Briefing Paper 3

Seismic Response of Wood-Frame Construction

Part A: How Earthquakes Affect Wood Buildings

Introduction

This Briefing Paper 3, *Seismic Response of Wood-Frame Construction*, consists of three parts that discuss how earthquakes affect wood-framed construction, including specifics regarding their earthquake-resisting elements, and identifies construction features required for good seismic performance. This Part A provides a brief overview of how earthquakes affect wood-frame construction and explains the load path in wood construction. Part B describes diaphragm chords and collector elements, lateral force transfer within diaphragms, and lateral force transfer from diaphragms to shear walls or frames. Part C discusses wood-framed, shear-wall construction including stiffness issues and hold-downs.

Earthquake Performance of Wood-Frame Buildings

Buildings are at rest when an earthquake arrives, and then are suddenly accelerated laterally by horizontal earthquake ground motion (Figure 1). The ground shaking is transferred to the building through its foundation. Although displacements are easier to visualize, it is the acceleration of the foundation being transferred to the entire building structure that causes forces to develop in the building structure as it attempts to resist the movement.

Earthquake ground motions can contain a similar period of vibration to that of the building and resonating motions will increase the resulting forces. Wood buildings are generally low-rise and use resisting systems like plywood shear walls that result in very short fundamental periods of vibration. Shallow earthquakes with particularly strong short-period motions are common in California and can strongly affect wood-frame buildings. This is especially true when a short-period building is close to the epicenter, and is subjected to "near source" ground motions, which are particularly rich in short-period waves (for more information on earthquake ground motions, see Briefing Paper 1, Part A).

Modern wood-frame buildings generally have good earthquake performance, but older construction can exhibit serious deficiencies that have resulted in deaths and serious injuries. Large apartment buildings with parking at ground level have collapsed and killed some of the occupants. Older houses often have a weakness in the cripple wall below the first-floor framing that can cause collapse of the cripple-wall level, or crawl space. While not usually life threatening, such damage can be very expensive to repair. Even newer construction in areas near active faults that were designed prior to enforcement of the 1997 *Uniform Building Code* (UBC) may not perform as well as expected.

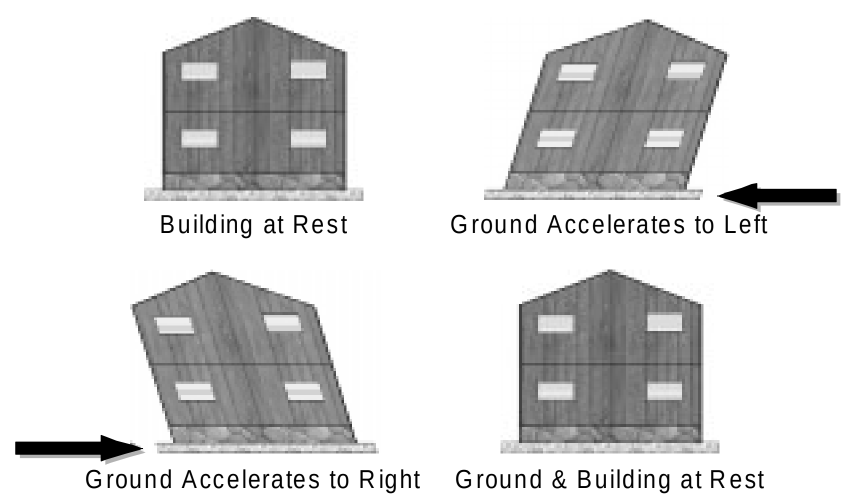

Figure 1. Cyclic response of wood buildings to earthquake motions.

The Load Path in Wood Construction

Horizontal earthquake-resisting forces follow specific horizontal and vertical load paths through the structural elements of a wood building from the roof to the foundation, as shown in Figure 2. Horizontal elements of the building, namely, its roof and floors, are called diaphragms, and they serve to transmit seismic design forces to shear walls or frames acting as lateral-force-resisting elements at each story level. The lateral forces to be resisted are summed sequentially to the lower floors. The largest resisting force, which acts at the lowest level of the building, is known as the base shear.

The diaphragms, shear walls, frames, and foundations are the primary load-path elements in wood buildings, and all these elements must have the necessary strength and stiffness to transmit and resist earthquake forces. The elements must also be properly interconnected to provide a continuous load path, so that forces can reach the foundation. In wood-frame construction, the connections typically use nails or staples, bolts, sheet metal straps, and other steel connecting hardware to link the primary elements together. Many of these connections are specifically and solely dedicated to resisting or transmitting lateral forces and are not used to support vertical loads. For this reason, improper connections along the lateral load path may not be noticed during construction. However, improper connections will result in a weak link whose failure can result in serious damage when the building is subjected to an earthquake.

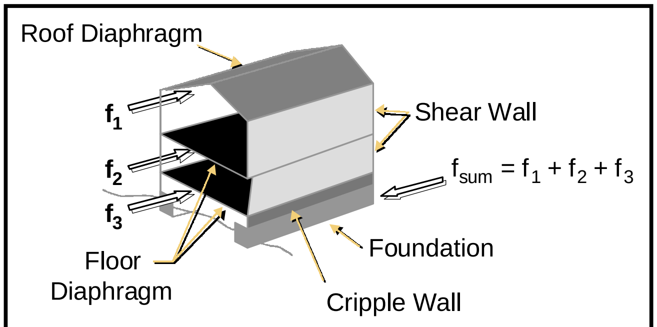

Figure 2. Lateral force load path. Note that horizontal elements resist horizontal forces (represented by double arrows); these forces are then transferred to the vertical elements, such as shear walls and cripple walls.

Resources for Additional Reading

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About this Briefing Paper Series

Briefing papers in this series are concise, easy-to-read summary overviews of important issues and topics that facilitate the improvement of earthquake-resistant building design and construction quality.

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