Dear Reader

Prof. Dipti Ranjan Sahoo is an Associate Professor in the Department of Civil Engineering at Indian Institute of Technology (IIT), Delhi. He received his Ph. D. degree in Civil Engineering from the Indian Institute of Technology (IIT), Kanpur and was a Post-doctoral Fellow at University of Texas at Arlington, USA. His research interests are design and behavior of reinforced concrete and steel structures under extreme loadings, performance-based seismic design, large-scale testing of structures, and passive structural control techniques.

He is a Fellow of Institution of Engineers (India) and is a recipient of Young Engineer Awards from Indian National Academy of Engineers, Institution of Engineers India, Department of Science and Technology, and Department of Atomic Energy. He is a member of various committees of Bureau of Indian Standards (BIS) codes and is currently serving as a member of working groups contributing to the revision of IS:456.

In this edition, Prof. Sahoo helps readers with behavior and design challenges and solutions, both that of concrete members with high strength materials and that of special concrete. We hope you find this edition interesting, please do share your feedback with us.

Production Editor
Indian Concrete Journal

Dear Colleague

It is a great pleasure to present this issue of the ICJ covering design and behavior of concrete structures with high-strength materials. With the significant advancement in material technology in last two to three decades, the attention is being shifted to the use of high-strength concrete and high-strength steel in the concrete constructions. High-strength materials have several benefits in terms of saving in cost, space, and time in many practical concrete applications. Further, special concrete such as, fiber-reinforced concrete provide better resistance to mechanical loading and environmental conditions. The design provisions of current Indian Standard code for design of concrete members (i.e., IS:456-2000 [1]) are mostly limited to M60 or lesser concrete grades. Further, the design guidelines of this code are applicable for the reinforcing steel of yield strength equal to or less than 500 MPa. Therefore, an edition focusing on the behavior and design issues of concrete members with high-strength materials and special concrete is the need of the hour to catch the attention of readers as well as code committees in India.

This edition comprises of six technical papers and one point-of-view highlighting the design issues and behavior of concrete members. These articles cover all important mechanical properties, namely, compressive strength, flexural strength, shear strength and fracture behavior of concrete members. This issue presents the experimental as well analytical studies to develop the design parameters for RC members with high-strength concrete, high-strength reinforcing steel, and fiber-reinforced concrete.

The point-of-view presents the need to revise the IS:456-2000 [1] provisions on the minimum percentage of longitudinal steel in a concrete beam, particularly with high-strength concrete. It is necessary to provide the minimum area of longitudinal steel in concrete members with very small flexural demand to ensure that the brittle failure of concrete should not govern when first crack appears in the member. Currently, IS:456-2000 [1] recommends a constant value of minimum percentage of longitudinal steel for beams of all grades of concrete. It has been shown that the value of minimum percentage of longitudinal steel recommended in IS:456-2000 [1] is derived assuming the characteristic compressive strength of concrete as 25 MPa (i.e., M25 grade of concrete). However, with the recent technological advancements in the field of concrete material, the use of high-strength concrete is preferred in the modern constructions. Since the high-strength concrete is more brittle as compared to the normal-strength concrete, it is therefore necessary to increase the minimum percentage of flexural reinforcement in concrete members with high-strength concrete. In this point-of-view, it is recommended that the minimum percentage of longitudinal steel should be computed based on the characteristic compressive strength of concrete, rather than using a constant value. Further, a comparative study has been presented on the requirement of minimum area longitudinal steel for different grades of concrete and reinforcing steel using the current IS:456-2000 [1] provisions and the proposed expression.

First technical paper of this edition is focused on the compressive stress-strain characteristics of both normal-strength and high-strength concrete. The primary goal of this study was to develop design parameters for compressive stress-strain high-strength concrete for the incorporation in design code IS: 456-2000 [1]. This paper presents the test results of standard cylinders and cubes of concrete subjected to monotonically increasing compressive loading till failure. Cube compressive strengths of concrete are varied in the range of 45-106 MPa corresponding to water-to-cement ratios of 0.2-0.47. The novelty of this study is the consideration of two different types of aggregates, namely, calc-granulite and granite, which are widely used in construction sectors in India. The paper highlights the observed values of cube-to-cylinder strength ratios of concrete vis-à-vis the recommended values in Eurocode 2 [2]. This paper concludes that the constant values of strain at the peak compressive stress as well as maximum strain as recommended by current IS:456-2000 [1] are not applicable for all grades of concrete. Accordingly, the design strain parameters for M25-M100 concrete grades have been proposed based on the findings of this study.

The next two companion papers are focused on the development of shear design provisions for RC members with and without shear reinforcement bars. In the first companion paper, a review of shear design provisions in different countries including India has been presented. The adequacy of current shear design provisions of IS:456-2000 [1] for concrete beams of varying concrete grades, member sizes, and area of longitudinal steel is evaluated by comparing the design provisions of different building codes [2-7] worldwide. This paper also highlights various critical parameters influencing shear strength of RC members and recommends a new expression to estimate the design shear stress of concrete. The proposed expression is applicable for both normal-strength and high-strength concrete as well as all member sizes. In addition, a simplified expression has been recommended to compute the maximum shear strength of concrete to be used in the design in order to avoid the occurrence of web crushing of concrete beams under shear. In the second companion paper, a review of widely adopted shear strength models of concrete has been presented. An expression to compute the design shear strength of RC beams with shear stirrups has been proposed. The validity of the proposed design expressions to compute the shear strength of RC members with and without shear stirrups has been investigated by comparing the predicted values with the test results reported in ACI-DAfStb database [8]. In addition, this paper recommends the expressions to consider the influence of axial load on shear strength of concrete members and to compute minimum shear reinforcement requirement in a RC member.

The last three papers of this edition present the evaluation of mechanical properties of fiber-reinforced concrete. In the recent years, there is an increased interest to adopt the recycled aggregates in concrete constructions. In fourth paper, authors have conducted an extensive experimental study on RC beams with self-compacting concrete. Test beams were prepared using either 100% natural aggregates or 100% recycled aggregates. The main parameters varied in this study are shear span to effective depth (a/d) ratio, grade of concrete, and volume fraction of steel fibers. In addition to the evaluation of workability of fresh concrete, shear behavior as well as toughness properties of test beams are studied. An analytical expression has been proposed to predict the shear strength of RC beams with self-compacting fiber-reinforced concrete. The fifth paper presents the influence of synthetic fibers on compressive strength of concrete. Volume fraction of synthetic fibers is varied in the range of 0-1% in the concrete mixes. Based on the test results, authors have recommended the optimum dose of synthetic fibers for concrete mixes. The sixth paper presents a study on the fracture behavior of high-strength concrete with and without steel fibers. Concrete grades are varied in the range of 45 -100 MPa. The improvement in fracture energy of high-strength concrete with the addition of steel fibers has been discussed in this paper.

I take this opportunity to thank all the contributing authors, reviewers and the ICJ production team for their efforts in bringing out this issue. I trust that the readers would find these articles informative and useful in practice.

References

1. IS: 456-2000 (2000). Code of practice for plain and reinforced concrete. Fourth Revision, Bureau of Indian Standards, New Delhi, India, 100 pp.

2. EN 1992-1-1 (2004). Design of concrete structures, Part 1: General rules and rules for buildings (Eurocode 2). European Committee for Standardization, Brussels, Belgium, 425 pp.

3. ACI Committee 318 (2014). Building code requirements for structural concrete (ACI 318-14) and commentary. American Concrete Institute, Farmington Hill, MI, 520 pp.

4. AS 3600:2018 (2018). Australian Standard concrete structures. Standards Australian Limited, Sydney, Australia.

5. CSA Committee A23.3 (2016). Design of concrete structures. Canadian Standards Association Group, Toronto, Canada.

6. BS 8110:1 (1997). Structural use of concrete-Part 1: Code of practice for design and construction. British Standards Institute, London, UK.

7. NZS 3101: Part 1, (2006), Concrete Structures Standard, Part 1- The Design of Concrete Structures. New Zealand Standards, Wellington, New Zealand.

8. Reineck, K.-H., Dunkelberg, D. (Eds.) (2017). ACI-DAfStb databases 2015 on shear tests for evaluating relationships for the shear design of structural concrete members without and with stirrups. Report for Research Project DAfStb V479. DAfStb H. 617, Beuth Verl. Berlin.