Behavior of self-compacting concrete using different percentage of admixture

A. Anitha[1], V.Prem Sai[1], L. Eswararao[1], V. Hasini[1], DivakarNaiko[1], G. Gowrisanakara Rao[2]

[1]B. Tech. Student, Department of Civil Engineering, Aditya Institute of Technology and Management, Tekkali, Srikakulam, India- 532201.

[2] Associate Professor, Department of Civil Engineering, Aditya Institute of Technology and Management, Tekkali, Srikakulam, India- 532201.

Abstract: *This project gives a review on Self Compacting Concrete (SCC) to be made using various Mineral Admixtures and different composition of chemical admixtures at constant height. In current scenario of construction industries due to demand in the construction of large and complex structures, which often leads to difficult concreting conditions. When large quantity of heavy reinforcement is to be placed in a reinforced concrete (RC) member, it is difficult to ensure fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is very difficult in this situation. That leads to the invention of new type of concrete named as self-compacting concrete (SCC). This type of concrete flows easily around the reinforcement and into all corners of the formwork. Self- compacting concrete describes a concrete with the ability to compact itself only by means of its own weight without the requirement of vibration. Self-compacting concrete also known as Self-consolidating Concrete or Self Compacting High Performance Concrete. It is very fluid and can pass around obstructions and fill all the nooks and corners without the risk of either mortar or other ingredients of concrete separating out, at the same time there are no entrapped air or rock pockets. This type of concrete mixture does not require any compaction and is saves time, labour and energy. The outcome of the project is used to find out how much time is to be required for SCC to spreading a certain area at constant height at different percentages of chemical admixture to give optimum compacting, filling ability (Flowability) and passing ability.*

1. INTRODUCTION

HISTORY OF SCC:

The introduction of the "modern" self-compacting concrete (SCC) is associated with the drive towards better quality of concrete pursued in Japan in late 1980"s, where the lack of uniform and complete compaction had been identified as the primary factor responsible for poor performance of concrete structures. There were no practical means by which full compaction of concrete on a site was ever to be fully guaranteed, instead, the focus therefore turned onto the elimination of the need to compact, by vibration or any other means. This led to the development of the first practicable SCC by researchers Okamura &Ouchy at the University of Tokyo. The SCC, as the name suggests, does not require to be vibrated to achieve full compaction. These include an improved quality of concrete and reduction of on-site repairs, faster construction times, lower overall costs, facilitation of introduction of automation into concrete construction. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials; this offers possibilities for utilization of "dusts", which are currently waste products demanding with no practical applications and which are costly to dispose of. Current Indian scenario in construction shows increased construction of large and complex structures, which often leads to difficult concreting conditions. Vibrating concrete in congested locations may cause some risk to labour in addition to noise stress. There are always doubts about the strength and durability placed in such locations. So, it is worthwhile to eliminate vibration in practice, if possible. In countries like Japan, Sweden, Thailand, UK etc., the knowledge of SCC has moved from domain of research to application. But in India, this knowledge is to be widespread.

1.1 OBJECTIVE:

The general objective of this project is to conduct an exploratory work towards the development of a suitable SCC mix design using mineral admixtures such as Fly ash, Rice Husk Ash (RHA) and chemical admixture (ArmixHyye Crete PC20) to evaluate at which percentage of chemical admixture satisfies the properties of Self-Compacting Concrete(SCC). The specific objectives are as follows:

- To find out the spread flow of Self Compacting Concrete with different percentage of chemical admixtures at constant height.
- To find out the passing ability of the Self Compacting Concrete.
- To find out the Compressive Strength of the Self Compacting Concrete.
- To find out the workability of Self Compacting Concrete.

1.2 ADVANTAGES OF SELF-COMPACTING CONCRETE:

- **Enhanced Workability:** Self-compacting concrete (SCC) offers superior flowability and can fill intricate forms without the need for mechanical consolidation, reducing labour and time required for placement.
- **Improved Quality and Uniformity**: SCC ensures homogeneous distribution of aggregates and reduces the risk of honeycombing or voids, leading to higher strength and durability of the concrete structure.
- **Reduced Construction Time and Costs**: By eliminating the need for vibration during pouring, SCC accelerates construction timelines, minimizes labor costs, and allows for faster formwork removal, contributing to overall project efficiency and cost savings.
- **Increased Durability**: Properly designed SCC mixes exhibit improved homogeneity and reduced segregation, contributing to enhanced durability and long-term performance of structures.
- **Better Structural Performance**: SCC can effectively fill intricate reinforcement arrangements, ensuring uniform distribution of concrete and improving the structural integrity of the final product.
- **Enhanced Construction Efficiency**: SCC speeds up construction processes by simplifying concrete placement and eliminating the time-consuming task of vibration, leading to faster project completion.
- **Environmental Benefits**: The use of SCC can reduce noise pollution and minimize the environmental impact associated with traditional concrete placement methods, such as vibration equipment and excess material waste

1.3 DISADVANTAGES OF SELF COMPACTING CONCRETE:

- **Higher Cost:** SCC often requires the use of specialized admixtures and high-performance materials, leading to higher initial material costs compared to conventional concrete mixes.
- **Complex Mix Design:** Designing an SCC mix requires careful consideration of various factors such as aggregate grading, viscosity modifiers, and superplasticizers, which can be more complex and time-consuming than conventional concrete mix designs.
- **Risk of Segregation:** Improperly proportioned SCC mixes or inadequate control during placement can lead to segregation, where aggregates separate from the cement paste, compromising the integrity and durability of the concrete.

ISSN 2321-2926

- **Limited Application in Certain Situations:** While SCC offers numerous benefits, it may not be suitable for all construction scenarios, such as projects with low slump requirements or in situations where traditional vibration methods are more practical or cost-effective.

LITERATURE REVIEW

1. PayalPainuly, ItikaUniyal (2016):Literature Review on Self-Compacting Concrete

This literature review provides a systematic exploration of self-compacting concrete (SCC), focusing on the use of finer materials as partial replacements for coarse and fine aggregates. The study aims to assess the feasibility of producing SCC with low segregation potential through experimental investigations.

Self-compacting concrete is renowned for its ability to flow and compact under its own weight, eliminating the need for external vibration during placement. However, achieving desired properties such as low segregation potential is crucial for its successful application in construction projects.

The review highlights the importance of the V-Funnel test as a method for evaluating segregation potential in SCC. By systematically replacing coarse and fine aggregates with finer materials, the study aims to identify optimal combinations that result in SCC with desirable properties.

Key points of the literature review:

- Emphasis on experimental approach: The study adopts a systematic experimental methodology to explore the effects of partial replacements of coarse and fine aggregates with finer materials.
- Focus on segregation potential: The V-Funnel test is utilized to assess the segregation potential of SCC mixes with varying compositions of aggregate replacements.
- Identification of optimal combinations: The review aims to identify combinations of materials that result in SCC with low segregation potential, thereby enhancing its suitability for practical construction applications.

Overall, this literature review contributes to the understanding of SCC by investigating the influence of aggregate replacements on its segregation potential. The findings offer insights that can inform the development of optimized SCC mixes for enhanced performance in construction projects.

2. Ravinder Kaur Sindhu (2017): Influence of Rice Husk Ash (RHA) on the Properties of Self-Compacting Concrete

This literature review focuses on the influence of rice husk ash (RHA) on both fresh and hardened properties of self-compacting concrete (SCC). RHA is considered as a supplementary cementitious material that can potentially improve the performance of SCC.

The review highlights the importance of RHA as a pozzolanic material with micro-filling effects, which can enhance the microstructure and pore structure of concrete. By replacing a portion of cement with RHA, the study aims to investigate its impact on various properties of SCC.

Key points of the literature review:

- Enhancement of properties: Cement replacement with 10-15% RHA is found to improve the strength and permeation properties of SCC.
- Pozzolanic effects: RHA exhibits pozzolanic properties, contributing to the formation of additional hydration

products and densification of concrete microstructure.

- Micro-filling effects: RHA particles fill in the voids within the concrete matrix, resulting in improved pore structure and overall durability.

Overall, this literature review underscores the potential benefits of incorporating RHA in SCC mixes, highlighting its role in enhancing both fresh and hardened properties. The findings provide valuable insights for optimizing SCC formulations to achieve superior performance in construction applications.

3. KaunteySachan (2021): Self-Compacting Concrete Overview

KaunteySachan's work on self-compacting concrete (SCC) offers a comprehensive overview of the material, focusing on testing methodologies and flowability assessment. SCC is a specialized type of concrete known for its ability to flow and fill formwork under its own weight without the need for mechanical consolidation.

Significance and Implications:

KaunteySachan's overview of SCC testing methodologies provides valuable insights for researchers, engineers, and practitioners involved in the design and implementation of SCC in construction projects. By highlighting the importance of flowability assessment and detailing relevant testing techniques, Sachan's work contributes to the optimization and quality assurance of SCC in various construction applications.

Conclusion:KaunteySachan's overview serves as a comprehensive guide to understanding SCC testing methodologies, particularly focusing on flowability assessment. By emphasizing the significance of proper testing techniques, Sachan's work enhances the knowledge base surrounding SCC and facilitates its effective utilization in construction projects.

4. “Mohammad Kamran, Mudit Mishra” 2014: Behaviour of self-compacting concrete using OPC with different proportions of Fly ash

Mohammad Kamran and Mudit Mishra's study on the behavior of self-compacting concrete (SCC) utilizing Ordinary Portland Cement (OPC) with varying proportions of fly ash offers a comprehensive examination of how the inclusion of fly ash impacts the properties and performance of SCC. Fly ash is a supplementary cementitious material commonly used in concrete production due to its pozzolanic properties, which contribute to enhanced strength, durability, and sustainability.

The study likely begins by providing background information on SCC and the benefits of incorporating fly ash as a partial replacement for OPC. Fly ash, a byproduct of coal combustion, is widely available and serves as a sustainable alternative to OPC, reducing the carbon footprint of concrete production while improving its performance.

Optimization and Recommendations:

Based on the experimental findings, Kamran and Mishra likely provide insights into the optimal proportions of fly ash for achieving desired SCC properties. Recommendations may also be offered regarding the practical application of fly ash-based SCC in construction projects, considering factors such as mix design considerations, quality control measures, and long-term performance.

Overall, Kamran and Mishra's study contributes valuable insights into the behavior of SCC incorporating fly ash, highlighting its potential to improve both the mechanical and durability properties of concrete while promoting sustainable construction practices. By elucidating the effects of fly ash on SCC behavior, the study informs concrete producers, engineers, and researchers seeking to develop high-performance and environmentally friendly concrete mixtures.

5. “Arulsivananantham.P, Gokulan R” 2017: A Review on Self Compacting Concrete

The review by Arulssivananantham.P and Gokulan R on self-compacting concrete (SCC) likely offers a comprehensive analysis of the key aspects surrounding this innovative construction material. It presumably covers a range of topics including the formulation, properties, production techniques, and applications of SCC. The review probably delves into the rheological properties of SCC, detailing its ability to flow and fill intricate spaces without the need for vibration, which is crucial for achieving uniform and high-quality concrete structures.

Additionally, it may discuss the various constituents of SCC such as cement, aggregates, supplementary cementitious materials, and chemical admixtures, along with their influence on the fresh and hardened properties of the concrete.

Furthermore, the review likely examines the performance of SCC in terms of durability, assessing factors such as resistance to segregation, shrinkage, and permeability, as well as its suitability for different environmental conditions.

Moreover, the review may explore the practical applications of SCC in construction projects, highlighting its advantages in terms of ease of placement, improved constructability, and enhanced structural performance.

Overall, the review by Arulssivananantham.P and Gkulan R is likely to provide valuable insights into the advancements, challenges, and opportunities associated with self-compacting concrete, serving as a valuable resource for researchers, engineers, and practitioners in the field of construction materials.

6. Huang, Fali, et al: "The rheological properties of self-compacting concrete containing superplasticizer and air-entraining agent

The rheological properties of self-compacting concrete (SCC) are crucial for ensuring proper flowability and workability during placement. Superplasticizers and air-entraining agents are commonly used additives in SCC to enhance its properties.

Superplasticizers are chemical admixtures that are added to concrete to improve its flowability without increasing water content. They work by dispersing cement particles more effectively, resulting in reduced water demand and increased workability.

Air-entraining agents are additives that create tiny air bubbles in concrete. These bubbles improve the durability of concrete by providing space for water to expand when it freezes, thereby reducing the risk of cracking.

1. OBJECTIVES OF THE STUDY:

2.1 MATERIALS:

The Materials used in SCC are the same as in conventional concrete except that an excess of fine material and chemical admixtures are used. Also, a viscosity-modifying agent (VMA) will be required because slight variations in the amount of water or in the proportions of aggregate and sand will make the SCC unstable, that is, water or slurry may separate from the remaining material. The powdered materials are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. The use of pozzolanic materials helps the SCC to flow better.

In the project, the materials used are mentioned below:

- Ordinary Portland Cement (OPC) 53 grade cement.
- Coarse aggregate (10mm size)
- Fine aggregate
- Mineral admixtures

i. Fly Ash
ii. Rice Husk Ash

- Chemical admixture (ArmixHyye Crete PC20)
- Water
-

2.2. CEMENT:

Ordinary Portland cement (OPC) of 53 grade (Priya Cement) was used.OPC 53 grade cement is a type of Ordinary Portland Cement (OPC) that is commonly used in construction. The "53 grade" designation refers to the compressive strength of the cement in megapascals (MPa) after 28 days of curing. OPC 53 grade cement typically has a compressive strength of 53 MPa or higher.

2.2.1 COARSE AGGREGATE:

Coarse aggregate is a term used in civil engineering and construction to describe the larger size particles of aggregates used in concrete. The coarse aggregate passing from 12.5mm sieve and retained on 10mm sieve are used.

2.2.2 FINE AGGREGATE:

Fine aggregate refers to the smaller particles in concrete mixtures, typically sand or crushed stone, that are used along with coarse aggregate (such as gravel or crushed stone) to create a dense and solid structure. Fine aggregate fills the voids between coarse aggregates and helps to produce a cohesive concrete mixture. It is essential for improving the workability, durability, and strength of concrete. Fine aggregate is usually composed of particles smaller than 4.75 millimeters (0.1875 inches) in diameter.

2.2.3 WATER:

Potablewater is used for mixing and curing of concrete.

2.2.4 MINERAL ADMIXTURE:

Mineral admixture refers to finely divided minerals that are added to concrete during its mixing to enhance certain properties or achieve specific performance characteristics. These admixtures are typically in powder form and are added either during the production of cement or directly to the concrete mix.

2.2.5 FLYASH:

Fly ash is a fine, powdery residue generated by burning pulverized coal in thermal power plants. It is collected from the flue gases using electrostatic precipitators or bag filters. Fly ash consists mainly of silica, alumina, and iron oxide, along with smaller amounts of calcium, magnesium, and other compounds.

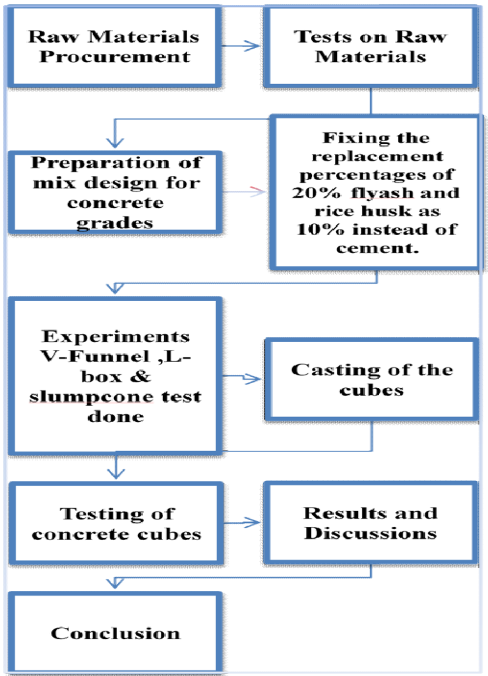
2.2.6 RICE HUSK ASH:

Rice husk ash (RHA) is a byproduct obtained from burning rice husks, the outer covering of rice grains, during rice milling or in specialized combustion processes. Rice husk ash is primarily composed of silica (around 80-95%), with small amounts of other minerals such as carbon, potassium, and calcium.

2.2.7 ARMIX HYYE CRETE CONCRETE:

ArmixHyye Crete PC20 is a high performance super plasticizer allowing production of consistent concrete properties around the required dosage. ArmixHyye Crete PC20 combines properties of water reduction and workability retention.

2. METHODOLOGY OF THE STUDY



4. LITERATURE REVIEW

4.1 L-BOX TEST:

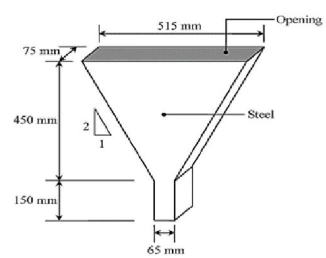
The L Box Test is a laboratory test used to assess the flowability and passing ability of self-compacting concrete (SCC) or other highly flowable concrete mixes. It is particularly useful in evaluating the ability of concrete to flow through narrow and congested spaces, such as reinforcing bars in heavily reinforced concrete elements.

In the L Box Test, a specially designed apparatus is used consisting of two perpendicular arms forming an "L" shape. The bottom of the L-shaped box has an outlet gate that can be opened or closed. The test involves filling the box with fresh concrete and then gradually opening the gate to allow the concrete to flow through a narrow gap between two vertical bars. The distance the concrete can flow beyond the vertical bars before stopping or separating is measured.The results of the L Box Test provide valuable information about the flowability and passing ability of the concrete mix, which can help in optimizing the mix design for specific construction applications. It is an important test in quality control and assurance processes for SCC and other flowable concrete mixes.

4.2 V-FUNNEL TEST:

The V-Funnel Test is another laboratory test used to assess the flowability and workability of self-compacting concrete (SCC) or other highly flowable concrete mixes. It measures the flow time of concrete passing through a funnel with a V-shaped profile.

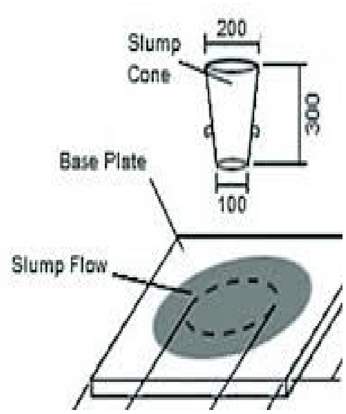
The V-Funnel Test provides valuable information about the rheological properties of concrete, helping to assess its ability to flow and fill formwork without segregation or excessive bleeding. It is widely used in research and quality control processes for SCC and other highly flowable concrete mixes.



4.3 SLUMPFLOW TEST:

The Slump Flow Test is a standard laboratory test used to assess the workability and flow properties of concrete, especially self-compacting concrete (SCC) and other highly flowable concrete mixes. It measures the spread of concrete when it flows outwards under its own weight after being placed in a conical mold.

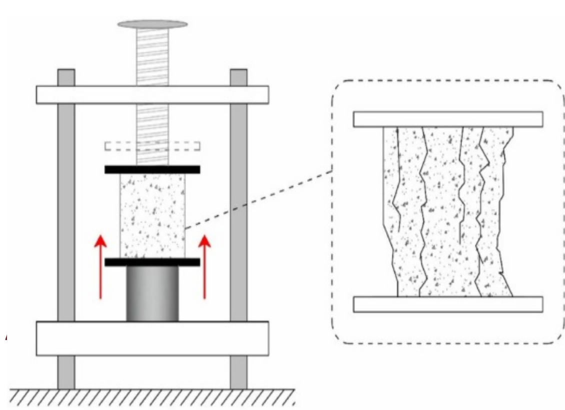
The results of the Slump Flow Test provide valuable information about the workability, flowability, and consistency of the concrete mix. A higher slump flow diameter indicates better flowability and workability, while a longer slump flow time may indicate higher viscosity and potential issues with flowability. These parameters are crucial for ensuring that the concrete can be easily placed, compacted, and finished on the construction site.



4.4 COMPRESSION TEST:

The Compression Strength Test, also known as the compressive strength test, is a fundamental procedure used to assess the mechanical strength and durability of concrete. It measures the maximum load that a concrete specimen can bear before failure occurs.

The compressive strength of concrete is calculated by dividing the maximum load sustained by the specimen by the cross-sectional area of the specimen. This value is crucial for assessing the quality and performance of concrete in structural applications. It is used to ensure that concrete meets the strength requirements specified in design codes and standards, thereby ensuring the safety and reliability of concrete structures.



5.RESULTS AND DISCUSSIONS

5.1 INTERPRETATION OF RESULTS:

- L-Box test is performed to check the passing ability of Self Compacting Concrete to flow through tight obstructions without segregation or blocking. As per **IS Code 10262-2019 (Clause no 7.2.2)-Pg no.11,** the blocking ratio of the concrete should be between**0.81.0**.
- V-Funnel test is performed to check the ease of flow of concrete (Viscosity), shorter flow time indicates greater flow ability, As per **IS Code 10262-2019(Clause no 7.2.4)-Pg** no.**11**, the viscosity is divided into two classes.
  V1<= 8 secs
  V2<=25 secs
  I. **V1** indicates good filling ability even with congested reinforcement
  II. **V2** is more likely to exhibit thixotropic effects.
- Slump flow test is performed to check the flow ability (Flowablity) and workability of Fresh concrete mix. As **per IS Code 10262-2019(Clause no 7.2.1)-Pg no.10**, the spread (slump flow) of SCC typically ranges from **550mm – 850mm** depending on the requirement of the project

5.2 Test results of concrete:

Percentage of Chemical Admixure	Box test (h2/h1)	V-Funnel Test	V-Funnel Flow Type	Slumpflow Test
0.5%	0.63	7 secs	V1	630mm
0.6%	0.9	7 secs	V1	715mm
0.7%	0.76	8 secs	V1	850mm
0.8%	0.9	45 secs	-	350mm

Type of test	Wt. of cube at 3 days (Kg)	Wt. of cube at 7 days (Kg)	Wt. of cube at 14 days (Kg)	Compression strength at 3 days (Mpa)	Compression strength at 7 days (Mpa)	Compression strength at 14 days (Mpa)
L-Box	7.6	7.88	8.03	20.26	27.02	44.87
V-Funnel	7.64	7.9	8.03	16.40	31.84	42.49

5.3 Test results of compression test at 0.8% of Chemical Admixture: M40

Type of test	Wt. of cube at 3 days (Kg)	Wt. of cube at 7 days (Kg)	Wt. of cube at 14 days (Kg)	Compression strength at 3 days (Mpa)	Compression strength at 7 days (Mpa)	Compression strength at 14 days (Mpa)
L-Box	7.5	7.9	8.06	16.6	30.12	41.50
V-Funnel	7.6	7.9	8.05	16.8	31.6	42.65

6. CONCLUSION

- From the values obtained in the results table, the Self Compacting Concrete (SCC) has good passing ability at 0.6%, 0.7% and 0.8%.
- From the values obtained in the results table, the SCC has good flow ability (flowability) at 0.6% and 0.7%.
- From the results obtained, the SCC has good spreading at 0.6% and 0.7%.
- In the end, the Self Compacting Concrete has achieved all the features like passing ability, flowability, workability and required compression strength at 0.6% and 0.7%.
- We can do this experiment by using different admixtures and different chemicals.

REFERENCES:

- **Sandhu, Ravinder Kaur, and Rafat Siddique:** "Influence of rice husk ash (RHA) on the properties of self-compacting concrete: A review." *Construction and Building Materials* 153 (2017): 751-764.
- **Painuly, Payal, and ItikaUniyal**: "Literature Review on Self Compacting Concrete." *International Journal of Technical Research and Applications e–ISSN* (2016): 2320-8163.
- **Devi, Kiran, Paratibha Aggarwal, and Babita Saini:** "Admixtures used in self-compacting concrete: a review." *Iranian Journal of Science and Technology, Transactions of Civil Engineering* 44 (2020): 377-403.
- **Kamran, Mohammad, and Mudit Mishra**: "Behavior of Self-Compacting Concrete using PPC and OPC with Different Proportions of Fly Ash." *International Journal of Research in Engineering and Technology* 3.9 (2014): 342-345.
- **Arulsivanantham, P., and R. Gokulan:** "A review on self compacting concrete." *International Journal of ChemTech Research* 10.11 (2017): 62-68.
- **Sua-iam, Gritsada, and NattMakul:** "Utilization of high volumes of unprocessed lignite-coal fly ash and rice husk ash in self-consolidating concrete." *Journal of cleaner production* 78 (2014): 184-194.
- **Huang, Fali, et al**: "The rheological properties of self-compacting concrete containing superplasticizer and air-entraining agent." *Construction and Building Materials* 166 (2018): 833-838.
- **IS 456:2000**: Indian standard plain and reinforced concrete by "Bureau of Indian standards"
- **IS 10262:2019**: Indian standard concrete mix proportioning by "Bureau of Indian standards"