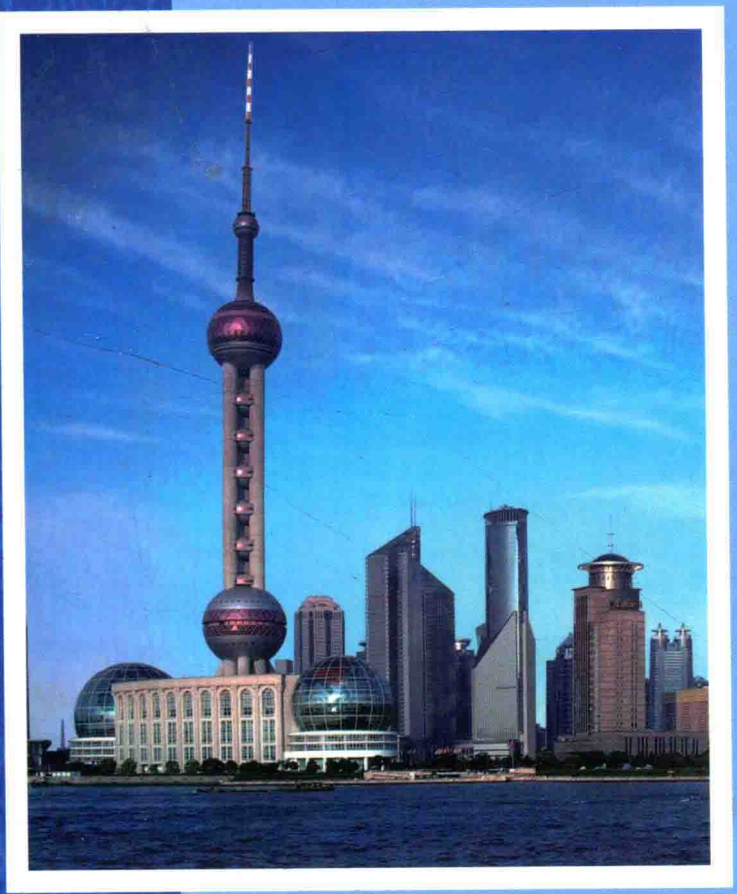
ELSEVIER

ADVANCES IN STEEL STRUCTURES



ICASS '05

Volume I

edited by
Z.Y. Shen, G.Q. Li
and S.L. Chan

ADVANCES IN

Proceedings of the
Fourth International Conference on Advances in Steel Structures

13 - 15 June 2005, Shanghai, China

Volume I

Edited by
Z.Y. Shen and G.Q. Li
Tongji University
S.L. Chan
The Hong Kong Polytechnic University

Organized by
College of Civil Engineering, Tongji University
And Department of Civil and Structural Engineering,
The Hong Kong Polytechnic University

Sponsored by
The China Society of Steel Construction
The China Society of Metal Structures for Buildings
The Shanghai Society of Metal Structures

ELSEVIER

Amsterdam • Boston • Heidelberg • London • New York • Oxford
Paris • San Diego • San Francisco • Singapore • Sydney • Tokyo

ELSEVIER B.V.
Radarweg 29
P.O. Box 211, 1000
AE Amsterdam
The Netherlands

ELSEVIER Inc.
525 B Street, Suite 1900
San Diego, CA 92101-4495
USA

ELSEVIER Ltd
The Boulevard, Langford Lane
Kidlington, Oxford OX5 1GB
UK

ELSEVIER Ltd
84 Theobalds Road
London WC1X 8RR
UK

ISBN: 0 08 0446 37 X

Printed in Great Britain

Elsevier Internet Homepage - http://www.elsevier.com
Consult the Elsevier homepage for full catalogue information on all books, major reference works, journals, electronic products and services.

Elsevier Titles of Related Interest

Deric Oehlers
Design of FRP and Steel Plated RC Structures
2004; ISBN: 0080445489

Poul Beckmann
Structural Aspects of Building Conservation
2004; ISBN: 0750657332

D.R.H. Jones
Failure Analysis Case Studies III
2004; ISBN: 0080444474

Andrea Carpinteri
Biaxial/Multiaxial Fatigue and Fracture
2003; ISBN: 0080441297

A. Momber
Hydroblasting and Coating of Steel Structures
2003; ISBN: 185617395X

Chan, Teng & Chung
ICASS 2002, Advances in Steel Structures
(2 Volume Set)
2002; ISBN: 0080440177

J.T. Katsikadelis
Boundary Elements: Theory and Applications
2002; ISBN: 0080441076

D. Francois
From Charpy to Present Impact Testing
2002; ISBN: 0080439705

Structural Engineering Compendium I
2002, ISBN: 0-08-044038-X

A. Chiba
Impact Engineering and Application (2-volume set)
2001; ISBN: 0080439683

P.J.M. Monteiro
Long Term Durability of Structural Materials
2001; ISBN: 0080438903

A. Zingoni
Structural Engineering, Mechanics and Computation
2001; ISBN: 0080439489

J. Zaras
Thin-Walled Structures - Advances and Developments
2001; ISBN: 0080439551

Related Journals

Elsevier publishes a wide-ranging portfolio of high quality research journals, encompassing the structural engineering field. A sample journal issue is available online by visiting the Elsevier web site (details at the top of this page). Leading titles include:

Advances in Engineering Software
CAD
Composites Part A: Applied Science and Manufacturing
Composites Part B: Engineering
Composite Structures
Computer Methods in Applied Mechanics and Engineering
Computers and Structures
Computer Science and Technology
Construction and Building Materials
Engineering Failure Analysis
Engineering Fracture Mechanics
Engineering Structures
International Journal of Fatigue
International Journal of Mechanical Sciences
Internationsl Journal of Solids and Structures
Journal of Constructional Steel Research
Mechanics of Materials
Mechanics Research Communications
Structural Safety
Thin-Walled Structures

All journals are available online via ScienceDirect: www.sciencedirect.com

To contact the Publisher

Elsevier welcomes enquiries concerning publishing proposals: books, journal special issues, conference proceedings, etc. All formats and media can be considered. Should you have a publishing proposal you wish to discuss, please contact, without obligation, the publisher responsible for Elsevier's Composites and Ceramics programme:

Keith Lambert
Senior Publishing Editor
Elsevier Ltd
The Boulevard, Langford Lane
Kidlington, Oxford
OX5 1GB, UK

Phone: +44 1865 843411
Fax: +44 1865 843931
E.mail: k.lambert@elsevier.com

General enquiries, including placing orders, should be directed to Elsevier's Regional Sales Offices – please access the Elsevier homepage for full contact details (homepage details at the top of this page).

PREFACE

These two volumes of proceedings contain 11 invited keynote papers, 33 invited papers, and 225 contributed papers presented at the Fourth International Conference on Advances in Steel Structures (ICASS '05) held on 13-15 June 2005 in Shanghai, China.

The conference was the fourth in the series of International Conferences on Advances in Steel Structures with the previous conferences being held in Hong Kong in December 1996, 1999 and 2002.

These conferences provide a forum for discussion and dissemination by researchers and designers of recent advances in the analysis, behavior, design and construction of steel structures. Contributions to the papers came from 22 countries around the world and cover a wide spectrum of topics including the current state-of-the-art as well as anticipating the future directions of research in steel, metal and composite structures.

The organization of the conference would not have been possible without the support and contribution of many individuals and organizations. The strong support from the Tongji University, Prof. Y.Y. Chen, Dean of the College of Civil Engineering and Prof. Q.L. Zhang, Vice-Dean of the College of Civil Engineering, has been pivotal in the successful organization of this conference. We also sincerely appreciate the support from the China Society of Steel Construction, the China Society of Metal Structures for Buildings and the Shanghai Society of Metal Structures.

We would also like to thank the valuable assistance from the members of the international advisory committee, the local advisory committee, the conference organizing committee, and, in particular, the panel of referees. We also wish to express our gratitude to all the contributors for their careful preparation of the manuscripts. Thanks are also due to all those who have devoted their time and effort to the organization of the conference and publication of the Proceedings, including staff and students in the Department of Building Engineering at the College of Civil Engineering, Tongji University.

Finally, we gratefully acknowledge our pleasant cooperation with Keith Lambert and Noël Blatchford of Elsevier Ltd in the UK.

Editors
Z.Y.Shen
G.Q.Li
S.L.Chan

INTERNATIONAL ADVISORY COMMITTEE

H. Akiyama	University of Tokyo	Japan
F. Albermani	University of Queensland	Australia
D. Anderson	University of Warwick	UK
P. Ansourian	University of Sydney	Australia
J.M. Aribert	INSA-Rennes	France
R.G. Beale	Oxford Brooks University	UK
R.G. Bjorhovde	University of Pittsburgh	USA
M.A. Bradford	University of New South Wales	Australia
R.Q. Bridge	University of Western Sydney	Australia
I. Burgess	University of Sheffield	UK
C.S. Cai	Kansa State University	USA
C.R. Calladine	University of Cambridge	UK
D. Camotim	Technical University of Lisbon	Portugal
S.F. Chen	Xi'an University of Architecture and Technology	China
S.J. Chen	Taiwan Construction Research Institute	Taiwan, China
W.F. Chen	University of Hawaii at Manoa	USA
Y.K. Cheung	University of Hong Kong	Hong Kong China
S.P. Chiew	Nanyang Technological University	Singapore
H.N. Cho	Hanyang University	Korea
C.K. Choi	Korea Advanced Institute of Science & Technology	Korea
K.P. Chong	National Science Foundation	USA
M. Chryssanthopoulos	University of Surrey	UK
A. Combescure	Laboratoire de Mechanique et Techonologie	France
J.G.A. Croll	University College London	UK
J.M. Davies	University of Manchester	UK
G.G. Deierlein	Stanford University	USA
S.L. Dong	Zhejiang University	China
P.J. Dowling	University of Surrey	UK
D. Dubina	University of Timisoara	Romania
M. Farshad	Swiss Federal Laboratories for Material Test & Research	Switzerland
F.C. Filippou	University of California at Berkeley	USA
J-M. Franssen	University de Liége	Belgium
Y. Fukumoto	Fukuyama University	Japan
H.B. Ge	Nagoya University	Japan
Y. Goto	Nagoya Institute of Technology	Japan
P.L. Gould	Washington University	USA

M. Green	Buro Happold Limited	UK
R. Greiner	Technical University of Graz	Austria
G.J. Hancock	University of Sydney	Australia
J.F. Hajjar	University of Minnesots	USA
K. Harada	Kyoto University	Japan
J.E. Harding	University of Surrey	UK
Y. Hasemi	Waseda University	Japan
Q.C. Hu	Beijing Institute of Architectural Design	China
H.C. Jiang	Shanghai Xian Dai Architectural Design (Group) Co. Ltd.	China
J.F. Jullien	INSA Lyon	France
K. Joel	CTICM	France
S. Kato	Toyohashi University of Technology	Japan
S. Kitipornchai	City University of Hong Kong	Hong Kong, China
S.D. Kim	Korea University	Korea
A.R. Kemp	University of Witwatersrand	South Africa
R.A. LaBoube	University of Missouri	USA
T. Lan	China Academy of Building Research	China
R.T. Leon	Georgia Institute of Technology	USA
S.F. Li	Tsinghua University	China
R. Liew	National University of Singapore	Singapore
J. Lindner	Technische Universitat Berlin	Germany
X.L. Liu	Tianjin University	China
L.W. Lu	Lehigh University	USA
Z.T. Lu	Southeast University	China
M. Mahendran	Queensland University	Australia
P. Makelainen	Helsinki University of Technology	Finland
P. Marek	Academy of Science of the Czech Republic	Czech Republic
C. Miki	Tokyo Institute of Technology	Japan
J. Melcher	Brno University of Technology	Czech Republic
D.A. Nethercot	Imperial College of Science, Technology & Medicine	UK
D.J. Oehlers	University of Adelaide	Australia
G.W. Owens	The Steel Construction Institute	UK
B.S. Rong	The Architectural Design & Research Institute of Guangdong Province	China
J.M. Rotter	University of Edinburgh	UK
B. Samali	University of Technology, Sydney	Australia
P. Schaumann	University of Hanover	Germany

H. Schmidt	University of Essen	Germany
N.E. Shanmugam	National University of Singapore	Singapore
S.Z. Shen	Harbin Institute of Technology	China
G. Sedlacek	Institute of Steel Construction	Germany
L.S.da Silva	Universidade de Coimbra	Portugal
T.T. Soong	State University of New York at Buffalo	USA
K. Takanashi	Kogakuin University	Japan
J.G. Teng	The Hong Kong Polytechnic University	Hong Kong, China
N.S. Trahair	University of Sydney	Australia
K.C. Tsai	National Taiwan University	Taiwan, China
L. Twilt	TNO Building and Construction Research	Netherlands
C.M. Uang	University of California at San Diego	USA
T. Usami	Nagoya University	Japan
A. Wada	Tokyo Institute of Technology	Japan
F. Wald	Czech Technical University	Czech Republic
E. Walicki	Technical University of Zielona Gora	Poland
C.M. Wang	National University of Singapore	Singapore
G.Z. Wang	Tsinghua University	China
Y.C. Wang	University of Manchester	UK
D. White	Georgia Institute of Technology	USA
F.W. Williams	Cardiff University	UK
B. Wong	Monash University	Australia
Z.B. Xia	Zhajiang University	China
Y. Xiao	University of Southern California	USA
Y. Xiao	University of Wales Swansea	UK
L. Xu	University of Waterloo	Canada
Y.B. Yang	National Taiwan University	Taiwan, China
K.M. Ye	Shanghai Construction Group	China
C.B. Yun	Korea Advanced Institute of Science & Technology	Korea
R. Zandonini	University of Trento	Italy
X.L. Zhao	Monash University	Australia
S.T. Zhong	Harbin Institute of Technology	China

LOCAL ADVISORY COMMITTEE

G.J. Bao	Shenzhen Jianshen Steel Constructional Co. Ltd.	China
L.H. Han	Fuzhou University	China
G.S. Tong	Zhejiang University	China
Y.Y. Cai	China Institute of Building Standard Design & Research	China
Z.X. Hou	Central Research Institute of Building and Construction	China
D.S. Wang	East China Architectural Design and Research Institute Co. Ltd.	China
C. Chai	Central Research Institute of Building and Construction	China
C.H. Ke	Beijing Institute of Architectural Design	China
Z.M. Wang	Tongji University	China
L.R. Chen	Beijing Institute of Architectural Design	China
J.M. Ko	The Hong Kong Polytechnic University	Hong Kong, China
M.Z. Wei	Chongqing University	China
X.T. Chen	Central-South Architectural Design Institute	China
S.J. Li	China Iron & Steel Association	China
X.M. Wu	China Architecture Design & Research Group	China
Y.J. Chen	Tongji University	China
C.L. Lu	Beijing University of Technology	China
Y.J. Xu	Northwest Design Institute	China
H.C. Cui	China Majesty Steel Structure Design Co. Ltd.	China
J.Y. Pan	China Academy of Railway Sciences	China
N.L. Yao	Shanghai Xian Dai Architectural Design (Group) Co. Ltd.	China
N.H. Dou	Northeast Design Institute	China
S.J. Pan	Tongji University	China
A.L. Zhang	China Construction Metal Structure Association	China
Z.H. Du	China Construction Metal Structure Association	China
G. Shen	Shanghai Metal Construction Association	China
Y.C. Zhang	Harbin Institute of Technology	China

M.D. Fan	Shanghai COSCO Kawasaki Heavy Industrial Steel Structure Co. Ltd.	China
Y.J. Shi	Tsinghua University	China
Z.Q. Zhang	Tongji University	China
Q. Gu	University of Science and Technology of Suzhou	China
G.P. Shu	Southeast University	China
X.H. Zhou	Chang'An University	China
Y.L. Guo	Tsinghua University	China
X.M. Tao	Northwest Design Institute	China

LOCAL ORGANIZING COMMITTEE

Co-chairmen

Z.Y. Shen	Tongji University
G.Q. Li	Tongji University
S.L. Chan	The Hong Kong Polytechnic University

Members

Y.Y. Chen	Tongji University
Q.L. Zhang	Tongji University
K.F. Cheung	The Hong Kong Polytechnic University
C.M. Chan	The Hong Kong University of Science & Technology
B. Young	University of Hong Kong
K.K. Kwan	University of Hong Kong
F.M.K. Tong	Architectural Services Department, HKSAR
J.M. Ding	The Architectural Design and Research Institute of Tongji University
C.G. Deng	Tongji University
R.J. Qian	Tongji University
R.L. Ma	Tongji University
M.J. He	Tongji University
L.W. Tong	Tongji University
Y.F. Luo	Tongji University
H.Z. Deng	Tongji University
F.F. Sun	Tongji University
X.Z. Zhao	Tongji University
S.C. Jiang	Tongji University
Y.Q. Li	Tongji University
S.W. Chen	Tongji University
G.X. Zhang	Shanghai Metal Construction Association

CONTENTS

VOLUME I

* Invited Paper

* Invited Paper

Frames

* Invited Paper

* Invited Paper

* Invited Paper

* Invited Paper