Summary

Two general aspects of design for fire safety are described in this book: fire performance of materials and products that are found in a fire system, and fire performance of the total fire system. When considering the first viewpoint, emphasis is on individual items which contribute to fire hazard by generating heat and smoke, or by loss of structural strength or integrity. In the second, the cumulative effects of individual items comprising the fire system are considered, and means of minimizing the impact of the total fire on life and property are the design goals.

The first paper by Roux and Berlin presented a systems approach to design for fire safety. The authors "develop a concept of viewing the fire problem as a set of interrelated, interdependent parts working together for the overall objective of the whole." The "Decision Tree" is a graphic representation of this concept in terms of the events leading to the ultimate goal—fire safety—by two means: preventing ignition and managing the fires impact.

A building fire safety model, based on fire behavior as characterized by "realms" or states of fire development, has been proposed. This computer simulation model provides a systematic procedure for measuring hazards of building fires in terms of rate of fire growth, likelihood of entrapment, and estimation of structural damage. The model is potentially useful for comparing fire safety levels provided by code compliance and for identifying voids in fire test data. It has been used to evaluate alternative building designs and to describe effectiveness of suppression mechanisms.

The effect of specific materials and product types on fire safety were examined by Abrams and Hilado. In both papers, basic properties and test information were given for a variety of materials. These data were then used to illustrate or predict improvement in safety of the fire system by using materials having better fire performance.

Abrams provided data giving the effect of changing temperature on strength, elasticity, and thermal properties for different inorganic building materials. Detailed references and graphical representation of modulus of elasticity, stress-strain relationships, strength, and thermal properties of these materials provide very useful, up-to-date information needed to predict performance of fire exposed structures.

Calculational methods for predicting structural performance are referenced and described for concrete and steel structures and structural members. Comparison between experimental and calculated fire resistance was given for many common structural types. A section of Abram's paper was devoted to an examination of structures exposed to actual fires to show that performance of a building can be predicted if proper consideration is given to material properties and the fire severity that can be expected.

Organic materials, with their remarkable range of physical properties and fire performance, are a difficult class of materials to characterize, particularly in respect to fire performance. Organics provide the fuel for fire. They are used as load bearing structural members, and often are found exposed as finishing material or in furnishings where combustibility is the major concern. Hilado and Murphy presented "combustibility" in terms of several fire response characteristics: heat and smoke release, smolder susceptibility, ignitability, flame spread, and flash-fire propensity. They believe that physical characteristics and placement of the materials control fire safety rather than chemical composition of the materials. For example, the authors reported that the addition of a cushion pad under a carpet had a greater effect on critical radiant flux by the flooring radiant panel test than the difference between carpets.

Hilado and Murphy do not agree that laboratory tests are misleading simply because they do not always predict behavior in real fires. They pointed out that, in general, materials that perform well in laboratory tests are not likely to be a hazard in a real fire.

The preceding authors presented fire performance and properties of materials that directly or indirectly are responsible for fire hazards. The last four authors examined the total fire system in order to understand and thereby abate the fire's development and its impact on the building.

Whether or not the occupants of a compartment will come out of a fire incident unharmed depends primarily on the characteristics of the fire in its earliest stages. Freely burning compartment fires do not necessarily proceed to full development. For those that do, the time to flashover is naturally the ultimate time that the occupants have to escape or to be rescued. Yet, the time of safe escape may be significantly less; lethal conditions may develop within 5 min, regardless of whether the fire ever reaches the flashover stage.

The paper by Pape and Waterman reviewed the state of the art in the prediction of the progress of compartment fires up to its self-termination or the point of flashover, whichever comes first. Such predictions have been made possible by recent strides in the "mathematical modeling" of fires. After a concise survey of the historical background, Pape and Waterman concentrated on presenting a review of several variants of the available models on preflashover fires. The model developed by the authors received principal attention. It is a modular model that views the overall fire process as an interaction of a number of processes developing in well identifiable control volumes in the compartment. The usual selection of these control volumes was as follows: lower compartment space, burning item(s), fire plume(s), hot upper layer, compartment boundaries, and inert items. The last one-third of the paper was devoted to a concise presentation of calculation schemes for following up the traits of preflashover fire growth.

Once a fire has developed beyond its incipient stage, there is a good chance that it will spread beyond the confines of the compartment of origin. This aspect of the fire problem was reviewed in Quintiere's paper. Fire may spread either through natural openings, such as windows, doorways, and air ducts, or through openings caused by the destruction of fire. Flames issuing from windows may ignite a neighboring building by radiation, or may cause ignition in other compartments above the fire cell by a combined convective-radiant process. Effective measures to combat the spread of fire through windows were outlined. If the door of the fire cell is left open or destroyed by the fire, the flames in the burning compartment usually overflow into the corridor and, if the corridor is lined with combustible materials, they may advance to great distances. The author throws some light on this problem by reviewing his own experimental findings on corridor fires as well as those of a Danish research group. The problems presented by service penetrations and some elements of the plumbing, electrical, and air distribution systems of modern buildings were then discussed. Finally, the criteria of designing the boundaries of building compartments with an eye to their performance in realistic building fires were discussed in some detail.

Since professional help in case of fire must not be taken for granted, the designer of the fire safety features of a building has to accept the responsibility to use the best available techniques to minimize the potential destruction even in that hypothetical case that the fire is not attended by fire fighters. The two last papers of this volume were devoted to surveying these techniques. Bryan's paper dealt with those which are aimed at coping with fires in their incipient stages, while Harmathy's paper was concerned mainly with some other techniques that ensure a certain degree of safety even after the fire has grown beyond the stage of easy manageability.

To present a foundation for selecting the best technique of preventing a fire from growing beyond its incipient stage, Bryan's paper first outlined some statistical data on the origin and causes of household fires. The discussion then was extended to the general traits of the earliest stages of fire incidents and to the role that the various articles to be found in residential buildings, such as furnishings and interior finish materials, play in the progress of fire. The complex problem of detection of fires received principal attention in the paper. The merits and demerits of the two basic types of smoke detectors, namely the ionization chamber and photoelectric detectors, were examined in great detail in terms of their sensitivities, reliabilities, maintainabilities, and stabilities, and the importance of apt placement of all detection devices was stressed. The paper closes with a review of fire suppression techniques, with emphasis on automatic sprinkling.

In spite of the use of detection and suppression devices, fires occasionally do reach the postflashover stage. It is essential, therefore, that buildings be designed for satisfactory structural performance even under postflashover conditions. A detailed survey of applicable design techniques was presented in Harmathy's paper.

The kind of fire safety provided by the stereotyped application of historic concepts is of very little value. To provide a sound basis for a truly effective design, the characteristics of fully developed fires and the mechanisms of spread of fire and smoke were discussed in the first several sections of Harmathy's paper. Although the conventional concept of relying exclusively on fire resistant compartmentation in the provision of postflashover fire safety is objectionable on several grounds, much of the information that has accumulated over the years on the fire resistance of building elements can be utilized in the design of buildings for fire tolerance. Fire tolerance design was described as "a practice involving engineering decisions on the required and expected performance of compartment boundaries and on the acceptability of the planned boundary elements" under real-world fire conditions which allow for the possibility of fire spread. A review of smoke control measures and a new technique of fire localization, referred to as fire drainage, completed the paper.

In the closing section of his paper, Harmathy stated: "It is a mistaken idea that conformance to the codes is all that is needed in the production of fire-safe buildings. A competent design team which maintains constant surveillance over the results of up-to-date research can always increase the level of fire safety far beyond that attainable by simple compliance with building code regulations, usually without any additional expenditures, and sometimes at substantial savings to the builder."

This publication intended to provide an up-to-date review of the state of the art in the field of fire technology for those who are interested in providing fire safety.

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