An Experimental Study on Self Compacting Concrete

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Abstract—Concrete occupies unique position among the modern construction materials, Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as a aggregate(usually made for different types of sand and gravel), that is bond by cement and water. This paper gives a review on Self Compacting Concrete (SCC) to be made using various Mineral Admixtures and Fibers. When large quantity of heavy reinforcement needs is to be placed in reinforced concrete (RC) member, it is difficult ensure fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibrators is very difficult in this situation This type of concrete mixture does not require any compaction and is saves time, labour and energy. This review paper explains the utilization of fibres and various mineral admixtures in the properties of Self Compacting Concrete. The addition of lime stone filer up to 20 % by cement weight reduced cost and enhanced the performance of self-compacted concrete SCC in fresh and hardened stages. It sounds like high slag Portland cement is proving to be effective in severe conditions, especially for first-generation self-compacting concrete (SCC) used in repair applications and in areas with limited access to vibration. The key is achieving the right balance between yield stress and viscosity in the paste, often facilitated by specially formulated high-range water reducers to maintain the desired flow characteristics.

Absolutely, achieving the right balance in concrete mix design is crucial to ensure strength, durability, and workability while also being cost-effective. Segregation can occur if the viscosity of the paste isn't sufficient to support the aggregate particles in suspension. This emphasizes the importance of selecting suitable ingredients and determining their proportions accurately to meet the desired concrete properties.

Keywords: Self Compacting Concrete, Mix design, Mineral Admixtures, Fibers, Strength, Durability, Workability.

I. INTRODUCTION

Exactly, self-compacting concrete (SCC) is designed to be a fluid mixture that can be placed without the need for external energy, such as vibration, even in challenging conditions or around congested reinforcement. It should maintain its homogeneity throughout the placing process and flow smoothly through the reinforcement without any manual intervention. These characteristics make SCC particularly useful in situations where traditional concrete placement methods are impractical or difficult.

In recent years, there is a growing interest in theuse of self-compacting concrete (SCC), which provides an overall structure durability. The self-compacting concrete is characterized by its capacity to flow and to fill out the most restricted places of the formwork, withoutlosing homogeneity. The uses of mineraladditions or powders have a purpose, besides substituting a part of the cement, it propitiates theappropriate viscosity so that the self-compactionis reached. Japan has used self-compacting concrete in It's interesting to note the varying adoption rates of self-compacting concrete (SCC) in different regions. While Europe has seen a significant increase in the construction of SCC bridges over the past five years, the use of SCC in highway bridge construction remains limited in the United States. However, there's growing interest in applying SCC technology in architectural concrete within the U.S. precast concrete industry. The high potential of SCC for broader structural applications in highway bridge construction suggests that its use may expand further in the future. however the relatively high material the cost remains a significant barrier to the widespread adoption of specialty concrete like self-compacting concrete (SCC) across various segments of the construction industry, including commercial and residential construction. SCC tends to be more expensive than conventional concrete with similar mechanical properties due to the higher demand for cementation materials and chemical admixtures, including high-range water-reducing admixtures (HRWRA) and viscosity enhancing admixtures (VEA). Using ground glass blast furnace slag GGBFS in self- compacting concrete are reported. These powders were used as a partial replacement of the cement content. The results indicated that self-compacting concrete could be successfully developed by incorporating either GGBS or SF and GGP together in the mix. The rheological properties of SCC mixes containing GGP was similar to those containing SF powder. Mixes with a combination of GGBS and SF showed a performance in between the GGBS mixes and SF mixes. Reducing the free water can decrease the VEA dosage necessary for stability. Indeed, high binder content in self-compacting concrete (SCC) often involves substitutions of cement with materials like fly ash or ground granulated blast furnace slag (GGBS), typically ranging from 20 to 40%. Additionally, low contents of micro silica can be employed in some cases. Cost reduction strategies for SCC can involve selecting appropriate concrete-making materials and admixture constituents, including partial substitutions of cement and supplementary cementitious materials with readily available fillers. These measures help optimize the material composition while maintaining the desired performance characteristics of SCC.

REQUIREMENTS FOR CONSTITUENT MATERIALS

1. CEMENT

All types of cement conforming to EN 197 are suitable. Correct, the choice of cement type is determined by the specific needs of the concrete, including strength and durability requirements. A C3A content exceeding 10% can lead to challenges in workability retention. Typically, cement content falls within the range of 350-450 kg/m3. Cement amounts surpassing 500 kg/m3 can pose risks, potentially increasing shrinkage. Conversely, less than 350 kg/m3 may necessitate the addition of other fine fillers like fly ash to maintain desired properties. Striking the right balance is essential for achieving optimal performance and characteristics in the concrete mix.

2. AGGREGATES

3. SAND

In self-compacting concrete (SCC), all typical concreting sands are suitable, whether crushed or rounded, and whether siliceous or calcareous. The presence of fines, particularly those less than 0.125 mm, is crucial for SCC rheology, and a minimum amount is necessary to prevent segregation. All types of coarse aggregates are compatible with SCC, with the normal maximum size generally ranging from 16 to 20 mm, although sizes up to 40 mm have been used. Consistency of grading is crucial.

Different aggregate types impact SCC properties: crushed aggregates enhance strength due to interlocking angular particles, while rounded aggregates improve flow due to lower internal friction. Gap graded aggregates often outperform continuously graded ones, as the latter may experience higher internal friction and reduced flow.

4. ADMIXTURE

Indeed, superplasticizers, also known as high-range water reducers, are vital admixtures in self-compacting concrete (SCC). They typically achieve water reductions exceeding 20%, enhancing flow ability and workability without compromising strength. Additionally, Viscosity Modifying Agents (VMAs) play a crucial role, especially when the powder content is limited. VMAs offer more control over segregation, promoting excellent homogeneity within the mix and reducing the risk of particle separation during placement. This combination of admixtures ensures SCC maintains its desired properties and performance characteristics.

5. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground granulated blast-furnace slag is a non-metallic product consisting essentially of silicates and aluminates of calcium and other bases.The process of quenching molten slag in water results in the formation of a glassy sand-like material known as granulated blast furnace slag (GBFS). When this granulated material is further ground to a particle size less than 45 microns, it achieves a specific surface area of about 400 to 600 m²/kg.

Notably, the chemical composition of blast furnace slag closely resembles that of cement clinker. This similarity allows for its effective use as a supplementary cementitious material in concrete production, contributing to its strength and durability characteristics.

I. AIM AND OBJECTIVES FOR SCC:

1. To identify the three key properties of SCC i.e., Filling, Ability, Passing ability and segregation resistance.
2. To determine the Workability of SCC using Slump Flow Test, Compression Test.
3. To study the Strength and behaviour of Ground Granulated Blast Furnace Slag (GGBFS) to the SCC.
4. Health and Safety benefits (as no vibration is required).

II. METHODOLOGY

- **TEST METHODS**

A wide range of test methods have been developed to measure and assess the fresh properties of SCC. Table 5 lists the most common tests grouped according to the property assessed. The various equipment for testing is as shown below. No single test is capable of assessing all of the key parameters, and a combination of tests is required to fully characterize an SCC mix. However, one of the well- known methods Indian methods of mix proportioning is published in the ICJ (Indian Concrete Journal) in 2004. It is titled "Mixture proportioning procedures for Self-Compacting Concrete" by Jagadish Vengala & RV Ranganath.

The various test are we performed in our project:

1) Compression Testing Machine
2) Slump Flow Test

HOW DOES ITS WORKS?

To achieve the desired properties of self-consolidating concrete (SCC), Okamura redesigned the mix design process focusing on three key aspects:

1. Reduction of aggregate content: This reduces friction and the frequency of collisions between particles, thus increasing overall concrete fluidity.
2. Increasing paste content: This further enhances fluidity by reducing obstacles to flow.

In rheological terms, SCC is often described as a Bingham fluid, exhibiting pseudo-plastic behavior where viscosity varies with shear rate. However, it’s characterized by two constants: viscosity and yield stress. In the performance-based definition of SCC, self-consolidation is primarily governed by yield stress, while viscosity affects homogeneity and the ability to flow through reinforcement. Adjusting SCC viscosity according to application needs, the yield stress remains lower compared to other concrete types to facilitate self-consolidation.

- **TESTS PERFORMED**

1. Compression Testing Machine:

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen. (Ex 100 mm cube according to ISI) divided by the area of cross section. The test of compressive strength should be made on 150mm size cubes. Place the cube in the compression-testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done.

2. Slump Flow Test:

Slump flow is one of the most commonly used SCC tests at the current time. This test involves the use of slump cone used with conventional concretes as described in ASTM C 143(2002). The main difference between the slump flow test and traditional slump tests, like ASTM C143, lies in what they measure. The slump flow test evaluates the “spread” or “flow” of the concrete sample once the cone is lifted, providing an indication of the concrete’s ability to flow and consolidate

horizontally. In contrast, traditional slump tests measure the "slump" or drop in height of the concrete sample after the removal of the slump cone, assessing the vertical deformability or workability of the concrete mix. The T50 test is determined during the slump flow test. It is simply the amount of time the concrete takes to flow to a diameter of 50 centimeter.

- **TEST REPORT**

OBSERVATION TABLE FOR NORMAL CUBES

Cube Size =150x150x150mm, Compressive Load= 1000 KN, Area of Cube= 22500mm^2

Sr. No.	Grade	Period	Cubes no.	Weight (gm)	Load (KN)	Compressive Strength of each cube (N/mm^2)	Average Compressive Strength (N/mm^2)
1	M25	After 7 Days	1	8460	370	16	17 N/mm^2
			2	8750	360	16.87	
			3	8790	400	17.88	
2	M25	After 14 Days	1	8650	455	20.52	21 N/mm^2
			2	8740	440	20	
			3	8790	490	21.02	
3	M25	After 28 Days	1	8740	560	25	25 N/mm^2
			2	8400	485	22	
			3	8800	510	23	

28 DAYS CALCULATIONS:

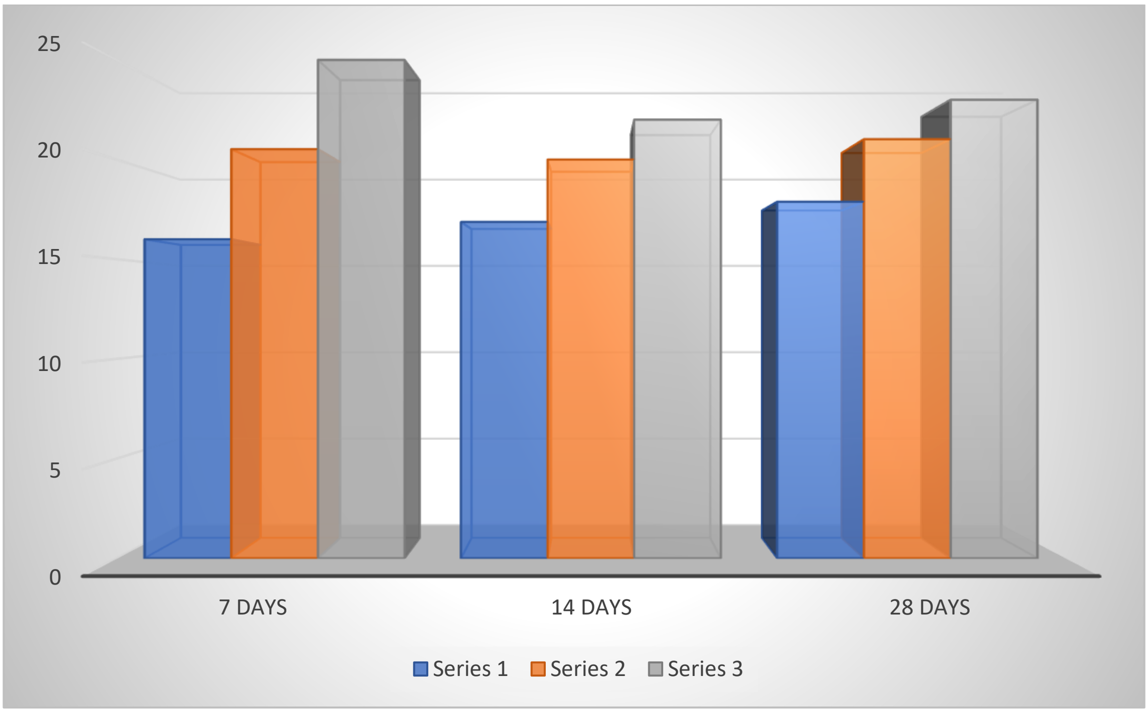
1) Compressive strength= Load/ Area

   = 560/22.5 = 25 N/mm^2

2) Compressive strength= 485/22.5 = 22 N/mm^2

3) Compressive strength= 510/22.5 = 23 N/mm^2
4) The Average Compressive Strength= 25+22+23= 25 N/mm^2

Normal Cubes Graph



Observation Table for SCC Cubes:

Cube Size =150x150x150mm,

Compressive Load= 1000 KN,

Area of Cube= 22500mm^2

Sr. No.	Grade	Period	Cubes no.	Weight (gm)	Load (KN)	Compressive Strength of each cube (N/mm^2)	Average Compressive Strength (N/mm^2)
1	M25	After 7 Days	1	8348	450	20	20.37 N/mm^2
			2	8296	455	20.22	
			3	8412	470	20.89	

2	M25	After 14 Days	1 2 3	8378 8418 8393	615 630 625	27.33 28 24.78	27.70 N/mm^2
3	M25	After 28 Days	1 2 3	8421 8384 8392	700 650 660	31.11 28.88 29.33	29.77 N/mm^2

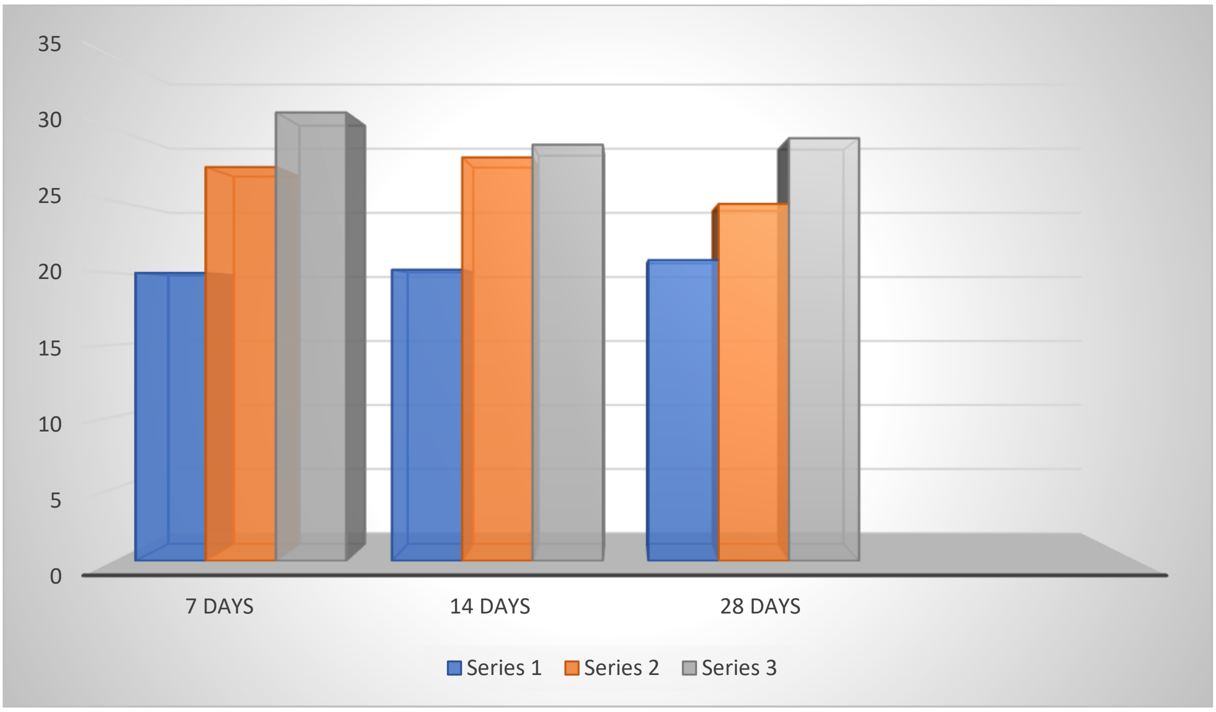
28 DAYS CALCULATIONS:

1) Compressive strength= Load/ Area

   = 700/22.5 = 31.11N/mm^2

2) Compressive strength= 650/22.5 = 28.88 N/mm^2
3) Compressive strength= 660/22.5 = 29.33 N/mm^2
4) The Average Compressive Strength= 31.11+28.88+29.33= 29.77 N/mm^2

SCC Cubes Graph



II. RESULTS:

After **7 days** casting of cubes further we get these results,

- For Compression Test:

Each three-cube average strength = **20.37 N/mm^2**

After **14 days** casting of cubes further we get these results,

- For Compression Test:

Each three-cube average strength = **27.70 N/mm^2**

After **28 days** casting of cubes further we get these results,

- For Compression Test:

Each three-cube average strength = **29.77 N/mm^2**

III. CONCLUSION

Based on the investigation conducted for the study of behavior of self-compacting concrete the following conclusions are arrived. Self-consolidating concrete (SCC) is highly recommended for use in complex frameworks with narrow spaces and congested steel reinforcement. Its exceptional flow ability allows it to navigate through tight spaces smoothly and without the need for vibration. SCC's ability to flow effortlessly and self-compact makes it an ideal choice for challenging construction scenarios where traditional concrete placement methods may be impractical or difficult. SCC is recommended in complicated frameworks which have narrow places and congested steel bars, because it can flow throw this place very smoothly and without vibration and give the best compaction and surface finishes. Trial and error method was been used to design the SCC mix because the is no standard method for SCC in any institutes and concrete mix plants. SCC is recommended in high rise building because by using SCC the time for construction will be shorter and also the cost will be cheaper than using ordinary concrete. Self-compacting concrete mixes SCC showbetter improvement in compressive strengthcompared to normal compacting concreteNC at various ages.

The addition of GGBS up to 20 % by cement weight reduced cost and enhanced the performance of self-compacted concrete SCC in fresh andhardened stages, and the improved increases in sever condition for concrete cast with highslag Portland cement.

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