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PERFORMANCE-BASED APPROACHES TO PROTECTING OUR HERITAGE

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ABSTRACT

The purpose of this paper is threefold; to emphasize the problem of fire safety for historic buildings, to identify potential for a performance-based approach to this problem, and to discuss development of performance objectives and criteria for heritage properties. With this effort we hope to encourage and facilitate the use of performance-based fire safety engineering in the preservation of historic structures.

The heritage building poses unique problems for fire protection. Unlike most public and commercial buildings, an historic structure exists as an artifact or visual record of architectural or historical significance. If the building is destroyed, this function ceases to exist. Creative solutions must be developed that meet fire and life safety objectives without compromising the historic or architectural significance of the heritage building.

Performance-based evaluation offers a logical and systematic approach to assessment of fire safety in historic properties. Restrictions such as the need for preserving the character of heritage buildings with sensitivity, awareness, and appreciation of significant features must be quantitatively formulated. Appropriate objectives and performance criteria are key to performance-based evaluation.

Some objectives of heritage properties are consistent with other types of buildings. Yet additional assumptions, variables, and constraints often prevail. Certain architectural features cannot be altered without destruction of the essence of the structure's meaning. Usual objectives of life safety, property protection, and mission continuity take on different proportions when preservation of the building in its original form is a transcending goal.

While performance criteria are formulated to identity measurable levels of success in achieving fire safety objectives, historic significance is an immeasurable value. No upper endpoint on the scale of cultural worth exists to quantify terms such as "priceless" and "irreplaceable". Yet, mechanisms and techniques for developing quantitative performance criteria do exist and are being used.

INTRODUCTION

No statistics are available to determine the vulnerability of historic buildings to fire. How much of our cultural heritage has been lost and continues to be lost to fire is unknown. Fire loss data is collected only on factors that relate to fire cause and origin. There is no fire loss data by historic significance or building age. We learn about fire losses of historic buildings by observing those that occur around us or through media attention to those that are most significant and newsworthy.

In many respects heritage buildings have been under served by the architectural and engineering communities and have not, as a whole, received the level of fire protection warranted buildings of such significance and distinction. This can perhaps be explained by the idiosyncratic nature of these buildings, which defy standard code and construction classification approaches given their unique and diverse building configurations, construction materials and occupancies. Additionally, heritage buildings have received inadequate attention, and subsequently inadequate protection, because they are difficult to retrofit: accessibility to concealed spaces is limited, aesthetic impacts are paramount, and many site and facility managers fear water damage to collections and insensitive installations that will destroy the historic character. Most important, however, is that heritage buildings do not conform to the generic building type on which building codes and fire protection applications, based on ideal new construction configurations, are based. Unlike new construction, for which code requirements focus on life safety, historic buildings present an additional challenge and focus not addressed by modern codes—that of protection of the property itself.

Until the late 1970s, most designated historic buildings were small historic house museums or monumental public structures with low hazard occupancies, minimal risk to life and a high degree of building supervision. The codes were either silent on these buildings or provided great discretion to the local code official. Although working in the absence of guidance for evaluating a structure that was so different from a new building, the code official was often hesitant to cause significant alteration of a building cherished by its community. Owners, pleased to have minimal requirements imposed and ignoring the possibility of a fire, considered leniency on the part of the code official a success.

The advent of the American historic preservation movement, most specifically the government efforts of the 1960s and 1970s, radically changed this “don’t see, don’t tell” approach. Thousands of buildings received historic designations and were rehabilitated for residential, commercial and institutional use. The inherent conflict of maintaining historic character while achieving the level of safety expected of new construction surfaced, and thirty years later remains unresolved. Only recently have rehabilitation codes been created by model code organizations and government entities that recognize the inherent differences between new construction, on which the codes are based, and rehabilitation. While the adoption of these codes represents progress, most retain the inflexibility and additional problems of other specification-based codes. Most are particularly inadequate in their approach to historic buildings, the subcategory of existing buildings with the highest requirement for property protection. None of the recent generation of rehabilitation codes has resolved the conflict between the technical language of the

codes and the philosophical language of the *Venice Charter*, or the *Secretary of the Interior Standards for the Treatment of Historic Properties*, documents used internationally and in the United States to prescribe appropriate preservation approaches and techniques.

The vulnerability of historic buildings to loss or damage from fire is reinforced with each major fire that destroys an historic structure and its contents, depriving future generations of their cultural heritage. Historic structures are not buildings that can readily be replaced, but rather irreplaceable artifacts whose value cannot be recovered by insurance payments. Very few organizations can match the financial resources used to reconstruct Britain's Windsor Castle or Yorkminster Cathedral. Instead, buildings of less significance, albeit with historic designations, often fall prey to the wrecking ball following a major fire.

HERITAGE PRESERVATION

Although American preservation efforts of the early 20th century were undertaken by the public and private sectors, it was the passage of the National Historic Preservation Act of 1966 that directed the creation of a national list of sites and properties with local, state, or national significance worthy of preservation. While the National Register of Historic Places originally included many of the nation's most pristine and significant resources, there are now more than 66,000 structures listed in the National Register and thousands more with separate state or local designations.¹ Tens of thousands of additional buildings are eligible for listing. Historic designations are granted to structures, sites, and objects, generally more than 50 years of age, which are associated with historical events or significant persons or have architectural or engineering significance. Buildings are designated individually or as components of historic districts. Most listed buildings are within historic districts: while many of these lack individual distinction, each building merits recognition and protection given its contribution to the whole. Groups of simple nineteenth century structures used for workers' housing, or a main street's intact commercial structures, are examples of structures that might be listed as part of an historic district. This approach to designation is not unique to the United States. Most nations have programs to designate individual structures or districts: often the latter are referred to as historic towns or historic town centers.

The designation process is only one illustration of how historic preservation has increasingly become part of society's cultural awareness. The United States and other countries have encouraged rehabilitation and restoration through grant and other financial incentive programs. Visitation to museums and historic sites is on the increase, heritage tourism has become recognized as an important economic development tool, and both the public and private sectors have focused on urban revitalization as an alternative to urban decay and suburban sprawl. All of these examples ensure that historic buildings will have a presence in the future's built environment.

Historic buildings are subject to many of the same threats as other existing buildings, including arson, lightning, construction operations, faulty equipment, and inadequate maintenance. They are also vulnerable to another type of destruction-- that caused by a lack of understanding of

how design professionals should respond to their unique configurations and performance characteristics. Standard fire protection approaches, based on ideal (new construction) conditions that drastically differ from the conditions presented by historic buildings, can have adverse impacts on historic materials and spaces and destroy the very materials or qualities that give the space its historicity. These damaging approaches include architectural changes, such as the removal of significant architectural features, as well as changes made for the installation of fire protection equipment. The problem is not in the introduction of these changes, but rather in their implementation without aesthetic sensitivity and an accurate understanding of how each change affects the fire safety of the building. Unfortunately, improvements heavily based on redundant fire safety features, and applications that do not directly address the specific hazards presented by a building, are usually unavoidable given the inability of specification-based codes to address a building's idiosyncracies. Moreover, the inherent bias of the codes to life safety results in inadequate property protection for the historic building.

Since fire protection measures are usually undertaken to meet code requirements, a brief summary of how codes address historic buildings is provided. Already mentioned is the tradition of codes to ignore historic buildings or rely on the code official to determine what is safe, or what is an acceptable equivalency to a specific code requirement. Over the last 40 years codes have been adopted or amended nationwide with increased specificity, reflecting suburban and urban growth, public and private efforts to improve housing conditions, the application of research and technology, the litigious nature of society, and society's unspoken expectations of increased safety. Simultaneously, codes have become increasingly complex by virtue of being available receptors for legislative reactions to catastrophic events, and by intentions to maximize standardization and predictability and minimize the role of the code official's discretion. All codes have added explicit sections or separate documents for rehabilitation, and a few have adopted similar provisions for historic buildings. These generally share the approach of having no requirements for the building when no work is proposed to occur, requiring only the proposed improvements to meet new construction standards when a project is of limited scope; and requiring full compliance with new construction standards when a financially substantial project or a change of occupancy is proposed. Few requirements are retroactive. Where special provisions for historic buildings do exist, the codes generally give the most leniency to historic sites and museums.²

While the codes' specific approaches to rehabilitation and other historic buildings vary widely, most have not addressed four basic problems: that no two historic buildings are alike in their construction, condition, integrity, and current or proposed use; that the specification-based system based on principles of new construction is inadequate; that no methods are commonly available to evaluate equivalently safe alternatives; and that the codes do not discriminate between goals relaxed to life safety, property protection and the minimizing of operational interruption. Performance-based codes are essential tools to confront these failings, and to eliminate the inherent system of redundancies that obscure the inability of specification-based codes to address specific hazards and acceptable risks.

LIMITATIONS OF EXISTING APPROACHES

The difficulties of changing a long ingrained system from specification-based to performance-based codes are not unique to heritage buildings, as thoroughly discussed in recent literature. While perhaps foremost are the obstacles to be encountered in radically transforming an entire system, equally significant is the challenge to establish a sound scientific and technical foundation on which the performance-based codes will be based. The recognition that the codes are suffused with sound logic, tradition, and experience, but also riddled with assumptions, errors and inconsistencies, is not a new observation. The situation was commented on as early as the 1920s, when the Senate Select Committee on Reconstruction and Production wrote:

The building codes of the country have not been developed upon scientific data but rather on compromises: they are not uniform in principle and in many instances involve an additional cost of construction without assuring most useful or more durable buildings.³

In the same decade, the Building Research Advisory Board (BRAB) took the first steps to define and study the performance concept in its entirety, noting it would:

...require years of effort to cover the existing state of the art plus the continuing job necessary to stay abreast of future ideas. Informed observers state that even if a start could be made today on the job of developing true performance standards to satisfy the needs of the building industry and assuming that financial and technical resources were available, the task would take several years to complete.^{4,5}

In 1966, the US Advisory Commission on Intergovernmental Relations, focused on the production of housing, also reported on the difficulty of creating performance-based standards given the need for scientific research, the lack of identification of characteristics essential to measure building performance, and the lack of a determination of the level of performance necessary. The Commission wrote that . . . Without a clear picture of what constitutes satisfactory performance and of how it will be determined, a great deal of research and technical work of an industry is wasted by misdirection. . .⁶

Even more recently, many of the code-related discussions of the late 1970s, whose impetus was the creation of housing standards and support of a variety of urban revitalization programs, noted the inability of rigid and specific specification-based requirements to keep pace with emerging technology and construction techniques. Some criticized the specification-based codes for prescribing materials and assemblies for which scientifically derived, verifiable understandings of behavior did not exist. In a 1978 hearing before the Senate Committee on Banking, Housing, and Urban Affairs, one participant noted that what was needed was. . . a reliable set of analytical methods by which the performance of a building and building components which already exist can be rapidly, readily and effectively assessed. . .⁷ While many organizational changes were made to the codes in the 1980s as a result of the previous decade's dialogues, including the adoption of rehabilitation and some historic building provisions and codes, the slowing of the economy in the late 1980s hampered many similar efforts.

PERFORMANCE-BASED CODES

Performance-based fire safety design begins with the identification of fire safety objectives. This step is necessary as a means to generate ideas for creating alternatives and, most important, to provide a basis for the evaluation of alternatives.

Goals and Objectives

Goals are statements that describe the aspirations of an organization or of society. They develop as generalities without regard for specific implementation or the cost or means of achievement. In this sense, goals are idealistic, i.e., they do not reflect existing resources or technology. They are the general end toward which some effort is directed. To establish a policy for achieving goals, objectives must be defined. Objectives are the specific results by which goals are fulfilled. Whereas goals are subjective and difficult to measure, objectives are more absolute and determinable. They are short-term practical and specific targets that motivate how a system is to perform.

Fire safety decision-makers seldom carefully articulate objectives for fire safety. Instead, many applications use vague statements like “life safety” as objectives. From the scientific point of view, such terms and phrases are too equivocal and may be misleading. To clarify the matter, scientists and engineers must replace vague statements of objectives with some precise and specific measures of performance.

The most commonly cited goals of fire safety are the concepts of life safety, property protection, and operational continuity. While these may have alternate labels, or more definitive constituents, the purpose of most past fire protection activity can be traced to one or more of these concepts.

Today, many fire protection philosophies implicitly or explicitly include preservation of the natural environment as a fourth fire safety objective.

Realistically, the objective of all fire safety engineering design is to minimize cost subject to imposed constraints defining a minimum acceptable level of fire safety. Alternatively, some acceptable level of fire safety at some acceptable level, or an equivalent level of fire safety at some lower cost, is sought. This might be considered optimal if it represents the lowest possible cost for attaining the specified level of fire safety. The critical problem with designing to a minimally acceptable level is that it does not identify a potential for a significant increase in safety at a marginal increase in cost. In some applications, there may be interest in exceeding the acceptable minimum level of fire safety. For these situations, new values for the constraints must be determined. Agreeing on a new reasonable level of safety is necessary and in some cases a higher level of safety can be provided for the same cost.

Performance Criteria

The performance-based approach is one that establishes fire safety objectives and leaves the means for achieving those objectives to the design professional. Implementation requires the capability to evaluate whether the stated fire safety objectives are met, which in turn mandates the establishment of an acceptable level of performance.

An acceptable level of performance is a performance criterion framed or formulated to identify a measurable level of success in achieving fire safety objectives. Heritage buildings present a particular challenge since their value scale has no endpoint, hence the terms "priceless" and "irreplaceable". Further, preservationists and conservators are often loth to assign a replacement value to the historic building. Some mechanisms and techniques for developing performance criteria, such as the Historic Quality Index developed by the US Government Services Administration (GSA), are useful models illustrating approaches to quantifying performance criteria.⁸

GSA's Historic Quality Index (HQI) represents that agency's approach to manage the thousands of federally owned historic buildings. The HQI acknowledges that government had limited financial resources to dedicate to preserving its historic structures, and creates a means to rate and compare the significance of individual architectural elements, building zones, and the individual building as a whole. A numeric rating is provided to each element, zone and building, and the three ratings are integrated into a single number that expresses the combined historic significance of the entire building. The index can be compiled from field survey data or a preexisting historic structure report, e.g., ASTM, 1996.⁹

The HQI approach presents a framework to be considered for fire safety applications to historic buildings. It establishes the possibility of selecting multiple levels of fire safety performance as a function of the significance of architectural features and spaces. For example, the following are proposed performance criteria for application to historic buildings, where areas, spaces and features have been rated on a Significance Rating of 1-4, with 1 representing the highest level of significance.

- 1) In any area with a Significance Rating of 1, a fire shall be controlled so as not to produce heat or other products of combustion that will cause damage to significant elements in the area. (Fire confined to the item first ignited).
- 2) In any space outside the room of fire origin, heat and other products of combustion shall not exceed a level that will cause damage to significant elements any area with a Significance Rating of 1 or 2. (Fire confined to the room of origin).
- 3) In any space outside the area or zone of fire origin, heat and other products of combustion shall not cause damage to any significant element in an area with a Significance Ratings of 1, 2 or 3. (Fire confined to the area or zone of origin).
- 4) The fabric of any building with a Significance Ratings of 1, 2, 3 or 4 shall not be exposed to heat or other products of combustion that exceed a level that will cause

damage to it. (Fire confined to the interior of the building.)

While the HQI presents an interesting model to be explored in detail, it may be of limited utility for establishing performance criteria for fire safety in the individual historic building. It was developed as a tool with which GSA could compare thousands of buildings, whereas the creation of fire safety performance criteria must be developed for each unique structure. Further, the unintended result of providing the highest degree of fire safety in the most significant area of a building is the likelihood of requiring the most architectural and engineering modifications or installations to that space.

Performance Evaluation

Performance evaluation consists of comparing predicted outcomes with stated objectives. All performance-based codes and fire safety design methods involve performance evaluation. In a performance-based code the method or methods of evaluation must be codified or standardized. An acceptable design is one that satisfies the specified performance evaluation. One tool used for performance evaluation is the algorithm or model that predicts the outcome of a fire or fire scenario. Models such as HAZARD I, FPETOOL, and FASTLite can be used to evaluate performance against the criteria listed above. However, since the conflict in heritage properties lies in achieving fire safety goals without building modifications that damage historic integrity, more comprehensive, hybrid models for fire safety are required. These models must be able to consider all of the attributes of a building and its occupants that affect both life safety and heritage preservation. For example, to address property protection thermal damage is of paramount concern, and thus temperature and heat flux are appropriate measures of performance.

CONCLUSIONS

In examining the state-of-the-art of fire safety in historic buildings, we have reached the following conclusions:

1. While protection of our heritage from fire is an important societal goal, historic buildings are not adequately protected from loss by fire.
2. Existing building and fire codes and standards do not adequately address the protection of historic buildings from fire.
3. Performance-based fire safety is a viable approach to protecting our heritage.
4. The creation of performance objectives and criteria for historic properties is a difficult but a feasible task
5. Additional research is necessary to identify appropriate methods for performance evaluation of fire safety in historic buildings.

The upcoming decades promise to be a time of extraordinary development in the fields of fire protection and building regulation, and heritage buildings will benefit tremendously from these advances. When applied to heritage buildings, performance codes will provide an unmatched opportunity to target a fire safety approach to each building's idiosyncratic characteristics. Given the conflicts raised in the current application of codes to historic buildings, the increasing ability to predict fire hazard and performance accurately and to provide a quantifiable basis for the acceptance of equivalent systems will ease the inherent conflict between building codes and traditional approaches to fire safety and historic properties.

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