Spotlight on Structures

Research Journal of The Institution of Structural Engineers

In this new section of *The Structural Engineer*, we shine a spotlight on papers recently published in *Structures* – the Research Journal of The Institution of Structural Engineers.

Structures is a collaboration between the Institution and Elsevier, publishing internationally-leading research across the full breadth of structural engineering which will benefit from wide readership by academics and practitioners.

Access to *Structures* is free to all during 2015. From 2016, Institution members will continue to receive free access as one of their membership benefits. The journal is available online at: **www.elsevier.com/locate/structures**

Structures Volume 1, Issue 1 features the following articles and is available online at www.sciencedirect.com/science/journal/23520124

Ultimate capacity of structural steel cross-sections under compression, bending and combined loading
Andrew Liew and Leroy Gardner

Thermoelastic buckling and post-buckling of weakened columns
Guotao Yang and Mark A. Bradford

High strength rubberized concrete containing silica fume for the construction of sustainable road side barriers
Mohamed Elchalakani

Characterization of concrete specimen fracture response: 2D numerical study
N. Trivedi, R. K. Singh and J. Chattopadhyay

Economical design procedures for built-up box sections subject to compression and bi-axial bending
Osama Bedair

Engineering stress solutions for bolted and pressurized steel structures
Nelli Aleksandrova

Using the vibration envelope as a damage-sensitive feature in composite beam structures
Stavros Kasinos, Alessandro Palmeri and Mariateresa Lombardo

Sustainable reinforced masonry walls under lateral in-plane load: Experimental behavior and code-based predictions
Richard P. Clarke

In addition, corrected proofs of the following articles 'in press' have been made available online since March:

Comparative Post-Yield Performance Evaluation of Flexural Members under Monotonic and Cyclic Loadings based on Experimental Tests

V. V. S. Surya Kumar Dadi[a] and Pankaj Agarwal[b]
[a] Department of Civil Engineering, Institute of Technology, Guru Ghasidas Vishwavidyalaya, Bilaspur, CG, India
[b] Department of Earthquake Engineering, Indian Institute of Technology, Roorkee, India
http://dx.doi.org/10.1016/j.istruc.2015.02.002

Highlights:

- Comparison of ductility under pushover and cyclic loading
- Plastic hinge parameter of flexural member
- Hysteresis behavior of flexural member under ductile reinforcement
- Acceptance criteria of flexural member
- Moment rotation relation under push over and cyclic loading

The non-linear performances of RC beam specimens under flexure are evaluated with constant % of Thermo Mechanically Treated (TMT) reinforcement in confined and unconfined conditions by pushover and cyclic loading. The pushover and cyclic behavior of the beam specimens is plotted in the form of load-deformation for determining the non-linear modeling parameters as per ASCE/SEI 41-06. The beam specimens under cyclic testing have shown large yield strength but low ductility as compared to pushover testing. It may be concluded that the ductility, which is synonymously used without the relevance either of monotonic or cyclic load of a component or a structure, may result to be lethal if appropriation is neglected in behavior factor in seismic design. The confining of transverse reinforcement is another significant parameter on which the post-yield force–deformation relationship and the resulting ductility of an RC component depend.

Blast Response of Segmented Bored Tunnel using Coupled SPH–FE Method

Sivalingam Koneshwaran, David P. Thambiratnam and Chaminda Gallage, Science & Engineering Faculty, Queensland University of Technology, Brisbane, Australia
http://dx.doi.org/10.1016/j.istruc.2015.02.001

Highlights:

- Coupled SPH/FEM was used to treat blast response of segmented bored tunnel
- Present results compared well with those from above and below ground experiments
- Segments in the tunnel rings respond as arch mechanism in transverse direction
- Circumferential joints are more likely to fail than radial joints under the blast
- Segments were damaged mainly due to the high bending stress caused by blast load

Underground transport tunnels are vulnerable to blast events. This paper develops and applies a fully coupled technique involving the Smooth Particle Hydrodynamics and Finite Element techniques to investigate the blast response of segmented bored tunnels. Findings indicate that several bolts failed in the longitudinal direction due to redistribution of blast loading to adjacent tunnel rings. The tunnel segments respond as arch mechanisms in the transverse direction and suffered damage mainly due to high bending stresses. The novel information from the present study will enable safer designs of buried tunnels and provide a benchmark reference for future developments in this area.

Uncorrected proofs of the following articles 'in press' are also available:

Effective width equations accounting for element interaction for cold-formed stainless steel square and rectangular hollow sections

M. Bock and E. Real, Department of Construction Engineering, Universitat Politècnica de Catalunya, Barcelona, Spain
http://dx.doi.org/10.1016/j.istruc.2015.02.003

Highlights:

- Numerical modelling of cold-formed ferritic stainless steel stub columns
- Study of the influence of some key parameters on the numerical response
- Successful validation of the scope of various methods to cover ferritic steel
- Incorporation of element interaction effects into the effective width formulation
- Reliability analysis and validation of the proposed method against existing tests

Rectangular hollow sections featuring high height-to-width (aspect) ratios have shown to offer improved ultimate capacity due to the effects of the interaction between the elements within the cross-section which are particularly significant for slender cross-sections (class 4) undergoing local buckling. The European design rules dealing with stainless steel, EN 1993-1-4, utilises the concept of cross-section classification and the effective width method for the design of slender cross-sections susceptible to local buckling neglecting such interaction effects, hence resulting in conservative predictions. This paper examines the benefits of element interaction effects on cold-formed ferritic stainless steel compressed sections on the basis of carefully validated finite element models. Following parametric studies, the applicability of various alternative design approaches accounting for element interaction to ferritic stainless steel is assessed and effective width curves, as well as a Class 3 limiting slenderness equation, are derived herein as an explicit function of the aspect ratio. Comparisons with the loads achieved in the FE models have shown that the proposed effective width equations allowing for the benefits of element interaction improve capacity predictions making design more cost-effective.

Sensitivity of Pushover Curve to material and geometric modelling – An Analytical investigation

Neena Panandikar (Hede) and K. S. Babu Narayan, Department of Civil Engineering, National institute of Technology, Surathkal-575025, Karnataka, India
http://dx.doi.org/10.1016/j.istruc.2015.02.004

Nonlinear static analysis or pushover analysis developed over the last two decades and became the preferred procedure for design and seismic performance evaluation, as this procedure is relatively simple and considers post-elastic behaviour. It provides information on seismic demands imposed by the design ground motion on the structural system and its components. Generation of pushover curve from analysis for reinforced concrete structure involves tremendous amount of computational efforts as the input data for analysis itself is quite exhaustive. The analysis results are very sensitive to the techniques employed in geometric and material modelling. This paper envisages presenting the sensitivity of pushover analysis results to geometric and material modelling parameters by comparing the analysis results with that of experimental investigations. Attempt has been made to understand the sensitivity of parameters like variation in material properties, inaccuracies in placement of reinforcement, effect of confinement of concrete and modelling techniques for elements and plastic hinges. SAP-2000 has been utilised in the current investigation and results have been highlighted suggesting strategies to enhance pushover analysis capabilities.

Stress field based truss model for shear-critical prestressed concrete beams

K. De Wilder[a], P. Lava[b], D. Debruyne[b], Y. Wang[b], G. De Roeck[a] and L. Vandewalle[a]
[a] Department of Civil Engineering, KU Leuven, Leuven, Belgium
[b] Department of Metallurgy and Materials Engineering, KU Leuven, Leuven, Belgium
http://dx.doi.org/10.1016/j.istruc.2015.02.006

Despite more than a century of continuous effort, shear still remains one of the few areas of research into fundamentals of the behavior of concrete structures where dispute remains amongst researchers about the mechanisms that enable the force flow through a concrete member and across cracks. This paper firstly presents the results of 9 full-scale prestressed concrete I-shaped beams subjected to a four-point bending test until failure. Two stereo-vision digital image correlation (DIC) systems were used to discretely measure three-dimensional displacements in both zones where a shear force exists. A numerical technique has been adopted to generate optimized patterns for DIC and the resulting speckle pattern was applied onto each specimen using a stencil printing technique. Using the sectional shear design procedure from Eurocode 2, a severe underestimation of the experimentally observed shear capacity was found. Therefore, a parametric nonlinear finite element (FE) model was constructed to further investigate the mechanical behavior. The ability of the FE model to reconstruct the observed structural behavior was validated using the experimental data concerning failure load, failure mode and (full-field) displacement data. Finally, based on the numerically obtained stress fields, an internally statically indeterminate truss model was proposed which clearly visualizes the flow of forces and accurately describes the observed failure load and failure mode. A simple relationship between the applied shear force and the amount of shear force carried by the shear reinforcement was proposed. The proposed relationship was validated using the reported experimental data.

Experimental Investigation of Crumb Rubber Concrete Columns under Seismic Loading

Osam[a] Youssf[a], Mohamed A. ElGawady[b] and Julie E. Mills[a]
[a] University of South Australia, Adelaide, Australia
[b] Missouri University of Science and Technology, MO, USA
http://dx.doi.org/10.1016/j.istruc.2015.02.005

Crumb rubber concrete (CRC) is a class of concrete that incorporates crumb rubber from used tyres as a partial replacement for the natural aggregates in conventional concrete. Previous research at the material level has shown that the rubber can improve the ductility, damping ratio, and energy dissipation properties of concrete, which are the most important parameters in concrete structures that are subjected to earthquake loads. However, CRC can have lower compressive strength when compared with conventional concrete. This paper describes experimental work conducted to explore the possible use of CRC for structural columns. Three reinforced concrete columns having 240 mm diameter and 1500 mm shear span were tested under axial compression load and incrementally increasing reversed cyclic loading. One column was constructed out of CRC and the other two were constructed out of conventional concrete but subjected to different axial loads. A snap-back test was conducted to evaluate the damping properties of each column. The results indicated that the use of CRC increased the hysteretic damping ratio and energy dissipation of the columns by 13% and 150% respectively. However, CRC decreased the viscous damping ratio compared to a conventional concrete column. The CRC column was able to sustain a lateral load and ultimate drift of about 98.6% and 91.5%, respectively, of those sustained by the conventional column. This investigation demonstrates that CRC provides an environmentally-friendly alternative to conventional concrete in structural applications.