

# CHAPTER 1

## 1. Introduction

### 1.1 Background

The majority of residential construction and a significant portion of light commercial and industrial construction has been, and will continue to be light-framed timber construction. Most of this construction utilizes light-timber framing. Innovations have been introduced to improve upon traditional light-framed construction. Structurally Insulated Panels (SIPS) or sandwich panels is one innovation gaining popularity due to energy efficiency and ease of construction. Sandwich panels consist of two facing materials, such as plywood or Oriented Strand Board (OSB), laminated to a core material, such as rigid insulation. These panel systems save the time and effort of constructing a frame to which sheathing is nailed to in a structure, as well as provide superior insulating properties.

Traditional timber construction has proven to be able to resist large lateral loads in high wind and earthquake prone areas mainly due to the lightweight construction and numerous redundancies. Shear walls and diaphragms resist horizontal forces, such as those produced by winds and seismic events. SIPS shear walls resist load in a different manner than traditional light-framed shear walls, therefore, it is important to understand how SIPS perform as shear walls.

Traditionally, the design of timber shear walls is based on values obtained from static, one-directional tests. Shear walls, however, perform differently when subjected to cyclic loads as may be experienced during a seismic event. For this reason, it is important to test shear walls under different loading conditions similar to those expected in service. As part of this investigation, shear walls were tested under both monotonic and cyclic loading to determine how the walls perform. Information obtained from testing will help answer questions of how SIPS perform as a lateral-force resisting element.

## **1.2 Objectives**

The objective of this investigation is to quantify the monotonic and cyclic response of structurally insulated panel shear walls. Data from monotonic and cyclic shear wall tests will be presented and discussed, and will be used to evaluate the adequacy of current design procedures. Performance of SIPS are also compared to that of light-framed shear walls.

## **1.3 Design Codes**

Current design values for shear walls in the codes are based on results obtained from full size, static, one-directional tests performed on shear wall systems. Wind or seismic loads, determined by local building codes, are compared with the design resistance that the shear walls can provide on a unit length basis. Design resistances for shear walls are obtained by dividing the static test capacities by a factor of safety, usually taken as near three. These values are usually found in charts as a function of sheathing thickness and nail spacing. Non-traditional construction options may be tested by the same means as conventional construction and a factor of safety applied to obtain an indication of resistance.

Dynamic or cyclic performance characteristics, such as energy dissipation, should be incorporated into design codes. A designer should consider the performance of shear walls under cyclic loading to get a conservative indication of how the wall will perform under seismic or high wind loading. This is especially true of a new material that has not been shown to perform well under extreme environmental events such as earthquakes. For this reason, it is important to compare the cyclic performance of new building systems to conventional ones.

## **1.4 Application**

This study will allow engineers to obtain allowable shear wall design values for a common type of SIPS wall system. Also, improvements to typical wall construction are suggested and tested. Cyclic performance of the stressed skin panel shear walls is

presented and comparisons made to light-framed construction to allow the engineer to understand how SIPS wall systems perform under dynamic loading when compared to light-framed timber construction.

## **1.5 Thesis Organization**

This thesis is organized in the following manner:

**Chapter 2** - A summary of research conducted to date on timber shear walls including the monotonic and cyclic racking performance of shear walls is provided.

**Chapter 3** - The test apparatus and procedures for monotonic and cyclic testing are discussed. Parameters used to quantify the monotonic and cyclic results are also presented and discussed. Finally, materials used and different wall configurations tested are presented.

**Chapter 4** - The results of the monotonic shear wall tests are presented, and the behavior of the walls under monotonic loading is discussed.

**Chapter 5** - The results of cyclic shear wall tests are presented, and the behavior of the walls under cyclic loading is discussed.

**Chapter 6** - The monotonic and cyclic performance of the shear walls is compared. Strengths and the load-drift behavior of the walls under the different testing procedures are discussed.

**Chapter 7** - The performance of SIPS shear walls is compared to that of light-frame construction under both monotonic and cyclic loading.

**Chapter 8** - The work performed is summarized and the conclusions drawn from the results obtained are presented.

## **1.6 Limitations of Study**

Although four different wall configurations were tested with the number of replicates recommended by ASTM E564, a limited amount of tests were performed. Only two or three specimens were tested for each variable being investigated. Considering the variability present in wood as a material, additional tests may be

beneficial to support these results. Also, only one type of SIPS, from one manufacturer, using drywall screw fasteners was tested. A more thorough investigation could include different types of SIPS and/or different types of fasteners which may be used in construction. The numerical results reported are limited to one brand of SIPS, though the trends observed in this thesis can be applied to other types of SIPS that use a rigid adhesive to attach the facings to the core and use hardened screws and an elastomeric adhesive for connecting separate elements. Due to time, material constraints, and test specifications, walls 8 ft long were tested. As has been done with other shear wall investigations, it may be useful to test long SIPS shear walls, with and without openings, to see if the results correlate with the findings of this thesis.