STRUCTURES CONGRESS '91
COMPACT PAPERS

Ninth Structures Congress
Indianapolis, Indiana
April 29 - May 1, 1991

Thomas G. Williamson, Congress Steering Committee Chairman

Sponsored by the Structural Division of the
American Society of Civil Engineers

Hosted by the
Metropolitan-Indianapolis Branch and
Indiana Section of ASCE

Participating ASCE Divisions:
Aerospace
Engineering Mechanics
Materials Engineering

Cooperating Organizations:
American Concrete Institute
American Institute of Steel Construction
American Institute of Timber Construction
Wind Engineering Research Council

This volume available only to Congress registrants

Produced by the American Society of Civil Engineers
345 East 47th Street
New York, NY 10017-2398
CONTENTS

Note: Sessions listed are not necessarily in order of presentation

Plenary Sessions

Research and Technology for Structural Engineering Productivity
Richard Wright ......................................................... 1

Needs and Opportunities in Computer-Aided Structural Engineering
Steven J. Fenves ....................................................... 8

Technical Sessions

M-1 Seismic Behavior of Buildings as Related to the Loma Prieta Earthquake

Performance of Engineered Buildings
John G. Shipp and Tom K. Chan ...................................... 16

Wood Building Performance in the Loma Prieta Earthquake
Stephen K. Harris, Tom Larsen, and Charles Scawthorn ............ 20

Recorded Responses of Two Tall Buildings During the Loma Prieta Earthquake
M. Celebi and E. Safak .................................................. 25

Seismic Behavior of Unreinforced Masonry Buildings Shaken by the Loma Prieta Earthquake
John Kariotis ................................................................. 30

Strengthening of Cripple Walls in Traditional Houses
Robin Shepherd ........................................................... 34

M-9 Active and Passive Control of Structures

Coupled Passive Control of Tall Buildings
L.A. Bergman, J. Tzioufas, D.M. McFarland and A. Kareem ........... 38

Towards a Computational Environment for Smart Structures
S.S. Chen ................................................................. 42

Cladding-Frame Connections of a Steel Building System
J.M. Cohen ................................................................. 46

Innovative Design of Energy Absorbing Tall Buildings Using Interchangeable Precast Elements
M.B. Wechsler .............................................................. 48


New Dimension Lumber Design Values Based on Full-Size Lumber Tests
Kevin C.K. Cheung and Don E. Wallace ................................ 52

Biaxial Beam-Column Equation for Wood Members
John J. Zahn ............................................................... 56
| M-15 New Concepts in Transmission Line Structure Assessment and Design II |
|-----------------------------|-------------------------|
| Integrating Testing into Transmission Tower Design | Donald D. Cannon, Jr. and Robert E. Nickerson 199 |
| Tower Member Strength: Results of TLMRC Testing | Robert E. Nickerson and Donald D. Cannon, Jr. 203 |
| Development of Reliability Classes for the Upgrading of Existing Towers | Michel Bruneau, Mohammed H. Magued and Robert B. Dryburgh 207 |

<table>
<thead>
<tr>
<th>M-16 Damage Risk in Design of Seismic Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ductility and Strength Demands for Seismic Design</td>
</tr>
<tr>
<td>Seismic Performance of RC Special Versus Intermediate Moment Frame Structures</td>
</tr>
<tr>
<td>Seismic Capacity Enhancement of R/C Frames by Means of Damage Control Design</td>
</tr>
<tr>
<td>Effects of Model Uncertainty of Seismic Response and Reliability of Structural Systems</td>
</tr>
<tr>
<td>Design of R/C Columns for Damage Control</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M-17 Load and Resistance Factor Design for Wood Construction II—Structural Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Reliability of Wood Panel Products</td>
</tr>
<tr>
<td>Reliability-Based Design of Wood Structural Systems</td>
</tr>
<tr>
<td>Reliability of Timber Structural Systems Under Combined Loading</td>
</tr>
<tr>
<td>LRFD Concepts for Wood Systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M-18 Outstanding Issues in the Prediction of Long-Span Bridge Response to Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent Topics of Wind Effects on Long Span Bridges</td>
</tr>
<tr>
<td>Wind Effects on Cable Stayed Bridges During Erection</td>
</tr>
<tr>
<td>Wind Tunnel Testing and Wind Load Prediction</td>
</tr>
<tr>
<td>Wind Effects on a Long Span Suspension Bridge</td>
</tr>
<tr>
<td>Long-Span Bridges in Wind: Unresolved Issues</td>
</tr>
</tbody>
</table>

| Wind Effects on Long-Span Bridges: Outstanding Issues | A.G. Davenport and J.P.C. King |
|-----------------------------------------------------|

<table>
<thead>
<tr>
<th>T-10 Seismic Behavior of Steel Structures with Semi-Rigid Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Behavior of Flexible, Semi-Rigid and Rigid Steel Frames</td>
</tr>
<tr>
<td>A Comparative Study of the Seismic Performance of Steel Structures with Semi-Rigid Joints</td>
</tr>
<tr>
<td>Earthquake Safety of Flexibly-Connected Steel Frames</td>
</tr>
<tr>
<td>Effect of PZ Flexibility on Seismic Response of Steel MRF</td>
</tr>
<tr>
<td>EBF’s with PR Flexible Link-Column Connection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M-6 Response of Structural Materials at High Rates of Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression and Tensile Strength Analysis of Concrete at High Strain Rates</td>
</tr>
<tr>
<td>Dynamic Hardness Testing of Polycrystalline MgO</td>
</tr>
<tr>
<td>Centrifugal Modeling of Deeply-Buried Structure Response to Blast Loading</td>
</tr>
<tr>
<td>Identification of Wall Concepts to Prevent Sympathetic Detonation in HPMSM</td>
</tr>
<tr>
<td>Dynamic Failure of Brittle Rods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T-1 Wind-Induced Response of Tall Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank One Center, Indianapolis—A Case History</td>
</tr>
<tr>
<td>Wind Response of a Structurally Linked High Rise Tower</td>
</tr>
<tr>
<td>NCNB Tower, Charlotte—A Case History</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T-2 Inspection, Evaluation and Maintenance of Steel Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing and Retrofit of Cracked Welded Steel Girders</td>
</tr>
<tr>
<td>A Program to Define and Evaluate Fracture Critical Bridge Members</td>
</tr>
<tr>
<td>An Expert System for Fatigue Inspection and Rehabilitation of Steel Bridges</td>
</tr>
</tbody>
</table>

*Manuscript not available at time of printing.*
Fatigue Cracking in Highway Sign Anchor Rods
John W. Fisher, Eric J. Kaufmann and James D. Culp ........................................ 319

T-3 Design of Wood Structures

Wood Structures—Hurricane Hugo Experience
Charles C. Hoover, Jr. .......................................................... 323
Wood Structures: Loma Prieta Earthquake Experience
L. Scott Turner, Frank Stewart and Kevin C.K. Cheung .................. 327
Design of Wood Structures: LRFD and ASD
David S. Gromala and Kevin C.K. Cheung ........................................ 331

T-4 Design, Testing and Performance of Cladding
and Curtainwall Systems

Design of Architectural Glazing for Tall Buildings
John Zils ........................................................................ 335
Architectural Glazing Products in the Curtain Wall System
James A. Rockar .................................................................. 339
Experimental Evaluation of Architectural Glazing Products for Tall Buildings
Chris P. Pantelides, Amy D. Horst and Joseph E. Minor ................. 350
Resistance of Architectural Glazing to Small Bomb Blasts
H. Scott Norville, Paul M. Bove and Ronald J. Massa ...................... 354

T-5 Fracture Mechanics Applications in Design

An Analytical Model for Rupture Strength of Concrete Beams
Yuan N. Li, and Robert Y. Liang .............................................. 358
Failure Prediction of Thin Beryllium Structures
Edward Mascorro, Paul N. Roschke and Photios Papados .................. 362
Fracture Mechanics Size Effect in Concrete Structures
Zdenek P. Bazant ................................................................ 366

T-6 Recent Advances in Earthquake Engineering

Cyclic Behavior of R/C Core Walls
Sharon L. Wood, Chadchart Sittipunt and William R. Lackner ........... 366
Full-Scale Implementation of Active Structural Control
T. T. Soong and A.M. Reinhorn ............................................. 370
Nonlinear Analysis of Concrete Dams
John F. Hall .......................................................................... 374
The Hybrid Frequency-Time Domain Procedure for Nonlinear Analysis
Gregory L. Fenves and Juan W. Chavez ..................................... 378
Tests on Large Scale Steel Moment Connections
Michael D. Engelhardt and Aburnasr Husain .......................... 382

T-7 Joints and Connections in FRP Composite Structural Systems

A Study of Structural Plastic Connections
Robert B. Austin, Wen S. Chan and Robert L. Yuan .............................. 386
Performance of Pultruded FRP Beam-to-Column Connections
Lawrence C. Bank and Ayman S. Mosallam .................................. 389
FRP Connectors: Axial Resistance vs. Transverse Pressure
James R. Doyle and Hota GangaRao ......................................... 393
Connection Design in Concrete Structures Reinforced with Fiber Reinforced
Plastic (FRP) Grids
Charles H. Goodspeed, Todd Gross, Robert Henry, Edwin R. Schmeckpeoper,
Joseph R. Yost and Mingfu Zhang ........................................ 397

T-9 The Dame Point Bridge

Planning and Management of the Dame Point Bridge
Larry Wehner ....................................................................... 397
Design of the Dame Point Bridge
Gerard F. Fox ........................................................................ 401
Construction Engineering of the Dame Point Bridge
Man-Chung Tang ....................................................................... 405
Bar Cables of Dame Point Bridge
Khaled Shawwaf ....................................................................... 409
Construction of the Dame Point Bridge
Steven Kaspar ......................................................................... 413

M-19 Connections for Metal Structures

The Design of Shear Tabs with Tubular Columns
Donald R. Sherman and Joseph M. Ales, Jr. .................................... 417
Results of Block Shear Tests for Angles in Tension
Howard I. Epstein .................................................................. 422
ATLSS Connections: Concept, Development and Study
Robert B. Fleischman, Le-Wu Lu, and B. Vincent Viscomi .................. 426
Analysis and Tests of Bolted Bracing Connections
Aldis Sigsudottir and Kurt H. Gerstle ........................................ 430

T-11 Analysis Techniques for Masonry Structures—An Update

An In-Plane Model for Masonry Subjected to High Stress Gradients
A.W. Page and S. Ali ................................................................ 434
Constitutive Modelling of Masonry Materials
Robert G. Drysdale and Ping Guo ............................................. 438
Nonlinear Analysis of Reinforced Concrete Masonry Structures Subjected to
Lateral Loads
Frieder Seible, Gregory R. Kinglsey and Albert Kürkchübasche .......... 442
Analysis of Concentrated Loads on Hollow Masonry
A.W. Page and N.G. Shrive ...................................................... 446

*Manuscript not available at time of printing.
Three Dimensional Failure Analysis of Composite Masonry Walls Subjected to Vertical and Horizontal Loads
Subhash C. Anand and Kishore K. Yalamanchili ........................................ 450

T-20 Panel Discussion on Building Motion and Its Mitigation

T-13 Fatigue and Fracture on Non-Metallic Materials
Fatigue Behavior of Composite Bridge Decks
Joseph M. Plecnik, Vijay S. Kopparam and O. Henriquez .................................. 454
Size Effect in Fatigue Fracture
Zdenek P. Bazant and Kangming Xu ................................................................. 458
Resistance to Fracture and Fatigue in Multi-Phase Materials Mesomechanics Approach
Michael P. Wnuk ......................................................................................... 462
Crack Growth Resistance of Strain-Softening Materials Under Flexural Loading
Tze-jer Chuang ......................................................................................... 466

T-19 Development of AASHTO LRFD Bridge Design Code
Overview and Live Load Considerations
John M. Kulicki and Dennis R. Mertz ............................................................... 470
New Aspects for the Design of Steel Bridges
Frank Sears .................................................................................................. 474
Design Provisions for Concrete Bridges
Robert C. Cassano ...................................................................................... 478
LRFD Provisions for Wood Bridges
Michael A. Ritter and Thomas G. Williamson .................................................. 482
Seismic Design Provisions of New LRFD Code
James E. Roberts and James H. Gates .............................................................. 486

T-15 Inelastic Analysis in Frame Design—Theory and Analysis
Moment Magnification Factor for Inelastic Frame
Eric M. Lui ................................................................................................. 490
On K-Factors for Beam-Column Design in Steel Frameworks
J.Y. Richard Liew, D.W. White and W.F. Chen ................................................ 494
Inelastic Amplification Factor for Beam-Columns
I.S. Sohal and N.A. Syed .............................................................................. 498
A Concentrated Plasticity Approach to Inelastic Design
Gregory G. Deierlein and William McGuire ................................................ 821

T-17 New Ideas and Concepts in Cable Suspended Bridges
Cable-Suspended Bridges with Spatial Cable Systems
Niels J. Gimsing .......................................................................................... 502
Long-Span Cable-Stayed Bridge with Longitudinally Elastic Supports
Manabu Ito, Shuichi Suzuki, Takeo Endo and Nobuhiko Takagi .................. 506
Seismic Responses of Cable-Stayed Bridges
Man-Chung Tang ....................................................................................... 510

Cable-Stayed Floating Bridges
Jörg Schlaich and Rudolf Bergherrmann .......................................................... 512

T-18 Probabilistic Fatigue Life Prediction Methods
Application of Field Data to Fatigue Life Evaluation
Jamshid Mohammadi .................................................................................. 516
Non-Normality Considerations in Stochastic Fatigue Life Prediction
S. Sarkani, D.P. Kihl and J.E. Beach ................................................................. 520
Probabilistic Fatigue Analysis and Design: An Overview
Paul H. Wirsching, T.Y. Torng, W. Scott Martin ........................................... 524
Computational Methods for Probabilistic Flaw Propagation Analyses
S. Sutharshana, N. Moore, M. Grigoriu and E. Fox ........................................ 528

T-14 New Timber Bridge Technology
Implementation of Timber Bridge Systems in West Virginia
Barry Dickson .............................................................................................. 532
Bridge Applications for Sawn Lumber Treated with Waterborne Preservatives
Ken Long ..................................................................................................... 536
Crashworthy Railing Systems for Timber Bridge Decks
Michael Ritter, Edward Post and Ronald Faller ............................................. 540

T-22 Performance of Structures in the 90's
Unexpected Performance of Structures
O.C. Gueldelhoefer ........................................................................................ 544
Performance of Deteriorated, Damaged, and Repaired Structures
S.G. Pinjarkar .............................................................................................. 548
Methods of Monitoring and Evaluation of Structural Performance
Michael Salgo .............................................................................................. 552
Fire Performance of Structures
Paul R. DeCicco .......................................................................................... 556
Performance of Structures During Construction
Robert Ratay ............................................................................................... 560

T-12 Design of Wind Sensitive Structures
The Use of Displacement Participation Factors in the Optimization of Wind Sensitive Buildings
Finley A. Charney ........................................................................................ 544
Wind Effects on Tension Leg Platforms
Peter Vickery ............................................................................................... 548
Long-Span Bridges in Wind: Future Research
Nicholas P. Jones and Robert H. Scanlan ....................................................... 552
A Case Study of the Wind-Induced Response of a Tall Building
A.A. Fediw, N. Isyumov, P.V. Banavalkar, and J.P. Colaco ......................... 831

*Manuscript not available at time of printing.
The Synchronous Pressure Acquisition Network (SPAN)
A. Steckley, S.L. Gamble, M. Accardo, P.A. Irwin, G.D. Schuyler .................. 556

T-21 Soil-Structure and Fluid-Structure Interaction
Seismic Analysis of a Lock and Dam System
Vincent P. Chiarito and James R. Morgan ............................................. 809
On Vibration Isolation of Elastic Structures
Heinz Antes ............................................................................................... 560
Seismic Lateral Earth Pressures in the Design and Analysis of Structures
Robert L. Hall and Stefan G. Bourn ......................................................... 564
Soil-Structure Interaction with Basemat Uplift-Sliding
P.N. Patel and C.C. Spyrakos ................................................................. 568

T-23 Inelastic Analysis in Frame Design—Implementation and Design Applications
Practical Problems in Inelastic Steel Design
William F. Baker ..................................................................................... 572
Limits on Elastic Second Order Analysis
John Springfield ....................................................................................... 576
A Case Study in Limit States Inelastic Analysis and Design
Ronald D. Zieman, Gregory G. Deierlein and William McGuire .............. 825
Advanced Analysis for the Design of Frames
Russell Q. Bridge, Murray J. Clarke, Gregory J. Hancock and Nicholas S. Trahair ... 580
Energy Dissipation in Braced Frames Subjected to Earthquakes
Socrates A. Ioannides, William F. O’Donnell and Enrique Martinez Romero .... 584

W-1 Approximate Methods of Structural Analysis and Design, and Verification Procedures I
Principles in Approximate Methods of Frame Analysis
John Roorda ............................................................................................. 588
Structural Approximations in Multi-Story Buildings
Hal Iyengar and Robert Sinn .................................................................... 592
Wind Frame Design for Mid-Rise Buildings
Horatio Allison ......................................................................................... 596

W-2 Inelastic Analysis of Joints in Reinforced Concrete Structures
Modeling of R.C. Beam-Column Connections Including Floor Slab
B.M. Shahrooz, S.C. Chern and S.J. Pantazopoulou .................................. 600
Evaluation of Joint Shear Strength for High-Strength Beam-Column Connections
Michael E. Kegler and Gilson Gulmaraes .............................................. 604
Supercomputing and Nonlinear Seismic Structural Response of Freeway Structures
G.L. Goudreau, D. Schauer, D. McCallen, G. Kay and R. Logan ............... 608
Design Considerations Based on Application of Nonlinear Finite Element Techniques to Bond Analysis
S.L. McCabe, D. Darwin, O.C. Choi and H. Hadje-Ghaaffari ....................... 612

W-3 Composite Materials for Infrastructure
Proposed Standard Specification for Structural Shapes
David J. Evans .......................................................................................... 616
Timoshenko Beam Stiffnesses for Laminated Structural Shapes
Ever J. Barbero ......................................................................................... 620
Static, Fatigue, and Creep Studies on Concrete Beams Post-Tensioned with GFRP Tendons
Joseph M. Plecnik, Waleed A. Azar, S.H. Ahmad and John M. Plecnik .......... 624
Use of GFRP Rebar in Concrete Structures
Richard D. Roll ....................................................................................... 629

W-4 Numerical Modeling of Wind Effects on Buildings I
Computation of 3-D Turbulent Wind Effects on Buildings
T. Stathopoulos and A. Baskaran ................................................................ 635
Numerical Simulation of Air Flow Around Surface-Mounted Rib by Means of ASM and k-€EVM
S. Murakami and A. Mochida .................................................................... 639
Computation of Pressures on and Velocities near the Texas Tech Building
R. Panneer Selvam and D.A. Paterson ..................................................... 643

W-5 Seismic Isolation of Bridges in the Eastern United States
The Seismic Risk of the Eastern United States
Klaus Jacob .............................................................................................. 647
Principles of Seismic Isolation
Ian Buckle ............................................................................................... 651
AASHTO Seismic Isolation Design Requirements for Highway Bridges
Ronald L. Mayes, Trevor E. Kelly, Lindsay R. Jones and Ian Buckle .......... 656
Case Studies of Seismically Isolated Bridges
Trevor E. Kelly and David M. Jones ....................................................... 660

W-6 Vehicular Impact and Wind Response of Bridges
General Vehicle and Traffic Conditions in Vehicle-Bridge Interactions
Edward C. Ting ...................................................................................... 664
Suppression of Wind Induced Vibrations of Bridge Towers
V. Ferraro, P.A. Irwin, and S.G. Arzoumanidis ....................................... 668
Bridge Monitoring for Vehicular Traffic and Evaluation of Dynamic Allowance
C. Spyrakos, I. Latheef and R. Coffman ................................................. 672
W-8  Approximate Methods of Structural Analysis and Design, and Verification Procedures II

Approximate Preliminary Methods for Design of Lateral Load Resisting Systems in High Rise Buildings
Charles H. Thornton, Leonard Joseph and Thomas Z. Scarangello ........................................... 676
Simplified Second-Order Inelastic Analysis for Steel Frame Design
Maheeb Abdel-Ghaffar, Donald W. White and Wai-Fah Chen ...................................................... 680
Analysis and Design of Structures with Outrigger Arms
Francois Cheong-Siat-Moy .......................................................... 684

W-9  Present and Future Developments in the Design and Analysis of Concrete Members

Design of Pretensioned Bridge Members with Debonded Strands
R. H. Lee, Julio A. Ramirez and S.F. Weintraut ........................................................................... 688
The Finite Block Method
Austin D. Pan and W.F. Chen .......................................................................................... 693
Bond of Epoxy-Coated Reinforcement Under Repeated Loading
D.B. Cleary and J.M. Ramirez .................................................................................................. 697

W-10 Tornado Resistant Design

Guidelines for Tornado Resistant Design
James R. McDonald and Robert C. Murray .................................................................................... 701
Design of Protective Areas in Schools
Harold W. Harris and Kishor C. Mehta .......................................................................................... 705
Lessons for Design Learned from Analyzing Tornado Damage
Timothy P. Marshall ................................................................................................................. 709
Tornado-Generated Missiles
James R. McDonald and N. Blair Nevins ........................................................................................ 713

W-11 Numerical Modeling of Wind Effects on Buildings II

Numerical Predictions of the Flow over a 2-D Building
A. Qasim, T. Maxwell and S. Parameswaran .................................................................................. 717
Applications of Rapid Distortion Theory in Wind Engineering
S.R. Ramsay .................................................................................................................................... 721
Models and Techniques in Computational Fluid Mechanics
R. Decker, P.A. McMurtry and J.C. Heinrich ................................................................................ 725

W-12 Seismic Isolation Retrofit of Buildings

Seismic Isolation Retrofit of an Apartment Building
Victor A. Zayas and Stanley S. Low ............................................................................................... 729
Seismic Isolation: An Emerging Rehabilitation Technique
Mason T. Walters, Eric Elsesser and Andrew S. Whittaker .............................................................. 733
Rehabilitation of the Mackay School of Mines, Phase III, with Base Isolation
D. Way and J. Howard ................................................................................................................ 737

W-13 Foundation Issues in Earthquake Response of Highway Bridges

Geotechnical Seismic Considerations for Highway Bridges
I.M. Idriss ................................................................................................................................. 837
Seismic Design of Abutment Walls
Raj Siddharthan .......................................................................................................................... 741
Communication Between the Geotechnical Engineer and the Structural Engineer in Seismic Design of Highway Bridges
John H. Clark ............................................................................................................................. 745
Lateral and Rotational Stiffness of Pile Foundations
Gary Norris ................................................................................................................................. 749

W-15 Approximate Methods of Structural Analysis and Design, and Verification Procedures III

Verification of Approximate Methods of Structural Analysis
R.Q. Bridge, M.J. Clarke, G.J. Hancock and N.S. Trahair ............................................................... 753
Verification of Advanced Analysis Techniques
Kurt D. Swensson ........................................................................................................................ 757
The Boundary Element Method in Engineering Practice
C.A. Brebbia ............................................................................................................................... 761

W-16 Connections in Monolithic Concrete Structures Subjected to Earthquake Loading

Shear Transfer at Slab-Wall Connections
S.J. Pantazopoulou and I. Imran .................................................................................................... 765
Behavior of High-Strength Concrete Frames
Mohammad R. Elsani .................................................................................................................... 769
Study of Reinforced Concrete Beam-Column-Slab Connections Subjected to Unidirectional and Bidirectional Loading
M.E. Kreger, J.O. Jirsa and Y. Kurose ........................................................................................... 773
Earthquake Type Loading on R/C Beam-Column Connections: Special Case of Wide Beams and Eccentric Beams
T.R. Gentry, G.S. Raffaelle and J.K. Wight .................................................................................... 777

W-17 Recent Developments in Structural System Optimization

Multiobjective Programming in Structural Analysis and Design
Avinash M. Nafday ........................................................................................................................ 781
Multiobjective Optimization of Random Structural Systems
Dan M. Frangopol and Minoru Jizuka ............................................................................................ 785
Multiobjective Design of Structural Systems
Mehrdad Soltani and Zhno Cheng .................................................................................................. 789
Optimization of Structural Frames Under Multiple Stress Constraints
Aydin Akbora, Ross B. Corotis, J.H. Ellis ......................................................................................... 793
Optimum Design of Partially Prestressed Concrete Girders
Mohammed Khaleel, Rafik Itani and Rachid Nakib ........................................................................ 797
INTRODUCTION

Structural engineers strive to shelter and support human activities with safe, functional, economic and esthetic structures. Engineers' productivity is measured by the value of their results and the efficiency with which their results are obtained. Also, incomes and quality of life for structural engineers depend on the value of results they provide for clients and employers.

Demands for improved structural engineering services include: reducing vulnerability to natural disasters, conserving and renewing existing structures, building on difficult sites, protecting the environment, conserving scarce resources, and creating structural systems consistent with evolving human aspirations.

Structural engineers will be challenged by colleagues abroad to maintain leadership and competitiveness in structural engineering practice in an increasingly international construction marketplace, [1]. Structural engineers also will be challenged by other professions which may take advantage of their growing knowledge and advanced technologies to extend their activities into what now is considered to be structural engineering practice. Productivity, value to the customer, should be the deciding factor.

Emerging technologies, such as advanced materials, artificial intelligence, automation and robotics, can greatly increase the powers of structural engineers [2]. Strong research, development and educational efforts are needed to adapt and exploit these opportunities. Technical leadership is key to the productivity and

---

1Director, Center for Building Technology, National Institute of Standards and Technology, Gaithersburg, MD 20899