

ACI

# STRUCTURAL JOURNAL

- 3 Experimental Study of Reinforced Concrete Bridge Columns Subjected to Near-Fault Ground Motions/*H. Choi, M. Saiid Saiidi, P. Somerville, and S. El-Azazy*
- 13 Fatigue Evaluation for Reinforced Concrete Box Culverts/*H. Maximos, E. Erdogmus, and M. K. Tadros*
- 21 Effects of Increasing Allowable Compressive Stress at Prestress Transfer/*D. B. Birrcher, O. Bayrak, and M. E. Kreger*
- 32 Bar Pullout Tests and Seismic Tests of Small-Headed Bars in Beam-Column Joints/*T. H.-K. Kang, S.-S. Ha, and D.-U. Choi*
- 43 A New Formula to Calculate Crack Spacing for Concrete Plates/*E. Rizk and H. Marzouk*
- 53 Performance Evaluation of Glass Fiber-Reinforced Polymer Shear Reinforcement for Concrete Beams/*E. A. Ahmed, E. F. El-Salakawy, and B. Benmokrane*
- 63 Pushover Analysis of Shear-Critical Frames: Formulation/*S. Guner and F. J. Vecchio*
- 72 Pushover Analysis of Shear-Critical Frames: Verification and Application/*S. Guner and F. J. Vecchio*
- 82 Investigation of Ultimate Strength of Deck Slabs in Steel-Concrete Bridges/*Y. Zheng, S. Taylor, D. Robinson, and D. Cleland*
- 92 FEA Implementation of Smeared Cyclic Bond Slip-Based Two-Dimensional Membrane Model/*M. So, T. G. Harmon, and S. Dyke*
- 101 Evaluation of Steel Fiber Reinforcement for Punching Shear Resistance in Slab-Column Connections—Part I: Monotonically Increased Load/*M.-Y. Cheng and G. J. Parra-Montesinos*
- 110 Evaluation of Steel Fiber Reinforcement for Punching Shear Resistance in Slab-Column Connections—Part II: Lateral Displacement Reversals/*M.-Y. Cheng and G. J. Parra-Montesinos*

A JOURNAL OF THE AMERICAN CONCRETE INSTITUTE



American Concrete Institute®  
Advancing concrete knowledge

## Board of Direction

### President

Florian G. Barth

### Vice Presidents

Kenneth C. Hover  
Richard D. Stehly

### Directors

Dennis C. Ahal  
Emmanuel K. Attiogbe  
Claude Bédard  
Ramón L. Carrasquillo  
Beverly A. Garnant  
Charles S. Hanskat  
Ronald Klemencic  
Colin L. Lobo  
Joseph C. Sanders  
Michael J. Schneider  
Andrea J. Schokker  
Kari L. Yuers

### Past President Board Members

Thomas D. Verti  
David Darwin  
Luis E. García

### Executive Vice President

William R. Tolley

## Technical Activities Committee

David H. Sanders, Chair  
Daniel W. Falconer, Secretary  
Sergio M. Alcocer  
David J. Bird  
Kenneth B. Bondy  
Chiara F. Ferraris  
Ronald Janowiak  
Michael E. Kreger  
David A. Lange  
Kevin A. MacDonald  
Antonio Nanni  
Hani H. Nassif  
Michael Sprinkel  
Pericles C. Stivaros

### Staff

*Executive Vice President*  
William R. Tolley

### Publishing Services

*Supervisor*  
John Q. Horn

### Editors

Carl R. Bischof  
Emily H. Bush  
Karen Czedik  
Kelli R. Slayden

### Manuscript Review Coordinator

Jamie A. McMann

### Administrative Assistant

Daniela A. Bedward

### Engineering

*Managing Director*  
Daniel W. Falconer

### Staff Engineers

Khaled Nahlawi  
Matthew R. Senecal  
Gregory Zeisler

# ACI Structural Journal

**JANUARY-FEBRUARY 2010, VOL. 107, NO. 1**

A JOURNAL OF THE AMERICAN CONCRETE INSTITUTE  
AN INTERNATIONAL TECHNICAL SOCIETY

- 3 Experimental Study of Reinforced Concrete Bridge Columns Subjected to Near-Fault Ground Motions**, by Hoon Choi, M. Saiid Saiidi, Paul Somerville, and Saad El-Azazy
- 13 Fatigue Evaluation for Reinforced Concrete Box Culverts**, by Hany Maximos, Ece Erdogmus, and Maher K. Tadros
- 21 Effects of Increasing Allowable Compressive Stress at Prestress Transfer**, by David B. Birrcher, Oguzhan Bayrak, and Michael E. Kreger
- 32 Bar Pullout Tests and Seismic Tests of Small-Headed Bars in Beam-Column Joints**, by Thomas H.-K. Kang, Sang-Su Ha, and Dong-Uk Choi
- 43 A New Formula to Calculate Crack Spacing for Concrete Plates**, by E. Rizk and H. Marzouk
- 53 Performance Evaluation of Glass Fiber-Reinforced Polymer Shear Reinforcement for Concrete Beams**, by Ehab A. Ahmed, Ehab F. El-Salakawy, and Brahim Benmokrane
- 63 Pushover Analysis of Shear-Critical Frames: Formulation**, by Serhan Guner and Frank J. Vecchio
- 72 Pushover Analysis of Shear-Critical Frames: Verification and Application**, by Serhan Guner and Frank J. Vecchio
- 82 Investigation of Ultimate Strength of Deck Slabs in Steel-Concrete Bridges**, by Yu Zheng, Su Taylor, Des Robinson, and David Cleland
- 92 FEA Implementation of Smeared Cyclic Bond Slip-Based Two-Dimensional Membrane Model**, by Migeum So, Thomas G. Harmon, and Shirley Dyke
- 101 Evaluation of Steel Fiber Reinforcement for Punching Shear Resistance in Slab-Column Connections—Part I: Monotonically Increased Load**, by Min-Yuan Cheng and Gustavo J. Parra-Montesinos
- 110 Evaluation of Steel Fiber Reinforcement for Punching Shear Resistance in Slab-Column Connections—Part II: Lateral Displacement Reversals**, by Min-Yuan Cheng and Gustavo J. Parra-Montesinos
- 119 Discussion**  
**Adaptable Strut-and-Tie Model for Design and Verification of Four-Pile Caps.** Paper by Rafael Souza, Daniel Kuchma, JungWoong Park, and Túlio Bittencourt  
**Two-Way Shear Strength of Slab-Column Connections: Reexamination of ACI 318 Provisions.** Paper by Widiyanto, Oguzhan Bayrak, and James O. Jirsa

*(continued on next page)*

Discussion is welcomed for all materials published in this issue and will appear in the November-December 2010 issue if received by July 1, 2010. Discussion of material received after specified dates will be considered individually for publication or private response. ACI Standards published in ACI Journals for public comment have discussion due dates printed with the Standard.

Annual index published in the March-April issue.

*ACI Structural Journal*

Copyright © 2010 American Concrete Institute. Printed in the United States of America.

The *ACI Structural Journal* (ISSN 0889-3241) is published bimonthly by the American Concrete Institute. Publication office: 38800 Country Club Drive, Farmington Hills, MI 48331. Periodicals postage paid at Farmington, MI, and at additional mailing offices. Subscription rates: \$161 per year (U.S. and possessions), \$170 (elsewhere), payable in advance. POSTMASTER: Send address changes to: *ACI Structural Journal*, P. O. Box 9094, Farmington Hills, MI 48333-9094.

Canadian GST: R 1226213149.

Direct correspondence to P.O. Box 9094, Farmington Hills, MI 48333-9094. Telephone: (248) 848-3700. Facsimile (FAX): (248) 848-3701. Web site: <http://www.concrete.org>.



**Behavior of High-Performance Steel as Shear Reinforcement for Concrete Beams.** Paper by Matthew S. Sumpter, Sami H. Rizkalla, and Paul Zia

**Investigation of Dispersion of Compression in Bottle-Shaped Struts.** Paper by Dipak Kumar Sahoo, Bhupinder Singh, and Pradeep Bhargava

**Deformation Capacity of Reinforced Concrete Columns.** Paper by Hossein Mostafaei, Frank J. Vecchio, and Toshimi Kabeyasawa

**Evaluation of Bundled Bar Lap Splices.** Paper by Tarek R. Bashandy

129 **Errata**

130 **In ACI Materials Journal**

## MEETINGS

2010

### JANUARY

**10-14—Transportation Research Board 89th Annual Meeting,** Washington, DC—contact TRB, telephone: (202) 334-2934; e-mail: trb-meetings@nas.edu; Web site: www.trb.org.

**27-30—International Association of Foundation Drilling Annual Meeting,** Tucson, AZ—contact Jan Hall, telephone: (214) 343-2091; e-mail: jhall@adsc-iafd.com; Web site: www.adsc-iafd.com.

### FEBRUARY

**1-5—World of Concrete,** Las Vegas, NV—contact WOC, telephone: (866) 860-1983 or (972) 819-7600; ACI members can register for free by clicking on the WOC logo on ACI's homepage at www.concrete.org.

**9-11—54th BetonTage,** Neu-Ulm, Germany—contact the organizers, telephone: +49-711-32732-300; fax: +49-711-32732-350; e-mail: info@betontage.de; Web site: www.betontage.de.

**18-20—The Precast Show,** Phoenix, AZ—contact the organizers, telephone: (800) 366-7731 or (317) 571-9500; fax: (317) 571-0041; Web site: theprecastshow.org.

**24-26—2010 Concrete Bridge Conference,** Phoenix, AZ—contact NCBC, telephone: (847) 966-6200; fax: (847) 966-9781; e-mail: nbc@cement.org; Web site: www.nationalconcretebridge.org.

### MARCH

**7-9—American Concrete Pipe Association Annual Convention,** Indian Wells, CA—contact ACPA, telephone: (972) 506-7216; fax: (972) 506-7682; e-mail: info@concrete.pipe.org; Web site: www.concretepipe.org.

**14-16—National Ready Mixed Concrete Association Annual Convention,** Austin, TX—contact Jennifer Leonard, telephone: (240) 485-1156; e-mail: jleonard@nrmca.org; Web site: www.nrmca.org.

### UPCOMING ACI CONVENTIONS

The following is a list of scheduled ACI conventions:

**2010—March 21-25,** Sheraton, Chicago, IL

**2010—October 24-28,** The Westin Convention Center, Pittsburgh, PA

**2011—April 3-7,** Marriott Tampa Waterside & Westin Harbour Island, Tampa, FL

**2011—October 16-20,** Millennium Hotel & Duke Energy Center, Cincinnati, OH

#### For additional information, contact:

Event Services, ACI

P.O. Box 9094

Farmington Hills, MI 48333-9094

Telephone: (248) 848-3795

e-mail: conventions@concrete.org

Permission is granted by the American Concrete Institute for libraries and other users registered with the Copyright Clearance Center (CCC) to photocopy any article contained herein for a fee of \$3.00 per copy of the article. Payments should be sent directly to the Copyright Clearance Center, 21 Congress Street, Salem, MA 01970. ISSN 0889-3241/98 \$3.00. Copying done for other than personal or internal reference use without the express written permission of the American Concrete Institute is prohibited. Requests for special permission or bulk copying should be addressed to the Managing Editor, *ACI Structural Journal*, American Concrete Institute.

The Institute is not responsible for statements or opinions expressed in its publications. Institute publications are not able to, nor intend to, supplant individual training, responsibility, or judgment of the user, or the supplier, of the information presented.

Papers appearing in the *ACI Structural Journal* are reviewed according to the Institute's Publication Policy by individuals expert in the subject area of the papers.

### Contributions to *ACI Structural Journal*

The *ACI Structural Journal* is an open forum on concrete technology and papers related to this field are always welcome. All material submitted for possible publication must meet the requirements of the "American Concrete Institute Publication Policy" and "Author Guidelines and Submission Procedures." Prospective authors should request a copy of the Policy and Guidelines from ACI or visit ACI's Web site at [www.concrete.org](http://www.concrete.org) prior to submitting contributions.

Papers reporting research must include a statement indicating the significance of the research.

The Institute reserves the right to return, without review, contributions not meeting the requirements of the Publication Policy.

All materials conforming to the Policy requirements will be reviewed for editorial quality and technical content, and every effort will be made to put all acceptable papers into the information channel. However, potentially good papers may be returned to authors when it is not possible to publish them in a reasonable time.

### Discussion

All technical material appearing in the *ACI Structural Journal* may be discussed. If the deadline indicated on the contents page is observed, discussion can appear in the designated issue. Discussion should be complete and ready for publication, including finished, reproducible illustrations. Discussion must be confined to the scope of the paper and meet the ACI Publication Policy.

Follow the style of the current issue. Be brief—1800 words of double spaced, type-written copy, including illustrations and tables, is maximum. Count illustrations and tables as 300 words each and submit them on individual sheets. As an approximation, 1 page of text is about 300 words. Submit one original typescript on 8½ x 11 plain white paper, use 1 in. margins, and include two good quality copies of the entire discussion. References should be complete. Do not repeat references cited in original paper; cite them by original number. Closures responding to a single discussion should not exceed 1800-word equivalents in length, and to multiple discussions, approximately one half of the combined lengths of all discussions. Closures are published together with the discussions.

Discuss the paper, not some new or outside work on the same subject. Use references wherever possible instead of repeating available information.

Discussion offered for publication should offer some benefit to the general reader. Discussion which does not meet this requirement will be returned or referred to the author for private reply.

**Send manuscripts to:**  
<http://mc.manuscriptcentral.com/aci>

**Send discussions to:**  
[Journals.Manuscripts@concrete.org](mailto:Journals.Manuscripts@concrete.org)