Oct 26th, 12:00 AM

Introduction

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Continuing Education

Eighteenth International Specialty Conference on
Cold-Formed Steel Structures

RECENT RESEARCH AND DEVELOPMENTS IN COLD-FORMED STEEL DESIGN AND CONSTRUCTION

Held in Orlando, Florida
October 26 & 27, 2006

Edited by
Roger A. LaBoube and Wei-Wen Yu

Department of Civil, Architectural & Environmental Engineering
University of Missouri - Rolla
Rolla, Missouri

Presented by

Department of Civil, Architectural & Environmental Engineering
Wei-Wen Yu Center for Cold-Formed Steel Structures
University of Missouri-Rolla

Sponsored by

American Iron and Steel Institute
Metal Building Manufacturers Association
Metal Construction Association
Rack Manufacturers Institute
Steel Deck Institute
Steel Stud Manufacturers Association
University of Missouri-Rolla

In Cooperation with

ASCE Committee on Cold-Formed Members
Canadian Sheet Steel Building Institute, Canada
SSRC Task Group on Thin-Walled Metal Construction
University of Strathclyde, Scotland, UK
Centre for Advanced Structural Engineering
of the University of Sydney, Australia

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for Cold-Formed Steel Structures

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PREFACE

Cold-formed steel members have been used in virtually every area of construction. In order to review the research findings and the design methods developed in this field, 17 International Specialty Conferences on Cold-Formed Steel Structures have been held since 1971.

In recent years, significant progress has been made in the development of design standards and in research studies of cold-formed steel members and structural systems throughout the world. The Eighteenth International Specialty Conference on Cold-Formed Steel Structures was held in Orlando, Florida on October 26 & 27, 2006. It was sponsored by the American Iron and Steel Institute (AISI), Metal Building Manufacturers Association (MBMA), Metal Construction Association (MCA), Rack Manufacturers Institute (RMI), Steel Deck Institute (SDI), Steel Stud Manufacturers Association (SSMA), and the University of Missouri-Rolla (UMR) in cooperation with the American Society of Civil Engineers (ASCE) Committee on Cold-Formed Members, Canadian Sheet Steel Building Institute (CSSBI), Structural Stability Research Council (SSRC) Task Group on Thin-Walled Metal Construction, the University of Strathclyde in Scotland and the Centre for Advanced Structural Engineering of the University of Sydney in Australia.

This publication contains 45 papers presented at the conference. These papers not only report the results of recent research but also discuss the technical developments in cold-formed steel design and construction.

As Directors of the Conference, we are very grateful to all the sponsors and supporting organizations for their financial and technical support and to all authors for their contributions in the field of cold-formed steel structures. Appreciation is also due to members of the Planning Committee (D. Allen. R.L. Brockenbrough, H.H. Chen, J. Crews, W.S. Easterling, D.S. Ellifritt, S.R. Fox, G.J. Hancock, R.B. Haws, D.L. Johnson, R.A. LaBoube, J.W. Larson, J.A. Mattingly, T.B. Pekoz, J. Rhodes, B.W. Schafer, W.E. Schultz, P.A. Seaburg, W.L. Shoemaker, T. Sputo and W.W. Yu) for review and selection of papers and their advice in preparation of the conference. We would also like to thank all of the session chairpersons listed in the program for their time and effort.

Special thanks are extended to Mrs. Christina Stratman and Mrs. Jaymie Greenway for their assistance in preparing this publication.

Roger A. LaBoube

Wei-Wen Yu

PROGRAM

Wednesday, October 25, 2006
6-9 p.m. **Registration:** Rosen Centre Hotel

Thursday, October 26, 2006
7 a.m. – 4 p.m. **Registration:** Rosen Centre Hotel

8:00 a.m. **Welcoming Remarks:**
R.A. LaBoube, University of Missouri-Rolla

8:15 a.m. **Remembering Don Wolford**
W.W. Yu, University of Missouri-Rolla

8:30 a.m. **Technical Session No. 1**
Element and Cross Section Behavior

Chairpersons:
W.S. Easterling, Virginia Tech, Blacksburg, VA, USA
D.L. Johnson, Maus Engineering, Wolfeboro, NH, USA

"Elastic Post-Buckling Behavior of Uniformly Compressed Plates"
M.C.M. Bakker, M.Rosmanit, and H. Hofmeyer, Technische Universiteit Eindhoven, Einhoven, The Netherlands

"Direct Strength Method for Lipped Channel Columns and Beams Affected by Local-Plate/Distortional Interaction"
N. Silvestre, P. Dinis, and D. Camotim, Technical University of Lisbon, Lisbon, Portugal

"Buckling Analysis of Cold-Formed Steel Members Using CUFSM: Conventional and Constrained Finite Strip Methods"
B.W. Schafer, Johns Hopkins University; Baltimore, MD, USA; and S. Adany, Budapest University of Technology and Economics, Budapest, Hungary

"A Detailed Examination of Interactive Buckling in Plain Channel Sections"
A. Aziz and J. Rhodes, University of Strathclyde, Glasgow, Scotland; M. Macdonald, Caledonian University, Glasgow, Scotland; and D. Nash, University of Strathclyde, Glasgow, Scotland

"Post-Buckling in the Distortional Mode and Buckling Mode Interaction of Cold-Formed Thin-Walled Sections with Edge Stiffeners"
D.C.Y. Yap and G.J. Hancock, University of Sydney, Sydney, Australia

9:45 a.m. **Break**

10:15 a.m. **Technical Session No. 2**
Flexural Members

Chairpersons:
D.S. Ellifritt, University of Florida, Gainesville, FL, USA
R.M. Schuster, University of Waterloo, Waterloo, Ontario, Canada

"Finite Element Modeling of Cold-Formed Steel Beams: Validation and Application"
C. Yu, University of North Texas, Denton, TX, USA; and B.W. Schafer, Johns Hopkins University, Baltimore, MD, USA

"Effective Width Method Based Design for Distortional Buckling of Cold-Formed Steel Beams"
C.Yu and T. Lokie, University of North Texas, Denton, TX, USA

"Increasing the Strength and Stiffness of Cold-Formed Hollow Flange Channel Sections for Web Crippling"
T. Wilkinson, P. Liu, J. Magpayo, and H. Nguyen, University of Sydney, Sydney, Australia

"Distortional Buckling of Simple Lipped Channel in Bending - Results of the Experimental Analysis Versus Direct Strength Methods"
C.E. Javaroni, UNESP, SP, Brazil; and R.M. Goncalves, University of Sao Paulo, Sao Paulo, Brazil

"Lateral Distortional Buckling Behaviour of a New Cold-Formed Hollow Flange Channel Section"
D. Mahaarachchi and M. Mahendran, Queensland University of Technology, Brisbane, Queensland, Australia

"Section Moment Capacity of a New Cold-Formed Hollow Flange Channel Section"
M. Mahendran and D. Mahaarachchi, Queensland University of Technology, Brisbane, Queensland, Australia

"Finite Element Analysis of Web Crippling Behaviour of Cold-Formed Steel Flexural Members"
M. Macdonald and M.A. Heiyantuduwa, Glasgow Caledonian University, Glasgow, Scotland; and J. Rhodes, University of Strathclyde, Glasgow, Scotland

"Parameter Study for First-Generation Sheeting Failure using a Theoretical and FE Model"
H. Hofmeyer, M. Rosmanit, and M.C.M. Bakker, Technische Universiteit Eindhoven, Eindhoven, The Netherlands

12:15 p.m. **Lunch**

1:30 p.m. **Technical Session No. 3**
Floor Joists and Floor Joist Assemblies

Chairpersons:
T. Sputo, University of Florida, Gainsville, FL, USA
W.E. Schultz, NUCOR Research and Development, Norfolk, NE, USA

"The Strength of Stiffened CFS Floor Joist Assemblies with Offset Loading"
S.R. Fox, Canadian Sheet Steel Building Institute, Cambridge, Ontario, Canada

"iSPAN, A Light Steel Floor System"
D..M. Fox, iSPAN, Richmond Hill, Ontario, Canada; R.M. Schuster, University of Waterloo, Waterloo, Ontario, Canada; and M.R. Strickland, Richmond Hill, Ontario, Canada.

"The Strength of CFS Floor Assemblies with Clip Angle Bearing Stiffeners"
S.R. Fox, Canadian Sheet Steel Building Institute, Cambridge, Ontario, Canada

"Vibration Characteristics and Acceptability of Cold-Formed Steel Joists"
Y.F. Chen, Penn State Harrisburg, Middletown, PA

2:30 p.m. **Technical Session No. 4**
Compression Members

Chairpersons:
J. Rhodes, University of Stratclyde, Glasgow, Scotland
B.W. Schafer, Johns Hopkins University, Baltimore, MD, USA

"Impact of Holes on the Elastic Buckling of Cold-Formed Steel Columns with Application to the Direct Strength Method"
C. Moen and B.W. Schafer, Johns Hopkins University, Baltimore, MD, USA

"Cold-Formed Steel Angles Under Axial Compression"
G.M.B. Chodraui, University of Sao Paulo, Sao Paulo, Brazil; Y. Shifferaw, Johns HopkinsUniversity, Baltimore, MD, USA; M. Malite, University of Sao Paulo, Sao Paulo, Brazil; and B.W. Schafer, Johns Hopkins University, Baltimore, MD, USA

3:00 p.m. **Break**

3:30 p.m. **Technical Session No. 5**
Rack and Frame Structures

Chairpersons:
J. Crews, Unarco Material Handling, Springfield, TN, USA
S.R. Fox, Canadian Sheet Steel Building Institute, Cambridge, Ontario, Canada

"Stability of Cold-Formed Steel Storage Racks under Variable Loading"
L. Xu, X.H. Wang, and H.L.Wang, University of Waterloo, Waterloo, Ontario,Canada

"Buckling Behavior of Cold-Formed Scaffolding Tubes"
A. Hubner and H. Saal, Universitat Karlsruhe, Karlsruhe, Germany

"GBT-Based Analysis of the Local and Global Buckling Behavior of Cold-Formed Steel Frames"
C. Basaglia, D. Camotim, and N. Silvestre, Technical University of Lisbon, Lisbon, Portugal

"Cold-Formed Steel Pitched-Roof Portal Frames of Back-to-Back Plain Channel Sections and Bolted Joints"
A. Stratan, Z. Nagy, and D. Dubina, Politehnica of Timisoara, Timisoara, Romania

"Development of a Portal Frame System on the Basis of Component Testing"
J. Rhodes, University of Strathclyde, Glasgow, Scotland; and R. Burns, Metsec PLC., Birmingham, UK

4:45 p.m. **Adjourn**

5:30 – 6:30 p.m.	**Reception: Sponsored by** **American Iron and Steel Institute** **Metal Building Manufacturers Association** **Metal Construction Association** **Rack Manufacturers Institutes** **Steel Deck Institute** **Steel Stud Manufacturers Association**

Friday, October 27, 2006

7 a.m. – Noon	**Registration:** Rosen Centre Hotel
8:30 a.m.	**Technical Session No. 6** **Design Standards and Guides Development**

Chairpersons:
R. L. Brockenbrough, R.L. Brockenbrough and Associates, Pittsburgh, PA, USA
W.W. Yu, University of Missouri-Rolla, Rolla, MO, USA

"A Design Guide for Bracing Cold-Formed Steel Structures"
T. Sputo, Sputo and Lammert Engineering, Gainesville, FL, USA; and J. Turner, Ground Floor Engineering, Ft. Lauderdale, FL, USA

"AISI Standards for Cold-Formed Steel Framing"
J.W. Larson, American Iron and Steel Institute, Washington, D.C., USA

"AISI Test Procedures for Cold-Formed Steel Structural Members and Connections"
H. Chen, American Iron and Steel Institute, Washington, D.C., USA; R.A.LaBoube, University of Missouri-Rolla, Rolla, MO, USA; T.M. Murray, Virginia Tech, Blacksburg, VA, USA; and T. Sputo, University of Florida, Gainsville, FL, USA

"Organizations and the Move Toward Standardization in the North American Cold-Formed Steel Framing Industry"
D. Allen, Steel Framing Alliance, Steel Stud Manufacturers Association, Washington, D.C., USA

"The New SDI Diaphragm Design Manual"
D. Li, Canam Steel Corporation, Point of Rocks, MD, USA

"MBMA-Sponsored Cold-Formed Steel Research 50th Anniversary Retrospective"
W.L. Shoemaker, Metal Building Manufacturers Association, Cleveland, OH, USA

"Designing Cold-Formed Steel Using the Direct Strength Method"
B.W. Schafer, Johns Hopkins University, Baltimore, MD, USA

10:15 a.m. **Break**

10:45 a.m. **Technical Session No. 7**
Building Roof Systems

Chairpersons:
W.L. Shoemaker, Metal Building Manufacturers Association, Cleveland, OH, USA
R.B. Haws, NUCONSTEEL, Denton, TX, USA

"Component Stiffness Method to Predict Lateral Restraint Forces in End Restraint Single Span Z-Section Supported Roof Systems with One Flange Attached to Sheathing"
M.W. Seek and T.M. Murray, Virginia Tech, Blacksburg, VA, USA

"Influence of Non-Structural Components on Roof Diaphragm Stiffness of Single-Story Steel Buildings"
S. Mastrgiuseppe and C.A. Rogers, McGill University, Montreal, Canada; and R. Tremblay and C.D. Nedisan, Ecole Polytechnique, Montreal, Canada

"Analysis of Conventionally Framed Hip Roofs Using Cold-Formed Steel Members"
L. Waldo, KPFF Consulting Engineers, San Diego, CA, USA; S.F. Stephens, Kansas State University, Manhattan, KS, USA; and R.A. LaBoube, University of Missouri-Rolla, Rolla, MO, USA

"Investigation of the Shear Stiffness of Profiled Steel Sheeting Diaphragms with Only Two Edges Fastened"
M. Duerr and H. Saal, Universitat Karlsruhe, Karlsruhe, Germany

11:45 a.m. **Lunch**

1:00 p.m. **Technical Session No. 8**
Wall Studs and Wall Stud Assemblies

Chairpersons:
D. Allen, Steel Stud Manufacturers Association, Washington, D.C., USA
J.W. Larson, American Iron and Steel Institute, Washington, D.C., USA

"Accumulation of Bracing Strength and Stiffness Demand in Cold-Formed Steel Stud Walls"
T. Sputo and K. Beery, University of Florida, Gainsville, FL, USA

"Local and Distortional Buckling of Cold-Formed Steel Studs Using Direct Strength"
J. Tovar, University of Texas, Austin, TX, USA; and T. Sputo, University of Florida, Gainesville, FL, USA

"Longwave Buckling of Cold-Formed Steel Studs Using Direct Strength"
T. Sputo, University of Florida, Gainsville, FL, USA; and J. Tovar, University of Texas, Austin, TX, USA

"Lateral Response of Sheathed Cold-Formed Shear Walls: An Analytical Approach"
L. Fiorino, G. Della Corte, and R. Landolfo, University of Naples "Federico II", Naples, Italy

"A Simplified Method of Evaluating Lateral Strengths of Shear Wall Panels with Cold-Formed Steel Framing"
L. Xu and J. Martinez, University of Waterloo, Waterloo, Ontario, Canada

"Testing and Design of Light Gauge Steel Frame/9mm OSB Panel Shear Walls"
C. Blais and C.A. Rogers, McGill University, Montreal, Canada

"Web Crippling of Sigma-Shaped Metal Studs in a Wall Assembly"
M.S. Boylan and E.A. Sumner, North Carolina State University, Raleigh, NC, USA; and N.A. Rahman and E.R. diGirolamo, The Steel Network, Raleigh, NC, USA

2:45 p.m. **Technical Session No. 9**
Connections

Chairpersons:
J. Mattingly, Nicholas J. Bouras, Inc., Summit, NJ, USA

H. Chen, American Iron and Steel Institute, Washington, D.C., USA

"Shear Lag Effect on Bolted L-Shaped Cold-Formed Steel Tension Members"
C.L. Pan, Chaoyang University of Technology, Taiwan, R.O.C.

"Single Bolted Tension Member Design - A New Approach"
D.M. Fox and R.M. Schuster, University of Waterloo, Waterloo, Ontario, Canada

"The Influence of Insulation on the Shear Strength of Screw Connections"
A.R. Lease, Cives Steel Corp., Winchester, VA, USA; and W.S. Easterling, Virginia Tech, Blacksburg, VA, USA

3:30 p.m.	**Closing Remarks:** R.A. LaBoube, University of Missouri-Rolla
3:45 p.m.	**Adjournment**

In Memory of

DON S. WOLFORD
1912 - 2006

BIOGRAPHY OF DON S. WOLFORD
(1912 - 2006)

Private Life

Mr. Donovan Semler Wolford was born June 5, 1912 in Indianapolis, Indiana. He was the only child of Emory Charles and Martha (Semler) Wolford. In 1917, his family moved to Troy, Ohio, where he graduated from Troy High School in 1930. He received his bachelor's degree in Mechanical Engineering from Ohio State University in 1934 and his ME in 1944. Upon leaving college, Don accepted an engineering position at Waco Aircraft Company, Troy, Ohio. Since 1935, he was employed by Armco Steel Corporation (formerly American Rolling Mill Company) Research Center in Middletown, Ohio. He retired at Armco in June 1977. During a period of 42 years in steel industry, he held various engineering positions at Armco including Research Assistant, Junior Research Engineer, Research Engineer, Senior Research Engineer (1935 – 1957); Supervising Research Mechanical Engineer (1958 –1970); and Principal Research Associate (1970 –1977).

During his long retirement after 1977, he produced separate genealogies for the Wise, Dell, Sixt, Wolford, Semler, and Marlatt families, tracing their migrations to the Midwest from Pennsylvania and New York, where they first entered America from Europe. In this work, he traveled across the United States and Europe and utilized his long-time interest in photography to copy old photographs and tintypes, some dating back to the 1840s.

Don married Dorothy (Jordan) in July 1951. They were members of Zion Lutheran Church, Middletown, Ohio. Their son, James J. Wolford, an Electronics Engineer, resides in Bolingbrook, Illinois. Their daughter, Elizabeth Ann (Wolford) Constantine, lives in Mechanicsburg, PA with her husband, Jan A. Constantine, and their son and two daughters.

Professional Life

Don's professional activities since 1941 have concentrated on structural design, especially for cold-formed steel structural members used in steel buildings and other structures. His early work involved carbon and stainless steel, then magnetic steel testing. He then embarked on a long-range program in developing structural design procedures for flat-rolled steels, both carbon and stainless, using laboratory tests to confirm design formulas.

In 1943, Don became associated with the major, dedicated effort leading to the development of the American Iron and Steel Institute's *Specification for the Design of Cold-Formed Steel Structural Members*, as a member of the Technical Subcommittee of the AISI Committee on Building Codes. Later he was chairman of the Research Subcommittee of the AISI Committee on Building Research and Technology. Since then he has served as a member of two engineering subcommittees – one for the AISI Committee of Sheet and Strip Steel Producers and the other for the AISI Committee of Structural Steel and Steel Plate Producers. He has sat as a member of various task groups on research projects initiated at various universities and institutions for the promotion of the use of steel by these products.

For the design of cold-formed steel structural members using carbon and low-alloy steel sheet, strip, plate or bar, Don provided important leadership and made significant contributions to the development of the AISI specifications, as a member and chairman of the AISI committees for more than 50 years. The first edition of the AISI Specification was published in 1946. He continued to supervise the AISI sponsored research on cold-formed steel and to participate in the revision of the Specification until he retired from the AISI Specification Committee in 1994.

With regard to cold-formed stainless steel design, in 1963 Don assumed the chairmanship of the AISI Subcommittee to develop the first edition of the AISI *Specification for the Design of Cold-Formed Stainless Steel Structural Members* published in 1968. This AISI Specification was revised in 1974 to reflect the technical developments and the results of continuing research. Under Don's leadership, the AISI Specification was updated to the ASCE Standards published in 1990 and 2002 (ANSI/ASCE-8-90 and SEI/ASCE 8-02). These two Standards were based on the load and resistance factor design (LRFD) concept with the allowable stress design (ASD) concept as an alternative.

In addition to Don's outstanding achievements and important contributions to the development of design specifications and standards, he published numerous technical papers and articles in various engineering journals and conference proceedings. He was also a contributor to engineering handbooks. His major publications are listed in the Appendix. Don was a guest speaker at various short courses, seminars, meetings, and conferences, and served as session chairman at the International Specialty Conferences on Cold-Formed Steel Structures for many years.

Professionally, Don was a Fellow of the American Society of Civil Engineers. He served as past chairman of the ASCE Committee on Cold-Formed Members

from 1971 through 1974. He was a member of the Planning Committee of the International Specialty Conference on Cold-Formed Steel Structures, the Transportation Research Board of the National Academy of Science and Engineering, the Building Research Institute, the American Iron and Steel Institute, and Theta Tau, a Professional Engineering Fraternity. Don was a Past Trustee and Past Elder of Bethlehem Lutheran Church of Middletown, Ohio; Past Treasurer, Secretary and President of Middletown Camera Club; and Past Vice President and President of Literary Critique Society of Southwestern Ohio. He was a registered engineer in the State of Ohio and was listed in *Who's Who in the Midwest, American Men of Science,* and *Who's Who in Engineering*.

Don's hobbies included 35mm. amateur photography; tracing family genealogy; symphonic, operatic and choral music; automobile repair; study of history; appreciation of great paintings; and geopolitics.

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Don's dedication and commitment to the cold-formed steel industry were exemplary and he will be fondly remembered by those who knew him.

Appendix

List of Major Publications of Don S. Wolford

"Significance of the Secant and Tangent Moduli of Elasticity in Structural Design," *Engineering Experiment Station News*, The Ohio State University, Vol. XV, No.3, June, 1943.

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