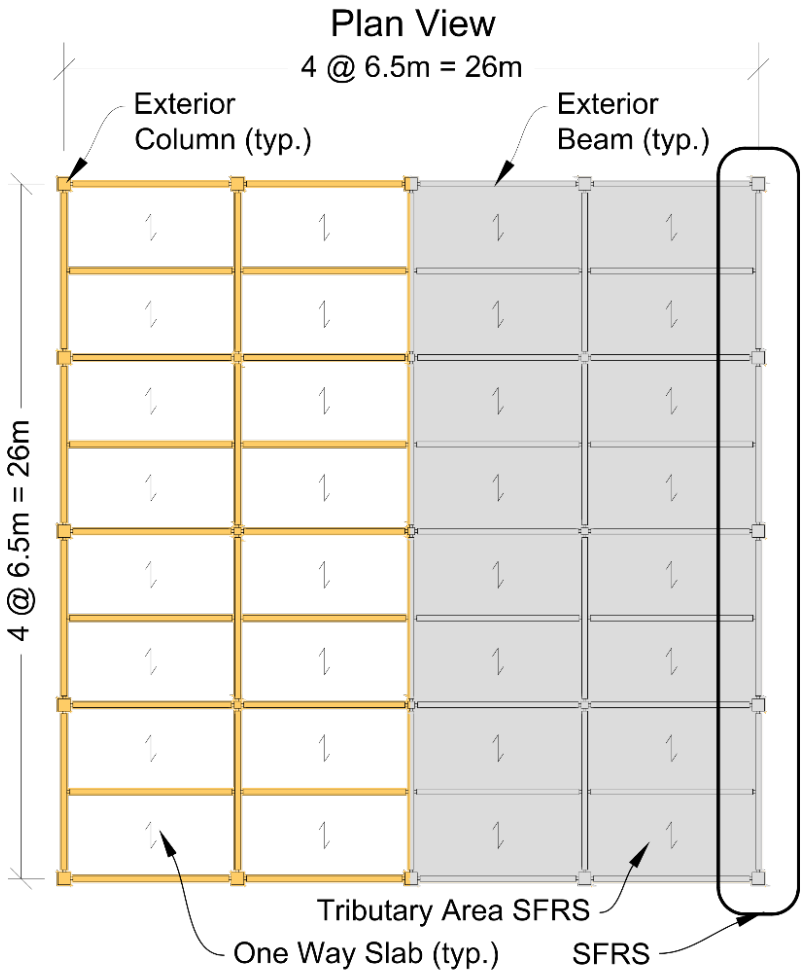
Research Interests:
- Replaceable Ductile Link Systems
- Adaptation of advanced bracing systems for heavy timber

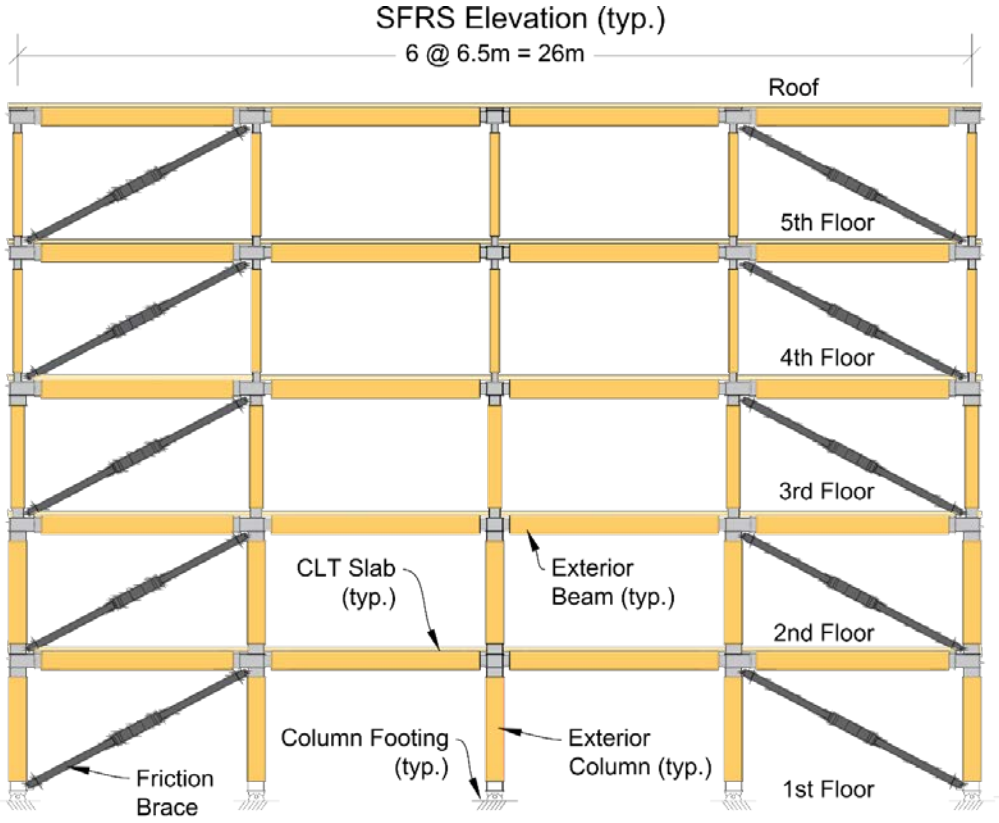
Innovative Hybrid Steel-Timber Frame



- Difficultly in effectively transferring high brace forces
- Integrated steel panel zone to transfer forces to wood elements
- Glued-in rod connection to transfer forces parallel to grain

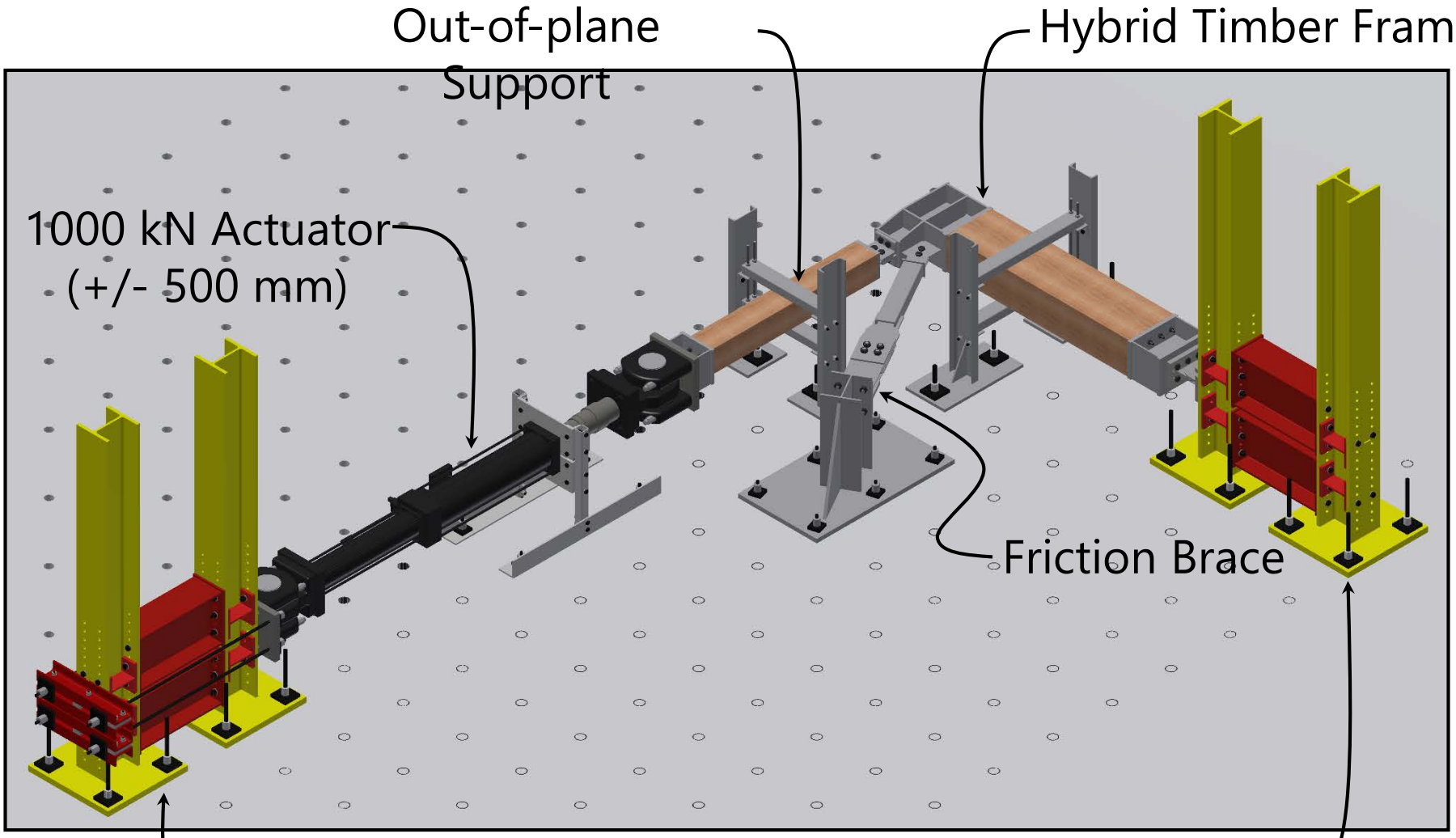
Prototype Heavy Timber Structure

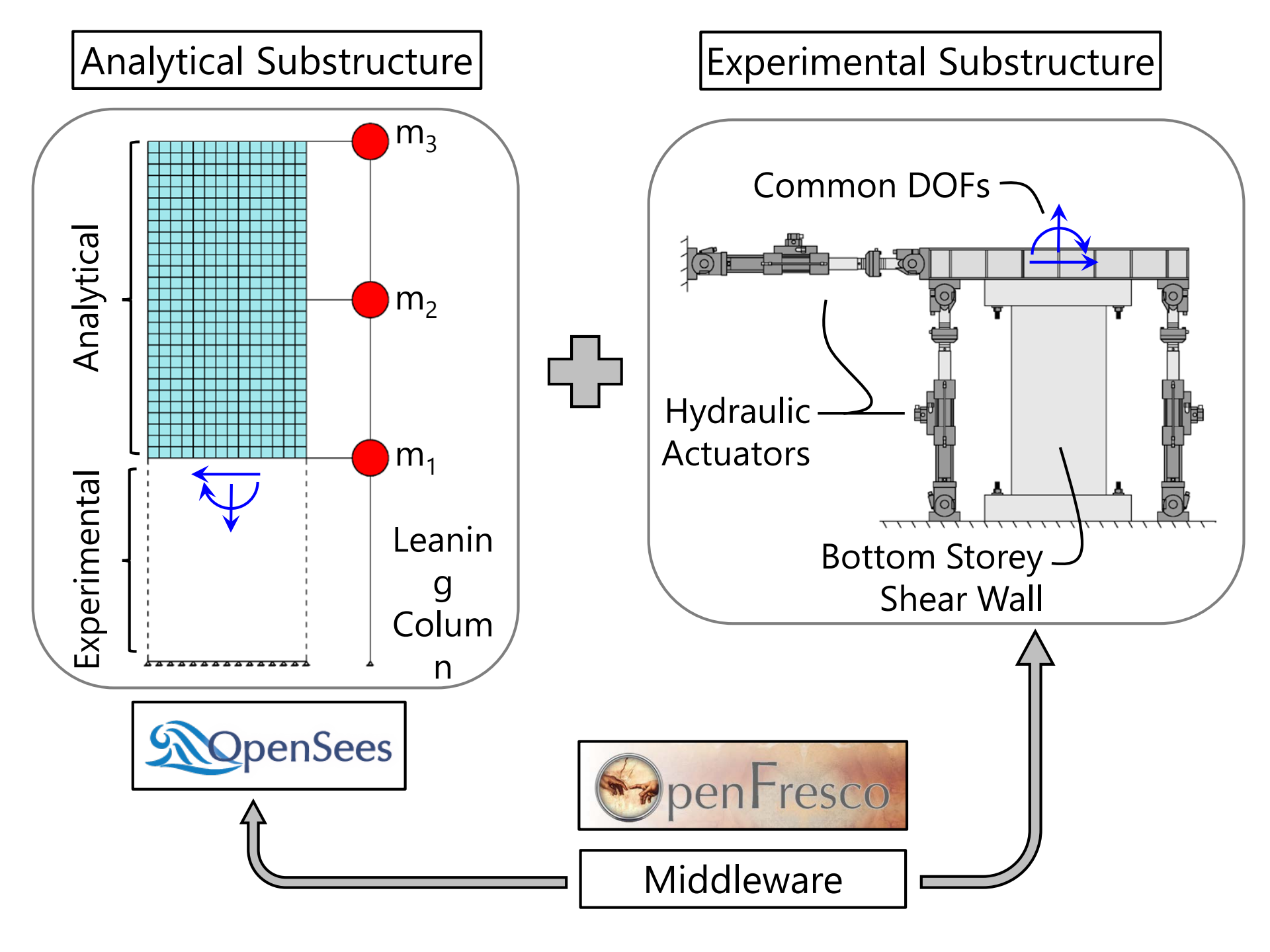




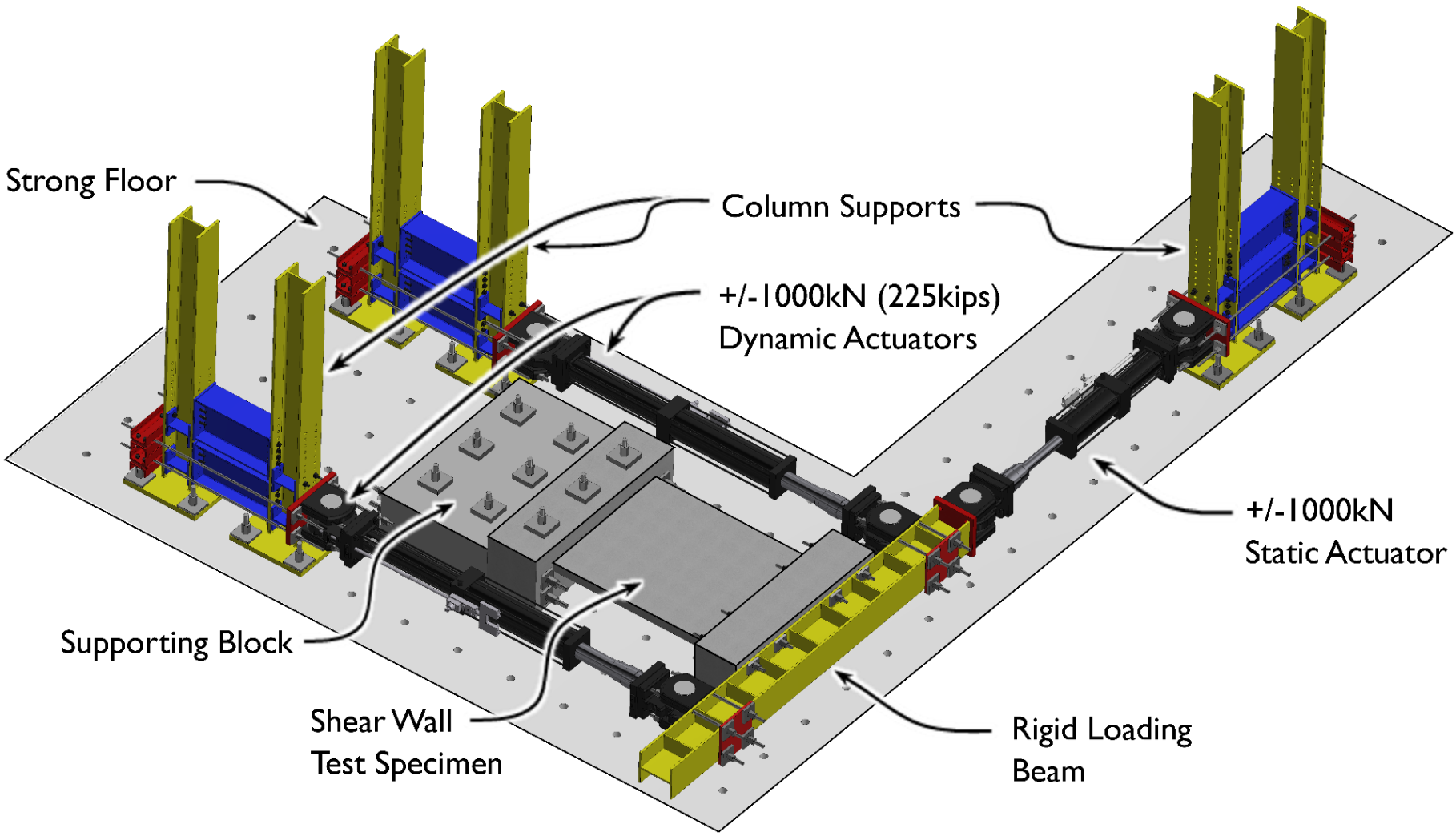
- Five-storey heavy timber structure (26 m x 26 m)
- Located in Victoria, British Columbia
- Glulam beams and columns, CLT slabs, and friction braces

Experimental Test Setup

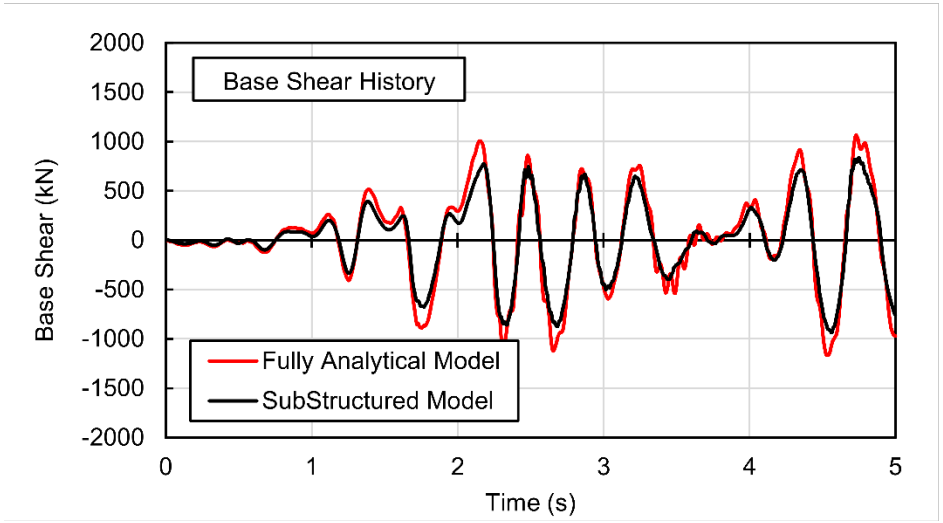


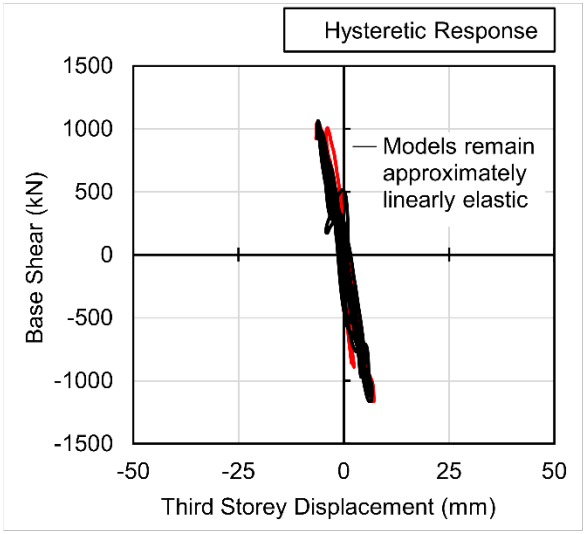

Analytical Substructure
Experimental Substructure
Analytical
Experimental
m3
m2
m1
Leaning Column
Common DOFs
Hydraulic Actuators
Bottom Storey Shear Wall
OpenSees
OpenFresco
Middleware

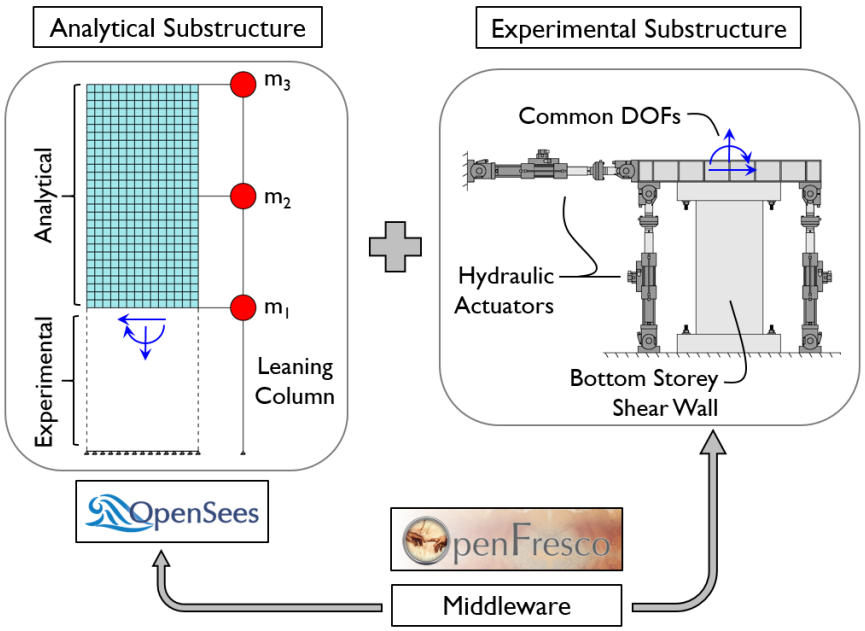
Experimental Test Setup

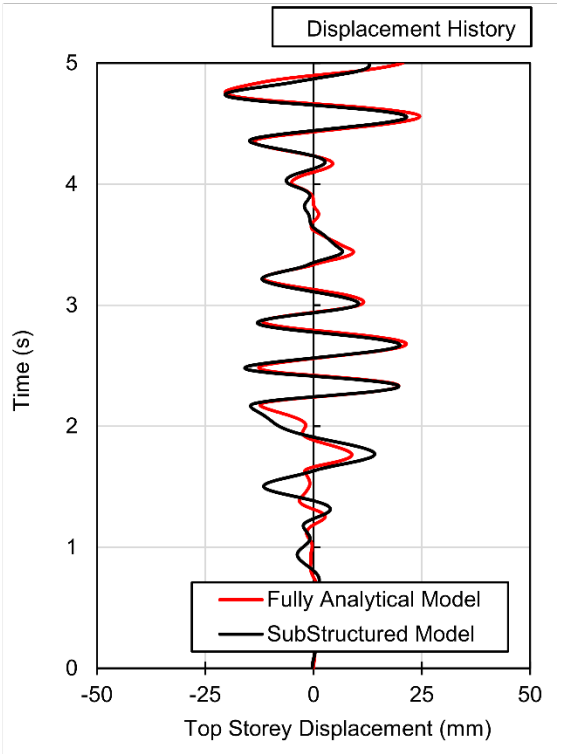


Substructured Model: Response to Loma Prieta Input Motion









Thank You!

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