Seismic Performance of 6-Storey Wood-Frame Buildings: Final Report

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Summary:

spIn this report, the seismic performance of 6-storey wood frame residential buildings is studied. Two building configurations, a typical wood-frame residential building and a building to be tested under the NEESWood project, were studied. For each building configuration, a four-storey building and a six-storey building were designed to the current (pre-April 6, 2009) 2006 BC Building Code (BCBC) and to the anticipated new requirements in the 2010 National Building Code of Canada (NBCC), resulting in four buildings with different designs. The four-storey building designed to the current 2006 BC Building Code served as the benchmark building representing the performance of current permissible structures with common architectural layouts.

In the design of both four-storey and six-storey buildings, it was assumed that the buildings are located in Vancouver on a site with soil class C. Instead of using the code formula, the fundamental natural period of the buildings was determined based on the actual mass and stiffness of wood-based shearwalls. The base shear and inter-storey drift are determined in accordance with Clauses 4.1.8.11.(3)(d)(iii) and 4.1.8.11.(3)(d)(iv) of BCBC, respectively.

Computer programs DRAIN 3-D and SAPWood were used to evaluate the seismic performance of the buildings. A series of 20 different earthquake records, 14 of the crustal type and 6 of the subcrustal type, were provided by the Earthquake Engineering Research Facility of the University of British Columbia and used in the evaluation. The records were chosen to fit the 2005 NBCC mean PSA and PSV spectra for the city of Vancouver.

For representative buildings designed in accordance with 2006 BCBC, seismic performance with and without gypsum wall board (GWB) is studied. For representative buildings designed in accordance with the 2010 NBCC, the seismic performance with GWB is studied. For the NEESWood building redesigned in accordance with 2010 NBCC, seismic performance without GWB is studied. Ignoring the contribution of GWB would result in a conservative estimate of the seismic performance of the building.

In the 2006 BCBC and 2010 NBCC, the inter-storey drift limit is set at 2.5 % of the storey height for the very rare earthquake event (1 in 2475 year return period). Limiting inter-storey drift is a key parameter for meeting the objective of life safety under a seismic event.

For 4-storey and 6-storey representative wood-frame buildings where only wood-based shearwalls are considered, results from both DRAIN-3D and SAPWood show that none of the maximum inter-storey drifts at any storey under any individual earthquake exceed the 2.5% inter-storey drift limit given in the building code. With DRAIN-3D, the average maximum inter-storey drifts are approximately 1.2% and 1.5% for 4-storey and 6-storey buildings designed with 2006 BCBC, respectively.

For the NEESWood wood-frame building, none of the maximum inter-storey drifts at any storey under any individual earthquake exceed the 2.5% inter-storey drift limit for 4-storey building obtained from SAPWood and 6-storey building obtained from DRAIN-3D and SAPWood. For any 4-storey building analysed with DRAIN-3D, approximately half of the earthquakes resulted in the maximum inter-storey drifts greater than 2.5% inter-storey limit. This is partly due to the assumptions used in Drain-3D model in which the lumped mass at each storey is equally distributed to all the nodes of the floor. As a result, the total weight to counteract the uplift force at the ends of a wall would be much smaller than that anticipated in the design, thus causing hold-downs to yield and large uplift deformations to occur.

Based on the analyses of a representative building and a redesigned NEESWood building situated in the city of Vancouver that subjected the structures to 20 earthquake records, 6-storey wood-frame building is expected to show similar or smaller inter-storey drift than a 4-storey wood-frame building, which is currently deemed acceptable under the current building code.
Building construction - Design
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Earthquakes, Effect on building construction

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