Abstract

A risk-informed and performance-based life safety concept in case of fire

Protection of the health and life of the occupants in case of a hostile fire is the main safety objective of Fire Protection Engineering. This is usually achieved by providing for the possibility of a safe evacuation from the building before the various effects of the fire inflict casualties on the occupants. The requirement of successful evacuation of buildings is manifested in nearly all of today's building fire codes in countries all over the world and is traditionally achieved by complying with so-called "deemed-to-satisfy" codes and regulations, implying that a building is safe if the so-called prescriptive requirements for the design of the escape routes from the codes are followed. Yet architecture has become increasingly complex during the last decades. On many occasions, these advancements have outrun the prescriptive requirements since atria or multi-functional assembly buildings cannot be realized in accordance with the codes. In such cases, shortcomings to the requirements are compensated for with so-called performance-based engineering methods as part of a holistic fire safety concept on an individual basis in order to maintain the required safety level. Yet the latter is usually unknown and various numerical simulations are carried out using (usually conservatively chosen) deterministic values as input parameters even though they are subjected to major uncertainties.

Within this thesis a probabilistic methodology is developed in order to quantify the safety levels implied by the prescriptive codes. The definition of risk and its relation to reliability and probabilistic design procedures is discussed and structured under various aspects. To achieve the most accurate solutions, various aspects of the current procedural methods of life safety analysis are analyzed, discussed, and improved. Based on the findings, stochastic models are found for the various uncertain parameters. After an introduction to reliability theory, an adaptive response surface method based on interpolating moving least squares (IMLS) is developed, validated and benchmarked. This allows for a fast and efficient calculation of failure probabilities of life safety design solution using state-of-the-art numerical fire protection engineering tools. The method is applied to a typical building and the current reliability levels are (quantitatively) derived considering various possible scenarios. A subsequent inclusion of various fire protection barriers (i.e. sprinklers etc.) shows their quantitative effect and how they can be considered within a probabilistic safety format. Thus a way for a risk-informed and performance-based life safety design is paved.