

# COMMENTS REGARDING NBC REVIE TO INCREASE LIGHTWEIGHT FRAME CONSTRUCTION TO 6 STOREYS

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## INTRODUCTION

They reflect the views of this author alone and not necessarily those of the National Fire Protection Association. These comments have been prepared from previous submissions prepared for code change proposals in BC and ON under NFPA's role to advocate for fire safety issue on behalf of the Canadian fire service. The opinion has been developed based on dialogue with fire service members across Canada over the past several years.

The proposed changes do present an added relative risk. Currently six storey construction is required to be non-combustible and sprinklered under NFPA 13. To suggest that increasing the height of combustible construction to six storeys and only requiring NFPA 13 provisions and stating the risk is diminished is disingenuous. It leads one to believe that the fire performance of the combustible construction would be the same as the non-combustible construction. It relies heavily of the performance of fire sprinklers and fire stopping. If however a fire gets undetected into a void or vertical space then the fire sprinklering and fire stopping may be ineffective. The fire service is concerned that the structure may not provide sufficient time for fire ground operations, and building evacuation. Furthermore there has been significantly greater treats during construction experienced recently tha must also be considered in the codes. Experiences and testing from the UK must also be considered.

It is the author's position that the proposal to increase the storey limit for combustible construction makes economic sense and should be considered in the codes provided that the increased risk presented by this type of construction can be mitigated and that addition changes to the NFC also be considered. The comments below are intended to identify these concerns for consideration in the codes.

## DISCUSSION

The concern is that expected building performance criteria must be established. Currently in the codes the expectations for continuous structures above three storeys to require 2 hour fire resistive construction. (Note: In BC there are examples of four storey construction where the first storey is concrete box and the three subsequent storeys are combustible. These are separated by 2 hour rated construction.) This is intended to prevent the structure from collapse and to provide adequate time for occupants to safely evacuate and the fire service to

conduct interior search and rescue and fire attack. If a combustible structure is to be permitted it should not go below the requirements of:

- Provide structural sufficiency for occupant evacuation and fire fighter operations
- Minimize damage to the structure
- Limit or prevent damage to adjacent structures

### Fire Resistance in Construction

Fire resistance in construction is assigned to assemblies of light construction. These have been based on full scale performance testing of structures in recognized test centres. In the case of light frame construction it is important that the interior linings of the structure either stop or delay the spread of fire. As stated above the current code requirement could be amended to permit combustible construction but that the hourly fire performance must continue to be proven to meet the required two (2) hour fire resistance ratings for the exterior, the floors, and the bearing columns.

NRC has done some tests to determine fire performance of certain wall and floor assemblies to increase their fire performance. It must be stressed that these assemblies require unique design and construction practices that may not be practiced in the province at present. Similarly, as reported in UK TF2000 study to assess increasing combustible construction heights, these design considerations are essential to ensure a fire in a compartment does not spread into the wall cavities. The task group should review relevant research that verified the fire performance of the design components – walls, floors, vertical shafts have been verified for 2 hour fire rating.

### Current Fire Tests and Research

No scientific data or tests showing the ability of the combustible construction to adequately perform to the code requirements beyond 3 storeys has been presented for review. Both ON and BC have commissioned consultants' report for their proposed changes – similar reports have not been presented by NRC or the proponent to my knowledge.

Very little live fire testing has been undertaken on full scale structures up to six storeys. The approval of this code change is therefore going to rely upon scientific modeling and other means.

No scientific data or tests showing the ability of the combustible construction to adequately perform to the code requirements beyond 3 storeys has been presented for review. A review of international studies did reveal a 1999 study out of the UK entitled TF2000 Project.

## Fire Modelling – FireCam and Others

No fire modeling studies to coincide with this submission have been presented. These can easily be commissioned and should be considered. One model that can be applied is the National Research Council of Canada's FiRECAM™ model.

FiRECAM™ is a computer model for evaluating fire protection systems in residential and office buildings that can be used to compare the expected safety and cost of candidate fire protection options.<sup>1</sup> More detailed information on the NRC model can be found at <http://irc.nrc-cnrc.gc.ca/fulltext/nrcc43092/nrcc43092.pdf>

The FiRECAM model produces two decision making parameters for the property. These are the Expected Risk to Life (ERL) and the Fire Cost Expectation (FCE). The ERL determines the number of expected fatalities per year for the structure and the FCE represents the total cost for a fire for the structure including all capital costs, maintenance costs, and expected fire losses. As all other jurisdictions have apparently accepted the sprinklering of these occupancies as the norm for fire and life safety the FCE factors were not studied in this report.

FiRECAM runs through a number of scenarios, using statistical data and established mathematical models. It then calculates the life hazard to the occupants for each scenario and multiplies this by the probability of that scenario occurring. The overall expected risk to life is sum of all probable fire scenarios in the structure.<sup>2</sup>

A detailed review of a number of design scenarios using the FiRECAM model could quantify the increased risk factors in changing the fire performance requirements for buildings.

### Insurability

The proposed changes are being promoted by industry as being cost-effective and innovative. What has not been considered is the impact that these changes might have on the insurance premiums faced by the home owner. Will there be a greater home insurance premium paid by a tenant in a combustible building versus non-combustible? What impact does this have on the affordability of the unit?

An area of further concern should be for the value of property at risk and the need to preserve or reduce property losses. This is not a current requirement of the building code. It is a simplification but this is a matter between the insurance companies and the property owners. Increasing the height of combustible construction has the potential to increase property losses due to fire. This would

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<sup>1</sup> <http://irc.nrc-cnrc.gc.ca/fulltext/rr134/rr134.pdf>

<sup>2</sup> <http://irc.nrc-cnrc.gc.ca/fulltext/nrcc43092/nrcc43092.pdf>

likely increase insurance premiums for these properties – a cost borne not by the builder who may reap savings but the unwitting property owner.

Some initial feedback this submitter received from a major insurance provider while attending the 2011 Canadian Home Builders Annual meeting is that insurance premiums on these units may be significantly higher than similar noncombustible units if an insurance carrier is to consider this premium or not. I have seen no information from the change proponent on costing studies and if so these should consider the potential impact this will have on the residents who may not find this cost until they go to occupy the unit.

### Cost-Benefit Analysis

A thorough cost benefit analysis is needed to be presented under this code change proposal. This must include an analysis of the number of lives potentially lost and increased injuries using a review such as FIRECAM and including the life time costs such as those borne by the resident.

### Sprinkler Systems NFPA 13 vs. NFPA 13R systems

Sprinkler systems if properly designed and installed can be very effective at suppressing or containing a fire. NFPA has compiled statistics over the years on the effectiveness of sprinklers. Automatic sprinklers are highly effective elements of total system designs for fire protection in buildings. Based on 2002-2004 fires reported to U.S. fire departments, when sprinklers cover the area of fire origin, they operate in 93% of all reported structure fires large enough to activate sprinklers. When they operate, they are effective 97% of the time, resulting in a combined effectiveness reliability of 90%. More detailed figures on the performance of sprinkler systems is attached as Annex A.

NFPA 13R systems are intended to cover residential occupancies up to 4 storeys. These new propose structures would no longer be acceptable under NFPA 13R and therefore would be required to be designed to NFPA 13 throughout the structure. This shall mean that all rooms and spaces shall now be sprinklered this would include attic spaces, all rooms, all closets, exterior balconies, etc. These would be areas that would have been excluded in residential construction up to and including four storeys.

NFPA 13 systems must be kept as the requirement. NFPA 13R systems are considered life safety systems and are not installed for property protection. They involve the use of residential sprinkler heads that are designed and listed to facilitate the early evacuation by occupants. They are not considered to be property protection sprinklers. Additionally masonry, concrete, and steel structures if built to this same height would also require to be designed to NFPA 13 requirements. There is no added protection over these other types of construction and therefore additional safety provisions must be found elsewhere.

A proposed change currently being reviewed under the NFPA standards development process is to clarify the scope of NFPA 13R to change it from residential properties up to four storeys to residential properties up to 60 feet from grade. If this happens there may be a future review under the NBC to replace the reference requirements from NFPA 13 to NFPA 13R. It is recommended that an annex note be added to the NBC to ensure that the intent would be that even if the NFPA 13R changes occur the commissions intention is to retain the added safeguards found in NFPA 13 because of the added risk posed by the combustible construction.

### Human Concerns

A look at the Canadian demographics reveals that Canadian population is aging. Health Canada reports that Canada faces significant aging of its population as the proportion of seniors increases more rapidly than all other age groups. In 2001, one Canadian in eight was aged 65 years or over. By 2026, one Canadian in five will have reached age 65. Currently this age bracket is at high risk to injuries or fatalities from fire.

Of great concern is that these facilities may be used for care occupancies within the provinces as there is much interpretation on these facilities as the code definitions often do not reflect practice in the field. This is a major issue for the fire service across Canada. Senior occupants and those with disabilities will have a greater than average inability for self-preservation. This places a greater reliance on fire service to assist staff in evacuation of these facilities. With any reduction in fire performance and no guarantee of the fire departments response capabilities these at risk occupancies must not be permitted under the code. Social housing is considered in this category as figures from Toronto Public Housing also reflects the greater than average concentration of the elderly and those with physical and mental disabilities.

Similarly, the design requirements for Assembly occupancies (Group A) and Care and Detention Occupancies require special safeguards. Group A occupancies usually represent the general public in large unfamiliar surroundings. Escape is contingent upon having adequate time to safely evacuate the personnel in a required time. No changes should be considered for this type of occupancy. Similarly, Group B occupancies rely on a defend in place concept. Occupants are either moved within the occupancy or enhance protection is provided to keep them in place during a fire. No reduction in fire performance should be considered for these occupancies and therefore should not be permitted in mid-rise construction.

In summary the following types of occupancies should not be permitted to be of combustible construction these should include:

- Any Group C occupancy used as an Assisted Living Centre, or public housing
- Any Group A Occupancy
- Any Group B Occupancy

### The UK Experience

In 1991 building regulation in the UK changed to become a performance-based approach. This increased opportunities for new designs if supported by proper engineering design. At least one key project was undertaken to consider the opportunities in increasing the allowable limits for combustible construction. This was the TF2000 Project.

Regulation changes in England and Wales in recent years mean that timber frame buildings can reach seven storeys without loss of economy from excessive fire protection requirements.

With the exciting opportunities this presents, comes the need to 'benchmark' the performance of timber frame construction and the need for more comprehensive design guidance for medium-rise timber frame buildings, particularly with regard to fire and disproportionate collapse. It was for this that the TF2000 project was created.<sup>3</sup>

In this project a test was in 1999 to look at the fire effects on undertaken on a full scale fire involving a six storey wood frame building. A detailed report can be found on the web. A summary of the fire test was:

The fire was ignited in the living area of the flat and progressed to flashover after approximately 24 minutes. Initial burning was concentrated in the front of the living area closest to the ventilation opening. To accelerate the time to flashover the Fire Brigade was asked to intervene by breaking a single windowpane in the kitchen area. This took place 21 minutes and 30 seconds from ignition. Following flashover the Fireline boards over the windows to the floor above were subject to a heat flux of approximately 30kW/m<sup>2</sup> (peak plume temperature in excess of 500 °C). The timber frame of the window would, if exposed, have ignited. Peak temperatures in the living area of the fire flat reached approximately 1000 °C and remained at this level until the test was stopped at 64 minutes having reached one of the planned termination criteria.<sup>4</sup>

NOTE: In the author's opinion, a problem with using this particular test for substantiation is that the fuel load was a timber crib fuel load only. This does not reflect current fuel loads such as those found in Canadian homes and as supported by NRC research in studies such as the National research Council of

<sup>3</sup> <http://projects.bre.co.uk/tf2000/index.html>

<sup>4</sup> <http://www.mace.manchester.ac.uk/project/research/structures/strucfire/CaseStudy/Timber/default.htm>

Canada test such as the *Fire Scenario Tests in Fire Performance of Houses Test Facility – Data Compilation Research Report: IRC-RR-208*. The fuel load in this case was determined based on survey of Canadian homes and was designed to be a mixed load of lumber and plastics. This is believed to be more reflective of Canadian homes and the fires currently faced by the fire service. The result in the NRC case is a fire that flashes over in less than four minutes (24 minutes in the UK example) and temperatures of 813 °C in 130 seconds in one scenario. *This is a more challenging fire scenario than that presented in the UK study.*

Conclusions from the TF2000 report included:

The compartment fire test met the stated objectives of the programme. The following conclusions may be drawn from an analysis of the data and from observations during and after the test.

- Derived values of time equivalence have demonstrated that the performance of a complete timber frame building subject to a real fire is at least equivalent to that obtained from standard fire tests on individual elements.
- Results indicate that fire conditions in the living room of the flat represented an exposure approximately 10% more severe than a standard 60 minute fire resistance test.
- The test has demonstrated that timber frame construction can meet the functional requirements of the Building Regulations for England and Wales and the Building Standards for Scotland in terms of limiting internal fire spread and maintaining structural integrity.

In meeting the requirements of the regulations and the objectives of the research programme a number of issues have arisen.

- The standard of workmanship is of crucial importance in providing the necessary fire resistance performance especially nailing of plasterboards.
- Correct location of cavity barriers and fire stopping is important in maintaining the integrity of the structure.
- This type of construction is one that, in the United Kingdom, has a relatively low market share generally and in medium rise terms is very recent. For this reason fire brigades are unlikely to be familiar with the type of construction details used. Clearly education on timber frame for these bodies is necessary.
- The issue of vertical flame spread from floor to floor via the windows needs to be addressed.<sup>5</sup>

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<sup>5</sup> ibid

NOTE: The project was comparing the fire performance to only a one (1) hour fire performance requirement. It was not sprinklered and the fuel configuration was well below what we would currently expect to find in Canadian residences with modern contents (24 minutes to flashover versus 3 minutes). It further identified the problem for vertical flame spread from floor to floor via the windows needs to be addressed. This should be a major concern as NRC testing performed for the City of Calgary and province of Ontario have both identified that flames would exit the window in the room of fire origin after around four minutes in design fire scenarios. This would ignite exposed materials on the outside of the window. In combustible construction this would wick up the outside of the structure thus putting more of the structure than the room or unit of fire origin at risk.

In the summer of 2011 the City of London produced a concise report<sup>6</sup> on the problems being experienced in the City of London, UK regarding mid-rise construction. It behooves us to study their experience and review their recommendations. It stated:

A fire test on a six storey timber framed building carried out in 1999 paved the way for greater use of this type of construction. Regulations and guidance that followed referred back to this test and rely heavily on the quality of workmanship and correct installation of various fire stopping measures to retain the integrity of the structure.

Questions have been asked as to whether the “laboratory” conditions of that test accurately reflect the reality of today’s construction sites, processes and workmanship and the performance of the material and the resilience of the system in the event of fire.

While the “test” fire was thought to be extinguished after 64 minutes, it resurfaced some hours later and spread “with abnormal rapidly fire development”. Nevertheless, the construction method was passed on the basis of the test fire being extinguished.

The standard of workmanship is of crucial importance in providing the necessary fire resistance performance especially nailing of plasterboards. Correct location of cavity barriers and fire stopping is important in maintaining the integrity of the structure. NRC should prepare a course that looks at the specific provisions that must now be considered in designing and accepting NFPA 13 sprinkler systems in mid-rise construction. As this is all relatively new this would benefit both building officials and designers. Additionally NRC should look at a course for architects, builders and code officials on construction requirements and fire

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<sup>6</sup> <http://www.london.gov.uk/who-runs-london/the-london-assembly/publications/housing-planning/fire-safety-in-london>

stopping for mid-rise constructions. Evidence of completion of these two courses should be completed by a designer as a condition of building approval.

### Integrity of Firestopping

It has been somewhat misleading on the part of MMAH and BC Building Policy in the code changes discussions to date to state that they are requiring firestopping and sprinklering of concealed spaces in accordance with NFPA 13. It has been implied that there may be additional fire stopping provisions that may be added over and above what may be required by a 6 storey non-combustible structure. This is not the case. NFPA 13 requirements for fire stopping are required regardless of whether the structure is combustible or non-combustible when you go over 4 storeys.

As the City of London report highlights the importance of quality in the application of firestopping methods is crucial in the field. Procedures should be looked into to verify the proper application of fire stopping during construction. The City of London report also emphasizes the need to maintain the integrity of the firestopping systems over the life of the building. This should be reviewed by the Task Group for changes in the Fire Code.

### Fire Code Concerns

As the NBC shall be undergoing changes to facilitate mid-rise construction a corresponding review of the National Fire Code (NFC) should also be undertaken as it is this author's opinion that enhancements are needed to correspond with this change of the NBC.

Firestopping Integrity - The NFC should consider a clause that requires that all fire stopping be maintained over the life of the structure. Because this fire stopping is crucial to mitigating the added risk the NBC and NFC should be amended to require that the engineer on record for the project submit a certification that fire stopping has been installed in accordance with the NBC, appropriate standards e.g. NFPA 13, and the listing requirements of the firestopping product. After a period of four years, or sooner if there is evidence of wood shrinkage in the structure, the fire stopping shall be re-evaluated by a professional engineer.

Exterior Cladding – If fire retardant treated wood is permissible on exterior surfaces what conditions are going to be required on the inspection and maintenance of these finishes? NFC needs a clause to specify the requirement to retreat fire retardants on exterior cladding to maintain their performance ratings. These should be spelled out in the NFC as these fire retardants can reduce in their performance over time. The better requirement is to not permit the use of fire retardant treatments as a means to make the exterior cladding non-combustible.

Balcony Protection Measures - NFPA 13 requires sprinklers on balconies and has specific provisions that permit sprinklers to be waived. The proposed changes will require these sprinklers regardless of the potential to waive the requirements found in NFPA 13. Furthermore it is assumed in NFPA 13 that the fire loads are reduced because you are following the NFPA 1 Fire Code or other fire safety precautions to limit the fuel loads. NFPA 1 Fire Code clause 10.11.6 prohibits barbeques or other cooking devices on balconies unless they are installed and listed equipment. The NFC should be amended to prohibit cooking or barbeques on balconies or patios in mid-rise construction unless it is installed listed equipment.

### Fire Department Concerns

There is a wide variety of fire department response capabilities across Canada; however, the proposed structures could be built in any community. The concern is that just because the structures are permissible under the code – should not mean they can be built. Approvals of such structures must consider the fire department response capability. The NBC makes certain assumptions already on the “adequacy of the fire department response” in regards to limiting distances but does not define these. If a community chooses to build such a structure without considering the factors of adequate fire department response, fire department training, resources, etc. the community assumes a legal liability in the event of a loss that is not clearly defined in the code. We must address fire department concerns such as defining “adequate response” and identifying and mitigating the added risks to fire suppression activities.

As an example highlighted by the UK experience there is heightened concerns about fire entering into wall cavities and thus spreading beyond the room of origin to other floors. How many Canadian fire departments have infrared cameras to detect hotspots in wall cavities? Do they have a knowledge of risks and have they amended their tactics and pre-incident plans. Does this now require aerial response? What happens if there is a delay? Fire department tools and resources to properly address such fires need to be confirmed before a council permits such construction in their area. Already we have seen White Rock, BC as an example – high rise structures being imposed on a volunteer fire department and other communities without having an aerial device. The fire service concerns are not met.

The trend across Canada is to the uniform application of the NBC. The problem is the NBC does not define what an adequate fire department response capability is and therefore structures that pose a significant challenge to even a career department with an excellent response time are being built in areas with a volunteer response capabilities. Of similar concern is that the core requirements of the NBC do not consider property preservation. If you can prove that all

occupants can safely evacuate in the required time then the fire service should not be entering and it is a matter between the property owner and their insurance company. This runs counter to the raison d'être of many fire departments who serve a valuable service to their communities in reducing property losses due to fire. It also increases the risk to the fire service who would attempt to reduce some of the property losses in these structures. If they do not perform interior fire attack are they exposing their communities to increased civil litigation? There is a serious potential disconnect between the minimums in the building code and community expectations.

A worst case scenario in analyzing the fire scenarios must be used. The proposal must assume that the building will be constructed in a community with a volunteer response and no aerial device. Alternatively the code must define what an adequate fire department response capability is for a fire in a completed mid-rise structure.

### Safety During Construction

In May 2011 Richmond, BC experienced a fire referred to as the Remy fire. This was a mid-rise construction project undergoing construction. It took all available suppression resources from Richmond, BC as well as additional resources from South Vancouver and Burnaby. The project was a total loss. A similar fire in Croydon in the UK highlighted significant concerns and major reviews by groups such as IFE.

The intended application for many of these projects is for infill construction in many urban centres. During construction these projects are the most vulnerable as well as exposing surrounding properties. Although some argue this is an insurance issue there is significant risks to occupied exposed properties. The City of London makes recommendations in this regard also points to consider should be:

- Review of code provisions for hot work
- Arson and site security
- Maintaining site access for FD response
- Hazmat storage
- Housekeeping
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It is recommended that the NFC require a Site Risk Assessment that would consider the unique aspects of the site including water supplies, exposures, etc.. This would factor in local fire service capabilities, mandate requirement for onsite visits and define responsibilities, have a Site Security & Emergency Notification component. This would be presented to the local fire authority for approval and this enable the local the FD to formulate its pre-incident plan.

### Fire Safety Plans

Because of the added relative risk posed by this type of construction and concern for the fire spreading into void and vertical spaces the prudent requirement for all these occupancies should be to require a total evacuation based on a decision by the local fire official. Means within the fire safety plans should be considered to facilitate this. The Fire Safety Plan should also include how the property owner shall ensure the integrity of the fire stopping over time.

## CONCLUSION

The proposal to increased height limitation of combustible construction to six storeys under the code is of interest Canada and its economy. It however has not been presented with any detailed scientific studies, performance based design submission, or fire modeling to show how it can be accomplished under the current codes despite the ability to submit such a proposal under the current codes. Additional fire safety considerations must be included in the code to mitigate the added risks factors. These have been identified above for consideration.

## ANNEX A - FIRE PERFORMANCE OF SPRINKLERS

The following material has been taken from the NFPA Report U.S. EXPERIENCE WITH SPRINKLERS AND OTHER AUTOMATIC FIRE EXTINGUISHING EQUIPMENT dated June 2007. It is available for free public download at: <http://www.nfpa.org/assets/files//PDF/OSsprinklers.pdf>

### **Sprinklers in the area of fire fail to operate in 7% of reported structure fires large enough to activate sprinklers.**

The other estimated failure rates shown in Table 3 are:

- 7% for wet pipe sprinklers,
- 13% for dry pipe sprinklers,
- 23% for dry chemical systems, and
- 5% for carbon dioxide systems

For major property classes and sprinklers, the estimated failure rates range from a low of 4% for

residential properties to a high of 20% for storage properties. For storage properties, the estimated

failure rates are 17% for wet pipe sprinklers and 26% for dry pipe sprinklers.

### **The majority of sprinkler failures occurred because the system was shut off.**

Table 4 provides the percentages of reasons for failure, after recoding, by type of automatic

extinguishing system and property use.

For all sprinklers:

- 66% of failures to operate were attributed to the system being shut off,
- 16% were because manual intervention defeated the system,
- 10% were because of lack of maintenance,
- 6% were because the system was inappropriate for the type of fire, and
- 2% were because a component was damaged.

**Table 3.**  
**Automatic Extinguishing System Operationality**  
**When Fire Was Large Enough to Activate System, by Property Use**  
**2002-2004 Non-Confined Structure Fires**

**A. All Sprinklers**

Property Use	Percent where systems failed to operate	Based on number of fires <sup>±</sup>
Public assembly (Eating or drinking establishment)	7% (8%)	800 (500)
Educational	11%	300
Health care**	8%	500
Residential (Apartment) (Hotel or motel)	4% (3%) (4%)	3,600 (2,500) (500)
Store or office	6%	1,600
Manufacturing	7%	2,300
Storage (Warehouse excluding cold storage)	20% (19%)	500 (300)
All structures***	7%	10,100