Quantifying the Performance of Retrofit of Cripple Walls and Sill Anchorage in Single Family Wood-Framed Buildings

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ABSTRACT

The PEER CEA Project set out to improve the body of available research regarding the seismic resilience of California's residential housing stock. This was approached by developing a simulation framework to establish a baseline comparison of damage costs between unretrofitted and retrofitted index buildings.

The Testing Group (Working Group 4) developed a testing program to support this effort by:

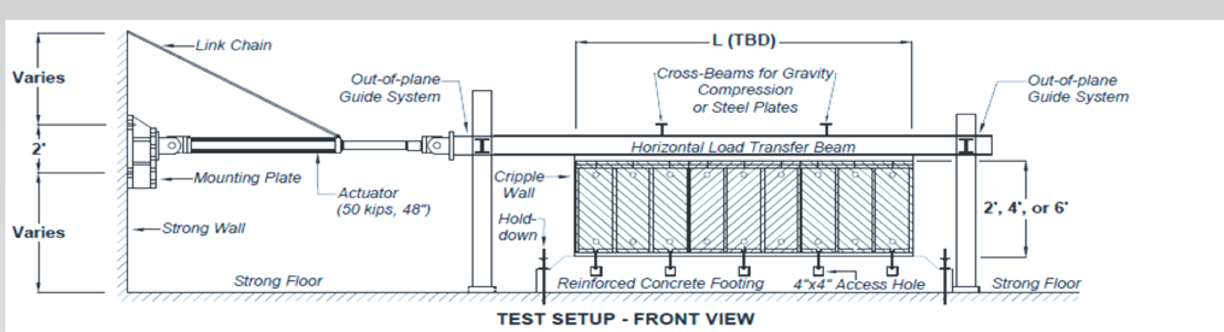
- Filling prioritized gaps in the component test record,
- Developing descriptions of hysteretic behavior to be used in Working Group 5 NLRHA modeling, and
- Collecting data on damage progression to be considered by Working Group 6 fragility/ damage functions.

The Testing Group work was divided into:

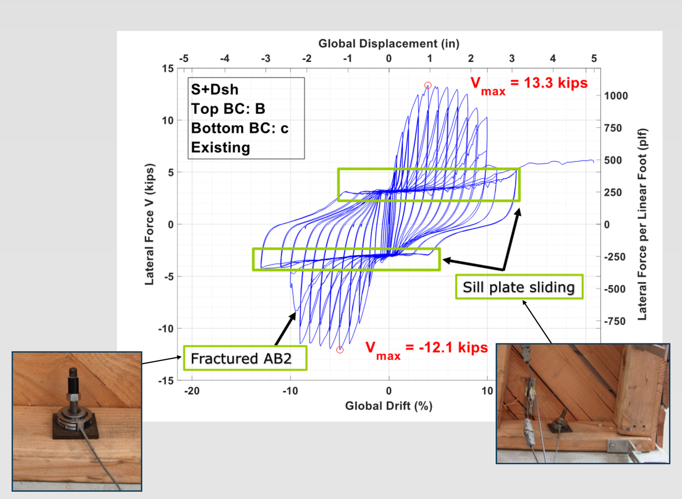
- Small component testing that permitted a wide range of bracing materials, combinations of materials, cripple wall heights, and boundary conditions to be investigated, and
- Large component testing that investigated upper end boundary conditions, bracing materials in occupied stories, and development of load path connections for cripple wall retrofit elements.

Note that information included in this poster is preliminary from an ongoing research project. See final research reports for final characterization of data.

SMALL COMPONENT TESTING INTRODUCTION



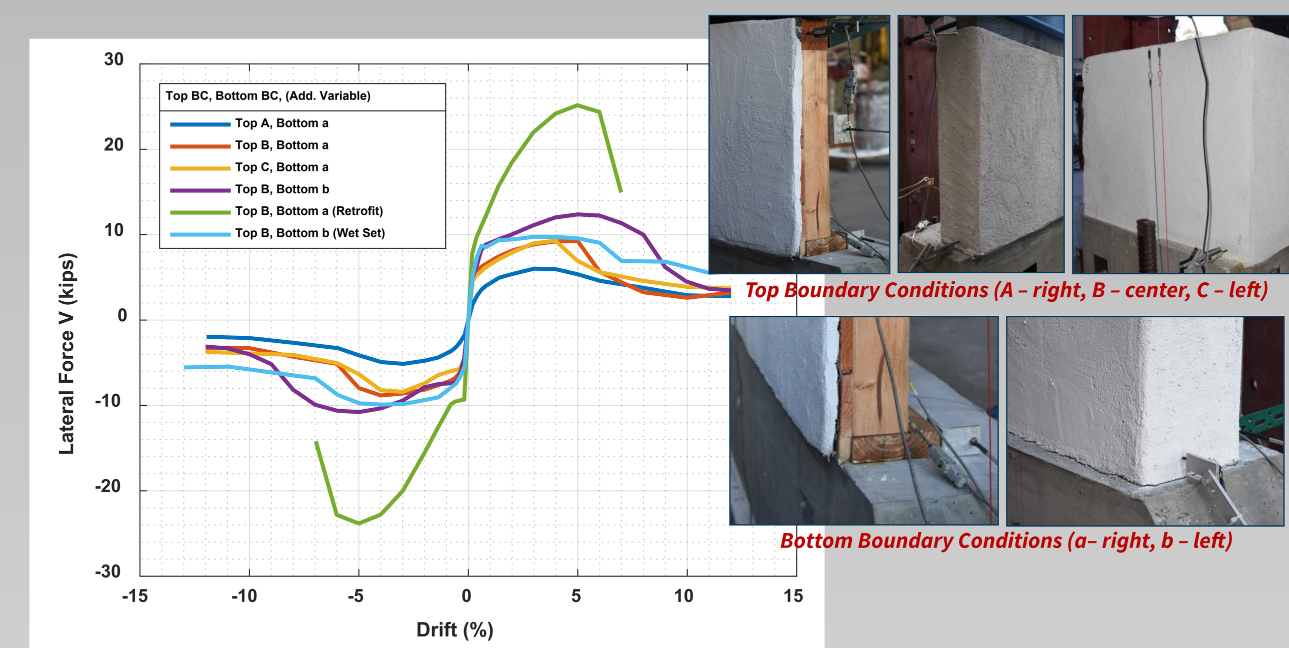
Test variables:



- Construction era
- Cripple wall height
- Retrofit condition
- Boundary conditions
- Sill anchorage condition
- Exterior finish type
- Applied axial load
- Loading protocol

Small component testing was the primary method for capturing load-deflection behavior for use in the Working Group 5 analytical modeling. The size of the specimens permitted a significant number of tests, exploring a range of variables in original construction and retrofit. An example of a resulting hysteresis curve is shown, with behaviors annotated. The full hysteresis is simplified into a backbone curve for subsequent illustrations.

SMALL COMPONENT TESTING - PHASE 1

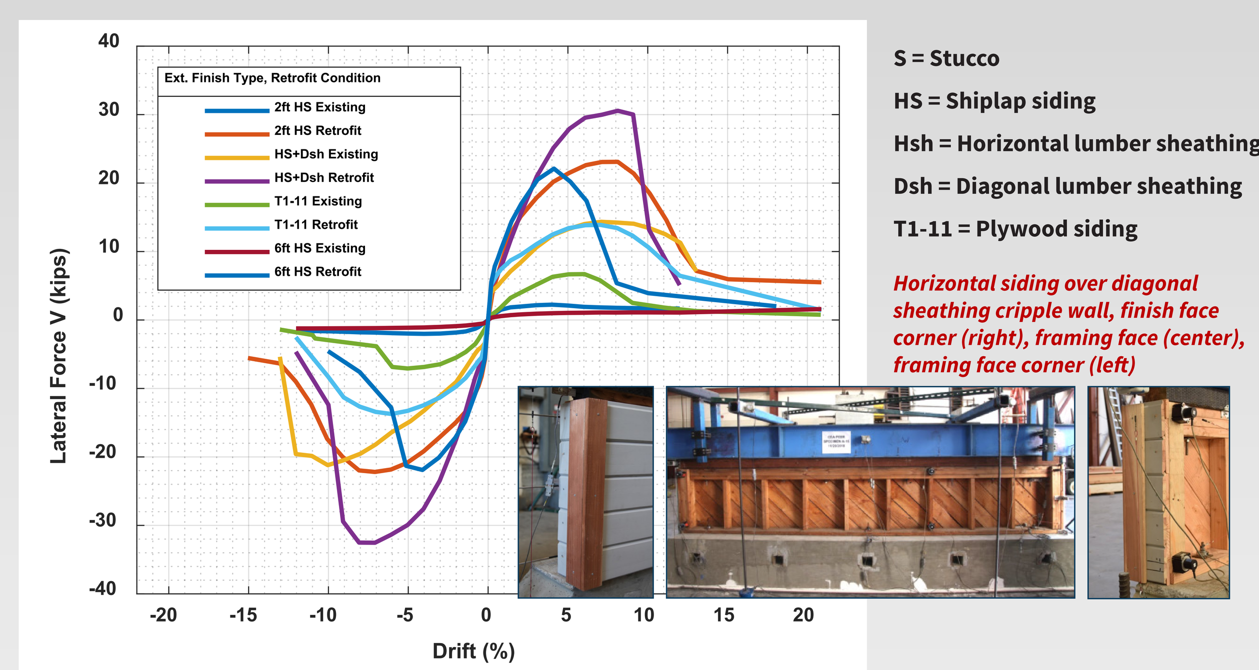


Top Boundary Conditions (A – right, B – center, C – left)

Bottom Boundary Conditions (a– right, b – left)

This figure illustrates load-deflection behavior for five two-foot tall cripple walls without retrofit and one with retrofit. The original bracing material for all was stucco applied over horizontal lumber sheathing. The five tests without retrofit use varying boundary conditions at the top, bottom and sides of the specimen to explore the influence of these conditions. The cripple wall with retrofit is seen to have a significantly higher peak capacity.

SMALL COMPONENT TESTING – PHASE 2

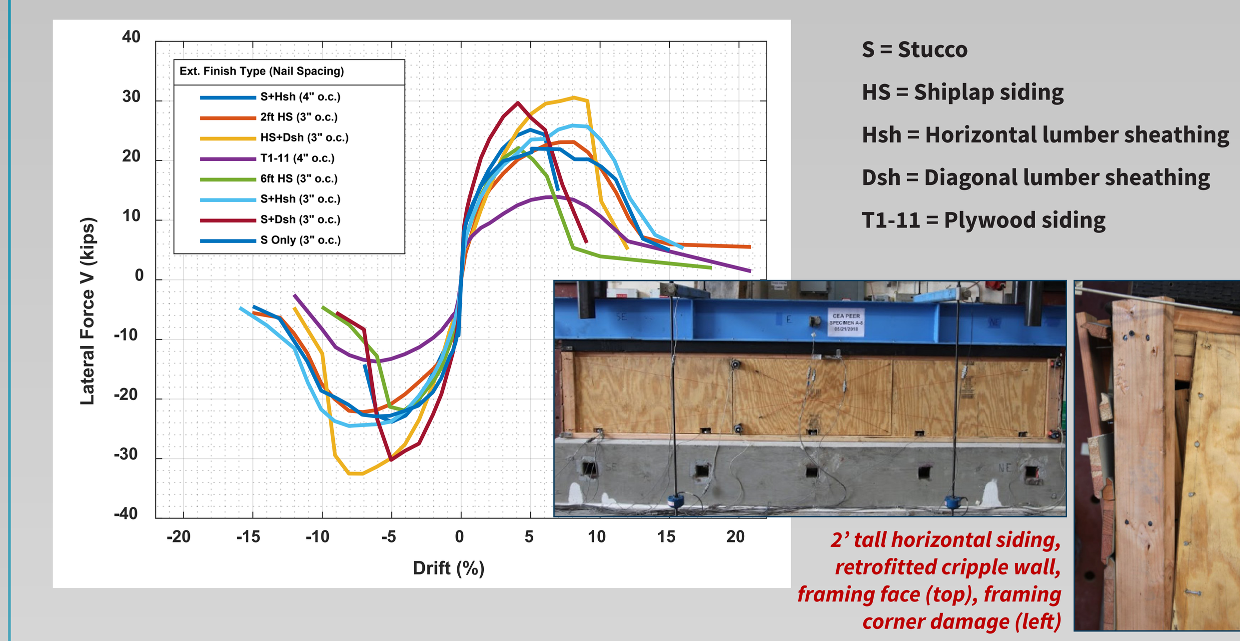


S = Stucco
HS = Shiplap siding
Hsh = Horizontal lumber sheathing
Dsh = Diagonal lumber sheathing
T1-11 = Plywood siding

Horizontal siding over diagonal sheathing cripple wall, finish face corner (right), framing face (center), framing face corner (left)

This figure illustrates load-deflection behavior of cripple walls both with and without retrofit, and having varying original bracing materials and heights. When considered as a group there is a significant overlap between walls with and without retrofit (the highest capacity shown is for a wall without retrofit). This illustrates the complexity of information, and the importance of this information to the Working Group 5 analytical studies.

SMALL COMPONENT TESTING – WITH RETROFIT

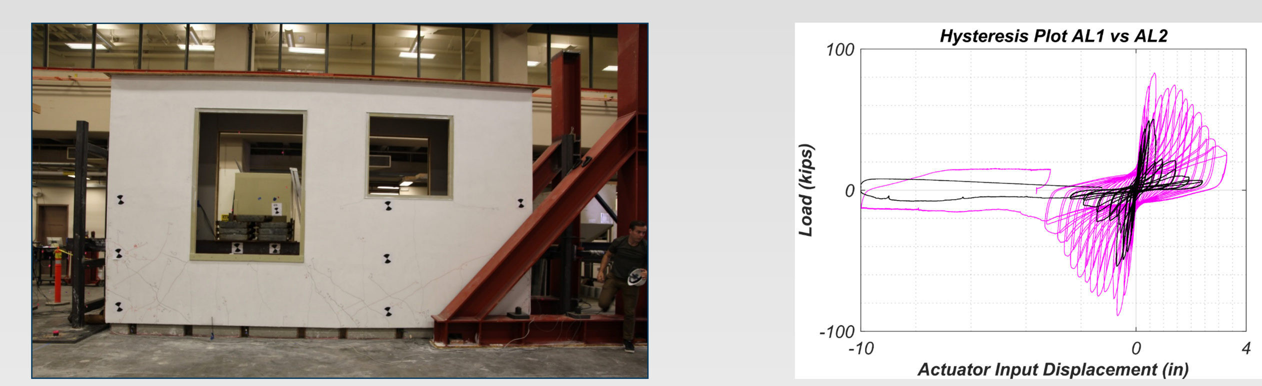


S = Stucco
HS = Shiplap siding
Hsh = Horizontal lumber sheathing
Dsh = Diagonal lumber sheathing
T1-11 = Plywood siding

2' tall horizontal siding, retrofitted cripple wall, framing face (top), framing corner damage (left)

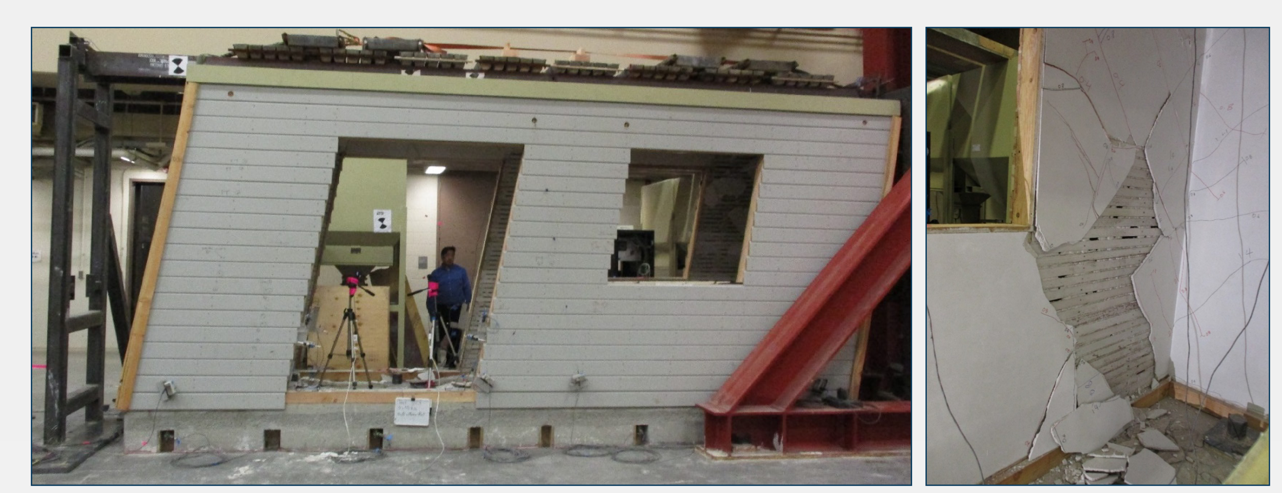
This figure illustrates load-deflection behavior of retrofit cripple walls with varying original bracing materials and cripple wall height. The peak capacities vary widely, indicating that the load deflection behavior is strongly influenced by the original wall materials and height, as well as the retrofit. This again illustrates the complexity of information, and the importance of this information to the Working Group 5 analytical studies.

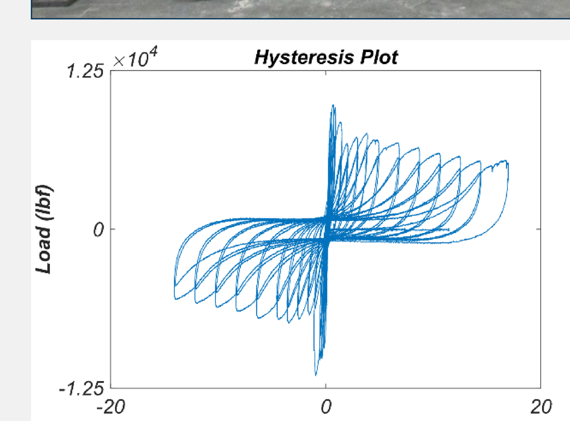
LARGE COMPONENT TESTING – CRIPPLE WALLS



In order to capture the most realistic possible boundary conditions for cripple walls with stucco, cripple walls incorporated into a representative structure were tested both with and without retrofit. The superstructure is four feet by twenty feet in plan, and includes doors and windows on two opposing walls. The comparison of pre-retrofit (black line) and retrofit (magenta) plots shows the significant improvement in capacity and toughness from retrofit.

LARGE COMPONENT TESTING – OCCUPIED STORIES





The testing of an occupied story with plaster on wood lath interior and shiplap exterior siding identified the plaster to contribute significantly to the peak capacity, but also to sustain significant damage at small deflections, leading to a drop in capacity. The remaining capacity continued to large deflections, and is thought to be due to the shiplap siding with some remaining strength contribution from the plaster.

LARGE COMPONENT TESTING – OCCUPIED STORIES

The testing of an occupied story with gypboard interior and plywood panel siding (T1-11) exterior identified the combination of materials to be a good contributor to strength and stiffness. Due to the low weight of the structure and superimposed load, the structure started to experience uplift from overturning forces, which eventually led to the withdrawal of nails to the sill plate, and resulted in failure in sliding, serving as a reminder of this behavior.

LARGE COMPONENT TESTING – LOAD PATH CONNECTIONS

The testing of a cripple wall with shiplap siding and cripple wall retrofit (designed in accordance with FEMA P-1100 prescriptive retrofit provisions) illustrated that load-path connection selected in accordance with this FEMA P-1100 Guideline were capable of developing the full capacity of the siding and retrofit plywood without signs of deterioration to these connections.

ACKNOWLEDGEMENTS

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