Curved Wall CLT Panels for Earthquake Protection

(OTT ID 1475)

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Current Problems

- Conventional, code-conforming construction saves lives, but not property damage caused by earthquakes
  - Rocking systems can achieve greater earthquake resiliency with latest researched designs and construction methods

- Conventional earthquake resistant structures are costly
  - Earthquake resiliency reduces damage, down time and repair costs
  - Cost-effectiveness of the rocking systems rivals conventional structures that rely primarily on ductility.

- Current construction materials are not sustainable
  - CLT (cross-laminated timber) is sustainable and becoming widely accepted worldwide

Specific Technological Solutions

- Works within platform assembly schemes to simplify construction sequencing
  - Introduces an efficient and effective construction method
- Uses 5-layers of CLT (cross-laminated timber) panels
  - Achieves Economic Resiliency with Sustainable Use
- Provides a new elliptical shaped CLT panel for high-rise construction
  - Such a system can decouple the building from ground motion
- Includes new connection methods which create a rocking behavior, amount of energy dissipation and lateral stiffness which is predictable for versatile application
  - Allows a smooth and predictable pendulum motion during an earthquake event

Intellectual Property and Licensing

- US provisional patent was filed in September 2018

- Looking for a development partner to:
  - Aid in further research development
  - Implement methods in testing
  - Provide feedback
  - License and develop the final product

Market Potential

Applications

- Sustainable, lightweight, and rigid load-bearing material that is quick to erect on building sites and provides superior earthquake resiliency compared to current methods.

Market

- The global cross laminated timber market is expected to be valued at $2B by 2025, according to a new report by Grand View Research, Inc.
- Earthquake losses in the United States add up to about $4.4 billion dollars a year, according to a study by the Federal Emergency Management Agency (FEMA) based on a new methodology to estimate earthquake risk and future losses by geographic area.
- The $4.4 billion estimate is extremely conservative and includes only capital losses such as repairing or replacing buildings, contents and inventory ($3.49 billion), and income losses - business interruption, wage and rental income losses ($0.93 billion).

Laboratory Tests Show Resiliency

- Key takeaways from this first iteration of laboratory tests demonstrate that both *rolling* and *slip-friction* pendulum configurations can achieve resiliency.

- With a partner, a second iteration of analytical and physical prototyping could improve the resiliency even further by preventing localized damage of each the *rolling* and *slip-friction* pendulum configurations.
  - Frictional energy dissipation increased wear of CLT panel, lateral stiffness of the system, and concentrated forces at pin connections.

Full Scale Modeling

Laboratory tests of the apparatus were produced conforming to North American manufacturing standards for grade V2M1 (ANSI/APA PRG 320 2018)

Simple analysis models predicted behavior of full-scale tests

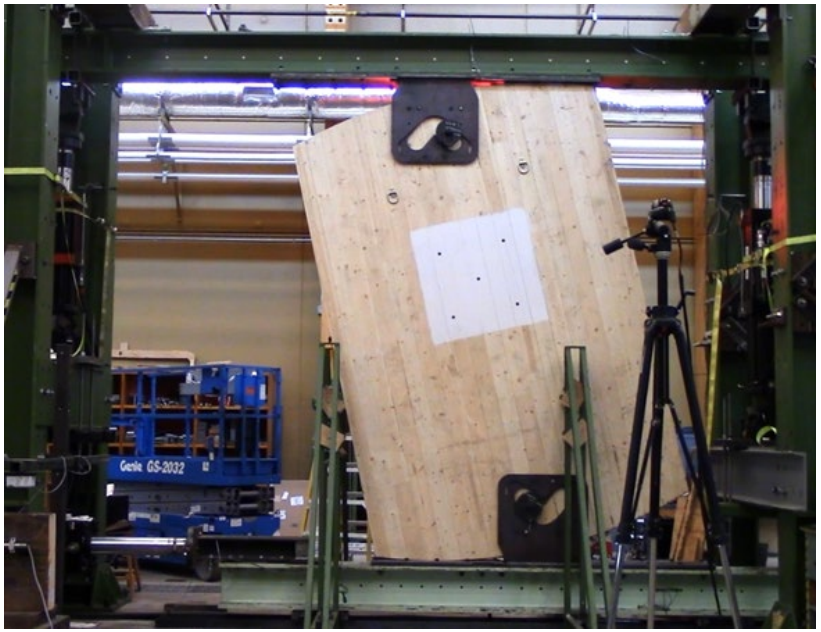

Figure A: Rolling Wall Panel

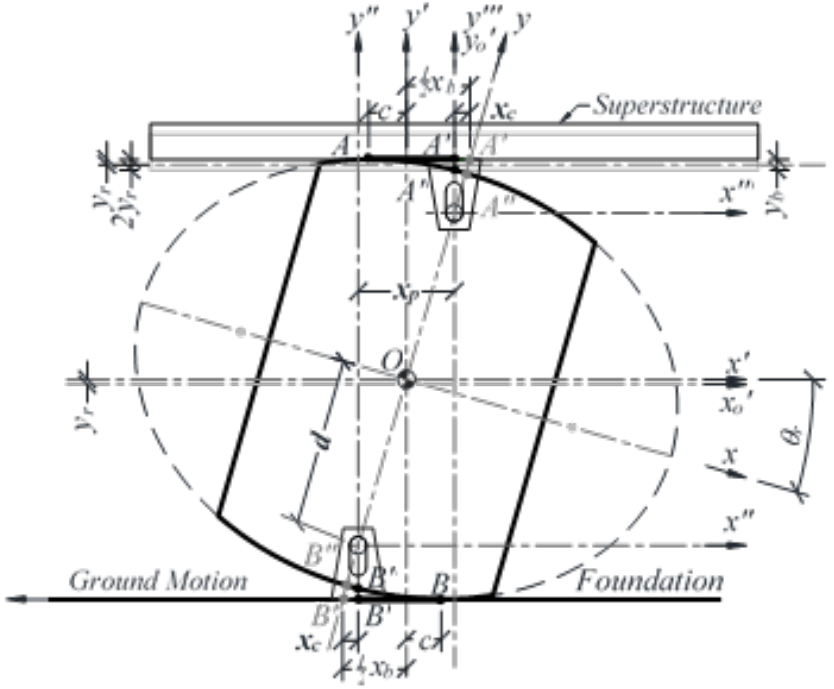

Figure B: Slip-Friction Pendulum Model

In Summary

- Elliptical eccentricity provided the key feature for passive self-centering within a platform construction scheme.
- Connection constraints dictated the modes of horizontal shear transfer and rocking.
- Vertical slots imposed horizontal connection constraint, which forced the panel into a *slip-friction* mechanism.
- *No-Slip Traction Rolling*, compared to *Slip-Friction Rocking,* demonstrated:
  - 3 times greater capacity for carrying superstructure weight, and
  - 17% greater lateral displacement capacity, and
  - 2 times lesser lateral stiffness.
- Rolling produced less damage than sliding at the timber contact zones along panel edges.

Next Steps

- Looking for partners to support testing of rolling and slip-friction pendulum configurations
- Looking for partners to license and develop a final prototype for use in the field
- Inventor has test data for 6 ellipse shaped panels of varying widths
- Results exist for both rolling and slip-friction configurations, which demonstrate how lateral stiffness and energy dissipation can be controlled
- The inventor has joined the USDA Forest Products Laboratory as a Research General Engineer starting January 2019.

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