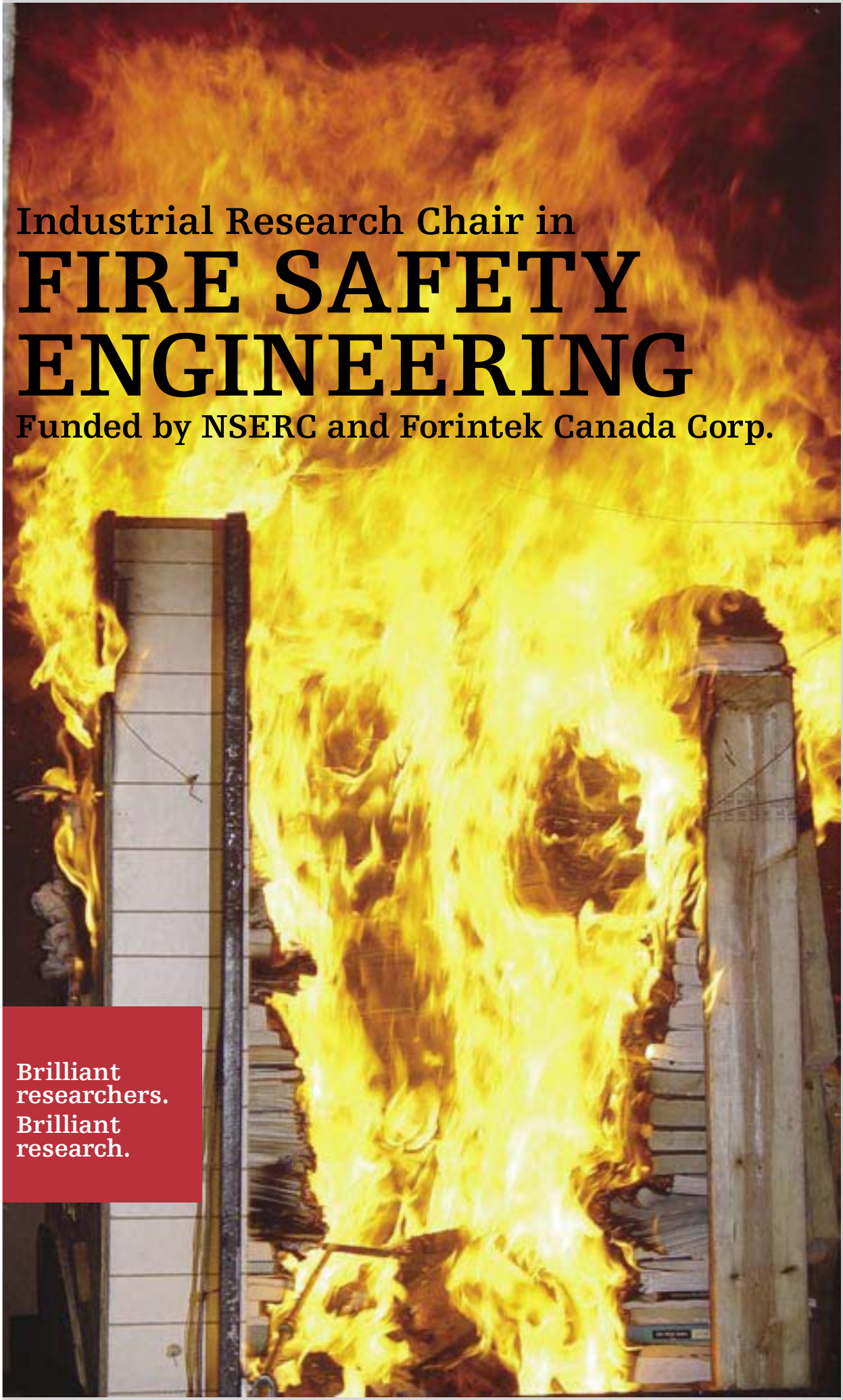
Industrial Research Chair in

FIRE SAFETY ENGINEERING

Funded by NSERC and Forintek Canada Corp.



Carleton UNIVERSITY
Canada's Capital University

Brilliant researchers.
Brilliant research.

Industrial Research Chair in Fire Safety Engineering

An Industrial Research Chair in Fire Safety Engineering was established in 2001 at Carleton with financial support provided by Forintek Canada Corp. and the Natural Sciences and Engineering Research Council (NSERC). In his first five-year term as the Chair, Professor **George Hadjisophocleous** (left) initiated a research program focusing on the development of computer models to predict the fire safety performance of light-frame wood buildings. As well as carrying out the research program, the Chair has led efforts to develop a graduate program in Fire Safety Engineering at Carleton University. This will be the first program in Canada offering opportunities for post-graduate education in Fire Safety Engineering.

Carleton University's (grey) and NRC's (brown) Fire Research Facilities.

Objectives

- Provide the scientific basis on which tools can be developed to cost-effectively deliver fire-safe, light-frame wood buildings under performance-based codes.
- Train highly skilled individuals. Serve as the hub of a network of educational centres on fire safety throughout Canada.

The Chair has just completed the last year of his initial five-year term, and with achievements clearly beyond expectations, it has been renewed for a second term.

Accomplishments during First Term

The Chair has made significant accomplishments during the first term in both research and educational areas. The Chair, with the support from Forintek and National Research Council (NRC) has established a graduate level program in fire safety engineering which consists of six graduate level courses covering all main areas of fire safety.

A number of research projects have been completed including the development of a fire risk model, development of design fires, and models to predict the performance of timber-frame floors.

- **Fire risk analysis model**
  A computer model, CUrisk, for fire risk analysis of commercial buildings has been developed that can be used to evaluate safety levels in these buildings. The model consists of a number of submodels dealing with various aspects of fire, such as fire development and spread; smoke movement; occupant evacuation; economic impact of fires and life safety.
- **Design fires for commercial buildings**
  A survey of fire loads in buildings was performed to determine fire loads and types of combustibles in commercial premises. Based on the analysis of the survey data, fuel packages representing fire loads and types of combustibles in these buildings have been designed and used to conduct full-scale experiments. The experiments provided details on the burning characteristics of the fuel packages including the heat release rate and production of toxic gases. The experimental data were used to generate input data for fire growth and smoke movement models. The computer model Fire Dynamics Simulator was used to simulate the experiments and also fires in actual stores. Design fires were developed and these will be an important input for the design of the fire protection systems in commercial buildings.

- **Fall-off of gypsum boards during FRR tests**
  The behaviour of gypsum boards in intermediate and full-scale fire resistance tests was studied using standard and non-standard exposures. The study investigated the fall-off time of the gypsum board for different floor assemblies and developed criteria for predicting the time to fall-off of gypsum board panels. Data on the fall-off of gypsum board under various design characteristics is an important piece of information needed for the development of models to predict the behaviour of floors when exposed to fires.
- **Analysis of data from full-scale fire tests in Kemano, B.C.**
  The physical layout of the houses and knowledge of the contents were used as input to simulate the Kemano fires in furnished houses using the Carleton University smoke model. Comparison of the experimental results and computer predictions show that the computer model accurately simulates the development of fires in such buildings.
- **Modelling heat and mass transfer of timber frame floors exposed to fire**
  A computer model is being developed to predict the thermal performance of timber frame floors exposed to a fire attack. The model considers both heat and mass transfer as a result of the fire as well the calcination of the gypsum board, and pyrolysis of the wood joists. The main output is the temperature profile in a floor assembly as a function of time.
- **Modelling structural performance of timber frame floors exposed to fire**
  A computer model using a finite element method has been developed to predict the structural performance of a timber-frame floor assembly when exposed to a fire. For this calculation the model uses the temperature predictions of the thermal model. The results of this model compare very well with data from full-scale experiments.

Experiment on design fires for buildings.

Facilities

With support from the Canada Foundation for Innovation, the Ontario Innovation Trust and in-kind contributions from a number of partners such as NRC, the Toronto Transit Commission and Ottawa Fire Services, a $10 million facility has been constructed that includes a 10-storey atrium, a 37m tunnel and a 25 x 25m burn-hall. In addition, this funding supported the development of a fire laboratory on the University campus that contains a number of laboratory-scale, state-of-the-art fire research apparatuses. With these research facilities, Carleton University has become one of the best-equipped universities in the world and has placed itself in the position to undertake challenging, small- and large-scale fire research projects.

New term program

With contributions to the Chair from NSERC, Forintek, the National Research Council and Carleton, the Chair has been renewed for a second 5-year term. (Forintek and industry, $500,000; Carleton University, $500,000; NSERC, $500,000; NRC, in-kind, $200,000).

The 5-year research program for the Chair's second term (2006 to 2011) includes a number of projects of interest to the wood industry:

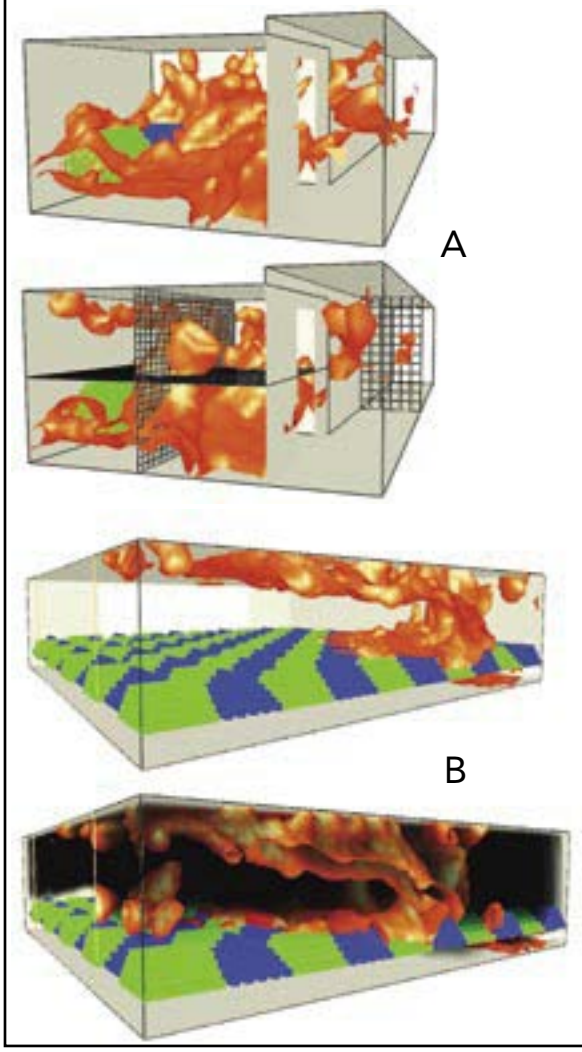
- **Development of additional design fires**
  Conduct a survey of fire loads and combustible materials in motels and hotels, small warehouses, offices with large open spaces, and educational facilities to develop design fires for these occupancies that can be used in engineered fire protection designs.
- **Development of fire spread model**
  Calculate probability of fire spread from compartment of fire origin to other locations in a building, considering spread through openings, concealed spaces and spread via window plumes.
- **Validation of models**
  Conduct experiments to obtain data to validate the fire development and smoke movement models in the NRC's 10-storey tower and housing facility.

- **Modelling spatial separations**
  Perform experiments and modelling of fire spread from building to building and investigate the impact of design fires and sprinklers on required spatial separation.
- **Use CUrisk for real building designs**
  Apply the CUrisk model for undertaking fire risk analyses of real buildings through collaboration with architects and designers.
- **Thermal and structural models for floor assemblies**
  Develop an integrated thermal and structural model to predict the performance of floor assemblies exposed to a fire attack representative of realistic fire scenarios involving either fully developed or localised fires.
- **Heavy timber connections**
  Perform experiments to study the behaviour of heavy timber connections at elevated temperatures using a medium-scale furnace.

Education and impact on industry

- **Six graduate level courses in fire safety engineering are being offered:**
  Introduction to fire safety engineering; Fire dynamics I; Fire dynamics II; Fire resistance; Fire modelling; and People in fires.
- **Students in program (2005-2006)**
  5 PhD students
  7 full-time master's students
  8 part-time master's students
- **Graduates of program**
  - 4 students graduated in 2004-2005
  - 4 students graduating in the spring of 2006

  All program graduates found jobs in the industry filling the need in Canada for highly qualified people in fire safety. Two graduates are employed by fire protection consulting firms, one by the Atomic Energy of Canada and two by Saudi Aramco.



Computer modelling of design fires:
A) experimental setup
B) real size store.

- **Short courses**
  The Chair initiated and organised three day short courses aimed at fire safety professionals as follows:
  1. Introduction to fire safety, May 2003
  2. Engineering fire safety systems, May 2004
  3. Fire and explosion investigations, May 2005
  4. Fire hazard and risk analysis, May 2006

  These courses have been very successful and have attracted participants from across Canada.

Full-scale fire tests used to validate CUrisk model.

Benefits to wood industry

The establishment and activities of the Research Chair in Fire Safety Engineering at Carleton University has benefited the wood industry in a number of areas as follows:

- **Foster market access to non-residential markets at home and abroad**
  - Design tools (fire-risk model and sub-models) to deliver cost-effective, fire-safe, wood-frame commercial buildings under performance-based codes.
  - Opportunities for Canadians to export wood-based building products and construction technologies.
- **Expand fire research capabilities of Canadian wood products industry**
  - Collaboration with Chair and his students.
  - Leveraged research dollars.
  - New fire research facility (funded by other organisations) will provide less expensive alternative for small-, medium- and full-scale fire experiments.
- **Promote performance-based design in Canada and abroad**
  - Prescriptive requirements often biased against the use of wood.
  - Performance-based requirements level the playing field. If performance can be met, wood products can be used.
- **Train highly-skilled individuals to design (or approve) fire-safe wood-frame buildings**
  - Graduate program in Fire Safety Engineering at Carleton University is the only program in Canada.
  - Short course for practitioners.
- **Lend credence to wood-industry's fire-safety research findings**
  - Research published jointly with independent research bodies such as Carleton University and NRC, carries an air of authority not easily conveyed if Forintek published results alone (especially in foreign markets).

carleton.ca/research

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