The Impact of Building Code Changes on Fire Service Safety

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Dramatic changes have been made in U.S. building codes over the past several years, but most of these changes have been made without significant input from those who face the dangerous challenges of fire suppression – the fire services.

Changes to the building codes are driven largely by architects, engineers, building owners, construction material manufacturers and others focused on controlling or reducing construction costs. There is surprisingly little testimony from the fire fighters, fire marshals, fire chiefs, fire inspectors and investigators. Among their own peer groups, the various fire services participate in the development of fire codes, but there has been historically little cross-over communication between construction interests and fire services when building codes are revised.

Unfortunately, fire services professionals are often not educated in building technology. Even veteran fire fighters can be at a loss to express themselves in "building code language" at technical committee meetings and, as a result, their contribution may be lost. A lack of specialized education in building construction can cost lives if fire fighters are unprepared to identify specific construction deficiencies or hazards while fighting fires. At the same time, most engineers, architects and manufacturers may never have faced a structural collapse during a fire, and, therefore, lack experience in dealing with fire hazards up close.

In an article entitled "Are Architects, Engineers and Code-Writing Officials Friends of the Firefighter", Vincent Dunn, a retired New York City Fire Department deputy chief, concluded that the code development community has embraced modern building construction methods without adequate consideration of the hazards they pose to fire fighters.
(http://www.ncma.org/online/Fire/vincedunn.pdf.)

Dunn identifies multiple areas of concern in the newest building code and standards. These include allowance of lightweight construction materials, including particle board I-beams, lightweight steel bar joist-truss for floor and roof construction, sheet metal C-beams for floor and roof assemblies, and insufficient spray-on insulation for steel structural members. Dunn also questions the elimination of fire-resistive construction to contain fires in favor of sprinkling. Dunn's assessment isn't surprising. There is mounting evidence that recent code changes designed to reduce construction costs are detrimental to building occupants and fire fighters.

Building Code Background

Over the past 30 years, the former three national model building codes groups – the Building Officials and Code Administrators International (BOCA), the Southern Building Code Congress International (SBCCI), and the International Conference of Building Officials(ICBO) have called for increased use of sprinklers, while steadily rolling back requirements for smoke control and fire-resistant components. These include fire and smoke dampers, doors, fireproofing, firestop systems, fire-rated glazing, and fire-rated walls, and fire-rated ceiling assemblies. Fire-rated components and materials help control the spread of fire, and limit the damage to a burning building and surrounding structures. More important, materials that contain or control fires give building occupants sufficient time to escape, and allow firefighters to act before the structure collapses.

The new International Building Code (IBC) represents a consolidation of the three regional model codes. In order to make the adoption of the IBC attractive to as many jurisdictions as possible, the International Code Council incorporated the least restrictive provisions of each former model code. Consequently the new codes, which have been widely adopted throughout the United States, represent an overall reduction in fire and life safety.

Examples of IBC Construction Trends

For example, BOCA allowed certain buildings with sprinklers to be constructed with no area restrictions or “fire ratings" as long as they were only one-story high. Under the IBC and the recently completed NFPA 5000 Building Code, such buildings can now be two-stories high and need not include fire-resistive construction.

The SBCCI Standard Building Code required structurally independent fire walls that separate building units to have a four-hour fire resistance rating. However, the new codes have reduced the ratings to as little as two or three hours, in most cases, depending on a building's occupancy and use.

The ICBO Uniform Building Code allowed sprinklers to be "traded off" for increases in the allowable height or area of buildings, while the IBC and NFPA 5000 Building Code allow increases in both height and area by as much as 200 to 300 percent without increasing fire-resistant construction. Tables 1 and 2 offer comparisons of allowable heights and areas of the former model codes with those of the new IBC.

Table 1 **- Allowable Areas (table values) of IBC and Model Codes**

IBC Use Group	Code	IBC Type of Construction (Square Footage Permitted)								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
B Business	IBC	UL	UL	37,000	23,000	28,500	19,000	36,000	18,000	9,000
	NBC	UL	34,200	22,500	14,400	19,800	14,400	21,600	15,300	7,200
	SBC	UL	UL	25,500	17,000	21,000	14,000	25,500	13,500	9,000
	UBC	UL	39,900	18,000	12,000	18,000	12,000	18,000	14,000	8,000
R-2 Apart. House	IBC	UL	UL	24,000	16,000	24,000	16,000	20,500	12,000	7,000
	NBC	UL	22,800	15,000	9,600	13,200	9,600	14,400	10,200	4,800
	SBC	UL	UL	18,000	12,000	18,000	12,000	18,000	10,500	7,000
	UBC	UL	29,900	13,500	9,100	13,500	9,100	13,500	10,500	6,000

UL = unlimited area
IBC=International Building Code
NBC=National Building Code
SBC=Standard Building Code
UBC=Uniform Building Code

Table 2 - Allowable Heights (table values) of IBC and Model Codes

IBC Use Group	Code	IBC Type of Construction (number of stories permitted)								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
B Business	IBC	UL	11	5	4	5	4	5	3	2
	NBC	UL	7	5	3	4	3	5	3	2
	SBC	UL	UL/80	5	2(5)	5	2(5)	5	2	2
	UBC	UL	2	4	2	4	2	4	3	2
R-2 Apart. House	IBC	UL	11	4	4	4	4	4	3	2
	NBC	UL	9	4	3	4	3	4	3	2
	SBC	UL	UL/80	5	2(5)	5	2(5)	3	3	2
	UBC	UL	12	4	2	4	2	4	3	2

UL = unlimited

Are Sprinklers Alone Enough?

Both construction and fire officials agree on the value of a properly designed, well maintained sprinkler system for commercial buildings. However, when fire service professionals vigorously campaign for increased use of sprinklers, they are frequently unaware that the installation of sprinklers simultaneously triggers a myriad of code provisions that permit multiple reductions and the complete elimination of many other built-in fire and smoke protection features that would otherwise be required by the building codes. Under the new building codes, any

and all such trade-offs could be applied in the same structure when sprinklers are installed.

The National Fire Sprinkler Association (NFSA) promotes sprinkler trade-offs on the basis of cost savings and the economic incentive to install active fire protection. Examples of what it calls "trade-ups" are listed on the NFSA website and described as construction "cost savings benefits" for installing sprinkler systems. According to the NFSA, sprinklers:

- Permit unlimited areas in two story business occupancies, factories, mercantile and storage buildings, (IBC Section 507.3)
- Delete the 1-hour fire resistance rating for attics and under floor concealed spaces used for storage of combustible materials, (IBC Section 413.2)
- Cancel the requirement for fire dampers at HVAC penetrations of 1 hour partitions that also serve as tenant separation and corridor walls, (IBC Section 715.5.3)
- Permit reductions in the minimum stairway width requirements (IBC Section 1003.3.3.1)
- Eliminate the requirement for a smoke barrier around an area of refuge, (IBC Section 1003.2.13.5.2)

In fact, there are literally hundreds of code-approved provisions to eliminate or reduce fire and smoke control features in the IBC when sprinklers are installed. This trend to reduce or eliminate passive features while installing more sprinklers flies in the face of traditional views on fire safety as espoused by generations of fire scientists, fire protection engineers, and published experts.

According to the National Fire Protection Association's "Fire Protection Handbook", Section 1, Chapter 1 of the eighteenth edition. (1997):

> "It is important to remember that fire protection requires the development of an integrated system of balanced protection that uses many different design features and systems to reinforce one another and to cover for one another in case of the failure of any one. Defense in depth and engineered redundancy are concepts that also are relevant here. The process of achieving that integration, balance and redundancy to attain fire safety objectives is the essence of fire protection engineering, including codes and standards.
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> "This means that success is not measured by the extent of use of any one technology or system or code. Success is measured by the extent of usage of effectively designed, integrated fire protection systems. No one system should be considered disposable and no one system should be considered a panacea.

> "Passive fire protection provides the final opportunity to stop the fire and smoke but also plays an essential role in providing automatic systems with a manageable fire to act on. Passive protection is designed to confine fire and smoke in zones, a concept called compartmentation. Special attention is given to protection of the building's structural framework."

In an article in the July 31, 2001 edition of the San Francisco Chronicle, Don Bliss, New Hampshire state fire marshal, was quoted as saying: "I'm very pro-sprinkler, but when you're talking about fire safety, you can't have just one line of protection. If we're depending on a sprinkler system to function and it fails, people will be at considerably more risk." (http://sfgate.com/cgi-bin/article.cgi?file=/chronicle/archive/2001/07/31/BU84064.DTL)

The *San Francisco Chronicle* article summarized the problems arising from over-reliance on sprinklers at the expense of balanced protection. It also quotes John Klote, a nationally recognized fire- and smoke-control expert from McLean, VA, who said, "We aren't including redundancy, which has been the cornerstone of fire safety over the decades. Everyone agrees that sprinklers are extremely good, but they are not perfect. If you have removed most of your other life-safety devices and then you have a deficiency in your sprinkler or the fire overpowers your sprinklers, you can have real problems."

Noted fire protection engineer Frances Brannigan warns in his book, "Building Construction for the Fire Service," that "there has been a trend to use more sprinklers in buildings, often with trade-offs such a reduction in traditional passive (built-in fire and smoke) protection. With most of the fire protection eggs in the sprinkler basket, it is vital that the basket be carefully watched."

But is the "sprinkler basket" being carefully watched? An NFPA report, U.S. Experience with Sprinklers, published in September 2001, assesses the impact of fires in public buildings during the period 1989 to 1998. The buildings studied include educational, health care and correctional facilities, apartments, hotels/motels, department stores, offices, and industrial, manufacturing and storage structures. In buildings with sprinklers, the sprinklers operated in 82.7% of the reported fire incidents, while failing to operate in 17.3% of the reported fire incidents (Table 3).

Table 3 **- U.S. Experience with Sprinkler Operation.**

Property Use	**% of Fires with Sprinklers[1]**	**% of Fires Where Sprinklers Operated[2]**	**% of Fires Where Sprinklers did not Operate**
Public Assembly	23.0	73.9	26.1
Educational	21.6	79.6	20.4
Health Care & Correctional	51.2	80.0	20.0
All Residential	2.6	84.6	15.4

1&2 Family	0.7	80.0	20.0
Apartments	6.6	82.7	17.3
Hotels & Motels	32.8	82.7	17.3
Department Stores	52.0	84.9	15.1
Offices	24.2	80.6	19.4
Industrial	12.6	85.9	14.1
Manufacturing	49.8	91.1	8.9
Storage	3.0	84.0	16.0
TOTAL		**82.7**	**17.3**

1 Estimated as percentages of structure fires with sprinklers present divided by the number of structure fires with sprinkler status known.
2 Excludes fires where sprinkler was present but fire was coded as too small to test operational status of sprinklers.
Data source: NFPA Report, U.S. Experience with Sprinklers, September 2001. National estimates based on 1989-1998 NFIRS and NFPA survey.

The Human Factor

Passive devices such as fire and smoke dampers and fire doors also fail to operate as intended due to human error, equipment malfunction or unauthorized tampering. Historical data indicates that buildings without the added benefit of active fire protection, having succumbed to maintenance failures and unintentional sabotage, do not always survive well in a fire incident. On-site maintenance people are often unacquainted with the fire protection function provided by fire-resistant wall, floor and ceiling assemblies. If a fire door is propped open, or a wall, or floor penetration has been left un-repaired, or if fireproofing has been scraped away to accommodate remodeling or repairs, a building's safety features cannot perform as intended.

Greater Challenges for Fire Fighters

Ultimately, reductions and eliminations of fire and smoke safety features based on sprinkler trade-offs are of paramount significance to fire fighters. These compromises are predicated entirely on sprinkler dependability. If sprinklers fail to operate satisfactorily in buildings built to the newest editions of the model codes, then those who enter a fire scene are going to be working under more stressful and dangerous conditions than ever before.

However, even when sprinklers activate satisfactorily, fire fighters will be exposed to new challenges when forced to deal with fire control in substantially larger spaces. With building codes permitting expanded height and areas, reductions in fire ratings of floors and wall assemblies, longer corridors distances, more combustible materials, narrower stairways, and fewer smoke control features, there is a greater potential for fires to spin out of control and spread to adjacent areas. This, in turn, will complicate the mission of fire fighters.

Three of these critical reductions are summarized in the Tables 4, 5and 6

***Table 4* – Egress stairway width per occupant served in the IBC.**

	Without Sprinklers		**With Sprinklers**[a]	
Occupancy	Stairways (inches per occupant)	Other egress components (inches per occupant)	Stairways (inches per occupant)	Other egress components (inches per occupant)
Occupancy other than those listed below	0.3	0.2	0.2	0.15
Hazardous	0.7	0.4	0.3	0.2
Institutional: (some cases)	NA	NA	0.3	0.2

a. Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903..3.1.1 or 903..3.1..2 where allowed.

***Table 5*- Changes to Egress Access Travel Distance[a] in the IBC**

Occupancy	**Without Sprinkler System** (feet)	**With Sprinkler System** (feet)
Assembly Educational Factories (some cases) Instititional (some cases) Mercantile Residential (some cases) Storage (some cases)	200	250[b]
Business	200	300[c]
Factory (some cases) Storage (some cases Underground buildings (some cases)	300	400[b]
Institutional	150	200[c]

a. See IBC 2000 for modification to exit access travel distance requirements.
b. Buildings equipped throughout with and automatic sprinkler system in accordance with Section 903.1.1 or 903.1.2. See Sections 903 for occupancies where sprinklers systems are permitted.
c. Buildings equipped throughout with and automatic sprinkler system in accordance with Section 903.3.1.1.

***Table 6* – Reductions in Corridor Fire-Resistance Ratings in the IBC**

Occupancy	Occupant Load Served By Corridor	Required Fire-Resistance Rating (hours	Required Fire-Resistance Rating (hours
		Without Sprinklers System	**With Sprinkler System[a]**
Assembly Business Educational Factories Mercantile Storage, Underground	Greater than 30	1	0

a. Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1. or 903.3.1.2

A Call to Action

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In response to this ominous trend, the fire services need to play a more active role as participants in the building code development process. There are over 1 million paid and volunteer firefighters in the U.S. These front-line soldiers in the war against fire clearly have a vested interest in building code issues. The time is overdue for the collective interests of the fire services to be reflected in the building codes. (To the International Code Council's credit, it has initiated programs to include the fire services professionals in the building code development process.)

At present, only a few dozen fire officials take an active speaking role at the building code hearings hosted by the International Code Council. In addition to becoming more knowledgeable about building code issues, firefighters can also leverage union resources, confer with their management, write letters, get involved with local code officials, and support local and national code modifications that promote balanced fire protection design. Firefighters are called upon daily to take the ultimate risk in protecting life and property. They deserve a voice and a place at the table as crucial decisions are made that affect their lives.

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Additional Resources

"Compartment and Dampers are Essential for Life Safety" - Johh H. Klote - http://www.afscc.org/AFSCCcompartmentationArticle.pdf

"Reliability of Automatic Sprinkler Systems" - William E. Koffel - http://www.fcia.org/articles/sprinklerreliability-3-04.pdf.

"Saving Lives Through Passive Fire Protection" International Firestop Council - http://www.firestop.org/pubs/0108Savinglives.PDF

"Making the Case for Balanced Design - Why Sprinklers Are Not Enough"
By Lee G. Jones**,** Sprinkler Age, Vol. 17, No. 9, 1998
http://www.fcia.org/articles/sprinklers.htm

"Maintaining Life Safety Effectiveness in the New Building Codes", Richard Licht - http://www.firestop.org/pubs/0107LifeSafetyEffect.pdf

"Balancing Active and Passive Fire Protection Systems in the Building Codes", Richard Licht - http://www.afscc.org/press1.htm

"Non-Residential Structure Fires in 2000" - U.S. Fire Administration/National Fire Data Center - http://www.usfa.fema.gov/downloads/pdf/tfrs/v3i10.pdf

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Sidebar

The Fire Marshal Perspective
The National Association of State Fire Marshals (NASFM) is a unified body that represents the interests of fire services across the country. This group, which includes the most senior fire official in each state, has taken a proactive stance on recent code changes. After a careful study of the two new building codes, the organization has made very specific suggestions for improving the fire-safety provisions of these codes.

A memo from the NASFM Codes Assessment Committee (CAS) to the Partnership for Safer Buildings on August 1, 2003 listed nine recommended alterations that reflect the association's building code fire-safety concerns. Central to committee conclusions was a concern that the new IBC relies too heavily on active fire protection measures in exchange for decreased ratings.

For example, the CAS recommended that high rise provisions in the new International Building Code be consistent with UBC 1997. The committee called for a return to the original levels of safety that existed prior to the consolidation of the three model codes by fully incorporating active and passive fire protection methods. CAS members concluded that if a sprinkler system were to fail, as it did in the case of the World Trade Center, occupants would stand little chance of evacuating safely in the time allotted by the fire-resistance ratings assigned to a building's structural elements.

Other CAS recommendations dealt with a range of concerns including egress values, height and area allowances, fire-resistance rating of fire barrier walls enclosing elevator shafts, and fire partition ratings. The committee concluded that both active and passive fire protection must be in place at adequate levels to achieve fire safety for both occupants and emergency responders.

Past NASFM President George Miller issued a statement on June 24, 2000, regarding the scope of the pending NIST investigation of the World Trade Center disaster. Miller noted that while there has been a measurable decline in structural fires along with improvements in protective gear, firefighting equipment, training and incident management over the past 25 years, the rate of on-duty firefighter deaths nevertheless remained steady over the same period. He concluded that it is crucial that authorities determine the role of modern building construction in fire development and the partial or total collapse of buildings due to fire.

Robert Polk, speaking on behalf of the National Association of State Fire Marshals' "Partnership for Safer Buildings" recently offered comments on trends in building codes at a meeting to update findings of the World Trade Center (WTC) Investigation. The meeting was hosted by the National Institute of Standards and Technology's National Construction Safety Team (NCST) Advisory Committee. Polk stated that recent fires "illustrate the importance of redundant fire protection, and the tragic consequences of cutting costs beyond what makes sense."

Except where lives can be saved, fire chiefs may now allow buildings to burn rather than risk firefighters' lives. The National Institute of Occupational Safety and Health is urging incident commanders to take special precautions against building collapse, and the National Construction Safety Team's work has only amplified this concern. Yet, states are moving forward with the latest versions of the model codes, which ignore what we are learning here. In some instances, jurisdictions are making further reductions in the levels of safety prescribed in the model codes."

NASFM has submitted proposals to the 2006 International Building Code and the 2006 International Fire Code as follows:

- Make all sprinkler requirements for new construction effective for existing buildings. "Cost was the only rationale for making a distinction in the first place."

- Restore the passive fire protection requirements that have been removed from the model codes. "Cost was the only rationale for eliminating these requirements."

- Provide new authority to allow fire code officials to direct the replacement of any recalled component of a fire protection technology. UL has informed us it "does not have any basis" for removing the listing of recalled sprinkler heads, yet the fact that these heads are listed prevents many states from taking action.

- Provide new authority for code officials to inspect and require the replacement of seriously deteriorated passive materials.

The NASFM's concerns were echoed by Dr. W. Gene Corley, Team Leader of the World Trade Center Building Performance Study, in a statement titled "*Have We Learned Enough About Fire Safety from 9/11?*" Corley stated that many building codes that establish fire safety standards for public and private buildings are based on the mistaken assumption that sprinklers virtually never fail, and that fire-resistant construction materials can, therefore, be minimized or eliminated.

"While the World Trade Center disaster was an extraordinary event involving impact trauma that the building's designers never envisioned, the sprinklers were overwhelmed," he said.
"However, the additional fire-resistant construction is believed to have helped reduce the death toll by delaying collapse of the twin towers."

Corley concluded that fire safety cannot be an "either-or" proposition. Buildings for which sprinklers are appropriate should also have fire-resistant construction for better fire protection. Anything less puts occupants and emergency responders at risk, and is therefore unacceptable.

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1. Karter, M.J., "2000 United States fire Loss Report," NFPA Journal, Vol. 95, No.5, pp. 81-87 (2001)
2. This graph is based on data from the FEMA Report "Firefighter Fatality Retrospective Study", April 2002/FA-220, Federal Emergency

Management Agency, United States Fire Administration National Fire Data Center