National Science Foundation Funded Research:
NEESR-CR: Enabling Performance-Based Seismic Design of Multi-Story Cold-Formed Steel Structures (CFS-NEES)

Introductory Presentation
for
Steel Stud Manufacturers Association
Today

• We have neither the modeling capabilities, nor the experimental understanding to complete a reliable seismic evaluation of CFS framed structures without relying on grossly conservative methodologies.

• We cannot model fundamentally important phenomenon, such as local buckling in the analysis tools currently used for inelastic time history analysis

• We know precious little about CFS interactions
  *sub-systems*: stud-to-track, joist-to-rim,
  *systems*: gravity and shear walls, floors, roofs, multi-story
  *combined systems*: LFRS vs. gravity vs. non-load bearing
  *whole buildings*

This project aims to set a new path for CFS seismic design to address these issues and enable true performance-based seismic design
Research Activities Summary

cold-formed steel
Frame FE

high fidelity
FE

sub-system testing

full-scale shaking

photo credit NEESWood
Figure 1 Schematic of proposed testing (a) sub-system tests of EXP-1, and system interaction testing of (b) a wall line with gravity and shear walls, EXP-2, and (c) a shear wall with floor detailing included, EXP-3

more on sub-system testing

in the JHU lab
more on full-scale testing

at the Buffalo NEES facility

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<thead>
<tr>
<th>Configuration</th>
<th>System Identification</th>
<th>Seismic Performance Evaluation</th>
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<tbody>
<tr>
<td>Bare Cold-Formed Steel Frame (CFSF)</td>
<td>Random Excitation</td>
<td>Small-Level Earthquake, Design Earthquake, Max Considered Earthquake</td>
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<td></td>
<td>System ID, Model validation</td>
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<tr>
<td>CFSF with Shear Walls</td>
<td>Contribution of shear walls</td>
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<tr>
<td>CFSF with Floor and Roof Diaphragms</td>
<td>Contribution of diaphragms</td>
<td>Interaction effects of diaphragms, Model validation for EQ loadings, Strength/Ductility</td>
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<tr>
<td>CFSF with All Structural Members Sheathed</td>
<td>Contribution of gravity walls</td>
<td>Interaction effects of gravity wall, Strength/Ductility with gravity wall</td>
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<tr>
<td>Complete CFSF including Nonstructural Members</td>
<td>Contribution of nonstructural members</td>
<td>Interaction effects of nonstructural members, Strength/Ductility</td>
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C. Rogers @McGill's Research

Specimen #1

Specimen #2

Specimen #3
Project Team

PI
B. Schafer
JHU

coPI
N. Nakata
JHU

coPI
S. Buonopane
Bucknell

Senior Personnel
R. Madsen
Devco

Int’l. Collaborator
C. Rogers
McGill

Domestic Collaborator
C. Yu
UNT
SSMA helped make this happen

• Through AISI involvement
  – Development of related codes and standards
  – Direct interaction with researchers

• Past research support for the PI
  – Distortional buckling investigation (material)
  – Direct Strength Method for members with holes (material)
  – Imperfection measurements of studs (funding)
  – Sheathing braced design of wall studs (funding and material)

investment in our research together now brings us to this $923,000 project
SSMA is a big part of the solution

• Direct involvement in industrial advisory board
  – Advice, details, first feedback, knowledge

• Support for experimental testing
Summary

• NSF funding for NEESWood was $1.4 million. For the first time CFS is in the game with $923,000 for CFS-NEES and also a $400,000 CAREER grant for Cheng Yu
• The “R” factor game that has been the heart of simplified seismic design is coming to an end as we know it and CFS currently lacks fundamental tools to leverage new methods
• Wood and other materials are developing new seismic resisting systems and CFS needs to play catch up here
• CFS-NEES represents a significant opportunity for the industry to regain its natural technical advantage, and to provide the enabling tools for modern earthquake engineering analysis, and the fundamental knowledge to leverage the true performance of our system
• SSMA’s involvement intellectually and financially is crucial to the project’s success. I look forward to working with you.
Supplementary: UB-NEES Facility
## Supplementary: Gantt Chart

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<tr>
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<th>2010-2011</th>
<th>2011-2012</th>
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<td>Su</td>
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### Experimental Tasks
- **EXP-1**: Joist-to-rim tests
- **EXP-2**: Shear wall with gravity wall test
- **EXP-3**: Shear wall with floor test
- **EXP-McGill**: Multi-story shear wall test (tests detailed to prototype building)
- **EXP-4**: Multi-story building test (prototype building design UB-NEES)

### Computational Modeling Tasks
- **CM-1**: OpenSees thin-walled frame element
- **CM-2**: Phenomenological connection elements
- **CM-3**: High fidelity wall and diaphragm models
- **CM-4**: Reduced order wall and diaphragm models
- **CM-5**: High fidelity whole building models
- **CM-6**: Reduced order whole building models
- **CM-7**: Incremental Dynamic Analysis (performed with increasing sophistication)