PERFORMANCE-BASED ASSESSMENT OF STEEL STRUCTURES UNDER FIRES

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This research seeks to develop a methodology and supported technologies to simulate and assess the performance of steel structures under fires. It includes an overall assessment framework consistent with the recent probabilistic seismic design methodology developed by PEER (Performance-Based Earthquake Engineering (PBEE)). Models and criteria will be improved to simulate performance of the steel frame of structures considering modeling uncertainties. This research contributes to the development of new AISC requirements for design of steel structures under fires.

Relatively little study of fire engineering has been done in the United States, while Great Britain, Australia and other countries are leading in this area. The US building codes on this subject are based on empirical formulas and lack comprehensive design guidelines. Societal interest for fire engineering has been increased since 9/11. Specifically, there is a need for more scientific understanding of structural behavior under fires and sophisticated design methodologies and supporting technologies to evaluate the risk of collapse under various fire scenarios. Like earthquakes, fires are low-probability, high-consequence events characterized by large uncertainties. Opportunities and societal interest in consistent risk analysis for multi-hazard events motivates collaboration of fire engineering to advanced probabilistic earthquake engineering.

Performance-Based Fire Engineering (PBFE) evaluates fire risks in four processes. In Fire Hazard Analysis, the fire Intensity Measures (IM), such as the room temperature of the fire or the resulting material temperatures, are assessed. This step is followed by Structural Simulation and Damage Analysis to determine Engineering Demand Parameters (EDP) that result from the fire, e.g. component forces and deflections, and Damage Measures (DM), which relate the EDPs to various strength or damage limit states. The final process is Loss and Risk Assessment, in which Decision Variables such as casualties and repair time/down time are calculated. The research will largely focus on Structural Simulation, based on Intensity Measures obtained from Fire Hazard Analysis. It will seek to better understand and present ways of looking at the entire structure or frame's performance due to the change in temperature. Steel is a material that is vulnerable to heat; its strength is reduced by 50% at 550 ºC. In the fully developed stage of a fire, the temperature can reaches more than 1000ºC. The effect of thermal expansion produces additional force and distortion. Unevenly distributed steel temperatures throughout elements or sections will impose deformations that affect structural stability and degrade the performance. Since temperature changes with time, time dependent simulations are necessary to provide better understanding of structural behavior under fire. The analysis results will provide essential information for improved building code provisions.

It is hoped that the results of this research will be a step towards making fire engineering in the United States a more rational process and provide a unifying basis for further work in the area. It is expected that this research will contributing to reduce structural fire risk and will lead to more reasonable and economical fire protection design