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BMS92 AND THE NIST WTC RECOMMENDATIONS

By Richard Schulte

After the collapse of the World Trade Center towers on September 11th, 2001, the United States Congress authorized funding for the National Institute of Standards and Technology (NIST) to conduct an investigation into the incident. A little over four years after September 11th, NIST published its final report on the World Trade Center (WTC) towers collapse. This report included recommendations how to make buildings, particularly high rise buildings, safer.

In November 2008, NIST published its final report on the collapse of World Trade Center Building 7. This report, referred to as NIST NCSTAR 1A, included many of the recommendations included in NIST's report on the WTC towers collapse in a different format and, it also included one additional recommendation.

The following are excerpts from the recommendation portion of NIST NCSTAR 1A (pages 63 through 73, NCSTAR 1A):

> "***Recommendation C (NIST NCSTAR 1 Recommendation 4). NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings) – and making related code changes now as much as possible – by explicitly considering factors including:***
>
> - ***timely access by emergency responders and full evacuation of occupants, or the time required for burnout without partial collapse;***
> - ***the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety;***
> - ***the need for redundancy in fire protection systems that are critical to structural integrity;***
> - ***the ability of the structure and local floor systems to withstand a maximum credible fire scenario[6] without collapse, recognizing that sprinklers could be compromised, not operational, or non-existent;***

- ***compartmentation requirements (e.g., 12,000 ft^2) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;***

- ***the effect of spaces containing unusually large fuel concentrations for the expected occupancy of the building; and***

- ***the extent to which fire control systems, including suppression by automatic or manual means, should be credited as part of the prevention of fire spread.***"

"[6] *A maximum credible fire scenario includes conditions that are severe, but reasonable to anticipate, conditions related to building construction, occupancy, fire loads, ignition sources, compartment geometry, fire control methods, etc., as well as adverse, but reasonable to anticipate operating conditions.*"

"***Recommendation F (NCSTAR Recommendation 8). NIST recommends that the fire resistance of structures be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without partial or global (total) collapse.*** *Such a provision should recognize that sprinklers could be compromised, non-operational, or non-existent. Current methods for determining the fire resistance rating of structural assemblies do not explicitly specify a performance objective. . . .*"

Interestingly enough, the recommendations cited above included in NIST's investigation reports on the collapse of the WTC towers and the WTC 7 Building seem to have already been addressed in a report titled "*Building Materials and Structures (Fire-Resistance Classifications of Building Construction)*" issued on October 7, 1942 by the Subcommittee on Fire Resistance Classifications of the Central Housing Committee on Research, Design and Construction. This report is referred to Report BMS92.

Based upon information provided in the report, this subcommittee consisted of four representatives from various agencies of the Federal Government. These agencies were:

- Public Buildings Administration
- Federal Housing Administration
- United States Housing Authority
- Home Owners' Loan Corporation

The report also indicates that the technical adviser to the subcommittee was S. H. Inberg, National Bureau of Standards (NBS).

Excerpts from BMS92 which address NIST's recommendations included in the World Trade Center collapse investigation report include the following:

"*The Subcommittee believes that the idea of designing some buildings for the full severity corresponding to the occupancy and others for a given established fire resistance, is a logical advance in fire protection engineering.*"

"*Chapter I offers a classification of building types from the standpoint of fire safety. The relations between combustible contents, fire severity, and fire resistance ratings are outlined and a method of evaluating the combustible contents of a building is given.*"

"*Chapter III summarizes the findings of actual surveys of combustible contents of buildings for a number of typical occupancies. This material is considered to be a reliable guide in making an estimate of the probable combustible contents of projected occupancies similar to those surveyed.*"

"*The Fireproof type includes all buildings of incombustible structure which will either withstand complete combustion of their contents without collapse or which will have a general fire-resistance rating of 4 hr and in addition other safeguards designed to prevent a more severe fire. Within this type, the classification is such that a building may be designed to have a fire resistance corresponding to the fire severity that may be created by the occupancy. This eliminates the common practice of requiring a uniform fire resistance for all Fireproof-type buildings, which results in excessive resistance for occupancies having light combustible contents and insufficient resistance where the combustible contents are very heavy. Economies are thus made possible in the former case and increased protection is required in the latter for buildings classed as Fireproof.*"

"*For buildings or portions of buildings used for residential purposes, the combustible contents were found to be uniformly within the low range. Even with concentrated furniture storage, they were equivalent to no more than 15 lb/ft^2.*"

"*Fire severity is used herein as a measure of the intensity and duration of a fire. It is expressed in terms of time of exposure equivalent to that in the standard furnace test as defined in American Standards Association A-2, 1942.*"

"*It has been found from burn-out tests performed in fireproof structures with various concentrations of combustibles having a calorific value in the range of wood and paper (7,000 to 8,000 Btu/lb) and assembled to represent building occupancies, that the relation between the amount of combustibles present and the fire severity is approximately as given in table 5.*"

"*It is considered sufficiently accurate in computing combustible contents to take wood, paper, cotton, wool, silk, straw, grain, sugar, and similar organic materials at their actual weights and to take animal and vegetable oils, fats, and waxes, petroleum products, asphalt, bitumen, paraffin, pitch, alcohol, and napthalene at twice their actual weights.*"

"*In apartments and residences, even with combustible floors and other woodwork, the amount of combustible contents was found to be relatively light, with the average below 10 lb/ft^2 of floor area. In areas containing concentrated furniture storage, the combustible contents were found to be no more than 14 or 15 lb/ft^2, which includes allowance for a wood finish floor and wood trim.*"

"*In office buildings the surveys indicate that the combustible contents in from 80 to 90 percent of the building will come within 20 lb/ft^2 of the floor area. This would include such areas as offices and reception rooms, even those containing files. In rooms used exclusively for filing or library purposes, the combustible contents might run as high as 80 lb/ft^2.*"

"*The essential conditions which can be provided by design for the safety of life and property against loss by fire in a building are structural resistance to collapse due to fire and to spread of fire, sufficient exit facilities, and adequate facilities for extinguishment. The degree of safety in a given case is dependent on the extent to which the foregoing conditions are realized.*"

"*In general no restrictions as to height have been applied to the Fireproof type of building, except for occupancies deemed specially hazardous. This may be justified on the basis that the building should withstand a fire completely consuming all combustible contents and trim without collapse of structural members, or that for the higher amounts of combustible contents, the fire resistance incorporated in the building, in combination with its fire-extinguishing equipments and the public fire protection, is deemed adequate to prevent such collapse.*"

"*Another reason for the very moderate restrictions on height applied to the Fireproof building is its inherent advantages in point of limiting the spread of fire and smoke, resulting in greater safety to occupants and less difficulty in extinguishing fires. With incombustible floor construction of the required degree of fire resistance and enclosed vertical openings, the fire will be prevented from spreading from floor to floor through interior channels and the travel of smoke will be greatly restricted. For other than the lighter amounts of combustible contents, fire may be communicated from floor to floor through unprotected exterior wall openings, but this can be prevented with moderate fire-fighting effort. The building is relatively safe for entry by fire-fighting forces, and fire fighting equipment can be provided within the building with the outlets and connections so located or protected as to give good assurance of its availability in case of fire.*"

"*These properties of the construction also enable conditions having a bearing on the safety of occupants to be evaluated with a good degree of reliability. While with non-fire resistive construction it is generally considered necessary to provide for exit of all occupants from the building or fire-division thereof within a given time, the greater barrier to spread of fire and smoke offered by the floors and other subdividing constructions in Fireproof buildings make it necessary to provide means for immediate exit only from the area directly involved. This greatly reduces the required capacity of stairs which otherwise would be prohibitive for high buildings.*"

"*Assuming that Fireproof buildings are designed to withstand a complete burning-out of contents and combustible trim without collapse, there should in effect be no limitations imposed on the score of degree of fire resistance other than its relation to the expected fire severity for the given building. However, considering that public control over the amount of combustible contents in a given building can be exercised only within limits even where the occupancy is subject to control, and further, that the degree of fire resistance of building members cannot be achieved within very definite limits, there is justification for applying more rigid restrictions to buildings with the lower degree of fire resistance, particularly from the standpoint of height.*"

"*For buildings generally associated with the lower range in combustible contents, such as residential and office buildings, it does not appear justifiable even from this standpoint to apply an unduly large factor of safety. Where the expected fire severity is in the range* [of] *1/2 to 1*[-]*1/2 hr, a 2-hr requirement for high buildings should give good assurance of stability under fire conditions. It is noted that fire resistance ratings are based on the performance of members near the lower range in size. For the larger size members used in all but the upper stories of such high buildings, there would be considerable increase in fire resistance above the nominal ratings for the same kind and thickness of protecting materials. Also, the structural continuity inherent in the type of construction increases the margin of safety on stability above that indicated in test furnaces for comparable fire exposure and loading of segregated columns, beams, and floor and wall assemblies.*"

"*For buildings other than those of the Fireproof type it is apparent that even in the range of fire resistance up to 3/4 hour a decided difference in hazard to life and property is presented that would justify recognition in height and area limitations.*"

Discussion

As noted above, the technical adviser to the subcommittee which developed Report BMS92 was S. H. Inberg of the National Bureau of Standards (NBS). The nist.gov website provides the following explanation as to the relationship between the National Bureau of Standards and the National Institute of Standards and Technology:

"*Over the past century, the National Institute of Standards and Technology has had several different names. Founded as the National Bureau of Standards in 1901, it was renamed Bureau of Standards in 1903. In 1934, the word "national" was affixed again to its name. For more than 50 years it remained the National Bureau of Standards, or NBS. It became the National Institute of Standards and Technology, or NIST, in 1988.*"

In other words, the National Bureau of Standards and the National Institute of Standards and Technology are the same Federal Government agency. Given this, the comparison of the recommendations for building codes contained in BMS92 issued in 1942 juxtaposed with the recommendations contained in the NIST WTC investigation reports is rather interesting.

In BMS92, the report clearly states that structural fire resistance ratings of 2 hours are more than adequate to prevent the collapse of high rise buildings containing either residential or office occupancies, even without sprinkler protection. In the NIST WTC investigation reports, the recommendations clearly imply that structural fire resistance ratings of 2 hours are inadequate, even with sprinkler protection. Given this, it seems reasonable to ask- which report developed by the Federal Government is correct, Report BMS92 or the NIST World Trade Center investigation report?

While we now know that the concept of equivalent fire severity discussed in Report BMS92 is technically flawed (because it does not consider the effect of ventilation on temperatures generated in a fire), this concept is an acceptable "rule-of-thumb" which can be used to determine the probable "severity" of a fire which could potentially occur in a building. Given that this concept does not address or incorporate either the effect of automatic fire control (sprinkler protection) or manual fire control (manual fire fighting), the use of this "rule-of-thumb" as a measure of potential "fire severity" of a fire in a building can be considered to be conservative.

Are 2 hour structural fire resistance ratings adequate for high rise office and residential buildings? The fire record for U.S. high rise buildings clearly shows that 2 hour structural fire resistance ratings are more than adequate. Since 1975, the BOCA Code has permitted the structural frame and floors to be provided with 2 hour structural fire resistance ratings in high rise buildings protected by a sprinkler system. In the intervening 35^{+} years since sprinklered high rise buildings have been permitted to utilize 2 hour structural fire resistance ratings, the only complete collapse of high rise office or residential buildings occurred on September 11^{th}.

Would an increase in structural fire resistance ratings from 2 hours to 3 hours, or even 4 hours have changed the ultimate outcome of the events which occurred in Lower Manhattan on September 11^{th}? In my opinion, the answer to that question is no.

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