Abstract List

Structural Steel & Concrete Composite Research Group
Annual Seminar — 2019

Design of buildings and infrastructures using steel and composite materials

Date: Friday, May 10, 2019    Time: 08:30 AM – 03:30 PM
Venue: LT2, Faculty of Engineering,
No.5 Engineering Drive 2, National University of Singapore
Singapore 117579
(Free Admission)
Chair: Prof. J. Y. Richard Liew
PDUs Pending

Organizer:
CENTRE FOR ADVANCED MATERIALS AND STRUCTURES
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING, NUS

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Abstract List

Structural Steel-Concrete Composite Research Group Annual Seminar 2019

The main objective of this annual seminar series is to provide a high quality forum for researchers and postgraduate students working in steel and concrete composite structures and materials to present their research outcome and achievements. Technical topics covering a wide spectrum of interests, including lightweight and high strength composite materials, advanced analysis of structures subject to extreme loads (impact, fire and blast, etc.), energy dissipation and absorption systems and novel structural systems related to offshore, marine, defence and civil infrastructural works have been selected for presentation. Each presentation will be followed by questions and answers so that comments and feedback can be gathered to help research staff and research students to improve their research.

Map of venue:
ENQUIRIES and REGISTRATION:

For registration, please contact:
CEE Office, Ms. Norela Bte Buang
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For seminar details, please contact:
Coordinator, Dr. Akshay Venkateshwaran
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For professional enquiry, please contact:
Seminar Chair, Professor J Y Richard Liew
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DESIGN OF STEEL FIBER REINFORCED CONCRETE ENCASED STEEL COLUMNS

Dr. Akshay Venkateshwaran

High strength concrete is found to experience brittle and explosive spalling failure at ultimate limit state. This study explores the possibility of completely replacing traditional steel bars by steel fibres in high strength concrete encased steel columns, leading to a more ductile structural behaviour, speedy and cost-effective construction. Direct compression tests were conducted on three short composite columns containing different percentages of hooked-end and small straight steel fibres. Six short columns were also tested under eccentric loading. In addition, the flexural behaviour of the proposed composite column system was investigated by testing three composite beams under four-point bending to obtain the axial load (N)–bending moment (M) interaction curve. The columns and beams were cast using three different hooked-end fibre dosages; that is, 0.5%, 1% and 1.5% by volume. All specimens had 0.5% small straight steel fibres. The hooked-end fibres provided the necessary structural integrity to the column system while the small straight steel fibres performed the role of bridging smaller cracks. Two analytical methods, one providing an exact solution and another a simplified solution, were proposed to predict the N-M interaction curve for the high strength concrete composite column containing steel fibers. The methods agreed well with the test results. Plastic design overestimated the load-carrying capacity of the composite columns by 18%, on average. Based on the performance of the proposed system, an optimum dosage of 1% hooked-end fibres and 0.5% small straight steel fibres by volume is recommended for high strength concrete encased steel columns.

BIOGRAPHY

Dr. Akshay Venkateshwaran is a research fellow in the Department of Civil and Environmental Engineering, National University of Singapore. He received his PhD degree from the National University of Singapore in 2018 and B.Eng. from Osmania University, India in 2011. His current research interests include fiber reinforced concrete and composite structures.

DESIGN OF HIGH STRENGTH COMPOSITE COLUMNS FOR TALL BUILDINGS

Mr. Lai Binglin

Concrete Encased Steel (CES) composite columns are commonly used in basement construction of high-rise buildings due to their high strength, high stiffness, full usage of materials, high resistance to fire and corrosion, as well as the significant savings of construction time and floor space. Existing design codes are limited to normal strength materials, which impedes the utilization of high strength composite columns in high-rise buildings. Some special concerns about high strength materials, including the inherent brittleness, premature cover spalling of high strength concrete, underutilized yield strength of high strength steel are properly resolved by our research group. My research focuses on the structural performance and design of high strength CES columns and Fiber-Reinforced CES (FRCES) columns. The comprehensive experimental, numerical, analytical, and statistical
studies are undertaken, aiming to give deep insight into the failure mechanism of CES members under varying loading conditions and finally contribute to the proposal of new design guide as well.

**BIOGRAPHY**

Mr. Lai Binglin received his Bachelor’s degree from Hohai University in Nanjing, China. He is currently a PhD student working under supervision of Professor J Y Richard Liew at NUS. His research mainly focuses on the structural behaviour of encased composite columns under static loading. He is proficient in structural design and numerical simulation. His work will contribute to the extension of existing design code of encased column with high strength concrete and high strength steel.

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**EXPERIMENTAL BEHAVIOR OF STEEL AND STEEL FIBER REINFORCED CONCRETE (SSFRC) STRUCTURE**

Dr. Kai Wu

An innovative method is proposed to replace the steel reinforcement cage by steel fiber to form a shape steel and steel fiber reinforced concrete to solve the construction problems of steel reinforced concrete structure, such as position conflict between shape steel and steel bars, or difficulty of concrete placement. 20 circular specimens and 16 square specimens were designed and experimented by push-out testing to investigate the bonding properties between shape steel and steel fiber reinforced concrete without steel reinforcement cage. Some important performance indexes, including load-slip curve, bond strength and interfacial energy were obtained. Through the four-point bending test of 18 specimens, the mechanical properties of SSFRC beam without rebar cages has been studied. The impact of steel fiber content, shape steel ratio, and shear span ratio on the mechanical properties have been analyzed. The bridging effect provided by steel fibers after cracking can effectively provide post-cracking tensile capacity.

**BIOGRAPHY**

Kai WU is an Associate Professor at Hohai University, China, undertaking the online opening course Steel Structure, which was awarded the National Excellent Online Opening Course of China. He has 31 invention patents of China authorized. He is also a member of China Steel Construction Society Association, in the sub-division of “Steel-Concrete Composite Structures” and “Stability and Fatigue of Steel Structure”. His research interests include steel structure, steel-concrete composite structure, and fiber-reinforced concrete members.
FIRE TESTS ON CONCRETE FULLY ENCASED STEEL COLUMNS (CESCS)

Mr. Li Shan

Concrete fully encased steel columns (CESCs) are characterized by superior fire resistance because concrete is inherently fire resistant and prevents the embedded steel from exposing to fire. The use of CESCs eliminates the fire protection required in most steel constructions. Despite CESCs are becoming popular in high-rise constructions, their fire performances remain to be investigated. A review of literature also shows there is a lack of test data for full-scale fire tests on CESCs, which are crucial for the development of a safe and efficient fire engineering design guide. In view of this, the fire performances of CESCs are investigated. Research findings will be presented, focusing on the full-scale fire tests on CESCs recently done.

BIOGRAPHY

Mr. Li Shan graduated from National University of Singapore with B.Eng (Highest Distinction) in Civil Engineering in 2016. Currently he is pursuing a PhD degree and working as a research engineer under the supervision of Prof. Richard Liew. His research areas are closely related to fire engineering, and the use of steel-fibre-reinforced concrete in composite structures.

STRUCTURAL BEHAVIOUR AND DESIGN OF SEMI-CONTINUOUS COMPOSITE BEAMS

Mr. Yuichi Nishida

In Singapore, nowadays steel-concrete composite structures are often adopted instead of conventional reinforced concrete structures especially in large-scale construction projects. For current composite structures, simple pin joints have been widely applied to beam-to-column joints and beam-to-beam joints. However, Semi-Rigid Joints (SRJs) can be an attractive alternative to simple pin joints in terms of economical design of long span composite floor beams to satisfy deflection and vibration requirements. Nonetheless, they are not often used in practice because more complicated and advanced design processes will be required for the application of SRJs. Specifically, calculation of design moment and deflection of composite beam supported by SRJs, called Semi-Continuous Composite Beams (SCCBs), is one of the most challenging problems.

This presentation provides an insight into the structural behaviour and design of semi-continuous composite beams (SCCBs) based on the analytical and experimental studies. Firstly, theoretical studies for the design moment and deflection of SCCBs, incorporating the structural properties of SRJs, will be discussed. Then, a full-scale beam test to investigate the structural behaviour of a SCCB will presented. And finally, the comparison of the test results and theoretical prediction in terms of the distribution of moment and deflection will be discussed. The final goal of this research is developing an appropriate and practical design method for SCCBs.
BIOGRAPHY

Mr. Yuichi Nishida received his Master’s degree from Kyushu University, Japan. He joined National University of Singapore as a M.Eng student from Aug, 2017 under the supervision of Prof. Richard Liew. His current research focuses on the design of semi-rigid composite joints and semi-continuous composite beams for steel-concrete composite structures.

FIRE SAFETY DESIGN OF BUILDING AND SPACE FRAME STRUCTURES

Dr. Yong DU

Fires in buildings especially have always been a threat to human life and property. The structural fire resistance has become an important and challenging issue for civil engineers across the world. In 2018, a performance-based national code for fire safety of steel structures has been published in China and created considerable interests among the engineering community. This presentation introduces the technology framework and advance design method on structural fire resistance. The presentation includes design fire scenarios, structural fire design strategies, advanced numerical models, and mechanical properties of materials at elevated temperature. The fire scenarios are compartment fire and open fire which are suitable for building compartment and space frame structures. The types of structures to be analyzed include building frames and pre-tensioned space frame structures. The fire resistance of steel members and steel concrete composite members will also be introduced. Case studies are used to illustrate the design strategy on how the fire performance of structure can be evaluated.

BIOGRAPHY

Dr. Du Yong is currently a professor of the Nanjing Tech University, a visiting professor in CEE, NUS. She serves as an academic member of the Expert Committee of China Steel Construction Society, Architectural Society of China. She is a Class 1 registered professional engineer in China. She has published about 50 paper and authored two text books on structural architecture and structural fire-resistance design, and is an expert in space frame structures and structural fire safety. She is responsible for the National Technical Code on Fire Safety of Steel Structure in Buildings, in China. She has been responsible for designing a number of buildings and structural projects, especially in fire protection of steel structures.
ULTRA-HIGH PERFORMANCE CONCRETE WITH FLY ASH

Dr. Padmaja Krishnan

In the recent years, there has been widespread adoption of ultra-high-performance concrete (UHPC) in severe environmental and loading conditions. With the construction industry increasingly adopting modular construction and pre-fabricated pre-finished volumetric construction (PPVC), greater emphasis has been placed on reducing the member size, thereby reducing transportation and lifting loads as well as increasing the usable space and UHPC with its higher specific strength (strength-to-weight ratio) can be ideal for this. However, UHPC generally incorporates silica fume and high cement content with low water/cementitious material (w/cm) ratio. Thus, to make UHPC more environmentally friendly and reduce its cement consumption, fly ash may be used as partial replacement for cement. Since both fly ash and silica fume are pozzolanic in nature, they compete for calcium hydroxide [Ca(OH)$_2$] from cement hydration. This study investigates the amount of fly ash and silica fume (as replacement for cement) and their combination on the pozzolanic reactions in pastes and compressive strength of corresponding mortars relevant to UHPC with a low w/cm of 0.19. Results indicate that there is limited Ca(OH)$_2$ in the paste with a combination of 10% silica fume and 30% fly ash at ages of 7, 28, and 56 days. The combination seems to have synergistic effect with the highest compressive strengths at 28 and 56 days in comparison to those of the control mortar and mortars with fly ash or silica fume. The results suggest that additional fly ash as cement replacement beyond 30% in the UHPC would most likely act as filler.

BIOGRAPHY

Dr. Padmaja Krishnan obtained her PhD degree from National University of Singapore in 2015 and is currently a Research Fellow in the Department of Civil & Environmental Engineering at the National University of Singapore. Her doctoral research was devoted to the development of multi-functional building materials for mitigation of ambient atmospheric pollutants. Her current research focuses on development of sustainable ultra-high performance concrete and lightweight concrete for Prefabricated Prefinished Volumetric Construction (PPVC).

LEGO-LIKE GROUTED SLEEVE CONNECTION FOR STEEL PPVC SYSTEM

Mr. Ziquan Dai

Grouted sleeve connection has been widely used in offshore industry connecting the offshore superstructure to their pile foundations. Its significant amount of axial, moment and shear resistance has been reported by many researchers. This type of connection has its advantages not only in strength, but also in productivity. It avoids using traditional welded connection or bolted connection in joining the vertical members of structures in critical environments that are usually labor-intensive and tolerance-stringent. Also, it has been proven that Steel PPVC systems are able to provide ductile structural performance in seismic zones and have become popular in public housings for their flexibility in architectural design. But the connections for Steel PPVC systems are usually completed using bolted connections which suffer from
access and tolerances issues. Thus, this presentation introduces a modified grouted sleeve connection for Steel PPVC system. The axial and bending behaviour of the proposed connection are studied by Finite Element Analysis. The failure mechanism is discussed and the performance is evaluated according to Eurocode 3.

**BIOGRAPHY**

Mr. Dai Ziquan obtained his master’s degree in computational engineering from Duke University. He joined National University of Singapore as a PhD student from Jan, 2016 under the supervision of Prof. Richard Liew and A/Prof. Pang Sze Dai. His research focuses on the fast joining techniques of PPVC and structural analysis of steel composite joints.

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**DESIGN OF LIGHTWEIGHT FIBER-REINFORCED CONCRETE SLAB WITHOUT CONVENTIONAL REINFORCEMENT**

Mr. Gilbert Sebastino

Recent developments in fiber reinforcement technology has enabled engineers to construct elevated flat slabs without conventional reinforcement. These steel fiber-reinforced concrete (SFRC) slabs has higher productivity compared to conventional reinforced concrete slabs, as they eliminate the need to cut, bend, and lay the reinforcing bars in the slab, which takes up a large amount of time, resources and manpower. Furthermore, SFRC slabs tend to have less shrinkage and cracking compared to normal concrete. The use of Lightweight Aggregate Concrete (LWAC) has several benefits, especially in construction of horizontal members in high-rise buildings. It possesses higher strength-to-weight ratio, which means that slabs and beams constructed out of LWAC will result in a lower dead load, which would translate in savings and reduction in size in columns and foundations. However, LWAC is an inherently brittle material which possesses a low tensile strength. Hence, LWAC lends itself well to being reinforced with fiber reinforcement. The combined lightweight steel fiber-reinforced concrete (LW-SFRC) would therefore be an excellent candidate as a material for the construction of high-rise elevated slab.

In this presentation, a literature study on SFRC & LWAC, and LW-SFRC material properties, as well as SFRC slab design will be conducted. The result of the material study conducted which compares NW- and LW-SFRC is presented, along with a proposed material prediction model for LW-SFRC. The result of a large scale SFRC slab test will also be presented and compared to the design values recommended by the existing model codes.

**BIOGRAPHY**

Mr. Gilbert Sebastiano is a third-year PhD candidate at the National University of Singapore focusing on the development of fiber-reinforced concrete and composite flooring system. He also obtained his Bachelor’s degree in Civil Engineering from NUS with Honors (Distinction). His undergraduate thesis discusses the high-speed projectile impact resistance of preplaced aggregate concrete. He has also done internships at Beca Carter Hollings & Ferner as a structural engineering consultant intern and in the NUS Geotechnical Centrifuge Lab as a research assistant.