

ATC-110 Prestandard & PEER/CEA Testing

Kelly Cobeen

Structural Engineer

Wiss Janney Elstner Associates

Acknowledgements:

ATC-110/ FEMA P-1100 Prestandard

Funding by:



Project Led by:



Applied
Technology
Council

Many great contributors!!

Seismic Retrofit – The Big Picture

Ultimate Goal:

Get seismic retrofit installed in LOTS of homes

- Reduce losses
- Increase post EQ habitability



Seismic Retrofit – The Big Picture

Need:

One definitive resource to provide guidance for assessment and retrofit

- Facilitate implementation
- Set method
- Set minimum retrofit level

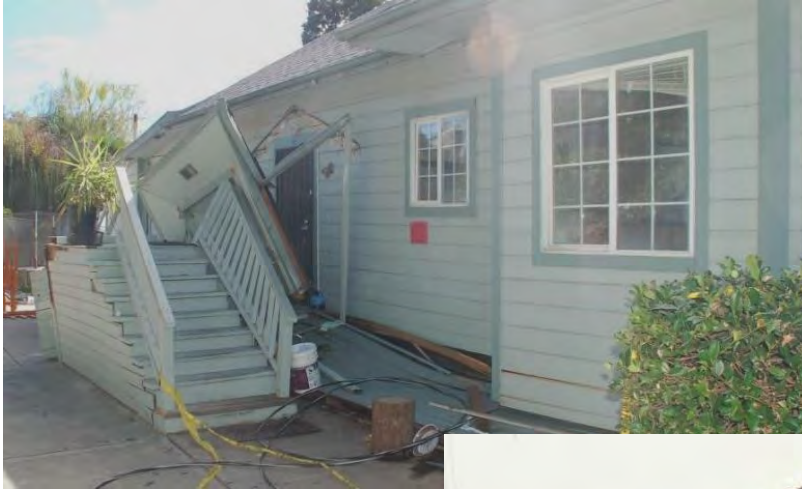


Seismic Retrofit – The Big Picture

ATC Project Vision:

- Use best available performance-based concepts and tools to pre-engineer
- Communicate in simplest possible method with simplified engineered and prescriptive methods (plan sets)
- Focus on vulnerability-based assessment and retrofit, prioritize vulnerabilities

Why a Retrofit Prestandard?



Why a Retrofit Prestandard?



Why a Retrofit Prestandard?



First, the plan!

VULNERABILITIES

- ✓ Cripple wall, anchorage to foundation
- ✓ Living space over garage
- ✓ Hillside dwelling
- ✓ Chimneys
- ☐ Split-level dwelling
- ☐ Inadequate wall bracing in occupied spaces
- ☐ Anchorage of slab-on grade dwelling
- ☐ Parts and portions (porches, stairs, landings)

ATC 110

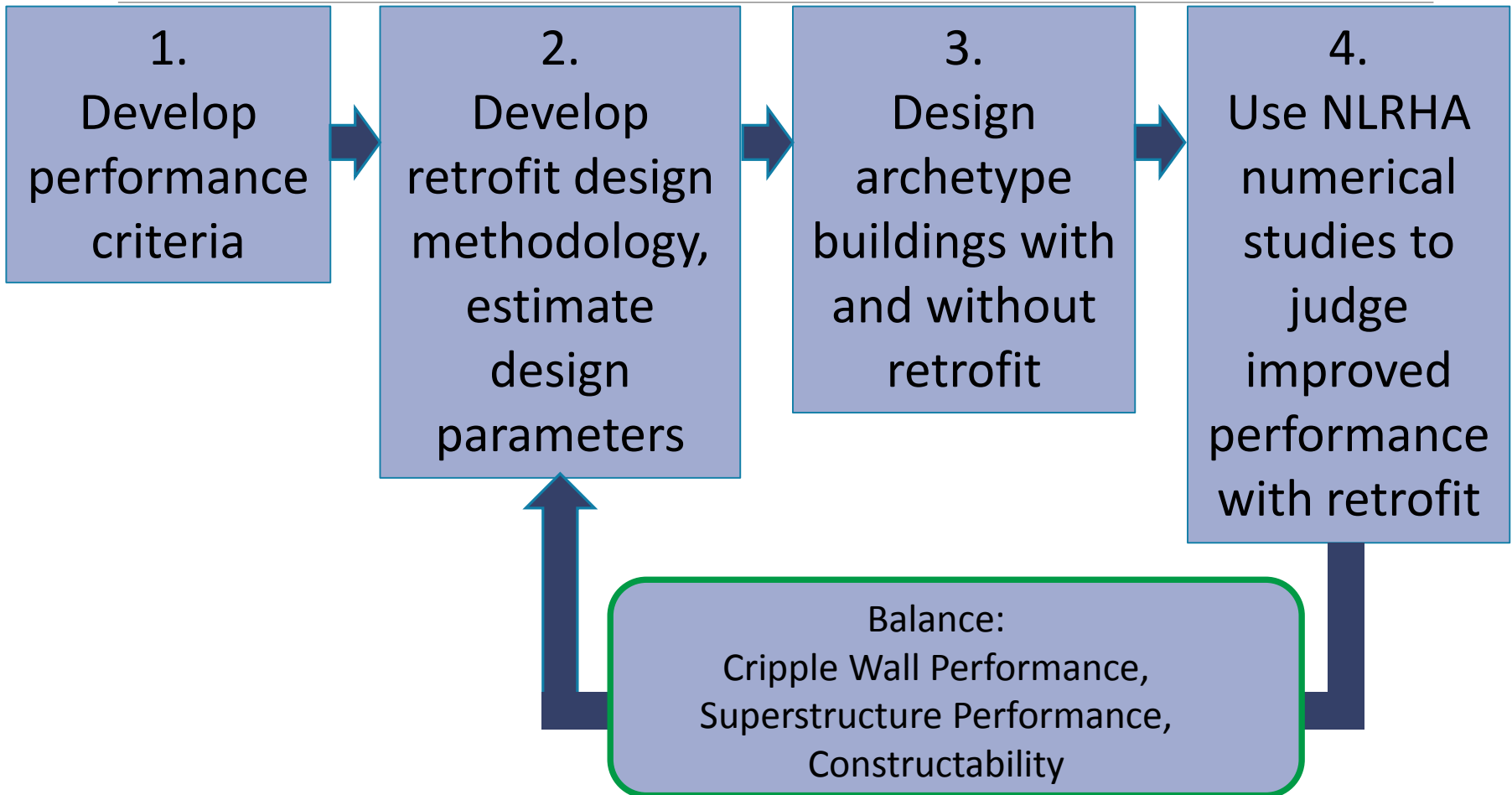
Plan for development of a prestandard for evaluation and retrofit of wood light-frame dwellings



ATC Applied Technology Council

Funded by
California Earthquake Authority
In cooperation with
Federal Emergency Management Agency

Development of Retrofit Design



Understanding the Existing Building Stock

AL22

Building Weight Summary (1500-B1)

Building Geometry Assumed:	Length of wall
L (ft) = 35	W = 35
V (ft) = 45	Roof Pitch = 12/12
Area 1st = 1225 (ft ²)	1) First Floor In = 3
Area 2nd = 400 (ft ²)	2) Second Floor In = 8
	3) 2nd Floor Out = 8
	4) Second Floor In = 8

Class	Roofing	1st Floor	2nd Floor	Exterior Wall	Interior Wall	Stable End Wall	Cripple Wall
Heavy	25.0	9.0	9.0	20.0	8.0	8.0	8.0
Medium				16.0			
Light	8.0	8.0	8.0	7.0	7.0	7.0	7.0

Type 1B.1.1 Horizontal sheathed exterior and gyprom interior plus light roof
Load Source:

Exterior Walls	Interior Walls	Floors	Roof	# of Floors
Light	Light	Light	Light	1

Floor & Roof Weight:

A _{ext}	A _{int}	A _{1st}	A _{2nd}	A _{roof}	A _{total}	W _{ext}	W _{int}	W _{1st}	W _{2nd}	W _{roof}	W _{total}
1225	0	1225	400	3	1850	18	18	108	36	22.5	222

Wall Weight (First Floor):

A _{ext}	A _{int}	A _{1st}	A _{2nd}	A _{roof}	A _{total}	W _{ext}	W _{int}	W _{1st}	W _{2nd}	W _{roof}	W _{total}
1225	0	1225	400	3	1850	18	18	108	36	22.5	222

Wall Weight (Second Floor):

A _{ext}	A _{int}	A _{1st}	A _{2nd}	A _{roof}	A _{total}	W _{ext}	W _{int}	W _{1st}	W _{2nd}	W _{roof}	W _{total}
0	0	0	400	0	400	0	0	0	36	0	36

Building Total Weight:

52.5 Mg (1163) 21.0

Type 1B.1.2 Horizontal sheathed exterior and lath and plaster interior plus light roof
Load Source:

Exterior Walls	Interior Walls	Floors	Roof	# of Floors
Light	Heavy	Light	Light	1

Floor & Roof Weight:

A _{ext}	A _{int}	A _{1st}	A _{2nd}	A _{roof}	A _{total}	W _{ext}	W _{int}	W _{1st}	W _{2nd}	W _{roof}	W _{total}
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Building Total Weight:


52.5 Mg (1163) 21.0




House Design No. 1511



FIRST FLOOR PLAN



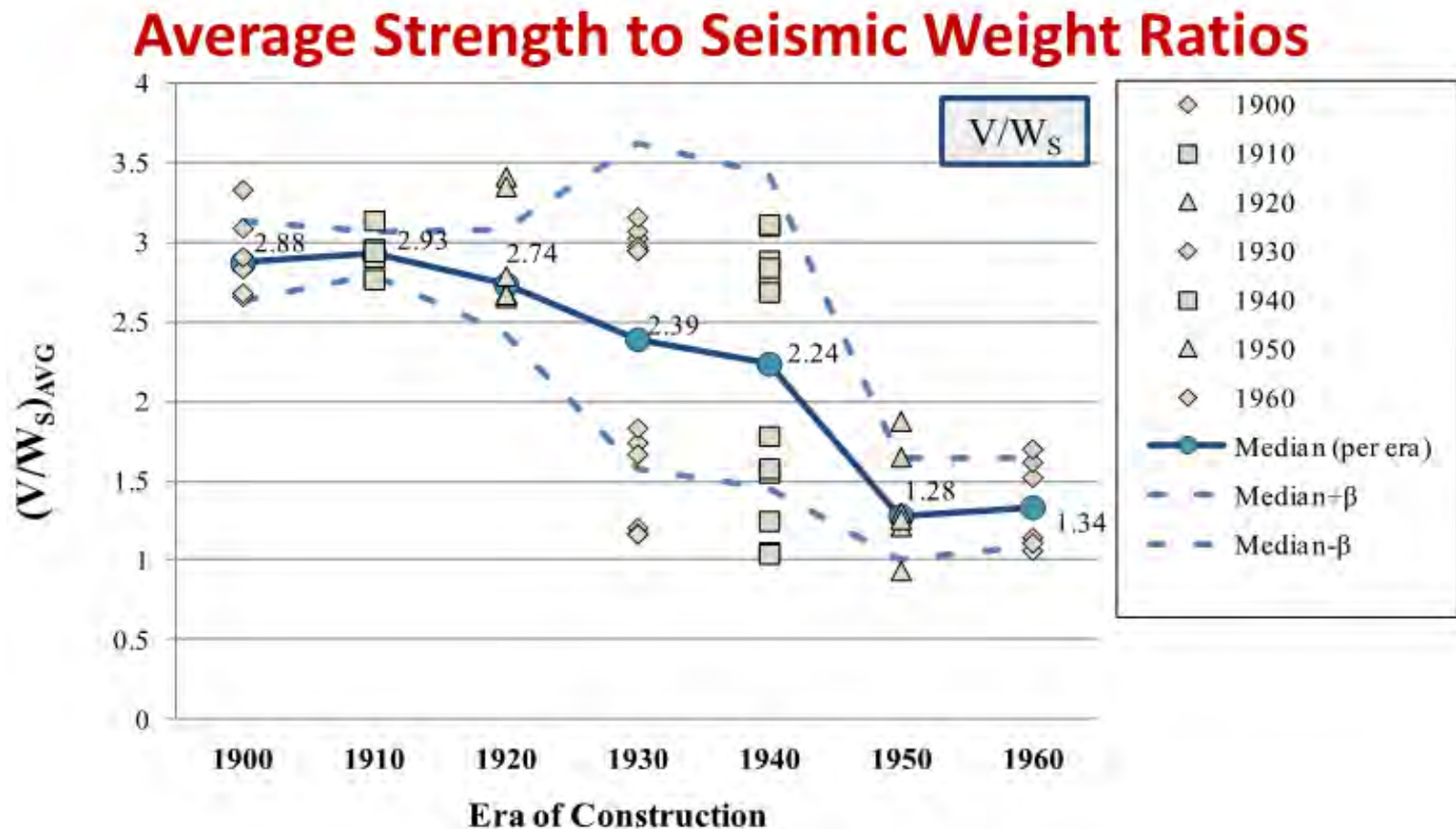
FIRST FLOOR PLAN



FIRST FLOOR PLAN

21 one-story homes (84 combinations)
 14 two-story homes (56 combinations)

Understanding the Existing Building Stock



Performance Criteria

Primary:

- Probability of collapse at MCE_R – FEMA P-695

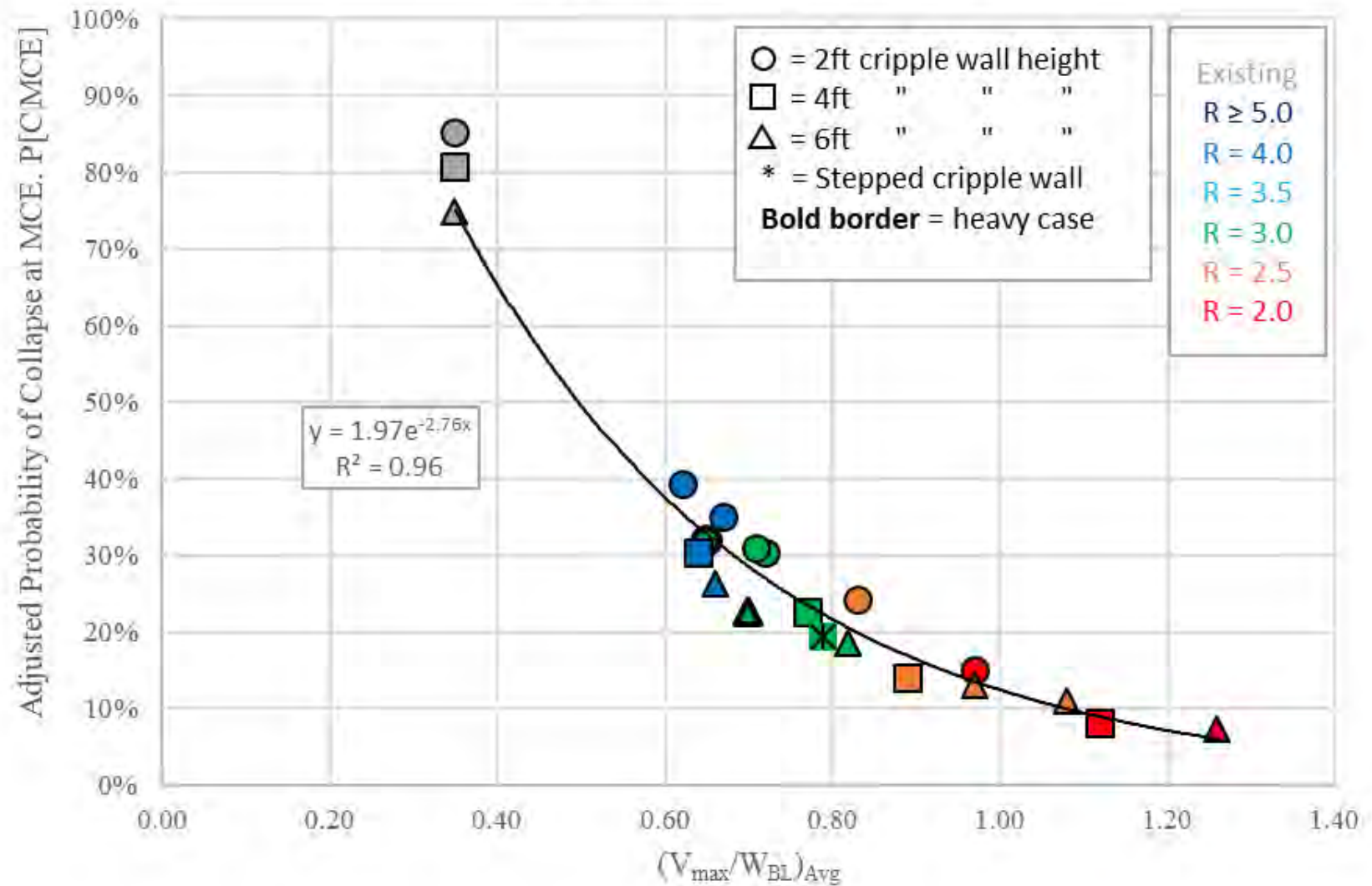
Secondary:

- Indicator of level of repair – probability of exceeding 0.75% drift at $0.4 MCE_R$ – FEMA P-58 Fragilities, CUREE EDA-02
- Indicator of safety for continued occupancy – probability of exceeding 1.5% drift at $2/3 MCE_R$ – CUREE EDA-02, FEMA P-807 Appendix D.9

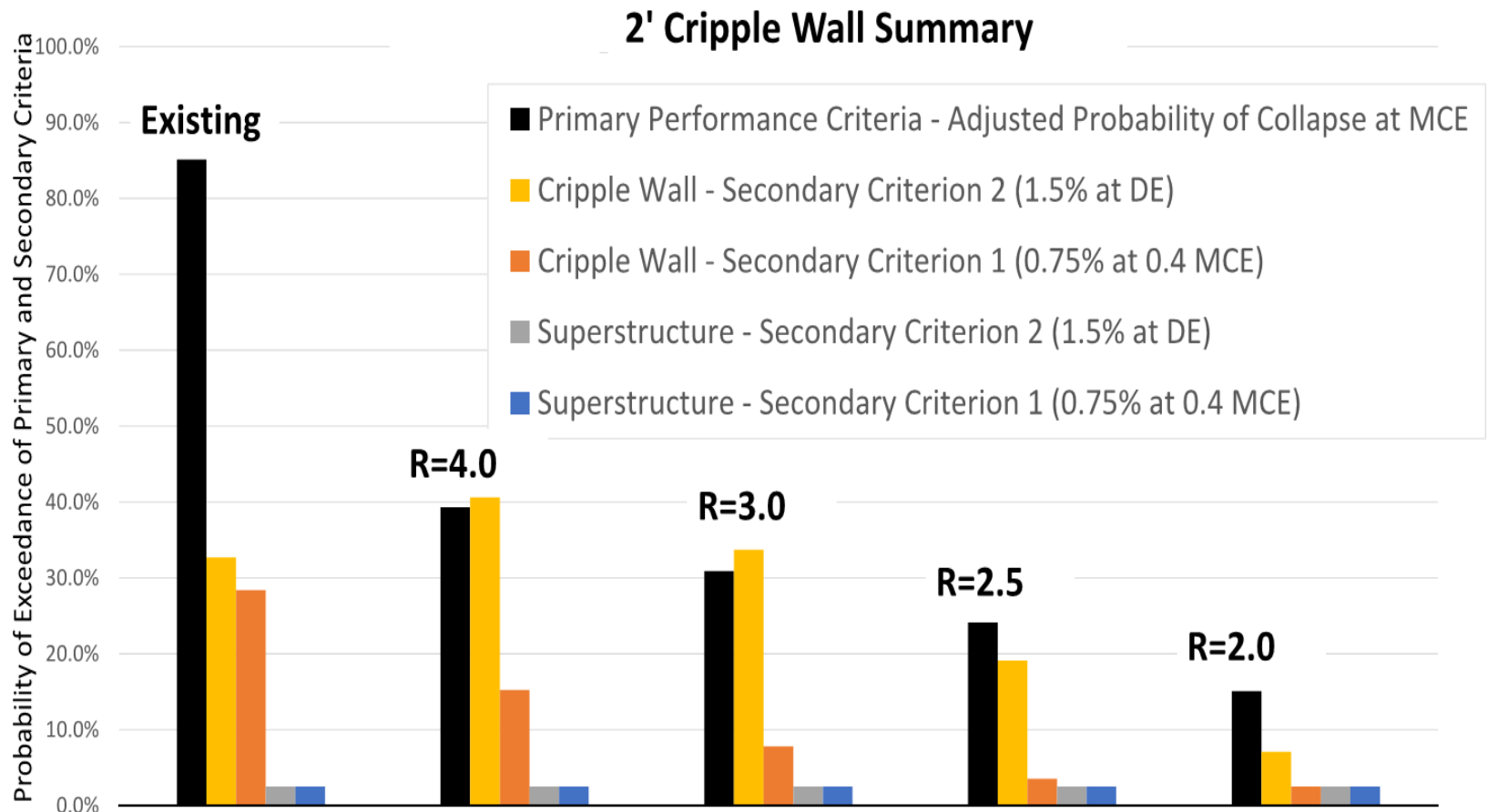
Design Method

- Equivalent lateral force with R-factor derived from performance-based numerical studies
 - R and Ω_0 factors, no drift criteria
- Design limited to retrofit elements and their connection to structure above and below
- Capacity based concepts applied to load-path connections
- Simplifying assumptions developed for overturning anchorage demand, capacity

Adjusted Probability of Collapse at MCE vs. Average Lateral Peak Strength: One Story Median Superstructure




Numerical Study Performance Results



Vision becomes reality! FEMA P-1100

<https://www.fema.gov/media-library/assets/documents/175158>



Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings

Volume 1 - Prestandard
FEMA P-1100 / Month 2018






Table C-1: ELIGIBILITY FOR USE

Requirement	Yes/No	Applicant Information
1. The structure is a one- or two-family dwelling.		
2. The structure is a detached structure.		
3. The structure is a single-unit structure.		
4. The structure is a detached structure.		
5. The structure is a detached structure.		
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SHEET INDEX

1. Cover Sheet	
2. Introduction	
3. Scope	
4. Definitions	
5. References	
6. Acronyms	
7. Abbreviations	
8. Symbols	
9. Figures	
10. Tables	
11. Appendix A	
12. Appendix B	
13. Appendix C	
14. Appendix D	
15. Appendix E	
16. Appendix F	
17. Appendix G	
18. Appendix H	
19. Appendix I	
20. Appendix J	
21. Appendix K	
22. Appendix L	
23. Appendix M	
24. Appendix N	
25. Appendix O	
26. Appendix P	
27. Appendix Q	
28. Appendix R	
29. Appendix S	
30. Appendix T	
31. Appendix U	
32. Appendix V	
33. Appendix W	
34. Appendix X	
35. Appendix Y	
36. Appendix Z	

VOLUME 1 - PRESTANDARD (Published)

VOLUME 2 – PLAN SETS (Coming Soon!)

Still on the Wish List – Retrofit Standards

- Finish vulnerabilities identified but not addressed in first group
- Update predictions of performance with new testing data to supplement existing, new analytical modeling information
- Review PEER Study results and consider influence on assessment and retrofit recommendations
- Trial testing of assessment and retrofit methods and feedback

PEER CEA Project

Note: information presented in the following slides depicts preliminary information from an ongoing research project.

Quantifying the Performance of Retrofit of Cripple Walls & Sill Anchorage in Single Family Wood-frame Buildings



Acknowledgements: PEER CEA Project

Funding by:



Project Led by:

Yousef Bozorgnia, P.I.



Many great contributors!

Testing Conducted by:

UC San Diego: Dr. Tara Hutchinson, Brandon Schiller

UC Berkeley: Kelly Cobeen, Dr. Vahid Mahdavifar

PEER CEA Project

Objective

- Improve the body of available research regarding the seismic resilience of California's residential housing stock

Method

- Develop a simulation framework to establish a baseline comparison of damage costs between unretrofitted and retrofitted index buildings

PEER CEA Project

Working Groups

- WG1 – Literature Review
- WG2 – Index Buildings
- WG3 – Loading Protocol
- WG4 – Testing
- WG5 – Analytical Modeling
- WG6 – Fragility Functions
- WG7 - Reporting

Working Group 4 Testing Program

Testing Program Purpose:

- Fill prioritized gaps in the component test record
- Develop descriptions of hysteretic behavior to be used in Working Group 5 NLRHA modeling
- Collect data on damage progression to be considered by Working Group 6 fragility/ damage functions

Testing Program

Testing Group A – Cripple wall components

- Group A Small Component - ongoing
- Group A Large Component - complete

Testing Group B – Load path connections

- Estimated testing March-May 2019

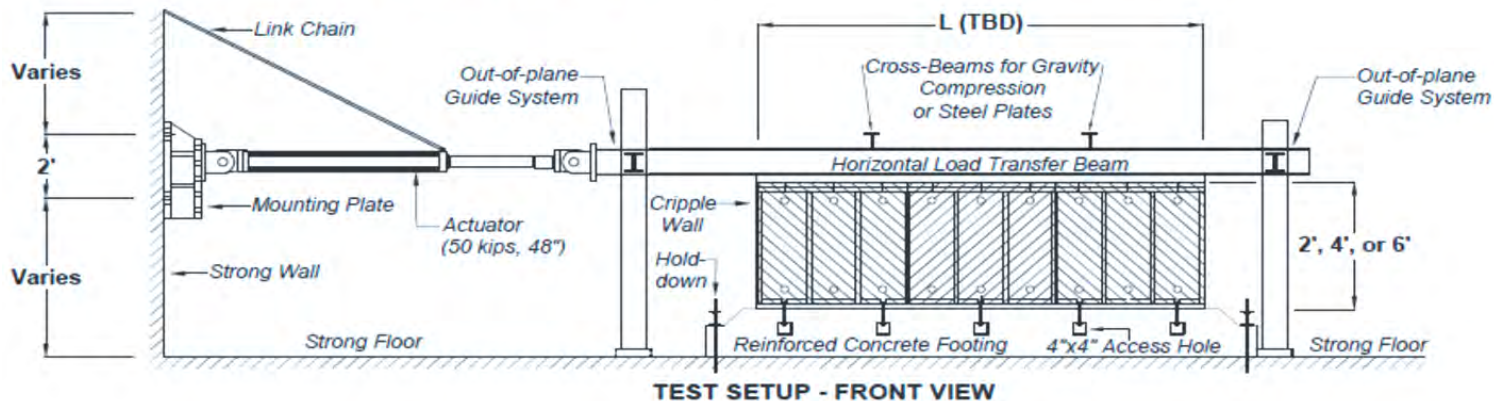
Testing Group C – Combined materials in occupied stories

- Shiplap, plaster on wood lath - complete
- Plywood siding, gypboard - est. February 2019

UCSD Small Component Test Scope

Credit: Tara Hutchinson and Brandon Schiller

- Experimentally investigate the **cripple wall-only** component behavior (~30 specimens) [4 Phases]
- Quasi-static reversed cyclic CW component tests; significant expansion of the UC Davis (CUREE) test program; support numerical modelers (WG5)
- Primary variables: 1) Construction era, 2) exterior finish type (including boundary conditions for stucco), 3) existing (unretrofit) vs retrofit [**sill anchorage & %bracing**], 4) axial load (single vs multi-story housing) [**light & heavy**], 5) CW height (and length) [**H = 2', 4', 6' & L = 12' or 16'**]



UCSD – Primary Test Outcomes

Credit: Tara Hutchinson and Brandon Schiller

- Force-displacement (drift) hysteresis of the CW component, in addition...
 - Peak strength
 - Drift at peak strength
 - Service-level drift and strength
- Damage as evolving during cyclic testing
 - Rich image dataset correlated with drift amplitude
 - 3-5 videos per test time-stamped
- Cross-comparison amongst key test parameters
 - Contribution of various finishes
 - Contribution of retrofit
 - Effect of boundary conditions

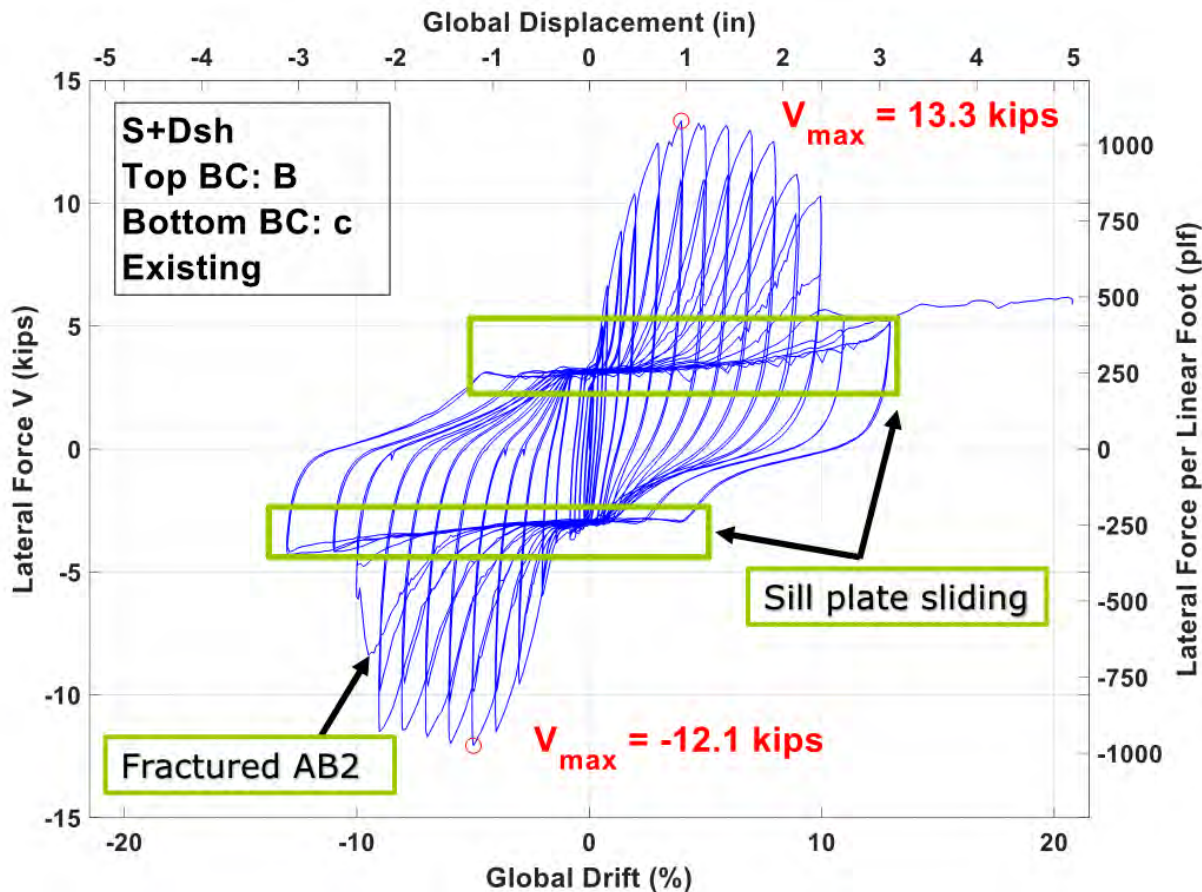
UCSD – Specimen A-15 Details

Credit: Tara Hutchinson and Brandon Schiller



UCSD – Specimen A-15 Hysteresis

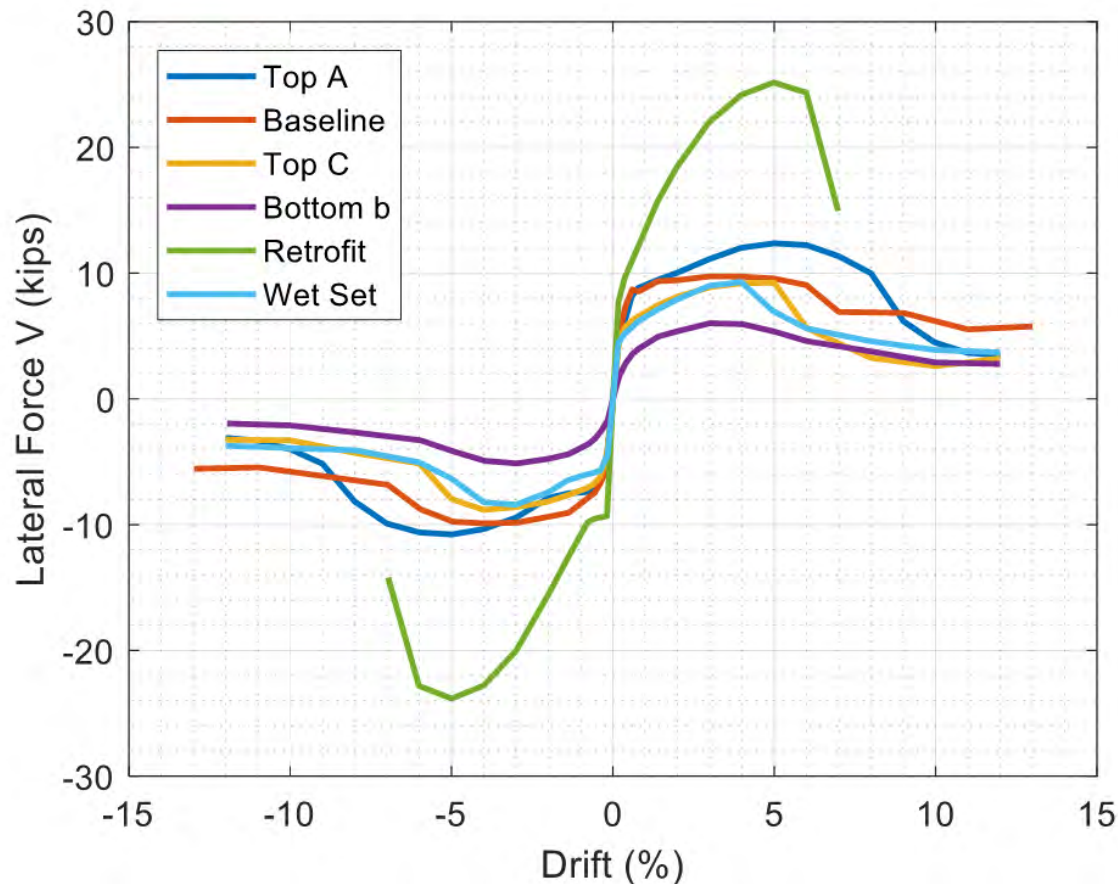
Credit: Tara Hutchinson and Brandon Schiller



Note: Preliminary information from an ongoing research project.

UCSD – Phase 1 Backbone Comparison

Credit: Tara Hutchinson and Brandon Schiller

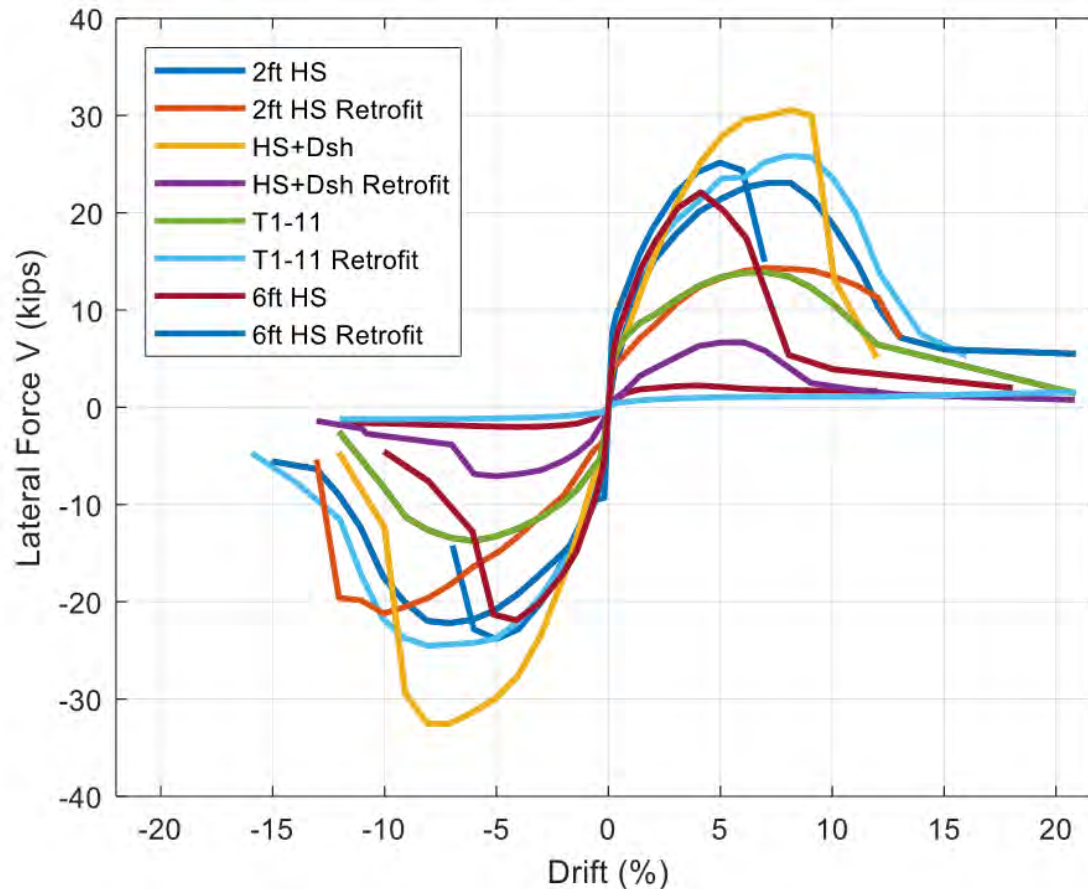


All specimens stucco over horizontal wood sheathing

Note: Preliminary information from an ongoing research project.

UCSD – Phase 2 Backbone Comparison

Credit: Tara Hutchinson and Brandon Schiller

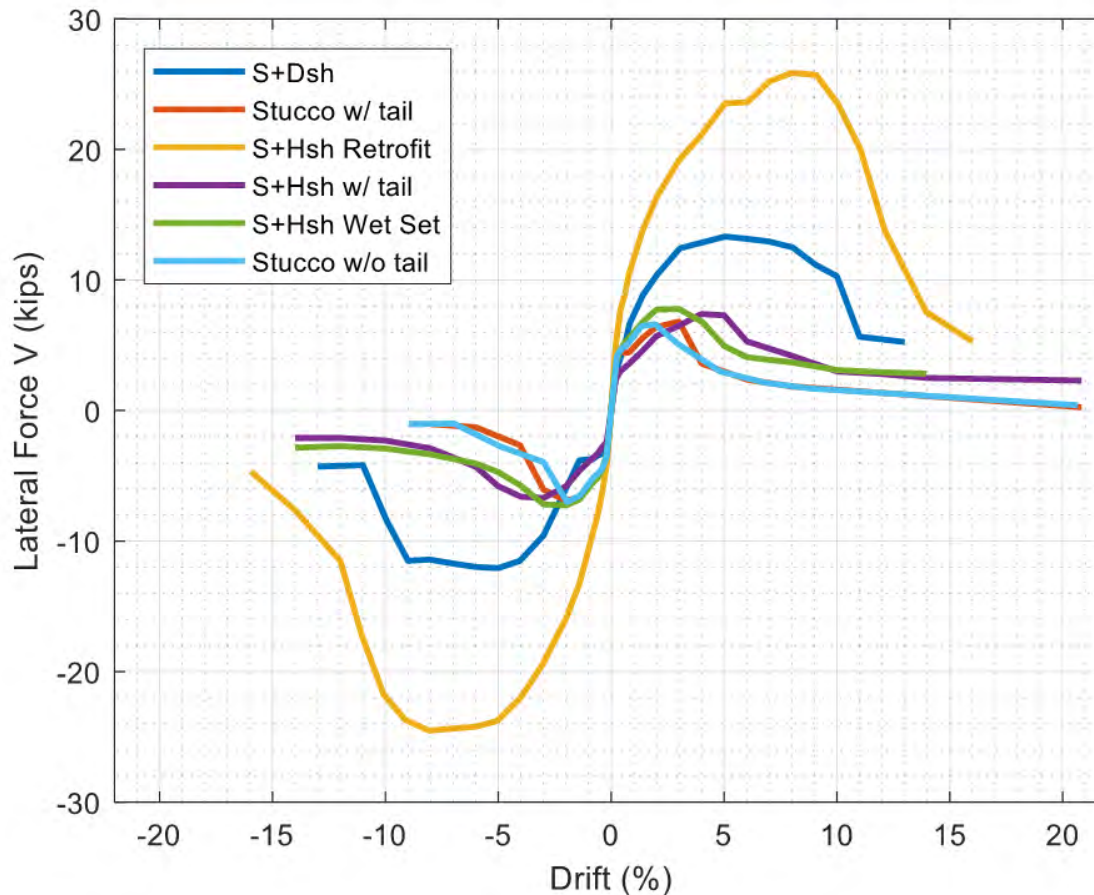


S = Stucco
HS = Shiplap siding
Hsh = Horizontal
lumber sheathing
Dsh = Diagonal lumber
sheathing
T1-11 = Plywood
siding

Note: Preliminary information from an ongoing research project.

UCSD – Phase 3 Backbone Comparison

Credit: Tara Hutchinson and Brandon Schiller

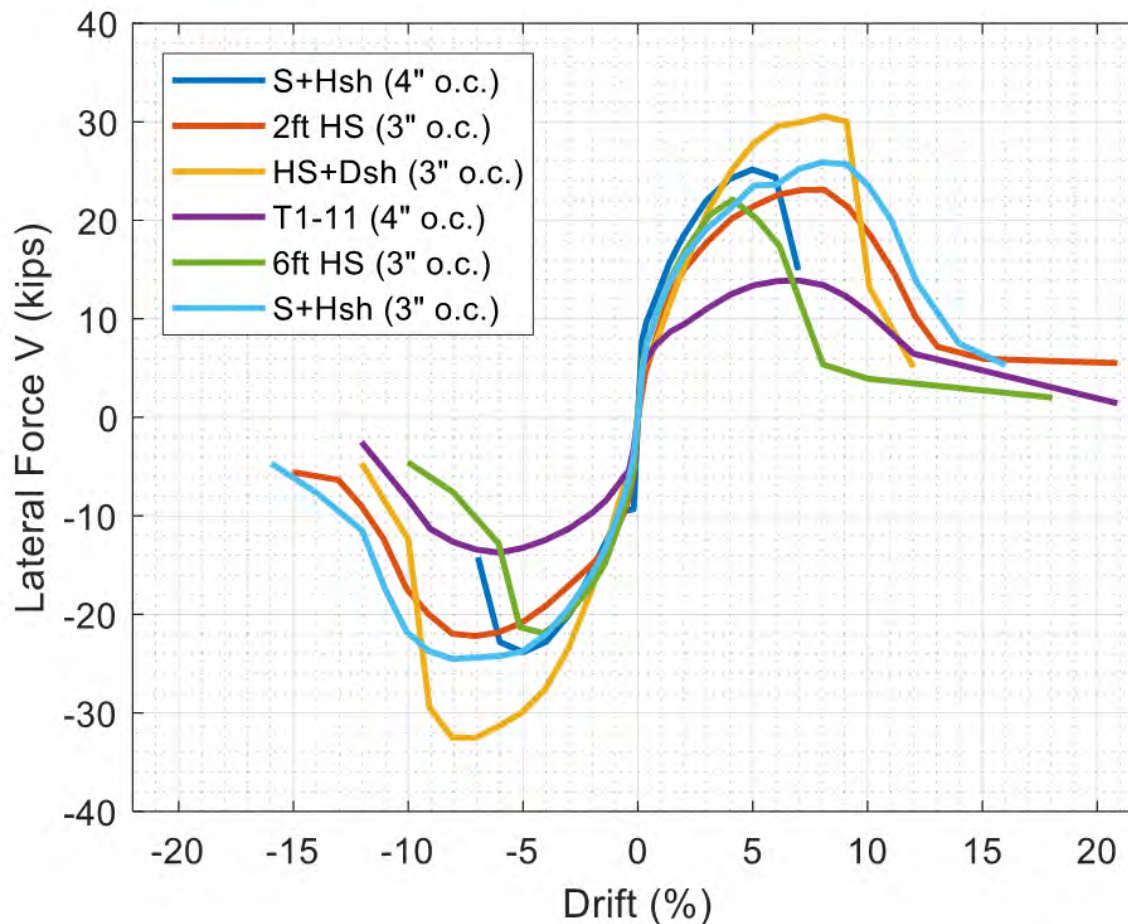


S = Stucco
HS = Shiplap siding
Hsh = Horizontal
lumber sheathing
Dsh = Diagonal lumber
sheathing
T1-11 = Plywood
siding

Note: Preliminary
information from an
ongoing research
project.

UCSD – Retrofit Specimen Backbones

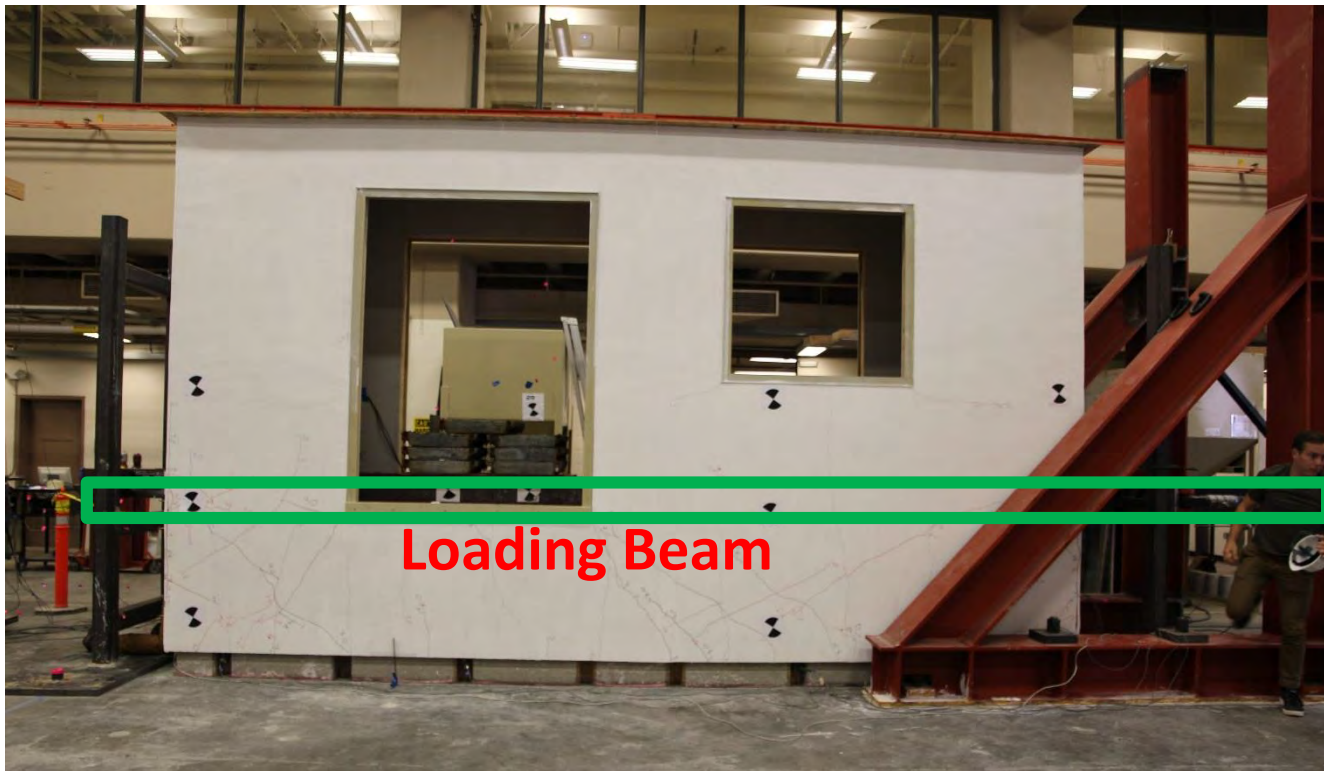
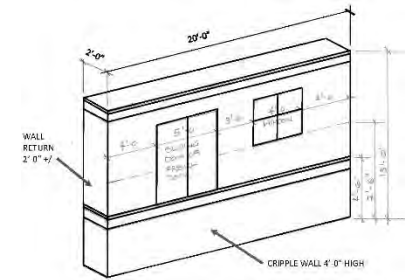
Credit: Tara Hutchinson and Brandon Schiller



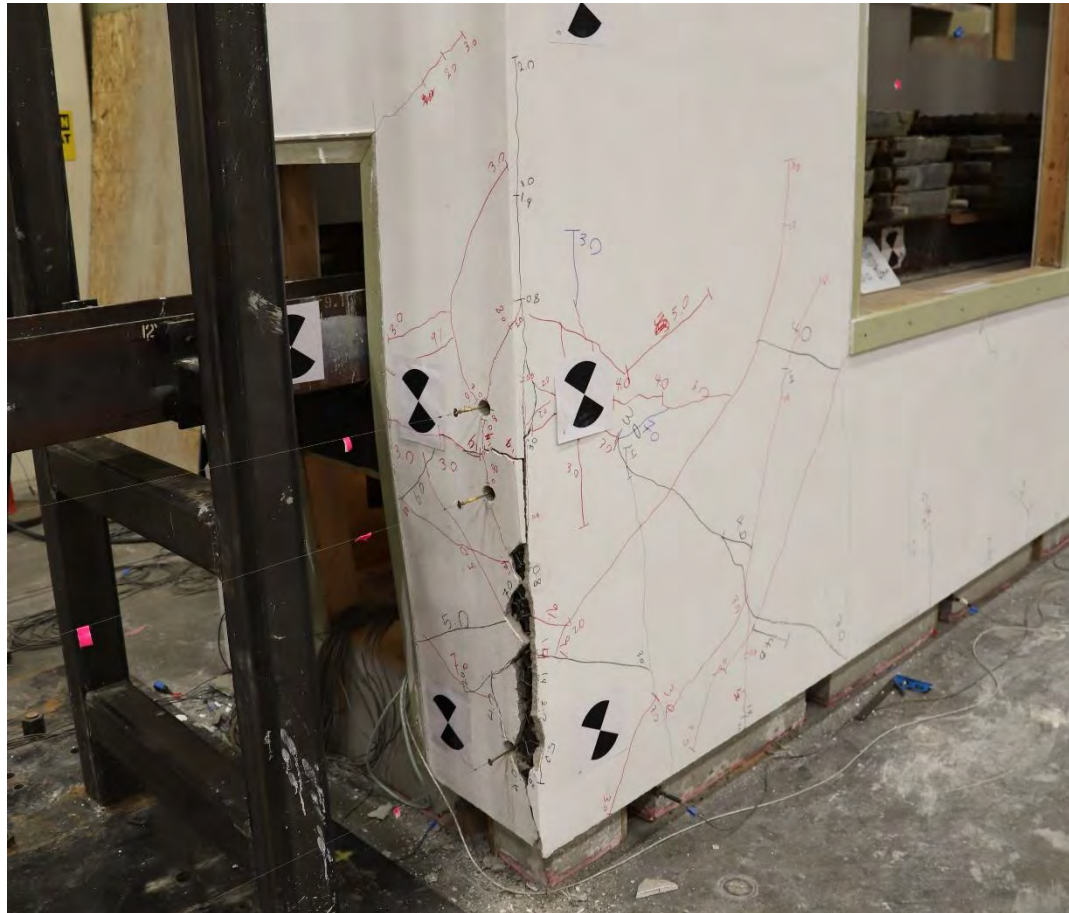
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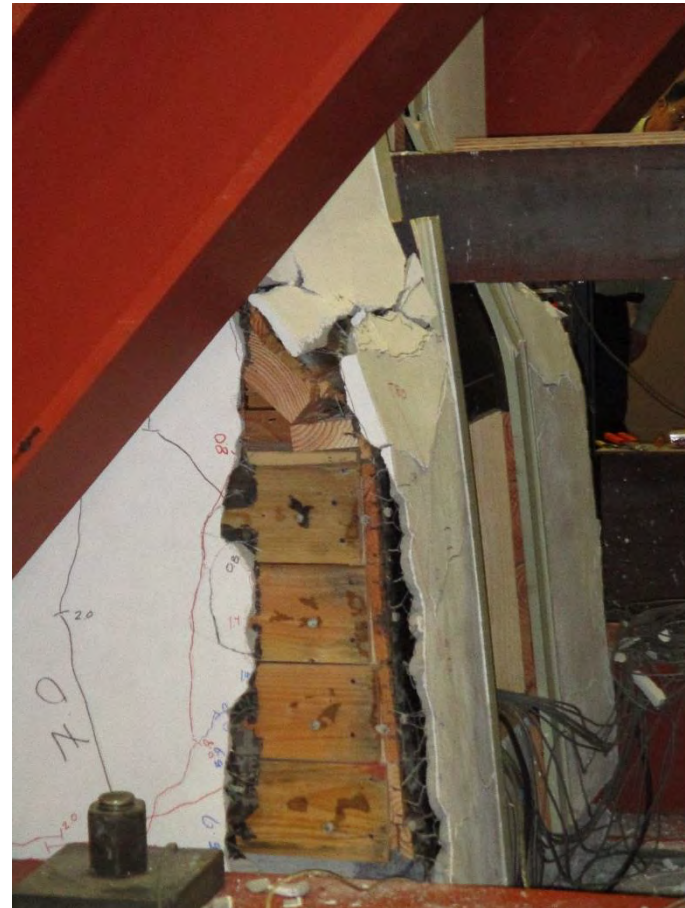
UCB – Group A Test Set-Up



UCB – Group A Stucco at End of Test



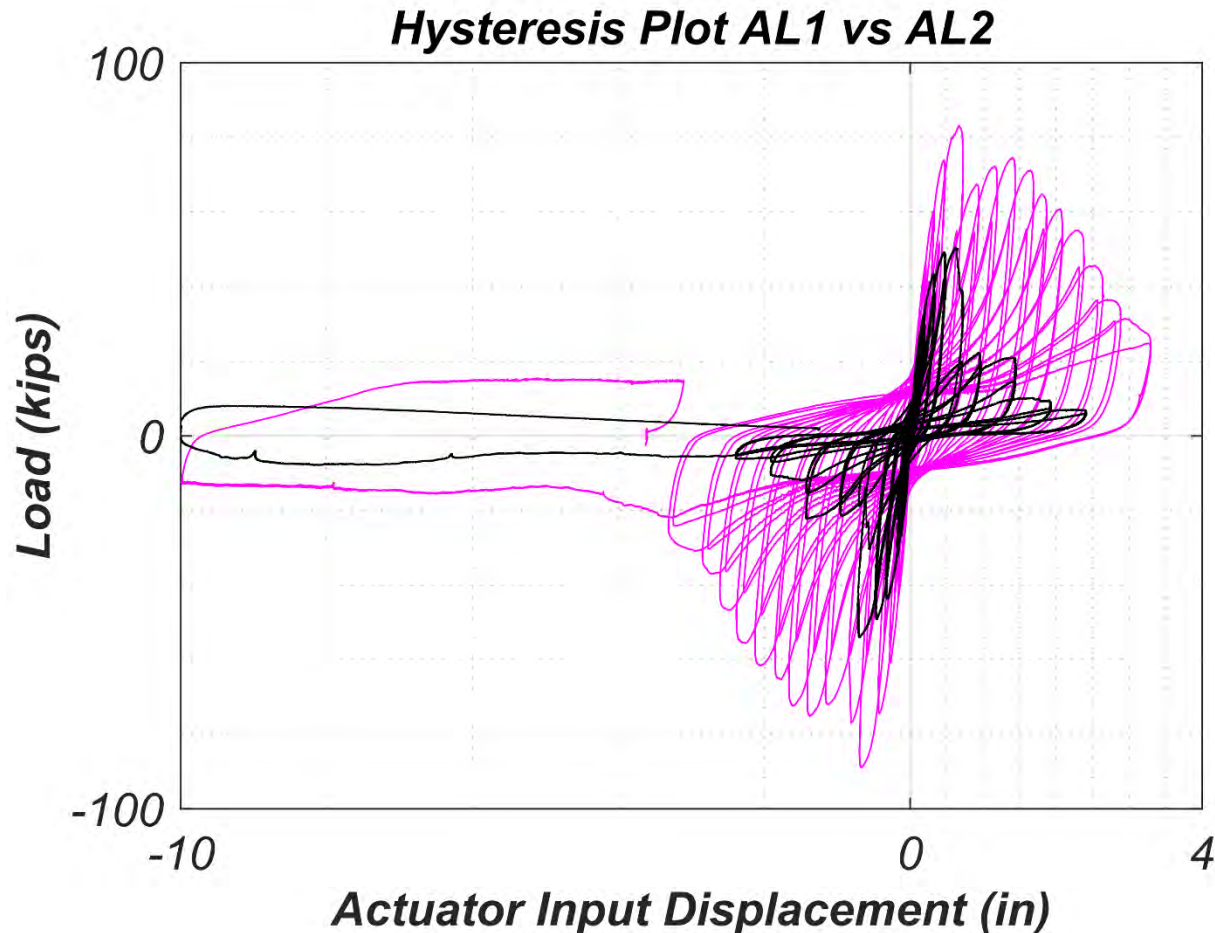
UCB - Diaphragm Pushed Off Walls



UCB - Cripple Wall Plywood Nail Back Out



UCB - With and Without Cripple Wall Retrofit



Note: Preliminary information from an ongoing research project.

UCB – Group C Shiplap, Plaster on Wood Lath



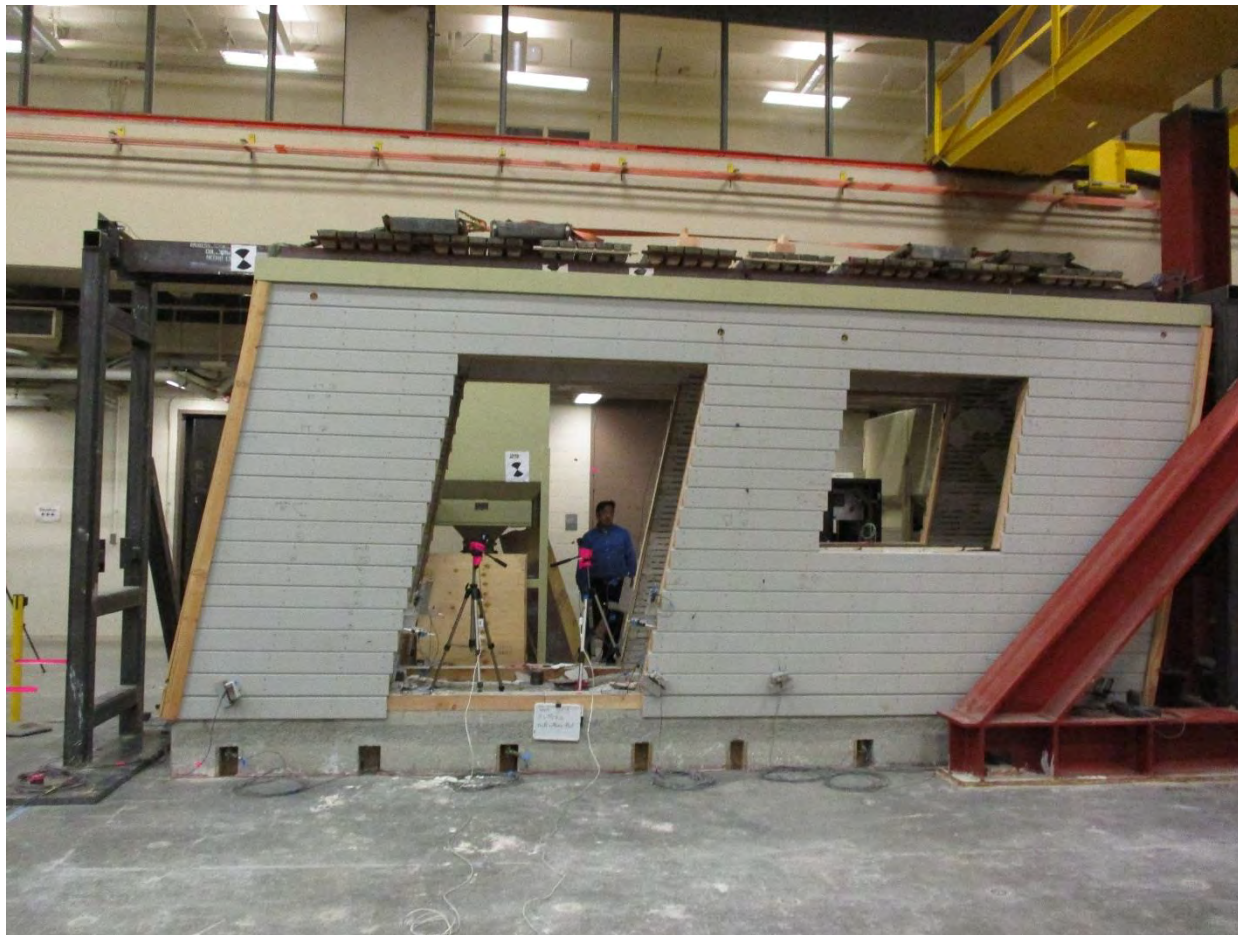
UCB – Group C Shiplap, Plaster on Wood Lath



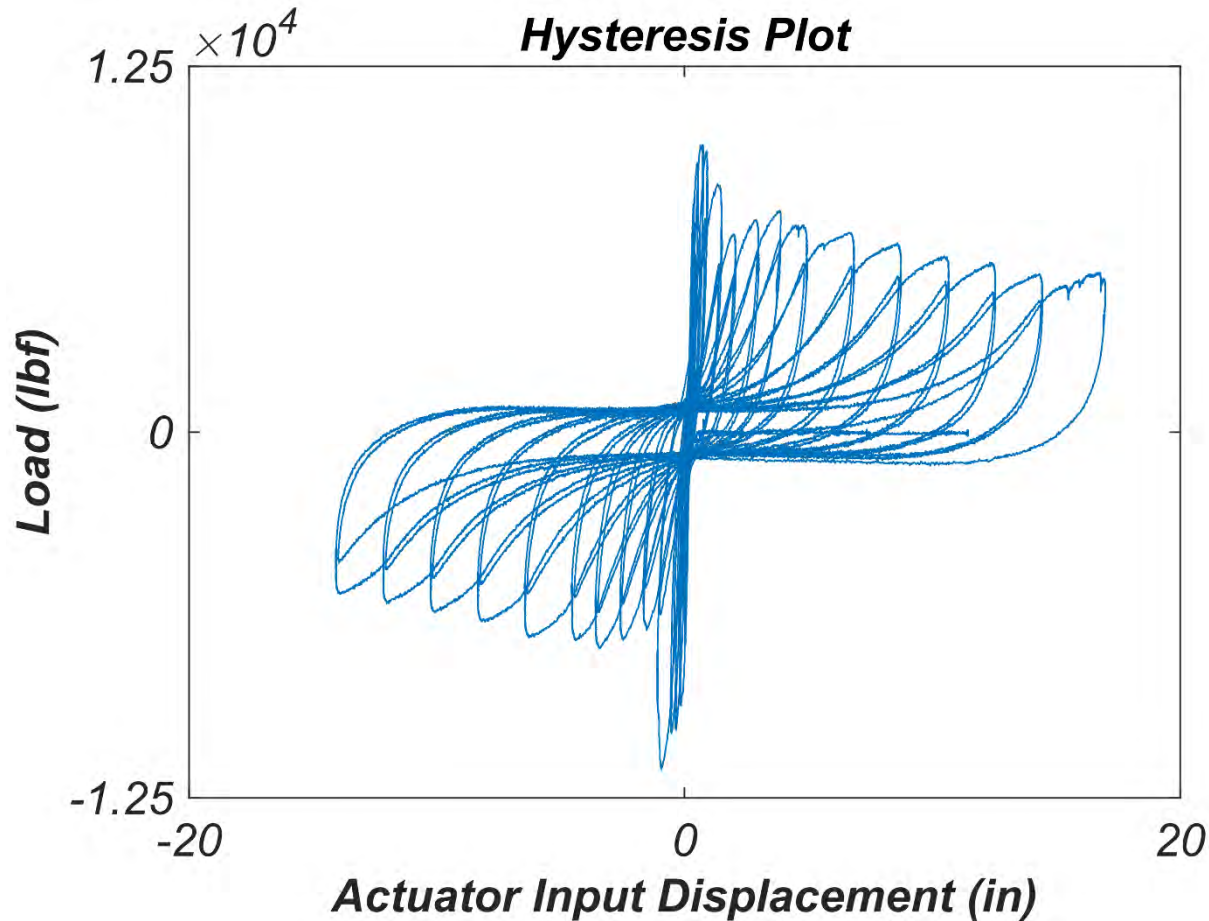
UCB – Group C Shiplap, Plaster on Wood Lath



UCB – Group C Shiplap, Plaster on Wood Lath



UCB – Group C Shiplap, Plaster on Wood Lath



Note: Preliminary information from an ongoing research project.

Still on the Wish List - Testing

- Full building validation testing
- More repeats of conducted tests to determine variability
- More tests of combined materials
- Testing of aged and deteriorated materials and assemblies
- Testing to study more complex geometries

Thank You!

Questions?
