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Balancing Life Safety with the Historic Preservation of Tall Buildings

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Abstract

Balancing life safety with historic preservation goals in historic buildings presents unique challenges. These challenges are further compounded when the historic building is also a tall building. Traditional regulations are geared primarily to new construction and do not address property protection or historic preservation goals. This is especially true of regulations for high rise buildings. Building regulations that specifically identify their goals, address building habilitation and include performance-based design options are much better suited for historic and culturally significant buildings. NFPA 909, *Code for the Protection of Cultural Resources*; NFPA 914, *Code for Fire Protection of Historic Structures* and NFPA 5000, *Building Construction and Safety Code* are examples of such regulations. These resources in addition with other tools available in evaluating the existing safety features of historic building, such as calculation methods, can be used by knowledgeable persons in developing design solutions that achieve the necessary level of life safety while preserving the historic fabric of the culturally significant tall building.

Keywords: Building Rehabilitation, Performance-Based Codes, Historic High-Rise Buildings, Building Codes, Building Regulations

1. Introduction

Until the past few decades, many existing buildings that had outlived their original purpose were demolished or left vacant. The end of the 20th century solidified a cultural shift in valuing existing buildings and communities. Current trends call for the adaptive reuse of these structures, many of which qualify as historic properties as deemed by a governmental agency. Adaptive reuse and building rehabilitation, especially of historic structures, present outstanding opportunities to preserve aspects of our cultural heritage, utilize existing resources and revitalize older communities.

The challenge that has emerged is the incorporation of public values that favor building rehabilitation and historic preservation with those associated with providing high levels of safety for building occupants. Other associated issues include the uniqueness of each rehabilitation project, achieving compliance with traditional prescriptive building regulations that were developed primarily for new construction, and the

lack of available resources for quantifying fire safety features of existing buildings. These issues are often further compounded when the historic property under consideration is a tall building.

2. Challenges of Historic Rehabilitation Projects

The protection of historic structures, especially tall buildings, is very different than that of new construction and other types of existing properties. In addition to fire and life safety, goals of the rehabilitation project include the preservation of the historic fabric of the building or structure. For example, in historic properties, design goals associated with providing adequate egress facilities parallel those associated with preserving the aesthetics of interior architectural details.

The art of effective historic preservation requires latitude in developing solutions that are consistent with the particular preservation needs of the building and that are also in concert with present life safety goals. Such design flexibility usually cannot be achieved with the prescriptive approaches embodied in traditional building regulations.

Traditional building regulations that consist primarily of prescribed solutions developed for new construction do not include provisions for historic

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preservation. Unlike new construction, which is designed for compliance with current building and safety regulations, existing historic buildings are unlikely to be in such compliance and the degree of fire safety inherent in the structure is often unknown and difficult to access. Bringing the historic building into full compliance with prescriptive requirements will very often destroy the characteristics and qualities that are to be preserved. Special consideration of such historic structures is therefore mandatory.

Both single-focus modifications in historic properties, such as the installation of a fire sprinkler system, or a more comprehensive reconstruction, such as floor plan reconfiguration, require the design team and the authority having jurisdiction (AHJ) to possess skills and knowledge beyond that necessary for new construction. The term AHJ is used in NFPA documents to describe the organization, office or individual responsible for enforcing the requirements of the applicable codes and standards. Depending upon the project, approval from a number of AHJ's may be necessary such as from the fire marshal, building official, electrical inspector and the insurance company representative.

The design professional and the AHJ must understand the building's structure, its inherent fire safety features and liabilities, and for historic buildings, its architectural significance. This understanding is essential because no two buildings are alike, and because the prescriptive approaches of traditional codes are often unreasonable, costly without providing measurable improvements in safety, and unnecessarily invasive to existing building fabric and ongoing operations (Watts and Kaplan, 2003).

The uniqueness of each building – by condition, history, inherent fire safety characteristics, and previous and proposed uses – makes the application of traditional prescriptive codes practically impossible. It is thus incumbent on the design professional to provide a thoughtful and creative approach to rehabilitation of the existing building based on knowledge of the fields of rehabilitation, architectural technology, fire protection and building regulations. Likewise, it is imperative that the AHJ recognize the uniqueness and the constraints associated with the rehabilitation of existing historic structures.

3. Tall Buildings as Historic Properties

Historic buildings are generally considered to be in a special class, based on society's emotional attachment

to them. Historic properties are those significant in history, architecture, archeology, engineering and culture. The field of historic preservation incorporates a range of activities involving the identification, planning, interpretation, maintenance, and rehabilitation of historic structures, objects, sites, buildings, and historic districts.

Buildings designated as historic are typically at least 50 years old and retain architectural and structural integrity that reflects their original design and construction (National Institute of Building Sciences, 2004). The term historic usually indicates that a federal, state or local agency has formally determined the structure as worthy of preservation and protection. This designation is essential when leniency from all provisions of new construction is sought. When a building is designated as historic, the AHJ can usually exercise more latitude in determining the applicability of prescriptive code requirements.

By their nature tall buildings, regardless of their age, often fall into the category of culturally significant structures, many holding icon status. Since the turn of the 20th century, taller and taller buildings have continually characterized and re-characterized our urban landscapes. As our tall buildings age, their impact on society's cultural heritage will expand spotlighting the need for the historic preservation of their unique characteristics when rehabilitation eventually occurs.

Largely a product of the 20th century, tall buildings didn't flourish until the necessary design and construction techniques were mastered (Grant, 2003). While more recently erected tall buildings such as the 454-m (1483-ft) Petronas Towers in Kuala Lumpur and the 509-m (1670-ft) Taipei 101 in Taipei punctuate society's current impressions of buildings that scrape the sky, older structures such as the 241-m (792-ft) Woolworth Building in New York City and the 381-m (102-ft) Empire State Building also in New York City held status as the world's tallest buildings when they were constructed during the first half of the 20th century. Numerous other not quite as famous less lofty buildings take prominent positions in our cityscapes, and hold great deal of cultural and historic significance. A database of high rise buildings identifies over 75,000 such structures across the globe (Emporis Building Database, 2004).

Mankind's desire to reach the sky can be traced back many centuries and predates the beginning of the

modern era of high rise construction which can be traced back to 1884 when the 55-m (180-ft) Home Insurance Company Building was erected in Chicago³. Prior to this date, tall structures were primarily constructed for religious or monument purposes. The 161-m (528-ft) Ulm Cathedral in Germany, the 169-m (555-ft) Washington Monument and the 300-m (528-ft) Eiffel Tower fall into this category. Although reaching significant heights, these structures are in a different category in terms of fire and life safety. Primarily their upper portions were designed for extremely minimal occupant loads, if intended to be occupied at all. The post 1884 tall building is designed on a structural frame that allows for maximizing the occupant load and utility of the space.

Whether significant because of distinctive architectural features, unique interior finishes, the collections within or the occurrence of some historic event, older tall buildings were not bound by the building and fire regulations of today. General features of the earliest tall buildings include exterior walls of stone or brick, floors of wood supported by steel or cast iron beams, and cast iron columns. During their time of construction, standards for the fire protection were virtually non-existent or in preliminary stages of development, egress was accomplished through a single stairway sometime protected at each level by a metal plated wooden door, and elevator shafts were unenclosed. Active fire safety systems such as sprinkler, detection, alarm and smoke control were lacking as were provisions to aid fire fighting and rescue operations.

Other features of early buildings consist of ceremonial lobbies and rotundas, monumental open stairways and unrated partitions. While the features of historic tall buildings tend to clash with current building regulations, they also provide for the unique character of the building that society desires to preserve. Any rehabilitation of these buildings would require compliance with current building regulations that as previously stated have been written largely for new construction (Alderson et al, 2001). The rigid application of prescriptive requirements intended for new construction is too often technically, aesthetically and financially disastrous for existing historic tall structures. Mandated interior demolition, reconstruction and reorganization to comply with prescribed current regulations would completely destroy that which is desired to be preserved.

4. Fire and Life Safety Concerns of Tall Buildings

Fire risk in high-rise and tall buildings has been of special concern to the fire community for as long as there have been high-rise buildings. Codes and standards reflect that concern with special requirements for such structures (Hall, 2003). For example chapter 11 of NFPA 101, (2003) *Life Safety Code*, and chapter 33 of NFPA 5000, *Building Construction and Safety Code* (2003) include provisions specific to high rise buildings.

Issues associated with high rise buildings center around the height of the building in conjunction with potentially high occupant loads and the ease of fire department access (Holmes, 2003). Due to their nature and design, tall buildings significantly increase the occupant, equipment, and material load in a given building. Stacking floor upon floor dramatically increases the number of occupants and potential fuel load that could be exposed to a given event when compared to lower-height buildings.

As the location of a potential fire could be on upper floors, equipment transport and force deployment efforts could exact an exhaustive toll on fire-fighting forces before they can even mount a fire attack. Limitations of present-day fire apparatus in reaching upper floors from the exterior of the building also exist.

In addition to its height, the location of existing tall buildings can further hinder the fire department's ability to approach both the building and area of fire origin within the building. As a result, the fire department might be forced to approach the fire from less advantageous positions. Where active suppression systems and compartmentation are not provided, approaching the area of fire origin becomes even more difficult as the fire is able to grow and spread unhindered. Delays in deploying equipment and fire fighters can exacerbate this situation resulting in a fire of greater magnitude by the time forces are in place to attack.

Egress and people movement systems also make tall buildings unique. Because of their height and overall size, it takes longer for occupants to reach a place of safety outside of the building. In new construction protected stairways with specific dimensions for stair features are required to be strategically located throughout the building to facilitate safe and efficient egress during an emergency. In existing structures, compliance with such requirements often requires

significant modification and reconstruction.

Physical and environmental forces can have a much greater impact on fire spread and smoke movement in high rise or tall buildings than in lower buildings. Stack effect and the impact of winds on high rise buildings can be significant. Current approaches to minimizing stack effect and impact of winds include airtight construction on interior and exterior partitions and floors, eliminating naturally ventilated shafts, and mechanical air movement and smoke management systems. Existing tall structures are likely to have open stairs and other vertical elements that exacerbate the impact of stack effect and wind.

Associated with office spaces, residential units or lodging accommodations, tall buildings also contain health care, assembly, detention and mercantile occupancies among others. Tall buildings often contain combinations of these occupancy groups. Each of these occupancies possesses its own unique fire and life safety concerns in addition to those associated with tall or high rise buildings. As historic tall buildings undergo rehabilitation, changes to their original occupancy and function occur, and many will need to accommodate greater occupant loads as the building attracts more visitors because of its cultural significance.

5. Traditional Building Regulations

Building regulations in any country are intended to reflect the public expectation for the built environment with regard to the minimum acceptable requirements for safety, health, usability, and in some cases public welfare. Overall, the intent of these regulations is to ensure that building occupants will not be harmed during normal building operations and during emergency situations such as fires. It is not typical of building regulations to address property protection, or the protection of the collections or the historic fabric of the building for any reason including cultural heritage (NFPA 909, 2001). One exception to this general statement is NFPA 5000, *Building Construction and Safety Code*, which specifically includes a cultural heritage goal.

In terms of fire and life safety, traditional building regulations are described as prescriptive as they typically specify construction features such as the building's maximum height and area; fire resistance ratings of structural members and wall assemblies; protection of openings in walls and floors; the ability of building components to resist the passage of

smoke; capacity, number, arrangement and enclosure of the means of egress; types of active fire safety systems to be installed; requirements for interior finish and the need for emergency power and lighting among other building features.

Most fire-related research and code requirements are based on principles applicable to new construction. Although it had been assumed that the provisions for new construction are appropriate to existing buildings, the high cost of applying new construction standards to existing structures often results in technical difficulties, inefficiencies, and in some cases redundancies. For the historic building, required removal or alteration of historically significant spaces or materials – the very elements that establish the building's historic significance – is a clear indication of the obstacles associated with the rehabilitation of historic structures.

Existing buildings have always presented difficulties in establishing the extent of applicable requirements. Often, the line is ambiguous between minor repairs not requiring a permit or code official involvement and more substantial projects, which, in the eyes of the code enforcer require both. Most difficult for enforcement personnel are situations in which the code insufficiently addresses an issue and instead relies on the individual's interpretation.

6. Non-traditional Building Regulations

While a certain degree of latitude is usually provided in the interpretation traditional prescriptive building regulations with respect to the rehabilitation and restoration of historic properties, the application of such regulations still poses a great deal of difficulty (Puchovsky and Quiter, 2003). Frequently encountered constraints include aesthetic objections to the degree of compartmentation required in the regulations, difficulty in determining the fire resistance inherent in existing structural members or an inability to meet egress requirement such as the required number of exits or maximum travel distances. While the equivalency option in many traditional building codes provides some relief in this regard, no established guidance existed that would aid both the design and the AHJ in making appropriate decisions about the goals of the code, how to specifically deal with building rehabilitation, and how and to what an equivalent means of protection should be provided.

NFPA 5000 a recently developed building code

specifically identifies the goals to be achieved. Five broad goals are identified and include safety, health, building usability, public welfare and property protection as it relates to the other four goals. Within the broad of goal of public welfare is the goal of cultural heritage which embodies the preservation of historic structures and their contents. Two options, prescribed solutions and a performance-based approach are provided within NFPA 5000 to comply with its goals.

Where building rehabilitation occurs, chapter 15 of NFPA 5000 is specific to such projects. The purpose of chapter 15 is to encourage the continued use or reuse of legally existing buildings and structures without requiring full compliance with other sections of the code (Solomon and Harrington, 2004). It is assumed that existing buildings comply with a basic level of safety which is typically less than that for new construction. Any rehabilitation work is required to at least maintain the current level of safety with the aim of increasing the level of safety to that required for new construction. With few exceptions upgrades are only required in areas where rehabilitation work occurs.

The intent of chapter 15 is to allow building elements to be rehabilitated in manners that previously would not have been expressly permitted by a building code, but would be typically addressed as alternative methods of compliance, equivalencies or the subject of appeal hearings. A stepped approach that triggers more comprehensive provisions is outlined. Minor levels of rehabilitation are to comply with minimal requirements where as major rehabilitation projects are to comply with more substantial provisions. Chapter 15 categories and defines various types of rehabilitation work as follows: repair, renovation, modification, reconstruction, change of use, change of occupancy classification, and addition with a special category for historic building.

NFPA 914, *Code for Fire Protection of Historic Structure*, (2001) specifically addresses historic structures including ongoing operations, renovations and restoration. The purpose of the NFPA 914 is to provide life safety and fire protection in historic buildings while protecting the elements, spaces and features that make these structures architecturally significant. The preservation of the building's historic fabric is a specific goal identified by the code. As with NFPA 5000, NFPA 914 includes prescribed solutions and a performance-based design option for achieving

compliance. In addition, NFPA 914 addresses management and operational systems that need to be developed and maintained when the historic property in operation.

The process in discussed in NFPA 914 begins with a detailed survey to document historic elements, spaces and features, both interior and exterior, and to prioritize their historic or cultural significance should some compromise be necessary to achieve minimum safety objectives. Then the fire hazards and safety deficiencies are identified and compliance options are determined that satisfy safety objectives without sacrificing historical features. NFPA 914 urges that all parties involved in rehabilitation or renovation work including contractors understand the significant features that are to be preserved and that periodic audits be undertaken.

7. Performance-Based Design for Building Rehabilitation

Performance-based approaches are well suited for the rehabilitation of historic properties regardless of if they are tall buildings or other types of structures. The performance-based approaches outlined in NFPA 5000 and NFPA 914 parallel that found in the *SFPE Engineering Guide to Performance-based Fire Protection Analysis and Design of Buildings* (2000). In such an approach, the project goals, which for historic properties include life safety and preservation, are explicitly defined and quantified. Ideally, the goals are quantified into specific performance criteria that can be measured. The performance approach also requires that specific fire hazards and fire scenarios under which the goals are to be achieved are specifically identified and agreed upon by the AHJs.

In both NFPA 5000 and NFPA 914 specific information is provided regarding the establishment of performance criteria, characteristics and assumptions about the people and property to be protected, design scenarios that capture the associated fire hazards, reference to evaluation and design tools such as computer models, the need for establishing safety factors and guidance on the types of documentation to be provided.

Performance-based design, especially in the historic preservation of tall buildings, can better suit the needs of the stakeholders by presenting a range of possible solutions. Such an approach is about required outcomes that explicitly describe the intent of the code

rather than about specific prescribed solutions (Bukowski et al, 2003). For example a computer fire model that calculates the spread of fire and smoke can be used to more strategically position sprinklers and smoke detectors, and egress models can be used to better assess the existing egress systems.

8. Concluding Remarks

Balancing life safety with historic preservation goals in historic buildings presents unique challenges. These challenges are further complicated when the historic building is also a tall building. Traditional regulations are geared primarily to new construction and do not address property protection or historic preservation goals. Building regulations that specifically identify their goals, address building habilitation and include performance-based design options are much better suited for historic and culturally significant buildings. These resources in addition with other tools available in evaluating the existing safety features of historic building can be used by knowledgeable persons in developing design solutions that achieve the necessary level of life safety while preserving the historic fabric of the culturally significant tall building.

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