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Wood-frame construction advantageous in areas prone to seismic activity

By Eric Karsh

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Some 1,400 years ago, tall wood-framed pagodas in Japan were built to 19 stories tall. In spite of the area's high seismic activity – including the 6.8 magnitude Hyogo-ken Nambu earthquake in 1995 that caused widespread damage – these structures still stand today.

The U.S. Geological Survey estimates more than a million earthquakes occur across the world each year. None can be prevented, but sound design and construction can minimize structural damage. Wood-framed structures, such as the pagodas in Japan, perform exceptionally well against lateral forces created by seismic activity. Years of building code development have proven that wood-frame construction meets and in many cases exceeds the most demanding seismic design requirements.

Wood has inherent characteristics that offer advantages over concrete, masonry and steel building designs. As a result, wood can be an ideal material in areas prone to seismic activity.

Light weight
Most earthquake damage is caused by seismic waves that force the ground to move. When the ground motion is strong enough, it causes the building's foundation to shake. Earthquake forces are proportional to a structure's mass, so heavy steel and concrete structures experience greater forces. Wood-frame construction is substantially lighter than other types of construction and has a high strength-to-weight ratio. As a result, properly designed and built wood-frame structures perform well during seismic activity.

Ductility
Wood-frame structures have numerous nailed connections and joints. This provides inherent ductility – much more so than most rigid masonry and concrete systems. Wood-frame buildings can flex, absorbing and dissipating energy when subjected to sudden earthquake forces.

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Redundancy
Similarly, sheathing and finishes attached to wood joists and studs provide redundant load paths for earthquake forces. These numerous small connections and load paths dissipate seismic forces. Should some connections be overloaded or fail, adjacent connections will usually provide alternate load paths and help avoid collapse. This said, systems with poorly designed load paths will be prone to damage or even collapse, regardless of the material used.

Strength and stiffness
An earthquake's lateral forces tend to distort building walls, causing them to rack. Shearwalls in wood construction provide necessary racking resistance. The stiffness and resistance of walls can be augmented in areas prone to strong earthquakes by increasing the thickness of structural panels, stud size, and number or size of nails.

Connectivity
Securely connecting a structure's walls, floors and roof framing make it a single, solid unit, which is critical to withstanding earthquake forces. All structural elements must be anchored to the building's foundation to resist racking, sliding and overturning during an earthquake. Standard connections and tie-downs manufactured for high-load designs make this quite simple.

Seismic design
The key to any seismic design is ensuring good behavior, not sufficient brute strength. This is particularly true for wood-frame structures, which are assigned a high ductility factor. While many wood-frame buildings inherit redundancy and ductility through the multiple load paths afforded by their very architecture, wood frame is increasingly used in wide, open structures such as highly glazed custom homes, schools and commercial buildings. North American timber codes are not particularly clear on this issue, but the principles of capacity design must be applied to the design of wood-frame structures as they would for any other structure.

Wood-frame systems, with solid design and construction, are proven to withstand the effects of powerful earthquakes. Wood's versatility and structural performance offer a range of additional benefits and make it ideal for a number of building types and geographies.

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