

Earthquake Resistant Engineering Structures 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 ERES VI are archived in the WIT eLibrary in volume 93 of
WIT Transactions on The Built Environment (ISSN 1743-3509).
The WIT electronic-library provides the international scientific community with
immediate and permanent access to individual papers presented at WIT conferences.
Visit the WIT eLibrary at www.witpress.com.

SIXTH WORLD CONFERENCE ON
EARTHQUAKE RESISTANT ENGINEERING STRUCTURES

ERES VI

CONFERENCE CHAIRMAN

C.A. Brebbia

Wessex Institute of Technology, UK

INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

Y. Ariga	M. Haroun	J.M. Nichols
T. Attard	A. Kappos	C.W. Roeder
D. E. Beskos	H. Kawakami	M. Saiidi
S. Dristos	P. Komodromos	E.J. Sapountzakis
G. Dundulis	G.G. Manolis	O. Sircovich Saar
M. Elgawady	G.C. Manos	C.C. Spyrakos
K. Fuchida		

Organised by

Wessex Institute of Technology, UK

Sponsored by

WIT Transactions on The Built Environment

WIT Transactions on The Built Environment

Transactions Editor

Carlos Brebbia

Wessex Institute of Technology
Ashurst Lodge, Ashurst
Southampton SO40 7AA, UK
Email: carlos@wessex.ac.uk

Editorial Board

E Alarcon

Universidad Politecnica de Madrid
Spain

S A Anagnostopoulos

University of Patras
Greece

H Antes

Technische Universitat Braunschweig
Germany

D E Beskos

University of Patras
Greece

F Butera

Politecnico di Milano
Italy

J Chilton

University of Nottingham
UK

M C Constantinou

State University of New York at Buffalo
USA

A De Naeyer

Universiteit Ghent
Belgium

J Dominguez

University of Seville
Spain

M N Fardis

University of Patras
Greece

L Gaul

Universitat Stuttgart
Germany

M Iguchi

Science University of Tokyo
Japan

W Jager

Technical University of Dresden
Germany

C Alessandri

Universita di Ferrara
Italy

E Angelino

A.R.P.A. Lombardia
Italy

D Aubry

Ecole Centrale de Paris
France

J J Bommer

Imperial College London
UK

P G Carydis

National Technical University of Athens
Greece

S Clement

Transport System Centre
Australia

G Degrande

Katholieke Universiteit Leuven
Belgium

W P De Wilde

Vrije Universiteit Brussel
Belgium

F P Escrig

University of Seville
Spain

C J Gantes

National Technical University of Athens
Greece

Y Hayashi

Nagoya University
Japan

L Int Panis

VITO Expertisecentrum IMS
Belgium

C M Jefferson

University of the West of England
UK

- D L Karabalis**
University of Patras
Greece
- W Jager**
Technical University of Dresden
Germany
- W B Kratzig**
Ruhr Universitat Bochum
Germany
- J W S Longhurst**
University of the West of England,
UK
- L Lundqvist**
Unit for Transport and Location Analysis
Sweden
- G D Manolis**
Aristotle University of Thessaloniki
Greece
- F M Mazzolani**
University of Naples "Federico II"
Italy
- G Oliveto**
Universita di Catania
Italy
- A S Papageorgiou**
Rensselaer Polytechnic Institute
USA
- A M Reinhorn**
State University of New York at Buffalo
USA
- C W Roeder**
University of Washington
USA
- M Saiidi**
University of Nevada-Reno
USA
- S A Savidis**
Technische Universitat Berlin
Germany
- Q Shen**
Massachusetts Institute of Technology
USA
- P D Spanos**
Rice University
USA
- H Takemiya**
Okayama University
Japan
- E Taniguchi**
Kyoto University
Japan
- M A P Taylor**
University of South Australia
Australia
- E Kausel**
Massachusetts Institute of Technology
USA
- A N Kounadis**
National Technical University of Athens
Greece
- A A Liolios**
Democritus University of Thrace
Greece
- J E Luco**
University of California at San Diego
USA
- M Majowiecki**
University of Bologna
Italy
- G Mattrisch**
DaimlerChrysler AG
Germany
- K Miura**
Kajima Corporation
Japan
- E Oñate**
Universitat Politecnica de Catalunya
Spain
- G G Penelis**
Aristotle University of Thessaloniki
Greece
- F Robuste**
Universitat Politecnica de Catalunya
Spain
- J M Roesset**
Texas A & M University
USA
- F J Sanchez-Sesma**
Instituto Mexicano del Petroleo
Mexico
- J J Sendra**
University of Seville
Spain
- A C Singhal**
Arizona State University
USA
- C C Spyarakos**
National Technical University of Athens
Greece
- I Takewaki**
Kyoto University
Japan
- J L Tassoulas**
University of Texas at Austin
USA
- R Tremblay**
Ecole Polytechnique
Canada

R van der Heijden
Radboud University
Netherlands

A Yeh
The University of Hong Kong
China

R Zarnic
University of Ljubljana
Slovenia

R van Duin
Delft University of Technology
Netherlands

M Zador
Technical University of Budapest
Hungary

Earthquake Resistant Engineering Structures VI

Editor

C.A. Brebbia

Wessex Institute of Technology, UK

WIT*PRESS* Southampton, Boston



Editor:

C.A. Brebbia

Wessex Institute of Technology, UK

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: 978-1-84564-078-1

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.

© WIT Press 2007

Printed in Great Britain by Athenaeum Press Ltd.

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.

Preface

This book contains selected papers presented at the 6th International Conference on Earthquake Resistant Engineering Structures (ERES) which took place in Bologna, Italy in 2007. This meeting is one of the successful series of conferences organised by the Wessex Institute of Technology (WIT). The series started in Thessaloniki (1996), followed by Catania (1999), Malaga (2001), Ancona (2003) and Skiathos (2005).

The meeting provides a forum for the discussion of the latest developments in innovative design and construction of new earthquake resistant structures as well as the retrofitting of existing buildings. The success of the ERES Conference is closely linked to the innovation and quality of the presentations. It continues to attract promising young researchers as well as familiar names in the field of earthquake engineering. This combination is the main reason why the ERES meetings continue to bring to the attention of the international scientific community original high quality papers.

The importance of conferences like ERES is that they allow rapid dissemination of the latest research before the lengthy process of appearing in learned journals is undertaken. The WIT proceedings – which are produced in time for the conference – are immediately followed by the archiving of all papers in the Transactions of Wessex Institute Library where they are permanently and widely available (www.witpress.com). The Library contains all WIT conference papers since 1993 and attracts nearly a quarter of a million abstract downloads per year. The importance of this archive can not be overemphasised as it is essential for researchers and practitioners to have rapid access to the latest developments, particularly in fields such as earthquake engineering.

The ERES/07 papers appearing in the present book have been divided into the following sections:

- Earthquake resistant design
- Bridges
- Seismic isolation
- Passive protection devices and seismic isolation
- Self-centering systems
- Site effects and geotechnical aspects
- Seismic behaviour and vulnerability

- Lifelines
- Monitoring and testing
- Retrofitting
- Structural dynamics

The Editor appreciates that the task of editing this volume would not have been possible without the generous cooperation of the members of the International Scientific Advisory Committee and other colleagues to whom he is indebted for reviewing the papers. He is also grateful to all authors for their excellent contributions.

The Editor
Bologna, Italy
2007

Contents

Keynote contribution

A road map for seismic prevention of damage <i>M. Maugeri & S. Grasso</i>	XIX
--	-----

Section 1: Earthquake resistant design

Vulnerability functions and the influence of seismic design parameters on initial costs for buildings provided with hysteretic energy-dissipating devices <i>J. García-Pérez, M. Zenteno & O. Díaz</i>	3
Seismic behavior over-resistance effects on buildings <i>J. A. Avila</i>	13
Design of reinforced concrete buildings according to the new NEHRP provisions <i>O. A. Mohamed & P. Khamwan</i>	23
Static and dynamic analytical and experimental analysis of 3D reinforced concrete panels <i>K. Numayr & R. Haddad</i>	33
Designing aspects of bridges placed in active seismic areas <i>V. Herak Marović, P. Marović & Ž. Nikolić</i>	43
Behaviour of coupling beams having vertical slits at the ends <i>S. B. Yuksel</i>	53
Principal stresses behaviour of a steel plate shear wall concerning buckling modes <i>P. Memarzadeh, M. Azhari & M. M. Saadatpour</i>	63

Earthquake architecture as an expression of a stronger architectural identity in seismic areas <i>T. Slak & V. Kilar</i>	73
---	----

Section 2: Bridges

Aspects of testing a large-scale two-span bridge model on multiple shake tables <i>N. Johnson, M. Saiidi & D. Sanders</i>	85
--	----

Seismic devices for bridges <i>D. Mestrovic & G. Grebenar</i>	95
--	----

**Section 3: Seismic isolation
(Special session by P. Komodromos and M. C. Pochas)**

Seismic isolation and energy dissipation: worldwide application and perspectives <i>A. Martelli</i>	105
--	-----

Study of the seismic response of reinforced concrete isolated elevated water tanks <i>V. I. Fernández-Dávila, F. Gran & P. Baquedano</i>	117
---	-----

Modeling of the structural impact of seismically isolated buildings <i>P. Polycarpou, L. Papaloizou, P. Komodromos & M. C. Phocas</i>	129
--	-----

Section 4: Passive protection devices and seismic isolation

Aseismic study of a building with the efficiency-enhanced damping system <i>S. S. Ke, W. S. Li & B. J. Shih</i>	141
--	-----

Introducing orthogonal roller pairs as an effective isolating system for low rise buildings <i>M. Hosseini & K. Kangarloo</i>	151
--	-----

**Section 5: Self-centering systems
(Special session by M. Elgawady)**

Seismic response three-dimensional analyses of ten-story steel frames with column uplift <i>M. Midorikawa, T. Azuhata & T. Ishihara</i>	165
--	-----

Shaking table test on seismic response of reduced-scale models of multi-story buildings allowed to uplift <i>T. Ishihara, T. Azuhata, K. Noguchi, K. Morita & M. Midorikawa</i>	175
Self-centering behavior of unbonded precast concrete shear walls <i>B. Erkmen & A. E. Schultz</i>	185
Displacement ductility demand and strength reduction factors for rocking structures <i>M. Trueb, Y. Belmouden & P. Lestuzzi</i>	195

Section 6: Site effects and geotechnical aspects

The 2006 Yogyakarta earthquake – a preliminary study of deaths <i>J. M. Nichols</i>	207
Local seismic amplification analysis in the industrial area of Sulmona, Central Italy <i>A. Rinaldini, A. Grillo & A. Marino</i>	215
Dynamic response of a large landslide during a strong earthquake <i>R. Meriggi & M. Del Fabbro</i>	225
Liquefaction potential evaluation for a site <i>S. Mittal & M. K. Gupta</i>	235

Section 7: Seismic behaviour and vulnerability

Seismic risk assessment of the Ignalina NPP refuelling machine <i>R. Bausys, G. Dundulis, R. Kacianauskas, D. Markauskas, S. Sliupa, E. Stupak & S. Rimkevicius</i>	247
Comparing static linear and nonlinear analyses of safe rooms in a poor performance masonry building <i>M. Mazloom</i>	259
Empirical fragility curves for Peruvian school buildings <i>A. Muñoz, M. Blondet, R. Aguilar & M.-A. Astorga</i>	269
Evaluation of lateral load pattern in pushover analysis <i>S. I. Javadein & R. Taghinezhad</i>	279

3-D reproduction analyses for actual earthquake behaviors of existing dams <i>Y. Ariga</i>	289
--	-----

Seismic hazard expression in risk assessment <i>X.-X. Tao, Z.-R. Tao & P. Li</i>	299
---	-----

Section 8: Lifelines

Seismic reliability and cost evaluation for a hospital lifeline network system <i>K. Fuchida</i>	309
--	-----

Human life saving lifelines and cost-effective design of an exclusive water supply system for fires following earthquakes <i>S. Takada & Y. Kuwata</i>	319
--	-----

Section 9: Monitoring and testing

Shaking table tests on shallow foundations <i>J. Estaire & V. Cuéllar</i>	331
--	-----

Development of a digitally-controlled single-axis earthquake shake frame for masonry walls testing <i>M. J. Guzman & S. L. Lissel</i>	343
---	-----

Determination of seismic transport effects on buildings <i>D. Makovička & D. Makovička Jr.</i>	353
---	-----

Section 10: Retrofitting

Towards a European code for seismic assessment and strengthening of existing buildings <i>S. Dritsos</i>	365
--	-----

Flexural retrofitting of reinforced concrete bridge pier type cross-sections with carbon fiber reinforcing plastics <i>G. C. Manos & V. Kourtides</i>	375
---	-----

Evaluating the retrofitting process for Imam (Soltani) Mosque monument after Silakhor Plan earthquake damage (31 March 2006) <i>H. R. Vosoughifar</i>	387
---	-----

Effect of connection procedures on the behaviour of RC columns strengthened with RC layers and jackets <i>A. P. Lampropoulos, O. T. Tsioulou & S. E. Dritsos</i>	399
Seismic assessment of buildings by rapid visual screening procedures <i>P. Kapetana & S. Dritsos</i>	409

Section 11: Structural dynamics

Three-dimensional seismic damage simulation of wooden houses using a rigid body-spring method <i>H. Kawakami, E. A. Tingatinga & H. Y. Chang</i>	421
Controlling nonlinear vibrations in steel structures using an evolutionary gain formulation to optimally satisfy performance objectives <i>R. Dansby & T. Attard</i>	431
Dynamic analysis of plates stiffened by parallel beams <i>E. J. Sapountzakis & V. G. Mocos</i>	443
Dynamics in the practice of structural design: the problems of implementation <i>O. S. Saar</i>	453
Effect of impulsive force on earthquake response of rocking structural systems <i>T. Azuhata, T. Ishihara & M. Midorikawa</i>	459
Author Index	469