ENGINEERING JOURNAL

Third Quarter 2009 Article Abstracts

The following papers appear in the third quarter 2009 issue of AISC's *Engineering Journal*. EJ is available online (free to AISC Members) at www.aisc.org/epubs.

Estimating Inelastic Drifts and Link Rotation Demands in EBFs

Paul W. Richards and Brandon Thompson

When designing eccentrically brace frames (EBFs), the inelastic rotation of the links is estimated to ensure that links will not experience excessive rotations. Typically, design engineers amplify elastic analysis results to estimate EBF link inelastic rotations. Twelve EBF frames of different height (3-, 9-, and 18- story) and strength were designed and two types of analyses performed: static elastic analysis under the design base shear; and non-linear dynamic analysis under ten design-level earthquakes. Roof drifts, story drifts, and link rotations were estimated by amplifying values from the static elastic analyses, and then compared with average values from the dynamic analyses. Poor correlation was observed. For the 3-story frames, estimated link rotations were as much as 63% lower than the rotations observed in the dynamic analyses. For the 9- and 18-story frames, estimated link rotations were as much as two times greater than those observed in the dynamic analyses. Calibrated amplification factors were developed for better estimation of link inelastic rotation. It is demonstrated that amplifying only the shear component of the elastic story deformations will lead to more reasonable estimates.

Experimental Study of Bolted Connection Strength at Elevated Temperatures

Liang Yu and Karl H. Frank

Single bolt (A325) connections were tested at temperature up to 800 °C (1472 °F) to investigate the effect of temperature upon their bearing capacity. Significant stiffness and strength losses were found between 400 °C (752 °F) and 800 °C (1472 °F). The failure mode changes from bearing to bolt shear between 300 °C (572 °F) and 400 °C (752 °F). Two-bolt (A490) connections are tested from ambient temperature to 800 °C (1472 °F) to study the effect of temperature upon the block shear capacity. Both the stiffness and the strength of the two-bolt connections decrease between 400 °C (752 °F) and 800 °C (1472 °F). The estimated strengths of steel at elevated temperatures given in the Appendix 4 of the 2005 AISC *Specification* overestimated the strength of the connections which failed in block shear of the plate or shear of the bolts. The constant load test results agreed well with constant temperature quasi static test results indicating that creep under constant load does not change the strength of connection at elevated temperature. Residual slip resistance capacity of fully tightened A490 bolt connection was tested after exposure to temperatures up to 800 °C (1472 °F). After exposure to a temperature above 400 °C (752 °F), the slip load resistance reduces considerably.

Collapse Performance of Low-Ductility Chevron Braced Steel Frames in Moderate Seismic Regions

Eric M. Hines, Mary E. Appel, and Peter J. Cheever

This paper discusses non-linear dynamic collapse behavior observed in analytical models of low-ductility chevron braced steel frames designed for 3-, 6-, 9- and 12-story building configurations in Boston, Massachusetts. For each building configuration, three separate designs were developed assuming R = 2, 3, and 4 with no seismic detailing, but accounting for some lateral capacity in the gravity system. A fourth design was developed as a low-ductility dual system, with a primary braced frame system designed to resist wind only, and a secondary moment frame reserve system. These analyses bring to light the need for a clear design philosophy for low-ductility structures in moderate seismic regions. Based on encouraging results for the low-ductility dual system, the concept of reserve system design offers a step toward the definition of this philosophy.

Experimental Evaluation of Kaiser Bolted Bracket Steel Moment-Resisting Connections

Scott M. Adan and William Gibb

The Kaiser bolted bracket (KBB) is a new beam-to-column moment connection that consists of proprietary cast high-strength steel brackets that are fastened to the flanges of a beam and then bolted to a column. This fully restrained connection is designed to eliminate field welding in steel moment frame construction. This paper summarizes the development of bolted bracket connections and presents the results of seven full-scale KBB tests. These tests were conducted to evaluate the connection for both the retrofit of existing and the construction of new steel moment frames. More specifically the tests were intended to assess the ductility of the connection under cyclic inelastic loading and to qualify their performance with respect to code requirements.

Experimental Investigation of Fillet-Welded Joints Subjected to Out-of-Plane Eccentric Loads

Amit M. Kanvinde, Gilbert Y. Grondin, Ivan R. Gomez, and Yukay Kwan

The current AISC design specification for welded connections does not make a distinction between joints subjected to eccentric loads in the plane of the weld group, and those subjected to eccentric loads not in the plane of the weld group. To address this issue, results from 60 tests on cruciform joint specimens are presented to examine the effect of combined shear and out-of-plane bending on the strength of fillet welded joints. All specimens are loaded in a three point bending configuration, such that the out-of-plane bending is resisted through a combination of tensile weld stresses and compressive bearing stresses between the connected plates. Two welding filler metals (flux-cored wires, toughness rated E70T7-K2 and non-toughness rated E70T-7), two nominal weld sizes (5⁄16 in. and ½ in.), three nominal load eccentricity ratios (0.75, 1.375 and 2.125) and three plate bearing widths (1.25 in., 1.75 in. and 2.5 in.) are investigated. Analysis of the test data, in addition to similar data available in the literature, reveals that the current (13th Edition *Steel Construction Manual*) AISC design tables for eccentrically loaded welds are highly conservative (i.e. test-to-predicted load ratios are, on average, 1.75; with a coefficient of variation = 0.25) for joints with out-of-plane eccentricity. This conservatism is attributed to the disregard of plate bearing stresses that significantly alter the stress distribution in the joint. An alternate approach that explicitly incorporates this bearing effect is proposed, and the resulting strength predictions are determined to be significantly less conservative when compared to the current design standards. Limitations of the research and future work are outlined.

DESIGN COMPETITIONS

ACSA/AISC 2008–2009 Steel Design Student Competition Winners

Woodbury University students took top honors in both categories of the ninth annual Steel Design Student Competition. Administered by the Association of Collegiate Schools of Architecture (ACSA) and sponsored by AISC, the program challenged students—working individually or in teams—to explore a variety of design issues related to the use of steel in design and construction. Students from four other schools also took home awards from the competition.

The first category, Life Cycle of a School, challenged architecture students to design a school for the 21st century that critically examined life cycle and proposed an innovative solution in steel. With the premise that the problem of urban growth and decay is larger than an individual building, entrants were tasked with considering a total life-cycle assessment approach to designing their building to be adaptable and flexible. The second category was open, with limited restrictions. Following are this year's winners.

Category I
First Place: The Cloud
Students: Reza Hadian and Sara Shakib
Faculty Sponsors: Scott Uriu
Woodbury University
Second Place: Didactic Shift
Students: Wilson Hugo Diaz and Liliana Gonzalez
Faculty Sponsor: Mark Owen and Gerard Smulevich
Woodbury University
Third Place: Air-Right School
Students: Yong Tan and Vanessa Banos
Faculty Sponsor: Mark Owen
Woodbury University
Honorable Mention: The Bio Rhythmic Charter School
Students: Erin Chapman and Nick Respecki
Faculty Sponsor: Pamela Harwood
Ball State University

Category II
First Place: The American Institute of Steel Reclamation
Students: Jeffrey Dahl and Jan Lim
Faculty Sponsor: Gerard Smulevich
Woodbury University
Second Place: Lakeside South Condominium
Student: Brian Pugh
Faculty Sponsor: Joy Monice Malnar
University of Illinois, Urbana-Champaign
Honorable Mention: Frequency In-Flux
Student: Rachel Glabe
Faculty Sponsors: Thomas Fowler IV, Mark Cabrinha, Ansgar M. Killing, and James Doerfler
California Polytechnic State University, San Luis Obispo
Honorable Mention: Transparency
Students: Kyle Doman and Breton Lujan
Faculty Sponsor: Michael Jenson
University of Colorado

For more on the program and winners, visit **www.acsa-arch.org**—and see the related news item at **www.aisc.org**.

SPECIFICATIONS

2010 AISC Specification Second Public Review

A limited portion of the 2010 draft of the AISC *Specification for Structural Steel Buildings* will be available for public review from August 14 through September 28, 2009. This is the second opportunity for the public to submit comments on the new specification; however, only portions that have been revised since the first public review (March 2009) will be open for comment. Look for a press release announcing the public review listed under "News" on the AISC home page (**www.aisc.org**) during this time. The draft specification and comment submittal form will also be available for download at **www.aisc.org/AISC341PR2** and **www.aisc.org/PRForm**. Hard copies will be available (for a $12 charge) by calling 312.670.5411.

Please submit comments using the form provided online to Cynthia J. Duncan, director of engineering, at duncan@aisc.org by September 28, 2009 for consideration.