NHERI TallWood

Testing of a Full-scale 10-story Resilient Wood Building

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COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

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University of Nevada, Reno

NZSEES Workshop
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CLT: A New Way to Build Tall in 100 Years

Home Insurance Building, Chicago 1884.
10 Story, 42 m (138 ft)

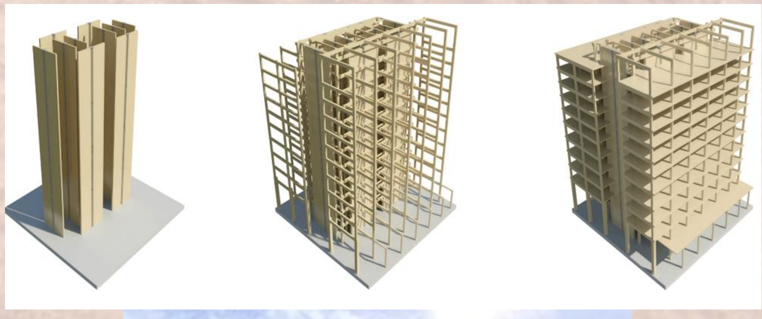
Ingalls Building, Cincinnati 1903.
16 story, 64 m (210 ft)

Forte Building, Melbourne 2012.
10 story, 32.2 m (106 ft)

Different Approaches for Tall CLT Building

Panelized Platform

Hybrid system



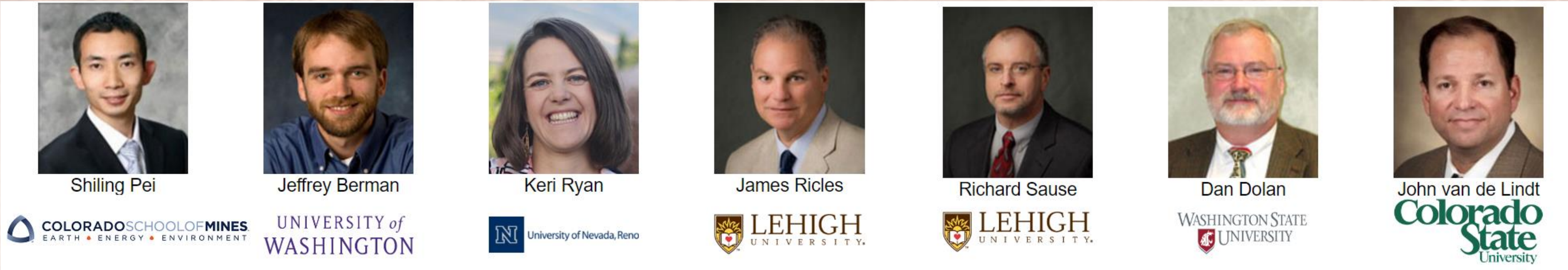
High Performance All Wood

NHERI TALLWOOD

NHERI

- Objective: Develop and validate a Resilience-based seismic design methodology for tall wood buildings
- Website: nheritallwood.mines.edu

PI



Senior Personnel

Advisory Panels with timber experts such as:

Prof. Stefano Pampanin
University of Canterbury

Prof. Hiroshi Isoda
University of Kyoto

Why Target Very High Performance (Resilience)?

- Because we need to
  - Large earthquakes render buildings un-useable for a LONG time
  - Current code does not address loss of use, but owners care.
- Because we can
  - Mass-Timber still relatively light
  - Mass-Timber systems can be very low damage (New Zealand researchers pioneered this effort)

Torre Higgins Building: The 20-story office building in Concepcion’s city center had significant damage, including four stories that collapsed starting on the 12th floor. (2010 Chile Earthquake)

Our Vision

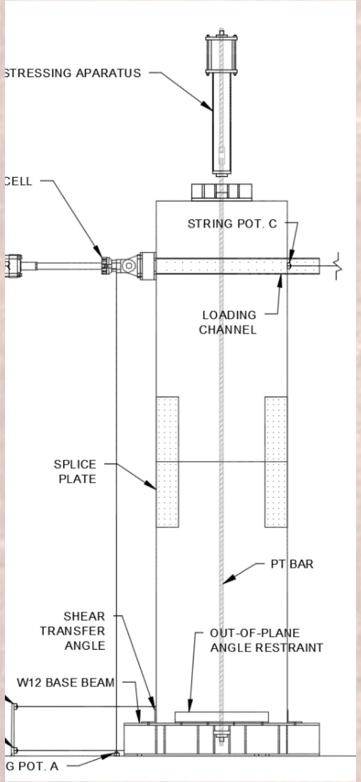
Minimize Owner Loss
Improve community hazard resilience

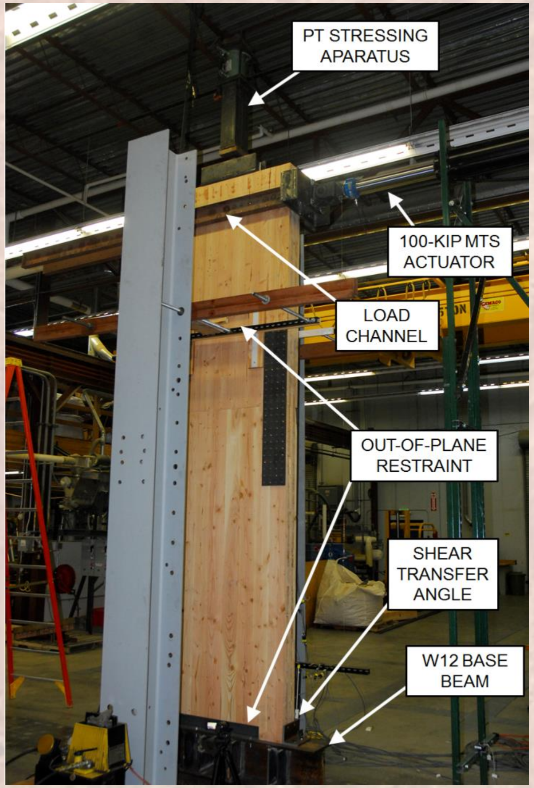
- Say you have a 18-story Mass Timber building on the West Coast

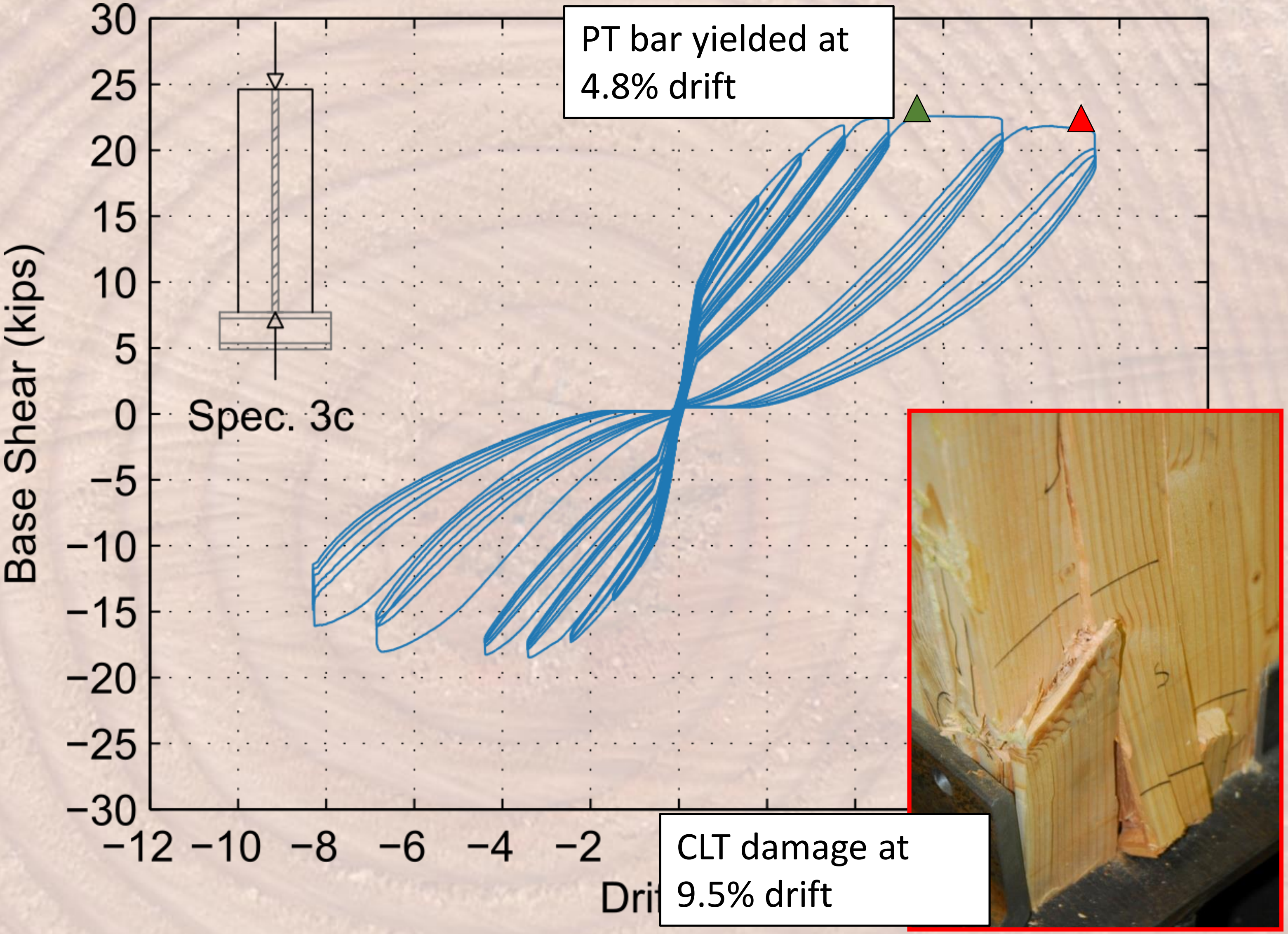
Seismic Hazard Levels (POE[1])	System performance	Structural components	Non-structural components	Estimated Repair Time[4]
Tier 3: Resilience (Resilient structural systems implemented, PBSD)				
Service Level Earthquake (50% in 30 yrs.)	Continuous Operation	Elastic/Resilient system operational	No damage	0~30 min
Design Basis Earthquake (10% in 50 yrs.)	Immediate Occupancy	Resilient system operational	Minor contents damage	1~7 days
Maximum Considered Earthquake (2% in 50 yrs.)	Planned Damage[3]	Resilient system repair needed at planned locations	Moderate damage	1~2 months
Near Fault Ground Motions	Limited Damage Probability of Collapse negligible	Damage extended to unplanned locations, repair may be costly	Moderate damage	2~6 months

Post-tensioned CLT rocking wall

Tested at WSU in the Planning Project

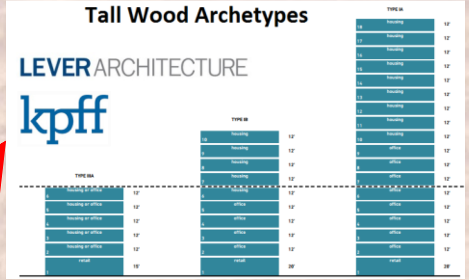




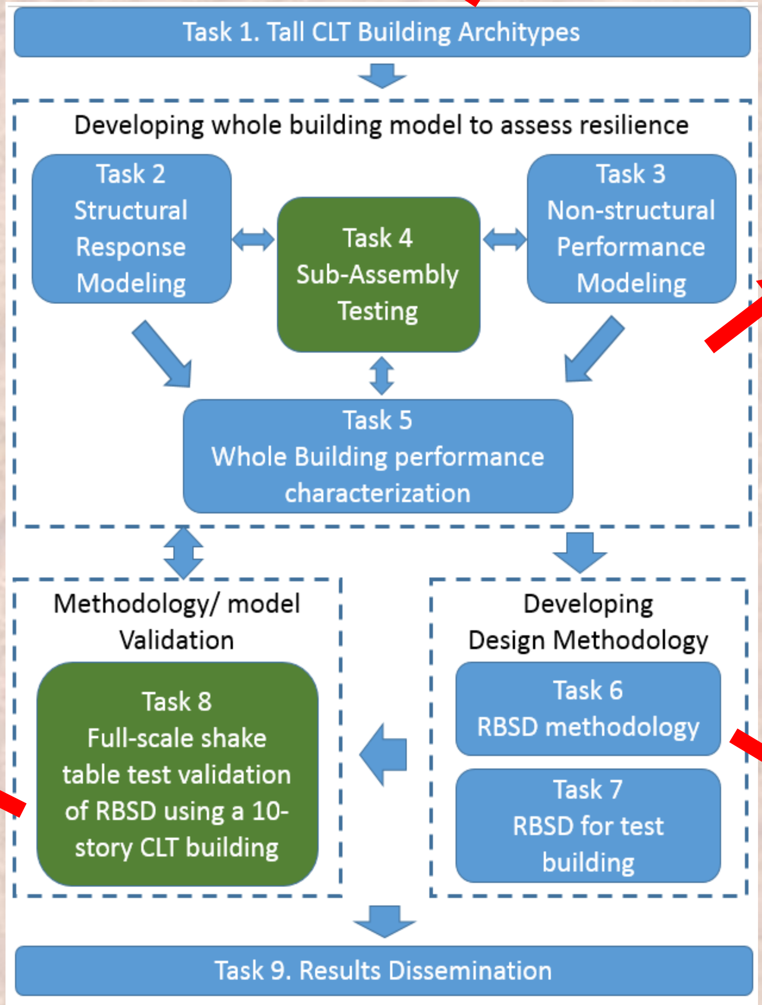


CLT damage at 9.5% drift

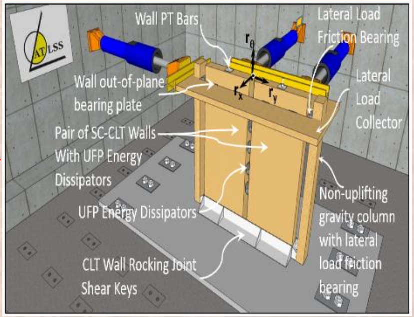
The plan to address what we don’t know

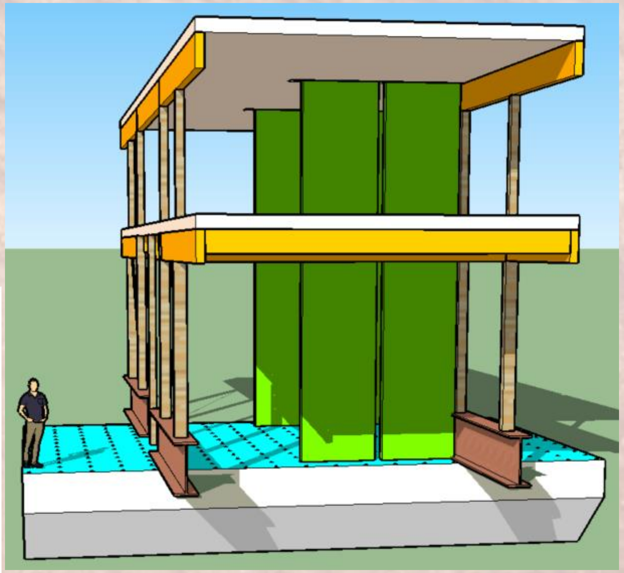


Almost done…

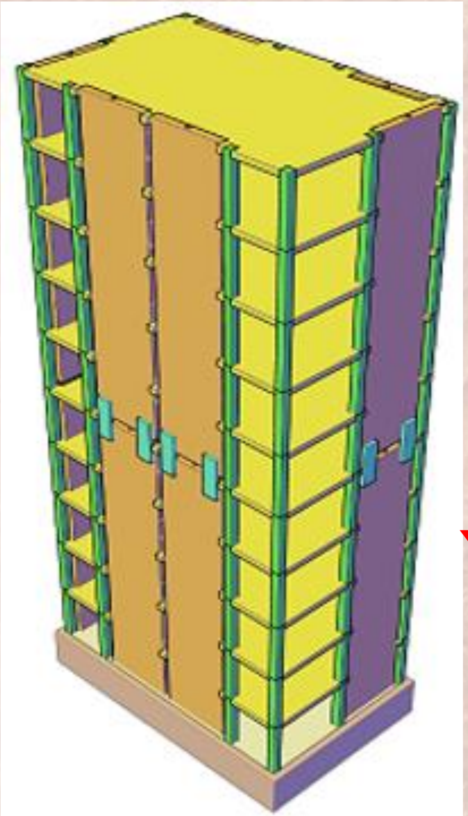


Lehigh 2017 test

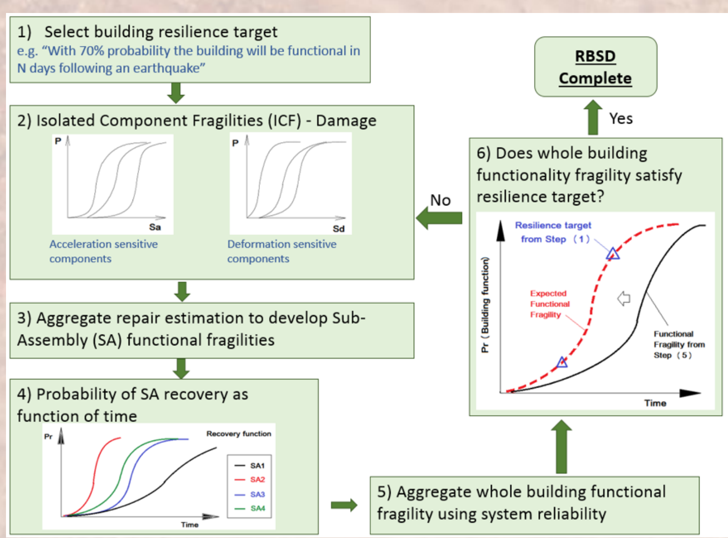




UCSD 2017 2-story test

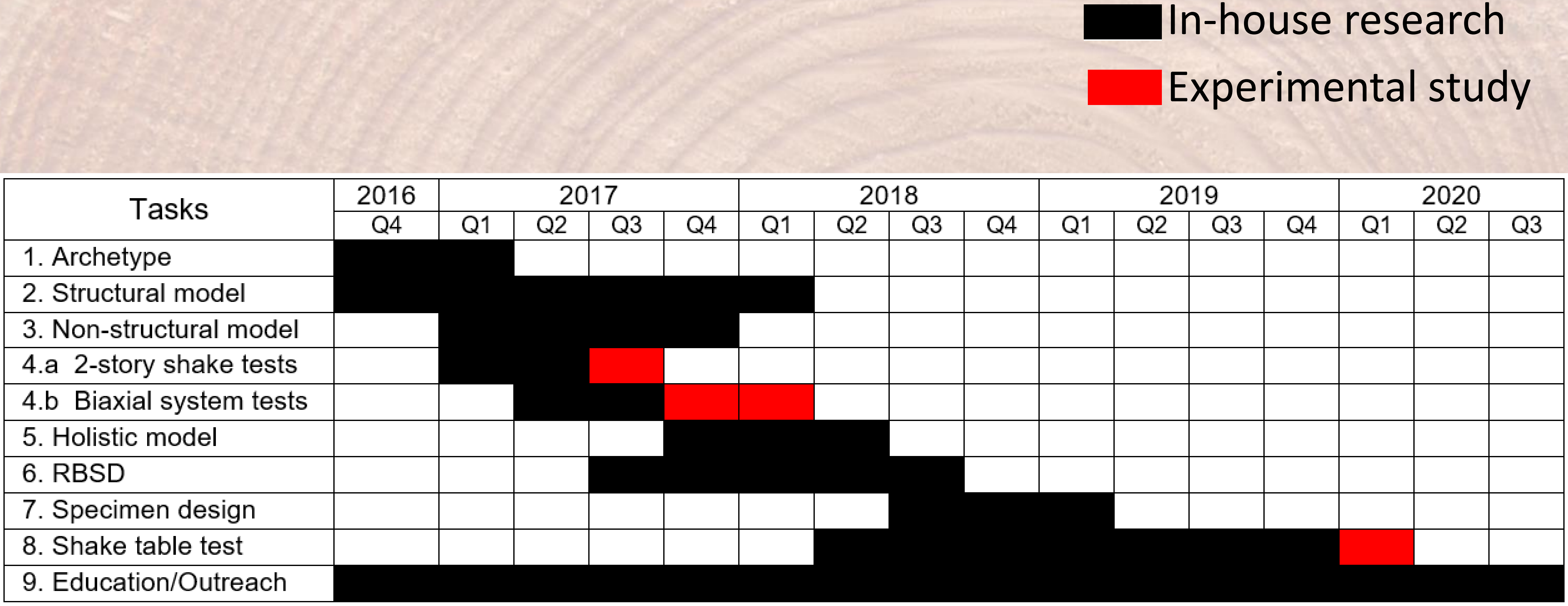


10-story test
validation in 2020



RBSD framework and methods

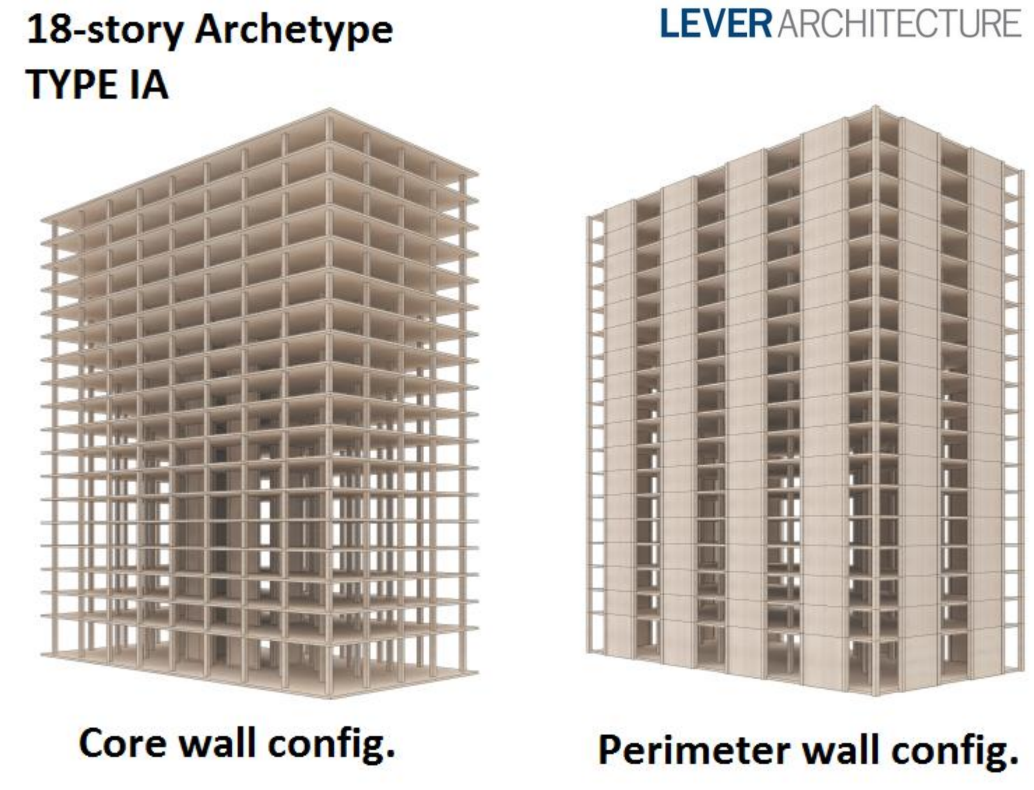
Timeline


In-house research
Experimental study
Tasks
2016
2017
2018
2019
2020
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
1. Archetype
2. Structural model
3. Non-structural model
4.a 2-story shake tests
4.b Biaxial system tests
5. Holistic model
6. RBSD
7. Specimen design
8. Shake table test
9. Education/Outreach

Archetype Development

- Archetype meeting at

LEVER Architecture, Nov 2016



- Archetypes representing key market for Tall wood
- 3~4 building heights, different floor arrangements

Wrapping up Archetypes by May 2017

Lehigh test

- Phase (1): Investigating the response of SC-CLT walls under in-plane loading.
- Phase (2): Investigating the response of SC-CLT walls and the gravity system under biaxial loading.
  - Phase (2-a): No gravity load transfer to rocking walls
  - Phase (2-b): Gravity load transfer to rocking walls
- Phase (3): Investigating the interaction of non-structural elements with SC-CLT walls and the gravity system.

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SIMPSON Strong-Tie®

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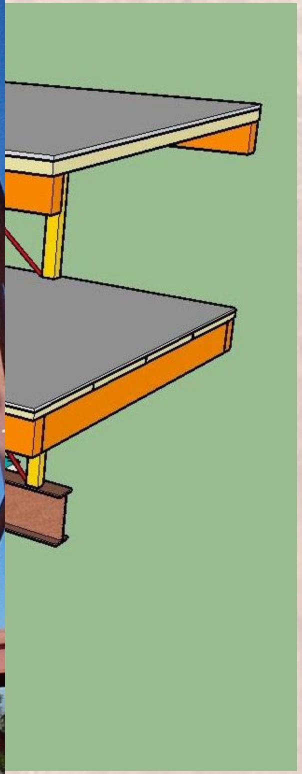

SPRINGFIELD OREGON

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In the next 3 years…

Key data obtained from Lehigh test and UCSD 2-story tests

↓

Numerical model validation and update

↓

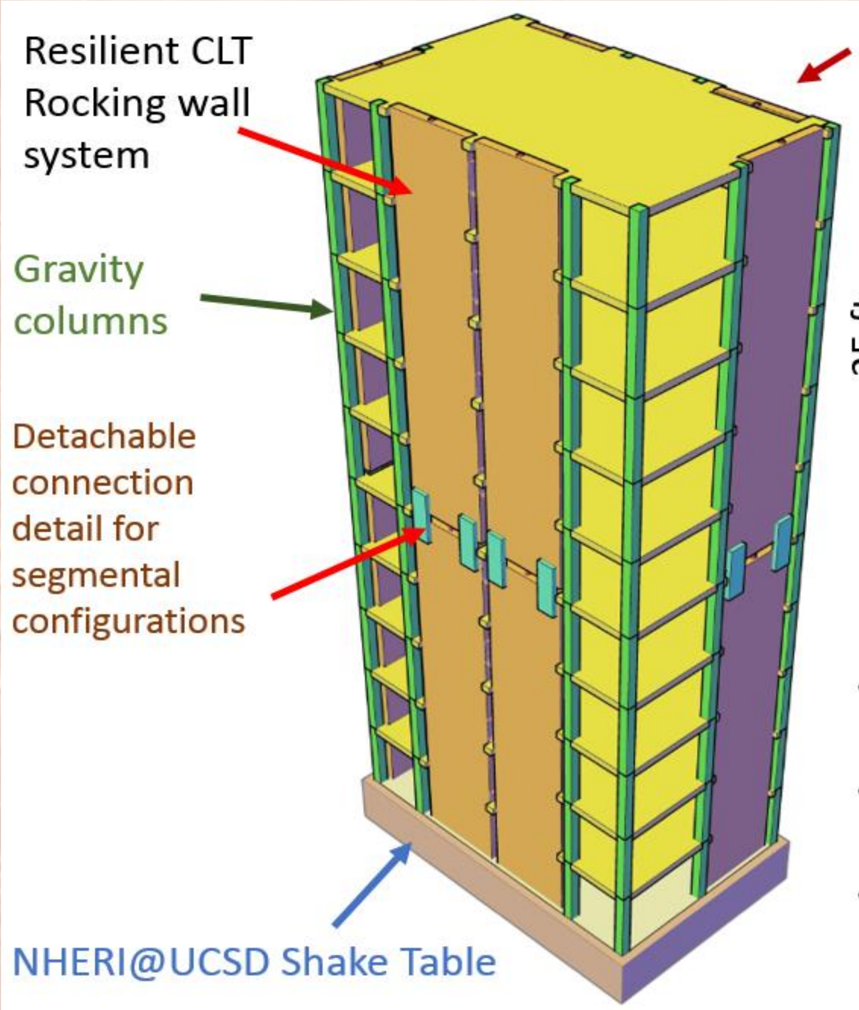
Developing RBSD for Archetype space

↓

Design Validation specimen

→

Come to San Diego and see how we do in 2020



- Both individual and coupled rocking walls included
- Intentional un-symmetric design to induce torsion
- Include two configurations: Monolithic and Segmental

Full-scale 10-story building seismic test at NHERI@UCSD shake table

And after that…

LET'S SET IT ON FIRE

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Tara Hutchinson

UC San Diego

Brain Meacham

WPI

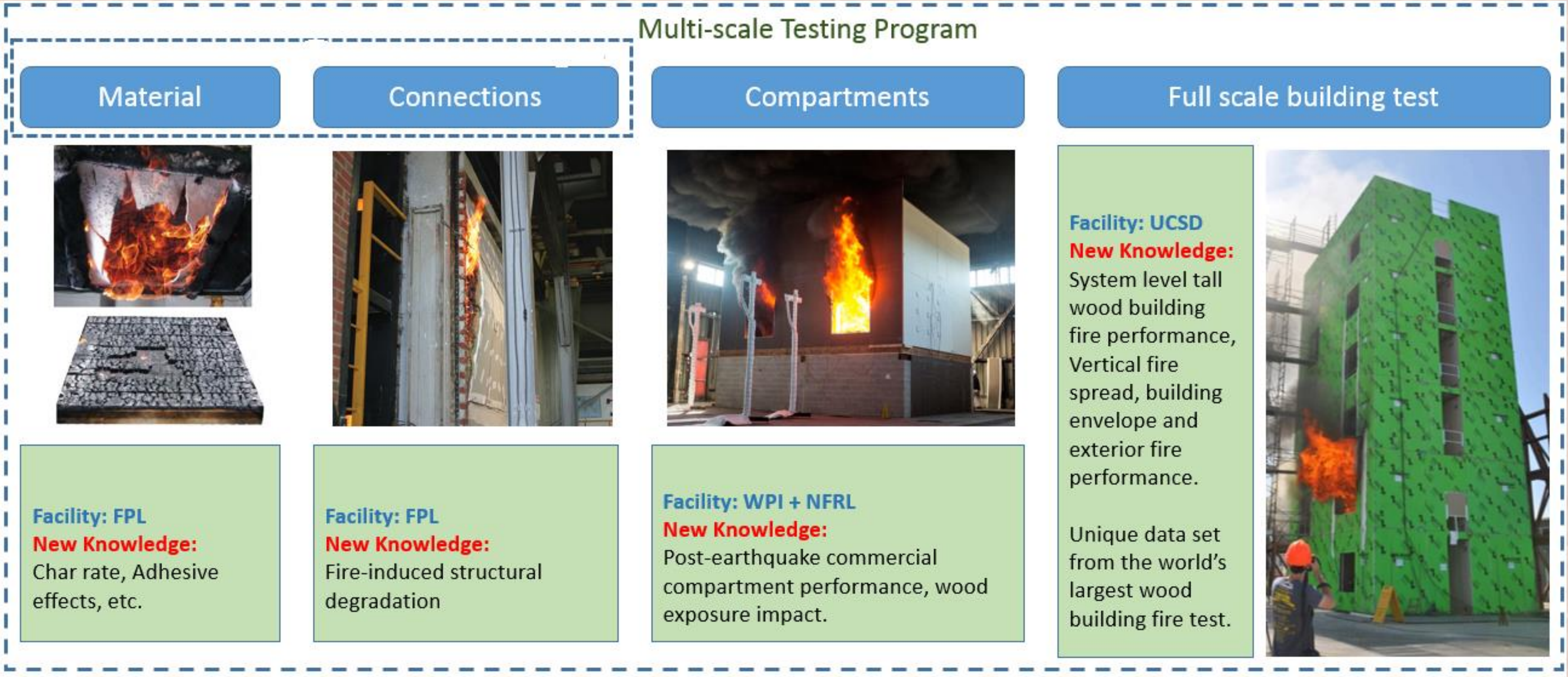
David Barber

ARUP

- A collaboration among Forest Products Lab, Colorado School of Mines, UCSD, Worcester Polytechnic Institute, and ARUP.
- Currently seeking funding to conduct systematic full-system fire test of tall wood building using the shake table specimen.

Systematic Multi-scale Fire Tests

- Trying to address questions related to mass-timber fire design and performance concerns.



Email us if you:

Are interested in support these research efforts

(Industry Sponsorship)

have a product, system, or idea you want to test

(Research Collaboration)

Summary

- Tall Wood has great potentials to be a high-performance competitor in high seismic regions.

- NHERI TallWood project focuses on tall wood building with open floor plan and resilient rocking wall system.
  - Two-story test coming this Summer
  - Leigh compatibility tests coming this Fall
  - Ten-story seismic test in 2020, with potential fire tests following.

- Light-weight and ductile, a new generation of high-performance wood buildings will emerge after key knowledge gaps are filled through research in the near future

Acknowledgement

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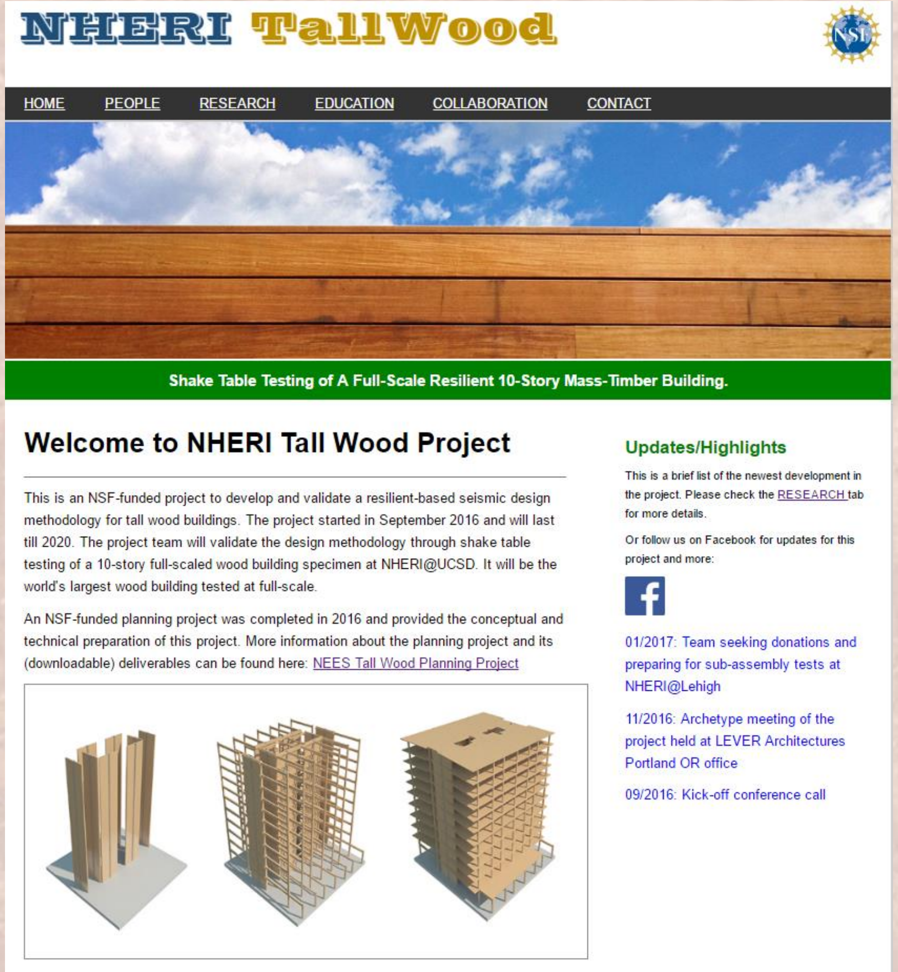
- Thanks to the financial support or material/labor donation from our collaborators on Mass Timber Research.

Thank You! & Questions?

Follow NHERI TallWood Project updates @
Nheritallwood.mines.edu



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