Modeling of Light-Frame Unibody Residential Buildings

PEER Internship Program – Summer 2013

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Introduction

In general, light-frame residential buildings have demonstrated to be generally safe and resilient against collapse in the event of a major earthquake. However, the damage afflicted to these structures can result in large economic losses for a region.

To enhance the life cycle of these types of structures, researchers have begun to explore a seismic design method called the unibody approach, which involves strengthening and stiffening partition walls so they too can help a house resist more lateral force. Typically, the contribution of architectural partition walls in light-frame residential buildings is highly penalized or neglected. The unibody approach amends this design flaw by rendering these walls structural through the use of adhesive, anchorages, and holdowns. In addition to fasteners, adhesives possess the ability to strengthen and stiffen the bond between framing elements and sheathing in the construction of light-frame structures.

Structural tests have been performed to understand the hysteretic behavior of light-frame unibody structures; however, very few computer models have been constructed to further this research.

A close up of a collapse-free house in Santa Monica that was none-the-less damaged heavily by the 1994 Northridge Earthquake. *"Northridge Earthquake, California"*. Photograph. 1994. Photograph by FEMA News Photo taken on 01/17/1994 in California. *Federal Emergency Management Agency*. 20 Sept 2013.

Research Objective

This project seeks to develop a simplified hysteretic OPENSEES model for the unibody approach that accounts for the addition of anchorages, holdowns, and adhesive between gypsum wallboard and wood framing elements for light-frame residential buildings. A model is proposed and then compared to the test data of 2 wall specimens and a room specimen.

Model Structure

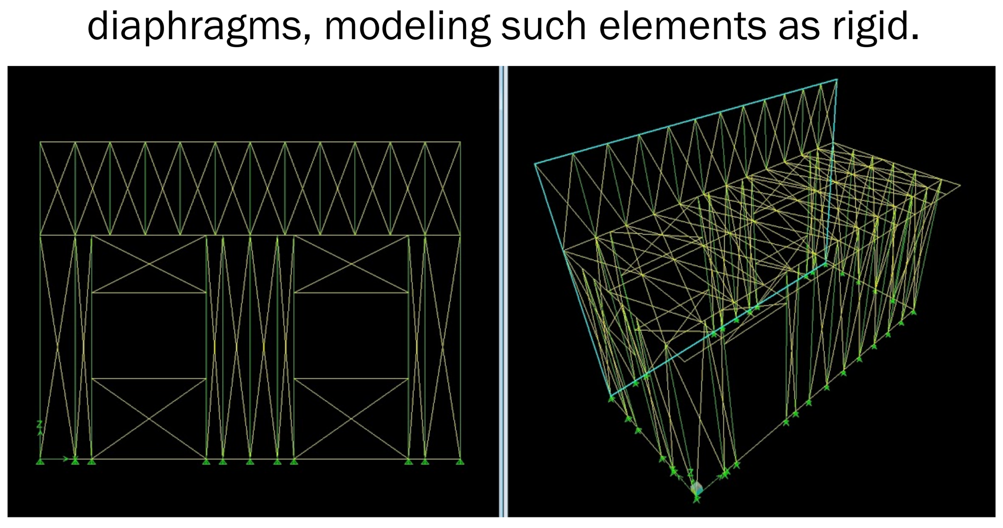
The proposed model incorporates the following key features:

1) it draws on existing experiential and analytical data,

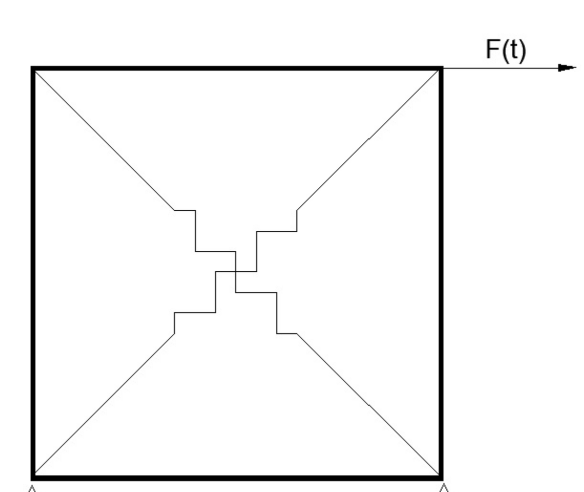
2) it employs diagonal non-linear link elements to represent the fasters' and adhesive's behaviors,

3) it uses the SAWS Material Model to represent mechanical screws' hysteretic behavior and the MODIMKPeakOriented Model for the adhesive, and

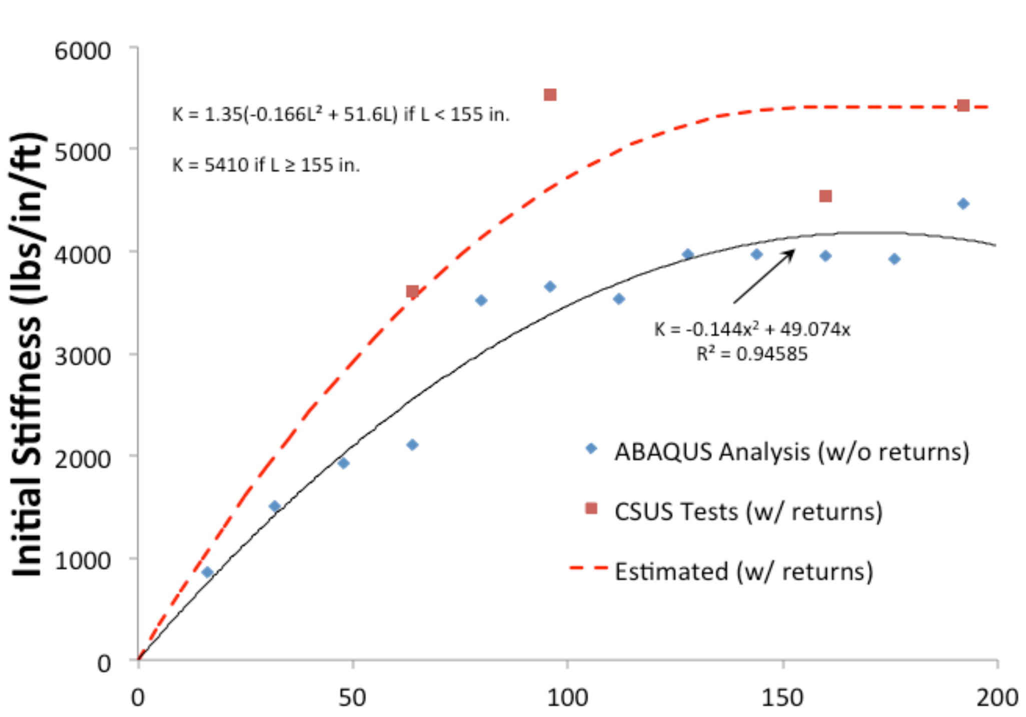
4) it assumes all other components act linearly, i.e. framing elements and roof/floor diaphragms, modeling such elements as rigid.



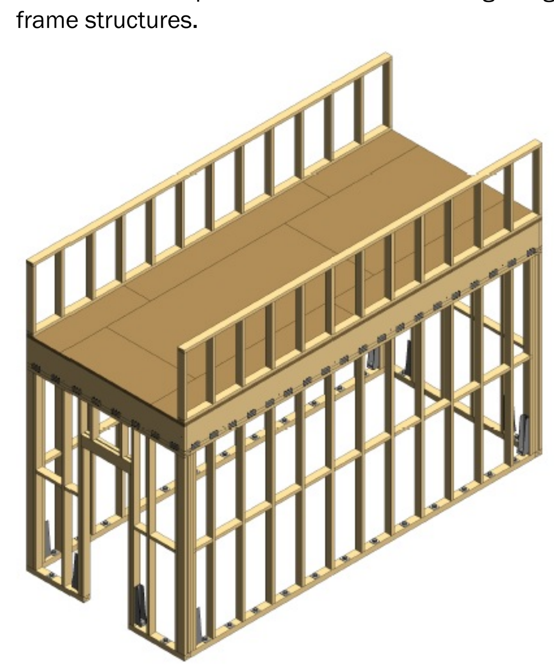
A graphical representation of the model for a room specimen with a wall elevation on the left and a three-dimensional orthographic view on the right



The diagonal hysteretic spring concept: diagonal link elements span between rigid pin-ended truss elements that represent the vertical framing in light-frame structures.



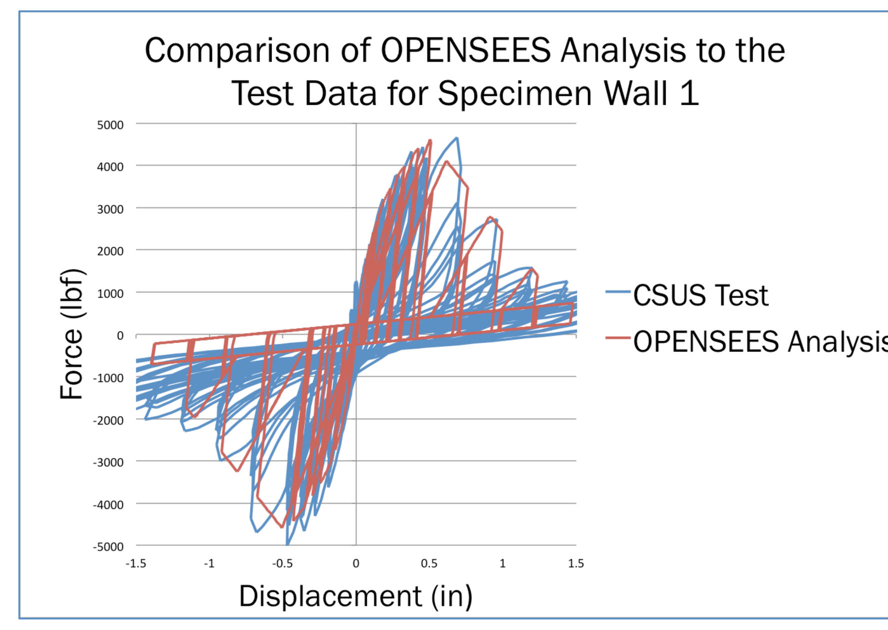
A combination of unibody wall tests performed at CSU Sacramento and detailed finite element ABAQUS simulations led to this relationship between stiffness and aspect ratio of light-frame unibody walls that serves as the basis for the proposed model.

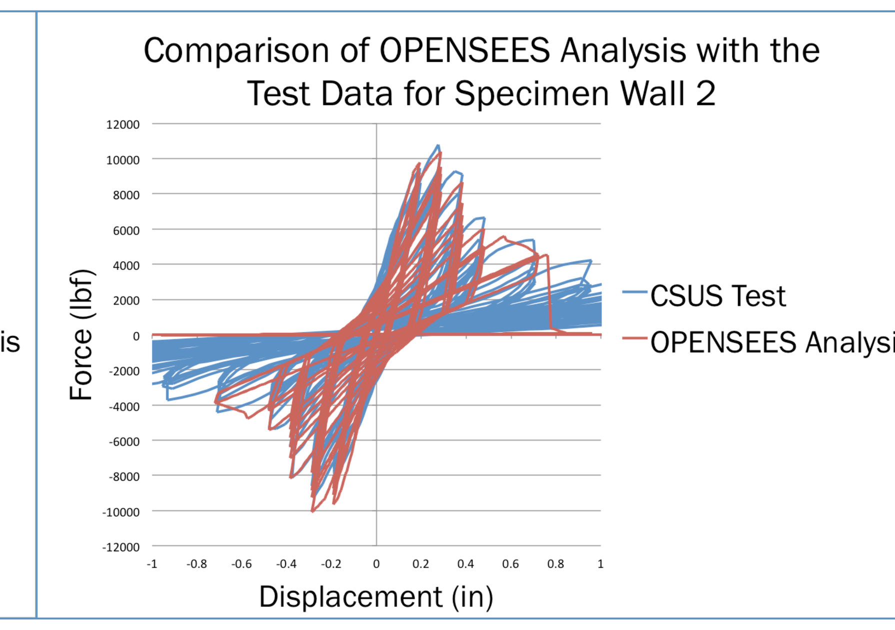


The room specimen used to verify the proposed model.

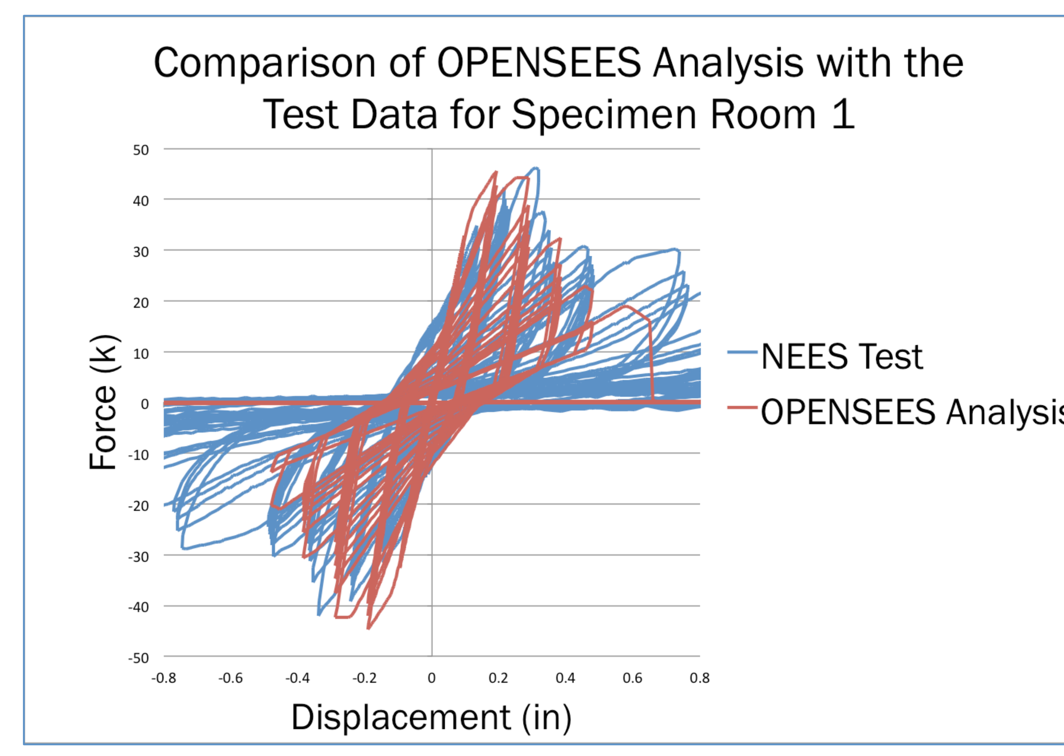
Model Verification

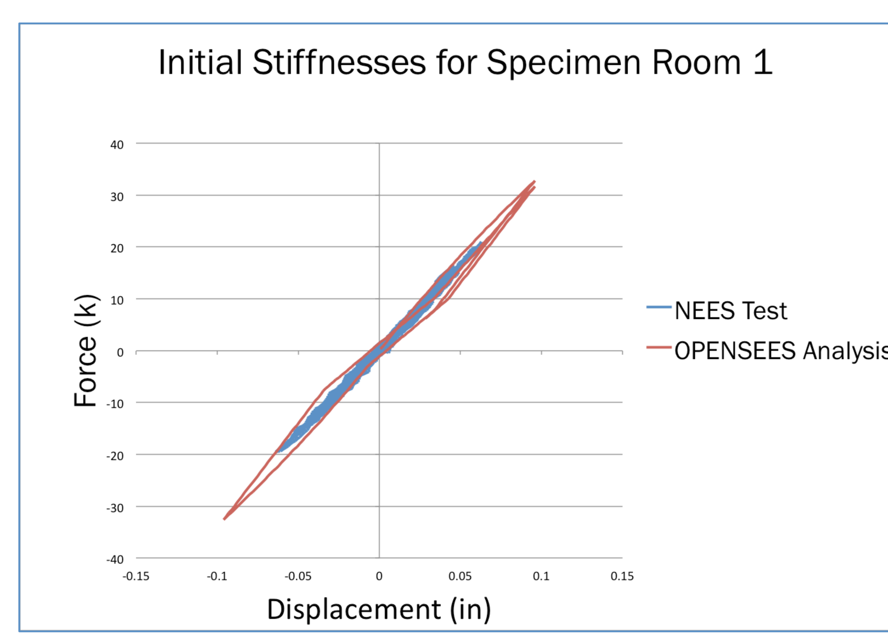
Wall Specimens:

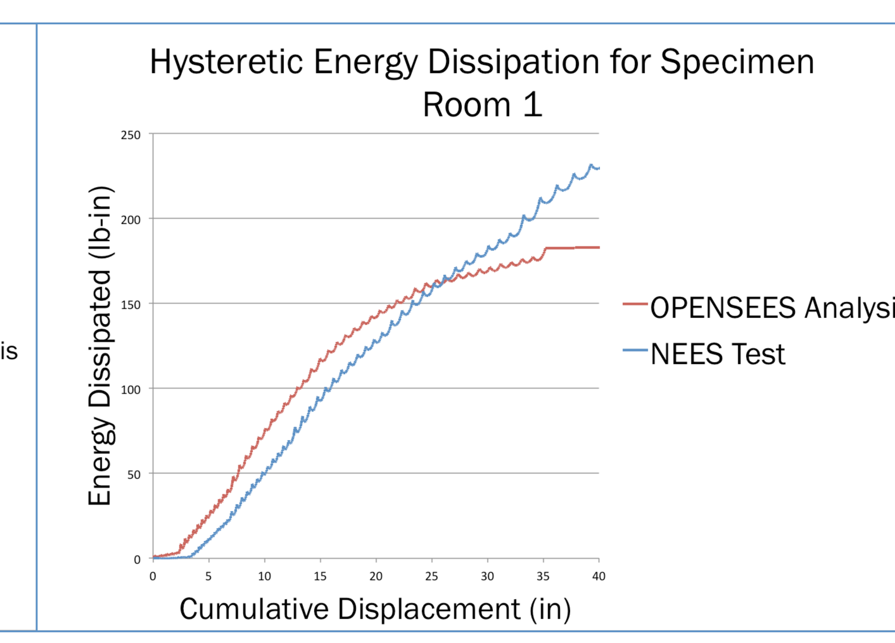




Room Specimen:







Conclusions

1) The proposed model for light-frame unibody residential buildings overall correlates well with the empirical data.

2) In particular, it matches the pinching behavior well.

3) The model performs better at lower levels of displacement, failing to match the data for the tested specimens at large non-linear deformation.

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