Dear Readers,

Our special themed edition covering research papers on various aspects of corrosion and its control in concrete structures (C3S) was very well received. We are pleased to share with you a sequel edition guest edited by Dr Radhakrishna G. Pillai and Dyana Joseline.

Dr Pillai is an associate professor in the Department of Civil Engineering at Indian Institute of Technology (IIT) Madras. He earned B.E. degree in Civil Engineering from the M. N. Regional Engineering. College (now MNNIT), Allahabad. Then, he earned M.S. and Ph.D. degrees in Civil Engineering at Texas A & M University, U.S.A. and has been passionate to combat corrosion of steel in reinforced and prestressed concrete structures. Beyond teaching in the areas of construction materials, concrete technology, and maintenance/repair of concrete structures, recently, he has been extending his research towards the extension of the residual service life of concrete structures through durable repair techniques such as cathodic protection. Most of his projects contribute to address the practical challenges and enhancing standards and specifications. He is also an active volunteer contributing to various association bodies like the Indian Concrete Institute (ICI), the NACE International Gateway India Section (NIGIS), and the International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM).

Dyana Joseline is a senior Ph. D. student in the Department of Civil Engineering at IIT Madras, Chennai, India. She holds an M. Tech. Degree in Structural Engineering from B.S. Abdur Rahman University, Chennai. Her Ph. D. work focusses on the scientific understanding of the corrosion mechanisms of prestressed steel in concrete, and the modification of existing practices of service life-based design and assessment of prestressed concrete structures. She aspires to build a career in academic research, conduct purpose-driven research and take it from lab to field. She has been involved in various technical activities of RILEM and NIGIS.

Production Editor
Indian Concrete Journal

Dear Colleagues,

Now-a-days, durability and/or service life based design of concrete structures is gaining acceptance worldwide. This is because of the realization that about 80% of structural failures are occurring due to the poor materials design of concrete, lack of timely inspections and repair, and eventual steel corrosion. In other words, the durability considerations in many structures today are severely inadequate and need significant improvements so that the onset of corrosion of steel reinforcement can be delayed. With this in mind, we bring you the second special edition of the Indian Concrete Journal (ICJ) focusing exclusively on the various aspects of corrosion and its control in concrete structures. This edition provides results from original research conducted in India and abroad on various approaches to combat corrosion in both existing and upcoming concrete structures.

India and many other countries have a large inventory of concrete structures that have not yet reached their desired service life (say, original design life) and are already experiencing severe corrosion damage (say, premature corrosion). According to the NACE IMPACT report published in 2016, such corrosion and subsequent repairs incur a total direct "cost of corrosion" of about 3.4% of global GDP; this is a higher value of 4.2% of GDP for India [1]. Moreover, if true data from all the concrete structures in India are collected, this cost could be much larger. Also, the indirect 'cost of corrosion' could be about 10 times more than that of the direct cost [1]. These are serious issues that need to be addressed by the civil engineers by bringing in durability and/or service life based design and construction approaches. Also, the condition of many structures indicates that soon, a large number of structures may experience severe corrosion and face the need of repair and repeated repairs – leading to significant replacement of materials and systems. Through personal discussions with top personnel in steel and cement industries, we came to know the 'hard-to-believe' facts that about 25% steel and cement made are used for repair, rehabilitation, and retrofitting works at various constructed facilities. If the repairs do not address the root cause of problems, they may fail in short time (say, within 5 years) [2], which can be avoided with the use of various corrosion control technologies.

Corrosion control can be implemented, and repairs can be made durable if both the structural/mechanical and electrochemical/chemical aspects of steel-concrete systems are adequately addressed by the repair materials and systems. If regular maintenance is done with suitable repair strategy, the number of structures that need repair can be reduced by about 80%. This means significant advantage in terms of the savings of natural resources (materials used) and money [3], and associated carbon footprint. Hence, it is high time that the stakeholders, especially the clients, ask for the desired service life of repair work and facilitate the necessary implementation strategies by changing the contract specifications appropriately. For this, the engineers of clients can be encouraged to adopt not only BIS but also other worldwide standard documents on best practices so that the desired life of structures can truly be achieved with minimal implications on life cycle cost. This approach is essential when some of the new technologies are to be implemented.

We have witnessed the continued use of many structures with severe corrosion – increasing the probability of failure and associated risk. The civil engineering fraternity must start perceiving the high risk associated with corrosion-induced

failures and start allocating larger budgets for frequent condition assessment and preventive maintenance measures. Such approach will help to ensure adequate safety of the users and minimize the life cycle cost and life-cycle material usage – better sustainability. Also, the efforts to ensure durability for the structures is of utmost importance because the money saved by avoiding repairs can be diverted to the development of new infrastructure. The design-for-durability strategy involves the use of high-performance materials, a change in the approach from prescriptive to performance-based specifications, and the adoption of regular condition assessment and preventive maintenance strategies. This special edition sequel will address these issues through various articles.

The six papers in edition have been ordered in the following subthemes: Service life design approaches for new structures, performance of various technologies available for "avoidance of deterioration", and cathodic protection for electrochemical repair of existing structures. The first paper of this edition is authored by Joanitta Ndawula, Dr Hans Beushausen and Dr Mark Alexander from the University of Cape Town, South Africa. This paper discusses the various approaches of service life design of concrete structures and then presents a detailed discussion on the "avoidance of deterioration" approach. A state-of-the art review of hydrophobic surface treatments for avoidance of corrosion and opportunities for further research in this area are also presented.

Then, four papers on the performance of various technologies available for "avoidance of deterioration" are provided. Usage of any new technology should be preferred only if there are no detrimental effects on the performance of the reinforced concrete system as a whole. The second paper by Mr. Raghava Kumar Vanama, Ms. Harinee Adepalli and Dr Balaji Ramakrishnan from IIT Bombay presents a comprehensive study on the influence of synthesized nano-hematite on the durability and microstructural characteristics of concrete. Through a systematic evaluation of various properties like workability, compressive strength, electrical resistivity, depth of chloride ingress, pore structure and microstructure, the authors have determined the optimum dosage of the nano-hematite. With a conclusion that a 'higher dosage' did not necessarily provide 'better performance', the general take-away from the paper is that it is important to select the optimum dosage of any new concrete additive by evaluating multiple aspects-including corrosion aspects, as shown in the next three papers. The third paper by Mr. Himanshu Guleria and others from Thapar Institute of Engineering and Technology in Patiala, Punjab, provides insights on the performance of corrosion inhibiting admixtures with Aminobenzoic Acid and Triethylphosphate functional groups in resisting carbonation and carbonation-induced corrosion. The fourth paper is by Mr. Shafeer Ahamed and others from B.S. Abdur Rahman Crescent Institute of Science and Technology in Chennai, Tamil Nadu. They have evaluated the effect of commercial corrosion inhibiting admixtures on the engineering and corrosion properties of reinforced concrete systems with flyash and slag-based cements. The fifth paper by Dr. Bhuvaneshwari and others from IIT Kanpur and CSIR-Structural Engineering Research Centre in Chennai, Tamil Nadu presents a preliminary evaluation of Titanium microalloyed steel, commonly used in automotive industry worldwide, for potential use as a concrete reinforcement. In addition, the editors believe that chloride diffusion coefficient and carbonation coefficient (along with the critical chloride threshold and critical pH) should always be determined and used to estimate the service life before utilizing new technologies in the field.

The sixth paper is authored by Dr George Sergi, a pioneering and leading researcher in the area of cathodic protection in concrete structures, and the technical director at Vector Corrosion Technologies, UK. It provides an overview of past experience and future opportunities in the usage of cathodic protection technology for extending the service life of concrete structures.

In short, this special edition calls for a major change in the mindset among the various stakeholders in the following lines: (i) utilize emerging technologies for avoidance of corrosion only if all relevant performances have been evaluated and (ii) utilize electrochemical repair methodologies (such as cathodic protection) to repair existing structures instead of conventional patch repair. The photos on the front cover page of this edition show the use of cathodic protection with embedded galvanic anodes in a power plant.

We thank the opportunity given in guest-editing this ICJ special edition on *corrosion and its control in concrete structures*. Journals like ICJ are well-read by the practicing engineers and decision makers in the concrete industry, especially in India. Such knowledgeable and wide readership (outside the academia and research community) has a huge role in implementing the latest technologies in the field of construction. Hence, we request the readers (the concrete technologists and researchers) to consider publishing in ICJ to take the results from the *purpose-driven research* in laboratories to the construction sites and thereby make a positive impact on the concrete construction sector.

Regards,
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