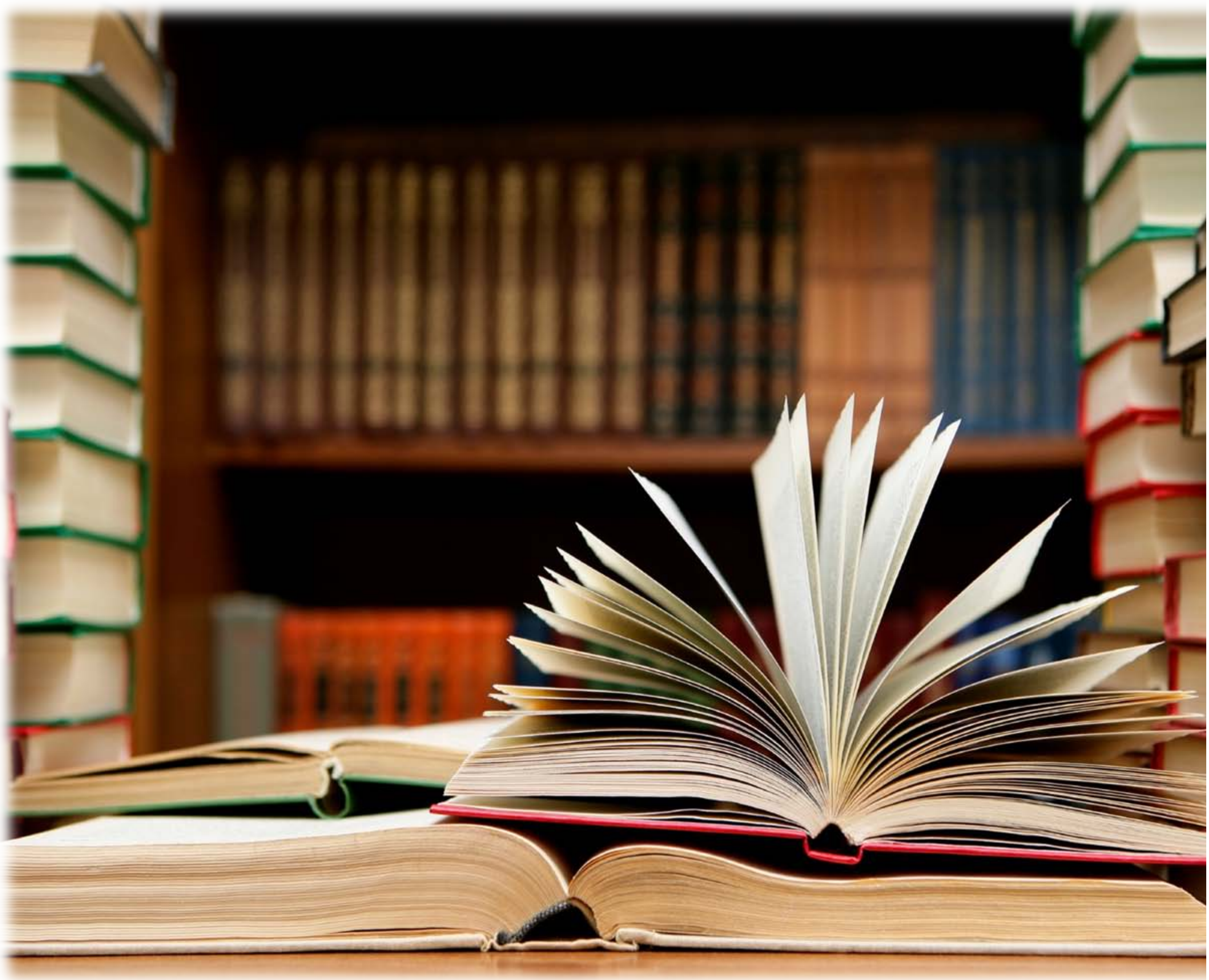
Evaluating Stakeholder Concerns with Wood Frame Buildings and Fire Risk

A Matter before the Ontario Legislature – Private Member's Bill 52, Ontario Forestry Industry Revitalization Act (Height of Wood Frame Buildings), 2012



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August 2012

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Executive Summary

1. This report evaluates the key stakeholder concerns with the proposed Ontario (ON) Private Member's Bill 52 – "Ontario's Forestry Industry Revitalization Act (Height of Wood Frame Buildings), 2012" (aka Bill 52): a matter that is currently before the Ontario Legislator.

2. The fundamental change to the provincial building code act that would be possible under Bill 52 would be to increase the maximum building height for wood frame buildings in ON to 6 storeys. The expected impacts, *inter alia*, include creation of jobs, increased availability of affordable housing, increased taxation density, and minimisation of the carbon footprint of building construction in ON.

3. Several key stakeholders within ON have raised a range of concerns towards the changes implicated by Bill 52, which largely focus on concerns with respect to the safety of the wood buildings that would be permitted under these proposed changes. These concerns are summarized within the report, and are responded to with respect to a range of information, including published proposals, research findings, analysis of fire incidents data, and case studies.

4. The proposed amendments implicated by Bill 52 are discussed with respect to similar changes that have already been implemented in 2009 to the British Columbia Building Code (BCBC). This demonstrates that Bill 52 is, in many ways, similar to the due process that has already taken place in BC, which has had immediate positive impacts on the local economy. Importantly, the process by which the BCBC was amended met similar expressions of concern and opposition within BC – a position from which the BC Fire Chiefs' Association has withdrawn.

5. The proposed amendments to the Ontario Building Code (OBC) under Bill 52 are also discussed, and it is explained that the proposed mid-rise wood frame buildings would be utilizing fire safety strategies that have already been demonstrated to be effective, and that implementation of the amendments under Bill 52 would mean that the new buildings would likely perform at least as well as the buildings that are currently permitted under the existing OBC. Furthermore, all proposed amendments to the OBC appear consistent with the intent of the National Building Code with respect to fire safety, and with current best-practice standards with respect to building egress.

6. A range of relevant research findings are discussed that cover fire simulation models, retrospective analysis of fire performance in mid-rise buildings, the significance of the timing of fire safety inspections for fire outcomes, the importance of the area of origin for fires that originate on balconies, the relevance of in-built fire safety systems (particularly sprinkler systems) for volunteer fire departments, examination of the fire services' perceptions of the safety performance of existing mid-rise wood frame buildings that have been in operation for many years, and the seismic response of wood frame buildings in the event of an earthquake. The summary finding across these studies is that they act to ameliorate the concerns raised towards Bill 52 with respect to life safety in the event of fire and seismic activity.

7. Two recent research reports are also discussed which make a case for an ideological shift for the fire service away from current norms and expectations with respect Fire Department costs and constantly building in higher levels of fire protection. Analysis of the overall costs associated with fire in the US reveal minimal reductions in dollar losses in the face of huge increases to the costs associated with fire departments and building construction costs. Furthermore, it is clear from effective fire prevention and operation strategies that the fire service needs to conceive itself as one component in a broader system, that needs to operate effectively and cohesively to reduce the risk of fire. Combined, these two studies call for innovation in order to cease the ever increasing cost of fire protection, with a view to simultaneously driving down costs and increasing the effectiveness of intervention for mitigating loss of property and life.

8. The researchers conclude by acknowledging that they are aware there are objections to the proposed Bill 52 in Ontario, largely stemming from perceptions within the fire service that these buildings will present significantly greater risk to life and property than those currently allowed under the existing building code. The researchers have examined these concerns and are unable to find evidence to substantiate these concerns.

Research Objectives

The purpose of this document is to analyze and address key concerns raised by the Ontario Office of the Fire Marshall, the Firefighters' Association of Ontario, and other key stakeholders who have responded to the Ontario Private Members Bill 52 – "Ontario's Forestry Industry Revitalization Act (Height of Wood Frame Buildings), 2012" (referred to as Bill 52 from this point onwards within this document).

The scope of this research exercise is as follows:

1. Analyzing all public documentation identifying concerns about Bill 52 and responding, wherever possible, to these concerns using evidence produced by:
    a. Published proposals regarding Bill 52,
    b. Relevant published research findings,
    c. Retrospective analysis of relevant fire incidents from BC, and
    d. Analysis of relevant case studies from areas that already have taller midrise combustible residential buildings.
2. Discussing the need for an ideological shift for the fire service towards (a) efforts to simultaneously improve fire safety while also stemming the ever increasing cost of fire protection, and (b) conceptualizing fire risk as existing within a system, comprised of building residents, building owners/responsible persons, and the fire service.

The Details of Bill 52

The exact content of the proposed Bill 52 is as follows [1]:

> **Bill 52 (2012) An Act to amend the Building Code Act, 1992 with respect to the height of wood frame buildings.**
>
> *Note: This Act amends the Building Code Act, 1992. For the legislative history of the Act, see the Table of Consolidated Public Statutes – Detailed Legislative History at www.e-Laws.gov.on.ca.Her Majesty, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:*
>
> *1. The Building Code Act, 1992 is amended by adding the following section:*
>
> **Wood Frame Buildings**
>
> ***Building code restriction, wood frame buildings***
>
> *30.1 (1) The building code shall not prohibit a building that is six storeys or less in building height from being of wood frame construction.*
>
> ***Same***
>
> *(2) For greater certainty, subsection (1) does not prevent the building code from,*
>
> *(a) imposing requirements on buildings of wood frame construction; and*
>
> *(b) prohibiting specified classes of buildings from being of wood frame construction.*
>
> ***Commencement***
>
> *2. This Act comes into force four months after the day it receives Royal Assent.*
>
> ***Short title***

3. The short title of this Act is the Ontario Forestry Industry Revitalization Act (Height of Wood Frame Buildings), 2012.

Explanatory Note

The Bill amends the Building Code Act, 1992 to provide that the building code shall not prohibit a building that is six storeys or less in building height from being of wood frame construction. This does not prevent the code from imposing requirements on or prohibiting specified classes of wood frame buildings.

At the time of writing this research note, following consideration by Ontario's Standing Committee on Regulations and Private Bills on June 6th 2012, Bill 52 has been ordered for Third Reading.

The Intent of Bill 52

At the time of producing this report, the Ontario Building Code (OBC) limits structural wood framing to buildings up to four storeys in height. The intention for Bill 52 is to amend the OBC to allow structural wood framing to be used in buildings up to six storeys in height. This is motivated by three broad factors:

1. A wish to increase demand for locally-sourced wood products in order to support the Ontario forestry sector.
   - As Nipissing MPP Vic Fedeli stated, "In the past several years, it is reported some 60 lumber mills have closed across the Northern Ontario, and 45,000 forestry jobs have been lost. Bill 52 is expected to have a reverse effect on this trend, and help re-start a revival in the forestry sector in Northern Ontario" [2].
   - Extending the construction of wood-frame buildings would increase domestic lumber demand, which would have a significant, positive impact on the economy. Fedeli [2] estimated this would result in 200,000 forest industry jobs and would stimulate 103 forest-dependent communities.
2. A desire to increase design/cost options for developers with the hope that this will facilitate increased construction [3].
   - There is a belief that taller wood framed buildings could provide more intensive land use within existing neighbourhoods, converting them into transit-supportive, pedestrian-oriented, affordable areas within cities.
   - Wood-frame buildings would reduce construction costs for mid-rise buildings by 12 to 15 percent, which would allow municipalities to build up instead of out [2].
   - "Market experts estimate that the mid-rise sector could represent 8 to 10 percent of the entire multi-storey market in Ontario in the next 20 years, up from 3 percent today [2012]. This bill will give wood-frame mid-rise buildings an opportunity to help meet that demand" [2].
3. The use of wood framing for a building has the potential to limit the extent to which construction impacts on the carbon footprint, as timber is a relatively low-energy intensive material to manufacture [4].
   - "Wood-frame structures contribute to Ontario's energy efficiency and conservation goals by sequestering more carbon than buildings made from concrete or steel" [2].

In short, the purpose of Bill 52 is to create Jobs, build affordable housing, provide for greater taxation density to communities, and reduce the carbon footprint of construction.

Summary of the Concerns towards Bill 52

Based on documentation provided to the researchers, the sources of concern about the proposed Bill 52 were generated by:

- The Canadian Institute of Steel Construction
- The Cement Association of Canada
- MasonryWorx
- The Fire Fighter's Association of Ontario
- The Ontario Office of the Fire Marshall
- The Ontario Association of Fire Chiefs'
- The Ontario Professional Fire Fighter's Association

The concerns raised were aggregated and can be broadly outlined as follows:

Process Concerns Raised

Science

- There is a concern that there is currently very little research evidence that would support these proposed changes. As a result, caution and time were argued for, to ensure there is a solid research basis for making these changes.

Harmonization

- It is argued that the proposed amendments to the OBC would be inconsistent with building code harmonization initiatives and past practices.
- There is also concern that a reliance on municipal bylaws to restrict construction height and type is inconsistent with the principle for a uniform provincial standard and is subject to Ontario Municipal Board appeals and external factors beyond the control of fire departments.

Consultation

- There is an assumption reflected in a number of consultation concerns that six-story combustible construction poses an increased risk for a number of reasons, including:
    - Capacity to respond to fire incidents at these types of buildings when (a) under construction, and (b) occupied.
    - A potential lack of cohesion and coordination between the Ontario Fire Code, the Ontario Building Code, and possibly occupational health and safety standards.
    - Capacity to undertake appropriate inspections of these new buildings.

Technical Issues Raised

Permitting Other Combustible Materials in Addition to Wood

- This concern focuses on the potential fire risks posed by structural and non-structural combustible materials (other than wood) that would be permitted under the proposed Bill 52 (e.g., combustible plastics). It is argued that these types of materials could significantly increase fuel loading.

Permitting Use of Engineered Wood Systems

- The concerns here can be summarized as:
  - A fear of rapid collapse of this type of light-weight wood framing when exposed to fire.
  - Increased risk over the life of the building due to damage, deterioration, and/or shrinkage of protective membranes.
  - Uncertainty as to the impact of cross laminated timber (CLT) on fire safety.

The Absence of an Overall Height Limit for the Construction

- The concern here is that the specifics of the building height limitations do not exclude combustible peaked roofs that potentially extend up to 2 storeys above the 18 metre sixth floor. The cause for concern here relates to potential equipment and accessibility challenges that this would pose for fire fighters.

The Absence of Sufficient Street Access Points for Fire Fighting

- The concern here is that the proposed Bill 52 only requires fire fighters have single street access to the main entrance of the building, which is considered to be insufficient.

Accessibility Concerns for Building Residents with Special Needs

- Due to building height and the shrinkage typically observed with wood construction, there is a concern that these buildings will pose accessibility challenges for some building residents (e.g., those with special needs and the elderly). This issue likely relates to the ability of all building occupants to successfully evacuate these types of buildings within the required time parameters.

The Absence of a Non-Combustible Exit Stairwell

- This concern relates to the potential for fire spread in exit stairwells. One source of this concern relates to the importance of stairwells as a staging area for firefighting operations.

Issues with Combustible Cladding and Roofing Systems

- The concern here is that the propose Bill 52 would allow for combustible cladding and roofing, which would greatly increase the probability of structural ignition as a result of interface fires, which could climb to the roof space of the building.
- The concerns here also cover the proximity between structures, and the impact that this would have due to radiant heat transfer and fuel load.

Concerns about the Capacity for All Fire Departments to Conduct Effective Operations

- These capacity concerns take a number of forms:

- It is argued that the additional height of these buildings is likely to prevent rural fire services from having sufficient time to conduct search and rescue in the event of a fire.
- Rural fire services may have to travel significant distances to fire incidents, significantly impacting response times.
- Rural fire services may not have appropriate equipment (ladder trucks, water pressure, etc.) and personnel to suppress fires on the upper-levels of these buildings.
- The proposed requirement for 1 hour floor fire separations in these combustible occupancies is a significant reduction in standard from the current requirement for 2 hour floor fire separations for 6-story, sprinklered, non-combustible buildings. This issue is believed to have the greatest significance for municipalities protected by volunteer fire departments, due to the increased time required for volunteers to respond to fire incidents.

Concerns about Training and Education

- The concern here is motivated by a perception that existing training and education standards will likely be inadequate for:
  - Construction processes for these proposed buildings.
  - Fire code changes.
  - Fire safety inspection staff – It was suggested that additional funding would be required to manage the increased inspections workload that would result from these buildings, both during and post-construction.
  - Pre-fire planning, and fire safety during and post-construction.
  - Any necessary amendments to firefighter standard operating procedures.
  - Firefighter education with respect to fire science and building construction.

General Concerns about Quality of Workmanship

- General concerns were raised with respect to building processes such as fire stopping, fire separations, issues of poor workmanship, and the integrity of the membrane protection during the life cycle of the building.

Concerns about the Moisture Content of the Wood

- Concerns here relate to the potential impact of transportation, site storage, and construction conditions on the wood products that will be used, with the potential that they may not always be in a condition as intended by their grading.

Concerns about the Likely Increase to Insurance Costs in these Types of Construction

- This concern relates to building integrity issues that may arise following a major fire incident, including water damage, mould, and mildew. In the event of these types of issues, it is unclear how long buildings would be uninhabitable for, and the extent of work that would be required to repair this damage could result in increases to insurance costs.

Concerns about the Lack of Information into the Impact of Seismic Activity on 6-Storey Combustible Construction

- It was suggested that no research into the impact of seismic activity has been conducted for buildings over 20 metres in height. It was also suggested that no research has been undertaken on seismic activity affecting a single building level.

Section Summary

The concerns raised are in many cases written on the basis of certain assumptions regarding the various fire protection features (or lack thereof) of the buildings that might be designed under the new Bill. Currently, the Bill 52 proposal makes no specific reference to detailed fire protection requirements that might otherwise apply. Thus, it is questionable whether some or even all of these concerns will be applicable in the end, and will depend upon the eventual code wording describing the specific acceptable solutions.

Interestingly and unsurprisingly, these locally-focused concerns largely mirror those summarized in Section 2.1 "Preliminary Survey of Industry Preconceptions" of the February 2012 report prepared by Equilibrium Consulting [4] entitled, "The case for tall wood buildings: how mass timber offers a safe, economical, and environmentally friendly alternative for tall building structures."

From this point onwards, the report will present additional information that relates to the concerns outlined, above. This will include an analysis of the British Columbia Building Code (BCBC) [5] with respect to 6-storey wood frame buildings, analysis of the 2011 proposed changes to the Ontario Building Code (OBC), and an overview of relevant published research findings.

Building Code Amendments in BC and Proposed Amendments in Ontario

From review of the comments and concerns outlined above, there are a broad range of issues around the uncertainly of the technical requirements for the proposed amendments. In order to respond to these, this section outlines the requirements that were implemented when amendments were made to the British Columbia Building Code (BCBC), corresponding specifications as they stand under the British Columbia Fire Code (BCFC), and the 2011 proposed potential changes to the OBC that were published by the Province of Ontario, Ministry of Municipal Affairs and Housing [6].

BCBC – Amendments to Manage Mid-Rise Wood Frame Construction

Provisions were made to the BCBC that were enacted by Ministerial Order in January, 2009, and came into effect in April, 2009. These amendments are summarized online by the Office of Housing and Construction Standards [7]. Essentially, these provisions allowed for mid-rise residential buildings of wood construction up to 6 storeys in height. The amendments to the BCBC involved alterations to *Related Undertakings* involving sprinkler protection, energy efficiency, occupancy, local government, and education/training. In addition to this, there were a range of specific new code provisions concerned with building height, combustibility of cladding, earthquake load and effects, configuration of timber shear wall systems, fire doors in public corridors, and issues focused on shrinkage of wood in structural designs. Some of the specific amendments include:

- Sprinkler protection to NFPA 13, i.e., sprinklers in crawl spaces, concealed spaces such as attics, and all combustible balconies and canopies.
- Standpipes located in exit shafts.
- A one hour fire resistance rating throughout.
- Non-combustible exterior cladding, limited combustible cladding (CAN/ULC-S134), or fire-retardant-treated wood cladding.
- Building height is less than 18 m between grade and upper most floor level of the top storey.

BCFC – Amendments to Manage Mid-Rise Wood Frame Construction during the Construction Stage

Owners and contractors are required to comply with the requirements of the BCFC (5.6) (development, implementation and maintenance) [8] of an approved fire department construction fire safety plan that applies to construction and demolition sites. To this end, the Surrey Fire Service has produced a safety plan bulletin that provides a detailed overview of the components of an effective strategy to managing these buildings during these vulnerable phases [9].

The Impact of the BCBC Amendments and the Genesis of the BC Fire Chiefs' Association Position on these Structures

As Fedeli explains [2], these amendments to the BCBC have had immediate positive impacts for the BC economy:

> *BC enacted the Wood First Act in 2009, and fast-tracked changes to its Building Code in 2009 to allow wood-frame construction up to six storeys. Since then, 11 projects have either been completed or are under construction, 98 projects are at the design, permit, or construction stage, and the BC Government has recently issued a request for proposal for a 10-storey wood-frame building. On a market scale, introducing a wood-frame option has made building mid-rise structures considerably more cost-effective.*

It is also important to briefly outline the genesis of the position that the BC Fire Chiefs' Association (BCFCA) has taken towards these 6-storey wood frame structures. In response to the suggested amendments to the BCBC to enable mid-rise wood-frame construction to proceed in BC, the Fire Service Liaison Group (FSLG) released a positional statement. The FSLG is "comprised of the five associations whose members are directly involved in fire service delivery in the province of BC – Fire Chiefs' Association of BC, Volunteer Firefighters' Association of BC, BC Fire Training Officers; Fire Prevention Officers' of BC; Professional Fire Fighters' Association of BC, and a representative of the Union of BC Municipalities" [10] and this positional statement took the form of a document entitled *Fire Service Liaison Group comments re: amending BC Building Code to allow for 6 story wood-frame construction*. To summarize the positional statement content, the major concerns raised included:

- Potential for shrinkage in the thickness of floor joists, which tends to compound with each additional storey;
- The time required to escape higher buildings during a fire incident will increase with the aging population;

- The different set of firefighting tactics required to combat high-rise structure fires;
- The equipment challenges associated with reaching balconies if they are higher than 3 stories from the ground;
- The equipment challenges associated with availability of infrared cameras to detect hotspots in wall cavities should a fire spread beyond the room or floor of origin; and
- The resourcing concerns with respect to level of service required to respond to an incident in a mid-rise wood-frame building;

It was also expressed within the FSLG document that, "it is an issue of more property loss and greater risk for occupants and firefighters in the event of fire, as wood is more combustible than concrete and steel" [10: 3]. This concern was expanded to encompass the potential for exposure to civil litigation should a fire department not perform interior attacks on fires in high-rise constructions, while facing the prospect of being under-resourced, under-trained, and-under staffed to address these incidents in a safe manner. When addressing the viability of such proposed changes to the Building Code, the FSLG report restates the position of Sean Tracey, who at the time of comment was the Canadian Regional Manager, NFPA, in suggesting that "a worst case scenario in analyzing the fire scenarios must be used. The building proposal must assume that the building will be constructed in a community with a volunteer response with limited resources and training" [10: 4]. The FSLG paper concluded by stating the two key items of concern from their perspective involved "mandatory inspections of buildings in regional [BC] and the ability for local governments to implement sprinkler bylaws in their jurisdictions" [10: 6]. Overall, the major concerns can be summarized with respect to:

(a) Fire risk, with the assumed greater risk that these buildings necessarily pose;

(b) Resourcing strain, with an emphasis on the 'worst-case scenario' involving a high-rise construction fire in a community with a volunteer department that has limited resources and training, and

(c) Infrequent approaches to fire safety inspections and the maintenance of safety systems, based on the known variation to fire safety inspection across BC. There is also some reference to the increased risk of these buildings during the construction phase.

This initial position statement from the BCFCA motivated a review of the differential fire performance of existing wood framed, multi-residential buildings as a function of their sprinkler protection status (completely protected vs. completely without protection). This analysis initially examined fires that occurred in Surrey, BC, and then expanded to examine the entire BC provincial database over a 5-year period [11]. The findings of this review are discussed below. The end result of this review process has been the withdrawal from the initial position adopted by the BCFCA, in favour of ongoing construction of these mid-rise wood frame buildings provided they comply with the additional safety requirements specified under the amended BCBC.

OBC Mid-Rise Wood Frame Construction – Potential Changes

Current provisions for Code requirements in Ontario that would be maintained as a minimum following the implementation of Bill 52 include [6]:

- One hour fire separations (e.g., between residential suites and around fire exits).

- Fire hose cabinets and standpipes to the NFPA 14 standard.
- Two means of exiting.
- Fire detectors in exit stairs and corridors.
- Smoke alarms in apartments.

In addition to these existing minimum code requirements, the Ontario Ministry of Municipal Affairs and Housing has released details of the potential changes to the OBC that may be implemented should the proposed six-storey structures be permitted. Unlike the BCBC amendments, which primarily address residential occupancy, the proposals in Ontario would allow for wood buildings up to six storeys in height of residential, office, and mercantile occupancies. These six-storey wood buildings would also be available for "mixed use" (a combination of residential and mercantile/office use). The OBC proposed changes would also allow wood construction to be constructed on top of one and two storey concrete construction ("podium portion" of a building) to a maximum of six storeys. This proposal is highly similar to the wood frame construction that already exists in Seattle, WA, USA. "Consistent with the [OBC]'s objectives of fire safety and structural sufficiency, potential changes to allow six storey wood frame buildings would have to meet all the requirements of four storey wood frame buildings plus a number of additional measures" [6]. As detailed by the Ontario Ministry of Municipal Affairs and Housing [6], the proposed amendments would include:

- Limiting building height to 18 meters between the average grade and the floor level of the top story.
- A more stringent fire sprinkler standard (NFPA 13 versus NFPA 13R), resulting in greater installation of sprinklers in concealed spaces such as crawl spaces and attics, as well as mandating sprinkler protection of all combustible balconies and decks covered with a roof.
- Limitations on exterior cladding combustibility or all exterior walls in addition to those walls near or at property lines, in accordance with the current code requirements for non-combustible sprinkler-protected buildings up to six stories.
- Clarification of fire blocking requirements in concealed spaces and crawl spaces, which will apply to all buildings subject to NFPA 13 requirements.
- Increased structural load factors and a requirement for the alignment of shear walls resisting horizontal loads.
- Clarification that a large building divided into smaller buildings by fire walls must have fire department access to each of the smaller buildings.
- Guidance on the proper design and construction of fire rated assemblies.
- Addressing potential wood shrinkage after construction in order to take into account matters potentially affected by wood shrinkage, e.g. continuity of fire separations, etc.

Under the existing OBC, there is a maximum building area and a maximum gross floor area for four storey wood frame buildings. Following the implementation of Bill 52, the maximum gross floor area that currently applies to four storey wood frame construction would continue to apply to six storey wood frame buildings.

Ontario Ministry of Labour – Managing Mid-Rise Wood Frame Construction during the Construction Stage

Rather than being under the jurisdiction of the Ontario Office of the Fire Marshal (OFM) and enforced by the fire services, construction site safety is regulated by the Ontario Ministry of Labour – under the Occupational Health and Safety Act (OHSA) there is a complete regulation for construction projects – and it is enforced by the Ministry of Labor's inspectors. Fire safety provisions are included in the many topics covered by the regulation. In addition to this, if the proposed changes outlined in Bill 52 are adopted, the Ontario Professional Engineers Act and the Ontario Architects Act both require that these buildings be designed by an engineer or an architect.

The Intent of the National Building Code with Respect to Fire Safety

The 2010 National Building Code of Canada (NBC) "addresses the design and construction of new buildings and the substantial renovation of existing buildings" [12]. This is an objective-based code format, with all requirements linked to at least one of the following four objectives:

- Safety
- Health
- Accessibility
- Fire and structural protection of buildings

With respect to Safety and of relevance to the current research question, the NBC lists the following objectives [12]:

> *An objective of this Code is to limit the probability that, as a result of the design, construction or demolition of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury.*
>
> ***OS1 Fire Safety***
>
> *An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to fire.*
>
> ***OS2 Structural Safety***
>
> *An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to structural failure.*
>
> ***OS3 Safety in Use***
>
> *An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to hazards.*
>
> ***OS4 Resistance to Unwanted Entry***
>
> *An objective of this Code is to limit the probability that, as a result of the design or construction of the building, a person in the building will be exposed to an unacceptable risk of injury due to the building's low level of resistance to unwanted entry.*

OS5 Safety at Construction and Demolition Sites

> *An objective of this Code is to limit the probability that, as a result of the construction or demolition of the building, the public adjacent to a construction or demolition site will be exposed to an unacceptable risk of injury due to hazards.*

With respect to Fire and Structural Protection of Buildings, the NBC specifies the following objectives [12]:

> *An objective of this Code is to limit the probability that, as a result of the design, construction or demolition of the building, the building or adjacent buildings will be exposed to an unacceptable risk of damage due to fire or structural insufficiency, or the building or part thereof will be exposed to an unacceptable risk of loss of use also due to structural insufficiency.*

OP1 Fire Protection of the Building

> *An objective of this Code is to limit the probability that, as a result of its design or construction, the building will be exposed to an unacceptable risk of damage due to fire.*

OP2 Structural Sufficiency of the Building

> *An objective of this Code is to limit the probability that, as a result of its design or construction, the building or part thereof will be exposed to an unacceptable risk of damage or loss of use due to structural failure or lack of structural serviceability.*

OP3 Protection of Adjacent Buildings from Fire

> *An objective of this Code is to limit the probability that, as a result of the design or construction of the building, adjacent buildings will be exposed to an unacceptable risk of damage due to fire.*

OP4 Protection of Adjacent Buildings from Structural Damage

> *An objective of this Code is to limit the probability that, as a result of the design, construction or demolition of the building, adjacent buildings will be exposed to an unacceptable risk of structural damage.*

The Intent of Current Safety Systems with Respect to Building Egress

The US National Institute of Standards and Technology (NIST), which is one of the oldest physical science laboratories in North America, explains that:

> *Currently, systems are designed around an antiquated concept of providing stair capacity for the largest occupant load floor in the building with little or no consideration of occupant behavior, needs of emergency responders, or evolving technologies [13].*

To address this issue, NIST is developing a:

> *[T]echnical foundation for egress provisions that eliminates egress design as a contributor to fire deaths and minimizes the total social cost of the provisions. This includes collection of data from building evacuations, human behavior research, and egress model evaluation [13].*

The range of topics that NIST is covering include:

- Design and construction of building exits
- Building occupant evacuation data
- Occupant behaviour
- Infrastructure of building egress

- Use of elevators during fire emergencies
- Review of building egress models

Although the NIST website does provide links to the progress made in this area to date, at the time of writing this report, this research does not provide definitive direction that would suggest anything about the proposed Bill 52 contradicts the current best-practices with respect to managing building egress.

Significance of these Potential Changes for the Concerns with Bill 52

Overall, therefore, the proposed changes in Ontario share a great deal of commonality with the changes that have already been implemented in BC. Overall, the proposed OBC changes include fire safety strategies that have been proven to be effective. Implementation of these suggested amendments would mean that these buildings would likely perform at least as well as buildings currently permitted under the existing building code. These strategies include:

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

In reference to the technical concerns identified with the proposed Bill 52, discussed above, these proposed amendments appear to alleviate some and refute others. First, the concerns about the combustibility of cladding and roofing systems are not substantiated from inspection of the proposed amendments. Next, with respect to combustibility of stairwells and moisture content of wood/quality of workmanship, it appears that there will be provisions in the amended OBC to ensure these are not issues.

Relevant Research Findings

This section provides an overview of a series of research findings that have direct relevance to the concerns that have been identified with respect to Bill 52. In broad terms, the following topics will be examined, and their relevance to the concerns outlined above explained:

- Outcomes from National Research Council simulation modeling that explored the impact of fire sprinklers on life safety.
- Findings from retrospective analysis of a large number of relevant fires in BC that examined (a) the impact of sprinkler systems on fire outcomes in multi-residential buildings, (b) the relationship between fire safety inspections and fire outcomes, and (c) the significance of the area of fire origin in multi-residential buildings for fire outcomes.
- The lessons-learned from two case studies: (a) from a volunteer fire department (Pitt Meadows, BC), which examined the impact of sprinkler systems on the required response times for the local volunteer fire service, and (b) from Seattle, WA, looking at the performance of fire and safety systems in existing mid-rise wood frame buildings.

- The outcomes of controlled, shake-table research that examines the structural performance of wood frame buildings in response to extreme seismic activity.

Fire Simulation Models and the Impact of Sprinklers on Life Safety

The National Research Council of Canada has developed a fire simulation model, FiRECAM™ (Fire Risk Evaluation and Cost Assessment Model), which is described as follows [14]:

> *FiRECAM™ (Fire Risk Evaluation and Cost Assessment Model) is a computer program that can be used to assess the level of fire safety that is provided to the occupants in an apartment or office building by a particular fire safety design. In addition, the model can assess the associated fire costs that include capital expenditures, maintenance of the fire protection system and expected fire losses. By comparison to the explicit or implied performance of a building code-compliant design, the model can assess whether a proposed design meets the performance requirements, or is equivalent or better in life risk performance to the building code-compliant design. This allows a designer to identify cost-effective fire safety designs that provide at least the required level of fire safety.* [1]

In order to evaluate fire risk and fire loss, this simulation tool models a range of ignition points in a building, and considers the way that the fire would develop, how smoke and fire would spread, what the likely building occupants' responses would be, and the likely fire department response [15]. With respect to the relationship between residential sprinkler systems and life safety, two FiRECAM™ studies have revealed modeling results that are directly relevant to the concerns raised in response to the proposed Bill 52. These relate to fire department response times and to the loss and damage associated with fires, both with and without sprinkler protection.

Impact of Fire Department Response and Mandatory Sprinkler Protection on Life Risks

A report by Bénichou and colleagues [16] from the National Research Council of Canada used FiRECAM™ to examine the significance of sprinkler protection and fire department response time on the level of fire safety building occupants experience in a 3-storey apartment building. The findings of this analysis with respect to relative expected risk to life are displayed in Figure 1, below (reproduced exactly from Bénichou *et al.*'s paper).

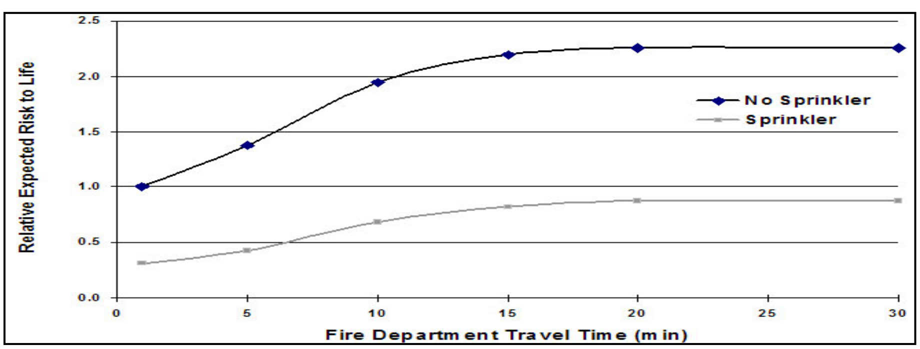

Figure 1. Relative expected risk to life as a function of fire department travel time and with and without sprinkler protection (replicated from [16] – Figure 7 in the original publication)

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[1] FiRECAM™ is a research tool and its use in supporting a design for regulatory approval is in no way endorsed by the Canadian Commission on Building and Fire Codes or by the Canadian Codes Center. Acceptance of the results obtained using this tool is entirely up to the Authority Having Jurisdiction.

As can be seen, the results of the FiRECAM™ simulation in this case demonstrates that, "the provision of sprinkler protection and the existing fire department response time (i.e., no new fire stations) provides a level of fire safety that is better than the case without sprinkler protection but with a shorter fire department response time (i.e., with new fire stations)" [16].

Impact of Sprinkler Protection and Fire Resistance Rating of Assemblies on Life Risks

In 2003, Hadjisophocleous published the outcomes of a study undertaken in partnership between Robidoux and Associates and the National Research Council of Canada, working on behalf of the American Forest and Paper Association [15]. This study involved the use of FiRECAM™ to evaluate the impact of sprinkler protection and fire resistance ratings of building assemblies on the relative expected risk to life for fires in a typical four-storey multi-family building.

FiRECAM™ was used to calculate the relative expected risk to life and expected losses for five different options:

1. 60-minute wall/floor/ceiling assembly without automatic fire sprinklers,
2. 60-minute wall/floor/ceiling assembly with automatic fire sprinklers in accordance with NFPA 13R,
3. 45-minute wall/floor/ceiling assembly with automatic fire sprinklers in accordance with NFPA 13R,
4. 60-minute wall, 45 minute floor/ceiling assembly with automatic fire sprinklers in accordance with NFPA 13R, and
5. 30-minute wall/floor/ceiling assembly with automatic fire sprinklers in accordance with NFPA 13R.

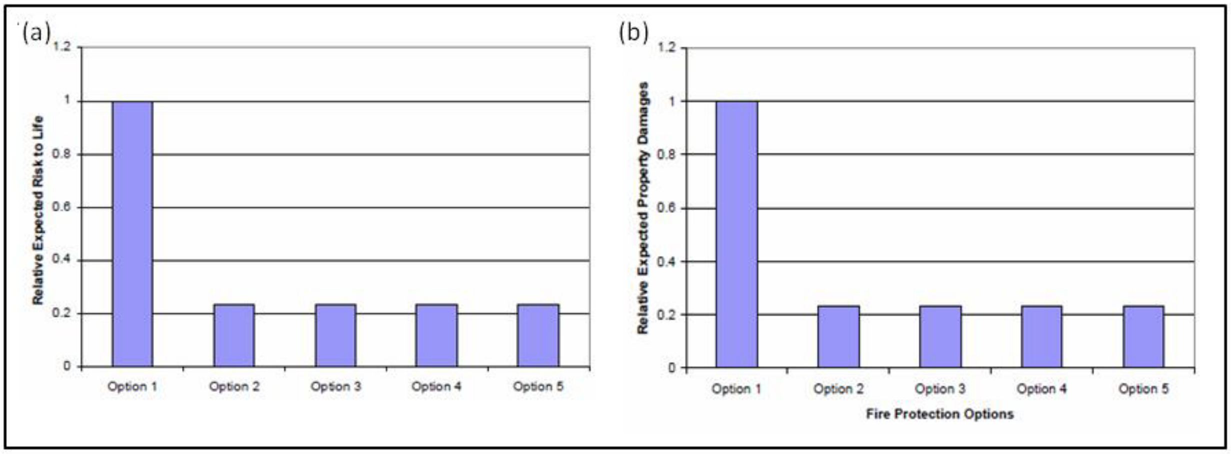

Figure 2. Relative expected (a) risk to life values, and (b) property damages for the five modeling options (replicated from Hadjisophocleous, 2003, Figure 2 and Figure 3, respectively)

Overall, as can be seen from Figure 2, regardless of the fire resistance rating of the building materials, this modeling indicates that providing there is a sprinkler system in the building reduces the risk to life to about 23 percent of the risk within the same building without sprinklers. Hadjisophocleous explains that these potential life savings are comparable to actual observed differences in casualties in the USA and Australia, where statistics demonstrate a death rate of 9 fatalities per 1,000 fires for apartment buildings without sprinklers and 2.7 fatalities in buildings with sprinklers. BC data also demonstrated a similar magnitude of difference [11]: 21.1 deaths per 1,000 fires in multi-residential buildings without sprinklers compared to 1.8 deaths per 1,000 fires in buildings with sprinkler protection. In addition to this, the modeling results also demonstrate a significant reduction in property losses for buildings that have sprinkler systems.[2]

Sprinkler Systems and Fire Outcomes in Multi-Level Residential Buildings in BC

Garis and Clare evaluated 1,942 fire incidents that occurred in BC between October 2006 and October 2011 [11].[3] Cases were analyzed if they occurred in apartment/townhouse structures that were either completely protected by sprinklers or completely without sprinkler protection. The key findings from this research are:

- Due to variations in the nature of size and spread of the fire, it was not always the case that the sprinkler system was required to activate to control the fires in buildings with sprinkler protection. It is important to emphasize that this does not reflect a failure of the sprinkler system as there are a range of broad types of fire control mechanisms, including burn-out, removal of fuel, use of make-shift aids, and use of hand-held extinguishers, which could be employed to prevent the fire expanding to the extent that the sprinkler system would activate.
- As a result of these factors, the sprinkler protection systems were only required to control fires in buildings with sprinkler protection for 21.6% (n = 122) of the fire incidents. In addition to this, the Fire Department was required significantly less often to control fires in buildings with sprinklers (19.5% of fires, compared to 39.0% in buildings with no sprinkler protection). Furthermore, when the Fire Department did respond to fires in buildings with sprinkler protection, significantly fewer resources were deployed, with multiple hose lines utilised in only 3.9% of cases, compared with 14.4% of cases in buildings without sprinklers.
- The 21.6% of fires in buildings with sprinklers that were controlled by the sprinkler systems **never extended beyond the floor of origin**, and were contained to the room of origin 96.2% of the time. In comparison, 18.8% of the fires in buildings without sprinklers extended beyond the room of origin, and 12.7% extended beyond the floor of origin.
- Death and injury were significantly less frequent in buildings with sprinklers. The odds of a fire-related death in a building without sprinkler protection (21.1 deaths per 1,000 fires) was 11.9 times greater than for fires in sprinkler protected buildings (death rates of 1.8 deaths per 1,000 fires).[4] Similarly, the odds of a fire-related injury in a building without sprinkler protection (127.1 injuries per 1,000 fires) was 2.9 times greater than for fires in sprinkler protected buildings (44.2 per 1,000 fires).
- Career and composite Fire Departments responded to 96.8% of these fire incidents. There was no indication of a rural/urban distinction in the performance of sprinkler systems, as fires in sprinkler protected buildings responded to by volunteer/paid-on-call and unclassified fire services were contained to the room of origin 100% of the time.

[2] The economic calculations do not consider the additional cost for the installation and maintenance of the sprinkler systems.

3 Full report available for download at: http://www.ufv.ca/Assets/CCJR/Reports+and+Publications/Research+Note+Series+-+Sprinkler+Systems+and+Fire+Outcomes+2012.pdf

[4] None of these fatalities were firefighters.

Relationship between Timing of Fire Safety Inspections and the Outcomes of Fire Incidents

Garis and Clare undertook a recent evaluation of 4,084 fire incidents that occurred in BC between 1999 and 2003 [17].[5] The purpose of this study was to explore the relationship between the most recent fire safety inspection that occurred at each property and the outcome of the fire incident (with respect to property loss and fire-related casualty). The key findings from this research are:

- The majority of fires (74%), injuries (81%), and deaths (74%) occurred within 1 year of the most recent inspections. The frequency of all of these declined with duration between inspection and fire event, up until the inspection was over 36 months prior to the fire. There was no meaningful distinction between the duration since last inspection and the frequency of fires at residential and non-residential properties.
- The timing of the most recent inspection did not influence the extent of fire spread. For those buildings that were inspected on a regular basis (at least once every 3 years), the timing of inspection (greater or less than every 12 months) had no significant effect on the extent of fire spread.
- For the 335 injuries included in the dataset, the injury rate per 1,000 fires was significantly greater for residential properties compared to non-residential ones. When looking within these occupancy classes, there was no indication that the rate of injury increased as a consequence with the duration between most recent inspection and fire incident. In fact, the only indication was the counter-intuitive finding the injury rate per 1,000 fires declined for those fires that occurred more than 1 year after the most recent inspection.

This research **was not** intended to suggest that fire safety inspections should not be done. Instead, the purpose of this research was to demonstrate that elapsed time since last inspection does not seem to influence fire outcomes with respect to extent of fire and fire related casualty.

Significance of Area of Origin of Fires that Commence on Balconies of Multi-Residential Buildings

Garis and Clare [18] are currently completing an analysis of the significance of the area of origin for fires that commence on balconies of multi-residential buildings. A sample of BC data was examined, which looked at residential structure fires in multi-residential buildings that occurred between October 2006 and October 2011 (n = 1,942 fires). For the purposes of this analysis fires that occurred in an "outside area" of the building ("court/patio/terrace area" and "exterior balcony," n = 165 cases) were compared with fires that occurred in all other locations (n = 1,777 cases).

Regardless of whether buildings were protected by sprinkler systems or not, the following relevant patterns were observed:[6]

- With respect to how fires were initially detected, fires that commenced on the outside area of interest were 7.4 times less likely to be detected by a smoke alarm, and were 1.5 times more likely to be detected by visual sighting.

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[5] Full report available for download at: http://www.ufv.ca/Assets/CCJR/Reports+and+Publications/Fire_Safety_Inspections.pdf

[6] All differences discussed here were statistically significant, $Z > |1.96|$.

- With respect to the extent of fire spread, fires originating in these outside areas were 2.4 times as likely to extend to the entire building and beyond the property as those that originated elsewhere.
- With respect to the method of fire control, fires that started in these outside areas were 1.5 times more likely to require fire department intervention to control the situation. Simultaneously, fires that did not occur in these outside areas were 5.2 times more likely to burn out on their own and were 3.7 times more likely to have been controlled by sprinklers.

Overall, this analysis revealed that fires that originated from either "court/patio/terrace area" or "exterior balcony" areas outside of the building were:

- More likely to have required visual sighting or personal detection (vs. smoke alarm).
- More likely to have extended to the building and beyond.
- More likely to have required the fire department to extinguish the fire.

Case Study: A Volunteer Fire Experience, Pitt Meadows Fire Department, BC

With strategic vision in the early 1990s, Pitt Meadows Volunteer Fire Department worked in partnership with the local council to implement a local sprinkler bylaw that required sprinkler systems to be installed in all new residential construction in the area [19]. This was done to achieve the best protection for the residents in the most cost effective manner possible. The outcomes of this process indicate significant reductions in extent of damage. One specific case study that is supportive of this contribution is outlined below [20: p.15]:

> *The Fire Department attended 12020 Harris Road to an apartment fire on January 16, 1992, at 01:15 hours. The occupant and his son had gone to bed at about 11:00 hours and left a large ham simmering on the stove. At 01:00 hours the pot boiled dry and the grease from the ham ignited and flashed over the ceiling of the kitchen, activating the sprinkler which in turn extinguished the fire. The sprinkler system not only alerted the residents of the suite, it activated fire alarm bells to ring throughout the building alerting all other tenants. The sprinkler system also summoned the Fire Department. The Fire Department arrived with twenty-two fire fighters to find the fire extinguished; all that was required for them to do was to shut off the sprinkler system and vacuum the water from the suite. (An interesting point in this incident is that the smoke alarm in the suite of the fire had been disconnected by the occupant as he frequently had false alarms due to his cooking habits.) The Fire Department was able to return 18 fire fighters within eighteen minutes after arriving to the fire, while another four fire fighters stayed for restoration purposes for another two hours. Typically, this type of incident would have taken all night, leaving the occupants without a home and possibly without life. The Fire Department believes that the effectiveness of sprinklers in terms of the life safety (for civilians and fire fighters), reduced manpower requirements, apparatus, and fire department growth, more than justifies the cost of installation of sprinklers.*

Case Study: Seattle Fire Service, WA

In order to examine the impact of 6 storey multi-residential wood frame buildings from another perspective, the authors contacted the Seattle Fire Department (WA), as this is an area that has allowed construction of these types of structures for twenty years. In response to the concerns surrounding this issue, the two responders provided the following summaries:

Seattle Deputy Fire Chief Fire Marshal

Following comments might be helpful, most from our Senior Fire Protection Engineer. Wood Frame Apartment Buildings are allowed to be 5 stories per Seattle Building Code when fully sprinklered per NFPA 13. Although classified as 5 stories, you can stack it on top of type one construction (basements / pedestal with three hour separation. When built on a slope this can look like a 7 or 8 story buildings where multiple basements are provided. They are fully sprinklered , all wood is covered with 5/8 type x gwb for a one hour rating, have stand pipes, fire alarms, exits, access, and not more than 75 feet to the highest level. 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. In one case, an occupant attempted to commit suicide by igniting a couch with gasoline and had more than one container of gas in the room – the occupant was burned but the fire was controlled by a sprinkler and never got big enough to be considered significant. Food on stove, combustibles left on stove, and such things as microwave fires all were easily controlled with sprinklers. SFD mandates fast response residential sprinklers in these kinds of occupancies and they are very effective.

Experimental Seismic Response of a Full-Scale Six-Story Light-Frame Wood Building

In two separate studies, van de Lindt and colleagues [21, 22] examined the outcomes of controlled, shake-table research that examines the structural performance of wood frame buildings in response to extreme seismic activity. Utilizing a full-scale mid-rise light-frame 6 storey apartment model, these researchers subjected the building to a series of earthquakes at the world's largest shake table in Miki, Japan. The building was made up of 1,350 m^2 of living space and had 23 apartment units. During testing, the building was exposed to three earthquakes ranging from seismic intensities corresponding to a once in every 72-years event to a once in every 2,500-years event (which equated to the Los Angeles earthquake). Overall, the researchers concluded that the building performed excellently, and sustained little damage across all trials. Video footage of these trials is available at: http://www.strongtie.com/about/research/capstone-media.html#videos.

Overview of the Significance of these Research Findings for the Concerns with Bill 52

In combination, these research findings appear to alleviate many of the major concerns identified with respect to the proposed amendments related to Bill 52.

- The simulation modeling results demonstrate that sprinkler protection simultaneously reduces the risk to life and property damage in the event of a fire, and achieves these results without the requirement of additional fire department resourcing. Furthermore, the fire resistance rating of the building materials involved did not impact on the fire performance of these structures when modeled in this way.
- Retrospective analysis of a large provincial dataset indicated that sprinkler systems reduce the loss of life and property damage in the event of a fire. Fire department resources are put under less strain in sprinkler protected buildings, and the fires are contained to a much smaller area.

- The timing of fire safety inspections does not directly influence the fire risk posed at these properties. This is not to say inspections should not be done. Instead it argues for a restructure of the current approach to inspections.
- One area of vulnerability that is clearly identified involves fires that originate on balconies of wood frame buildings. Under the proposed amendments to the OBC, with full sprinkler protection on buildings, non-combustible exteriors, additional fire separations in roof spaces, and sprinklers within most building cavities, the proposed amendments to the OBC appear to address all of these known limitations and weaknesses which have combined to make balcony fires so destructive in the past.
- The volunteer fire department case study experience provides support for the effectiveness of sprinklers in all buildings, regardless of the location and career status of the local fire service.
- The retrospective case study from the US provides support for the ongoing effectiveness of the life safety additions that will be implemented in these mid-rise wood frame buildings under the proposed changes for Bill 52.
- The findings from the shake table research support the seismic stability of these structures, ameliorating concerns raised with respect to performance of these mid-rise structures in the event of an earthquake.

Ideological Shift for the Fire Service

In view of the concerns that have been raised towards the proposed Bill 52, and in addition to the research evidence already outlined, this section briefly summarizes the logic of two recent reports, both of which make a case for an ideological shift for the fire service away from current norms and expectations. The first of these reports examines the factors that are driving the increasing total cost of fire in the US. The second outlines the logic for adopting a systems approach to managing fire risk within the community.

Understanding What is Driving the Increasing Total Cost of Fire

Frazier [23] explains that it is "important to estimate and track trends in the magnitude of the main components of the total cost of fire to assist in fire protection policy trade-offs. Moreover, the apparent and hidden costs of fire protection need to be compared to the losses averted and losses incurred." Understanding the total cost of the fire problem is crucial in order to raise the awareness of the public and decision-makers to the economic magnitude of an often underestimated cost.

The most recent estimates for the total cost of fire in the US was produced by Hall [24],[7] released in 2010. The take home messages of this analysis have important implications for the response to concerns as raised in this report. Overall, Hall estimated that in 2007 the total cost of fire represented approximately 2.5% of the US gross domestic product ($347 billion). Deconstructing this total revealed that economic loss (property damage) due to fire (direct and indirect, reported and unreported) was estimated at $18.6

[7] Hall explains that it is critically important "to understand that most methods used to estimate the total cost of fire are "soft," and few would stand up to the rigors of detailed analyses,-if indeed the necessary data to perform such analyses were available. Efforts to date have most likely achieved an understanding of the order of magnitude of the problem and of the relative importance of each component. To effectively use this information in policy decisions, it is necessary to establish good quantitative means to derive estimates."

billion, which represented a 13% decrease compared to 1980 estimates (when adjusted for inflation using CPI).

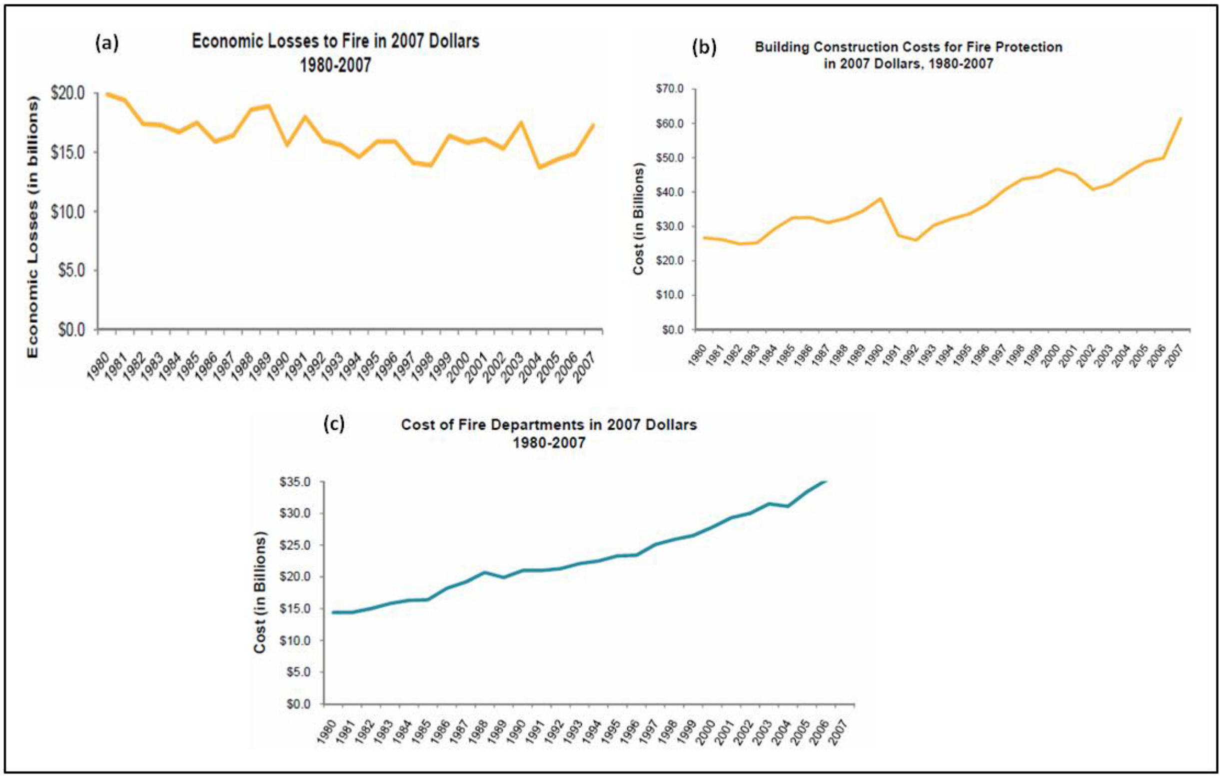

Figure 3. 2010 US-based estimates of (a) economic losses to fire, (b) building construction costs for fire protection, and (c) costs of fire departments, all in 2007 US dollars, indexed relative to 1980 values (replicated from Hall [18])

However, this improvement came at the expense of: (a) a 156% increase in the cost of career fire departments, (b) a 67% increase in the net difference between fire-related insurance premiums paid and estimated insurable economic losses, and (c) a 130% increase in the costs of new building construction for fire protection. These results are displayed in Figure 3, above (direct extracts from Figures displayed in the Hall [18] report). “These building construction costs include passive protection, such as compartmentation, and active protection, such as detection and sprinkler systems” [24: iv]. As a consequence of these findings, Hall [24] discusses why there is a dual interest in reducing fire losses on the one hand, while achieving this at lower costs. This is because the growth in total costs of fire that has been observed in the US over the last three decades has been driven by increased protection costs rather than greater fire losses. 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.

The Systems Approach to Managing Fire Risk

In 2008, Jennings [25] produced a report for Surrey Fire Services, BC, that examined the local response to high-rise fires. As a consequence of this review, Jennings proposed that a systems approach be adopted to managing fire incidence and fire loss in residential structures. A system, in this context, can be conceived of as a larger group of components operating with some degree of interdependence (structure) to achieve some outcome. The rules for a system are:

1. A system does something.
2. Addition or removal of components changes the system.
3. A component is affected by its inclusion in the system.
4. Components are perceived to be related in hierarchical structures.
5. There are means for control and communication which promote system survival.
6. The system has emergent properties, some of which are difficult to predict.
7. The system has a boundary.
8. Outside the boundary is a system environment which affects the system.
9. A system is owned or valued by someone.

The key to embracing a systems approach within the fire service actually requires a broad shift in focus. The typical role that the fire service has taken is suppression-focused, with reaction and response the key. In contrast, the systems approach requires the fire service to view themselves as one of three components that interact, and all of which play a role in mitigating risk of fire. The three elements of any building that influence fire risk are essentially (a) the occupant, (b) the responsible person (owner, manager, etc.), and (c) the fire service. The goal of these three elements is identical, but their responsibilities are distinct. For fire incidents in mid-rise buildings, this systems approach can be modified such that the three components are:

- (The Occupants) Public Education: The occupants must be trained to leave the building when the alarms activate – this is the role of the buildings management and must be strictly enforced.
- (The Responsible Persons) Building Construction/Code Enforcement: The buildings' safety systems must be maintained in a state of readiness both during construction and once construction is complete, by building contractors and owners/operators.
- (The Fire Service) Fire Suppression: The role of the fire department can then be staged to meet the priorities of the fire incident that primarily focuses on fire suppression.

An additional contribution that the systems model makes to managing fire risk within residential buildings is to emphasize the distinction between fire initiation and fire loss. Fire initiation is a fire starting – for example through careless cooking. Fire loss is the toll of death, injuries, and dollar loss caused by the fire. We can compare two fires with an identical fire initiation and end up with two totally different fire losses because of a number of mitigating factors. These factors include the building stock (is the fire in a single family dwelling or apartment), and social and demographic variables (numbers of people present, type of housing unit, etc.). We can use the conceptual model to design interventions to reduce the toll of fires. Public education can be targeted at reduction of incidence (general fire prevention) or reduction of losses (home escape planning), for example. We can conceive of the mid-rise fire problem in the same fashion. Policies or programs can be thought of as interventions in the system that will influence the outcomes in terms of losses from mid-rise fires.

Each element **must** be addressed in order to be effective. Any single area in isolation cannot achieve success by itself. Overall, a systems approach to fire risk mitigation in mid-rise buildings can guide the development of interventions to reduce the fire problem. To achieve this goal it is crucial that interventions are balanced against the limited resources available to address them, as well as their likelihood of success given regulatory, legal, and technical constraints.

Significance of these Findings for the Concerns with Bill 52

This review of the factors that are driving the overall cost of fire do not support arguments that (a) career fire department resourcing and (b) improvements to building safety systems are the only ways to protect against fire losses in these (or any) types of buildings. Instead, fire services need to be mindful of the rate of return on their investment – potentially measured through dollar loss estimates or lives saved – carefully considering these factors when advocating for additional building safety features. Furthermore, conceptualizing fire risk management within a system provides additional strategies for approaching risk in multi-residential buildings that maximize efficiency and minimize the complete dependence on the fire service.

Conclusions

The researchers wish to conclude by acknowledging that they are aware there are objections to the proposed Bill 52 in Ontario, largely stemming from perceptions within the fire service that these buildings will present significantly greater risk to life and property than those currently allowed under the existing building code. The researchers have examined these concerns and are unable to find any fact or any evidence to substantiate these concerns that have been presented with respect to Bill 52.

This examination has been extensive from the researchers' perspectives. A range of simulation research, retrospective quantitative analysis , and case studies has been considered. The overwhelmingly consistent theme that emerges from this process is that although fire services typically have responded to these types of proposed changes with concerns, all available information suggests that these types of structures will perform at least as well from a safety perspective as those that are already permitted. This opinion is based on the evidence presented in its entirety. No contrary information has been knowingly excluded in the production of this report. This said, the research has identified two major vulnerabilities with mid-rise wood frame buildings. The first concerns these buildings while under construction. The second, concerns fires that originate from the exteriors of these buildings (most typically from balconies). Having noted this, it is also important to acknowledge that the proposed Bill 52, in conjunction with the 2011 proposed OBC changes, makes provisions that would address both of these weaknesses.

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Acknowledgements

Special thanks to Rebecca Denlinger, BC Fire Commissioner and her staff for the provision of the BC data discussed in this report. This work would not have been possible without the contributions of these individuals.