Innovative Structural Concrete Elements of Super High Strength and Ductility

By

Professor Antoine E Naaman

Michigan University

Abstract

This presentation describes the initial evaluation of an innovative structural concept for reinforced concrete in which unstressed prestressing strands and carbon FRP (CFRP) bars are used as primary reinforcement in a high performance fiber reinforced cement composite (HPFRCC) flexural beam. By taking advantage of the high compressive strength, strain capacity, and strain-hardening behavior of the HPFRC matrix, as well as the high tensile strength of steel strands or CFRP bars, a flexural performance significantly superior to what can be possibly achieved with conventional reinforced concrete beams is obtained. The preliminary phase of this research which deals with laboratory testing and analytical modeling of beams designed according to the above concept is described. The experimental program included three simple span beams and three two-span continuous rectangular beams (to simulated bridge decks). It is observed that such reinforcing systems would carry at least two times the load of an equivalent conventional reinforced concrete beam, while also providing at least two times the energy absorption capacity and related ductility. The crack width limit state as well as other serviceability limit states would also remain non critical. Applications range from long-span (lighter-weight for same performance) structural concrete elements to concrete bridge decks.

About the Speaker

Antoine (Tony) E. Naaman is Professor of Civil Engineering in the Department of Civil and Environmental Engineering at the University of Michigan, Ann Arbor, USA. He obtained his MS (1970) and Ph.D. (1972) degrees in Civil Engineering from the Massachusetts Institute of Technology. He has been involved in teaching and research since 1970. He is a Fellow of the American Concrete Institute, the Prestressed Concrete Institute, the Amercian Society of Civil Engineers, and the International Ferrocement Society. His research interests include prestressed concrete, high performance fiber reinforced cement composites, and the integration-tailoring of advanced construction materials to improve structural performance. Dr. Naaman's research studies have led to more than 300 technical publications, including two textbooks, one on Ferrocement and one on Prestressed Concrete, and eight co-edited books. Professor Naaman has received several professional awards, including the ASCE T.Y. Lin Award twice (1980, 1993), the PCI Martin P. Korn Award twice (1979, 1986), Germany's Alexander von Humboldt Award (1989), the Hwa Ying Foundation for Culture and Education award (P.R. China, 2000), and the Japan Concrete Institute award (2004).

Steel in Fire

By

A/Professor J Y Richard Liew
National University of Singapore

Abstract

It is now widely accepted that advanced fire engineering design provides greater advantages over the simplified design method as it allows engineers to generate more economical designs without compromising the levels of fire safety. The key feature in advanced fire engineering design is the assessment of the structural fire resistance. This lecture presents an integrated approach for performance based structural fire engineering design and discusses the various methods adopted in modelling the behaviour of natural fire, heat transfer to structure and structural response at high temperature. Structural response calculations from simplified methods to advanced finite element modelling are presented. The basis to model geometric nonlinearity and material plasticity using appropriate constitutive law at elevated temperature is explained. Various issues related to finite element modelling are discussed. An attempt is made to link the fire resistance time with the emergency escape time so as to maintain adequate safety margin in fire design. Finally, future trends for research work are identified.

About the Speaker

Dr Richard Liew is the director of the structural engineering programme in the Department of Civil Engineering at the National University of Singapore. He has authored four books and published more than 160 technical papers and book chapters related to stability analysis and design of frame structures, composite structures and lightweight space frame systems. He also authored more than 12 book chapters in engineering handbooks, design guide books and international/national standards. His main specialties are on high-rise steel buildings, large span structures, steel-concrete composite systems and fire safety design and forensic engineering of structures. He is a Chartered Engineer (CEng), Member of the Institution of Structural Engineers, London, (MIStructE) and a Professional Engineer in Singapore. He is active professionally by providing advisory services and organizing advanced courses. He is an expert in international codes of practices including Europe and Asia. He served in the editorial boards of five renowned journals related to steel and composite structures.

Floating Steel Structures

By

Professor E. Watanabe
Kyoto University

Abstract

For countries with very limited land, energy, natural resources and susceptibility to natural disasters such as earthquake and floods, floating structures look very promising. In this lecture, structural and civil engineers are introduced to the world of floating plated structures that have been gradually appearing in the waters off developed coastal cities and countries with coastlines. For the first time in history, plated structures are regarded as global structural systems in the forms of pontoon-type, although plates have been used only as structural components or elements in certain structural systems as walls, slabs, bulkheads and web plates. The lecture brings to attention the early, the present and future applications of floating structures and will provide a description of a very large floating structures (VLFS) highlighting its advantages (under certain conditions) over the traditional land reclamation in creating space from the sea. Included are topics of large-scale floating oil storage bases, Mega-float Project, JSSC's Moby Dick and Yumemai Bridge of Osaka City, Japan. Recently, an attempt has been made to utilize fluid for seismic isolation. The typical and realistic one is partially-floating structural system, in which the structure weight is partially supported by buoyancy and base-isolation devices, such as laminated rubbers, for supporting the remaining weight. This new structural system first applied to a wind-tunnel experimental facility of Shimizu Corporation in Japan, which was completed just on August, 2005.

About the Speaker

Eiichi Watanabe is a Professor Emeritus, Kyoto University and the Chairperson of Board of Directors of Foundation of Osaka Regional Planning Institute. He graduated from Kyoto University in 1964, received his 1st M. Sc. In 1966, from Kyoto University, 2nd M. Sc. in 1968 and Ph. D in 1969 from Iowa State University as a Fulbright grantee and Dr. Eng. from Kyoto University. Professor Watanabe has served as a vice president of JSCE from 2004 to 2005 and is serving as a vice president of IABMAS, member of board of directors of JSSC and Chairmen of Bridge Asset Management for Aomori Prefecture and City of Osaka and a member of European Academy of Sciences . His research interests are in the areas of steel structures, buckling, earthquake resistant design, reliability, maintenance and durability of steel bridges, corrugated steel webs, steel Cables, creep and relaxation of cables, offshore structures, floating bridges He has written over 420 scientific publications besides with about 30 books including Structural Mechanics I and II, Maruzen, 1999 and 2000, respectively (in Japanese), Encyclopedia of Bridges, Blue Backs, Kohdansha, 1991 (in Japanese), editor of Theoretical and Applied Mechanics 1996, Northholland, 1997 and Theoretical and Applied Mechanics, Vol. 50, Science Council of Japan, 2001.

High-Performance Lightweight Concrete for Floating Structures

By

A/Professor Min-Hong Zhang
National University of Singapore

Abstract

Lightweight aggregate concrete has been used for structural purposes for many years. One of the advantages of lightweight aggregate concrete is its low unit weight that reduces the self weight of structures and it is also ideal for applications in floating structures. With technology advancement, high-strength high-performance lightweight aggregate concrete with compressive strength of 100 MPa has been produced in laboratory, and that with compressive strength $\geq$ 70 MPa have been used for bridges and oil platform in marine environment. For reinforced concrete structures exposed to seawater, the ability of concrete to protect steel reinforcement from corrosion is an important issue that affects the long-term durability of such structures. This lecture presents state-of-the-art information of such concrete from material science perspectives, and discusses approaches to make lightweight yet dense concrete for applications in marine environment. It also describes a few cases of applications in marine environment including Heidrun tension leg oil platform in the North Sea and Nordhordland floating bridge.

About the Speaker

Dr. Zhang Min-Hong is Associate Professor with Department of Civil Engineering and Director of Centre for Construction Materials and Technology, National University of Singapore. Prior to joining NUS, she was Research Scientist at Canada Centre for Mineral and Energy Technology (CANMET), a Canadian Federal Government research organization in Ottawa.

Dr. Zhang is Director of Singapore Concrete Institute. She is a Professional Engineer registered in Ontario, Canada, a Fellow of American Concrete Institute (ACI), and a member of ACI Committees 213-Lightweight Aggregate and Lightweight Concrete, 232 - Fly ash and Natural Pozzolans, and 234 - Silica Fume in Concrete. She is also a member of ASTM Committees C1-Cement and C9-Concrete and Aggregate, and a former member of International Federation for Structural Concrete (FIB) Task Group on lightweight concrete.

Her research interests include lightweight aggregate concrete, high-strength high-performance concrete, and microstructure of composite materials. She has authored and co-authored more than 60 papers which include over 40 papers in peer reviewed international journals. Her papers have been well cited, with more than 170 citations. She is listed in the Marquis Who's Who in the World, 2006.

Simplified Approach for the Buckling and Nonlinear Analyses of Structures Based on the Rigid Element Concept

By

Professor Y. B. Yang
National Taiwan University

Abstract

The buckling displacements of a structure can be decomposed into two parts as the *rigid displacements* and *natural deformations.* The effect of rigid displacements can be duly considered by the *geometric stiffness matrix* derived for a rigid element from the virtual work equation using a *rigid displacement field*, and that of natural deformations approximately by the *elastic stiffness matrix*. For a two-node *rigid* beam element, the geometric stiffness matrix can be easily derived is the same, whether it is straight or curved, as long as they have identical nodal degrees at the two ends. Thus, the geometric stiffness matrix for the two-node *curved beam element* can be obtained by transforming the one in the Cartesian coordinates to the cylindrical coordinates. For a three-node *triangular plate element* (TPE), the geometric stiffness matrix can be obtained as the composition of the geometric stiffness matrices for the three rigid beams lying along the three sides.

The geometric stiffness matrices in this way can be used along with *compatible* elastic stiffness matrices in the buckling and nonlinear analysis of various structures. The present approach is featured by the fact that all the geometric stiffness matrices derived can be expressed in *explicit* algebraic form. Good characteristics of convergence are achieved as the finite element mesh is refined. The robustness of the proposed approach is tested in the buckling and nonlinear analyses of various structures, including beams, curved beams, 2D and 3D frames, plated, and shells.

About the Speaker

Yeong-Bin Yang received his Ph.D. degree from Cornell University in 1984. He is currently a professor at the Department of Civil Engineering, National Taiwan University, President of the Chinese Institute of Civil and Hydraulic Engineering, and CEO of the Accreditation Council of Institute of Engineering Education Taiwan.

Dr. Yang was the Chairman of Department of Civil Engineering, NTU, from 1995 to 1998. He then served as the Dean of College of Engineering for two terms from 1999 to 2005. He has published two books: *Theory and Analysis of Nonlinear Framed Structures* (Prentice-Hall 1994) and *Vehicle-Bridge Interaction Dynamics – with Applications to High Speed Railways* (World Scientific 2005). He also published over 130 technical papers in professional journals.

He received a number of important awards, including the Distinguished Research Award from the National Science Council, R.O.C. (5 times), and was the recipient of Dr. Y. T. Lee's outstanding scholarship. Currently, he is an Editor of the *International Journal of Structural Stability and Dynamics*, and members of editorial boards of several international journals.