LIGHT FRAME UNIBODY RESIDENTIAL STRUCTURES

PEER Internship Program – Summer 2013

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Introduction

Currently, the building code designs for collapse prevention. While the code provides adequate life safety for residential structures, the seismic damages to a home can be overwhelming for home owners.

http://www.baylocalize.org/about/our-mission

1) Lack of resiliency


http://www.riversideca.gov/fire/disasterpreparedness/earthquakes.asp

2) Seismic damage and repairs


http://www.city-data.com/disaster-photos/2268.html

3) Household displacement


http://savemymoney.us/

4) Economic losses

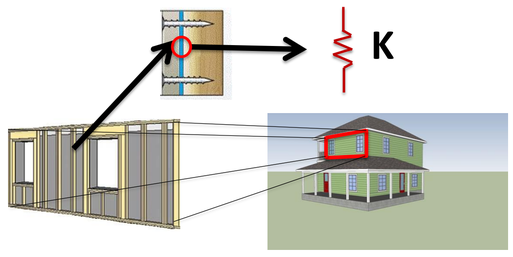
Homes may be rendered uninhabitable due to seismic damages and residual displacements. Repairs may not be an option; therefore, households are displaced. By implementing the light frame unibody system, these factors can be significantly reduced.

Research Purpose

More studies are needed to assess which type and brand of construction adhesive has better performance and cost effectiveness to be implemented in unibody system.

- *Evaluate the bonding properties of six different construction adhesives*

- *Find the stiffness and shear strength of six different construction adhesives*



Light Frame Unibody Background

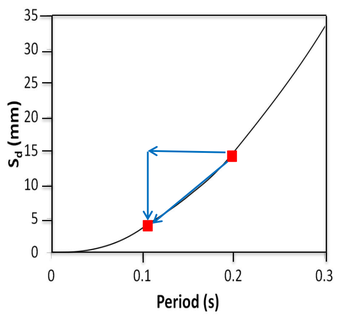
The light frame unibody system incorporates the architectural features with the exterior walls to help resist lateral loading due to wind or earthquake loads. Adhesive is utilized in combination with mechanical fasteners to achieve the unibody system in an inexpensive manner.

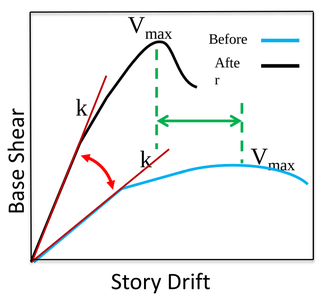
$$T = 2\pi\sqrt{\frac{m}{k}}$$

$k \uparrow \Rightarrow T \downarrow \Rightarrow S_d \downarrow$

Benefits

- *Adhesive + mechanical fasteners increases strength and **stiffness***
- *Period of the home is decreased reducing the displacement and damage*

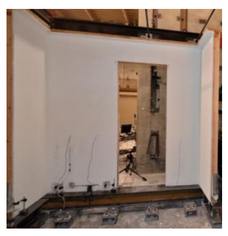




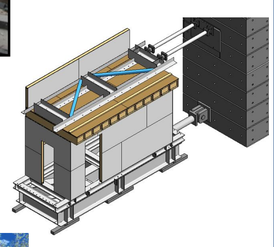
Light Frame Unibody Previous & Current Testing

The overall project is a four phase project.

1. *The first phase consisted of 4'x4' shear walls, which was conducted at Stanford University.*
2. *The second phase consisted of full scale shear walls, which was conducted at California State University, Sacramento.*
3. *The third phase is currently on-going, where four quasi static full scale room test are being conducted at UC Berkeley Richmond Field Station.*
4. *The final phase is a shake table test of a full scale home, which will be conducted in San Diego.*


2.) Full Scale Wood-frame Wall Test Setup


1.) 4ft x 4ft Wall Tests Setup


3.) Room Test Setup


4.) Full Scale Two Story Home

Objectives

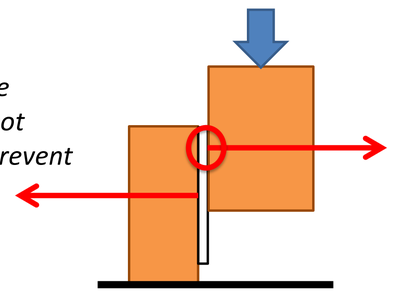
- Investigate the behavior of the adhesive connection between the gypsum and wood stud
- Investigate the possible advantages of some adhesives versus others
- Determine the best overall product for the light frame unibody system
- Create a model representing the results found from testing

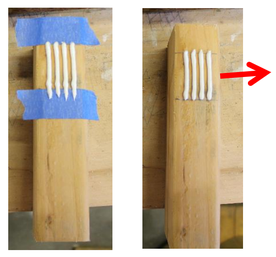
Adhesive Testing

A simple push-through test was designed to investigate the properties of the adhesive.

Setup Description

- *Epoxy was used for the connection that was not being considered to prevent any type of failure*

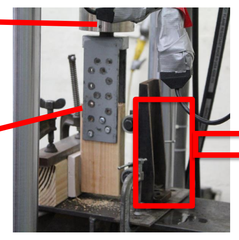

Push Through Test


Area of Adhesive Applied

- *Area of adhesive used was controlled to a 1.5 in x 1.5 in area*

Test Setup

- *A small actuator was used to conduct the push through*
- *A yolk was attached by drilling screws to the displacing 2x4*


Test Setup


Rotation Prevention Device

Results

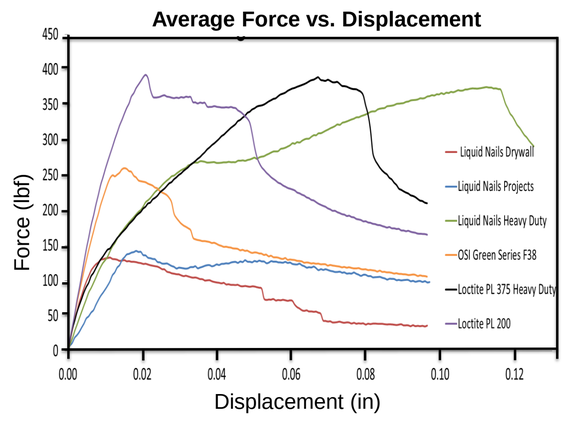
Experimental Test

The test results produced a force versus displacement graph representing the six adhesives tested.

- *The two failure modes consisted of the failure of the paper backing of the gypsum and the failure in the gypsum itself.*

Gypsum Paper Backing Failure

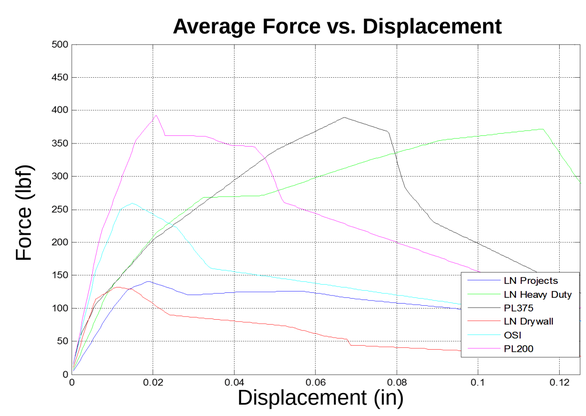
Gypsum Failure



Analytical Model

An analytical model was created with the properties found from the results by use of OPENSEES.

- *The model uses uniaxialMaterialMultiLinear to represent the adhesive connection.*
- *This uniaxial material uses the multiple points of the force versus displacement envelope to create a plot to represent the test results.*



Conclusion

Crucial data was lost with the damaged specimens and due to insufficient and inconsistent data selecting a "best" adhesive is difficult without further testing.

- Two potential best adhesives being Liquid Nails Heavy Duty, and Loctite PL 375 VOC Heavy Duty Construction Adhesive.
- The common failure mode is in the paper backing of the drywall and not the adhesive.
- Further testing must be completed to finalize the decision of the best product and recommendations for future testing are:
  - *Using a mold of the specimen to help create identical specimens*
  - *Using a more efficient attachment method to attach the displacing 2x4 to eliminate the damage which was caused by the drilling procedure*
  - *Edges making contact with the base of test area and the wheels of the instrument should be flat*

The models and test values can be applied to designing the properties of a shear wall if a certain adhesive is implemented in the construction; however, more testing must be completed to achieve higher accurate results.

Aknowledgements

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