A New Tool for Assessing the Fire Resistance of Wall Assemblies

To obtain a satisfactory level of safety, buildings must comply with various requirements, including those dealing with the fire resistance of wall and floor assemblies used to form separations between dwelling units in multi-family residential applications. Adequate fire resistance lowers the risk for building occupants and minimizes the property damage.

The adequacy of fire resistance can be assessed using engineering calculations, which are becoming increasingly important as research tools in the area of fire protection because they can help reduce the high costs and time required for testing, and provide engineers and industries with a better insight into the performance of assemblies in fire tests. This is particularly so in cases where the results of standard fire tests are not available, and when non-typical specimen sizes, loading conditions and fire scenarios must be considered.

Dr. Benichou, in collaboration with Forintek Canada Corp., spearheaded and completed an innovative research project on the development of a fire resistance model for lightweight assemblies. In the project, Dr. Benichou produced an innovative new numerical model to predict the fire-resistance behaviour of lightweight wood-stud wall assemblies subjected to fire. The model can provide an alternative to costly fire-resistance testing and can be used for risk assessment. The numerical model is used to trace the complex thermal and structural interactions in a given wall assembly exposed to fire, by coupling two models—a thermal response model and a structural response model.

The thermal response model determines the time it takes for the wall to fail thermally, the temperature distribution across the wall, the rate of advance of the char layer into the wood and the joint openings while taking into account various material properties.

To determine the structural response, a critical elastic buckling-load model is used in conjunction with the thermal response model. This model calculates the degradation of the thermo-mechanical properties of wood, the reduction in the cross-section of the studs, the critical elastic buckling-load of the stud and the time it takes the wall assembly to fail structurally. The fire-resistance model was validated against a number of full-scale fire-resistance tests conducted at NRC and showed very good predictions. The model and its prediction results have been published in leading international peer-reviewed papers, providing comprehensive information on fire resistance modelling of wall assemblies in the open literature and gaining international recognition among peers and industries

The integrated fire-resistance model for lightweight wood-frame wall assemblies has shown itself to be suitable for assessing the time it takes load-bearing wood-frame wall assemblies to fail, using both thermal and structural failure criteria. The model is being used to plan experimental programs and to develop fire resistance design guidelines.

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Figure 1 shows a wall after it has been exposed to a standard fire. The model is based on observed behaviour from experimental data as shown in Figure 1.

Figure 1. A Wood-Stud Wall Buckles during a Fire Test

Typical performance of a wood-stud assembly is shown in Figure 2 below, which illustrates the critical elastic buckling-load relative to time as predicted by the structural response model. The intersection of the horizontal line with the elastic buckling-curve represents the theoretical time it takes for the wall to fail structurally for a particular applied load.

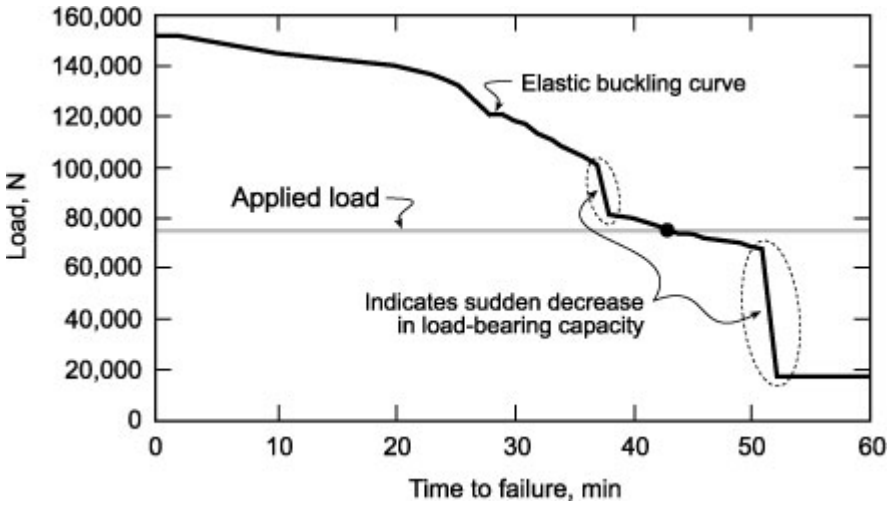

Figure 2. Typical Fire-Resistance Performance of a Wood-Stud Assembly as Predicted by Structural Response Model