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Introduction

The practice of fire safety designs is changing in many countries. The change is from traditional practice that simply follows the prescriptive code requirements to those that are based on fire safety analysis to obtain the required level of fire safety for the occupants. The change is a result of many countries moving towards the more flexible performance-based codes. Performance-based codes allow flexibility in fire safety designs as long as the designs can provide the required level of fire safety to the occupants.

Fire risk assessment is an assessment of the fire risks, or the levels of fire safety, that are provided to the occupants and property in a performance-based fire safety design. Fire safety designs involve the use of fire protection measures to control fire growth and smoke spread and to expedite occupant evacuation and fire department response. None of these fire protection measures, however, is 100 % effective. For example, sprinklers do not have 100 % reliability in controlling fires, nor do fire alarms have 100 % reliability in getting occupants to leave immediately. As a result, certain levels of fire risks to the occupants and property are implied in each fire safety design. The assessment of these levels of fire risks is the subject of fire risk assessment.

Guidelines on fire risk assessment have been produced by fire protection organizations such as the NFPA (National Fire Protection Association) and SFPE (Society of Fire Protection Engineers) in the USA (NFPA 551, 2007; SFPE, 2006). Other international organizations such as ISO are also planning to introduce reference documents on fire risk assessment. These guidelines are for the benefits of fire protection engineers and regulators to allow them to have a common vision on what is required in the submission and approval process in fire risk assessment.

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They describe this process from beginning to end, including the setting of risk thresholds and the selection of fire scenarios. These guidelines, however, do not describe the actual fire risk analysis. This book, on the other hand, describes the basic principles of fire risk analysis, or fire risk assessment, in buildings. This book, therefore, is suitable for use as a reference to these other guidelines.

Research and technical papers are produced regularly on the advancement of fire risk assessment. These papers usually focus on a certain aspect of the fire risk assessment. They seldom describe the fundamentals that underpin fire risk assessment. This book is suitable for use as a reference to these papers.

This book is also suitable for use as a textbook on fire risk assessment. The book describes the complex fire risk assessment principles in a way that is easy to follow.

This book is divided into two parts. The first part is devoted to the traditional fire risk assessment methods. The first part consists of four chapters, from Chapter 2 to Chapter 5. The second part is devoted to fire risk assessment methods based on a fundamental approach. The second part consists of eight chapters, from Chapter 6 to Chapter 13.

Chapter 2 is an introduction to fire risk assessment. Fire protection measures are shown as fire barriers. They are grouped into five major barriers. The risks to occupants and property depend on how successful these barriers are in controlling fire initiation, fire growth, smoke spread, and in expediting occupant evacuation and fire department response.

Chapter 3 is a discussion of how fire risk assessment can be conducted by using past experience or incident data. This approach is only valid if the present situation and those in the past are exactly the same. Often, they are not.

Chapter 4 is a discussion of how qualitative fire risk assessment is conducted. Qualitative fire risk assessment involves the use of risk matrix, checklist method or event tree, and the use of qualitative subjective opinion on the occurrence and consequence of fire hazards.

Chapter 5 is a discussion of how quantitative fire risk assessment is conducted. Quantitative fire risk assessment involves also the use of risk matrix, checklist method or event tree, and the use of quantitative subjective opinion on the occurrence and consequence of fire hazards.

Chapter 6 is an introduction to fire risk assessment based on a fundamental approach. Fire scenarios are constructed based on the success and failure of fire protection measures. For each fire scenario, the outcome of occupant deaths and property loss is determined based on modelling

of fire growth, smoke spread, occupant evacuation, fire department response and eventually fire spread through breaching boundary elements. The assessment of risks to life and property is based on occupant deaths and property losses from all fire scenarios.

Chapter 7 is a discussion of fire growth scenarios. Fire growth scenarios are constructed based on the success and failure of fire control measures. The fundamental characteristics of fire growth in a compartment are described. The development of a fire in the compartment of fire origin can be modelled using fire growth models.

Chapter 8 is a discussion of fire spread probabilities. The probability of failure of a boundary element is described. The probability of fire spread through multiple boundary elements is also described. Fire spread through multiple fire resistant boundary elements is a relative slow process in comparison to smoke spread, occupant evacuation and fire department response.

Chapter 9 is a discussion of smoke spread scenarios. Smoke spread scenarios are constructed based on the success and failure of smoke control measures. The fundamental characteristics of smoke spread are described. Smoke spread in a building can be modelled using smoke spread models.

Chapter 10 is a discussion of occupant evacuation scenarios. Occupant evacuation scenarios are constructed based on the success and failure of occupant evacuation measures. The fundamental characteristics of occupant evacuation are described. Occupant evacuation can be modelled using occupant evacuation models. Early evacuation is critical. Occupants are trapped in the building if they can not evacuate in time before the arrival of the critical smoke conditions in the evacuation routes that prevent evacuation.

Chapter 11 is a discussion of fire department response. The fundamental characteristics of fire department response are described. The effectiveness of fire department rescue and suppression efforts depends on fast response time and adequate resources. For occupants who are trapped and can not be rescued by firefighters, expected deaths are assessed based on the length of their exposure to untenable smoke and fire conditions.

Chapter 12 is a discussion of uncertainty in fire risk assessment. Probability concepts are introduced. The discussion is mainly on uncertainty, or reliability, in fire safety designs. Methods that can be used to assess uncertainty are described.

Chapter 13 is a discussion of fire risk management. Fire risk management includes the consideration of cost-effective fire safety design options

that can provide equivalent level of fire safety but have the lowest fire costs. Fire risk management also includes the consideration of regular inspection and maintenance of fire protection systems to ensure that these systems can maintain their reliabilities. Some previous case studies from the computer fire risk-cost assessment model *FiRECAM* are discussed.

References

NFPA 551 (2007) *Guide for the Evaluation of Fire Risk Assessments*, National Fire Protection Association, Quincy, MA.

SFPE (2006) *Engineering Guide to Fire Risk Assessment*, Society of Fire Protection Engineers, Bethesda, MD.