

Computational Structures Technology

Saxe-Coburg Publications on Computational Engineering

Engineering Computational Technology

Edited by: B.H.V. Topping and Z. Bittnar

Civil and Structural Engineering Computing: 2001

Edited by: B.H.V. Topping

Computational Modelling of Masonry, Brickwork and Blockwork Structures

Edited by: J.W. Bull

Innovative Computational Methods for Structural Mechanics

Edited by: M. Papadrakakis and B.H.V. Topping

Parallel and Distributed Processing for Computational Mechanics: Systems and Tools

Edited by: B.H.V. Topping

High Performance Computing for Computational Mechanics

Edited by: B.H.V. Topping and L. Lämmer

Computational Mechanics for the Twenty-First Century

Edited by: B.H.V. Topping

Parallel Finite Element Computations

B.H.V. Topping and A.I. Khan

Computational Structures Technology

Edited by
B.H.V. Topping and Z. Bittnar



© Civil-Comp Ltd., Stirling, Scotland

published 2002 by
Saxe-Coburg Publications
Dun Eaglais, Kippen
Stirling, FK8 3DY, Scotland

Saxe-Coburg Publications is an imprint of Civil-Comp Ltd

ISBN 1-874672-16-4

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Front Cover Image: Finite element mesh and
effective stress contours of an automotive wheel rim

Back cover Image: Frequency analysis of a
turbine disk using over 67,000 degrees of freedom

Both images are reproduced courtesy of ADINA R&D, Inc.

Printed in Great Britain by Bell & Bain Ltd, Glasgow

Contents

Preface	iii
1 On the Finite Element Analysis of Shells and their Full Interaction with Navier-Stokes Fluid Flows K.J. Bathe, J.F. Hiller and H. Zhang	1
2 Nonlinear Shell Problem Formulation accounting for Through-the-Thickness Stretching and its Finite Element Implementation A. Ibrahimbegovic, B. Brank and J. Korelc	33
3 Concrete Structures Subject to High Temperature C.E. Majorana, D. Gawin, F. Pesavento and B.A. Schrefler	63
4 Stochastic Modelling of Failure and Size Effect of Concrete Structures D. Novák	93
5 Nonlocal Formulations for Softening Materials M. Jirásek and B. Patzák	123
6 Computational Aspects in Thermo-Hydro-Mechanical Analysis of Porous Media, Part I: Transport Processes J. Šejnoha, Z. Bittnar, T. Krejčí and J. Kruis	153
7 Computational Aspects in Thermo-Hydro-Mechanical Analysis of Porous Media, Part II: Practical Implementation of Creep and Shrinkage Analysis into Finite Element Software L. Jendele and Z. Bittnar	183
8 Recent Developments in Modelling and Design of Laminated and Piezolaminated Structures by the Finite Strip Method M.A. Ramos Loja, C.M. Mota Soares and C.A. Mota Soares	197
9 Refined Computational Models for Laminated Shells M. Touratier	221
10 A Mortar Approach for the Analysis and Optimization of Composite Laminated Plates C. Ciniuni and P. Venini	239

11	Dynamic Analysis of Structural Systems using Component Mode Synthesis G. Muscolino	255
12	Group-Theoretic Applications in Solid and Structural Mechanics: A Review A. Zingoni	283
13	Topological Transformations in Structural Mechanics A. Kaveh	319
14	Structural Damage: Simulation and Assessment Y.S. Petryna, W.B. Krätzig and F. Stangenberg	351
15	Form Finding, Analysis and Computer Aided Design of Tension Structures T. Nouri-Baranger	379
16	Research on Thin-Walled I-Beams Curved In-Plan M.A. Bradford and Y.-L. Pi	409
	Author Index	431
	Keyword Index	432

Preface

This volume comprises the Invited Lectures presented at The Sixth International Conference on Computational Structures Technology (CST 2002). The conference was held concurrently with The Third International Conference on Engineering Computational Technology (ECT 2002). Both conferences were organised in conjunction with, and held at, the Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic, from 4 to 6 September 2002. These conferences are part of the CST–ECT series that commenced in 1991.

The first Computational Structures Technology Conference was held in Edinburgh in 1991. At the 1991 conference most of the papers concentrated on the solution of structural engineering problems using computational techniques. Today, the computational technology aspects of the modelling and solution procedures are important if we are to harness the full power of the latest developments in computational hardware and software. Another important research trend is the solution of multi-physics problems where the solution of the structural engineering problem has to be embedded within a much more complex system involving fluid or other models. The lectures included in this volume reflect these research trends.

In this volume of Invited Lectures the topics covered include:

- fluid-structure and fluid-solid interaction (Chapters 1 & 6)
- linear and non-linear finite element techniques (Chapters 1, 2, 3, 4, 15 & 16)
- materials and fracture mechanics modelling (Chapters 3, 4, 5, 6, 7 & 14)
- damage mechanics (Chapters 3, 4, 5 & 6)
- analysis and design of composites and laminates (Chapters 8, 9 & 10)
- dynamic analysis (Chapter 11)
- new techniques for structural mechanics (Chapters 12 & 13)
- damage assessment techniques (Chapter 14)
- optimization in structural analysis and design (Chapters 8, 10 & 15)

We are grateful to the authors and co-authors of the special lectures included in this volume. Their contribution both to the CST 2002 conference and this book is greatly appreciated.

We are indebted to Adina R&D for the two computer generated images shown on the cover of the book.

Other papers presented at the conferences in 2002 are published as follows:

- *The Invited Lectures from ECT 2002 are published in:* Engineering Computational Technology, B.H.V. Topping and Z. Bittnar (Editors), Saxe-Coburg Publications, Stirling, Scotland, 2002.
- *The Contributed Papers from CST 2002 are published in:* Proceedings of the Sixth International Conference on Computational Structures Technology, B.H.V. Topping and Z. Bittnar (Editors), (Book of Abstracts and CD-ROM), Civil-Comp Press, Stirling, Scotland, 2002.
- *The Contributed Papers from ECT 2002 are published in:* Proceedings of the Third International Conference on Engineering Computational Technology, B.H.V. Topping and Z. Bittnar (Editors), Saxe-Coburg Publications, Stirling, Scotland, 2002.

These Conferences could not have been organised without the contribution of many who helped in their planning, organisation and execution. We are particularly grateful to Jelle Muylle who once again, so expertly, guided the design of this volume of lectures. We are also grateful to the following staff and students of the Faculty of Civil Engineering at the Czech Technical University: Alexandra Kurfürstová, secretary of the Department of Structural Mechanics and PhD students Jitka Poděbradská, Richard Vondráček and Matěj Lepš.

Barry H.V. Topping and Zdeněk Bittnar