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Probabilistic loss assessment of light-frame wood construction subjected to combined seismic and snow loads

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ABSTRACT

In some areas, e.g., mountainous areas in the western United States, both seismic and snow loads are significant. Limited research has been conducted to investigate the seismic risk of light-frame wood construction in those areas considering the combined loads, particularly the snow accumulation. An object-oriented framework of the risk assessment for light-frame wood construction subjected to combined seismic and snow hazards is proposed in this paper. A typical one-story light-frame wood residential building is selected to demonstrate the proposed framework. Economic losses of the building due to the combined hazards are evaluated using the proposed framework. It is found that in areas with significant snow accumulation, the snow load has significant effects on the seismic risk assessment for light-frame wood construction.

1. Introduction

Light-frame wood construction is widely built in the United States (U.S.). Approximately 90% of residential buildings are light-frame wood construction. In the 1994 Northridge earthquake, 24 fatalities and $20 billion insured losses were claimed due to damage of wood buildings [1]. Snow hazard also threatens life safety and causes economic losses. In January 2006, 65 people died and 170 people were injured in the Katowice Trade Hall roof collapse due to heavy snow loads in Poland [2]. The March 1993 east coast storm in the U.S. caused economic losses of $1.75 billion [3]. In February 2008, the snow hazard in China caused direct economic losses of $7.7 billion [4].

Extensive studies have been performed to investigate the performance of light-frame wood construction subjected to seismic loads. For example, Li and Ellingwood [1] performed fragility analysis to light-frame wood shear walls. van de Lindt and Gupta [5] investigated damage of light-frame wood shear walls due to earthquake. Pei and van de Lindt [6] developed a framework for loss estimation of wood construction subjected to seismic loads. However, limited research has been performed considering combined seismic and snow hazards.

The Bernoulli pulse process (referred to as the Bernoulli model later in this paper) was used to model the snow load. Ellingwood and Rosowsky [7] examined the snow and earthquake load combination for limit state design. In their study, the snow load was simulated using the Bernoulli model. Snow accumulation was modeled by rectangular or triangular load shape. Lee and Rosowsky [8] performed fragility analysis for a light-frame wood building subjected to combined snow and earthquake loads. In those studies, the stochastic characteristic of the snow load was not explicitly considered, which might underestimate the effect of snow accumulation on buildings in areas with heavy snow loads. In addition, the Bernoulli model cannot simulate the snow accumulation, which is a common phenomenon in areas with heavy snow load. In some areas of the Western US, both earthquake and snow hazards are significant for an extended period of time. But limited research has been performed to investigate the seismic risk of light-frame wood construction considering combined earthquake and snow loads. In this study, this topic is investigated and a Filter Poisson Process (FPP) model [9] is used for the snow load simulation.

The snow participation factor used in the load combination (e.g., combination of snow and seismic loads [10]) for seismic structural design has been investigated (e.g., [7]). Recently, fragility analyses [8] were applied to wood construction subjected to combined seismic and snow loads. While some of the above

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