Simulating the Coupled Fire-Thermal Structural Response of Complex Building Assemblies

KULDEEP PRASAD and HOWARD R. BAUM
Building and Fire Research Laboratory
National Institute of Standards and Technology
100 Bureau Drive, Gaithersburg, MD 20899 USA

ABSTRACT

There has been a resurgence of interest in the response of building structures to fires over the past several years. Typically, simulations of thermally induced structural response are de-coupled from fire dynamics. The thermal environment in such simulations is specified by a time temperature curve and attention is confined to the structural response (stress analysis) to spatially uniform enclosure temperatures. As a result the structural response of the building to spatially and temporally varying fires can not be studied. Simulation of the effects of severe fires on the structural integrity of building requires a close coupling between the gas phase energy release and transport phenomena and the stress analysis in the load bearing materials.

A methodology has been developed for coupling the Fire Dynamics Simulator [1] with finite element methods for predicting the coupled thermal – structural response of structural components and assemblies [2]. A simple radiative transport model that assumes the compartment is divided into a hot, soot laden upper layer and a cool relatively clear lower layer is employed to account for sub-grid structural members. Finite element models are developed for the critical structural components and the role of imperfection in fireproofing is demonstrated. An interface is constructed for mapping the results of the thermal analysis on the structural components to predict the spatially varying body loads. The methodology is employed to predict the thermo-structural response of complex building assemblies.

KEYWORDS: structural response, structural design, modeling

REFERENCES

[1] McGrattan, K.B., Baum, H.R., Rehm, R.G., Hamins, A., Forney, G.P., Floyd, J.E., Hostikka, S., and Prasad, K., “Fire Dynamics Simulator (Version 3) – Technical Reference Guide” National Institute of Standards and Technology Report NISTIR 6783, Nov. 2002.

[2] Prasad, K. and Baum, H.R., “Coupled Fire Dynamics and Thermal Response of Complex Building Structures,” *Proceedings of the Combustion Institute 30,* 2005, pp. 2255-2262.