Practice Points NUMBER 23

Fire-Safety Approaches for Historic Buildings in the United States

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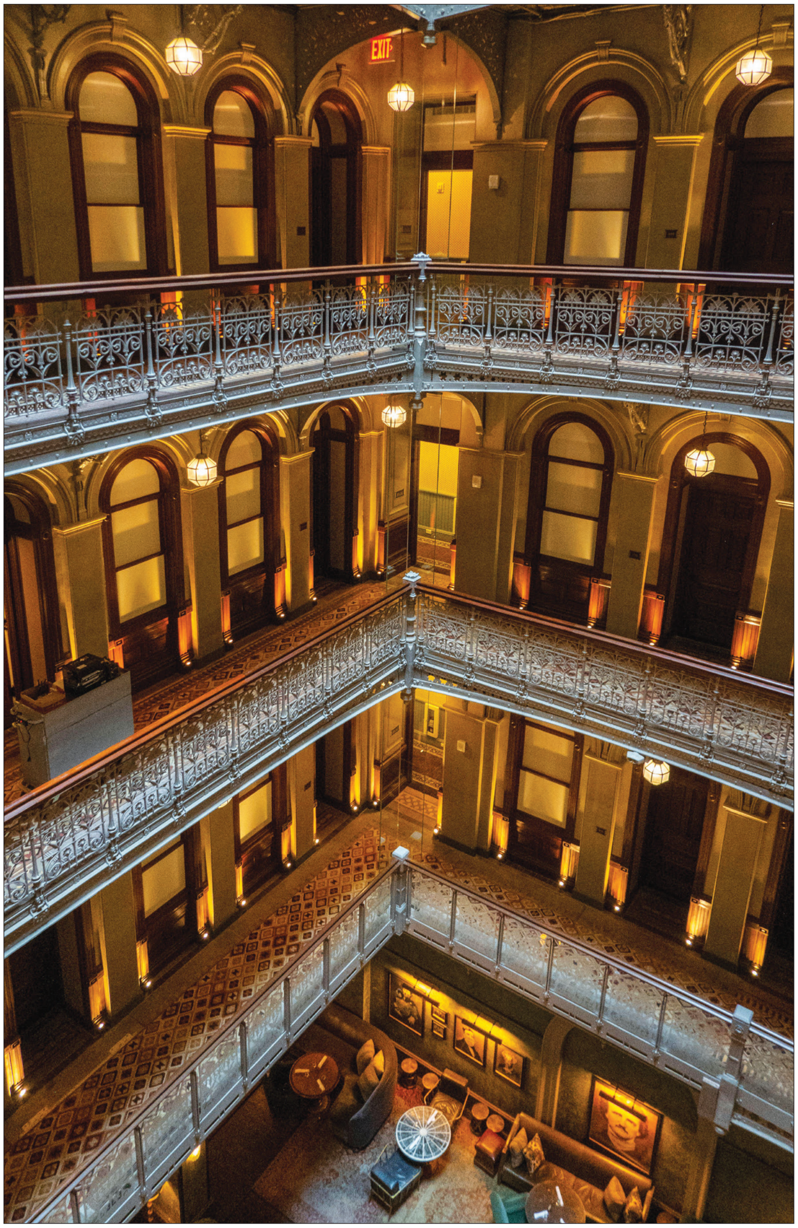
Fig. 1.
Beekman Hotel and Residences, New York, New York, built 1883, showing atrium balconies after renovation with retractable smoke curtains below each balcony concealed from view and vertical glass barriers at balcony corners to limit smoke migration as part of a smoke-control system. Courtesy of Randy Duchaine, Alamy Stock Photo, 2021.



In the United States, fires in historic structures occur more commonly than one may realize, due in part to a dearth of data. Many fires, such as the loss of the First Baptist Church in Morristown, New Jersey, in 2000 or the Cleveland Abb House in Washington, D.C., in 2021, show up only in local news.[1] Such fires can be devastating, not just in terms of loss of human life and property damage but also in terms of the loss to cultural heritage. The fire at Notre-Dame Cathedral in Paris in April 2019 attracted worldwide attention. The destruction of the timber spire and roof was extensive. Stone vaults were punctured by falling debris; exterior walls leaned inwards; flying buttresses were distressed; and lead vapor contaminated areas several miles downwind. In addition, many works of art and religious items were damaged. Restoration work may take five years to more than a decade to complete.[2]

However, the impact of fires in historic buildings, large and small, can be reduced with risk analysis and careful implementation of mitigation measures. Stakeholders must approach fire protection and life safety as an integral part of their responsibility as stewards of a historic building. Physical construction work or the resulting changes to a historic building being altered can increase the likelihood or consequences of fire.[3] Even a relatively small fire can be catastrophic should an artifact, a component of the building's historic fabric, or a critical architectural feature be destroyed. Additionally, installing a fire-safety feature without due consideration can damage or disturb the historic fabric of the building it is intended to protect.

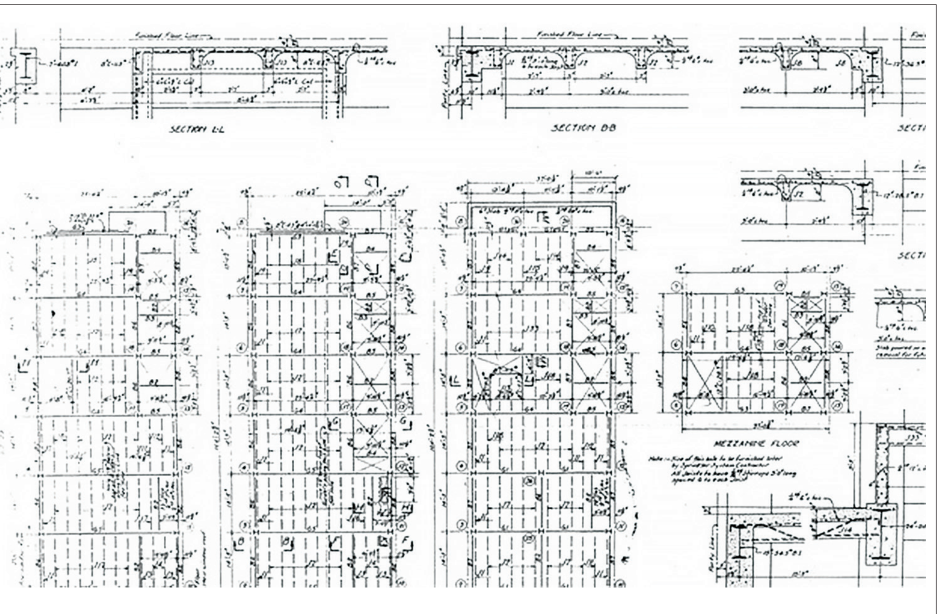


Fig. 2.
Sales Building, Cunningham Piano Co., 1312 and 1314 Chestnut Street, Philadelphia, Andrew J. Sauer and Co., Architects and Engineers, commission 245, sheet 10, structural drawing, November 1922. Structural drawings like this can aid in evaluating the fire resistance of beams, girders, and floor assemblies.

Modern building codes allow for historic-preservation programs to achieve code compliance through prescriptive or performance-based solutions. This *Practice Point* is intended to provide a general understanding of the fire-safety objectives commonly applied to preservation and adaptive-reuse projects. Based on these objectives, fire-safety approaches to solving problems in historic structures are identified and presented. Included are various code-compliance options and assessment tools to develop a comprehensive plan to meet fire-safety objectives. While focused on practices in the U.S., similar concepts and approaches can apply in Canada and Europe.

Guidance on Protecting Historic Buildings

Common fire-safety strategies may be at odds with the preservation goals of a project. One example is the restoration of New York City's landmark Beekman Hotel and Residences, where decorative railings and balusters prevented the installation of deployable smoke curtains because the curtains could not be sealed at the corners of the atrium. The solution was to design custom-made glass corner pieces to seal the gaps (Fig. 1). In other cases, fire-safety features can impact the interior or exterior aesthetic qualities of the structure. Finding the necessary balance can be challenging because building and fire codes are often geared towards modern construction materials and methods. In addition, risk-mitigation objectives and cost concerns of the stakeholders must be included to provide a well-developed, effective plan.

To help achieve balance within code-compliance constraints, several resources can serve as guidelines for assessing historic structures and then to identify and prioritize protection measures. These resources include the U.S. National Park Service's (NPS) *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring & Reconstructing Historic Buildings*, various publications by the National Center for Preservation Technology and Training, and *Fire Safety Retrofitting in Historic Buildings,* published by the Advisory Council on Historic Preservation and the U.S. General Services Administration (GSA).[4]

NPS standards and guidelines provide a framework and general information for decision-making about work or changes to historic buildings. This framework outlines four approaches to the treatment of historic properties: preservation, rehabilitation, restoration, and reconstruction. Selecting the appropriate approach for a particular project typically depends on the building's historic significance and current physical condition in conjunction with its proposed use and the stakeholders' goals. The extent of available documentation on the building's structure, architectural features, and engineering systems may also be a factor (Fig. 2). Tailored guidelines can then be applied for each approach based on examples of conditions and generally acceptable solutions such as:[5]

- Upgrades or modifications to existing historic stairways and elevators should not damage or negatively impact the character of the stairway or elevator. This approach includes avoiding damaging or making inappropriate alterations to adjacent features, spaces, or finishes, while still complying with egress requirements, flame-spread limitations, or fire-rated shaft enclosures (Fig. 3).
- When a new stairway or elevator is necessary to provide access or achieve life-safety objectives, alterations that impact character-defining spaces, features, or finishes should be avoided. A new exterior location on a secondary or less visible elevation should be considered (Fig. 4).
- A fire-suppression system should be installed so as to avoid altering historic features and finishes. For example, covering such features or finishes with gypsum board to address flame spread or fire resistance is generally not acceptable (Fig. 5).

Providing solutions to code requirements is an important part of protecting the historic character of a building. Code-compliance solutions must be sensitive to their potential impact on a building and its contents. For these reasons, coordinating with code officials, insurers, and emergency responders early on in a project can ensure that compliance expectations are met. Guidance can also be found in publications from the National Fire Protection Association (NFPA), including NFPA 909, *Code for the Protection of Cultural Resource Properties;* NFPA 914*, Code for the Preservation of Historic Structures;* NFPA 550, *Guide to the Fire Safety Concepts Tree;* and NFPA 551, *Guide to the Evaluation of Fire Risk Assessments.* Additional fire-protection approaches used in the U.S., Canada, and Europe are listed in the suggested readings at the end of this *Practice Point.*

Historic Buildings and Building Codes

So how do building codes in the U.S. address historic buildings given not only their physical challenges but also their importance in society? In many jurisdictions, historic buildings are addressed within the provisions for existing buildings by providing exemptions or alternatives to prescriptive requirements for other existing buildings. Some examples of such codes with provisions for historic buildings are the International Existing Building Code (IEBC); NFPA 5000, *Building Construction and Safety Code*; NFPA 101, *Life Safety Code*; and the California Historical Building Code. For work in federally owned historic properties, the GSA uses P100, *Facilities Standards for the Public Buildings Service*.

These standards direct project teams to develop approaches based upon state rehabilitation codes, the IEBC, and national performance-based codes to balance prescriptive requirements with preservation goals. Also referenced are NFPA 914, the U.S. Department of Housing and Urban Development's *Guideline on Fire Ratings of Archaic Materials and Assemblies*, and the GSA publication entitled *Fire Safety Retrofitting in Historic Buildings.* Specific alternative approaches can be found in P100, Section 7.13.3, and a number of technical guides published by GSA that address fire-alarm and sprinkler systems and fire prevention in historic buildings.[6]

This *Practice Point* focuses on the IEBC because of its broad adoption across the U.S., along with NFPA 914, as a nationally recognized standard specifically addressing historic buildings.

Fig. 3.
Historic buildings, like this early twentieth-century example, that have single egress stairs pose significant challenges to fire-safety planning. Photograph by the author, 2022.

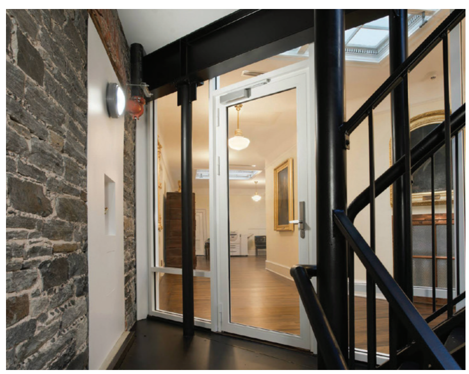


Fig. 4.
City Hall, New York, New York, built 1803–1812, showing recently constructed stair providing a second means of egress with glass and exposed structure integrated into the existing space. Designed by architects Beyer Blinder Belle. Photograph by John Bartlestone.

Fig. 5.
City Council Chamber, City Hall, New York, New York, showing automatic sprinklers integrated into the ceiling, including the perimeter of the ceiling mural and below the balcony. Courtesy of Felix Lipov, www.shutterstock.com, 2017.

What is a historic building? The IEBC identifies historic buildings and structures as being one or more of the following:

- "Listed, or certified as eligible for listing, by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, in the National Register of Historic Places.
- "Designated as historic under an applicable state or local law.
- "Certified as a contributing resource within a National Register, state designated or locally designated historic district."[7]

Generally, historic buildings and districts may be considered notable for their importance to society by connection to an event or person, their distinctive architectural character or artistic value, or a potential to yield historical information.[8]

Fig. 6.
Determining the fire-resistance of legacy construction materials and assemblies often requires invasive probes that should be carefully planned. In this image, the types and thickness of materials comprising an existing partition wall were determined in order to calculate its potential fire resistance. Photograph by the author, 2012.

Using the International Existing Building Code with Historic Buildings

The IEBC encourages the reuse of existing buildings while also maintaining a minimum standard of fire safety. The IEBC can be applied to repairs, alterations, changes in use or occupancy classification, or additions to historic buildings. Several code-compliance approaches are available. Primarily, these include prescriptive compliance, work-area compliance, and performance-based compliance methods. Additional options are to follow the code adopted at the time of the building's original construction if approved by the code official or to comply with the provisions of the International Building Code (IBC) for new construction. Mixing-and-matching compliance of these approaches is not allowed, and all members of the design team must follow that same approach.

Method 1: Prescriptive compliance method. The prescriptive compliance method was originally contained in Chapter 34 of the IBC. For alterations to existing buildings in general, the work must leave the building no less conforming with the IBC than it was prior to the alteration. All new work must comply with the IBC provisions for new construction. The minimum requirements contained in Chapter 11, "Construction Requirements for Existing Buildings," of the International Fire Code must also be met.

For historic buildings in particular, fire safety is addressed from a hazards-based approach. The designer, in conjunction with the code official, should identify hazards, such as limited exits or unenclosed vertical openings. The code official can then accept compliance with the appropriate provisions of the IEBC and the IBC, along with certain mandatory provisions contained in IEBC Section 507. While this is the most conservative of the IEBC compliance methods, it can be challenging to agree on the extent to which existing conditions must comply with the IBC. For this reason, this method tends to work well for relatively new buildings built using codes comparable to the IBC, but this method can be difficult to apply to historic buildings.

Method 2: Work-area compliance method. The work-area compliance method is often useful because it provides three levels of alteration, as well as changes in occupancy and additions. Each area within the structure can be classified separately to suit the work to be performed. As the scope of work increases, so does the extent to which the work areas must comply with IBC requirements. Establishing separate work areas can be beneficial where work may be limited in some areas and more extensive in others or for older buildings not in compliance with more recent editions of the IBC.

There are specific provisions for historic buildings intended to help address their preservation challenges while establishing minimum fire-safety requirements. This approach also allows the code official to remedy unsafe conditions. Included are several specific fire-safety alternatives or exemptions to address common problems. Two examples of permissible fire-safety alternatives are:

- Meeting modern requirements for fire resistance is often a challenge in historic structures due to legacy materials or methods of construction (Fig. 6). An alternative is to provide an automatic fire-extinguishing system with occupant and fire-department notification where the code official determines that a distinct fire hazard is not created by the rehabilitation work.
- Main entrance doors and grand stairways are often key elements in the historic character of a building. The code official may permit existing door and stairway widths to be maintained if there is sufficient width and height for a person to pass during egress. Similarly, the code official may allow existing front or main exit doors to swing inwards if other means of egress have sufficient capacity for the total occupant load, if the inward swinging doors are arranged to stay open during occupancy, or if new outward swinging doors provide for climate control and safe egress while the existing doors remain open.

Method 3: Performance compliance method. The performance compliance method may be the least understood and the least used of the three primary compliance methods. The performance compliance method is used to evaluate proposed work based on a numerical scoring system. It recognizes that it is impossible to physically inspect and evaluate every aspect of an existing building because many features are concealed. There are no special provisions for historic buildings because compliance is inherently performance-based and site-specific. This method can be valuable for buildings with significant areas that do not comply with the IBC. Relative to the other methods, this method may identify more options for compliance.

This method also identifies several general safety concerns along with 21 elements to evaluate the level of safety for an existing building. These elements are placed in three categories that are used to generate a risk-based score for the overall building:

- Fire safety, which includes structural fire resistance, automatic fire detection, fire-alarm system, automatic-sprinkler system, and fire-suppression system features.
- Means of egress, including exit capacity and number, dead-end corridors, emergency lighting, and travel distance.
- General safety, which combines the fire-safety and means-of-egress parameters.

Based on the occupancy of the building, mandatory minimum scores are provided for each of these three categories. The building's score is compared to the minimum mandatory scores. The difference between the two scores must be greater than zero in each category in order for the building to pass.

Historic Buildings Using NFPA 914

NFPA 914 defines historic preservation as encompassing "all aspects . . . related to the maintenance of a historic structure, site or element in its current condition, as originally constructed, or with the additions and alterations determined to have acquired significance over time."[9] While NFPA 914 is considered a "code" by the NFPA and must be considered for federal historic properties, most jurisdictions in the U.S. do not adopt NFPA 914 because it is not a referenced standard in the IBC or IEBC. However, as a recognized resource, a code official may approve the use of NFPA 914 as an alternative compliance method.

Fire-safety and preservation objectives. When applying NFPA 914, the project objectives should reflect the risks acceptable to stakeholders responsible for the historic structure. Fire-safety objectives include:

- Providing an egress system to protect occupants who are not near the origin of the fire.
- Ensuring structural integrity during a fire.
- Ensuring that the building's construction and its operational continuity are sufficient to meet the stakeholders' goals for life safety and preservation of the building's historic fabric.
- Providing security measures to achieve those goals.

NFPA 914 also provides objectives for preservation projects. These include:

- Providing fire-protection features and security measures in a manner to preserve the building's character (Fig. 7).
- Minimizing removal or alteration of historic materials or architectural features.
- Treating distinctive features with sensitivity.
- Encouraging compatible uses.
- Performing work so that, if it were to be removed in the future, the essential form and integrity of the building or structure is maintained.

Process and assessment methodology. With the project objectives established, NFPA 914 provides a process for assessing a historic building, developing design options, and reviewing those options for conformance with the objectives. Once the design has been deemed acceptable, the work can be implemented, compliance audits performed, and deficiencies resolved. Since many conditions in historic buildings are concealed or unknown during the design stages due to the limited ability to make destructive probes, the design option development step may need to be revisited.

NFPA 914 includes a detailed assessment of the fire-safety features and historic integrity of the structure. This assessment is to be conducted by individuals with expertise in historic preservation, fire protection, and security. The first part of the assessment involves the identification of historic elements and spaces by the preservation architect. The identified elements and spaces are then prioritized for preservation. This is a critical step where the NPS standards and guidelines can be useful. A

Fig. 7.
Stephen A. Schwarzman Building, New York Public Library, New York, New York, completed 1911, showing the integration of fire-alarm devices in a way that respects the historic aesthetic of the space. Photograph by Michelle Dalhoff, Wiss, Janney, Elstner Associates, Inc., 2020.

similar process identifies and prioritizes fire-safety issues.

Once the problems are identified, the fire-protection engineer prioritizes each item by relative risk. A commonly used method is fire-risk indexing, which considers the building in its entirety by measuring relative strengths and weaknesses of deficiencies, as well as potential improvements. Examples are the IEBC's performance-compliance approach and NFPA 101A, *Alternative Approaches to Life Safety*. After prioritizing the issues, options to resolve the deficiencies are appraised. This can be accomplished through prescriptive or performance approaches, or, unlike the IEBC, a combination approach.

Operational procedures not directly addressed in the IBC or the IEBC can be incorporated into the proposed solutions—by considering factors such as staffing levels, employee training, human behavior, and costs—and then presented to the code official.[10] This approach presents a broader set of tools relative to the IEBC prescriptive or work-area compliance methods. Examples may include:

- Fire-prevention practices that eliminate ignition sources or limit combustible materials.
- Security practices to limit access and opportunities to introduce ignition sources.
- Frequent guard tours or video surveillance to serve as a fire watch.
- Enhanced emergency response to mitigate incipient fires in high-value areas.
- Planning for salvage operations to allow for more rapid protection of items or features not directly involved in a fire.
- Implementing permitting programs, hot work best practices, and temporary protection measures during maintenance, construction, and demolition work.[11]

Prescriptive option. Under NFPA 914, the prescriptive option allows for flexibility on a component basis. Compliance can be achieved by meeting the applicable codes to the greatest extent possible and, where approved by the code official, applying the following:

- Alternatives such as listed exceptions to prescriptive requirements or safety features that can compensate or offset code-compliance deficiencies.
- Equivalencies using different materials, systems, methods, or approaches from those given in the applicable code if it can be demonstrated that the same degree of safety is provided as prescriptive requirements. To demonstrate equivalency, precedents, ad hoc or informal solutions based on subjective logic, or qualitative approaches like NFPA 550's Fire Safety Concepts Tree can be used.
- Code modifications or waivers where compliance is impractical and safety is not compromised.

Performance option. NFPA 914's performance option can be used for systems or operations. Using this option requires a qualified person who is acceptable to the code official and also requires the involvement of multiple members of the project team. Many performance-based designs are complex, so the code official can also require a third-party review prior to acceptance. Selected systems and operational features must be maintained for the life of the building. If the design does not identify specific redundancies, impairment of any single component may require a fire watch or a provision for the building to be vacated by the code official.

The performance option addresses the building holistically. It requires the evaluation of a minimum of eight design-fire scenarios addressing life safety and building protection. The scenarios must be challenging but realistic for the building in terms of the initial fire location, early rate of fire growth, and smoke generation. The design-fire scenarios must include a typical fire for the occupancy, as well as more challenging scenarios. Examples include an ultrafast fire in the primary means of egress, a concealed fire, and a scenario where the fire-protection systems are impaired. Evaluating and establishing design-fire scenarios is a critical step requiring the expertise of a qualified fire-protection engineer.

Risk Assessment

As technology has evolved since fire-engineering concepts were developed in the 1970s, the acceptance of performance-based, risk-informed approaches to fire safety has increased significantly. Evaluating solutions that balance preservation and fire-safety objectives for a particular historic building alteration must involve careful consideration of risk. To understand the risk associated with implementing a particular design approach or feature in a historic building, the probabilities and consequences associated with fire and other undesirable events must be identified, paired, and characterized. The fire-risk assessment will break down the likelihood and consequences of specific fire scenarios in the context of specific fire-safety concepts and systems or combinations thereof.

Selecting an appropriate fire-risk-assessment methodology should take into consideration "stakeholder objectives and acceptance criteria, scope of the fire risk assessment, intended audience and decision makers, regulatory and/or litigation considerations, precedents for similar applications, available resources and data, cost and time constraints, personnel capabilities, and the possible need to address uncertainties."[12] Qualitative fire-risk assessments and cost-benefit analysis are commonly used methodologies, but quantitative methods can also be used.[13]

Determining the likelihood or probability of a fire scenario often looks at loss statistics and may address uncertainty and other variables through mathematical methods. Consequences are anticipated using past losses or risk indexes developed from expert knowledge; probabilistic methods, such as fault trees; failure mode and effect analysis; or deterministic methods, such as modeling fire effects or occupant egress times. Statistics regarding fire loss in historic structures are not tracked in the U.S.; most databases on fire loss are based upon the use of the building and not its historical or cultural value.[14] Therefore, loss statistics for modern building uses may need to be adjusted through mathematical methods to account for this uncertainty and potential variability. Data on fire losses in other countries may also be considered but should be evaluated carefully before doing so.

The Fire Safety Concepts Tree, found in NFPA 550, can be used as a tool to assist fire-protection engineers in developing and communicating fire protection and fire-safety design alternatives on historic building alteration projects (Fig. 8). Different fire-prevention and consequence-management strategies are organized into a logic tree structure allowing the fire-protection engineer to identify and compare potential approaches, their impacts, gaps in protection, and redundancies.[15] The Fire Safety Concepts Tree assists in communication of a holistic, systems-based approach to address a project's fire-safety and preservation objectives.

Closing

In summary, this article highlights the importance of integrating preservation and life-safety goals and objectives for projects involving historic structures. This includes methods of assessing conditions, identifying and prioritizing issues, and developing design options. Design options for addressing code compliance were also discussed and include prescriptive solutions using alternative approaches and performance-based engineering methods. Finally, two tools were mentioned for identifying and prioritizing life-safety issues and evaluating potential solutions. This includes the NFPA 550 Fire Safety Concepts Tree and the risk-indexing method in Chapter 12 of the IEBC.

For historic properties in the U.S., risk-based approaches and even prescriptive requirements within existing building codes can be improved through better data collection on fire loss. The key to successful implementation of a balanced level of fire safety in historic buildings is an integrated approach

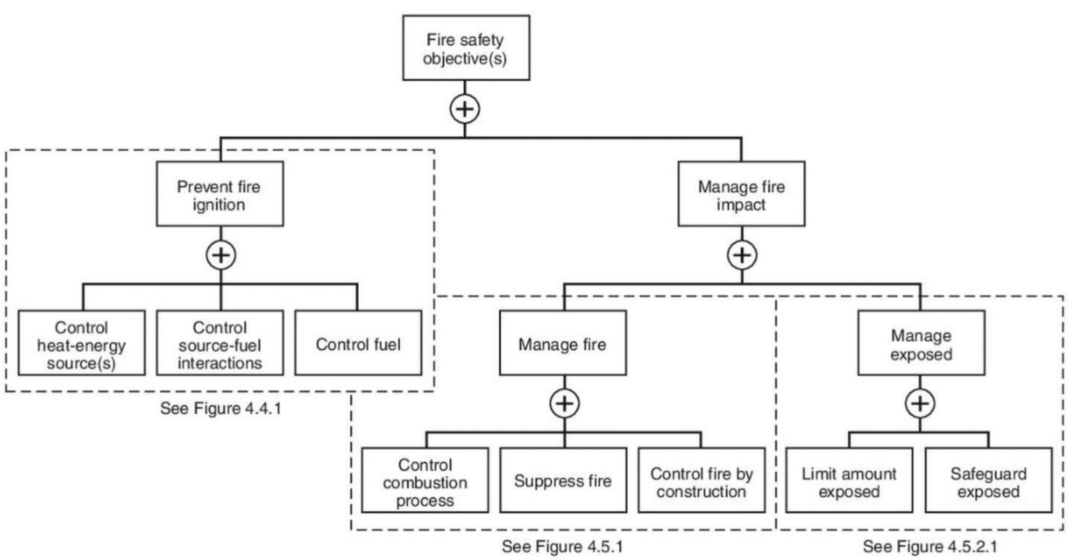


Fig. 8.
The Fire Safety Concepts Tree can be used to evaluate and communicate fire-safety approaches in historic buildings; reproduced with permission of NFPA from NFPA 550, Guide to the Fire Safety Concepts Tree, *2022 ed. Copyright © 2021, National Fire Protection Association. For a full copy of NFPA 550, please visit www.nfpa.org.*

that combines the expertise of preservation architects with fire-protection engineers. This integration will allow the greatest flexibility whether the choice is to use a prescriptive approach supplemented by alternatives, equivalencies, or modifications or in the development of a performance-based design.

Acknowledgments

Special thanks to Kyle M. Normandin and Nicholas E. Ozog, both of Wiss, Janney, Elstner Associates, Inc., for their guidance and contributions to this article.

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APT's mission is to advance appropriate traditional and new technologies to care for, protect, and promote the longevity of the built environment and to cultivate the exchange of knowledge throughout the international community.

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