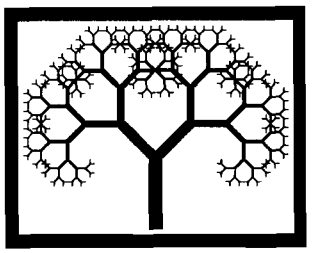
COMPUTATIONAL STEEL STRUCTURES TECHNOLOGY

COMPUTATIONAL STEEL STRUCTURES TECHNOLOGY

Edited by
M. Iványi, J.P. Muzeau and B.H.V. Topping



CIVIL-COMP PRESS

CIVIL-COMP PRESS
10 Saxe-Coburg Place
Edinburgh, EH3 5BR, UK

CIVIL-COMP PRESS is an imprint of Civil-Comp Limited

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0-948749-72-5

Printed in the Scottish Borders
by
MEIGLE PRINTERS LIMITED
Galashiels, Scotland

❖CONTENTS❖

5. DESIGN OF STEEL STRUCTURES

❖PREFACE❖

This volume contains a selection of contributed papers presented at *The Fifth International Conference on Computational Structures Technology* and *The Second International Conference on Engineering Computational Technology*, held in Leuven, Belgium from 6-8 September 2000. The papers in this volume include the following topics: Computer Aided Design of Steel Structures; Analysis of Steel Structures; Modelling of Steel Structures; Analysis, Modelling and Design of Steel Connections; and Design of Steel Structures. The complete list of conference proceedings volumes are as follows:

- Identification, Control and Optimisation of Engineering Structures
  G. De Roeck and B.H.V. Topping (Editors)
  Civil-Comp Press, 2000, ISBN 0-948749-74-1
- Computational Civil and Structural Engineering
  G. De Roeck and B.H.V. Topping (Editors)
  Civil-Comp Press, 2000, ISBN 0-948749-73-3
- Computational Steel Structures Technology
  M. Iványi, J.P. Muzeau and B.H.V. Topping (Editors)
  Civil-Comp Press, 2000, ISBN 0-948749-72-5
- Computational Concrete Structures Technology
  Z. Bittnar and B.H.V. Topping (Editors)
  Civil-Comp Press, 2000, ISBN 0-948749-71-7
- Developments in Engineering Computational Technology
  B.H.V. Topping (Editor)
  Civil-Comp Press, 2000, ISBN 0-948749-70-9
- Computational Techniques for Materials, Composites and Composite Structures
  B.H.V. Topping (Editor)
  Civil-Comp Press, 2000, ISBN 0-948749-69-5
- Computational Mechanics: Techniques and Developments
  B.H.V. Topping (Editor)
  Civil-Comp Press, 2000, ISBN 0-948749-68-7
- Finite Elements: Techniques and Developments
  B.H.V. Topping (Editor)
  Civil-Comp Press, 2000, ISBN 0-948749-67-9
- Computational Engineering using Metaphors from Nature
  B.H.V. Topping (Editor)
  Civil-Comp Press, 2000, ISBN 0-948749-66-0
- Computational Mechanics for the Twenty-First Century
  B.H.V. Topping (Editor)
  Saxe-Coburg Publications, 2000, ISBN 1-874672-13-X

I should like to thank all the authors for their contributions and in particular those who presented their papers in Leuven. I must also thank the members of the Conference Editorial Boards who helped in many ways before and during the conference.

P.L. Gould, USA; Prof. R.V. Grandhi, USA; Prof. D. Grierson, Canada; Prof. R. Haftka, USA; Prof. P. Hajela, USA; Prof. P. Hamelin, France; Prof. D. Hartmann, Germany; Prof. G.R. Heppler, Canada; Prof. J. Herskovits, Brazil; Prof. M. Hoit, USA; Prof. T.J.R. Hughes, USA; Prof. M. Ibrahimbegovic, France; Prof. H. Irschik, Austria; Prof. M. Iványi, Hungary; Prof. K. Jarmai, Hungary; Prof. M. Kamiya, Japan; Prof. T. Kant, India; Prof. B. Karihaloo, Wales; Prof. S. Kato, Japan; Prof. J.T. Katsikadelis, Greece; Prof. A. Kaveh, Iran; Prof. M. Kawaguchi, Japan; Dr A. Khan, Australia; Prof. U. Kirsch, Israel; Dr. M. Kleiber, Poland; Prof. M.D. Kotsovos, Greece; Prof. V. Koumousis, Greece; Prof. A. Kounadis, Greece; Prof. W.B. Kräzig, Germany; Prof. B.H. Kroplin, Germany; Prof. P. Ladèveze, France; Prof. K.L. Lawrence, USA; Prof. S.H. Lee, USA; Prof. Le Tallec, France; Prof. A.Y.T. Leung, England; Prof. R. Levy, Israel; Prof. A. Liolios, Greece; Prof. P.B. Lourenço, Portugal; Prof. I. MacLeod, Scotland; Dr J. Mackerle, Sweden; Prof. G. Manfredi, Italy; Prof. H.A. Mang, Austria; Prof. D. Manolis, Greece; Prof. J.B. Martin, South Africa; Prof. H.G. Matthies, Germany; Dr E.A.W. Maunder, England; Prof. I.M. May, Scotland; Prof. F. Mazzolani, Italy; Prof. J.L. Meek, Australia; Prof. U.F. Meissner, Germany; Prof. C. Meyer, Germany; Prof. M. Mikkola, Finland; Dr. S. Modak, USA; Dr. K. Morgan, Wales; Prof. C.A. Mota Soares, Portugal; Prof. Z. Mroz, Poland; Dr. A. Muc, Poland; Prof. J.-P. Muzeau, France; Prof. A. Needleman, USA; Prof. G.P. Nikishkov, Japan; Prof. A.K. Noor, USA; Prof. H. Nooshin, England; Prof. R. Ohayon, France; Prof. N. Olhoff, Denmark; Prof. J. Oliver, Spain; Prof. E. Onate, Spain; Prof. E. Papa, Italy; Prof. M. Papadrakakis, Greece; Prof. P. Papalambros, USA; Prof. D. Parsons, USA; Prof. P. Pedersen, Denmark; Dr D. Peric, Wales; Prof. J. Petrolito, Australia; Prof. C.P. Providakis, Greece; Dr. E. Providas, Greece; Prof. J. Rakowski, Poland; Prof. C.V. Ramakrishnan, India; Prof. E. Ramm, Germany; Prof. F.G. Rammerstorfer, Austria; Prof. B.D. Reddy, South Africa; Prof. E. Riks, The Netherlands; Prof. H. Rothert, Germany; Dr. E. Salajegheh, Iran; Prof. A. Samartin, Spain; Prof. A. Samuelsson, Sweden; Prof. J.L.T. Santos, Portugal; Prof. E. Schnack, Germany; Dr B.A. Schrefler, Italy; Prof. G.I. Schueller, Austria; Prof. K. Schweizerhof, Germany; Dr A. Selby, England; Prof. G.J. Simitses, USA; Prof. S. Sloan, Australia; Prof. P. Spanos, USA; Dr E. Spreeuw, The Netherlands; Prof. G. Steven, Australia; Prof. H. Sugimoto, Japan; Prof. K.S. Surana, USA; Prof. C.C. Swan, USA; Prof. C.A. Syrmakezis, Greece; Prof. B.A. Szabo, USA; Dr K.Y. Sze, Hong Kong; Prof. I. Takewaki, Japan; Prof. T. Tarnai, Hungary; Prof. J.W. Tedesco, USA; Prof. A.B. Templeman, England; Prof. G. Thierauf, Germany; Prof. R. Tinawi, Canada; Dr. V.V. Toropov, England; Prof. M. Touratier, France; Prof. P. Trompette, France; Prof. G. Tsamasphyros, Greece; Dr G. Turvey, England; Prof. F. van Keulen, The Netherlands; Prof. J. Vantomme, Belgium; Prof. I. Vardoulakis, Greece; Prof. F. Venancio-Filho,Brazil; Dr. P. Venini, Italy; Prof. K.S. Virdi, England; Prof. W. Wagner, Germany; Prof. X. Wang, USA; Prof. Z. Waszczyszyn, Poland; Prof. N.P. Weatherill, Wales; Prof. R. Weixin, Singapore; Prof. D.W. White, USA; Prof. N.E. Wiberg, Sweden; Prof. E.L. Wilson, USA; Prof. M. Witkowski, Poland; Prof. U. Wittek, Germany; Dr J.P. Wolf, Switzerland; Dr J. Wood, Scotland; Dr R.D. Wood, Wales; Prof. P. Wriggers, Germany; Dr. G. Yagawa, Japan; Prof. Y-B. Yang, Taiwan and Dr T. Zimmermann, Switzerland.

The members of the Editorial Board for Engineering Computational Technology Conference 2000, were: Prof. R. Abascal, Spain; Dr R. Adey, England; Prof. M.H. Aliabadi, England; Dr. C.J. Anumba, England; Prof. C.G. Armstrong, Northern Ireland; Prof. Z.P. Bazant, USA; Prof. A.I. Beltzer, Israel; Prof. G.F. Carey, USA; Dr. B. Codenotti, Italy; Prof. L. Damkilde, Denmark; Prof. F. Darve, France; Dr M. Dayde, France; Dr C. Di Napoli, Italy; Prof. E. Dick, Belgium; Prof. I.S. Duff, England; Dr A. Duller, Wales; Prof. D.J. Evans, England; Prof. A. Faghri, USA; Dr J. Fingberg, Germany; Prof. U. Gabbert, Germany; Prof. R.R. Gajewski, Poland; Prof. L. Gaul, Germany; Dr P.L. George, France; Prof. D. Givoli, Israel; Prof. B. Gustafsson, Sweden; Dr S. Hernandez, Spain; Dr. S. Idelsohn, Argentina; Prof. M.H. Imam, Saudi Arabia; Prof. A.R. Ingraffea, USA; Prof. K. Ishii, Japan; Dr M. Isreb, Australia; Prof. Y. Jaluria, USA; Prof. J. Jeronimidis, England; Dr P.K. Jimack, England; Dr M. Kara, England; Prof. T.G. Keith Jr., USA; Prof. V.M. Kovenya, Russia; Dr B. Kumar, Scotland; Prof. Y.S. Kim, USA; Dr D. Kiritsis, Switzerland; Dr. L. Lämmer, Germany; Prof. P. Leger, Canada; Dr G. Lonsdale, Germany; Prof. T. Lookman, Canada; Prof. J.J. McGuirk, England; Dr J.J. McKeown, Northern Ireland; Dr. R.I.Mackie, Scotland; Prof. M. Malafaya-Baptista, Portugal; Prof. N.C. Markatos, Greece; Prof. K. Matsuno, Japan; Prof. G. Meier, Italy; Prof. A. Meyer, Germany; Dr. J. Miles, Wales; Prof. G. Molnarka, Hungary; Prof. C.M. Mota Soares, Portugal; Prof. Z. Mroz, Poland; Dr M. Napolitano, Italy; Prof. D.T. Nguyen, USA; Prof. A.K. Noor, USA; Prof. P.H. Oosthuizen, Canada; Prof. K. Orsborn, USA; Prof. M.P. Païdoussis, Canada; Dr P.C. Pandey, India; Dr I.C. Parmee, England; Dr R. Pozo, USA; Dr A Preumont, Belgium; Prof. H-W. Reinhardt, Germany; Prof. Z. Ren, Slovenia; Dr L.M. da S. Ribeiro, Portugal; Prof. J. R. Rice, USA; Dr D. Robinson, Northern Ireland; Prof. D. Roose, Belgium; Prof. F-X Roux, France; Dr M.G. Sainsbury, Hong Kong; Prof. H. Schaeffer, USA; Prof. K.N. Seetharamu, Malaysia; Prof. R.P. Shaw, USA; Prof. M.S. Shephard, USA; Dr J. Sienz, Wales; Dr H.D. Simon, USA; Prof. K. Sobczyk, Poland; Dr J. Sobieski, USA; Prof. B. Spalding, England; Prof. G.E. Stavroulakis, Germany; Prof. B. Sunden, Sweden; Prof. K.K. Tamma, USA; Dr T.D. Taylor, USA; Dr A.S. Usmani, Scotland; Prof. W.S. Venturini, Brazil; Prof. V.R. Voller, USA; Dr C. Walshaw, England; Dr M. Wolfshtein, Israel; Dr P K Woodward, Scotland and Prof. L.C. Wrobel, England.

These Conferences could not have been organised without the contribution of many people who helped in their planning, organisation and execution. Professor G. De Roeck was a valuable source of help locally in Leuven and in many aspects of the organisation of the conferences. Professor K.J. Bathe and Professor A.K. Noor were a constant source of encouragement and their continued support of this series is gratefully acknowledged. Professor Z. Bittnar,

Professor M. Iványi, Professor J.P. Muzeau and Professor G. De Roeck contributed to the success of the meeting by helping with the organisation and editorial of the volumes as listed above.

My thanks are also due to all at Civil-Comp Press for their help and perseverance in the realisation of this conference, particularly Mrs Rosemary Brodie. The assistance of members of the Structural Engineering Computational Technology Research Group at Heriot-Watt University, Edinburgh is gratefully acknowledged particularly from Roman Putanowicz, Janos Nezö and Péter Iványi. The delights of Leuven were first drawn to my attention by Jelle Muylle, a former student of Professor G. De Roeck. Jelle's tireless and enthusiastic assistance in bringing these Conferences to fruition is gratefully acknowledged.

Barry H.V. Topping
Department of Mechanical and Chemical Engineering
Heriot-Watt University, Edinburgh
August 2000