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A Comparison of Stability Design Requirements: A Work in Progress of SSRC Task Committees on Systems and Extreme Loads and the ASCE/SEI Methods of Design Committee

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Abstract
Varied analytical approaches, philosophies of design and standards have created a complex landscape for designers of steel-framed lateral systems subjected to a combination of static, dynamic, blast and/or temperature loads. This session will present the progress of a combined effort of the ASCE/SEI Methods of Design Committee and the SSRC Task Groups on System Stability and Extreme Loads. The project will develop a comprehensive case study to elucidate the differences in analysis and design philosophies for stability assessment of frames by developing independent designs of the same framing system using different standards and design threats. The resulting designs will be both compared and contrasted for analysis rigor, controlling limit states of the resulting designs and stability assessment approaches. The case studies will involve input of practitioners and academics.

It's the Same Building, Isn't It?

In the last decade, the manner in which frame stability is assessed in the AISC specification has changed significantly. Exclusive of the inelastic design provisions of Appendix 1, there are three separate elastic approaches provided, all with distinct modeling and analysis requirements. In particular, the engineer is now required to explicitly consider how nonlinearity and inelasticity will be accounted for in the design. While the resulting structural design is very similar regardless of the approach used, the analysis results can vary significantly depending on the approach. This can be attributed to differing means of accounting for inelastic stiffness reduction, imperfection effects, the impacts of both on system performance, and how the associated limit states consider the length of the member.

When considering extreme loads, the situation becomes more complicated. There are provisions in the AISC Specification (AISC 2010a) for fire, and provisions are proposed for the next edition to consider structural integrity. There are different standards and provisions entirely (e.g. AISC (2010b), DoD (2009), FEMA (2000)) for seismic and blast, and depending on the use of the building, there may be more than one to be considered during design. The result is a multitude of provisions that include differences in philosophies of how strength and stability are assessed, the level of rigor required in both determining loads and performing analyses, and the manner in which the parameters that affect overall system stability are addressed. For example, a significant

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philosophical difference exists between design for blast and design for fire in that blast is purposely threat-independent while fire provisions were developed to consider a specific design threat.

Adding to the complexity are improvements in the ability to model geometric behavior, explicitly capture effects of inelasticity, and perform both nonlinear and dynamic analyses. The benefit of these advances is a more robust means for capturing structural response to specified loads and, in some instances, a simplified design check (e.g. Surovek et. al 2012, Surovek and Ziemian 2005). The drawbacks include a more complex set of requirements for modeling and a higher onus on the engineer to fully understand complex structural behavior not implicitly captured in design equations.

The objective of this project is to provide guidance to the design engineer, faculty member and/or student in the primary similarities and differences in design standards and design practice for the same building subjected to typical design loads and extreme loads. A panel from the project team, composed of academics and practitioners, will present the initial results that include:

- Independent designs of the same building using different code provisions based on the design load conditions or threats (e.g. static, seismic, blast, progressive collapse and fire)
- Comparisons of methods of analysis, level of analysis rigor and means of accounting for material and geometric nonlinearity in each design
- Comparisons of the resulting designs

The building to be used in the case study is shown in Figure 1. The building is based on examples used by AISC-WET and the steel design text by Geschwindner (2011) to illustrate simple steel frame design and has been modified slightly for this project. It utilizes braced framing in the N-S direction and moment frames in the E-W direction, has composite floors and simply-supported steel joist roof framing.

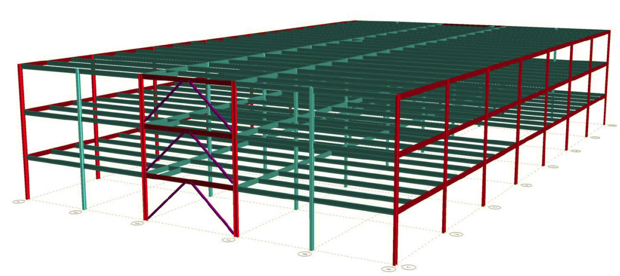

Figure 1: Isometric View of Case Study Steel Framed Building

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References

AISC (2010a). *Specification for structural steel buildings* (AISC 360-10) and commentary, American Institute of Steel Construction, Chicago, IL.

AISC (2010b). *Seismic provisions for structural steel buildings* (AISC 341-10) and commentary, American Institute of Steel Construction, Chicago. IL.

Geschwindner, L.F. (2011), Unified Design of Steel Structures, 2nd Edition, John Wiley and Sons, 540 pgs.

Dept. of Defense (DoD). (2009). "Design of buildings to resist progressive collapse." UFC 4-023-03, Washington, DC

FEMA (2000). *Recommended seismic design criteria for new steel moment frame buildings*, FEMA 350, Federal Emergency Management Agency, Washington, DC

Surovek, Andrea E. and Ziemian, Ronald D. (2005), "The Direct Analysis Method: Bridging the Gap from Linear Elastic Analysis to Advanced Analysis in Steel Frame Design," *Proceedings of the ASCE Structures Congress*, New York, April.

Surovek, Andrea E., ed. (2012), *Advanced Analysis in Steel Frame Design: Guidelines for the use of Direct Second-Order Inelastic Analysis*, Report of the Special Project Committee on Advanced Analysis, Technical Committee on Structural Members of the Structural Engineering Institute of ASCE, 56 pgs.