Research Project Highlight

Fire Performance of Steel-Frame Buildings using OpenSees

TSRP Topic – Areas of Application – A3

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Start-End Dates:
07/01/2020 – 06/30/2021

Abstract
During a fire, significant plastic deformations are imposed on structural members due to the degradation of material properties and thermal expansion of the members themselves. While in an earthquake, large plastic deformations occur in the lateral framing systems; during a fire, plastic deformations occur in the gravity floor framing. Due to the ability of OpenSees to simulate this behavior of steel-frame structures in earthquakes, it is uniquely positioned to incorporate structural fire engineering simulation abilities for gravity framing and multi-hazard simulations. This project is a multi-agency collaboration between Oregon State University, the National Institute of Standards and Technology, and the American Institute of Steel Construction to develop benchmarked, open sourced models for the fire behavior of steel-frame structures through the use of OpenSees. The research will: (1) develop a new connector definition in OpenSees that can simulate the force-deformation-moment-rotation behavior of simple connections, (2) use the already developed modeling methodologies and the new connector definition to benchmark three-dimensional system level behavior of steel-frame buildings in fires against large-scale experimental tests at NIST, (3) further develop Wiki pages for other researchers or industry practitioners to use to utilize OpenSees for structural fire engineering, and (4) create a simplified connection model for prediction for axial force demand for design of connections during fire, working collaboratively with AISC *Specification* Technical Committee 8.

Deliverables
A PEER report and several conference and journal papers describing the modeling methodologies, benchmarking process, new connector definition, and use of simplified connection model.

Research Impact
The development of benchmarked finite element modeling capabilities for structural fire engineering to be performed by practitioners would allow the field of structural fire engineering to be adopted by more high-quality practicing engineers. Due to the overwhelming use of OpenSees among the seismic and steel research community, there are a significant number of practicing engineers currently in industry

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with extensive knowledge on the program. This knowledge base makes this program a unique player for implementing structural fire engineering within the industry practice. The ability of finite element modeling programs to consider the capacity of simple connections to resist imposed flexural and axial demands can demonstrate the inherent robustness of many existing steel buildings to fire loading conditions. This research also demonstrates a growing trend in structural engineering to move towards buildings that can be occupiable after an extreme loading scenario (fire, seismic, column removal). This trend supports business continuity and shelter-in-place goals for post-extreme event conditions in addition to economic security and stability throughout a community. The results of this research can lead to more economic connection design that considers multi-hazard resilience. This more economical design could potentially lead to more sustainable benefits for steel construction in a life cycle analysis.

Project Image

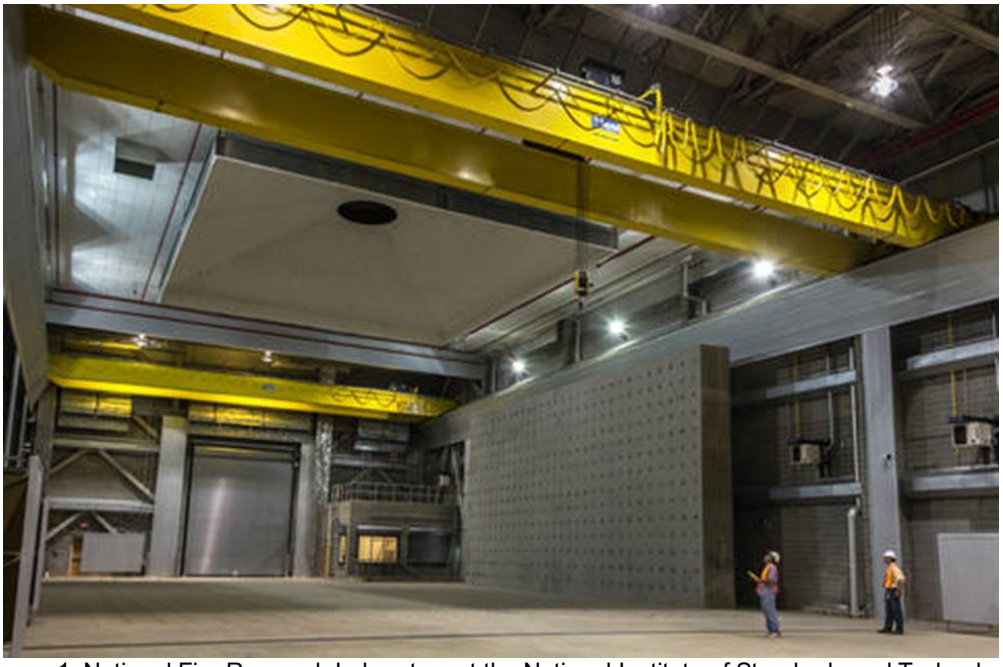

Figure 1: National Fire Research Laboratory at the National Institute of Standards and Technology (source: https://www.nist.gov/el/fire-research-division-73300/national-fire-research-laboratory-73306)

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