



HIGH PERFORMANCE STRUCTURES AND MATERIALS VI

 **WIT***PRESS*

Editors
**W.P. De Wilde,
C.A. Brebbia &
S. Hernández**

High Performance Structures and Materials VI

Editors

W.P. de Wilde

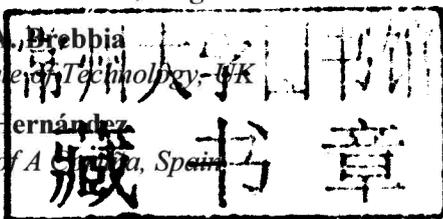
Vrije Universiteit Brussel, Belgium

C.A. Brebbia

Wessex Institute of Technology, UK

S. Hernández

University of A Coruña, Spain



WITPRESS Southampton, Boston



Editors:

W.P. de Wilde

Vrije Universiteit Brussel, Belgium

C.A. Brebbia

Wessex Institute of Technology, UK

S. Hernández

University of A Coruña, Spain

Published by

WIT Press

Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK

Tel: 44 (0) 238 029 3223; Fax: 44 (0) 238 029 2853

E-Mail: witpress@witpress.com

<http://www.witpress.com>

For USA, Canada and Mexico

Computational Mechanics Inc

25 Bridge Street, Billerica, MA 01821, USA

Tel: 978 667 5841; Fax: 978 667 7582

E-Mail: infousa@witpress.com

<http://www.witpress.com>

British Library Cataloguing-in-Publication Data

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

ISBN: 978-1-84564-596-0

eISBN: 978-1-84564-597-7

ISSN: 1746-4498 (print)

ISSN: 1743-3509 (on-line)

The texts of the papers in this volume were set individually by the authors or under their supervision. Only minor corrections to the text may have been carried out by the publisher.

No responsibility is assumed by the Publisher, the Editors and Authors for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. The Publisher does not necessarily endorse the ideas held, or views expressed by the Editors or Authors of the material contained in its publications.

© WIT Press 2012

Printed in Great Britain by Lightning Source, UK.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Publisher.

High Performance Structures and Materials VI

WIT*PRESS*

WIT Press publishes leading books in Science and Technology.
Visit our website for the current list of titles.
www.witpress.com

WIT*eLibrary*

Home of the Transactions of the Wessex Institute.
Papers presented at High Performance Structures and Materials VI
are archived in the WIT eLibrary in volume 124 of WIT Transactions on
The Built Environment (ISSN 1743-3509).
The WIT eLibrary provides the international scientific community with immediate
and permanent access to individual papers presented at WIT conferences.
<http://library.witpress.com>

SIXTH INTERNATIONAL CONFERENCE ON
HIGH PERFORMANCE STRUCTURES AND MATERIALS

**HIGH PERFORMANCE
STRUCTURES AND MATERIALS VI**

CONFERENCE CHAIRMEN

W.P. de Wilde

Vrije Universiteit Brussel, Belgium

C.A. Brebbia

Wessex Institute of Technology, UK

S. Hernández

University of A Coruña, Spain

INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

I. Iskhakov

T. Katayama

B.S. Kim

S. Kravanja

A. Maheri

D. Northwood

P. Prochazka

H. Sakamoto

M. Sejnoha

H. Takagi

K. Takemura

K. Tanaka

Organised by

Wessex Institute of Technology, UK

Vrije Universiteit Brussel, Belgium

University of A Coruña, Spain

Sponsored by

WIT Transactions on the Built Environment

*International Journal of Computational Methods and Experimental
Measurements*

WIT Transactions

Transactions Editor

Carlos Brebbia

Wessex Institute of Technology
Ashurst Lodge, Ashurst
Southampton SO40 7AA, UK

Editorial Board

- B Abersek** University of Maribor, Slovenia
Y N Abousleiman University of Oklahoma, USA
P L Aguilar University of Extremadura, Spain
K S Al Jabri Sultan Qaboos University, Oman
E Alarcon Universidad Politecnica de Madrid, Spain
A Aldama IMTA, Mexico
C Alessandri Universita di Ferrara, Italy
D Almorza Gomar University of Cadiz, Spain
B Alzahabi Kettering University, USA
J A C Ambrosio IDMEC, Portugal
A M Amer Cairo University, Egypt
S A Anagnostopoulos University of Patras, Greece
M Andretta Montecatini, Italy
E Angelino A.R.P.A. Lombardia, Italy
H Antes Technische Universitat Braunschweig, Germany
M A Atherton South Bank University, UK
A G Atkins University of Reading, UK
D Aubry Ecole Centrale de Paris, France
J Augutis Vytautas Magnus University, Lithuania
H Azegami Toyohashi University of Technology, Japan
A F M Azevedo University of Porto, Portugal
J Baish Bucknell University, USA
J M Baldasano Universitat Politecnica de Catalunya, Spain
J G Bartzis Institute of Nuclear Technology, Greece
S Basbas Aristotle University of Thessaloniki, Greece
A Bejan Duke University, USA
M P Bekakos Democritus University of Thrace, Greece
G Belingardi Politecnico di Torino, Italy
R Belmans Katholieke Universiteit Leuven, Belgium
C D Bertram The University of New South Wales, Australia
D E Beskos University of Patras, Greece
S K Bhattacharyya Indian Institute of Technology, India
E Blums Latvian Academy of Sciences, Latvia
J Boarder Cartref Consulting Systems, UK
B Bobee Institut National de la Recherche Scientifique, Canada
H Boileau ESIGEC, France
J J Bommer Imperial College London, UK
M Bonnet Ecole Polytechnique, France
C A Borrego University of Aveiro, Portugal
A R Bretones University of Granada, Spain
J A Bryant University of Exeter, UK
F-G Buchholz Universitat Gesanthochschule Paderborn, Germany
M B Bush The University of Western Australia, Australia
F Butera Politecnico di Milano, Italy
W Cantwell Liverpool University, UK
D J Cartwright Bucknell University, USA
P G Carydis National Technical University of Athens, Greece
J J Casares Long Universidad de Santiago de Compostela, Spain
M A Celia Princeton University, USA
A Chakrabarti Indian Institute of Science, India
J-T Chen National Taiwan Ocean University, Taiwan
A H-D Cheng University of Mississippi, USA
J Chilton University of Lincoln, UK

- C-L Chiu** University of Pittsburgh, USA
- H Choi** Kangnung National University, Korea
- A Cieslak** Technical University of Lodz, Poland
- S Clement** Transport System Centre, Australia
- M W Collins** Brunel University, UK
- J J Connor** Massachusetts Institute of Technology, USA
- M C Constantinou** State University of New York at Buffalo, USA
- D E Cormack** University of Toronto, Canada
- M Costantino** Royal Bank of Scotland, UK
- D F Cutler** Royal Botanic Gardens, UK
- W Czyczula** Krakow University of Technology, Poland
- M da Conceicao Cunha** University of Coimbra, Portugal
- L Dávid** Károly Róbert College, Hungary
- A Davies** University of Hertfordshire, UK
- M Davis** Temple University, USA
- A B de Almeida** Instituto Superior Tecnico, Portugal
- E R de Arantes e Oliveira** Instituto Superior Tecnico, Portugal
- L De Biase** University of Milan, Italy
- R de Borst** Delft University of Technology, Netherlands
- G De Mey** University of Ghent, Belgium
- A De Montis** Universita di Cagliari, Italy
- A De Naeyer** Universiteit Ghent, Belgium
- W P De Wilde** Vrije Universiteit Brussel, Belgium
- D De Wrachien** State University of Milan, Italy
- L Debnath** University of Texas-Pan American, USA
- G Degrande** Katholieke Universiteit Leuven, Belgium
- E del Giudice** University of Milan, Italy
- S del Giudice** University of Udine, Italy
- G Deplano** Universita di Cagliari, Italy
- I Doltsinis** University of Stuttgart, Germany
- M Domaszewski** Universite de Technologie de Belfort-Montbéliard, France
- J Dominguez** University of Seville, Spain
- K Dorow** Pacific Northwest National Laboratory, USA
- W Dover** University College London, UK
- C Dowlen** South Bank University, UK
- J P du Plessis** University of Stellenbosch, South Africa
- R Duffell** University of Hertfordshire, UK
- N A Dumont** PUC-Rio, Brazil
- A Ebel** University of Cologne, Germany
- E E Edoutos** Democritus University of Thrace, Greece
- G K Egan** Monash University, Australia
- K M Elawadly** Alexandria University, Egypt
- K-H Elmer** Universitat Hannover, Germany
- D Elms** University of Canterbury, New Zealand
- M E M El-Sayed** Kettering University, USA
- D M Elsom** Oxford Brookes University, UK
- F Erdogan** Lehigh University, USA
- D J Evans** Nottingham Trent University, UK
- J W Everett** Rowan University, USA
- M Faghri** University of Rhode Island, USA
- R A Falconer** Cardiff University, UK
- M N Fardis** University of Patras, Greece
- P Fedelinski** Silesian Technical University, Poland
- H J S Fernando** Arizona State University, USA
- S Finger** Carnegie Mellon University, USA
- E M M Fonseca** Instituto Politécnico de Bragança, Portugal
- J I Frankel** University of Tennessee, USA
- D M Fraser** University of Cape Town, South Africa
- M J Fritzler** University of Calgary, Canada
- T Futagami** Hiroshima Institute of Technology, Japan
- U Gabbert** Otto-von-Guericke Universität Magdeburg, Germany
- G Gambolati** Universita di Padova, Italy
- C J Gantes** National Technical University of Athens, Greece
- L Gaul** Universität Stuttgart, Germany
- A Genco** University of Palermo, Italy
- N Georgantzis** Universitat Jaume I, Spain
- P Giudici** Universita di Pavia, Italy
- L M C Godinho** University of Coimbra, Portugal

- F Gomez** Universidad Politecnica de Valencia, Spain
- R Gomez Martin** University of Granada, Spain
- D Goulias** University of Maryland, USA
- K G Goulias** Pennsylvania State University, USA
- F Grandori** Politecnico di Milano, Italy
- W E Grant** Texas A & M University, USA
- S Grilli** University of Rhode Island, USA
- R H J Grimshaw** Loughborough University, UK
- D Gross** Technische Hochschule Darmstadt, Germany
- R Grundmann** Technische Universitat Dresden, Germany
- A Gualtierotti** IDHEAP, Switzerland
- O T Gudmestad** University of Stavanger, Norway
- R C Gupta** National University of Singapore, Singapore
- J M Hale** University of Newcastle, UK
- K Hameyer** Katholieke Universiteit Leuven, Belgium
- C Hanke** Danish Technical University, Denmark
- K Hayami** University of Toyko, Japan
- Y Hayashi** Nagoya University, Japan
- L Haydock** Newage International Limited, UK
- A H Hendrickx** Free University of Brussels, Belgium
- C Herman** John Hopkins University, USA
- I Hideaki** Nagoya University, Japan
- D A Hills** University of Oxford, UK
- W F Huebner** Southwest Research Institute, USA
- J A C Humphrey** Bucknell University, USA
- M Y Hussaini** Florida State University, USA
- W Hutchinson** Edith Cowan University, Australia
- T H Hyde** University of Nottingham, UK
- M Iguchi** Science University of Tokyo, Japan
- D B Ingham** University of Leeds, UK
- L Int Panis** VITO Expertisecentrum IMS, Belgium
- N Ishikawa** National Defence Academy, Japan
- J Jaafar** UiTm, Malaysia
- W Jager** Technical University of Dresden, Germany
- Y Jaluria** Rutgers University, USA
- C M Jefferson** University of the West of England, UK
- M K Jha** Morgan State University, USA
- P R Johnston** Griffith University, Australia
- D R H Jones** University of Cambridge, UK
- N Jones** University of Liverpool, UK
- N Jovanovic** CSIR, South Africa
- D Kaliampakos** National Technical University of Athens, Greece
- N Kamiya** Nagoya University, Japan
- D L Karabalis** University of Patras, Greece
- A Karageorghis** University of Cyprus
- M Karlsson** Linkoping University, Sweden
- T Katayama** Doshisha University, Japan
- K L Katsifarakis** Aristotle University of Thessaloniki, Greece
- J T Katsikadelis** National Technical University of Athens, Greece
- E Kausel** Massachusetts Institute of Technology, USA
- H Kawashima** The University of Tokyo, Japan
- B A Kazimee** Washington State University, USA
- S Kim** University of Wisconsin-Madison, USA
- D Kirkland** Nicholas Grimshaw & Partners Ltd, UK
- E Kita** Nagoya University, Japan
- A S Kobayashi** University of Washington, USA
- T Kobayashi** University of Tokyo, Japan
- D Koga** Saga University, Japan
- S Kotake** University of Tokyo, Japan
- A N Kounadis** National Technical University of Athens, Greece
- W B Kratzig** Ruhr Universitat Bochum, Germany
- T Krauthammer** Penn State University, USA
- C-H Lai** University of Greenwich, UK
- M Langseth** Norwegian University of Science and Technology, Norway
- B S Larsen** Technical University of Denmark, Denmark
- F Lattarulo** Politecnico di Bari, Italy
- A Lebedev** Moscow State University, Russia
- L J Leon** University of Montreal, Canada
- D Lesnic** University of Leeds, UK
- D Lewis** Mississippi State University, USA
- S Ighobashi** University of California Irvine, USA

- K-C Lin** University of New Brunswick, Canada
- A A Liolios** Democritus University of Thrace, Greece
- S Lomov** Katholieke Universiteit Leuven, Belgium
- J W S Longhurst** University of the West of England, UK
- G Loo** The University of Auckland, New Zealand
- J Lourenco** Universidade do Minho, Portugal
- J E Luco** University of California at San Diego, USA
- H Lui** State Seismological Bureau Harbin, China
- C J Lumsden** University of Toronto, Canada
- L Lundqvist** Division of Transport and Location Analysis, Sweden
- T Lyons** Murdoch University, Australia
- Y-W Mai** University of Sydney, Australia
- M Majowiecki** University of Bologna, Italy
- D Malerba** Università degli Studi di Bari, Italy
- G Manara** University of Pisa, Italy
- S Mambretti** Politecnico di Milano, Italy
- B N Mandal** Indian Statistical Institute, India
- Ü Mander** University of Tartu, Estonia
- H A Mang** Technische Universität Wien, Austria
- G D Manolis** Aristotle University of Thessaloniki, Greece
- W J Mansur** COPPE/UF RJ, Brazil
- N Marchettini** University of Siena, Italy
- J D M Marsh** Griffith University, Australia
- J F Martin-Duque** Universidad Complutense, Spain
- T Matsui** Nagoya University, Japan
- G Matrisch** DaimlerChrysler AG, Germany
- F M Mazzolani** University of Naples "Federico II", Italy
- K McManis** University of New Orleans, USA
- A C Mendes** Universidade de Beira Interior, Portugal
- RA Meric** Research Institute for Basic Sciences, Turkey
- J Mikielawicz** Polish Academy of Sciences, Poland
- N Milic-Frayling** Microsoft Research Ltd, UK
- RA W Mines** University of Liverpool, UK
- C A Mitchell** University of Sydney, Australia
- K Miura** Kajima Corporation, Japan
- A Miyamoto** Yamaguchi University, Japan
- T Miyoshi** Kobe University, Japan
- G Molinari** University of Genoa, Italy
- T B Moodie** University of Alberta, Canada
- D B Murray** Trinity College Dublin, Ireland
- G Nakhaeizadeh** DaimlerChrysler AG, Germany
- M B Neace** Mercer University, USA
- D Neculescu** University of Ottawa, Canada
- F Neumann** University of Vienna, Austria
- S-I Nishida** Saga University, Japan
- H Nisitani** Kyushu Sangyo University, Japan
- B Notaros** University of Massachusetts, USA
- P O'Donoghue** University College Dublin, Ireland
- R O O'Neill** Oak Ridge National Laboratory, USA
- M Ohkusu** Kyushu University, Japan
- G Oliveto** Università di Catania, Italy
- R Olsen** Camp Dresser & McKee Inc., USA
- E Oñate** Universitat Politècnica de Catalunya, Spain
- K Onishi** Ibaraki University, Japan
- P H Oosthuizen** Queens University, Canada
- E L Ortiz** Imperial College London, UK
- E Outa** Waseda University, Japan
- A S Papageorgiou** Rensselaer Polytechnic Institute, USA
- J Park** Seoul National University, Korea
- G Passerini** Università delle Marche, Italy
- F Patania** University of Catania, Italy
- B C Patten** University of Georgia, USA
- G Pelosi** University of Florence, Italy
- G G Penelis** Aristotle University of Thessaloniki, Greece
- W Perrie** Bedford Institute of Oceanography, Canada
- R Pietrabissa** Politecnico di Milano, Italy
- H Pina** Instituto Superior Técnico, Portugal
- M F Platzer** Naval Postgraduate School, USA
- D Poljak** University of Split, Croatia
- V Popov** Wessex Institute of Technology, UK
- H Power** University of Nottingham, UK
- D Prandle** Proudman Oceanographic Laboratory, UK
- M Predeleanu** University Paris VI, France
- I S Putra** Institute of Technology Bandung, Indonesia
- Y A Pykh** Russian Academy of Sciences, Russia

- F Rachidi** EMC Group, Switzerland
- M Rahman** Dalhousie University, Canada
- K R Rajagopal** Texas A & M University, USA
- T Rang** Tallinn Technical University, Estonia
- J Rao** Case Western Reserve University, USA
- J Ravnik** University of Maribor, Slovenia
- A M Reinhorn** State University of New York at Buffalo, USA
- G Reniers** Universiteit Antwerpen, Belgium
- A D Rey** McGill University, Canada
- D N Riahi** University of Illinois at Urbana-Champaign, USA
- B Ribas** Spanish National Centre for Environmental Health, Spain
- K Richter** Graz University of Technology, Austria
- S Rinaldi** Politecnico di Milano, Italy
- F Robuste** Universitat Politecnica de Catalunya, Spain
- J Roddick** Flinders University, Australia
- A C Rodrigues** Universidade Nova de Lisboa, Portugal
- F Rodrigues** Poly Institute of Porto, Portugal
- C W Roeder** University of Washington, USA
- J M Roesset** Texas A & M University, USA
- W Roetzel** Universitaet der Bundeswehr Hamburg, Germany
- V Roje** University of Split, Croatia
- R Rosset** Laboratoire d'Aerologie, France
- J L Rubio** Centro de Investigaciones sobre Desertificacion, Spain
- T J Rudolphi** Iowa State University, USA
- S Russenchuck** Magnet Group, Switzerland
- H Ryssel** Fraunhofer Institut Integrierte Schaltungen, Germany
- S G Saad** American University in Cairo, Egypt
- M Saiidi** University of Nevada-Reno, USA
- R San Jose** Technical University of Madrid, Spain
- F J Sanchez-Sesma** Instituto Mexicano del Petroleo, Mexico
- B Sarler** Nova Gorica Polytechnic, Slovenia
- S A Savidis** Technische Universitat Berlin, Germany
- A Savini** Universita de Pavia, Italy
- G Schmid** Ruhr-Universitat Bochum, Germany
- R Schmidt** RWTH Aachen, Germany
- B Scholtes** Universitaet of Kassel, Germany
- W Schreiber** University of Alabama, USA
- A P S Selvadurai** McGill University, Canada
- J J Sendra** University of Seville, Spain
- J J Sharp** Memorial University of Newfoundland, Canada
- Q Shen** Massachusetts Institute of Technology, USA
- X Shixiong** Fudan University, China
- G C Sih** Lehigh University, USA
- L C Simoes** University of Coimbra, Portugal
- A C Singhal** Arizona State University, USA
- P Skerget** University of Maribor, Slovenia
- J Sladek** Slovak Academy of Sciences, Slovakia
- V Sladek** Slovak Academy of Sciences, Slovakia
- A C M Sousa** University of New Brunswick, Canada
- H Sozer** Illinois Institute of Technology, USA
- D B Spalding** CHAM, UK
- P D Spanos** Rice University, USA
- T Speck** Albert-Ludwigs-Universitaet Freiburg, Germany
- C C Spyarakos** National Technical University of Athens, Greece
- I V Stangeeva** St Petersburg University, Russia
- J Stasiak** Technical University of Gdansk, Poland
- G E Swaters** University of Alberta, Canada
- S Syngellakis** University of Southampton, UK
- J Szymd** University of Mining and Metallurgy, Poland
- S T Tadano** Hokkaido University, Japan
- H Takemiya** Okayama University, Japan
- I Takewaki** Kyoto University, Japan
- C-L Tan** Carleton University, Canada
- E Taniguchi** Kyoto University, Japan
- S Tanimura** Aichi University of Technology, Japan
- J L Tassoulas** University of Texas at Austin, USA
- M A P Taylor** University of South Australia, Australia
- A Terranova** Politecnico di Milano, Italy
- A G Tjihuis** Technische Universiteit Eindhoven, Netherlands
- T Tirabassi** Institute FISBAT-CNR, Italy
- S Tkachenko** Otto-von-Guericke-University, Germany
- N Tosaka** Nihon University, Japan

- T Tran-Cong** University of Southern Queensland, Australia
- R Tremblay** Ecole Polytechnique, Canada
- I Tsukrov** University of New Hampshire, USA
- R Turra** CINECA Interuniversity Computing Centre, Italy
- S G Tushinski** Moscow State University, Russia
- J-L Uso** Universitat Jaume I, Spain
- E Van den Bulck** Katholieke Universiteit Leuven, Belgium
- D Van den Poel** Ghent University, Belgium
- R van der Heijden** Radboud University, Netherlands
- R van Duin** Delft University of Technology, Netherlands
- P Vas** University of Aberdeen, UK
- R Verhoeven** Ghent University, Belgium
- A Viguri** Universitat Jaume I, Spain
- Y Villacampa Esteve** Universidad de Alicante, Spain
- F F V Vincent** University of Bath, UK
- S Walker** Imperial College, UK
- G Walters** University of Exeter, UK
- B Weiss** University of Vienna, Austria
- H Westphal** University of Magdeburg, Germany
- J R Whiteman** Brunel University, UK
- T W Wu** University of Kentucky, USA
- Z-Y Yan** Peking University, China
- S Yanniotis** Agricultural University of Athens, Greece
- A Yeh** University of Hong Kong, China
- B W Yeigh** SUNY Institute of Technology, USA
- J Yoon** Old Dominion University, USA
- K Yoshizato** Hiroshima University, Japan
- T X Yu** Hong Kong University of Science & Technology, Hong Kong
- M Zador** Technical University of Budapest, Hungary
- K Zakrzewski** Politechnika Lodzka, Poland
- M Zamir** University of Western Ontario, Canada
- R Zarnic** University of Ljubljana, Slovenia
- G Zharkova** Institute of Theoretical and Applied Mechanics, Russia
- N Zhong** Maebashi Institute of Technology, Japan
- H G Zimmermann** Siemens AG, Germany

Preface

This book contains most of the papers presented at the 6th International Conference on High Performance Structures and Materials held at the Wessex Institute of Technology in the New Forest, UK. The Meeting was co-organised by the Wessex Institute, the Free University of Brussels and the University of A Coruña.

The Conference followed the success of the previous five meetings in the series, held in Seville in 2002; Ancona in 2004; Ostend in 2006; The Algarve in 2008; and Tallin in 2010.

This volume addresses issues involving advanced types of structures, particularly those based on new concepts or new materials. The objectives of many papers is to search for high performance but altogether sustainable materials of the type which are now receiving increased attention.

The contributors also underline a series of current trends in structural design, including the interaction of three key components i.e. materials selection – component design – structural and construction design. These trends take into account optimisation principles in such a way that the maximum amount of structural materials can be transformed, re-used, dismantled and displaced. These concepts contribute significantly to the sustainability of the constructions. An excellent example of these principles is included in the special session on Transformable Structures, organised by Niels De Temmerman and some of his co-workers, which includes several case studies.

This volume is a valuable contribution to our understanding of materials and structures and their interaction. The Editors are grateful to the members of the International Scientific Advisory Committee who helped select the papers published in this volume, as well as to all authors for their excellent contributions.

The Editors
New Forest, 2012

Contents

Section 1: Emerging structural applications

An application of Taguchi's method to robust design of aircraft structures <i>S. Hernández & J. Díaz</i>	3
An analytical model for deformation analysis of wind turbine adaptive blades <i>H. Zhang, A. Maheri, A. Daadbin & P. Hackney</i>	13
The application of actively tensioned membranes as formwork for complex curvatures in concrete structures <i>S. Belton</i>	27
Recent findings about combined size and rate effects on material properties <i>Z. Chen & S. Jiang</i>	39
A new reinforced concrete beam <i>N. M. Elbasha</i>	53

Section 2: Material characterisation

Evaluation on mechanical properties of a single trabecular in bovine femur <i>S. Enoki, M. Higashiura, M. Sato, K. Tanaka & T. Katayama</i>	65
Hole expansion of dual phase steels <i>L. Xu, F. Barlat, M. G. Lee, K. S. Choi & X. Sun</i>	75
Effects of revibration on early age retarded concrete <i>M. M. Kassim</i>	85

High-cycle fatigue characteristics of squeezed cast aluminum alloy smooth specimens cut from car wheels <i>M. Goto, N. Teshima, S. Z. Han, K. Euh & T. Yakushiji</i>	95
Development of the continuous process method for ECAP using a tri-axis rotary die and microstructural evolution of semi-solid aluminium alloy <i>K. Natori, F. Nomura, Y. Arao & T. Tanaka</i>	107
Acoustic properties of auxetic foams <i>I. Chekkal, C. Remillat & F. Scarpa</i>	119
Coatings or impregnations to adequately treat and protect different substrates: toolbox treatments to obtain optimal results in singular buildings <i>N. García-Pascua, L. Granizo, M. Donadio, H. Baenziger, A. González-Lucas, F. González, M. J. Rubio & O. Videra</i>	131
Effect of fiber interval on tensile strength of fiber reinforced plastics in multi-fiber fragmentation test <i>A. Maki, A. Sakuratani, T. Atsuoka & T. Hirayama</i>	145
Mechanical damage characteristics of elementary hemp fibers and scale effect of fiber strength <i>J. Andersons & R. Joffe</i>	157
Probing the constitutive behaviour of an Al-Sn-Si alloy by tensile testing and instrumented indentation <i>R. Schouwenaars, H. A. Durán, A. Bravo, V. H. Jacobo & A. Ortiz</i>	169
Section 3: Composite materials and structures	
Effective mechanical and transport properties of polysiloxane matrix based composites <i>M. Maršálková, S. Urbanová, J. Salačová & M. Šejnoha</i>	185
Shape optimal design of phases in composites: harmonic problem <i>P. P. Prochazka</i>	197
Experimental analysis of composite steel-concrete slabs <i>R. Karásek, J. Holomek, M. Bajer & J. Barnat</i>	209
Vibration of fiber reinforced anisotropic composite plates with nanofiber reinforced matrices <i>C. C. Chamis & P. L. N. Murthy</i>	217

Flexure behaviour of strengthened steel poles <i>M. Khedr, T. Romeh & A. Seleemah</i>	229
Heating properties of carbon fibers by using direct resistance heating <i>S. Enoki, K. Iwamoto, R. Harada, K. Tanaka & T. Katayama</i>	239
Moulding of carbon fiber reinforced polycarbonate (CF/PC) using UD tape <i>M. Shinohara, S. Isshiki, Y. Fukushima, T. Katayama & K. Tanaka</i>	249

Section 4: Contact mechanics

Design of a vacuum based test rig for measuring micro adhesion and friction force <i>M. A. Yaqoob, M. B. de Rooij & D. J. Schipper</i>	261
Numerically and parallel scalable TFETI based algorithms for quasistatic contact problems of mechanics <i>O. Vlach, Z. Dostál, T. Kozubek, A. Markopoulos & T. Brzobohatý</i>	275
Parallel solution of contact shape optimization problems with Coulomb friction based on domain decomposition <i>P. Beremlijski, T. Brzobohatý, T. Kozubek, A. Markopoulos & J. V. Outrata</i>	285

Section 5: High performance concretes

High performance and serviceability of fibre reinforced concrete <i>P. J. Sasturkar</i>	299
Fracture energy of hybrid polypropylene–steel fiber high strength concrete <i>H. S. J. Al Hazmi, W. H. Al Hazmi, M. A. Shubaili & H. E. M. Sallam</i>	309
Tensile behaviors of highly flowable strain hardening fiber reinforced concrete <i>W. C. Liao</i>	319
Effect of silica fume and MIRHA on thermal conductivity of cement paste <i>S. A. Farhan, M. F. Khamidi, M. H. Murni, M. F. Nuruddin, A. Idrus & A. M. Al Yacouby</i>	331

Section 6: Steel structures

Damage mechanism for high strength steel part frame without diaphragm <i>Y. Kimura & T. Ishihara</i>	343
Elastically connected and offset members at Seville April Fair gateways <i>M. T. Rodríguez-León & J. Sánchez</i>	353
Shear tests of hollow flange channel beams with stiffened web openings <i>M. Mahendran & P. Keerthan</i>	365

Section 7: Natural fibre composites (Special session organised by K. Takemura)

Mechanical performance of bacterial cellulose nanofibre-reinforced epoxy composites <i>H. Takagi, A. N. Nakagaito & K. Uchida</i>	379
Effects of microfibrillated cellulose addition and water absorption on mechanical properties of jute/PLA composites <i>K. Takemura, S. Takai & H. Katogi</i>	387
Elastic and dynamic response characteristics of kenaf/polypropylene composites <i>N. V. David, S. Khairiyah & P. P. Anwar Majeed</i>	395
Development of green composites using agricultural waste <i>T. Ota & A. Uehira</i>	407
Effect of treatment using silane coupling agent on creep properties of jute fiber reinforced composites <i>K. Takemura, Y. Takada & H. Katogi</i>	417

Section 8: Experiments and numerical analysis

Proposal of sheet buckling design criteria for high strength steel under impact crushing <i>K. Watanabe, K. Natori, H. Enjoji, T. Tanaka & Y. Imaida</i>	427
Numerical analysis of the influence of deep energy level traps in SiC Schottky structures <i>A. Koel, T. Rang & G. Rang</i>	439

Bonded anchors in high performance concrete <i>J. Barnat & M. Bajer</i>	449
Section 9: Transformable structures (Special session organised by N. De Temmerman)	
Transformable structures in architectural engineering <i>N. De Temmerman, L. Alegria Mira, A. Vergauwen, H. Hendrickx & W. P. De Wilde</i>	457
Structural optimisation of deployable scissor structures using new computational methods <i>L. Alegria Mira, N. De Temmerman & C. Preisinger</i>	469
Four-dimensional design and analysis of modular footbridges in developing countries <i>L. Pyl & C. W. M. Sitters</i>	481
Analysing the applicability of deployable scissor structures in responsive building skins <i>A. Vergauwen & N. De Temmerman</i>	493
Author index	505