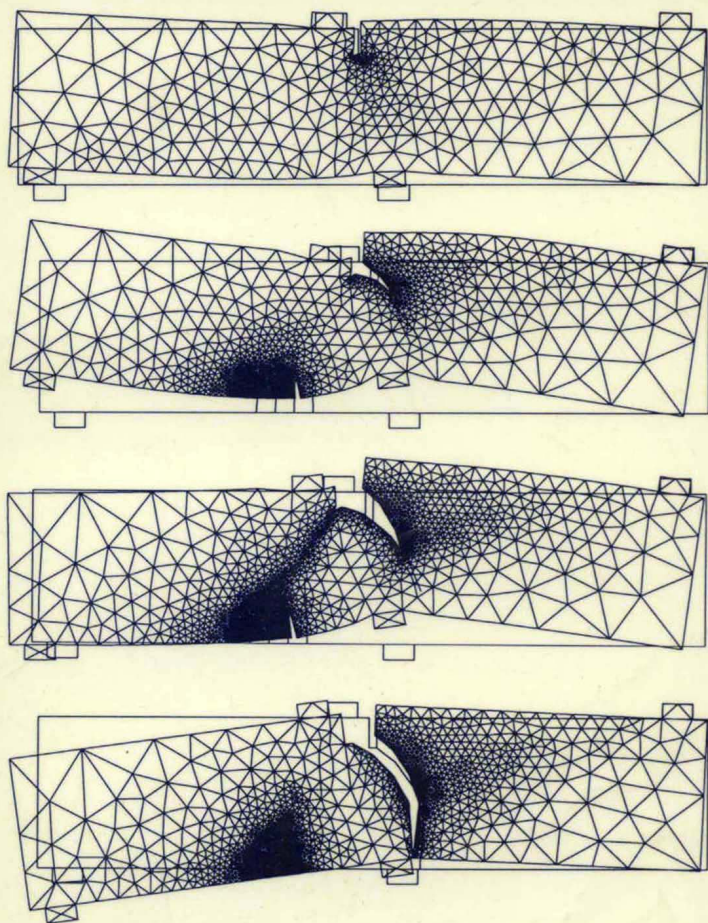


# ENGINEERING MECHANICS

PROCEEDINGS OF 10TH CONFERENCE

VOLUME 1



EDITED BY STEIN STURE

## ABSTRACT

This proceedings, *Engineering Mechanics: Proceedings of the 10th Conference*, contains papers presented at the Conference held in Boulder, Colorado, May 21 - 24, 1995. The purpose of the Conference was to examine current knowledge and recent advances in mechanics as applied to the various fields in civil engineering. With this in mind, papers covered diverse topics such as computational mechanics, dynamics, elasticity, experimental analysis and instrumentation, fluids, granular flows, inelastic behavior, probabilistic methods, and turbulence.

### Library of Congress Cataloging-in-Publication Data

Engineering mechanics: proceedings of the 10th conference: University of Colorado at Boulder, Boulder, Colorado, May 21-24, 1995 / sponsored by the Engineering Mechanics Division of the American Society of Civil Engineers and the Department of Civil, Environmental and Architectural Engineering of the University of Colorado at Boulder; co-sponsored by the Colorado Section, ASCE; edited by Stein Sture.

p. cm.

Proceedings of the 10th ASCE Engineering Mechanics Conference.

Includes index.

ISBN 0-7844-0083-0

1. Mechanics, Applied—Congresses. I. Stein, Sture. II. American Society of Civil Engineers. Engineering Mechanics Division. III. University of Colorado, Boulder. Dept. of Civil Environmental, and Architectural Engineering. IV. American Society of Civil Engineers. Colorado Section. V. ASCE Engineering Mechanics Conference. S. O. 1995. University of Colorado, Boulder) TA349.E45 1995 95-15185  
620.1—dc20 C4

The Society is not responsible for any statements made or opinions expressed in its publications.

Photocopies. Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by ASCE to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$2.00 per article plus \$.25 per page copied is paid directly to CCC, 222 Rosewood, Drive, Danvers, MA 01923. The identification for ASCE Books is 0-7844-0083-0/95 \$2.00 + \$.25. Requests for special permission or bulk copying should be addressed to Permissions & Copyright Dept., ASCE.

Copyright © 1995 by the American Society of Civil Engineers, All Rights Reserved.

Library of Congress Catalog Card No: 95-15188

ISBN 0-7844-0083-0

Manufactured in the United States of America.

## *PREFACE*

Welcome to the 10th ASCE Engineering Mechanics Conference, held at the University of Colorado at Boulder, May 21–24, 1995. The technical program is rich and diverse and comprises over 400 presentations including three keynote lectures. The topics covered in the 80 sessions reflect activities of the Technical Committees of the Engineering Mechanics Division and include Computational Mechanics, Dynamics, Elasticity, Experimental Analysis and Instrumentation, Fluids, Granular Flows, Inelastic Behavior, Probabilistic Methods, Properties of Materials, Stability and Turbulence.

The purpose of the Conference is to examine current knowledge and recent advances in mechanics as applied to the various fields of civil engineering. Engineering mechanics is about discovering and developing new knowledge, and applying it for the good of the public. Our activities address both existing problems and fundamental issues. We provide the basic knowledge for designing, construction, and management of the infrastructure. We are also involved in protection or restoration of the integrity of the natural and man-made environments. We are experts in dealing with complex analysis problems, and we are the authorities when it comes to reconciling conflicts involving the quantifiable. As a profession and as individuals we are aware of the many societal issues, which shape our work. Based on these factors, we might conclude that the field of mechanics is flourishing; there is a demand for our services; and the opportunities for research and funding are bountiful. Yet, to paraphrase Charles Dickens, “These are the worst of times and the best of times.” On one hand, current political realities have resulted in significantly diminished funding for research in mechanics, especially defense-oriented work. In the civilian sector we continuously read about down-sizing and reduction of traditional funding sources for fundamental as well as applied research. At the national level it is expected that the private sector somehow will provide support, especially in the form of industry-government-university collaboration, which is the current fashion in technology reinvestments and other programs. On the positive side, new initiatives are emerging, especially in the areas of materials, environmental mechanics, etc., which should cause excitement, especially for a young, enthusiastic and agile generation of mechanicians. The programs at recent mechanics conferences show richness and diversity in the profession, which demonstrates the vitality of our work. There is also hope, if we look at our fundamental mission to widen the knowledge base, and to extend technical concepts to new and innovative endeavors. This becomes apparent if we consider the rejuvenation of traditional fields such as mechanics and materials, and dynamics and controls, and interdisciplinary fields. In fact, the new emphasis by NSF on deterioration science, assessment technology, and renewal engineering are very much aligned with our current civil engineering research activities, although terminologies have changed and sound more inspired.

At the educational frontier we face an even more severe erosion of the role of engineering mechanics. Traditional values of quantitative analysis are challenged by superficial thinking in qualitative terms. Often it seems that we spoonfeed our students and grant credit for work that is no longer quantitative. Modern curricula seem to sidestep the rigors of traditional training in engineering mechanics in favor of virtual reality and glitzy topics. Concepts such as “teaching calculus on demand,” sound like

teaching swimming to a drowning person. There is a need to reaffirm the virtues and role of engineering mechanics in the educational process. In fact, our alumni in engineering practice tell us to emphasize the fundamentals in our curricula rather than applications, which our graduates will have ample opportunities to pursue in their practice, if they have a solid analysis background. Clearly, we need to emphasize to our students that virtual work is far more real than virtual reality.

Stein Sture  
Editor

Boulder, February, 1995

## FOREWORD

The Proceedings represent the effort of a large number of EMD Technical Committee Chairs, session organizers, and authors. The Organizing Committee acknowledges the significant contributions made by those involved. The support of headquarters staff in producing the Program and Proceedings, and the work of the Office of Conference Services staff at the University of Colorado at Boulder are gratefully acknowledged.

For this Conference over 440 abstracts were received in response to the initial Call for Papers. These were reviewed by the EMD Technical Committees, and 403 were accepted for compact-paper submission. Each of the papers included in the proceedings has been accepted for publication by the Proceedings Editor. All papers are eligible for discussion in the *Journal of Engineering Mechanics* and eligible for ASCE awards.

The following have been actively involved in formulating the program for the Conference:

Ronald C. Averill  
Marijan Babic  
R.E. Baddour  
Prasanta K. Banerjee  
Ever J. Barbero  
Zdenek P. Bazant  
J.L. Beck  
Jacobo Bielak  
Arthur Boresi  
A. Bossavit  
C.S. Chang  
C.-J. Chen  
H.-C. Chen  
W.F. Chen  
Rene Chevray  
Vincent H.H. Chu  
Allen T. Chwang  
Yannis F. Dafalias  
George Deodatis  
J. Finnie  
Dan M. Frangopol  
M. Garcia  
Roger Ghanem  
Mircea Grigoriu  
Leonard R. Herrmann  
Lawrence Jacobs  
Nicholas P. Jones  
J.W. Ju  
A. Kareem  
Leon M. Keer

James T. Kirby  
Raymond D. Krieg  
P.H.S.W. Kulatilake  
J.S. Lee  
Robert Y. Liang  
Eric Lui  
Loren D. Lutes  
Ramesh B. Malla  
E. Maragakis  
Sami F. Masri  
G.A. Maugin  
Jacky Mazars  
Leonard Meirovitch  
Daniel A. Mendelsohn  
Cesar Mendoza  
Gregory R. Miller  
Ronald Y.S. Pak  
Anthony Palazotto  
V. Panoskaltis  
A.S. Papageorgiou  
K.C. Park  
Ralph Peek  
Philip C. Perdikaris  
Gilles Pijaudier-Cabot  
Marek-Jerzy Pindera  
Raymond H. Plaut  
J.N. Reddy  
Mehdi Saiidi  
Stuart B. Savag  
Howard L. Schreyer

Surendra P. Shah  
P.S. Benson Shing  
Y. Shindo  
M.P. Singh  
Masanobu Shinozuka  
Pol D. Spanos  
B.F. Spencer  
Theodore Stathopoulos  
Tsung-Chow Su  
Srinivasan Sridharan

John L. Tassoulas  
T.R. Tauchert  
G.E. Tsiatis  
H.S. Tzou  
F.E. Udawadia  
George Z. Voyiadjis  
K.H. Wang  
Richard N. White  
Kaspar J. Willam

For any additional organizers or reviewers whose names were inadvertently omitted  
I extend my thanks to you as well.

Stein Sture  
Editor

Boulder, February, 19

## CONTENTS

### KEYNOTE LECTURES

<b>Advanced Cement-Based Composites</b>	
S.P. Shah .....	1
<b>Challenges in Computational Mechanics Applied to Offshore Engineering</b>	
P.G. Bergan .....	29
<b>Active and Hybrid Structural Response Control of Building Structure</b>	
T. Kobori .....	45

### SESSION 1-A

#### COMPUTATIONAL APPROACHES FOR COMPOSITE STRUCTURES—I

<b>Micromechanical Modeling of Damage and Inelasticity in Composite Materials in Macroscopic Structural Analysis</b>	
R.W. Macek, J.P. Gardner, and R.M. Hackett .....	58
<b>Random Vibration of Laminated Composite Plates with Shear Non-Linearity</b>	
R.S. Harichandran and M. Naja .....	62
<b>BEM for Scattering of Elastic Waves by Cracks in Laminated Plates</b>	
J. Zhu, A.H. Shah, and S.K. Datta .....	66
<b>Detecting Damage in Composite Structures via Finite Element Model Updating</b>	
F.M. Hemez and C. Farhat .....	70
<b>Compression Strength of Pultruded Fiber Reinforced Composites</b>	
J. Tomblin and E.J. Barbero .....	74

### SESSION 1-B

#### DYNAMIC SOIL-STRUCTURE INTERACTION—I

<b>Effect of Spatially Varying Ground Motion on Earth Dam Response</b>	
R.S. Harichandran and M.-T. Chen .....	78
<b>Dynamic Soil-Bridge Interaction</b>	
R. Betti .....	82
<b>Experimental Modeling of Pile Group in Clayey Soil</b>	
R.Y.S. Pak, B.B. Guzina, and F. Abedzadeh .....	86
<b>Consistent Infinitesimal Finite-Element Cell Method for Incompressible Unbounded Medium</b>	
J.P. Wolf and C. Song .....	90

## SESSION 1-C FRACTURE AND FAILURE OF ENGINEERING MATERIALS

<b>Thermal Effects Near Crack and Contact Area Edges</b>	
L.M. Brock .....	94
<b>Weight Functions for a Penny-Shaped Crack in a Transversely Isotropic Body: Closed Form Solutions</b>	
M.T. Hanson .....	*
<b>Simulation of Fracture of Masonry</b>	
A. Ghosh, A.M. Amde and J. Colville .....	98
<b>Critical Loading Rate for a Particulate Solid</b>	
D. Chandra .....	102

## SESSION 1-D NONMETALLIC REINFORCEMENT FOR CONCRETE STRUCTURES

<b>Evaluation of Kevlar Fabric Reinforcement for Masonry Walls</b>	
J. Gilstrap, C.W. Dolan and J.B. Christensen .....	106
<b>Engineering Properties of Composite Prestressing Tendons</b>	
J.J. Schemmel and E.F. O'Neil III .....	110
<b>Bond of FRP Rods Embedded in Concrete</b>	
T.E. Boothby, A. Nanni, C.E. Bakis, and H. Huang .....	114
<b>Laminated Composite Reinforcing for Concrete Structures</b>	
P. Petrina and R.N. White .....	118
<b>Tendon Relaxation in FRP Tendons</b>	
J. Currier, C.W. Dolan and E.F. O'Neil .....	122

## SESSION 1-E MODELING FOR MATERIALS WITH DISCONTINUITIES AND HETEROGENEITIES—I

<b>Prediction of Material Strength and Fracture of Brittle Materials Using the Sphinx Smooth Particle Hydrodynamics Code</b>	
D.A. Mandell, C.A. Wingate, and R.F. Stellingwerf .....	126
<b>Fracture Simulations of Brittle Heterogeneous Materials</b>	
E. Schlangen .....	130
<b>Strength and Stiffness Degradation of Concrete in Compression</b>	
Y.-H. Lee, K. Willam and D.M. Frangopol .....	134
<b>Further Developments on the Multicrack Model for Concrete</b>	
I. Carol and P.C. Prat .....	138
<b>A Concrete Material Model for DNYA3D</b>	
L.J. Malvar, J.E. Crawford, D.A. Simons, and J.W. Wesevich .....	142

## SESSION 1-F PROBABILISTIC METHODS IN WIND ENGINEERING

<b>Optimized Design of Transmission Lines in Hurricane Regions</b>	
P.J. Vickery, L.A. Twisdale and S.L. Wilson .....	147

---

\*Manuscript not available at time of printing.



<b>Wind Effects: A Non-Gaussian Perspective</b>	
K.R. Gurley, A. Kareem and M.A. Tognarelli .....	151
<b>Proper Orthogonal Decomposition Analysis of Wind Pressure on Low-rise Building</b>	
B. Bienkiewicz, S.-H. Jeong and H.-J. Ham .....	155
<b>Moment-Based Probability Models for Wind Engineering Applications</b>	
S.R. Winterstein and C.H. Lange .....	159

## SESSION 1-G UNCERTAINTY EVALUATION IN GEO-ENGINEERING—I

<b>Probabilistic Assessment of Footing Immediate Settlement: Geotechnical Uncertainty vs. Model Sophistication</b>	
P.L. Bourdeau and A. Ashmawy .....	163
<b>Application of Advanced Probabilistic Methods to Underground Tunnel Analysis</b>	
B.H. Thacker .....	167
<b>A Comparison of Pile Design Methods Using Model Factors</b>	
K.E. Tuomi and M.J.S. Roth .....	171
<b>Probabilistic Site Characterization Strategy for Natural Variability Assessment of Rock Mass Properties</b>	
Hang Gao and Kunsoo Kim .....	175
<b>On Characterization of Self-Affine Fractal Profiles</b>	
A. Ghosh and S.-M. Hsiung .....	179

## SESSION 1-H DYNAMIC INSTABILITY OF STRUCTURES

<b>Sensitivity of Unilateral Buckling</b>	
P. Vielsack .....	183
<b>Flutter and Divergence Instability of Nonconservative Plates</b>	
Q. Zuo and H.L. Schreyer .....	187
<b>Dynamic Instability of Viscoelastic Plates Subjected to Randomly Varying In-Plane Loads</b>	
S. Subramanian .....	191
<b>Overturning of a Rigid Block Under Horizontal Base Excitation</b>	
W.T. Fielder, L.N. Virgin and R.H. Plaut .....	195
<b>Dynamic Buckling and Post-Buckling of Stressed Composite Arches</b>	
A. Mirmiran .....	199

## SESSION 1-I TURBULENT JETS AND PLUMES

<b>Turbulent Thermals and Plumes in Rotating Fluids</b>	
C.Y. Ching and H.J.S. Fernando .....	203
<b>A Global Ocean 3-D Plume Dispersion Model</b>	
G.R. Stegan and R.K. Dewey .....	207
<b>Analysis of a Natural Convection Loop which Includes Reservoirs</b>	
J.C. Fuentes and W.D. Baines .....	211
<b>A Length-Scale Model for the Merging of Jets in a Coflow</b>	
M.J. Davidson, Y. Wang and K.L. Pun .....	215

<b>Modelling the Effect of Vertical Flow-Developer on Ice Cover</b>	
M.A. Helsten, P.F. Hamblin and R.E. Baddour .....	219

## SESSION 1-J

### DAMAGE MECHANICS IN ENGINEERING MATERIALS—I

<b>On the Constitutive and Damage Modelling of Composite Systems</b>	
J.L. Chaboche, P.M. Lesne and J.F. Maire .....	223
<b>Experimental Investigation of Crack Interaction and Coalescence</b>	
H. Deng, J.W. Ju and M.E. Fournery .....	227
<b>From Damage to Fracture Mechanics and Conversely—A Combined Approach</b>	
J. Mazars and G. Pýaudier-Cabot .....	231
<b>Residual Effects in Continuum Damage of Ceramics at Fatigue</b>	
J. Najjar and H.-J. Klumpp .....	235

## SESSION 2-A

### COMPUTATIONAL APPROACHES FOR COMPOSITE STRUCTURES—II

<b>A Note on the Free Vibration Analysis of Anisotropic Cantilever Beams</b>	
H. Murakami, E. Reissner, and J. Yamakawa .....	241
<b>3-D Singular Stress Fields in Anisotropic Materials with Complex Orders of Singularity</b>	
S.S. Pageau and S.B. Biggers .....	245
<b>Computational Issues Associated with Hyper-Anisotropic Media</b>	
V.N. Kaliakin and P. Šimáček .....	249
<b>Toward Overlay-elements for the 3-D Analysis of Wear Composites</b>	
N. Gebbeken .....	253
<b>Stiffness Matrix Formulation for Anisotropic Beams</b>	
A.M. Badir .....	257

## SESSION 2-B

### DYNAMIC SOIL-STRUCTURE INTERACTION—II

<b>Validational Issues for SSI Codes</b>	
A.J. Philippacopoulos and N. Simos .....	261
<b>An Application of System ID in Dynamic Modeling</b>	
E.J. Stauffer, H. Law, R.Y.S. Pak, and H.-Y. Ko .....	265
<b>SSI: Modal Synthesis for Structures with Kinematic Constraints</b>	
E. Kausel .....	269
<b>Centrifuge Modeling of Cantilever Retaining Wall Subjected to Seismic Loads</b>	
M.M. Dewoolkar, A.T. Stadler, H.Y. Ko, and R.Y.S. Pak .....	273

## SESSION 2-C

### MECHANICS OF NONLINEAR AND HETEROGENEOUS SYSTEMS

<b>Ladder Models for the Constitutive Behavior of Heterogeneous Materials</b>	
G. Losi .....	277

<b>Finite Element and Simplified Methods for Analysis of Thin-Walled Composite Open Sections</b>	
B. Omidvar and A. Ghorbanpoor .....	281
<b>Coupled Force Density-Direct Stiffness for Cable-Beam Systems</b>	
M.I. Hoit and P.M. Christou and R.A. Cook .....	285
<b>Analysis of Cable Nets for Boulder Impact</b>	
G. Hearn and L. Akkaraju .....	289

## SESSION 2-D

### NOVEL EXPERIMENTAL TECHNIQUES FOR THE EVALUATION OF WIND EFFECTS ON STRUCTURES

<b>Infrared Thermography for the Evaluation of Wind Regime around Buildings</b>	
H. Wu and T. Stathopoulos .....	293
<b>The University of Notre Dame Atmospheric Wind Tunnel</b>	
F.L. Haan, A. Kareem and A. Szewczyk .....	297
<b>Wind Simulation for Wind Effects on Low Structures</b>	
J.E. Cermak and L.S. Cochran .....	301
<b>System Identification using Output Measurements</b>	
T. Shi, N.P. Jones and J.H. Ellis .....	305

## SESSION 2-E

### MODELING FOR MATERIALS WITH DISCONTINUITIES AND HETEROGENEITIES—II

<b>A Stochastic Approach with Moving Jump Conditions for Localization</b>	
Z. Chen .....	309
<b>Homogenization Techniques for Modelling of Randomly Packed Granules</b>	
L. Ma and C.S. Chang .....	313
<b>Size Effect Determination of Macrofracture Characteristics of Random Heterogeneous Material</b>	
Z.P. Bazant and M. Jirásek .....	317
<b>Effective Elastoplastic Behavior of Two-Phase Ductile Matrix Composites: Micromechanics and Computational Aspects</b>	
J.W. Ju and K.H. Tseng .....	321
<b>Solidification Theory and Mechanisms of Aging Creep of Concrete</b>	
Z.P. Bazant, Y. Xi and S. Baweja .....	1372

## SESSION 2-F

### ENVIRONMENTAL PROBABILISTIC ENGINEERING

<b>Probabilistic Analysis of Reinforced Soil Slopes</b>	
W.A. Kitch, S.G. Wright and R.B. Gilbert .....	325
<b>Stochastic Finite Element Analysis of Coupled Flow Problems</b>	
R. Ghanem .....	329

<b>Stochastic Characterization of Natural Variability of Mechanical Properties of Rocks</b>	
K. Kim and H. Gao .....	*
<b>First-Order Reliability Analysis of Wood Structural Systems</b>	
W.M. Bulleit and W. Liu .....	333

## SESSION 2-G UNCERTAINTY EVALUATION IN GEO-ENGINEERING—II

<b>Study of Effect of Joint Geometry Parameters on the Permeability of Jointed Rock</b>	
B. Panda and P.H.S.W. Kulatilake .....	337
<b>Flow Through Earth Dams with Spatially Random Permeability</b>	
G.A. Fenton and D.V. Griffiths .....	341
<b>Reliability Assessment of Underground Shaft Closure</b>	
A.F. Fossum and D.E. Munson .....	345
<b>Keyblock Sizes and Tunnel Rock Loads</b>	
M. Mauldon and Ming Zhao .....	349

## SESSION 2-H NONCLASSICAL PROBLEMS IN STABILITY OF STRUCTURES

<b>Dynamic Stability Analysis of a Bridge Pier</b>	
T. Münz and K. Willam .....	353
<b>Buckling of Underground Pipes with Soil Interaction</b>	
G. Lin .....	357
<b>Stability of Structures with Constraints in Displacements</b>	
L.A. Godoy and A.E. Mirasso .....	361
<b>A Finite Element Approach to the Buckling Behavior of Helical Soil Piers</b>	
B. Gunnick, S. Gammon, M. Barker and R. Berry .....	365

## SESSION 2-I MODELING OF TURBULENCE

<b>Simulation of the Flow Field at an Interconnected Riverine System</b>	
K.-H. Wang and T.G. Cleveland .....	369
<b>Application of Turbulence Theory to a Laboratory Surf Zone</b>	
N.J. Sultan and F.C.K. Ting .....	373
<b>Unsteady RANS Simulation of Viscous Nonlinear Free Surface Flows</b>	
H.-C. Chen .....	377
<b>Computation of Shallow Recirculating Flow</b>	
S. Babarutsi, M. Nassiri and V.H. Chu .....	381

---

\*Manuscript not available at time of printing.

## SESSION 2-J DAMAGE MECHANICS IN ENGINEERING MATERIALS—II

<b>Damage Evolution in Metal Matrix Composites Subjected to Thermomechanical Fatigue</b>	
D.H. Allen, K.L.E. Helms and L.D. Hurtado .....	385
<b>Finite Element Implementation of the Overall Approach to Damage in Metal Matrix Composites</b>	
G.Z. Voyiadjis and A.R. Venson .....	389
<b>CDM Analysis of Creep Rupture of Weldments</b>	
D.R. Hayhurst and I.J. Perrin .....	393
<b>Damage Models for Masonry Structures</b>	
E. Papa .....	397

## SESSION 3-A COMPOSITE MATERIALS FOR CIVIL STRUCTURES

<b>Optimum Design Considerations for Composite Bridges</b>	
M.R. Dunham, F.W. Barton, C.A. Orozco and T.T. Baber .....	401
<b>Design of FRP Shapes for Civil Structures</b>	
H.A. Salim, J.F. Davalos, E.J. Barbero, R. Lopez-Anido, and P. Qiao .....	405
<b>Finite Element and Simplified Methods for Analysis of Thin-walled Composite Open Sections</b>	
B. Omidvar and A. Ghorbanpoor .....	*

## SESSION 3-B NUMERICAL METHODS IN ELASTODYNAMICS

<b>Simulating Long Period Ground Motions in Three-Dimensional Basins Using a Staggered-Grid Finite-Difference Approach</b>	
R.W. Graves .....	409
<b>The Indirect Boundary Element Method for Dynamic Elasticity</b>	
F.J. Sánchez-Sesma .....	413
<b>A Hybrid Numerical Technique, Combining the Finite Element and Boundary Element Methods, for Modeling Elastodynamic Scattering Problems</b>	
B. Zhang, A.S. Papageorgiou and J.L. Tassoulas .....	417

## SESSION 3-C RECENT DEVELOPMENTS IN ELECTROMAGNETO-MECHANICS—I: THEORY AND APPLICATION

<b>Piezoelectric Sensors and Resonators in Quartz</b>	
J. Söderkvist .....	421
<b>A Quadruple Theory of Thermoelastic Dielectrics</b>	
V.K. Kalpakidis and C.V. Massalas .....	
<b>Saint-Venant's Principle for Linear Piezoelectric Porous Materials</b>	
R.C. Batra and J.S. Yang .....	425

---

\*Manuscript not available at time of printing.

<b>Magnetoelastic Instability of Superconducting Partial Torus</b>	
X.J. Zheng and J.S. Lee .....	429
<b>Configurational Forces and Coherent Phase Transition Fronts in Thermo-electro-elastic Solids</b>	
G.A. Maugin and C. Trimarco .....	433

### SESSION 3-D EMERGING METHODS OF NONDESTRUCTIVE EVALUATION

<b>Analysis of Acoustic Surface Waveguides for Nondestructive Evaluation of Concrete Structures</b>	
R.H.L. Chen and Y. He .....	437
<b>Ultrasonic Testing of Mild Steel in Uniaxial Tension</b>	
Z. Radakovic, K. Willam and L. Bond .....	441
<b>Investigation of Scattering Losses in Concrete Using Laser Ultrasonics</b>	
L.J. Jacobs and D.A. Bruttomesso .....	445
<b>High Speed NDT of Concrete Using Impact Echo Scanning</b>	
L.D. Olson and Dennis A. Sack .....	449

### SESSION 3-E

<b>Finite Element Procedures for Early-Age Concrete Considering Environmental Effects</b>	
R.Y. Liang and Y.-Z. Niu .....	453
<b>A Cohesive Zone Model for Cracks Terminating at a Bimaterial Interface</b>	
A. Romeo and R. Ballarini .....	457
<b>Force-Deformation Relationships for Rough Interfaces</b>	
A. Misra and X. Chen .....	461
<b>A Fundamental Study on the Discontinuities and Heterogeneities of Asphalt Concrete</b>	
J.N. Meegoda and K.G. Chang .....	465
<b>Fractal Dimension of Granular Materials and Their Engineering Properties</b>	
L.E. Vallejo and Y. Zhou .....	469
<b>Nonlocal Plasticity Model for Boundary Element Analysis</b>	
F.-B. Lin and G. Yan .....	473

### SESSION 3-F PROBABILISTIC METHODS IN EARTHQUAKE ENGINEERING

<b>Effects of Laterally Nonhomogeneous Medium on Earthquake Motion</b>	
R. Zhang, L. Zhang and M. Shinozuka .....	477

### SESSION 3-G RECENT DEVELOPMENTS IN DISCRETE ELEMENT METHODS

<b>Discrete Element Analysis of Clays</b>	
J. Chen, A. Anandarajah and N. Lu .....	481

<b>Evaluation of Numerical Integration Methods in Discrete Element Analysis</b>	
K. Achempong and C.S. Chang .....	485
<b>Experimental Study of Micro-Element for Concrete</b>	
T.-T. Ng and J. Kong .....	489
<b>Dynamic Wave Propagation in Particulate Materials with Different Particle Shapes Using A Discrete Element Method</b>	
J.R. Williams, H. Rege, R. O'Connor, and K. Amaratunga .....	493
<b>Micromechanics of Continuum Models for Granular Materials</b>	
R.I. Borja and J.R. Wren .....	497

### SESSION 3-H STABILITY OF PERIODIC STRUCTURES

<b>Analysis of Biaxial Strength of Fiberboard</b>	
M.W. Johnson, Jr. ....	501
<b>A Transfer Matrix-Perturbation Approach to the Buckling Analysis of Nonlinear Periodic Structures</b>	
A. Luongo .....	505
<b>An Analysis of Stiffened Cylindrical Shells under Interactive Buckling</b>	
S. Sridharan .....	509

### SESSION 3-I TEACHING TURBULENCE

<b>Teaching Turbulence in Graduate Engineering Course</b>	
C.-J. Chen .....	513
<b>Teaching Turbulence in a Graduate CFD Course</b>	
H.-C. Chen .....	517
<b>Application of Video Imaging Processing in the Study of Environmental Flows</b>	
J.H.-W. Lee .....	

### SESSION 3-J DAMAGE MECHANICS IN ENGINEERING MATERIALS—III

<b>Current Issues in Elastic Degradation and Damage</b>	
I. Carol, K. Willam and E. Rizzi .....	521
<b>Elastoplastic Bifurcation in Cosserat Continua</b>	
M.-M. Iordache and K. Willam .....	525
<b>Constitutive Singularities of Combined Elastic Degradation and Plasticity</b>	
E. Rizzi and K. Willam .....	529

### SESSION 4-A NEW DEVELOPMENTS IN PLATE AND SHELL FINITE ELEMENTS

<b>Laminated Composite and Sandwich Shell Analysis via Efficient Transverse Shear/Normal Deformation Shell Element</b>	
A. Tessler .....	533

<b>Nonlinear Analysis of Laminated Composite Structures Using a Layerwise Theory</b>	
R. Zinno and E.J. Barbero .....	537
<b>Efficient <math>C^0</math> Finite Elements Based on Modified High-order Zig-zag Laminate Theories</b>	
R.C. Averill and Y.C. Yip .....	541

#### SESSION 4-B DYNAMIC FLUID-STRUCTURE INTERACTION

<b>Wind-Tunnel Experiments to Study the Galloping Vibrations of Traffic Signal Light Structures</b>	
N. Pulipaka, J.R. McDonald and P.P. Sarkar .....	545
<b>Collision of Cylinders in Random Seas</b>	
J.M. Niedzwecki and O.J. Rijken .....	549
<b>Pressures on a Flat Roof-Application of Quasi-Steady Theory</b>	
H.W. Tieleman and M.R. Hajj .....	557
<b>Developments in Long-Span Bridge Aerodynamics</b>	
A. Jain, N.P. Jones and R.H. Scanlan .....	561
<b>Scattering of Waves by Submerged Shell with Oscillator: Tail Wags Dog</b>	
E. Kausel .....	565

#### SESSION 4-C RECENT DEVELOPMENTS IN ELECTROMAGNETO-MECHANICS—II: FRACTURE AND WAVES

<b>Some Problems of Electroelastic Fracture</b>	
C. Dascalu and G.A. Maugin .....	569
<b>Electro-Mechanical Constitutive Behavior of Various Compositions of PZT: I. Experiment</b>	
C.S. Lynch .....	573
<b>Diffraction of an Antiplane Shear Wave by a Finite Crack in an Orthotropic Piezoelectric Ceramic</b>	
Y. Shindo and F. Narita .....	577
<b>Quasi Buckling Generated by Transverse Loads</b>	
J. Söderkvist .....	581

#### SESSION 4-D EXPERIMENTAL STUDIES ON BRIDGES

<b>Measured and Predicted Stress Histories in Bridge Girders due to Vehicular Loading</b>	
L.-Y. Lai .....	585
<b>Experiments on Stressed Beams for Timber Bridges</b>	
R. Hussein .....	589
<b>Experimental Evaluation of Wheel Load Distribution on Steel I-Girder Bridges</b>	
K.M. Tarhini .....	593
<b>Acoustic Emission Source Location Based on Lamb Waves</b>	
A.K. Maji and D. Satpathi .....	597



<b>Fatigue Study of R/C Highway Bridge Decks Using Physical Models</b>	
M.F. Petrou and P.C. Perdikaris .....	601

## SESSION 4-E MECHANICS OF GRANULAR MATERIALS—I

<b>Direct Observation of Deformation of Granular Materials Through X-ray Photographs</b>	
S. Nemat-Nasser and N. Okada .....	605
<b>Kinematics of 2-D Particulate Media Utilizing Image Analysis</b>	
S.G. Paikowsky and F. Xi .....	609
<b>Image Analysis of Fine-Grain Granular Flow: Conditions for High Quality Measurement Results</b>	
L. Gustafsson and O. Marklund .....	614
<b>Equilibrium in a 2-Dimensional Granular Flow</b>	
F. Cantelaube-Lebec, Y. Limon-Duparcmeur, D. Bideau, and J.P. Troadec .....	618
<b>Granular Materials as Multibody Systems with Variable Topology</b>	
O. Vinogradov .....	622

## SESSION 4-F STOCHASTIC MECHANICS

<b>Application of the Monte Carlo Method in Statistical Fracture Mechanics</b>	
A. Chudnovsky and M. Gorelik .....	626
<b>Micromechanically Based Stochastic Finite Elements</b>	
M. Ostoja-Starzewski .....	630
<b>On Evaluation of Certain Fracture Parameters</b>	
B.I. Kunin .....	631
<b>Random Vibration Analysis of Dynamic Systems with Frequency Dependent Parameters or Fractional Derivatives</b>	
P.D. Spanos and B.A. Zeldin .....	635
<b>On the Effective Elastic Moduli of Granular Materials</b>	
K. Alzebedeh and M. Ostoja-Starzewski .....	639

## SESSION 4-G COMPUTATIONAL MODELS FOR CONCRETE AND REINFORCED CONCRETE—I

<b>A Constitutive Model for Reinforced Concrete Based on Stress Decomposition</b>	
P.H. Feenstra and R. de Borst .....	643
<b>A Model for Bond Between Steel Bars and Concrete</b>	
J.V. Cox and L.R. Herrmann .....	647
<b>Rate Dependent Elastic-Viscoplastic Formulation for Computational Failure Simulations in Concrete</b>	
G. Etse and K. Willam .....	651
<b>Tension Stiffening Effect in Smeared Crack Model</b>	
V. Cervenka and J. Margoldova .....	655