NEWBuildS

Technical Note 4

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FIRE LOADS AND DESIGN FIRES FOR MID-RISE BUILDINGS

KEYWORDS: Fire load, Design fire, Mid-rise wood building

OVERVIEW OF PROJECT

The introduction of the objective-based codes paved the way for the ultimate implementation of performance-based design approach for fire resistance design. In spite of this change, there are still restrictions on building area and height for some types of building occupancies as well as restrictive fire resistance requirements among other things. To implement performance-based design, it is necessary to show that the proposed solutions meet the minimum performance requirements of the acceptable solutions defined in the code. Design fires, the characteristics of which depend on the type, amount, and arrangement of fire loads and ventilation, are used in evaluating fire protection designs. It is necessary to perform fire load surveys to determine the fire load density, types, and distribution of combustible materials and building characteristics that can realistically be expected in mid-rise buildings. The main objectives of this research are:

- To develop fuel packages and fire loads for residential and non-residential mid-rise buildings;
- To determine the fire characteristics of these selected fuel packages, such as heat release rate, and production of toxic gases;
- To develop design fires for mid-rise wood buildings.

The objectives of this research were achieved through: (1) a thorough review of available literature on mid-rise buildings built with both combustible and non-combustible construction, fire load surveys and fire loads, fire scenarios and design fires, statistical data on fires in residential and office buildings; and (2) fire simulations using the fire risk analysis model, CUrisk. The literature review provided valuable information and data about fire loads for mid-rise buildings which helped with the development of fuel packages for the same. The fire load data in conjunction with statistical data was used to select fire scenarios from which design fire scenarios were chosen. The fire loads and information from fire statistics was then used as input to perform simulations using the two-zone fire risk analysis model, CUrisk, in order to determine the characteristics of design fires for a mid-rise wood building.

KEY RESULTS

A survey for mid-rise buildings was not conducted for this research due to challenges such as the time consuming nature of such surveys. Research has shown that no definite relationship between the fire load and building height. The results of fire load density data compiled from various authors for residential buildings are presented in Table 1. The fire load densities for offices were found to depend on the use of the space. The mean fire load densities found for rooms in office buildings by various authors ranged from 348 MJ/m^2 to 1321 MJ/m^2. The peak fire load densities ranged from 1340 MJ/m^2 to 9681 MJ/m^2. The literature review showed that most of the available surveys have usually focused on particular occupancies and not necessarily on buildings of particular heights. Data available from surveys already conducted was used to develop fire loads for mid-rise wood buildings. Based on the fire load surveys and fire statistics, fuel packages were established and design fire scenarios selected. Simulations were performed using CUrisk, a fire risk analysis computer model software. The modelling involved a six-storey building with six apartments per floor. Design fires were established

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for living rooms, bedrooms, and kitchens according to the results that were obtained from the simulation. The results show that closed doors delay, if not prevent smoke spread from the compartment of fire origin allowing occupants in other areas of the building time to evacuate.

Table 1: Summary of fire load densities for residential buildings

	Fire Load Density (MJ/m^2)		
	Mean	95th Percentile	Maximum
All residential buildings	370 - 550 (per room)	-	-
Living room	288 - 600	450 - 790	633 - 1700
Bedroom	534 - 944	712 - 846	738 - 1000
Dining room	393	576	901
Kitchens	807	940	1244

The modelling exercise generated heat release rate (HRR) curves, temperature profiles, and gas production curves for the case study building. Figures 1 and 2 show the proposed design HRR curve for kitchen and living room respectively. The peak HRR observed for the kitchen is much lower due to the absence of windows in this compartment.

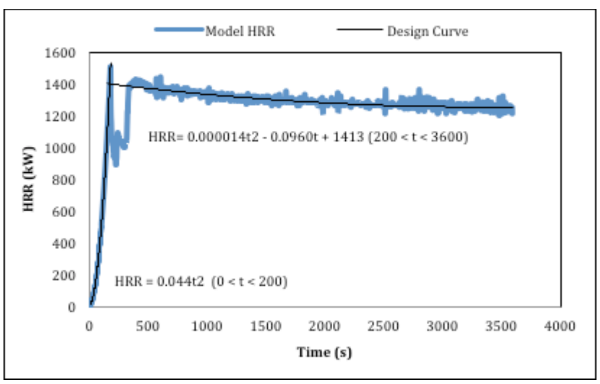

Figure 1- Design HRR curve for kitchen.

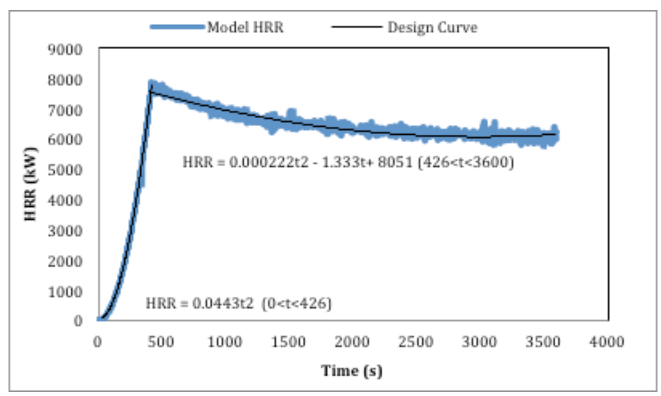

Figure 2 – Design HRR curve for living room.

The temperatures observed in the various rooms of fire origin go up to 1,360°C. Temperatures of up to 830°C were observed in rooms adjacent to the room of fire origin. The smoke layer in the room of fire origin, as well as, in adjacent rooms drops quickly as the fire progresses. The smoke is contained in the apartment of fire origin in the scenarios where main apartment doors are closed while it spreads to the corridor, to other apartments, and other floors in the instances where the main doors are open. The rise of smoke in a particular room causes the increase of carbon dioxide, carbon monoxide, and soot and the drop in oxygen levels. A drop in oxygen levels is also observed due to the presence of smoke. A more detailed presentation of the results of the CUrisk simulation is available in the thesis.

THESIS

Ocran, N. 2012. Fire loads and design fires for mid-rise buildings. MASc thesis. Carleton University, Ottawa, ON.