

# ***Stability Design of Steel Structures – Benefits of Employing Modern Methods of Structural Analysis***

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## **Summary**

Prior to its 13<sup>th</sup> (2005) edition, the words “structural analysis” do not appear in any provisions of the American Institute of Steel Construction’s *Specification for Structural Steel Buildings*. Given the developments in computational hardware and structural analysis software, the specification is now significantly changed to permit practicing engineers to take full advantage of such capabilities. This course will focus on reviewing and demonstrating the benefits of employing modern structural analysis methods in the stability design of steel structures.

## **Lectures**

1. Course Introduction; Modern Methods of Structural Analysis, from Linear to Nonlinear – Part I
2. Modern Methods of Structural Analysis, from Linear to Nonlinear – Part II
3. Modules for Learning Structural Stability
4. Second-Order Elastic Analysis – Getting it Right
5. The AISC Direct Analysis Method from Soup to Nuts
6. Stability Design of Low- and Medium-Rise Steel Buildings
7. Stability Design – Advanced Applications
8. New Opportunities - Design by Inelastic Analysis

## **Description of Lectures**

- 1. Course Introduction; Modern Methods of Structural Analysis, from Linear to Nonlinear – Part I (R.D. Ziemian)**  
AISC’s *Direct Analysis Method* is based on the principle that simplifications in the design process can be granted as more and more factors known to impact structural stability are included in the analysis. After providing an overview of this logic, this two-part lecture will focus on describing how modern structural engineering software includes such factors within the analysis. Part I will cover first-order elastic analysis by the stiffness method, which is the core for almost all of today’s structural engineering analysis software.
- 2. Modern Methods of Structural Analysis, from Linear to Nonlinear – Part II (R.D. Ziemian)**  
Time to go nonlinear! Using the approach provided in Lecture 1, the participants will receive a basic introduction to nonlinear methods of structural analysis. This session will give an overview of how material nonlinear behavior and/or second-order effects can be included in modern structural analysis software.
- 3. Modules for Learning Structural Stability (R.D. Ziemian)**  
With a basic understanding of linear and nonlinear analysis now in hand, it is time to explore and gain hands-on experience in understanding factors that are known to impact structural stability. Modern computer software makes it easy to use non-linear

computational analysis as a virtual lab for learning many important concepts related to designing for stability. An overview of several learning modules developed for a better understanding of topics such as elastic and inelastic flexural and lateral-torsional buckling, inelastic force redistribution, and second-order effects will be presented. Course attendees will be encouraged to download a simple analysis software package (at no charge) and work the examples and modules at the conclusion of the lecture.

**4. Second-Order Elastic Analysis – Getting it Right (D.W. White)**

Various methods of second-order elastic frame analysis, ranging from intelligent application of amplification factors with first-order analysis to three-dimensional matrix structural analysis models, are reviewed. Emphasis is on the sufficiency of the methods for different problems, methods of sanity checking and ensuring that the analysis is correct, and various essential concepts important for design application.

**5. The AISC Direct Analysis Method from Soup to Nuts (D.W. White)**

This session presents a comprehensive overview of the Direct Analysis Method of design, which was first introduced in Appendix 7 of the 2005 AISC 13<sup>th</sup> Edition Specification and is referred to as the preferred method of design in Chapter C of the 2010 AISC 14<sup>th</sup> Edition Specification. The lecture emphasizes the key fundamental concepts and the practical application of the method to a range of structure types.

**6. Stability Design of Low- and Medium-Rise Steel Buildings (D.W. White)**

The application of some of the most useful techniques and procedures for stability design of steel buildings will be presented using a single relatively comprehensive building design example, all within the context of the Direct Analysis Method. The approaches emphasized will include: application of live load reduction equations to account for global reduction in second-order effects; preliminary estimation of sidesway amplification based on wind drift, seismic drift and seismic  $P-\Delta$  limits; preliminary strength design; preliminary lateral stiffness design; and basic stiffness optimization based on virtual work.

**7. Stability Design – Advanced Applications (D.W. White)**

This module investigates the application of modern structural analysis methods to several challenging stability design problems, including the sizing of general stability bracing for beams, beam-columns and frames, design of steel arches, and checking of stability during erection. The Direct Analysis Method as well as rigorous inelastic buckling analysis capabilities will be demonstrated.

## **8. More Opportunities - Design by Inelastic Analysis (R.D. Ziemian)**

In the 14<sup>th</sup> edition of the AISC Specification, the provisions for employing inelastic analysis in design have been fully revised. Certain levels of inelastic analysis may now be used in place of the Specification's design equations when confirming the adequacy of the structural system and its components. The associated requirements for this approach will be reviewed and examples presented.

### **Instructor Bios**

**Donald W. White** is a professor at the Georgia Institute of Technology School of Civil and Environmental Engineering. Dr. White's research covers a broad area of design and behavior of steel and composite steel-concrete structures as well as computational mechanics, methods of nonlinear analysis and applications to design. Dr. White is a Member of AISC's Committee on Specifications, and is past chair of the Structural Stability Research Council Task Committee 29, Inelastic Analysis for Structural Design and 5, Beams. Dr. White received the 2005 Special Achievement Award from AISC for his research on design criteria for steel and composite steel-concrete members in bridge and building construction. He received the 2006 Shortridge Hardesty Award from ASCE for his research on advanced frame stability concepts and practical design formulations. Dr. White is the 2009 recipient of the Theodore Higgins Award from AISC and the 2010 Raymond C. Reese Prize from ASCE for his research and development activities in the area of stability analysis and design.

**Ronald D. Ziemian** is a professor at Bucknell University. He received his BSCE, MENG, and PhD degrees from Cornell University. In addition to authoring papers on the design and analysis of steel and aluminum structures, Dr. Ziemian is co-author of the textbook *Matrix Structural Analysis* (Wiley, 2000) and the editor for the 6th edition of the *Guide to Stability Design Criteria for Metal Structures* (Wiley, 2010). He is currently the treasurer and was the former chair of the Structural Stability Research Council. Dr. Ziemian is a Member of AISC's Committee on Specifications, chairs AISC's Task Committee 10 on Frame Stability, and he recently completed his term as chair of AISC's Task Group on Inelastic Analysis and Design. He also serves on the AISI and Aluminum Association Specification Committees and is active with the Steel Joist Institute. Dr. Ziemian was awarded the ASCE Norman Medal (1994) for his paper on employing advanced methods of inelastic analysis in the limit states design of steel structures. He has also received the AISC Special Achievement Award (2006) and the ASCE Shortridge Hardesty Award (2013) for his contributions to the profession related to the stability analysis and design of metal structures.