Steven Thomas Craft

Thesis

CUWoodFrame—a heat and mass transfer model for light-frame wood floors exposed to fire

Abstract

As performance-based techniques become increasingly accepted in the design of fire-safe buildings, the ability to predict the response of light-frame wood assemblies exposed to realistic fire scenarios is needed. This work is part of a larger project at Carleton University to develop a model to predict the risk from fire to occupants and property in multi-storey non-residential buildings of light-frame wood construction.

A two-dimensional finite-element model called CUWoodFrame has been developed to simulate the heat and mass transfer in both gypsum board and wood in order to predict the thermal response of a wood-frame floor assembly exposed to fire. The mass transfer analysis considers water vapour in gypsum board and both water vapour and volatile pyrolysis products in wood. Calcination of gypsum board and pyrolysis of wood are predicted using Arrhenius expressions. The evaporation of water is modelled assuming the partial pressure of water vapour is equal to the equilibrium vapour pressure.

Comparisons are made to tests conducted using the cone calorimeter, and intermediate-scale and full-scale fire-resistance furnaces. Tests completed using the cone entailed exposing a sample consisting of two layers of gypsum board protecting a layer of wood to three different heat fluxes. The tests completed using the fire-resistance furnaces were carried out using two different exposures. One test in each furnace was conducted using the standard temperature-time curve, while the other was subjected to an alternative exposure.

Comparisons between experiment and model predictions show good agreement when comparing temperatures behind each layer of gypsum board. When modelling an assembly, cavity temperatures are under-predicted resulting in an under-prediction of the temperatures in the floor joist since the heat transfer to the joist is predominantly from the cavity.

A sensitivity analysis has been conducted to study the variability in the predictions of the model caused by uncertainties in the thermal and physical properties of gypsum board and wood. Within the analysis, each parameter was varied based on the variability reported in the literature. Results indicate the variability used in the sensitivity analysis for thermal conductivity of gypsum board has the greatest impact on the time until the wood begins to char.

Degree

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Completion

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Supervisors

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