Fire & Safety Risk Posed by Large Wood Frame Residential Buildings

What are the Concerns and How Can we Mitigate

CITY OF SURREY

Len Garis – Joe Clare

Fire Chief City of Surrey, Adjunct Professor - School of Criminology and Criminal Justice & Associate to the Centre for Social Research University of the Fraser Valley, Affiliated Research Faculty - John Jay College of Criminal Justice, The Christian Regenhard Centre for Emergency Response Studies, New York

Canadian Wood Council

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Professor / Fire Chief Len Garis

October , 2017

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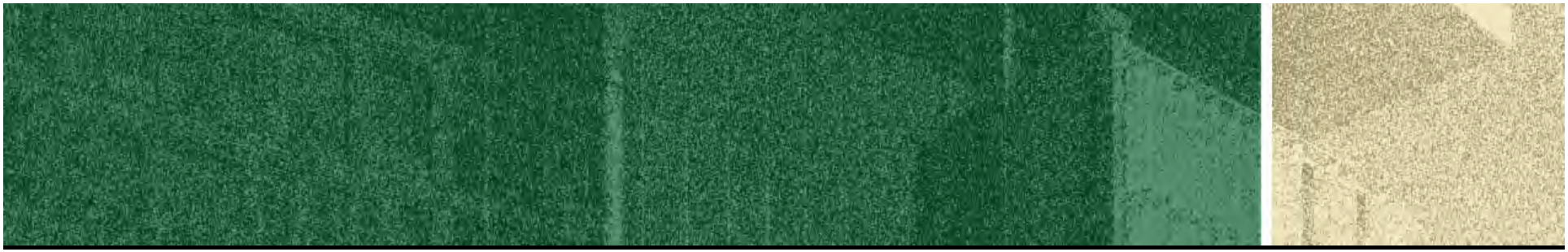
Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

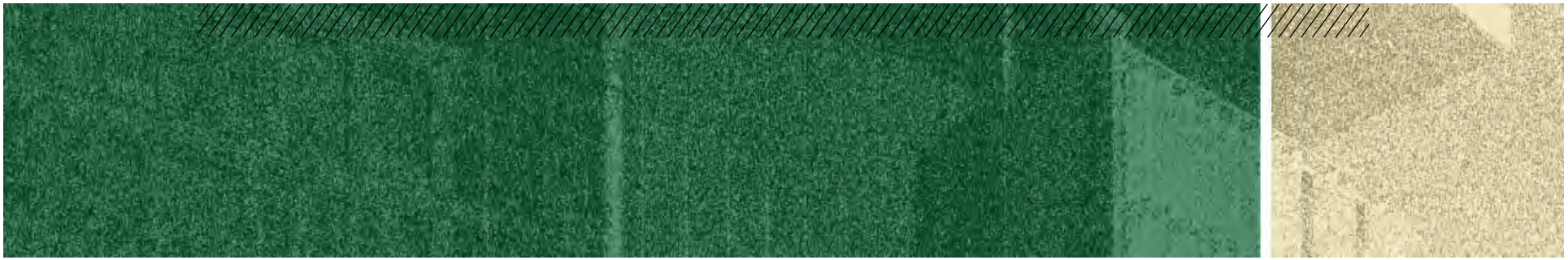


Len Garis, the Fire Chief for the City of Surrey, Professor at the University of the Fraser Valley, Affiliated Research Faculty, John Jay College of Criminal Justice , New York, will discuss research undertaken in partnership with Dr. Joe Clare and will examine stakeholder concerns with the fire and safety risks posed by wood frame residential construction. The talk will commence by discussing the background to the concerns from the fire service with respect to these structures, and how these contrast with the benefits that have been identified for these buildings. The specific nature of the concerns that have been raised by the key stakeholders will be outlined and then discussed with respect to research findings that have examined these issues, including an overview of the National Research Council work that has contributed to the safety margins relied on in the new building codes, and a retrospective analysis of recent fire outcomes for relevant structures in BC. Vulnerabilities with previous constructions that have been identified will be discussed, along with an explanation as to how the amended building code addresses these. The talk will conclude by explaining that, based on available simulation and retrospective data, and acknowledging the amendments that have been made to the building code to protect these new, taller wood frame buildings, there does not appear to be data-driven support for the concerns raised by key stakeholders with respect to these structures. In addition, the rate-of-return on the increasing demands for fire protection relative to the reduction in fire losses will be explained, with the intent of demonstrating that the ever-growing total cost of fire requires all stakeholders to be more mindful of adding additional costly safety components without considering their effectiveness.

Learning Objectives

At the end of the this course, participants will be able to:

- The specify the nature of the concerns that have been raised by the key stakeholders in reference to tall wood construction will be outlined and then discussed with respect to research findings that have examined these issues, including an overview of the National Research Council work that has contributed to the safety margins relied on in the new building codes, and a retrospective analysis of recent fire outcomes for relevant structures in BC. Vulnerabilities with previous constructions that have been identified will be discussed, along with an explanation as to how the amended building code addresses these.
- The talk will conclude by explaining that, based on available simulation and retrospective data, and acknowledging the amendments that have been made to the building code to protect these new, taller wood frame buildings, there does not appear to be data-driven support for the concerns raised by key stakeholders with respect to these structures.
- discussing the background to the concerns from the fire service with respect to these structures, and how these contrast with the benefits that have been identified for these buildings.
- the rate-of-return on the increasing demands for fire protection relative to the reduction in fire losses will be explained, with the intent of demonstrating that the ever-growing total cost of fire requires all stakeholders to be more mindful of adding additional costly safety components without considering their effectiveness.

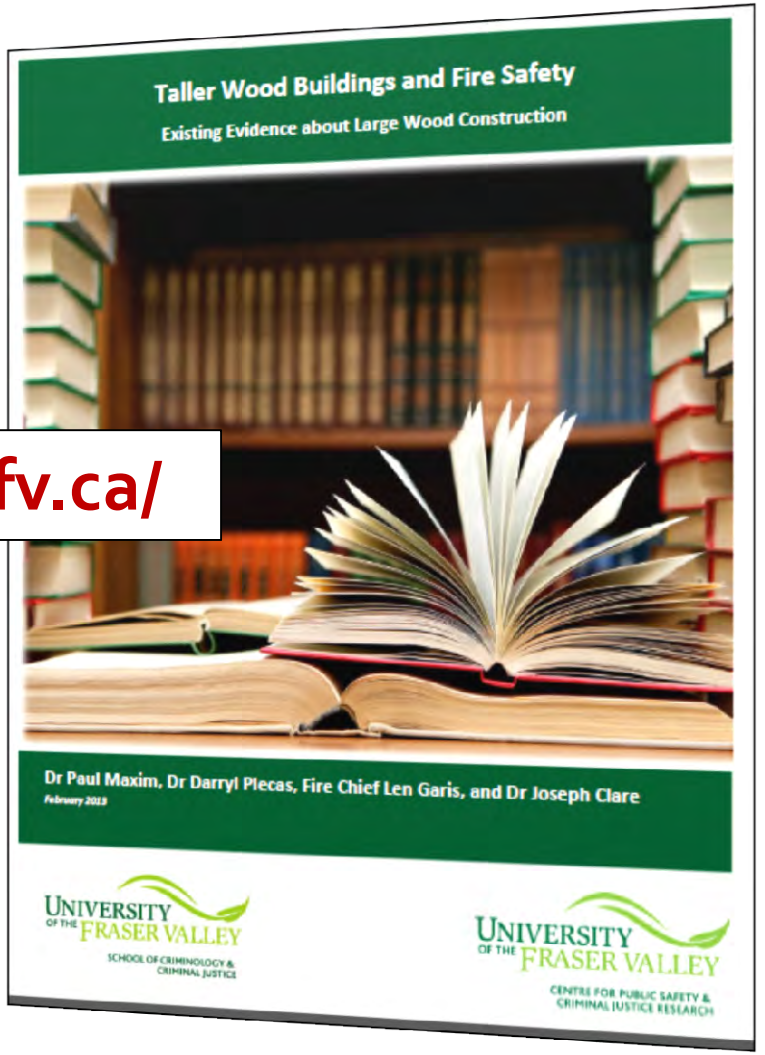


This concludes The American Institute of Architects Continuing Education Systems Course

Canadian Wood Council www.cwc.ca
Wood *WORKS!* Alberta www.wood-works.org

Challenging the *Implicit* Assumption

http://cjr.ufv.ca/



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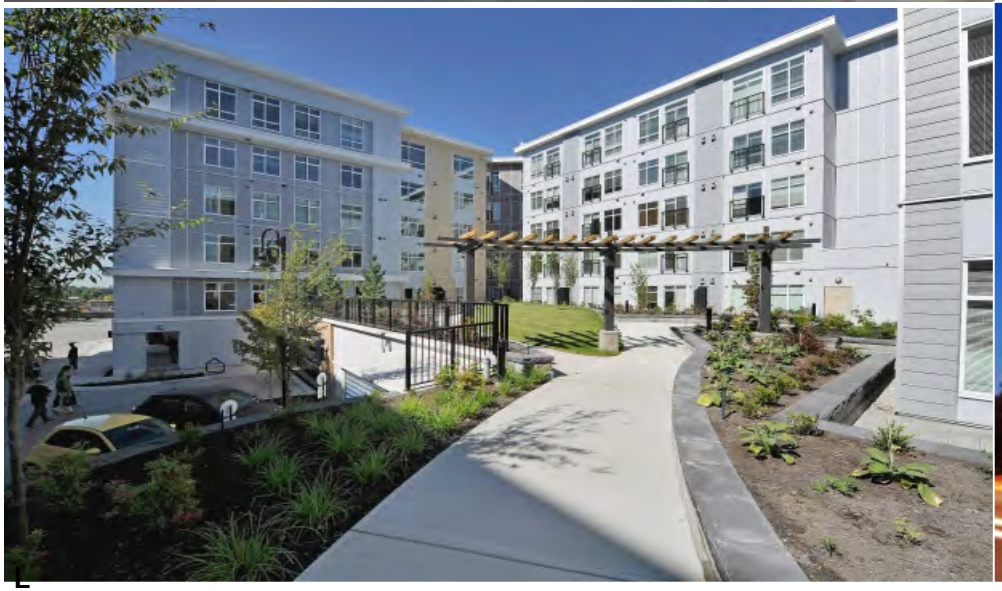
Large Wood Frame Residential



Challenging the *Implicit* Assumption

The instinctive response from the fire service with respect to wood frame buildings…

taller…

Therefore…

more risk for fire and safety…

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Three Takes on Wood Frame Construction

- **Developers**
- **Community**
- **Fire Service**

1. What the Developer Sees…

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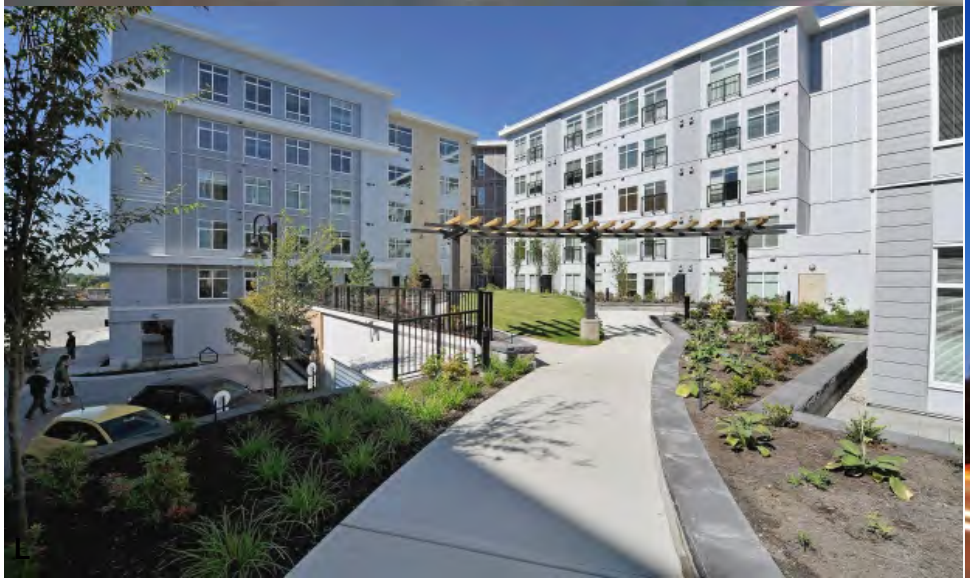
2. What the Public Sees…



3. What the Fire Service Sees…

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Understanding the Benefits

- Increase demand for local wood products
- Create jobs and stimulate the economy
- Increase housing affordability ≈ 15% - 20%
- Lower carbon foot print
- More intensive land use

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Fire Service Concerns Raised

- **Science**
  - **Expressed lack of research and/or evidence to support**
- **Harmonization**
  - **Not consistent with other building codes**
- **Consultation**
  - **Stakeholders outline a number of issues**
    - **Response times**
    - **Resourcing**
    - **Construction site safety**

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Code Changes in BC 2009 / National Building Code 2015

- Compartmentalization
- Fire resistant assemblies
- More stringent sprinkler protection
- Control of moisture content
- Construction risk mitigation

Research Relating to these Concerns

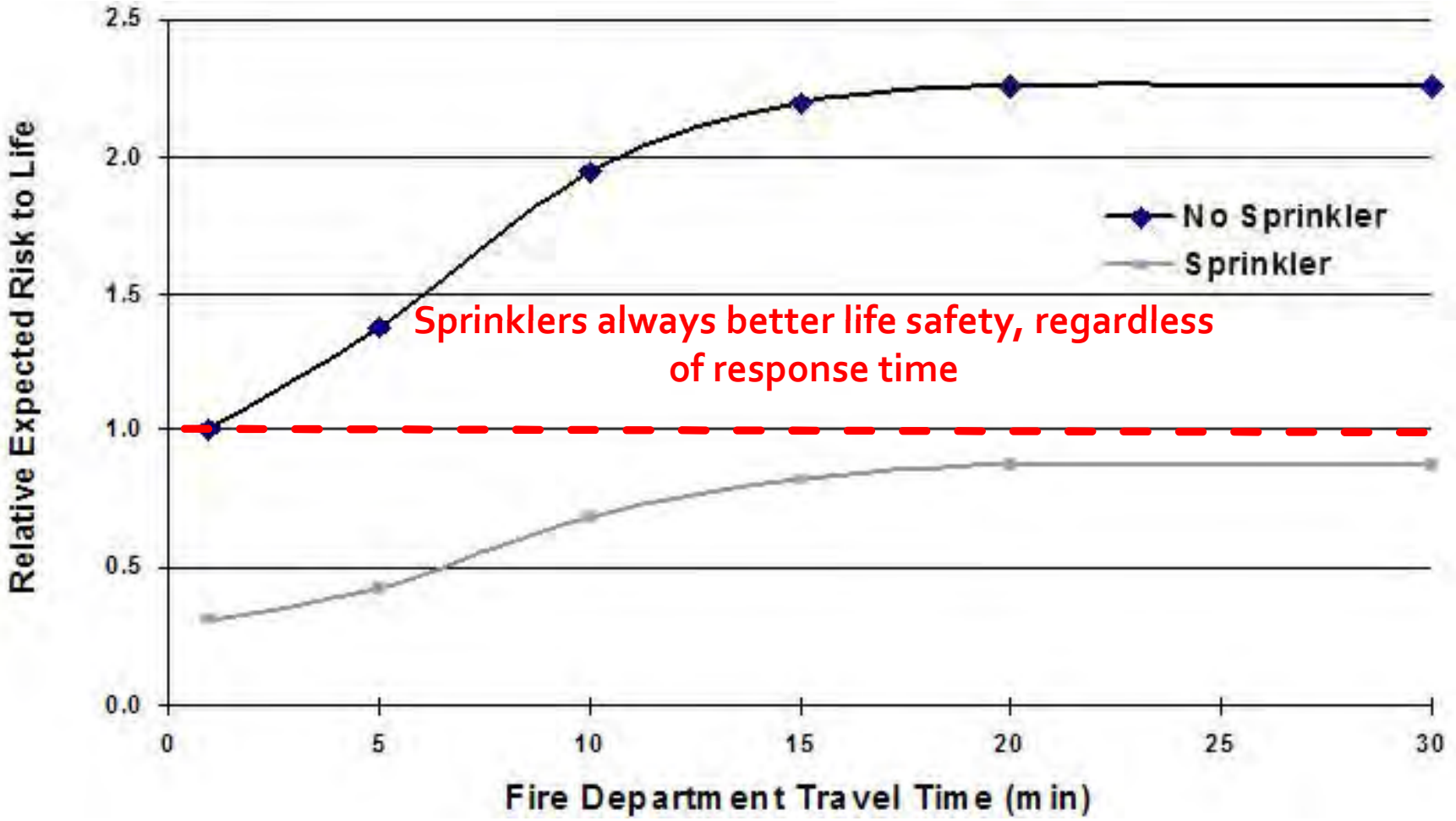
1. National Research Council simulation modeling
2. Retrospective analysis of fires in BC
3. Case studies from other jurisdictions that have these buildings
4. Future research underway – proposed

FiRECAM™ Sprinkler Study #1

- **Two variables of interest**
  - **Civilian / Firefighter Injuries**
  - **Sprinkler protection**
  - **Additional fire departments**

FiRECAM™ Sprinkler Study #1

"Predicts lessor Risk to life"



FiRECAM™ Sprinkler Study #1 Fire Separations - NRC Modeling

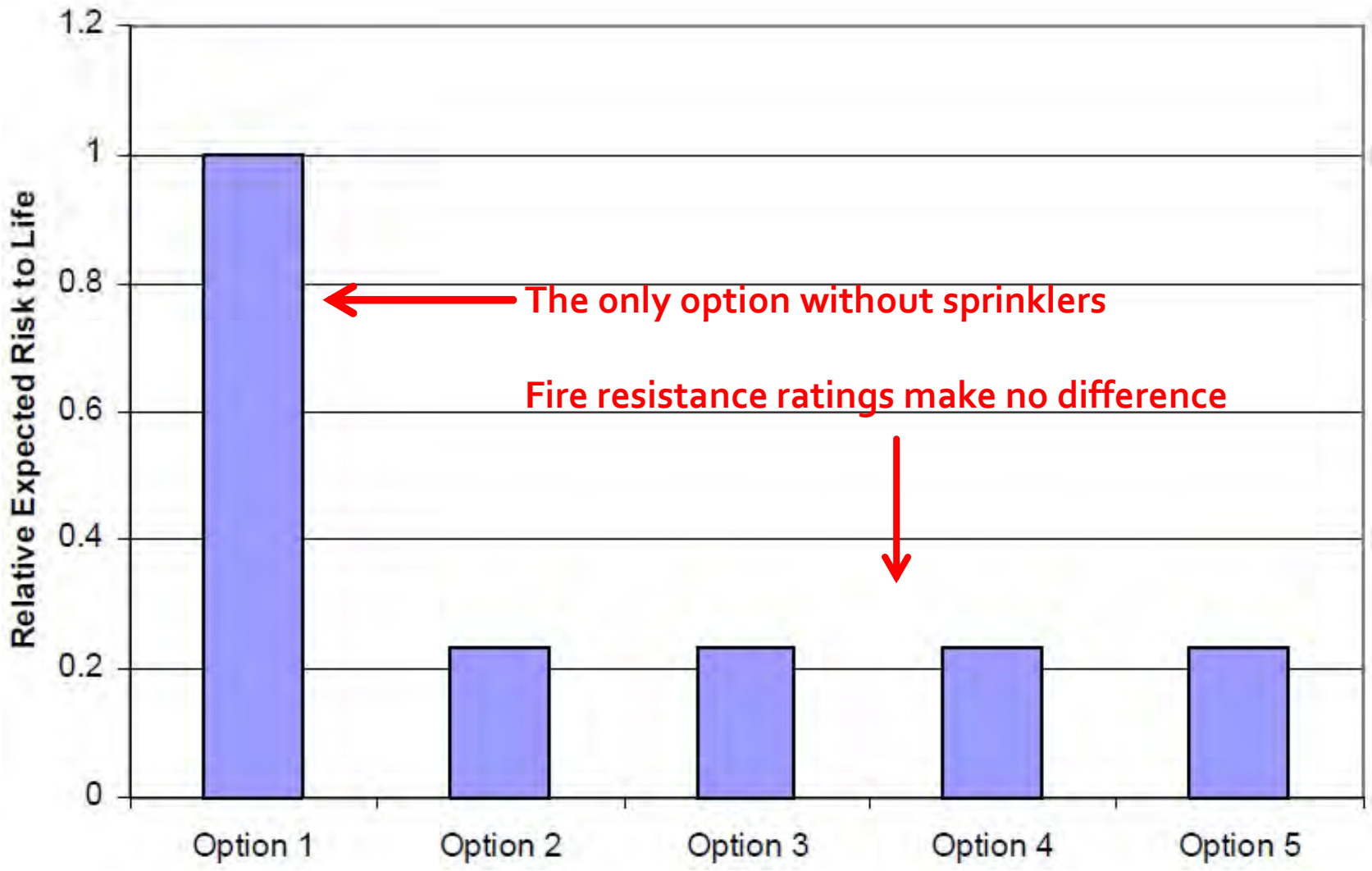
- **Fire Separations , Calculated the relative expected risk to life and expected losses for five different options:**

  1. **60-min wall/flooring/ceiling assembly <u>without sprinklers</u>**
  2. **60-min wall/flooring/ceiling assembly with sprinklers**
  3. **45-min wall/flooring/ceiling assembly with sprinklers**
  4. **60-min wall and 45-min floor/ceiling assembly with sprinklers**
  5. **30-min wall/flooring/ceiling assembly with sprinklers**

- **Sprinklers modeled at NFPA13R**

FiRECAM™ Sprinkler Study #1

"Predicts lessor Risk to life"



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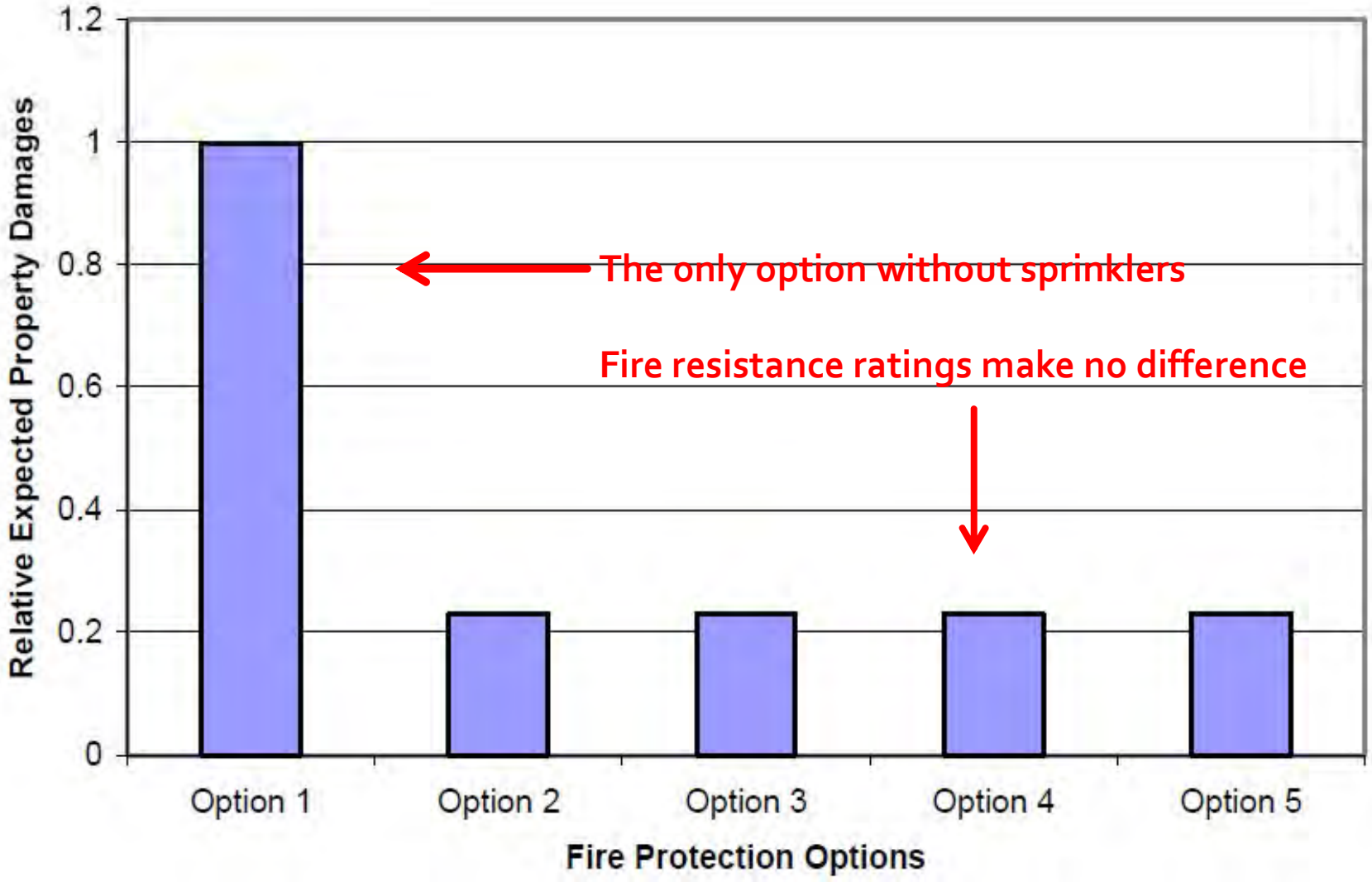
FiRECAM™ Sprinkler Study #1

"Predicts lessor Risk to Damage"



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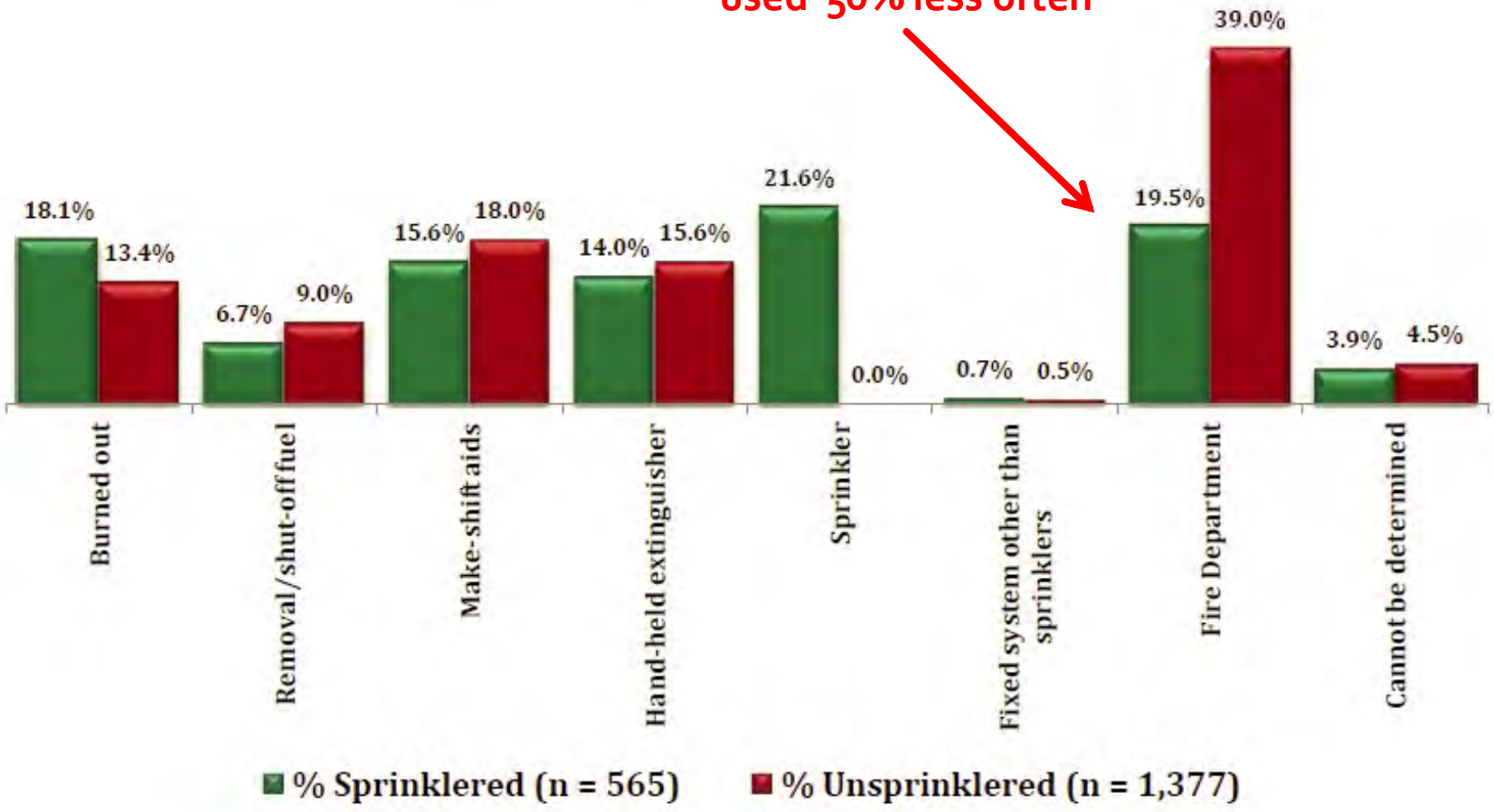
Research Part 2 – BC Data

- **Set of 1,942 fire incidents that occurred in apartments**
  - **Occurred in BC**
  - **October 2006 to October 2011**
  - **Compared fires in completely sprinkler protected buildings (n = 565)**
  - **With fires in buildings without any sprinkler protection (n = 1,377)**
- **Looked at**
  - **Initial detection**
  - **Extent of fire spread**
  - **Method of fire control**

Method of Fire Control by Sprinkler Status

FIGURE 1: WITHIN-GROUP PERCENTAGES OF BROADLY GROUPED METHODS OF FIRE CONTROL BY SPRINKLER PROTECTION STATUS

Multiple-hose lines were used 50% less often



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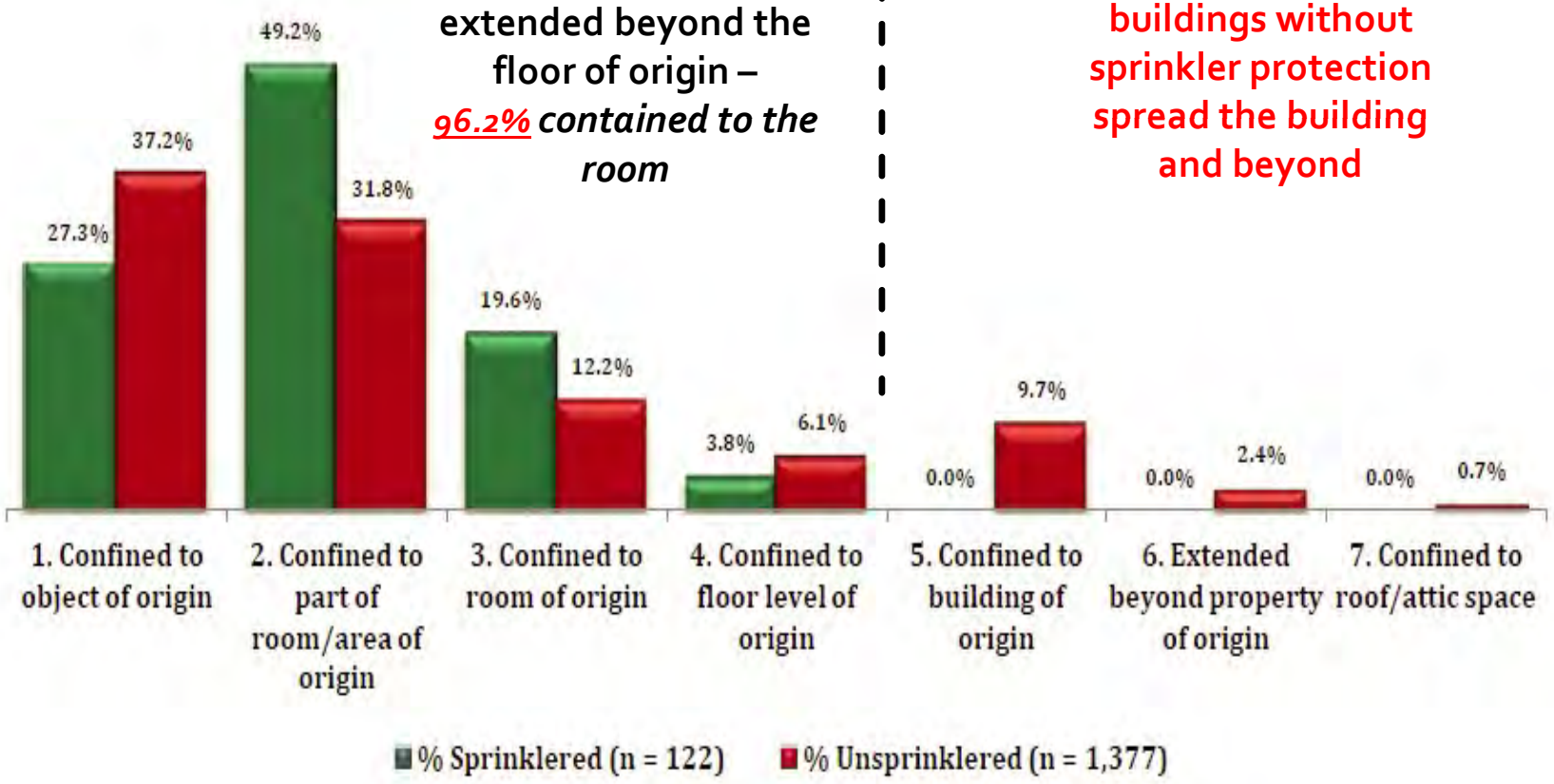
Extent of Fire Spread by Sprinkler Status

FIGURE 2: PERCENTAGE (AND CUMULATIVE PERCENTAGE) OF EXTENT OF FIRE SPREAD BY SPRINKLER PROTECTION STATUS

Fires controlled by sprinklers never extended beyond the floor of origin – *96.2% contained to the room*

12.7% of fires in buildings without sprinkler protection spread the building and beyond



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Civilian / Firefighter injuries

N = (9,841 Fires / 144 Deaths / 696 Injuries) (Oct 2009 - 2011)

- Fire Fighters 2 times greater to be injured w/o Sprinklers
- Civilians 9.3 times greater to be injured w/o Sprinklers

Severity of injuries	Civilian injuries (n=608)		Fire fighter injuries* (n=88)	
	No sprinkler protection (n=571)	Sprinkler protection (n=37)	No sprinkler protection (n=84)	Sprinkler protection (n=4)
< 1 day in hospital/off work	55.0%	67.6%	56.0%	75.0%
1-2 days in hospital and/or off work 1-15 days	30.5%	24.3%	36.9%	25.0%
≥ 3 days in hospital and/or off work > 15 days	14.5%	8.1%	7.1%	0.0%
Total	100.0%	100.0%	100.0%	100.0%
Injury rate per 1,000 fires	63.6	43.0	9.4	4.7

Research Part 3 – Case Studies

- **Seattle Fire Service, WA**
- **Protects an area that has had 6-storey multi-residential wood frame buildings for 20 years**
- **Deputy Fire Chief Fire Marshal**

  "We have been allowing this in Seattle for roughly 20 years and although we may have hundreds of buildings like this we have not seen large losses…"

- **Seattle Battalion Chief**

  "The fires I have had in these buildings have been controlled by sprinklers and confined to the room of origin…"

  "The Seattle Fire Department mandates fast response residential sprinklers in these kinds of occupancies and they are very effective…"

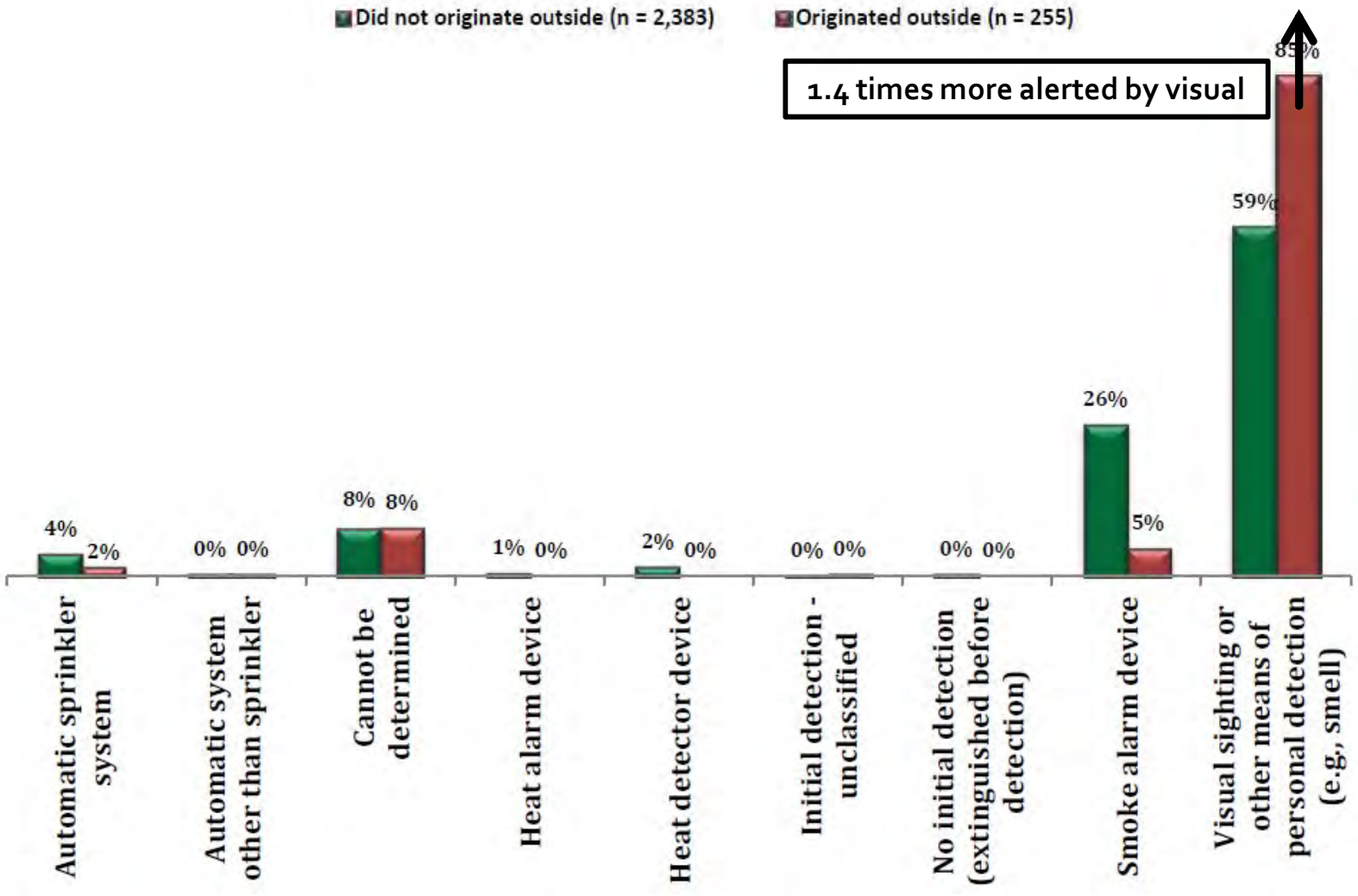
Vulnerability #1 – External Origin Fires

- **Fires that commence on the outside of the building:**
  - **Exterior balconies**
  - **Court/patio/terrace area**

Analyzing the Risk with Balcony Fires

- **Set of 2,638 fire incidents that occurred in apartments/ townhomes**
  - **Occurred in BC**
  - **October 2006 to October 2011**
  - **Initially looked at sprinkler protection status – not predictive**
  - **Compared fires that started on balconies and court/patio/terrace (n = 255)**
  - **With all other apartment/townhome fires (n = 2,383)**
- **Looked at**
  - **Initial detection**
  - **Extent of fire spread**
  - **Method of fire control**

Initial Detection for Balcony Fires



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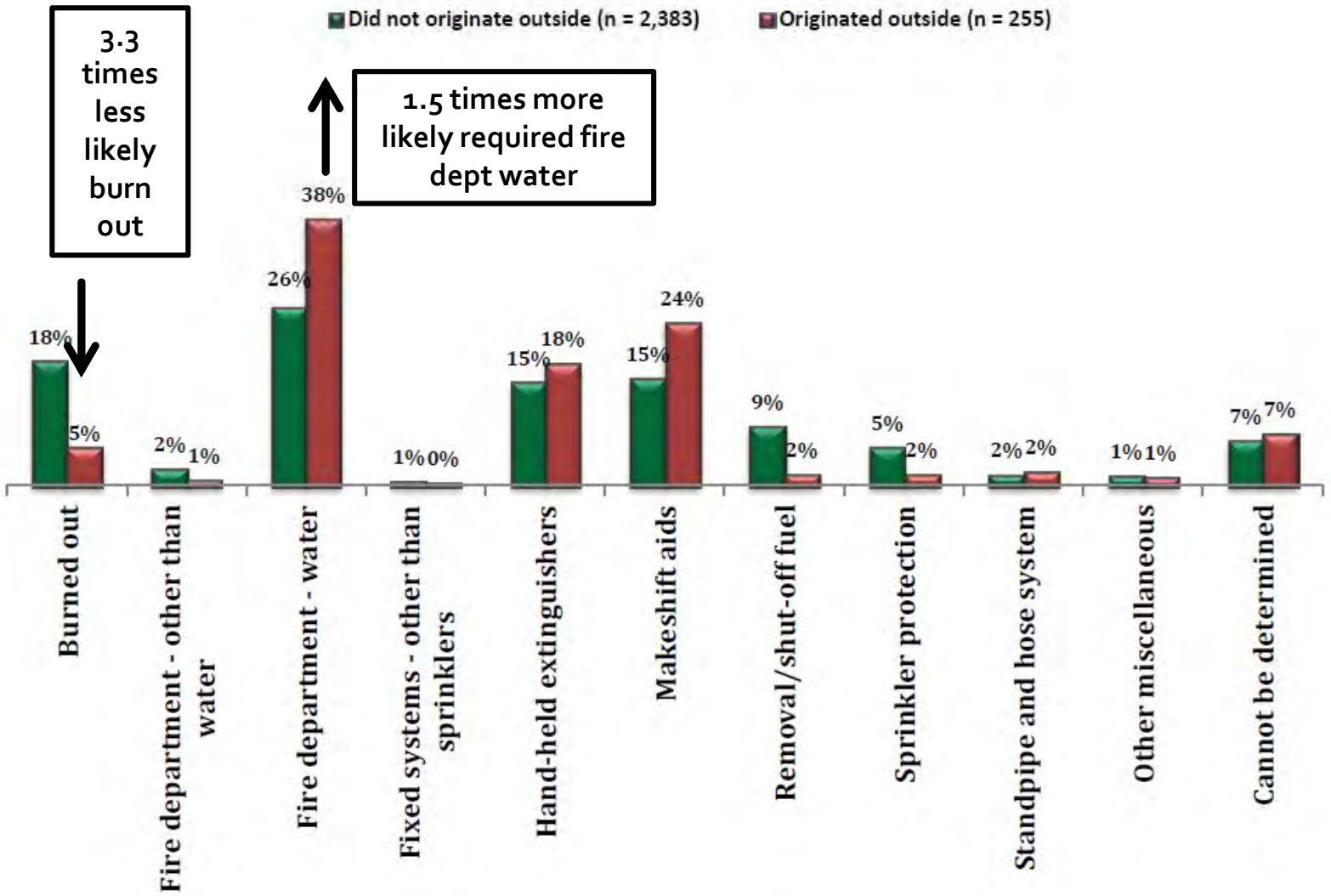
Method of Fire Control for Balcony Fires



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Vulnerability #2 – Buildings Under Construction

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What Causes Fires when Under Construction?

- **Leading causes for fires when under construction:**
  - **Incendiary / suspicious events**
  - **Smoking on site**
  - **Open flames/ embers**
  - **Heating equipment**

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Construction Fire Safety Plans

SURREY FIRE SERVICE

Construction Fire Safety Plan Bulletin

The B.C. Fire Code requires building owners/contractors to comply with the requirements of the BC Fire Code 5.6 Construction and Demolition Sites

CITY OF SURREY FIRE SERVICE

8767 132 Street Surrey B.C., V3W 4P1
Fire Prevention: 604-543-6780
Fax: 604-594-1237 www.surrey.ca

Revised July 29, 2011

CITY OF SURREY
FIRE SERVICES

This bulletin is provided by the Surrey Fire Service to assist owners, contractors, and workers on the requirements of a Construction Fire Safety Plan (CFSP). The document is intended to provide a brief overview of existing information that has previously been developed. Each site and construction project will have site specific issues that will need to be addressed in the CFSP.

During the construction phase, a building is at its most vulnerable state. A CFSP is a part of a system that is intended to protect the building during this vulnerable stage. Once a building is completed, there are a number of life safety systems in place to protect the building and its occupants. These include fire alarm systems, sprinklers, and fire compartmentalization. During construction these fire safety measures may or may not be installed or fully operational. Therefore, the CFSP must address hazards that could be present during construction.

The leading causes of fire in buildings under construction or demolition are:

- Incendiary/suspicious events.
- Smoking on site.
- Open flames/embers.
- Heating equipment.

While minimizing the fire hazards at a construction site, the CFSP must also take into account the impact a fire would have on the neighboring building(s).

It is the owner's responsibility to develop a Construction Fire Safety Plan that meets the requirements of the BC Building and

Construction Fire Safety Plans

- **Fire safety plan requirements:**
  - **Fire safety training for onsite staff**
  - **Enforcement of best practices**
  - **Features co-ordination – fire wall construction – fire doors**
  - **Site security – active watchman service**

Construction Fire Safety Education

http://cjr.ufv.ca/

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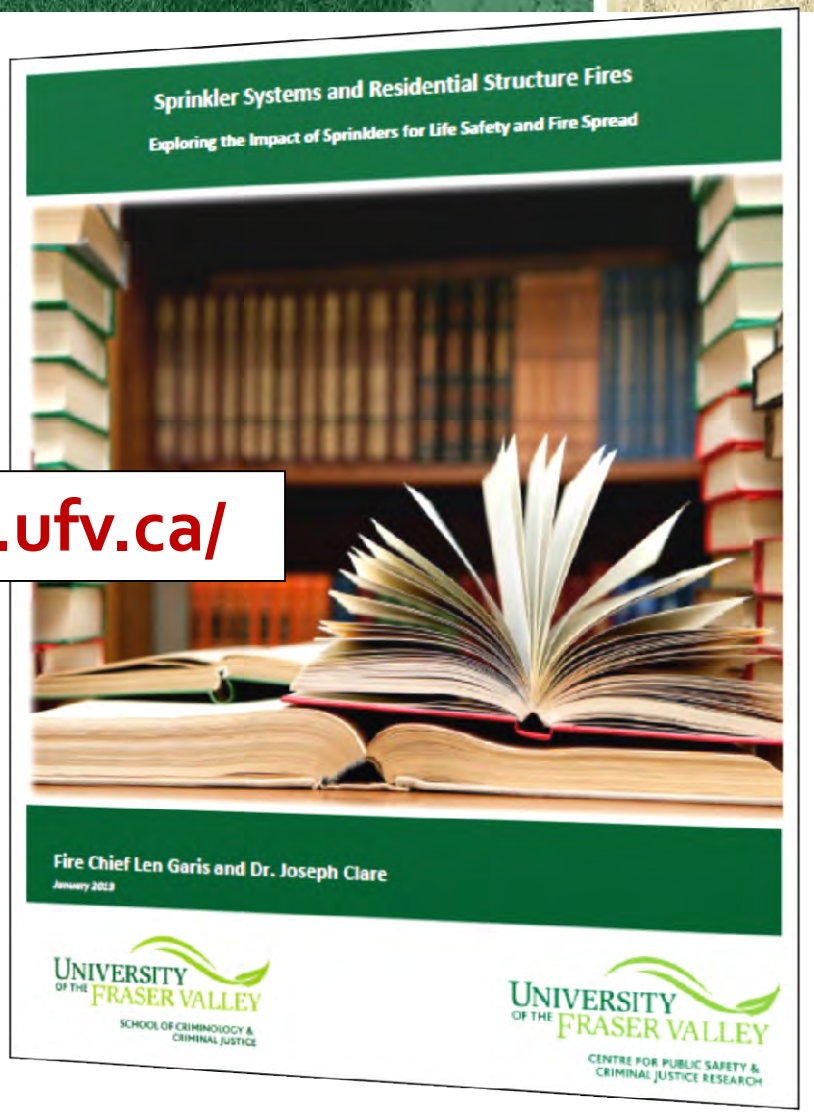
Conclusions

- **Extensive examination**
  - **Simulation, retrospective quantitative analysis, case study**
- **Overwhelmingly consistent theme that emerges**
  - **Although fire services typically have responded to these types of proposed changes with concerns**
  - **Available information suggests these structures will perform at least as well from a safety perspective as those that are already permitted**
- **Existing code changes make provisions to address the weaknesses for**
  - **Buildings while under construction.**
  - **Fires that originate from the exteriors of these buildings (most typically from balconies).**

The Question posed:
Does Construction Type make a difference ?



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The Question posed:
Does Construction Type make a difference ?

- **In the first part we reviewed reported fires in British Columbia, 2008 – 2013 in the second part we looked at 2006 to 2014**
  - **11,875 / 20,110 were retained for subsequent analysis**
  - **There were 107 / 254 deaths and 772 / 1,376 injuries**
- **Looked at fires that occurred in the following five construction types:**
  - **Combustible construction – open wood joist**
  - **Protected combustible construction – wood protected by plaster/gyproc**
  - **Heavy Timber construction**
  - **Non-combustible construction exposed steel**
  - **Protected non-combustible construction - protected steel or concrete**

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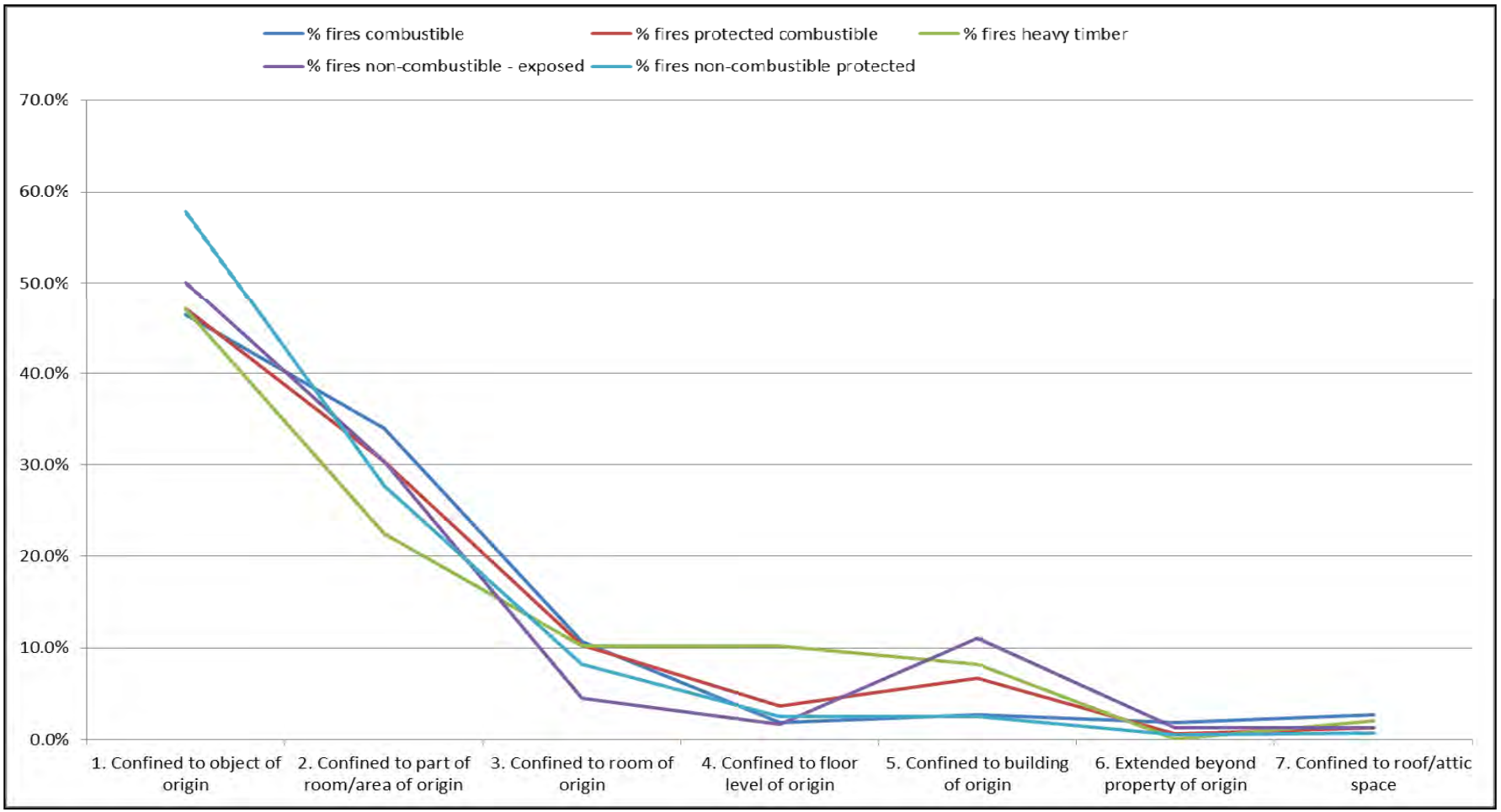
Does Construction Type make a difference ?

- **Looking at (n = 11,875)**
  - **Frequency of fires , deaths and injuries by general construction type**
  - **Extent of fire spread by general construction type**
  - **Frequencies of fires, sprinkler protection, smoke alarm activation and injury rate general construction type**
  - **Extent of fire spread by general construction type and protection type**
  - **Method of fire control by general construction type**
  - **Fire related causalities by general construction type**
  - **Fire Related causalities by construction type in the presence of a working smoke alarm and sprinkler protected**

Does Construction Type make a difference ?



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Some aspects about building height

BC Residential Structure Fires, Injuries & Deaths by Building Floor (2006-2016)

Between 2006 & 2016:

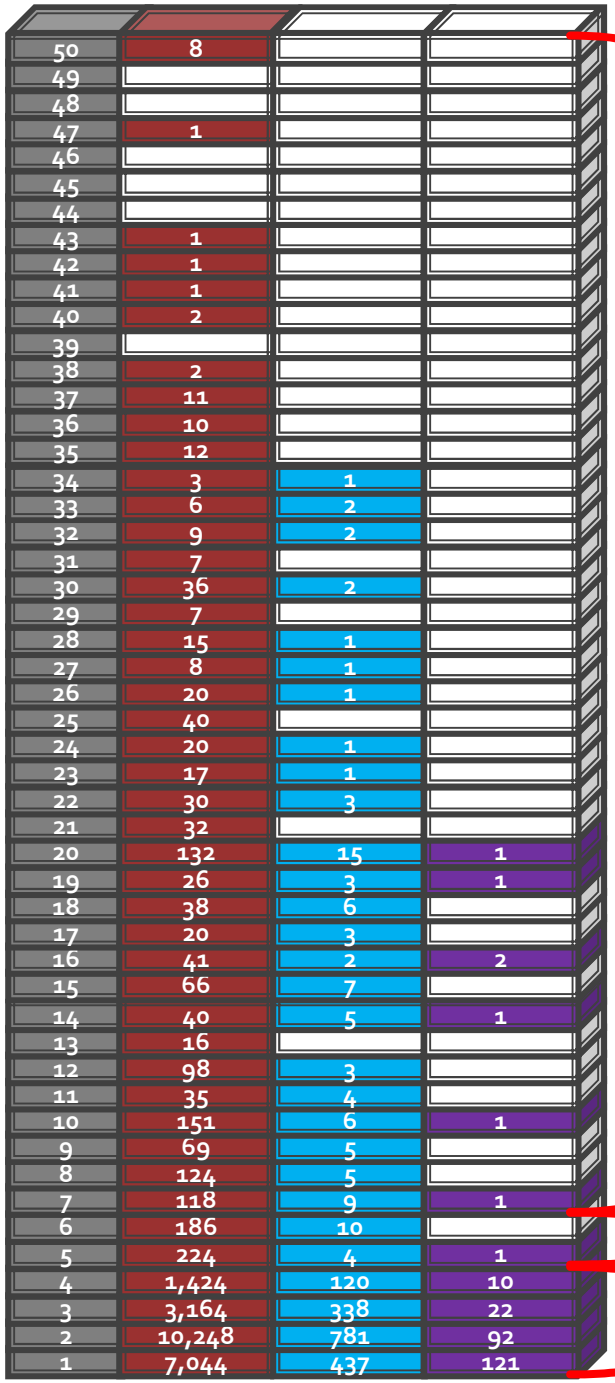
79,998 Fires

30,038 Structure fires

24,452 Residential Structure Fires

1,820 Residential Injuries

282 Residential Deaths



BC Residential Structure Fires, Injuries & Deaths by Building Floor (2006-2016)

Between 2006 & 2016:

- 79,998 Fires
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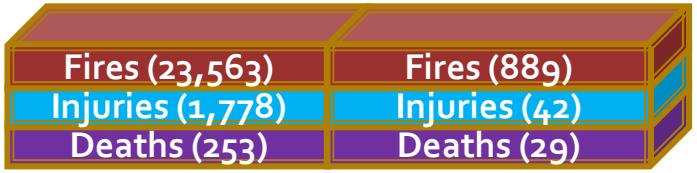
- 1,820 Residential Injuries
- 282 Residential Deaths

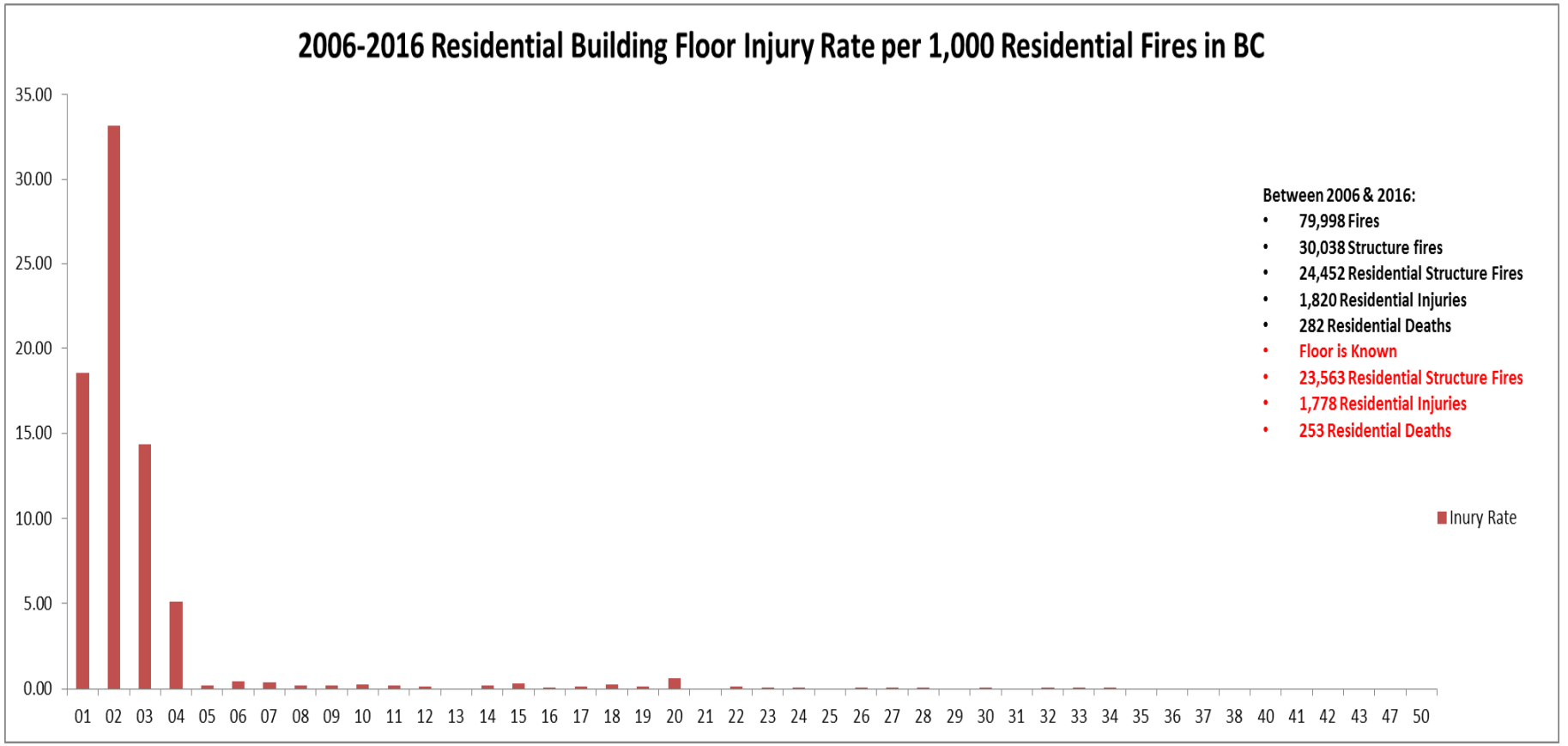
2.77% / Floor 6-50

Floor Known Floor Unknown



0.40% / Floor 5-6

96.83% / Floor 1-4


2006-2016 Residential Building Floor Injury Rate per 1,000 Residential Fires in BC
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41 42 43 47 50
Between 2006 & 2016:
• 79,998 Fires
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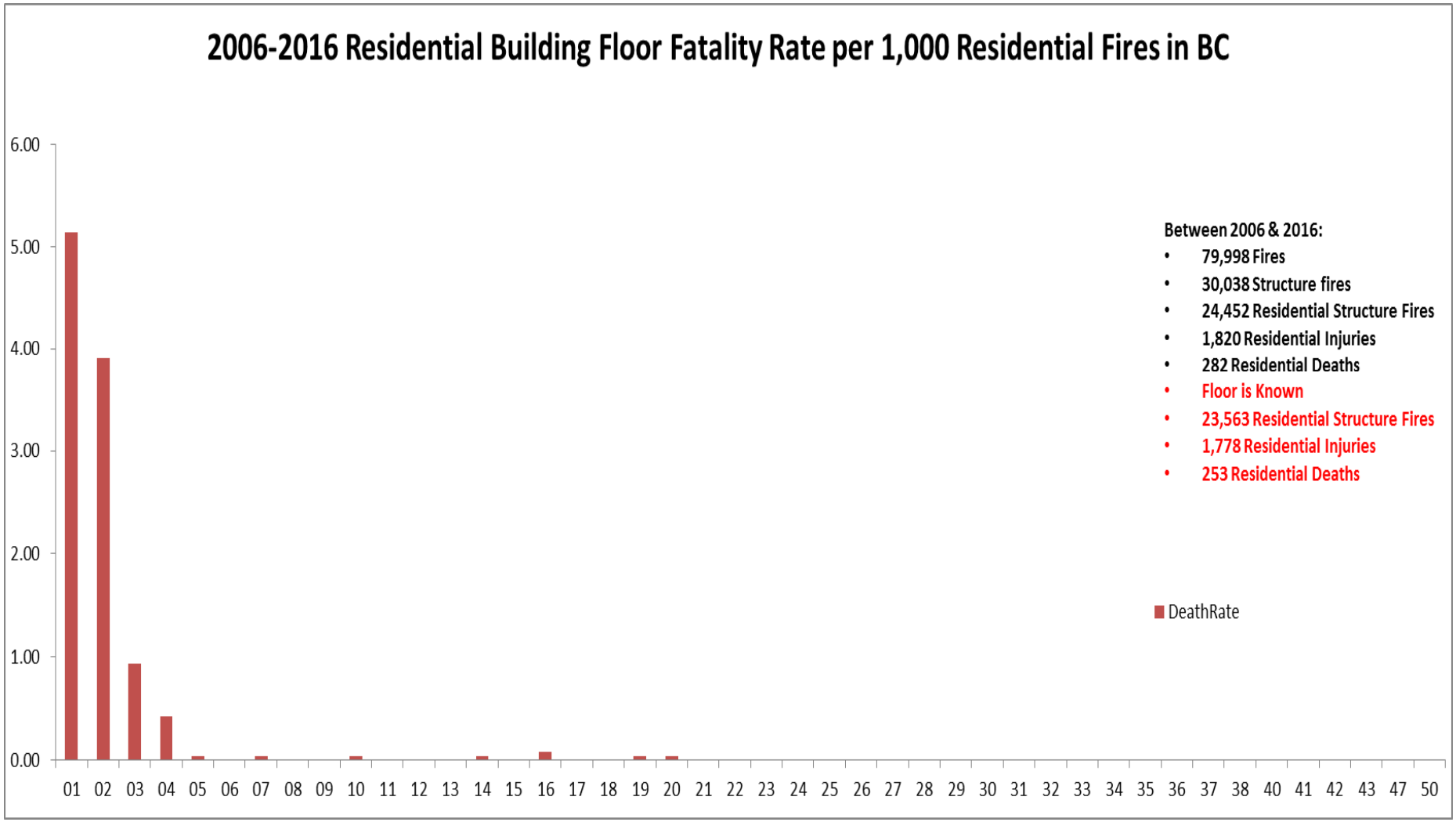
• 282 Residential Deaths
• Floor is Known
• 23,563 Residential Structure Fires
• 1,778 Residential Injuries
• 253 Residential Deaths
Inury Rate


2006-2016 Residential Building Floor Fatality Rate per 1,000 Residential Fires in BC
6.00
5.00
4.00
3.00
2.00
1.00
0.00
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41 42 43 47 50
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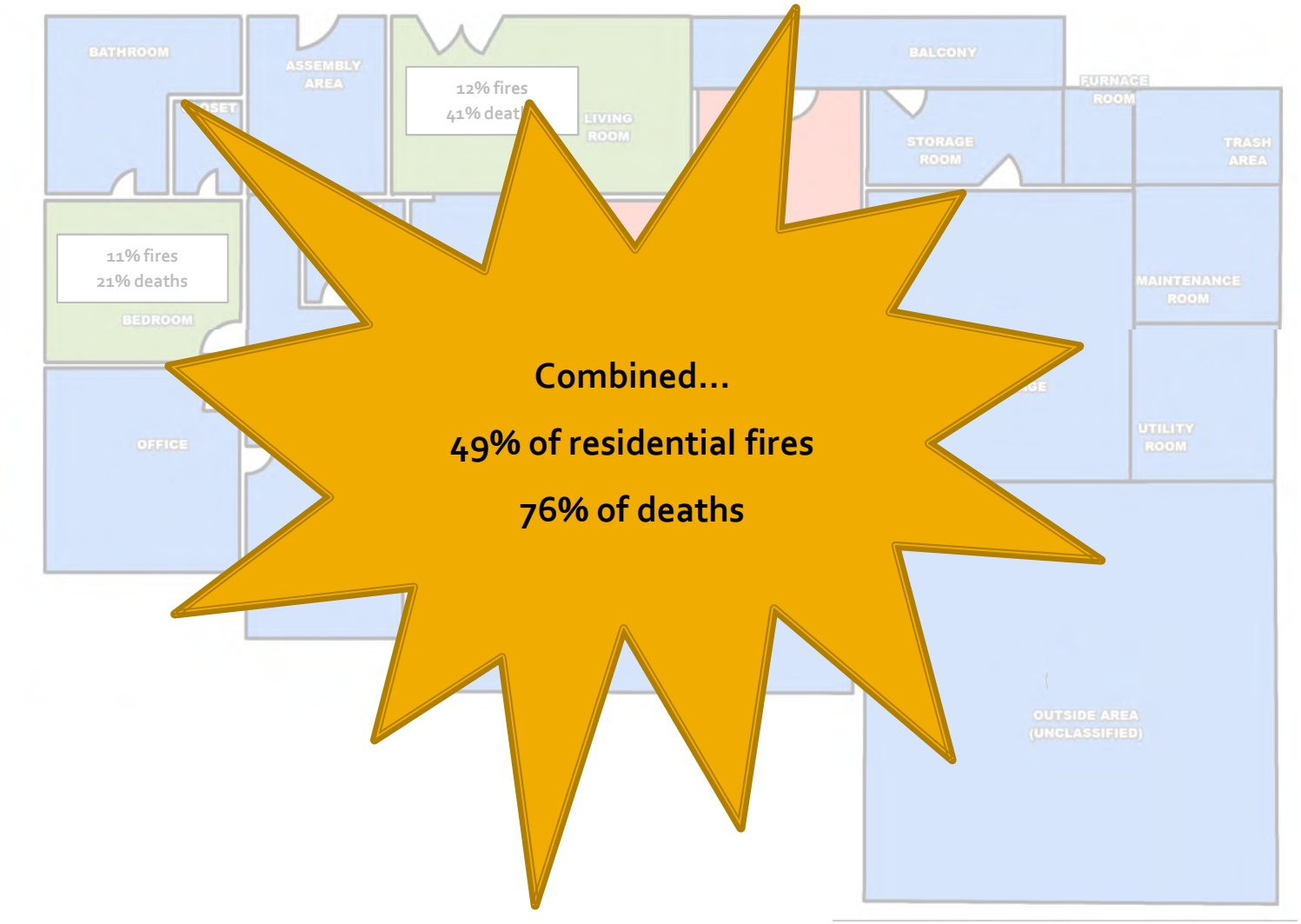
DeathRate

Room-specific findings

Room-specific findings



Conclusion- Short Answer No!

We found causalities by construction type in the presence of a working smoke alarm and sprinkler protected

- **Had one death across all construction types**
- **Had an Injury rates that were similar**
- **The fires spread were remarkable similar with no distinguishable differences by construction type, most fires were confined to the room of origin.**

Not Just Talking About Smoke Alarms

- **US Fire Administration research (2008)**
  - **Fire sprinklers alone – chances of dying in a fire decrease by 69% (compared to no sprinklers)**
  - **Smoke alarms alone – chances decrease by 63% (compared to no alarm)**
  - **Sprinklers AND smoke alarms – chances decrease by 82%**
- **Fire risk is non-random**
- **Not advocating for blanket approaches – more thoughtful and risk driven**

Research Part 2 – National Fire Incident Data

NFID database contains:

- 439,256 fire incidents 2005 to 2015
- 205,332 structure fire incidents
- 1,733 fire-related deaths (10 were firefighters)
- 12,503 persons injured were reported over these ten years
- 3,308 were firefighters

British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and New Brunswick

Canadian Association Workers Compensation Boards of Canada Contains: by nature , body part , source and event

firefighters

15,422 lost time incidents

568 deaths

2005 – 2015

Research Part 2 – National Fire Incident Data

Table B: NFID Coverage (6 provinces) as a percentage of the Canadian Population , July 2014

Jurisdiction	Population, July 1, 2014		NFID Population coverage	
	Number	Percent	Number	Percent
Newfoundland and Labrador	528,333	1.5	0	0
Prince Edward Island	145,832	0	0	0
Nova Scotia	943,294	3	0	0
New Brunswick	754,865	2	754,865	2
Quebec	8,214,503	23	0	0
Ontario	13,685,171	39	13,685,171	39
Manitoba	1,280,953	4	1,280,953	4
Saskatchewan	1,121,285	3	1,121,285	3
Alberta	4,108,283	12	4,108,283	12
British Columbia	4,645,261	13	4,645,261	13
Yukon	36,872	0	0	0
Northwest Territories	43,889	0	0	0
Nunavut	36,023	0	0	0
Canada/ NFID Total	**35,544,564**	100	**25,595,818**	72

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Research Part 2 – National Fire Incident Data

Severity of Injuries – Injury Rates for Civilian and Firefighters, Fire Related Civilian Deaths n=1,345), Injury's (n=6,956), Fire Related Firefighter Injures (n=1,956), Deaths (n=2) Classified as Residential Use 2005 to 2015

			Civilian		Firefighter		Civilian		Firefighter	
Smoke Alarm Working	Partial and/ or Full Sprinkler	Fires (%) Total	Injuries (%) Total	Injury Rate per 1,000 Fires (95% CI)	Injuries (%) Total	Injury Rate per 1,000 Fires (95% CI)	Death (%) Total	Death Rate per 1,000 fires (95% CI)	Death (%) Total	Death Rate per 1,000 fires (95% CI)
Yes	Yes	2,054	146	71.1	23	11.2	6	2.9	0	0.0
		1.6%	*2.1%*	*(60.0 - 82.2)*	*1.2%*	*(6.6 - 15.7)*	*0.4%*	*(0.6 - 5.3)*	*0.0%*	*0.0*
No	Yes	1,526	82	53.7	10	6.6	6	3.9	0	0.0
		1.2%	*1.2%*	*(42.4 - 65.0)*	*0.5%*	*(2.5 - 10.6)*	*0.4%*	*(0.8 - 7.1)*	*0.0%*	*0.0*
Yes	No	38,750	3,028	78.1	676	17.4	289	7.5	0	0.0
		29.8%	*43.5%*	*(75.5 - 80.8)*	*34.6%*	*(16.1 - 18.7)*	*21.5%*	*(6.6 - 8.3)*	*0.0%*	*0.0*
No	No	87,580	3,706	42.3	1,247	14.2	1,044	11.9	2	0.023
		67.4%	*53.2%*	*(41.0 - 43.6)*	*63.8%*	*(13.5 - 15.0)*	*77.6%*	*(11.2 - 12.6)*	*100.0%*	*(-0.009 - 0.054)*
T		129,910	6,962	53.6	1,956	15.1	1,345	10.4	2	0.015
		100%	*100.0%*	*(52.4 - 54.8)*	*100.0%*	*(14.4 - 15.7)*	*100.0%*	*(9.8 - 10.9)*	*100.0%*	*(-0.006 - 0.037)*

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Research Part 2 – National Fire Incident Data

Nature of Causality - Severity of Injuries – Injury Rates for Civilian (n=6,927) and Firefighters (n=1,956), in Combination of a Working Smoke Alarm and or Sprinkler System Classified as Residential Use 2005 to 2015

Severity Of Injury	Smoke Alarm Working	Civilian Injuries (n = 6,927)				Firefighter Injuries (n =1,956)			
	Sprinkler Present	Yes Yes	No Yes	Yes No	No No	Yes Yes	No Yes	Yes No	No No
	Minor < 1 day in Hospital / off work	80	45	2,044	2,205	10	7	549	971
	(% Total)	*54.8%*	*54.9%*	*67.6%*	*60.0%*	*43.5%*	*70.0%*	*81.2%*	*77.9%*
	Light 1-2 days in Hospital and/ or off work 1-15 days	51	30	377	558	13	3	25	88
	(% Total)	*34.9%*	*36.6%*	*12.5%*	*15.2%*	*56.5%*	*30.0%*	*3.7%*	*7.1%*
	Serious ≥ 3 days in Hospital and/ or off work 15 days	15	7	604	911	0	0	102	188
	(% Total)	*10.3%*	*8.5%*	*20.0%*	*24.8%*	*0.0%*	*0.0%*	*15.1%*	*15.1%*
	Total	146	82	3,025	3,674	23	10	676	1,247
	(% Total)	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*
	Injury Rate per 1,000 fires	71.1	53.7	78.1	42.0	11.2	6.6	17.4	14.2

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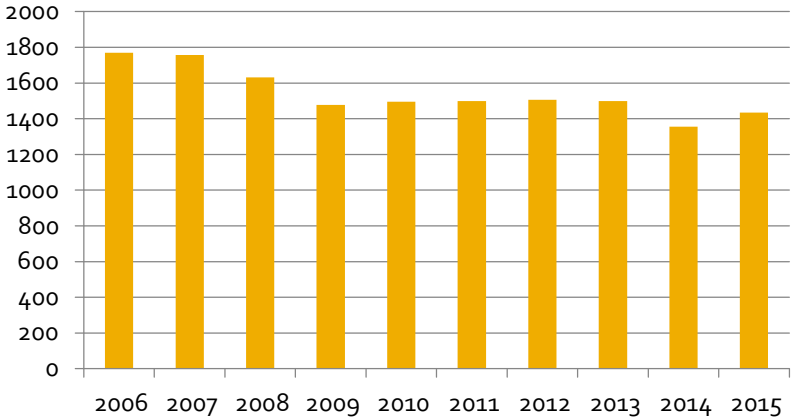
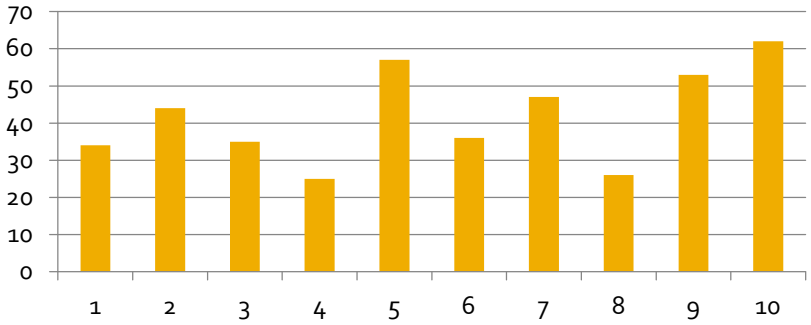
Research Part 2 – Canadian Association Workers Compensation Boards of Canada

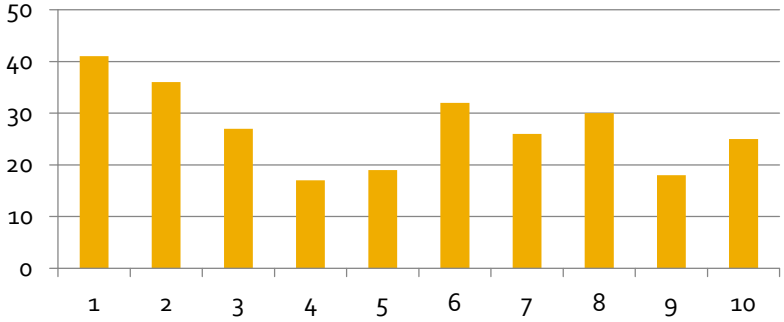
Traumatic Injuries are declining



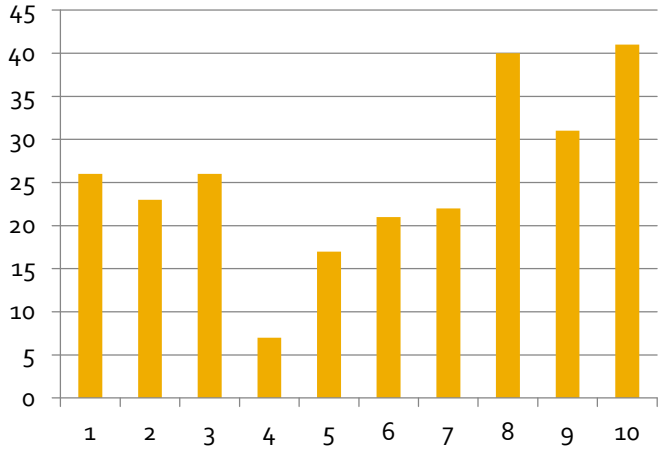
Death from Cancers are increasing



Burn Injuries declining



Mental Injuries are increasing



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The Future?

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Building Taller from Wood is it safe

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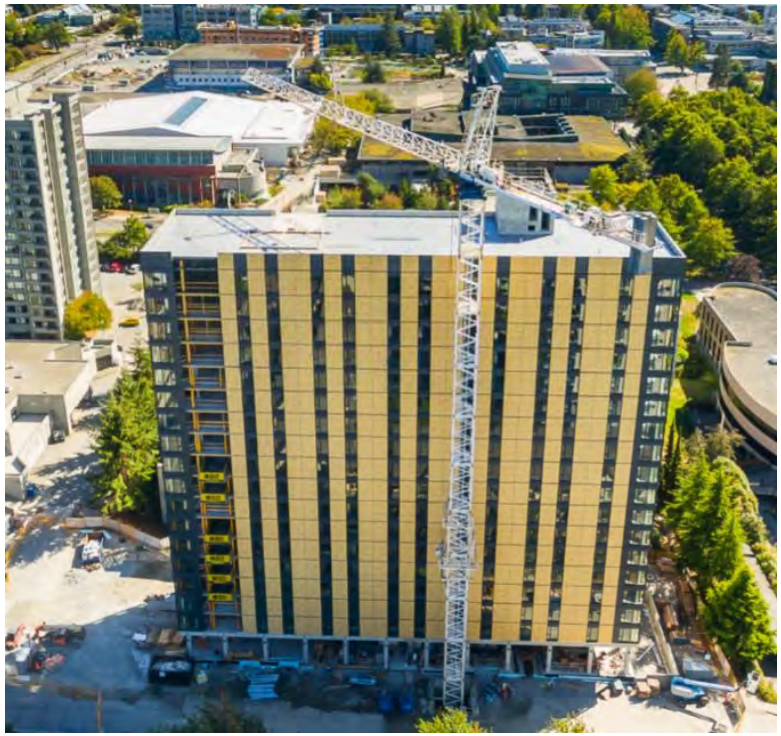
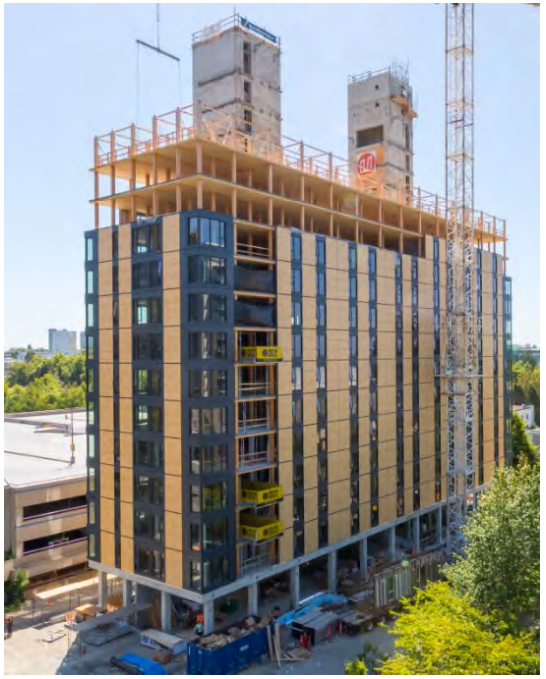
Building Taller from Wood is it safe



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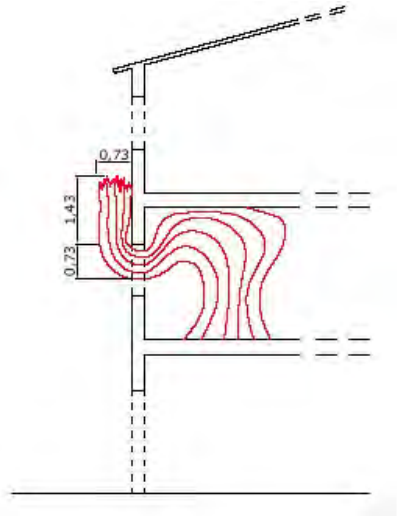
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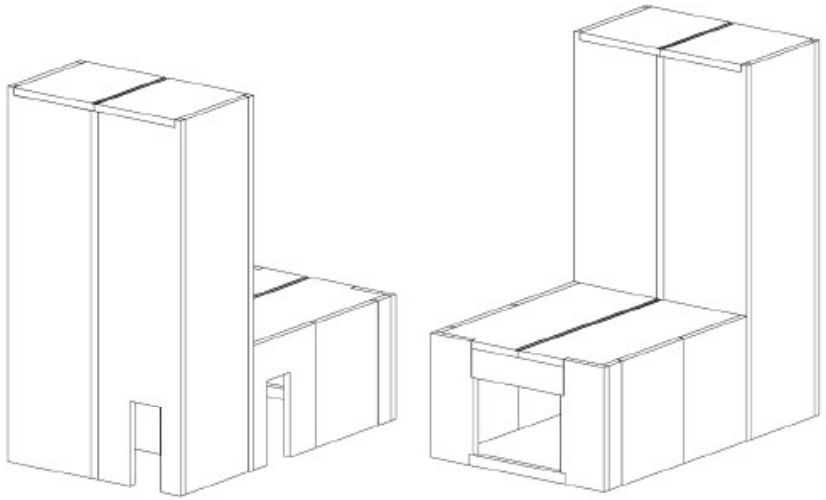
1,43
0,73


75

April 8, 2015

Client Report: A1-006010.1

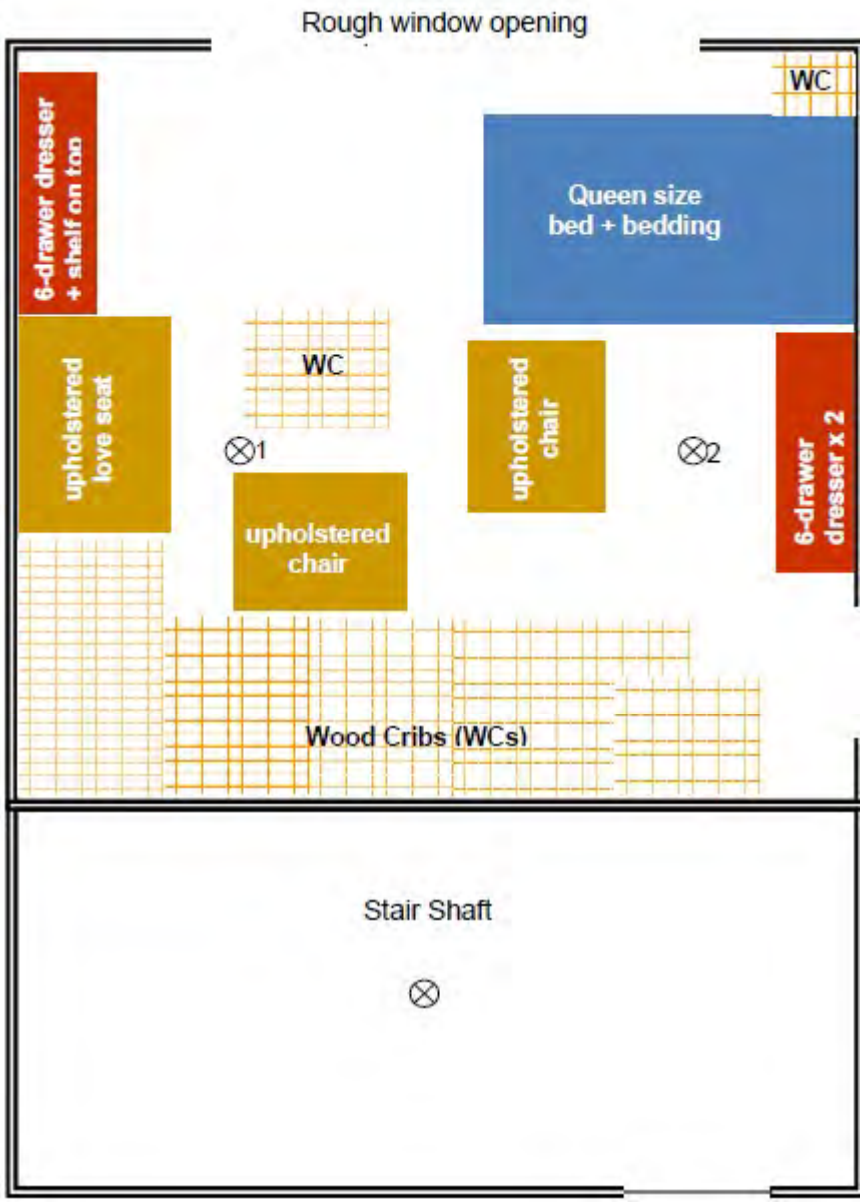


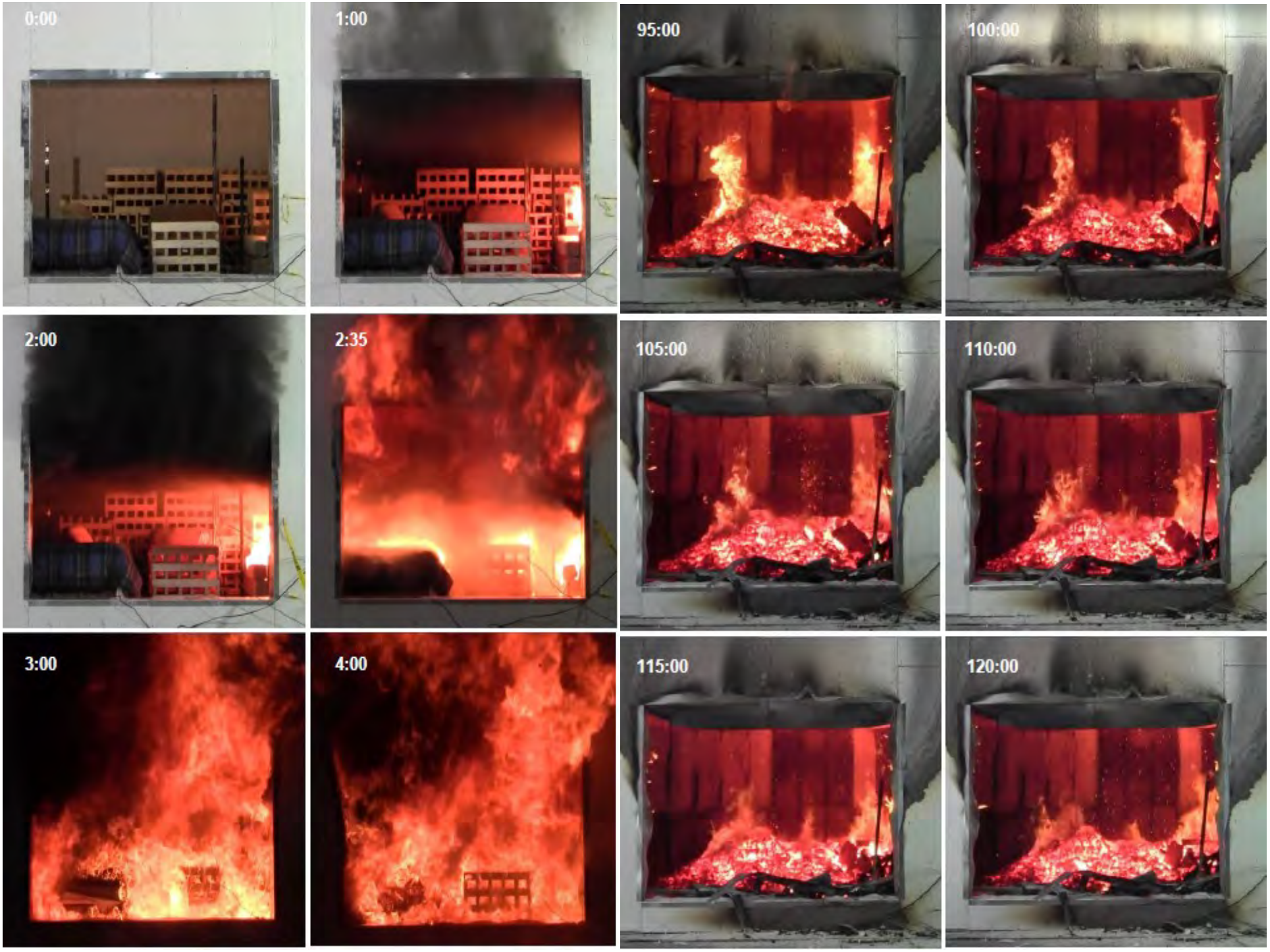
NATIONAL RESEARCH COUNCIL CANADA

Fire Demonstration –

Cross-Laminated Timber Stair/Elevator Shaft

For
FPInnovations


Rough window opening
WC
6-drawer dresser + shelf on top
Queen size bed + bedding
upholstered love seat
WC
upholstered chair
6-drawer dresser x 2
1
2
upholstered chair
Wood Cribs (WCs)
Stair Shaft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1:00
95:00
100:00
2:00
2:35
105:00
110:00
3:00
4:00
115:00
120:00

Figure 32. Inside of the fire compartment after the fire demonstration.

6 CONCLUSIONS

The demonstration results have demonstrated that the severe, high-intensity fast growing fire in the adjacent apartment had no impact on the mass timber stair/elevator shaft; the conditions inside the stair/elevator shaft were unchanged before, during and after the fire.

Total Cost of Fire NFPA

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What's Driving the Total Cost of Fire

- **The most recent estimates for the total cost of fire in the US was produced by John Hall in 2010.**
  - **Economic loss (property damage) due to fire (direct and indirect, reported and unreported) estimated at $18.6 billion**
  - **<u>13% decrease</u> compared to 1980 estimates (CPI adjusted)**

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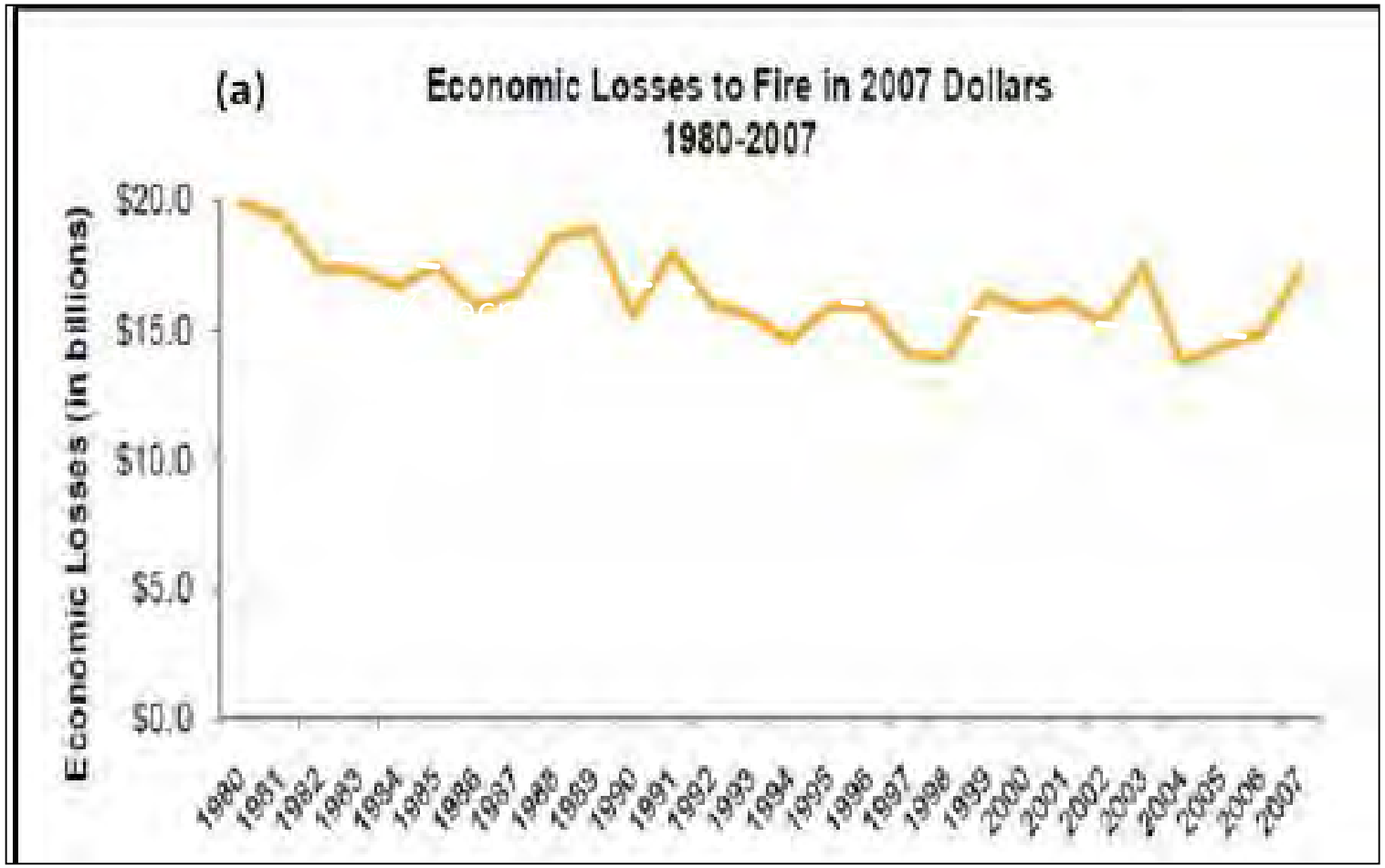
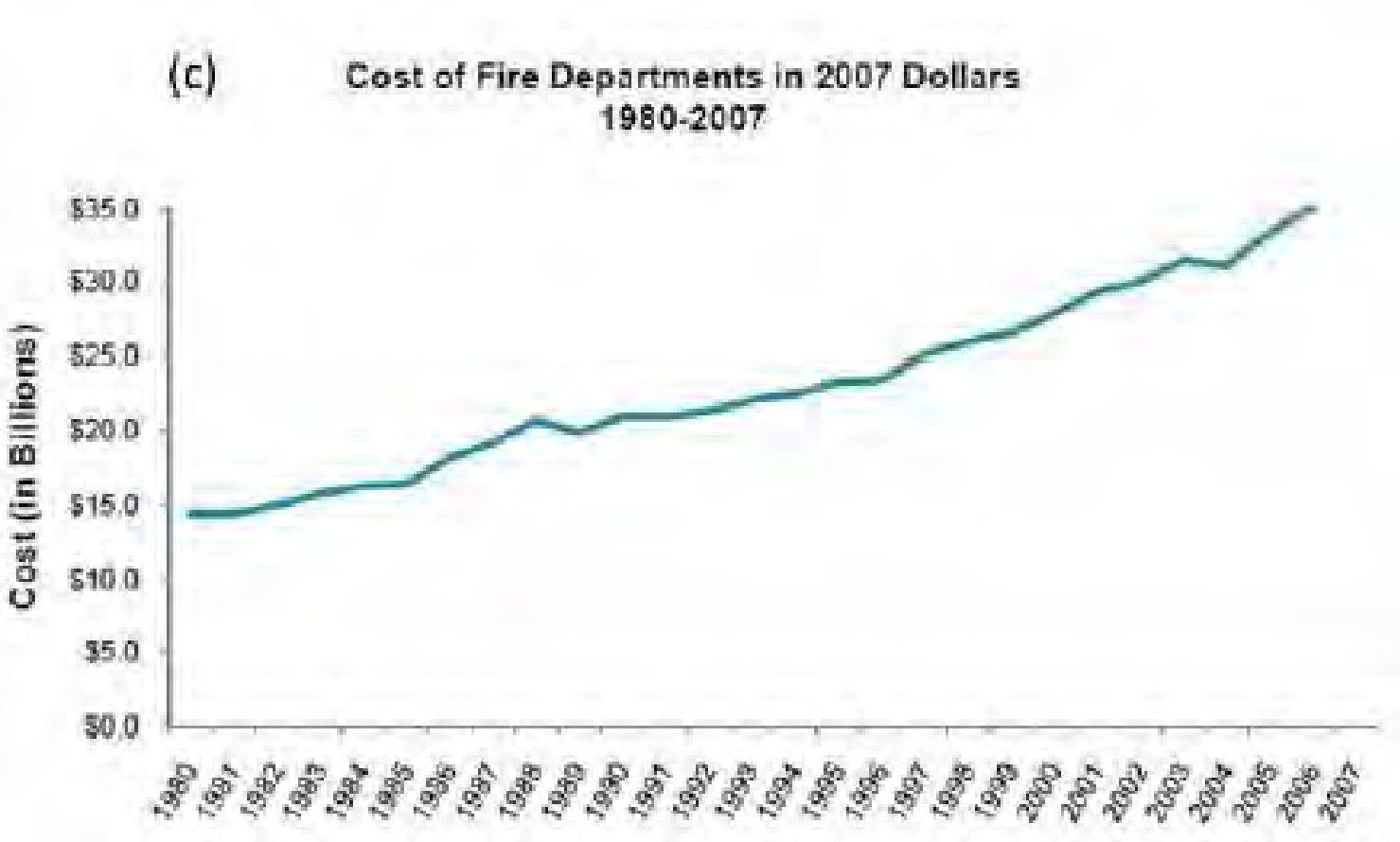
Summarizing the Trends for Cost of Fire (-13%)



J.R. Hall Jr., *The total cost of fire in the United States*, 2012, National Fire Protection Association, Fire Analysis and Research Division: Qunicy, MA. p. 31.

Summarizing the Trends for Cost of Fire (+156%)



J.R. Hall Jr., *The total cost of fire in the United States*, 2012, National Fire Protection Association, Fire Analysis and Research Division: Qunicy, MA. p. 31.

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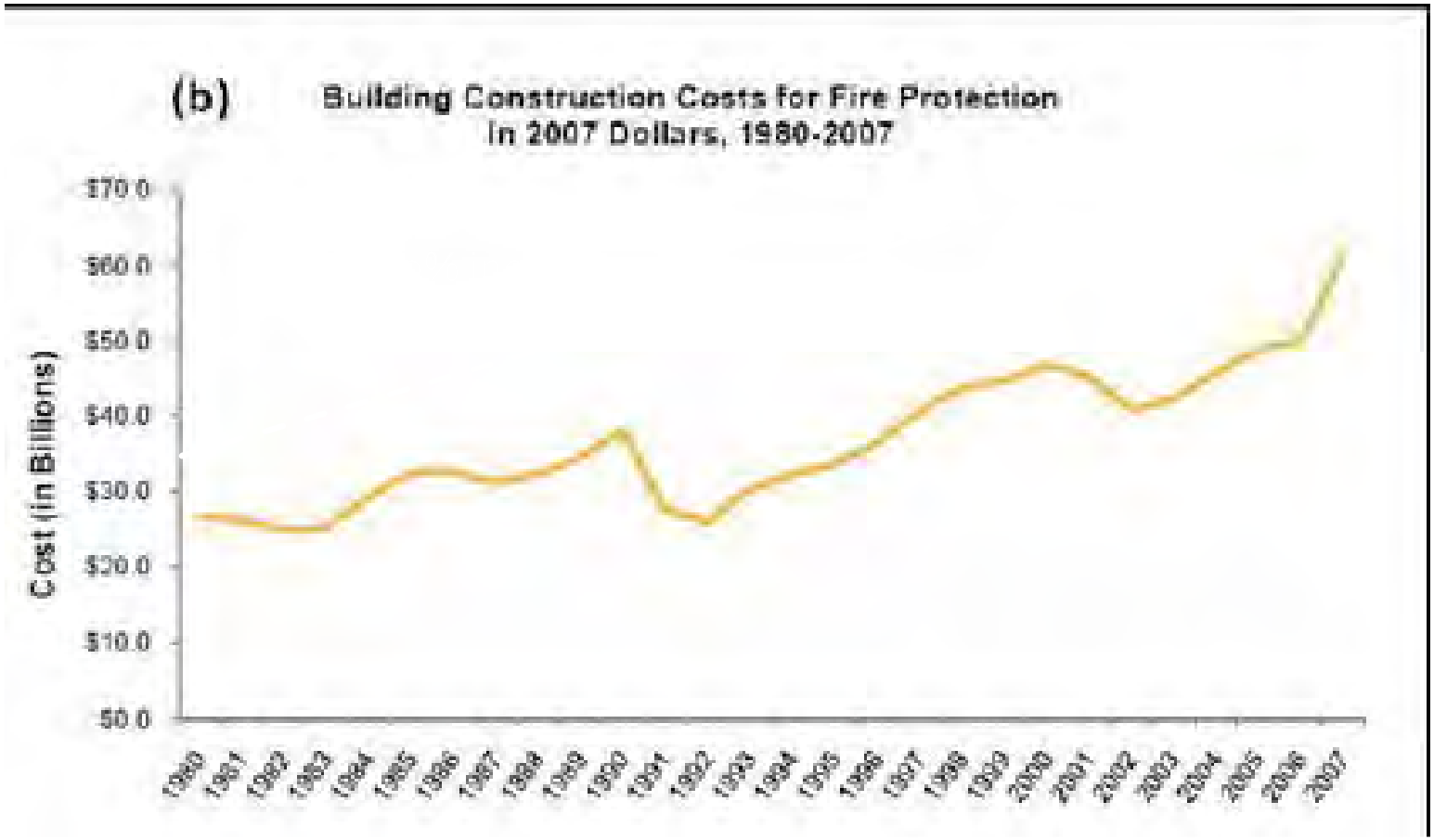
Summarizing the Trends for Cost of Fire (+130%)



J.R. Hall Jr., *The total cost of fire in the United States*, 2012, National Fire Protection Association, Fire Analysis and Research Division: Qunicy, MA. p. 31.

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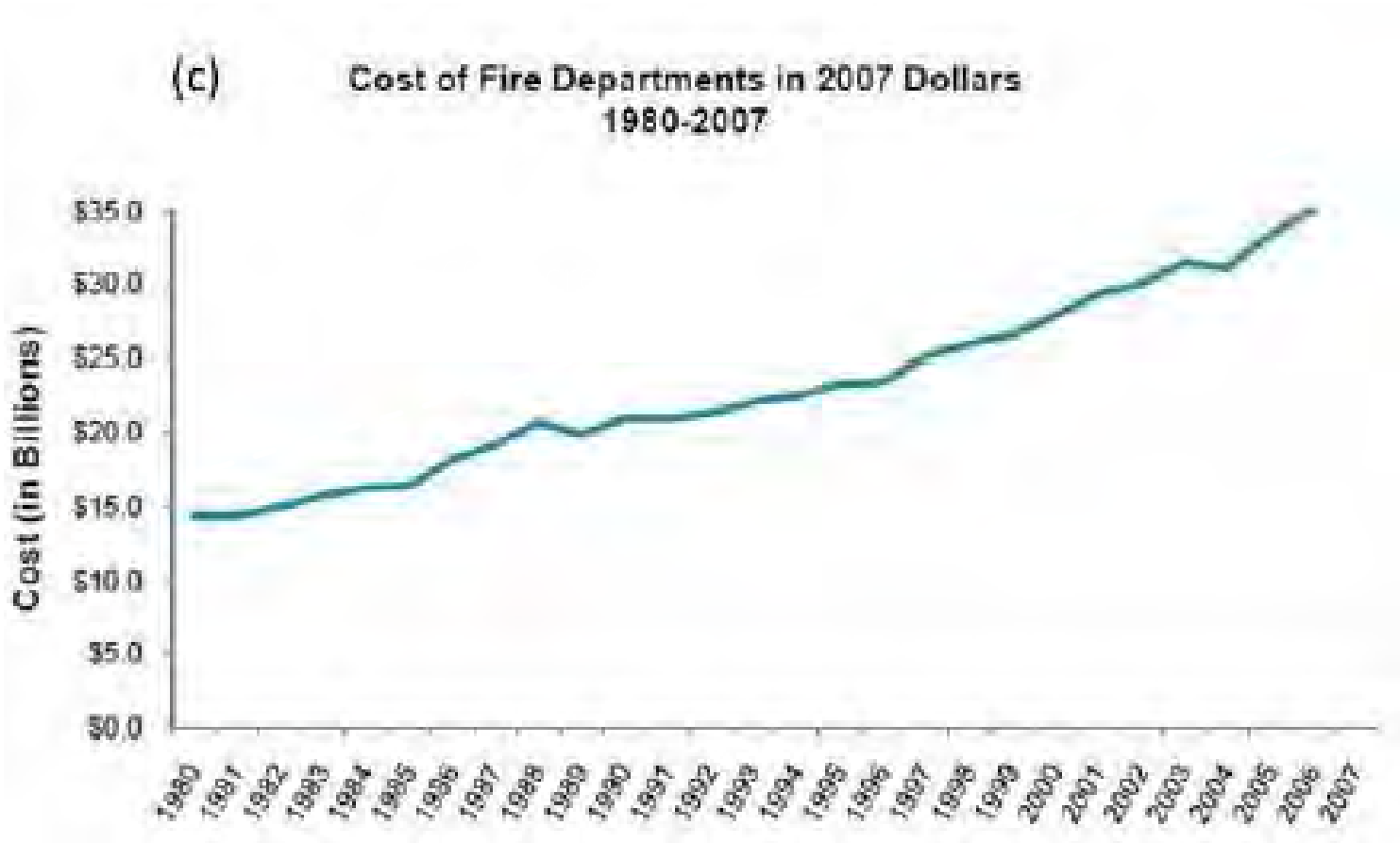
Summarizing the Trends for Cost of Fire



J.R. Hall Jr., *The total cost of fire in the United States*, 2012, National Fire Protection Association, Fire Analysis and Research Division: Qunicy, MA. p. 31.

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At What Cost Was the 13% Decrease?

- 156% increase in the cost of career fire department
- 67% increase in the net difference between fire-related insurance premiums paid and estimated insurable economic losses
- 130% increase in the costs of new building construction for fire protection
- "These building construction costs include passive protection, such as compartmentation, and active protection, such as detection and sprinkler systems"

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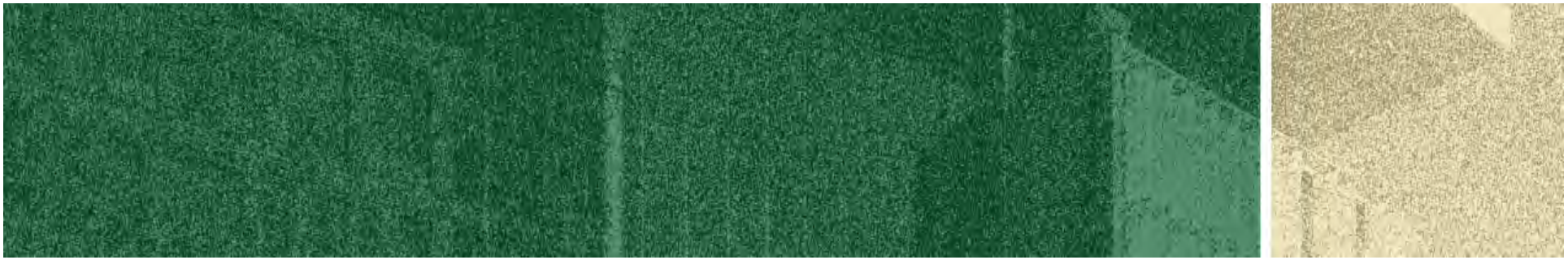

- **Hall discusses that these trends clearly indicate there is a need for product innovations and other programs (including education) that can simultaneously improve fire safety but at a lower cost.**

Questions?

len.garis@ufv.ca

(604) 543-6701

CITY OF SURREY