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Quantifying the impacts of moisture and load on vertical movement in a simulated bottom floor of a 6-storey platform frame building

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Abstract:

Vertical movement of wood frame buildings has become an important consideration in recent years with the increase of building height in Europe, North America, and Asia up to 6-storeys. This movement is composed of wood shrinkage and load-induced movement including initial settlement and creep. It is extremely difficult to identify the relative contributions of these components while monitoring full size buildings. A laboratory test was therefore designed to do this under controlled environmental and loading conditions. Two identical small-scale platform frame structures with dimensional lumber floor joists were designed and constructed, with built-in vertical movement and moisture content monitoring systems. The two structures were first conditioned in a chamber to achieve an initial moisture content (MC) about 20% to simulate typical MC on exposed construction sites in wintertime in Coastal BC. After the two structures were moved from the conditioning chamber into the laboratory environment, using a unique cantilever system, Structure No. 1 was immediately loaded to measure the combined shrinkage and deformation in the process of drying. Structure No. 2 was not loaded until after the wood had dried to interior equilibrium moisture content to observe the shrinkage and load-induced movement separately. The load applied on the two structures simulated a dead load experienced by the bottom floor of a six-storey wood frame building. The vertical movement and MC changes were monitored over a total period of six months. Meanwhile, shrinkage coefficients were measured by using end-matched lumber samples cut from the plate members of the two structures to predict the shrinkage amounts of the horizontal members of the two structures.

The results suggested that a load must be applied for movement to “show up” and occur in a downward direction. Without loads other than the wood weight, even shrinkage could show as upward movement. Monitoring of Structure No. 1 appeared to separate the contributions of wood shrinkage, initial settlement (bedding-in movement), and creep reasonably well. The entire movement amount reached about 19 mm after six months, which was comparable to the vertical movement measured from the bottom floor of a 4-storey wood-frame building in BC. Shrinkage accounted for over 60% of the vertical movement, with the other 40% contributed by load-induced movement including initial settlement and creep (when elastic compression was neglected); the magnitude of creep was similar to the initial settlement amount. Structure No. 2 showed less vertical movement but an increased settlement amount at the time of loading, indicating the presence of larger gaps between members when the wood was dry (with an estimated MC of 11%) before loading. Depending on construction sequencing, such settlement should occur with increase in loads during construction and can therefore be ignored in design. However, this test suggested that there may be a need to consider the impact of creep, in wet climates in particular, in addition to wood shrinkage.

This laboratory test will be maintained for a longer period to observe any further vertical movement and the relative contributions of shrinkage and creep. Similar tests should be conducted for structures built with engineered wood floor joists, given the fact that most mid-rise platform buildings use engineered wood floor joists instead of lumber joists.

Documents