RESILIENT AND ADAPTIVE DESIGN USING WOOD

Wrap, Japan. Photography: Masao Nishikawa Photography Studio

FACT SHEET
SUSTAINBILITY

BACKGROUND

Individuals in the design and construction community are increasingly choosing materials, design techniques and construction procedures that improve a structure's ability to withstand and recover from extreme events such as intense rain, snow and wind, hurricanes, earthquakes and wildfire. In addition, buildings are increasingly designed to be more adaptable in order to accommodate future occupancies and user needs. As a result, specifying robust materials and design details, and constructing flexible and easily repairable buildings are becoming important design criteria.

WHAT YOU NEED TO KNOW

Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.[1] For a building, this means being designed to withstand and recover quickly from adverse situations such as flooding and high winds, with an acceptable level of functionality. A structure built to withstand such natural disasters with minimal damage is easier to repair and can contribute to sustainable development – it minimizes human risk, reduces material waste and lowers restoration costs.

Building Codes and Standards

Building codes establish minimum requirements for construction in order to limit the effect of potential hazards. Their goal is to minimize risk to the health and safety of occupants, provide barrier-free accessibility and mitigate excessive use of energy. While building codes and standards support increased performance requirements specific to critical and essential facilities, such as hospitals and fire stations, these requirements are not intended to completely limit damage or ensure the structure is able to continue to function following an extreme event.

Resilience to seismic events

Most wood structures are built using lightweight wood-frame construction and numerous fasteners and connectors which contribute to resisting seismic forces. Properly designed wood-frame buildings that comply with code requirements have been shown to suffer limited damage from seismic events and high winds. The benefits of wood construction were apparent after the 2010 and 2011 earthquakes in Christchurch, New Zealand. One research study found that timber-framed houses generally performed well and exceeded standards.[3] A second study showed that engineered timber structures generally performed well both for safety and serviceability, with most buildings ready for occupation within a short time after the events.[4]

Seismic Performance

In 2007, researchers used a shake table in Miki, Japan, to test the performance of a seven-storey building with floors and walls made of cross-laminated timber. It was subjected to 14 consecutive seismic events and suffered minimal structural damage. Following the test, the structure was disassembled and shipped to Italy where it is now functioning as a student residence.[2]

SOFIE Project - Seismic test on 7-storey CLT building
Photo Credit: Cnr-Ivalsa Trees and Timber Institute of the National Research Council of Italy ©Romano Magrone

Resilience to extreme weather events

As a result of shifting weather patterns due to climate change, there is a growing interest in adaptation and designing for resilience. Higher temperatures can increase the odds of more extreme weather events, including severe heat waves and regional changes in floods, droughts and potential for more severe wildfires. There are more intense and more frequent hurricanes, and precipitation often comes in the form of intense single-day events. Warmer winter temperatures cause water to evaporate in the air and if the temperature is still below freezing, this can lead to unusually heavy snow, sleet or freezing rain, even in years when snowfall is lower than average. [5]

A resilient building is able to deal with changes such as a heavier snow load, wider temperature fluctuations, and more extreme wind and rain. Existing wood buildings can be easily adapted or retrofitted if there is a need for increased wind or snow loading. Wood buildings that are properly designed and constructed perform well in all types of climates, even the wettest. Wood tolerates high humidity, and can absorb and release water vapour without compromising the structural integrity.

A report by the U.S. Federal Emergency Management Agency (FEMA) found that new wood-frame homes built in accordance with jurisdictional regulations performed well during the 2004 hurricane season – including those in areas where wind gusts reached 240 kilometres (150 miles) an hour for three seconds.[6]

Resilience to wildfire

In some regions, climate change is seen to be contributing to increasingly complex wildfire seasons, which results in greater risk of extreme wildfire events. In several Canadian regions where the risk is highest, Canada's FireSmart initiative is working with homeowners and local communities to build communities that are more resilient to wildfires.[7]

It is widely recognized that maintaining a defensible space or a spatial separation between the wildland and a structure is one of the best defenses against risk of fire spread at the wildland-urban interface (WUI). Fuel reduction and fuel modification programs are considered essential to reducing the potential threat of major WUI fires. Sound, effective fire safety and fire prevention practices, including fire safe building standards and codes, are also critical to the prevention of future wildfire-related losses.[8]

Some wildland fire regulations target specific construction features in WUI areas, such as exterior decks, roof coverings, and cladding. A number of wood products meet those regulations for various applications, including heavy timber elements, fire retardant treated wood and some wood species that demonstrate low flame spread ratings (i.e., less than 75).[9]

Adaptability for future uses

Buildings which have the flexibility to change uses over their lifetime will reduce the need to demolish and rebuild new structures. Wood structures lend themselves to be readily adapted due to the ease of workability which results from the lightweight and low density properties of the material, allowing wood building systems to be cut, shaped, removed and reconfigured with ease. Design for adaptability recognizes that the needs of society are constantly changing. A design that allows for easy alterations and renovations can extend the service life and reduce potential environmental impacts and life cycle costs associated with new construction.

FOR MORE INFORMATION

- reThink Wood
- American Wood Council *Resiliency*
- American Institute of Architects/National Institute of Building Sciences *Preparing to Thrive: The Building Industry Statement on Resilience*

[1] American Institute of Architects, National Institute of Building Sciences et al. *Preparing to Thrive: The Building Industry Statement on Resilience.* 2016.
[2] NZ Timber Design Journal. *Japan Kobe Earthquake Shake Table Simulation.*
[3] Morris, Hugh and David Carradine, *Lateral Load Tests of Houses Damaged in the Christchurch New Zealand Earthquakes*, 2014.
[4] Buchanan, Andrew; David Carradine, Justin Jordan, Bulletin of the New Zealand Society for Earthquake Engineering, December 2011*, Performance of Engineered Timber Structures in the Canterbury Earthquakes.*
[5] US Environmental Protection Agency. *Understanding the Link Between Climate Change and Extreme Weather.*
[6] FEMA, *Summary Report on Building Performance. 2004 Hurricane Season*. March 2005. Page 13.
[7] CCFM Canadian Wildland Fire Strategy.
[8] State of California, *Governor's Blue Ribbon Fire Commission*. Pages 13 and 47.
[9] California Department of Forestry and Fire Protection, Office of the State Fire Marshal, Wildland Urban Interface Products.