ANNUAL CONCRETE FORUM 2023

TOWARDS CLIMATE-FRIENDLY CONCRETE CONSTRUCTION

Date : 5 December 2023 (Tuesday)
Venue : Sheraton (Hong Kong) Hotel, 20 Nathan Road, Tsim Sha Tsui

Co-organisers

混凝土科技常務委員會
Standing Committee on Concrete Technology (SCCT)

CEDD

香港建築業物料聯會有限公司
HONG KONG CONSTRUCTION MATERIALS ASSOCIATION LIMITED

香 港 混 凝 土 學 會
Hong Kong Concrete Institute

THE HONG KONG INSTITUTION OF ENGINEERS 香港工程師學會
Civil Division 土木分部

THE HONG KONG INSTITUTION OF ENGINEERS 香港工程師學會
Geotechnical Division 岩土分部

THE HONG KONG INSTITUTION OF ENGINEERS 香港工程師學會
Materials Division 材料分部

THE HONG KONG INSTITUTION OF ENGINEERS 香港工程師學會
Structural Division 結構分部

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香港科技大學
The Hong Kong University of Science and Technology

土木及環境工程學系
Department of Civil and Environmental Engineering

PROGRAMME

8:30 **Registration**

9:00 **Welcome Address**
Ir Michael H S FONG, JP, Director of Civil Engineering and Development

9:15 **Morning Opening Speech**
Ir Roger Y L WONG, JP, Deputy Secretary (Works) 2, Development Bureau

SESSION ONE – ADVANCEMENTS IN TECHNOLOGY AND DESIGN OF LOW CARBON CONCRETE

9:30 **Keynote Speech One**
Ir Prof Jinguang TENG, President, The Hong Kong Polytechnic University
" FRP-UHSC-Steel Double-Skin Tubular Members for Sustainable Structures "

10:00 **Two Presentations**
Ir Jacky ZHONG, Senior Structural Manager, China State Construction Engineering (Hong Kong) Limited
" Greening the Concrete Jungle: Why Structural Engineers Hold the Keys "

Dr Ivan SHAM, Chief Commercial Officer, Nano and Advanced Materials Institute (NAMI)
" Our R&D Journey on MiC: Materials, Design & Implementation "

10:30 **Tea Break**

SESSION TWO –THE SUPPLY-SIDE OF LOW CARBON CONCRETE MATERIALS

10:45 **Keynote Speech Two**
Mr Ivan FU, Chairperson, Committee on Environment, Construction Industry Council (CIC)
" The Opportunities for Low Carbon Materials "

11:15 **Two Presentations**
Ir Alan CHAN, Technical Manager, Hong Kong Concrete Limited (Member of Hong Kong Construction Materials Association)
" Opportunities and Challenges on Production and Application of Low Carbon Concrete with Ground Granulated Blast Furnace Slag (GGBS) "

Ir Raymond CHEUNG, Director, Green Island Environmental Technologies Limited
" Quality Assurance in Production of GGBS "

11:45 **Morning Panel Discussion**
Moderator - Ir Jenny F YEUNG, Chairperson, Standing Committee on Concrete Technology (SCCT)

12:00 **Forum Lunch**

13:30 **Afternoon Opening Speech**
Ir Dr Raymond W M CHEUNG, JP, Head of Geotechnical Engineering Office, Civil Engineering and Development Department

SESSION THREE –SMART APPLICATIONS OF LOW CARBON CONCRETE

13:45 **Keynote Speech Three**
Ir Thomas LAU, Head of Civil Engineering, Mass Transit Railway Corporation (MTRC)
" Boosting Concrete with GGBS for Sustainable and Low-Carbon Solutions "

14:15 **Two Presentations**
Ir Ka Yan CHU, Senior Project Engineer, Gammon Construction Limited
" Adoption of Ground Granulated Blast Furnace Slag (GGBS) Concrete in Deep Foundation "

Mrs Christine COURTEL, Independent Concrete Expert, Bouygues Travaux Publics
" A Case Study of GGBS Concrete for Critical Structure and Early Strength in Trunk Road T2 Project "

14:45 **Tea Break**

SESSION FOUR – INNOVATIONS IN LOW CARBON TECHNOLOGY

15:00 **Keynote Speech Four**
Ir Dr Tommy LO, Chairman, Materials Division of Hong Kong Institution of Engineers
" PCMs Energy Storage Technology: Green Concrete Construction "

15:30 **Two Presentations**
Dr Zhenyu HUANG, Associate Professor, Shenzhen University
" Recent Development and Application of Lightweight Low Carbon LC3 Concrete "

Dr Hailong YE, Assistant Professor, The University of Hong Kong
" Cement-Free GGBS Binders and Concrete for Green Construction "

16:00 **Closing Presentation**
Prof Jianzhuang XIAO, Vice President, Guangxi University
" Research Progress on 3D Printed Concrete with Recycled Materials "

16:15 **Afternoon Panel Discussion**
Moderator – Ir Prof Richard PANG, Adjunct Professor, Hong Kong Chu Hai College and The University of Hong Kong

16:30 **Closing Remarks**
Ir Aaron K M BOK, Immediate Past President, Hong Kong Institution of Engineers

16:40 **Group Photos**

17:00 **End of Forum**

WELCOME MESSAGE

Ir Michael H S Fong, JP
Director of Civil Engineering and Development

I would like to extend a warm welcome to all distinguished guests and participants of the Annual Concrete Forum 2023.

The Hong Kong SAR Government announced the Climate Action Plan 2050 in 2021, with the vision of achieving a "Zero-Carbon Emissions • Livable City • Sustainable Development", outlining the strategies and targets for combating climate change and achieving carbon neutrality. The construction industry in Hong Kong has taken up an imperative role in the economic and infrastructure development in Hong Kong. It therefore bears the important social responsibility in responding to the climate call. As construction materials constitute about 11% embodied carbon and concrete is a major material used in construction, the Development Bureau (DEVB) has committed to spearheading the wider adoption of low carbon concrete in Hong Kong.

The Standing Committee on Concrete Technology (SCCT), administrated by the Civil Engineering and Development Department under the DEVB, organises the Annual Concrete Seminar every year, with the objective of sharing experiences on the latest development in concrete technology. Amidst the pandemic in the past few years, the Annual Concrete Seminar 2022 was successfully held in hybrid mode with the theme “Low Carbon Concrete on the Move”.

With a view to driving the momentum of this low carbon concrete initiative, the SCCT has joined hands with key industry stakeholders and professional institutions, including the Hong Kong Institution of Engineers (HKIE), the Hong Kong Construction Materials Association, the Hong Kong Concrete Institute, and with the support of the Construction Industry Council, to organise the signature event this year. The event has been designed to serve as a platform for stakeholders and professionals in the field to share their expertise and exchange their views on the opportunities and challenges on the path towards low carbon concrete construction in Hong Kong. Therefore, the event has been specially named as the Annual Concrete Forum with the theme of "Towards Climate-Friendly Concrete Construction."

We hope that the Forum will mark an important milestone while we shall continue our concerted efforts in encouraging the wider and innovative use of low carbon construction materials, thereby contributing towards Hong Kong's sustainable development.

MESSAGE FROM THE ORGANISING COMMITTEE

Ir Jenny F Yeung
Chairperson of Organising Committee of
Annual Concrete Forum 2023 and
Standing Committee on Concrete Technology

On behalf of the Organising Committee, I would like to sincerely welcome all honourable guests, prestigious speakers, industry experts and fellow colleagues to the Annual Concrete Forum 2023.

With more focus than ever on embodied carbon in construction, there has been an imminent need for the construction industry to transform from the traditional use of concrete with a large carbon footprint to the innovative use of low carbon concreting materials. Under the theme of "Towards Climate-Friendly Concrete Construction.", the annual event of the Standing Committee on Concrete Technology (SCCT) this year is staged as a special occasion for the construction and concrete industry stakeholders to align vision and mission towards our common goal of carbon reduction.

Through the preparation of the Forum, the SCCT is very pleased to have worked closely with Organising Committee Members coming from different sectors, including professional bodies, universities, concrete and material testing industries etc. Members' efforts, especially in identifying speakers, securing sponsors, promotion of the Forum among their respective networks, as well as providing valuable advice in every aspect, are gratefully acknowledged.

I would also like to express our gratitude to the senior management of the Development Bureau and SCCT' s member departments for their utmost support. Heartfelt thanks are extended to our distinguished speakers, all of them are renowned experts in the field and some of them have come from Mainland China specially for this event. Special thanks to our supporting organisations and sponsors for their assistance in various aspects. Last but not least, the presence of each of the participants means a lot to us as the Forum could not have materialised without you. The popularity of the Forum also reflects that the construction industry as a whole is heading to the same direction in helping the city to progressively achieving carbon neutrality.

HONOURABLE SPEAKERS AND MODERATOR

MORNING OPENING SPEECH

Ir Roger Y L Wong, JP
Deputy Secretary for
Development (Works) 2, DEVB

In March 2022, Ir Roger Y L Wong was appointed as Deputy Secretary for Development (Works) 2 to oversee public works policy and infrastructure development.

Ir Wong joined the Hong Kong Government in 1995 as an Assistant Engineer. Before joining the Development Bureau (DEVB), he worked in the Highways Department, Civil Engineering and Development Department and Water Supplies Department and oversaw the strategic planning and implementation of various highway, new development area and water supply projects.

AFTERNOON OPENING SPEECH

Ir Dr Raymond W M Cheung, JP
Head of Geotechnical
Engineering Office, CEDD

Ir Dr Raymond W M Cheung has more than thirty years' experience in civil and geotechnical engineering. He has been participated in a number of mega infrastructure projects in Hong Kong under the Airport Core Programme, including Chek Lap Kok International Airport reclamation, Airport Railway and Western Harbour Crossing, before joining the Hong Kong SAR Government in the late 1990s. He is a member of various international technical committees such as the European School Scientific Committee of Landslide Risk Assessment and Mitigation (LARAM) and the International Network on Landslide Early Warning Systems (LandAware). He is currently Head of the Geotechnical Engineering Office (GEO) of the Civil Engineering and Development Department (CEDD) overseeing control of geotechnical works, setting geotechnical standards, testing and development of construction materials, mining operation and quarrying, cavern and underground space development, the Landslip Prevention and Mitigation Programme, and the landslide emergency services.

HONOURABLE SPEAKERS AND MODERATOR

MODERATOR

Ir Prof Richard Pang
Adjunct Professor of
Department of
Civil Engineering,
Hong Kong Chu Hai College

Richard is a Fellow of the Hong Kong Institution of Engineers (HKIE) and a RPE in the Civil, Geotechnical and Structural Disciplines.

Richard had served as a Deputy Head of GEO and Assistant Director (Technical) of CEDD of the HKSAR Government. He was a former Chairman of the Standing Committee on Concrete Technology. He had also served as the Director - Industry Development of the Construction Industry Council.

Richard was a former Chairman of the HKIE Geotechnical Division. He is an adjunct professor in the Department of Civil Engineering of the Hong Kong Chu Hai College and the University of Hong Kong.

CLOSING REMARKS

Ir Aaron K M Bok
Immediate Past President,
HKIE

Ir Aaron K M Bok is a Registered Professional Engineer in Civil Discipline and a Fellow of Hong Kong Institution of Engineers (HKIE) and Hong Kong Institution of Highways and Transportation. He has served different departments and bureau in the Government including Water Supplies Department, Transport Department, Highways Department, Civil Engineering and Development Department (CEDD) and Development Bureau over his 37 years' services. Before retirement in 2021, he was the Head of Civil Engineering Office of CEDD. Currently, Ir BOK serves as Project Team Leader in the Health Projects Unit of CEDD.

Ir BOK has wide experience on traffic and transport planning, new town development, policy formulation, major reclamations and planning, design and construction of major infrastructures projects, including the Hong Kong-Zhuhai-Macao Bridge, Central – Wan Chai Bypass and Island Eastern Corridor Link, Widening of Tuen Mun Highway/ToloHighway/Fanling Highway, Lung Mei Artificial Beach, Central Kowloon Route, Lung Kwu Tan reclamation and replanning, site formations and infrastructures for over 80 housing developments; and the construction of quarantine units that help combat COVID-19, etc. He was elected as an Election Committee Member (Engineering Subsector) in 2021. He is also a Director of the Engineering Forum, a Board member of Engineers Registration Board as well as the School Managers of three schools. He is currently a member of the Aviation Development and Three-Runway System Advisory Committee and a co-opt member of the Advisory Committee on the Northern Metropolis Subcommittee on Transport and other infrastructures. Ir Bok was the President of the HKIE in the 2022/23 session and is now the Immediate Past President.

SESSION ONE – ADVANCEMENTS IN TECHNOLOGY AND DESIGN OF LOW CARBON CONCRETE

KEYNOTE SPEECH ONE

FRP-UHSC-STEEL DOUBLE-SKIN TUBULAR MEMBERS FOR SUSTAINABLE STRUCTURES

Prof Jin-Guang Teng
President, The Hong Kong Polytechnic University

Professor Jin-Guang Teng, President and Chair Professor of Structural Engineering of The Hong Kong Polytechnic University, is a Member of the Chinese Academy of Sciences, a Corresponding Fellow of the Royal Society of Edinburgh and a Fellow of the Hong Kong Academy of Engineering Sciences.

His main research areas include the structural use of fibre-reinforced polymer (FRP) composites in construction and steel structures. Many of his research findings have been adopted by relevant design codes/guidelines in China, the United States, Europe, the United Kingdom and Australia. The research awards he has received include the State Natural Science Award of China (Second Class) and the inaugural IIFC Medal from the International Institute for FRP in Construction (IIFC).

ABSTRACT

The rapid development of concrete technology over the past two decades has allowed the strength of concrete incorporating coarse aggregate to go beyond 150 MPa. Such concrete, referred to as ultra-high strength concrete (UHSC), possesses great potential in creating a sustainable future for infrastructure due to its high strength-to-weight ratio. However, the practical use of UHSC remains to be properly explored due to a lack of research at both material and structural levels as well code provisions for concrete at such high strengths. At the structural level, research is needed to address the issue of inadequate ductility and the need for structural member forms that cater for a very high compressive strength of concrete in combination its much lower tensile strength and relatively low elastic modulus.

Against the above background, this presentation provides a summary of results from a recent study undertaken at The Hong Kong Polytechnic University (PolyU) on the development of a new UHSC and its use in an innovative structural member form that is referred to as FRP-concrete-steel double-skin tubular members (DSTMs) previously invented at PolyU. The research programme started with investigations into the properties (e.g., compressive strength, tensile strength, and shrinkage properties) of a UHSC which was made with commercially available raw materials. Laboratory tests on the structural behaviour of DSTMs incorporating the new UHSC (i.e., FRP-UHSC-steel DSTMs) were then conducted, demonstrating their excellent mechanical resistance and good ductility. The presentation will conclude with a discussion of the carbon footprint of these innovative structural members: the high material strength of UHSC combined with the strong durability enabled by the FRP tube ensures the low carbon footprint of these FRP-UHSC-steel DSTMs.

SESSION ONE – ADVANCEMENTS IN TECHNOLOGY AND DESIGN OF LOW CARBON CONCRETE

PRESENTATION

GREENING THE CONCRETE JUNGLE - WHY STRUCTURAL ENGINEERS HOLD THE KEYS

Ir Jacky Y Zhong
Senior Structural Manager, China State Construction Engineering (HK) Ltd

Ir Jacky Y Zhong, MHKIE, RPE(STL), MIStructE, CEng, CCBM, 1RSE-PRC(GBA), MIET, with more than 13 years of practical experience in building and civil engineering projects in the Greater Bay Area, currently serves as a Senior Structural Manager at the China State Construction Engineering (Hong Kong) Limited, a Deputy Structural Director of China State Construction International Medical Industry Development Co., Ltd., a Part-time Lecturer (Non-clinical) in the Department of Civil Engineering at The University of Hong Kong, as well as the Director of the Architectural, Engineering and Construction Professionals Committee, Hong Kong Chamber of Commerce, Qianhai.

His research interest covers smart construction technology, low carbon material, digitalization, high-rise building, seismic engineering and has published around 10 nos. of research articles in high-ranked journals. With great enthusiasm for structural engineering, he specializes in the design and technical management of complex and large-scale projects by adopting innovative approaches and digital solutions. He has been involved vigorously in various types of significant development projects in Hong Kong, Macau, and Mainland China. The projects he has participated in have won multiple awards, such as the HKIE Structural Division Structural Excellence Award, China Construction Engineering Luban Prize (Overseas Projects), etc.

Ir Zhong adheres to the principle of 'Leveraging Hong Kong's strengths to serve the needs of the country,' actively offering advice and suggestions to the governments of mainland cities in the Bay Area, promoting Hong Kong' s project management practice, international standards, and advanced technologies, etc.

ABSTRACT

This presentation provides recent advancements in the technology, design and construction of low carbon structures, and proposes a holistic approach to achieve low carbon project delivery – "**Integrated Design, Smart Construction, Lower Carbon, Higher Performance**". As Hong Kong plays a key role to lead in technology development, global collaboration, and policy support in pursuit of carbon neutrality. A rethinking to establish a conceptual framework of "**Ecosystem**" for the sustainable urban development of Hong Kong and the rest of cities in the Greater Bay Area (GBA) is proposed.

Since a building' s structure contributes to approximately 50% of its embodied carbon, the role of structural engineers is crucial in the pursuit of carbon neutrality. At material level, low carbon concrete with SCM such as GGBS has been widely adopted in the projects worldwide. To minimize embodied carbon, the most critical step for structural engineers is to carefully select appropriate materials and utilize them with maximum efficiency. At structure level, optimizing the design of reinforced concrete structures contributes to the reduction of global carbon emissions and decreases construction costs in buildings. The advanced techniques of structural optimization, covers the parametric modelling, structural topology optimization, etc., will be elaborated with examples. DfMA approach that aims to achieve high-productivity construction is promoted. At project Level, the whole life cycle CO_2 will be optimized by applying BIM-based life-cycle assessment (LCA) method. A comprehensive cradle-to-grave investigation of embodied carbon and operational carbon, and effective measures in the design and construction with multi-disciplinary collaboration are the keys to success.

Further, to promote the Greater Bay Area in its pursuit of becoming a world-class region of carbon neutrality, it is proposed to establish an "**ecosystem**" that comprises the elements of new development philosophy, policy support, GBA collaboration, technology advancement, GBA standards, and youth development.

SESSION ONE – ADVANCEMENTS IN TECHNOLOGY AND DESIGN OF LOW CARBON CONCRETE

PRESENTATION

OUR R&D JOURNEY ON MIC: MATERIALS, DESIGN & IMPLEMENTATION

Dr Ivan Sham
Chief Commercial Officer, NAMI

Dr Ivan Sham (PhD (HKUST), MBA (Strathclyde)) is Chief Commercial Officer (CCO) cum R&D Director of Construction at NAMI, a HK government-funded R&D institute on advanced materials. As CCO, Dr Ivan Sham oversees the applications and impact of the corporate level of NAMI technologies, and strategic collaboration with the industries and various government departments. As R&D Director, he leads a team of 35 scientists and professional engineers focusing on advanced cementitious materials, polymeric materials and structural analysis with PhD in materials science, chemistry, engineering, etc.

He was an Outstanding Alumnus of Mechanical Engineering of HKUST and a Croucher Post-doc Fellow. He has over 50 publications in international peer-reviewed journals/conferences and 15 granted patents in the US and China.

Dr Sham was the Chairperson of IEEE-CPMT (HK Chapter, 2009-10), and a member of the council of IOM3-HK Chapter since 2018. He is now a Fellow of IOM3.

ABSTRACT

According to the announced Hong Kong's Climate Action Plan 2050, energy saving and green buildings will be of primary importance, aiming to reduce the electricity consumption of commercial and residential buildings. In fact, in relation to the latest Hong Kong Energy End-use Data 2021, air-conditioning is the largest source of electricity consumption in residential and commercial buildings, representing 26% and 22% of the total respectively. Obviously, concrete is still the major building material for buildings in Hong Kong, it would be highly desirable if new-generation concrete technologies with superior thermal insulation could be identified and applied in compliance with the local building ordinance.

In addition, the Government of HKSAR has been proactively advocating Modular-integrated-Construction (MiC) to enhance productivity, safety and sustainability of the construction industry. Nevertheless, some technical issues of MiC are still worthwhile to be properly investigated for better adoption. The concrete-based MiC module is generally small and heavy due to the normal concrete density (2400kg/m^3), and the internal configuration relatively lacks flexibility due to the consideration of the overall structural stability of the module after wall removal. Although the steel-based MiC module is favourable for light weight, flexibility for connecting modules and large-size room space, the drywall system with rock wool inside, which is most commonly adopted at present in steel MiC module, is not always preferred by some users particularly residential owners.

To address the above mentioned emerging demands from energy saving, and sustainable buildings to MiC markets, in this talk we will introduce an innovative hybrid MiC system approach, from materials, design to implementation. A high-performance lightweight concrete material has been introducing to the industries with 40% lighter in weight, C25/C35 grade compressive strength and 3 times better thermal insulation when compared to normal concrete. A new generation lightweight hybrid steel-concrete module is established which could achieve a large module size but with reasonable weight (12-14 tons for a module of 6m long). This lightweight concrete wall can also provide sufficient anchorage strength (4000N) for direct high-level wall cupboard installation, superb fire and acoustic resistance, and long-term durability similar to normal concrete. As a result, this hybrid steel-concrete MiC can provide the same “user experience” as traditional concrete-based buildings to the occupants, while all the other advantages due to the steel MiC construction can also be demonstrated. On top of that, the superior thermal insulation can enable modules made of this foamed concrete can possess potentially considerable electricity savings.

We believe this lightweight and energy-saving concrete for MiC will truly provide buildings with thermal regulating, literally “warm in the winter and cool in the summer (冬暖夏涼)” feature for the building sustainability of Hong Kong.

SESSION TWO - THE SUPPLY-SIDE OF LOW CARBON CONCRETE MATERIALS

KEY NOTE SPEECH TWO

THE OPPORTUNITIES FOR LOW CARBON MATERIALS

Mr Ivan Fu
Chairperson of Committee on Environment, CIC

Mr Ivan Fu is a Director of LWK + PARTNERS and CEO of its holding company, with over 30 years of industry experience. He has been extensively involved in projects across Greater China and Asia Pacific, while leading the Group through its diversification from architectural design into urban planning, interiors, landscape, heritage conservation and digitalisation. The Group employs over 1,000 members of staff. Ivan has been participating actively in various public platforms in Hong Kong and mainland China, including statutory bodies like Town Planning Board, Construction Industry Council, Urban Renewal Fund, Enhancing Self-Reliance Through District Partnership Programme and China Green Building Council. Ivan is particularly interested in conservation and sustainability in social and environmental sense. He involved in various forward looking projects to address social needs and environmental issues. Projects like Blue House, Light Housing, homeless home are well received by the public with social impact. He is appointed a Justice of the Peace and is a Medal of Honour recipient in Hong Kong SAR.

ABSTRACT

The HKSAR Government has announced its commitment to achieving carbon neutrality in Hong Kong before 2050. With the construction sector responsible for around 40% of global energy-related emissions, it plays a crucial role in meeting this target. Concrete is undeniably the most ubiquitous material globally, owing to its exceptional strength, durability, and the widespread availability of its constituents. However, concrete bears an enormous carbon footprint compared to other construction materials, with cement production for concrete alone accounting for a staggering 8% of global carbon emissions.

Hong Kong's construction industry will reach HK$300 billion per year over the next decade. The demand for residential housing in Hong Kong is also expected to reach 430,000 units. To minimize the environmental impact of the emerging construction and meet global sustainability goals, using low-carbon concrete becomes more urgent and imperative.

But several barriers need to be overcome in embracing the low carbon concrete, including policy gaps, lack of incentives, supply chain barriers and limited awareness and demand. This speech will focus on promoting low-carbon concrete in Hong Kong, specifically addressing policy readiness, government support, supply chain improvements, and private sector involvement. It will highlight successful low-carbon concrete projects and provide recommendations for further promotion.

The Construction Industry Council (CIC) has taken proactive steps to reduce carbon emissions in the construction industry. CIC initiatives such as the CIC Carbon Assessment Tool, CIC Green Product Certification, CIC Sustainable Finance Certification Scheme and iBeam Unison will be highlighted in the speech. These initiatives aim to accelerate the reduction of carbon emissions and promote sustainability in the construction industry.

In conclusion, the construction sector's transition to low-carbon concrete is crucial for mitigating environmental impact and achieving sustainability goals. Through collaborative efforts and the implementation of initiatives by organizations like the CIC, Hong Kong can drive industry-wide change and create a more sustainable future.

SESSION TWO - THE SUPPLY-SIDE OF LOW CARBON CONCRETE MATERIALS

PRESENTATION

OPPORTUNITIES AND CHALLENGES ON PRODUCTION AND APPLICATION OF LOW CARBON CONCRETE WITH GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ir Alan Chan
Technical Manager,
Hong Kong Concrete Ltd (Member of HKCMA)

Ir Alan Chan has been working in concrete industry for over ten years after graduation from the Bachelor degree of Materials Engineering in the City University of Hong Kong. As a Technical manager, he is responsible for the R&D of concrete mix design, quality control of raw materials and concrete products, and provide technical advices and solutions for different infrastructure projects. He is also one of the representatives of Hong Kong Construction Materials Association - Ready Mixed Concrete Committee (HKCMA - RMCC) Technical sub-committee to provide technical consultancy on concrete related specification with different parties.

ABSTRACT

Achievement of carbon neutrality before 2050 is an ultimate goal for Hong Kong's Climate Action Plan in response to the Paris Agreement. Green Buildings has been classified as one of the four major decarbonization strategies in the plan. Cement is regarded as the key ingredient for the high carbon footprint of the concrete mix due to the huge energy consumption in the manufacturing process. In view of this situation, concrete suppliers play an important role to strive for the goal of carbon neutrality with using different green materials to replace conventional cement in the ready-mixed concrete production such as Ground Granulated Blast-furnace Slag(GGBS). In the presentation we will discuss about the opportunities and challenges on the application and production of GGBS concrete as well as the supply of GGBS for the demand of Hong Kong market.

SESSION TWO - THE SUPPLY-SIDE OF LOW CARBON CONCRETE MATERIALS

PRESENTATION

QUALITY ASSURANCE IN PRODUCTION OF GGBS

Ir Raymond Cheung
Director, Green Island Environmental Technologies Ltd

Ir Cheung is a Chartered Engineer and a Registered Professional Engineer in Chemical Engineering. He has over 29 years of cement plant operation and process engineering experience in the cement process and air pollution control technology. He is now a Division Manager in Green Island Cement Co. Ltd, responsible for the overall operation of the cement plant and Director of Green Island Technologies Limited, responsible for the development of the environmental business of the Company.

Ir Cheung was one of the Project Management Team members and was the Commissioning Manager of the new GBFS grinding plant.

ABSTRACT

GGBS is a low embodied carbon cementitious material which will help to reduce the carbon footprint of concrete significantly. As compared to OPC and PFA, it is relatively new to the HK Construction Industry. This presentation will present how it is prepared and how it performs differently to OPC and PFA, and what to look at in setting up a QA scheme for the GGBS concrete production.

GGBS is well known of its low embodied carbon, superior performance in term of preventing chloride ion permeability, and reduce thermal stress of hardened concrete. It is produced from finely grinded Granulated Blast-furnace Slag (GBFS), a by-product in the steel refinery industry. In the process, limestone is added to the iron ore to extract the “impurities” from the iron melt, forming slag which has very close chemical composition as cement clinker. The slag is removed from the furnace and is water quenched to keep the minerals in glass state rather than crystal state in order to maintain its reactivity. Therefore, the chemistry of slag inherent from the feed stock and the glass content associated by the process of the Blast-furnace determine the inherent pozzolanic properties of the final GGBS.

Similar to the production of cement, the reactivity of slag is released by fine grinding the GBFS, that is increasing its surface area to react with water. Vertical roller mills are employed for this operation as this type of mill usually integrated with a separator on its upper part and allows a high volume of hot gas flow through the mill circuit as carrier and drying gas, hence allows grinding of high moisture raw material such as GBFS which usually contains 10% moisture or higher.

The grinding process is crucial to the performance of GGBS as it affects the concrete performance in terms of workability, activity and its optimal percentage in mix design. The coarse portion is inactive in the hydration process and acts as very fine aggregate in the concrete only. The over-fine portion is highly reactive and affects the setting behaviour of the fresh concrete, hence the workability, slump retention and use of admixtures in concrete. A finely controlled grinding process will hence provide the concrete producer a consistent GGBS performance. These control measures include control of material depth at grinding table, pressure of roller, air flow across the mill, speed of separator and a particle size analyser on the finish product.

While GGBS is specified in General Specification for Building to comply BS EN15167-1, the fineness and activity index requirements are far from the industrial norm to produce quality structural concrete. It is advised that a more stringent requirement is set in the General Specification for its use in structural concrete.

SESSION THREE - SMART APPLICATIONS OF LOW CARBON CONCRETE

KEY NOTE SPEECH THREE

BOOSTING CONCRETE WITH GGBS FOR SUSTAINABLE AND LOW-CARBON SOLUTIONS

Ir Thomas Lau
Head of Civil Engineering, MTRC

Ir Thomas Lau obtained his first degree in Civil and Structural Engineering from the University of Hong Kong in 1998, and the Master of Art in Transport Policy and Planning from the University of Hong Kong in 2002.

Upon graduation in 1998, Thomas joined an international consultancy firm and has acquired extensive experience in engineering design and project management for large-scale infrastructure projects, such as West Rail, Central Reclamation, Dubai Metro, Central Wanchai Bypass, West Island Line, South Island Line, Shatin Central Link and High Speed Rail.

Since 2010, Thomas has joined MTR Corporation Limited (MTRCL) and has taken a key role in the design management of the High Speed Rail Project.

Since 2014, Thomas has joined the Civil Division of HKIE as a committee member. In 2016, Thomas was elected as an Elected Ordinary Member of the Council of the HKIE Headquarter. In 2018, Thomas was elected as an Executive Member of the HKIE Headquarter.

Currently, Thomas is the Head of Civil Engineering (Capital Works) leading a group of subject matter experts, in Civil, Geotechnical, PWay and Material disciplines, to support different project teams to deliver the RDS-2014 new extension projects.

ABSTRACT

The MTR Corporation has committed to reduce carbon emission on the carbon footprint of operation of existing rail networks and embodied carbon from construction activities for new railway lines. The Corporation has demonstrated a dedication to sustainability by the early adoption of Pulverised Fuel Ash (PFA) and Ground Granulated Blast-furnace Slag (GGBS) since 1998, despite it was not being a common requirement in industry.

While GGBS is a proven green material that enhances concrete sustainability and durability, challenges remain regarding its early concrete strength and limited usage in Hong Kong. To promote the utilization of GGBS and hence to reduce the embodied carbon of concrete in construction projects, a comprehensive study was conducted in collaboration with the Hong Kong Institution of Engineers – Materials Division and the Civil Engineering Development Department.

The primary objective of the study is to optimize concrete mixes with high percentages of GGBS by evaluating their impact on early strength development and durability. The technical findings and analysis were presented at the Materials Science and Technology in Engineering Conference (MaSTEC) in November 2023. The study revealed that, compared to Portland cement (PC) and PFA under the same curing conditions, GGBS mixes exhibited lower early strength, particularly with higher than 65% GGBS replacement. However, over a period of 28 days, the strength difference between GGBS mixes and PC/PFA diminished. Additionally, GGBS mixes demonstrated lower temperature rise during curing, improving concrete durability and reducing the risk of thermal cracking when compared to ordinary PC and PFA concrete.

The research outcomes provide valuable insights and encourage the application of high percentages of GGBS in various structural elements of future railway projects. By boosting concrete mixes with GGBS, significant reductions in carbon emissions can be achieved, contributing to sustainable and low-carbon construction practices. Furthermore, from the client's perspective, a roadmap will be developed to specify the minimum dosage of GGBS to be adopted for future Projects.

This study contributes to the growing understanding of GGBS utilization in the construction industry, emphasizing its potential for reducing carbon emissions and promoting sustainable practices. The findings serve as a guide for stakeholders to adopt GGBS in a wider extent as green materials in construction projects.

SESSION THREE - SMART APPLICATIONS OF LOW CARBON CONCRETE

PRESENTATION

ADOPTION OF GROUND GRANULATED BLAST FURNACE SLAG (GGBS) CONCRETE IN DEEP FOUNDATION

Ir Ka Yan Chu
Senior Project Engineer,
Gammon Construction Ltd

Ir Chu Ka Yan is a Senior Project Engineer at Concrete Technology Department in Gammon and obtained Master of Science in Civil Infrastructural Engineering and Management from Hong Kong University of Science and Technology. She is dedicated to concrete technology related to sustainability and currently provides technical support aspects of concrete to construction teams including the development of Grade 60 GGBS tremie mix implemented in Gammon foundation project.

ABSTRACT

Today, concrete is the most widely utilized construction material globally, with three tonnes per year used for every person in the world. In fact, it is the highest consumed product on earth besides water. However, the production of Portland cement - an essential constituent of concrete - leads to the release of significant amounts of CO_2, a greenhouse gas (GHG); production of one ton of Portland cement produces about one ton of CO_2 and other GHGs. Concrete, therefore, has a colossal carbon footprint.

Gammon recently investigated new alternatives for more sustainable concrete mixes including the use of ground granulated blast-furnace slag (GGBS) and CarbonCure technology which injects waste carbon dioxide into the mixing process. Of which, the use of GGBS in a Grade 60 tremie concrete mix that we have already successfully used on one of our foundations' projects.

However, GGBS concrete is not the same as PFA concrete commonly used in infrastructure projects. It' s no secret that utilizing sustainable raw materials in concrete can be more expensive than conventional products because the source of advanced materials is unstable or limited in Hong Kong. We have our procurement and sustainability department to source all sustainable concrete materials. There are also certain challenges including the lack of guidelines associated with advancing technology in the local market, adding facilities into limited-sized batching plants, and no confidence from clients when piloting use.

After designing GGBS concrete mixes, we considered our supply capacity, extra silo for materials storage, and confidence from clients. Therefore, we carried out a series of trials for verification before adoption and closely communicated with our GGBS supplier to guarantee the required quantity. Our whole team is dedicated to implementation of the GGBS concrete and trying to strive for excellence on the concrete performance.

The successful development and field application of GGBS Concrete in bored piles has not only proved the concrete is high potential to widely adopt in foundation projects, but also demonstrated a continuous decarbonisation improvement to various stakeholders of construction industry. The eventual elimination of coal use at Hong Kong' s power stations means PFA will no longer be produced. We aim to widely implement GGBS concrete mixes on a range of Gammon works in future.

SESSION THREE - SMART APPLICATIONS OF LOW CARBON CONCRETE

PRESENTATION

A CASE STUDY OF GGBS CONCRETE FOR CRITICAL STRUCTURE AND EARLY STRENGTH IN TRUNK ROAD T2 PROJECT

Mrs Christine Courtel
Independent Concrete Expert, Bouygues Travaux Publics

Christine, an independent Concrete Expert of Bouygues Travaux Publics, has more than 30 years worldwide experience in concrete mix design and in assistance to Bouygues Travaux Publics and Dragages Hong Kong Ltd. for concrete operations like Trunk Road T2, Central-Kowloon Route, MTR-1201, TM-CLK Link tunnel and varies public projects in the past years.

In 2018 and 2000, she had involved in designing and quality controlling the concrete mixes more than 100,000 m^3 of D-wall made with self-compacting concrete with 65% GGBS for CYP Melbourne Metro Tunnel, Australia, and a concrete mix of precast concrete segment for a 7.16km long TBM-bored tunnel with 66% GGBS for Groene Hart Tunnel, Netherlands.

In 2022, her shotcrete design mix was awarded by the American Shotcrete Association for “Outstanding International Shotcrete Project of the Year” for West Connex Project 3A Project in Sydney, Australia.”

ABSTRACT

The construction industry is determined to reduce carbon emissions from concrete. The aim is to use less clinker by reducing the Ordinary Portland Cement (OPC) and encouraging the use of Supplementary Cementitious Materials (SCM) such as Pulverized Fuel Ash (PFA), Ground Granulated Blast-furnace Slag (GGBS), and other SCMs as much as possible.

However, the availability of PFA is significantly decreasing due to the phase-out of coal-fired electricity generation in Hong Kong. As a result, our major client, Civil Engineering and Development Department (CEDD), anticipates the need to replace PFA concrete with GGBS concrete in their new projects, including critical concrete elements.

Nevertheless, there is always a dilemma between productivity and reducing the percentage of OPC when it comes to the production cycle and critical elements.

In our case study of the Trunk Road T2 project, we will explain how the use of GGBS concrete with monofilament polypropylene (PP) fiber for casting overhead ventilation duct (OHVD) slabs of tunnel with spans up to 15 meters, enabling reduction of CO_2 emissions without affecting the production cycle and maintaining suitable fresh concrete properties.

Anticipating the future "disappearance" of PFA, two concrete mixes with GGBS (designed strengths of 45 MPa and 60 MPa) are specifically developed for casting long-span OHVD slabs that require early age compressive strength. These mixes have the specificity to contain PP fibers, limited design flow values due to the curved shapes of the structures, long workability retention, and early strength for formwork removal. The percentage of GGBS in the mixes has been optimized to significantly reduce the concrete emission factor compared with an equivalent PFA-based mix, while maintaining a reasonable limit to avoid impacting negatively the early age compressive strength.

Since 1955, Bouygues and Dragages have been renowned for their commitment to delivering innovative engineering solutions to the city. Over the past 30 years, we have consistently implemented the maturity method using the Arrhenius law to effectively control the in-situ compressive strength of concrete before striking the structures. This approach has been successfully applied to various projects, including the Kwun Tong Bypass, Taikoo Shing, and more recently, the CEDD's Liantang and Trunk Road T2 projects.

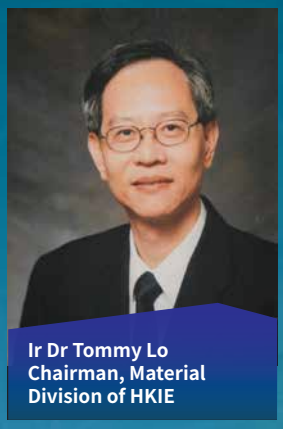
To reduce a substantial amount of CO_2 emissions from concrete in Hong Kong, the use of GGBS should not be limited to foundation works, massive structures, and base slabs where early strength is not required. It should be extended to concrete structures that require PP fiber concrete with controlled early striking for in-situ lining and OHVD structures for tunnel projects, as well as precast segmental lining, which constitutes a significant volume of concrete in tunnel works.

Furthermore, the upcoming use of new generations of admixtures and suitable types of slag activators will make it possible to greatly increase the percentages of GGBS for casting such elements, moving towards achieving zero concrete carbon emissions.

SESSION FOUR - INNOVATIONS IN LOW CARBON TECHNOLOGY

KEY NOTE SPEAK FOUR

PCMS ENERGY STORAGE TECHNOLOGY: GREEN CONCRETE CONSTRUCTION



Ir Dr Tommy Lo
Chairman, Material Division of HKIE

Ir Dr Tommy Lo retired from Department of Architecture and Civil Engineering, City University of Hong Kong. Chairman of Materials Division and Fellow member of Hong Kong Institution of Engineers (HKIE). He is also Fellow of Hong Kong Institute of Concrete and Honorary fellow of Guangdong Institution of Engineer. In 2018, Dr Lo was awarded Natural Science Award (2nd Class), GuangDong Province, People Republic of China. He was listed as top 2% most highly cited scientists, according to metrics compiled by Stanford University 2021.

ABSTRACT

Phase Change Materials (PCMs) Energy Storage Technology is an active solution towards carbon neutrality. PCMs serves as highly efficient thermal energy storage mediums, proficient in absorbing and releasing thermal or cold energy during the physical phase change. Cool storage with phase-change materials can help balance the daily ups and downs of electrical power consumption, cutting energy costs and promoting more efficient energy use, savings can be substantial. The integration of PCMs into concrete changed the thermal energy storage capacity of building envelopes, thus introduced a novel temperature regulator for indoor temperature of buildings. PCMs concrete alters the thermal response characteristics of structures, thereby reducing the impact of temperature fluctuations on their interactions with surroundings. In this presentation, phase change material-enhanced concrete and the potential application of PCMs-enhanced energy storage systems in buildings will be introduced. The experimental results on a competitive renewable energy exchange model study using PCM buried pipes within pile foundations harnessing shallow geothermal energy will be presented. The objective of the study is to enhance ground-source heat pump systems, optimizing geothermal energy utilization. PCMs energy storage technology contributes to the versatility and sustainability of green concrete and low carbon technology.

SESSION FOUR - INNOVATIONS IN LOW CARBON TECHNOLOGY

PRESENTATION

RECENT DEVELOPMENT AND APPLICATION OF LIGHTWEIGHT LOW CARBON LC3 CONCRETE

Dr. Zhenyu Huang
Associate Professor and Assistant Dean of the College of Civil and Transportation Engineering, Shenzhen University

Dr Zhenyu Huang is an Associate Professor and Assistant Dean of the College of Civil and Transportation Engineering at Shenzhen University, P.R.China. He is one of the deputy directors of Guangdong Provincial Key Laboratory of Durability for Marine Civil Engineering. In 2022, he was honored with the prestigious Outstanding Youth Fund of Guangdong Province. He obtained his PhD from National University of Singapore (NUS) at 2015. Subsequently, he served as a Postdoctoral Research Fellow at both the Center for Offshore Research and Engineering (CORE) and the SembCorp-NUS Joint Laboratory, affiliated with the same institution.

His main research focuses on the marine Resilient Materials and Composite Structures. He has published over 60 papers in International journal and conference focusing on the research and advancement of sustainable metal-composite materials and related technologies. He was selected for the World's Top 2% Scientists 2022 list (Single recent year impact). Moreover, he holds 20 patents in his field of expertise. His significant research impacts have been honored with numerous accolades, e.g., Dr Huang's work earned him the second prize at the prestigious Guangdong Provincial Science and Technology Progress Award. He has won the only one Best Composite Structure Paper Award at the 8th International Conference on Steel and Aluminum Structures (ICSAS 2016). Additionally, he secured the Best Paper Award at the International Conference on Engineering Research and Practice for Steel Construction (ICSC 2018).

ABSTRACT

Limestone calcined clay cement (LC3) offers a promising solution to the prevailing challenges in the cement and concrete industry, such as elevated carbon emissions, extensive energy consumption, and resource limitations. Comprising ordinary Portland cement (OPC) clinker, calcined clay, limestone powder, and gypsum, LC3 has garnered attention as an eco-friendly alternative.

This presentation aims to showcase recent advancements in the research and development of LC3-based materials, focusing on low carbon concrete and lightweight, highly ductile cement composites. The discussion will encompass aspects of material workability and mechanical properties, as well as the durability performance of both materials and structural members. Additionally, the presentation will delve into the flexural, shear, and dynamic impact behavior of LC3 concrete structures, including beams, columns, and more. The findings from this research offer crucial insights into the fundamental aspects of LC3 concrete, providing valuable information and guidance for the future application of LC3 binders in structural concrete.

SESSION FOUR - INNOVATIONS IN LOW CARBON TECHNOLOGY

PRESENTATION

CEMENT-FREE GGBS BINDERS AND CONCRETE FOR GREEN CONSTRUCTION

Ir Dr Hailong Ye
Assistant Professor of Department of Civil Engineering, HKU

Ir Dr Hailong YE is an Assistant Professor in the Department of Civil Engineering at the University of Hong Kong (HKU). He obtained his Ph.D. degree in civil engineering from The Pennsylvania State University and worked at The University of Sheffield, before joining HKU. Dr. Ye' s research interest includes cement chemistry, geopolymer and alkali-activated concrete, and corrosion control of concrete structures. He was listed in the top 2% scientists in the world for career-long impact in building and construction. His contribution to the fundamental understanding of concrete durability was recognized by the Natural Science Award from the Ministry of Education of China. Dr. Ye is a member of HKIE, ACI, ASCE, ACerS, and RILEM, and serves as an Editor of ASCE' s Journal of Materials in Civil Engineering and Elsevier journal CEMENT.

ABSTRACT

Concerns about the CO_2 emission related to ordinary portland cement manufacturing have driven the innovation and development of low-carbon construction materials. Cement-free alkali-activated material - sometimes called geopolymer cement - has been a promising option, as it could offer up to 90% reduction in CO_2 emission and its production is primarily based on the use of industrial byproduct, including granulated ground blast-furnace slag (GGBS). Nevertheless, the broad application of cement-free GGBS-based binders and concrete in the industry has been hindered partially due to the unclear durability and long-term performance. In this work, the durability performance of GGBS-based materials in extreme service conditions is discussed, particularly in the marine and sewer environments. In addition, this work introduces several innovative GGBS-based materials for both general and special applications, including marine binders, antimicrobial coatings, fire-resistant high-strength green concrete, “just add water” cement-free binders with comparable performance as conventional cement, and soil stabilizing agents.

SESSION FOUR - INNOVATIONS IN LOW CARBON TECHNOLOGY

CLOSING PRESENTATION

RESEARCH PROGRESS ON 3D PRINTED CONCRETE WITH RECYCLED MATERIALS

Dr Jianzhuang Xiao
Vice President,
Guangxi University

Dr Jianzhuang Xiao was born in 1968 and was promoted to a full professor in 2004 at Tongji University, Shanghai, China. He was the former Head of Structural Engineering Department, College of Civil Engineering, Tongji University. He was appointed as the vice president of Guangxi University in 2023. He has been engaged in fundamental research on material properties and structural behaviors of recycled aggregate concrete, including seismic behavior and fire performance, for more than 20 years. Recently, he studies the 3D printed concrete with recycled aggregates and recycled powder producing from construction & demolish waste.

He was awarded the Distinguished Young Scholars of China by the National Natural Science Foundation of PR China in 2013 and the Alexander von Humboldt Foundation Fellowship in Germany in 2004. He has won one second-class National Awards of Scientific and Technology Progress in China and 7 first-class Province/Ministry Awards of Scientific and Technology Progress in China. He has 56 authorized invention patents in China and 2 patents in Australia 3 patents in South Africa. He chaired 25 international and national academic conferences. He is the author of 4 Chinese monographs and 1 English monograph published by Springer. He gave more than 40 invited keynote speeches and was honored with the UKIERI Award in 2015 and the Outstanding Contribution in the Broad Field of Concrete Technology and Sustainability in 2018. He published more than 300 papers in the international journals with an H-index of 62. He was ranked the World's Top 2% Scientists (2020, 2021, 2022, 2023) in the field of Construction and Civil Engineering.

He edited the first Technical Code for Recycled Aggregate Concrete in China and technically supported the first 12-story recycled aggregate concrete structure in China. He was the Chairman of RILEM Technical Committee for Structural Behavior and Innovation of Recycled Aggregate Concrete and the director of the Recycled Aggregate Concrete Committee in China. Currently, he is the founder and executive-editor-in-chief of Journal of Low-carbon Materials and Green Construction (https://www.springer.com/journal/44242); Editor-in-chief of Journal of Asian Concrete Federation; Associate Editor-in-chief of Journal of Renewable Materials and Associate Editor-in-chief of Journal of Sustainable Structures; Editor of Journal of Building Engineering (Elsevier); Member of Technical Committee ADC: Assessment of Additively Manufactured Concrete Materials and Structures; Member of Technical Committee PFC: Performance requirements and testing of fresh printable cement-based materials.

ABSTRACT

3D printed concrete (3DPC) has been developed rapidly in recent years with its advantages of automation and digitization, and has received extensive research attention worldwide. In this study, recycled materials including recycled coarse aggregate (RCA), recycled fine aggregate (RFA) and recycled powder (RP) were used in 3DPC, and the fresh and hardened properties of 3D printed recycled concrete were investigated. The addition of RP increased the time loss of flowability, reduced the open time and increased the penetration resistance stress, which was related to the hydration variations. The addition of RP significantly increased the static yield stress, compressive strength and elastic modulus before hardened, illustrating the development of buildability. Using RFA as a sustainable substitution for natural aggregates highly increased the static yield stress, viscosity, and thixotropy, while improved deformation resistance and improved the buildability of 3DPC. The addition of RCA accelerated the loss of flowability and enhanced the overall buildability of the printed filament, which was associated with the high-water absorption of RCA. In summary, the application of recycled materials of 3DPC is still in the stage of single-component partial replacement or full replacement, and the low-carbon and economic additional properties of the prepared products are relatively low, the application of multi-component recycled materials combination and multi-component recycled materials is suggested to be explored in the future.