Chapter 1 – Introduction

1.1 – Description of the Problem

Durability of wood and wood-based composites is a topic of discussion among scientists, engineers, and architects, but this subject has only recently received widespread attention. This is directly related to an increased awareness of material deterioration issues stemming from recent unexpected structure failures. The costs and consequences associated with building collapses are considerable, especially when human lives are involved. Ninety percent of the nearly two million new homes built each year in the United States utilize light-frame wood construction. Unfortunately, homes are not engineered the same as large capital-intensive projects such as office buildings and skyscrapers. Instead, the design and engineering of residential construction relies heavily on prescriptive guidelines (e.g., nail and stud schedules), which give little attention to material deterioration over time. This is disappointing considering that for a majority of the population a house will represent their single largest purchase.

Further emphasizing the importance of degradation prediction, countries throughout the world are strongly considering including durability requirements as part of their certification codes for building materials. Consequently, those manufacturers who cannot maintain the requirements will experience a substantial loss in market share locally and the possibility of exclusion from international markets.

The basis for the existing prescriptive building codes are historical observations and therefore, are not entirely applicable to modern designs without incorporating some uncertainty in estimations of durability and reliability. An integration of material degradation models into traditional prescriptive design rules will provide a more precise approximation of a structure's long-term reliability. An analysis of the mechanisms of wood deterioration is required to build models that can accurately predict the effects of degradation on the performance of wood structures. A seemingly infinite array of factors can cause the weakening of wood-based building materials. Ultimately, climatic conditions, maintenance treatments, and material properties are the general parameters mutually contributing to the deterioration of wood materials. Unfortunately, rules and

design criteria for moisture management within structures are based on theories and often lack sufficient supporting evidence or experimental validation.

Currently, the design of wood connections is based on a yield model, which determines a connection's performance based upon the bearing resistances of the wood members and the fastener, or dowel (AF&PA 1997). The yield model has been validated experimentally and shown to correctly estimate the behavior of laterally-loaded single and double-shear wood connections. Nevertheless, the holistic influence of continuous environmental conditions acting upon a structure is largely unknown and is not included in the yield model. In terms of structural stability, connections, or joints, are one of the most vital elements in a structure and can often limit the overall strength, serviceability, and durability of wood-frame buildings. Evaluating the effects of moisture on wood deterioration processes can provide data useful in developing predictive models for degradation of construction materials.

Furthermore, the capability to accurately predict durability will significantly aid engineers and architects in designing structures with improved service-life and safety. This is especially important if one considers that most people in the United States live in a house, townhouse, or apartment built with wood framing, and almost every geographical region is susceptible to some type of natural disaster (e.g., earthquakes, hurricanes, tornadoes, etc.), which results in unforeseen structural failures.

This thesis discusses an investigation into the variation of the mechanical properties of nailed-connections fabricated using typical materials, exposed to repeated moisture loading and unloading, and then finally, tested to failure. In addition, a comparison of observations and yield model estimations is presented.

1.2 – Objectives

The effect of cyclic moisture infiltration in light-frame wood connections has received limited research attention. Specifically, the connections between wood-based composite materials (OSB, plywood) and solid wood studs are of interest. A comprehensive understanding of connection performance will enhance construction methods and material design; therefore, improving the overall performance and robustness of light-frame structures in the future. The objectives of this project are threefold:

- To measure strength and stiffness performance of cyclic moisture conditioned connections.

- To determine the effect of cyclic moisture exposure on connection performance.

- To evaluate the accuracy of the general dowel equations for estimating yield of connections and to observe post-yield failure modes.

1.3 – Overview

This thesis presents all investigational, experimental, and analytical measures performed as part of this research project.

- Chapter 1, the current section, includes a brief discussion of durability in wood construction, a problem statement, and the objectives.

- Chapter 2 is a literature review of research and publications relating to durability-based design for housing systems, wood durability issues, and wood connection design.

- Chapter 3 describes the experimental design and laboratory procedures involved. Thorough explanations of equipment, specimen fabrication, and descriptions of all tests performed are included.

- Chapter 4 presents comparisons of the performance results received from each test. Statistical analysis procedures are also discussed.

- Chapter 5 reports on the conclusions of this project. In addition, suggestions and remarks are included concerning future wood durability research.

- The appendices contain all supporting data and calculated performance values of each individual specimen tested.