Dear Readers,

It is with great pleasure we bring to you this special edition with research papers covering various aspects of corrosion and its control in concrete structures (C3S). This edition has been guest edited by Dr. Radhakrishna G. Pillai and Dr. Deepak K. Kamde.

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).

Dr. Deepak K. Kamde is an Institute Postdoctoral Fellow at the Department of Civil Engineering, IIT Madras, India. He earned his B.Tech. degree in Civil Engineering from Shri Ramdeobaba College of Engineering and Management, Nagpur and M. Tech. degree in Structural Engineering from S. V. National Institute of Technology Surat, Gujarat. In 2020, he earned a Ph.D. degree in Civil Engineering from IIT Madras. His Ph.D. work at IIT Madras focused on understanding the corrosion mechanisms and estimating the service life of concrete structures with coated steel reinforcement. He has co-authored multiple papers and is a recipient of four national and international awards in this area. He continues to pursue his research interests in the areas of corrosion, durability, service life estimation, repair, and cathodic protection of concrete structures. He is actively involved in the activities of ICI, RILEM, and NIGIS; and served as a president of NIGIS - South Zone Student section (2018-2020).

On behalf of the ICJ team we wish you, your family and friends a very happy Diwali, and a prosperous new year.

Production Editor
Indian Concrete Journal

Dear Readers,

Now-a-days, durability and/or service life based design of concrete structures is gaining acceptance worldwide. This is because about 80% of structural failures are due to the poor materials design of concrete, lack of timely inspections/repair, and eventual steel corrosion; *and not due to inadequate structural designs.* In other words, the durability considerations in many structures today are severely inadequate and need to be improved so that the onset of steel corrosion can be delayed. With this in mind, we bring you the first 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 National Association of Corrosion Engineers (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 the 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 Bureau of Indian Standards (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 will address these issues through various articles.

The nine papers in edition has been ordered in the following subthemes: Corrosion condition assessment, performance of advanced materials, advances in service life estimation, and the advances in cathodic protection. The first paper of this edition is authored by Dr. Carmen Andrade, a world-renowned authority on corrosion and its control in concrete structures – from Centre Internacional de Mètodes Numèrics a l'Enginyeria (CIMNE), Barcelona, Spain. This paper provides guidelines for measuring corrosion parameters such as corrosion potential, resistivity, polarisation resistance of RC systems, the corresponding measurement techniques and data interpretation. Some possible 'on-site' assessment strategies for various site conditions are also discussed in this paper.

Then, five papers on the advantages of the use of advanced materials are provided. The second paper by Dr. Raghu Babu and Dr. Kondraivendhan from the Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat presents the possible corrosion resistance of the concrete containing metakaolin and red mud as supplementary cementitious materials. The third paper by Dr. Kaur and others provides insights on the electrochemical properties and performance of migratory type corrosion inhibitors that can be applied on the surface of concrete on existing structures in order to resist carbonation and carbonation-induced corrosion and is based on an original work at Thapar Institute of Engineering and Technology in Patiala, Punjab. The fourth paper by Mr. Ojha and others from the National Council for Cement and Building Materials (NCCBM). They have conducted short-term and long-term (1-year) tests on organic bipolar corrosion inhibiting admixture and highlighted the correlations between the various test methods and expected field performance in the long run. The fifth paper by Ms. Joseline and Dr. Pillai from the IIT Madras presents the hidden nature of corrosion in prestressed concrete structures and the associated challenges of detecting corrosion. It also suggests to use fly ash and bipolar corrosion inhibitors and specify "Mx-Dy" concretes to enhance the service life of prestressed concrete systems.

The sixth paper is authored by Ms. Arya and others and is based on original experimental research conducted at the RIT (Government Engineering College) in Kottayam, Kerala. This paper focusses on the corrosion resistance of the cement-polymer-composite (CPC) coated steel rebars and clearly concludes that the currently adopted site practices can lead to early corrosion initiation and adversely affect the service life of RC systems. The seventh paper is by Dr. Haji and Ms. Roopa from the B.S.A.R. Crescent Institute of Science & Technology in Chennai. Their paper discusses the mechanical and corrosion characteristics of the galvanized steel rebars and observed about 2 to 3 times better corrosion resistance than the uncoated rebars, without compromising the bond strength. The editors believe that the high abrasion/crack resistances are very critical for realizing the claimed corrosion resistance; hence, unless the construction sites are able to start handling rebars like babies and ensure no damage to the nonmetallic coating, it is not advisable to use rebars with nonmetallic coating.

The eighth paper of this edition is authored by Dr. Zakka and Dr. Otieno from the University of Witwatersrand, South Africa. This paper considered the fact that corrosion initiation and service life are governed by the corner rebars and recommends to use 2D chloride transport models (instead of 1D models) to estimate service life. The final paper of this edition is by Mr. Naveen and others from IIT Madras and Vector Corrosion Technologies India and Canada. This paper presents a field case study on a recent cathodic protection technology - with the use of hybrid anodes - to enable fast re-passivation of steel and further protection from corrosion.

In short, this special edition calls for a major change in the mindset among the various stakeholders in the following lines: (i) introduce specifications to achieve corrosion resistance and durability for new structures (say, Mx-Dy concretes instead of just Mx concretes); (ii) introduce cost-effective, relevant and frequent condition assessment and estimation and updation of residual service life of structures; and (iii) introduce the concept of specifying target service life for repairs on existing structures.

We thank the opportunity given in guest-editing this ICJ special edition on *corrosion and its control in concrete structures*. The ICJ is 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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Guest Editors
The Indian Concrete Journal

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