NEESWood: Development of a Performance-Based Seismic Design Philosophy for Mid-Rise Woodframe Construction

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ABSTRACT

While woodframe structures have historically performed well with regard to life safety in regions of moderate to high seismicity, these types of low-rise structures have sustained significant structural and non-structural damage in recent earthquakes. To date, the height of woodframe construction has been limited to approximately four stories, mainly due to the lack of understanding of the dynamic response of taller (mid-rise) woodframe construction, non-structural limitations such as material fire requirements, and potential damage considerations for non-structural finishes. Current building code requirements for engineered wood construction around the world are not based on a global seismic design philosophy. Rather, wood elements are designed independently of each other without consideration of the influence that their stiffness and strength have on the other structural components of the structural system. Furthermore, load paths in woodframe construction arising during earthquake shaking are not well understood. These factors, rather than economic considerations, have limited the use of wood to low-rise construction and, thereby, have reduced the economical competitiveness of the wood industry in the U.S. and abroad relative to the steel and concrete industry. This project seeks to take on the challenge of developing a seismic design philosophy that will provide the necessary mechanisms to safely increase the height of woodframe structures in active seismic zones of the U.S. as well as mitigating damage to low-rise woodframe structures. This will be accomplished through the development of a new seismic design philosophy that will make mid-rise woodframe construction a reality in regions of moderate to high seismicity. Such a design philosophy falls under the umbrella of the performance-based design paradigm.

In Year 1 of the NEESWood Project, a full-scale seismic benchmark tests of a two-story woodframe townhouse that will require the simultaneous use of the two three-dimensional shake tables at the SUNY- Buffalo NEES node will be performed. As the largest full-scale three-dimensional shake table test ever performed in the U.S., the results of this series of shake table tests on the townhouse will serve as a benchmark for both woodframe performance and nonlinear models for seismic analysis of woodframe structures. These efficient analysis tools will provide a platform upon which to build the performance-based seismic design (PBSD) philosophy. The PBSD methodology will rely on the development of key performance requirements such as limiting inter-story deformations. The method will incorporate the use of economical seismic protection systems such as supplemental dampers and base isolation systems in order to further increase energy dissipation capacity and/or increase the natural period of the woodframe buildings.

The societal impacts of this new PBSD procedure, aimed at increasing the height of woodframe structures equipped with economical seismic protection systems, will also be investigated within the scope of this NEESWood project. Once the PBSD philosophy for mid-rise (and all) woodframe structures has been developed, it will be applied to the seismic design of a mid-rise (five or six-story) multi-family residential woodframe apartment building. This mid-rise woodframe structure will be constructed and tested at full-scale in a series of shake table tests on the E-Defense (Miki) shake table in Japan. The use of the E-Defense shake table, the largest 3-D shake table in the world, is necessary to accommodate the height and payload of the mid-rise building. There will be a general solicitation in the U.S. and in the international earthquake engineering community for payload projects to be conducted during this series of tests, thus maximizing the benefit to cost ratio for the world’s earthquake engineering community. This additional objective of developing collaborative linkages between NEES and Japan’s National Institute for Earth Science and Disaster Prevention (NIED) E-Defense Project will help form the “…global seamless network for earthquake engineering…”.

The **intellectual merit** of NEESWood is the development of a new design philosophy that will provide a logical, economical basis for the design of mid-rise woodframe construction. Numerous contributions to earthquake engineering will result from successful completion of the NEESWood Project.

The **broader impacts** of NEESWood are that it will provide a seminal advancement in seismic design of woodframe construction as well as the full-scale seismic testing of structural systems including dynamic distributed testing between two sites. When this challenge is successfully met, mid-rise woodframe construction will be an economic option in seismic regions around the U.S. and the world.