

# A Course on Structural Design for Fire Conditions

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## ABSTRACT

The paper discusses a graduate-level course that has been developed and taught by the writers on the subject of structures in fire. The course is offered within the Civil and Environmental Engineering (CEE) Department at Worcester Polytechnic Institute under the catalog listing *CE 534 Structural Design for Fire Conditions*. It contributes to both the structural engineering curricula within the CEE Department and to the curricula within the Fire Protection Engineering Department. In addition to graduate students, the course has attracted advanced undergraduate students.

The purpose of the course is to familiarize students with the body of knowledge available to predict the behavior of structures in fire and to adapt a performance-based approach to structural design, utilizing the process of design-by-analysis. The course's technical content is based on research conducted during the last four decades in Europe, Canada, and the United States. With an emphasis on evaluating performance, treatment of traditional prescriptive codes and standards for structural fire safety is a small portion of the course, limited to an overview of standard furnace testing and fire endurance requirements.

Classroom lectures and homework assignments are geared toward understanding material and structural behavior during fire conditions and developing calculation tools for predicting the behavior of steel, concrete, and wood structures in a given time-temperature environment. Fundamental concepts of heat transfer and mathematical models for the determination of thermal response for transient conditions are also covered. The calculation tools, including heat transfer analyses, are typically implemented within MS-EXCEL. Spreadsheet applications are promoted to foster hands-on learning, to develop student insight into the analyses, and to facilitate parametric investigations.

Student teams also prepare and present a term-long research project. The projects are selected from a recommended list of topics, devised to build from the classroom lectures and homework assignments to deeper study of larger assemblies and systems. The completed report contains a synthesis of library research to identify the current state of the art, parametric studies and calculations to explore performance and sensitivity, and an investigation into typical construction details and installation techniques. Students are expected to characterize changes in structural

performance with changes in insulation systems, structural elements, and time-temperature environments as part of their project presentations.

The course has been successful in stimulating the interest of structural engineering students in the topic of structures in fire. Several students have proceeded from this course into M.S. theses prepared under the direction of the writers. In turn, the library research, analytical tools, and findings from these theses have been incorporated into subsequent offerings of the course.