

Self-Compacting Concrete Mix Design And Fresh Property

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ABSTRACT

Self-Compacting Concrete (SCC) is a special type of concrete that can flow and compact under its own weight without the need for mechanical vibration. This project focuses on the design and performance evaluation of M40 grade Self-Compacting Concrete using conventional materials and chemical admixtures. The objective of the study is to assess the fresh and hardened properties of SCC and to compare its performance with the requirements specified by standard guidelines.

Fresh concrete properties were evaluated using slump flow, V-funnel, L-box, and J-ring tests to assess flowability, passing ability, and resistance to segregation in accordance with EFNARC recommendations. Hardened properties were determined through compressive strength tests on cube and cylindrical specimens at 7 and 28 days of curing.

The experimental results indicate that the developed SCC mix exhibits excellent workability and self-compacting characteristics. The compressive strength values achieved satisfy the requirements of M40 grade concrete, demonstrating that SCC can provide both high strength and improved construction efficiency. The study concludes that M40 grade SCC is suitable for use in densely reinforced and complex structural elements, where conventional vibration is difficult.

Keywords: SCC, Admixtures, Concrete

INTRODUCTION

1.1 GENERAL

Self-compacting concrete (SCC) is a modern form of concrete that is specifically designed to flow under its own weight and compact itself without the need of external vibration or mechanical compaction. It is highly fluid with excellent filling ability and passing ability i.e the ability to flow through congested reinforcement and segregation resistance. With the tremendous development of construction of mega structures the world over, the demand for self compacting concrete (SCC) application is increasing. Many sites have the problems of congestion of reinforcement in principal structural members.

1.1.2 Material Used in Self-compacting Concrete

1. Cement:

2. Aggregates:

3. Water:

4. Mineral Admixtures:

5. Chemical Admixtures:

Superplasticizer:

1.1.3 Properties of Self-compacting Concrete:

- Self-compacting concrete and traditional vibrated concrete with comparable compressive strengths have comparable qualities. Hence SCC can be utilized in most applications where traditional vibrated concrete is employed.

- However, the composition of SCC differs from that of conventional concrete, and the difference exists in the performance during the fresh state; not much in terms of hardened state attributes.
- Self-compacting concrete with the same water cement or cement binder ratio has a little higher strength than typical vibrated concrete, owing to an improved interface between the aggregate and solidified paste due to the absence of vibrations.
- SCC varies from normal concrete in that its fresh qualities are critical in determining whether or not it can be successfully laid. To guarantee that its ability to be placed stays satisfactory, the aspects of workability that affect its filling ability, passing ability, and Segregation resistance must all be properly regulated.

LITERATURE REVIEW

2.1 Okamura & Ouchi (1990s) – Origin and Development of Self-Compacting Concrete:

In the late 1980s, Okamura and Ouchi from Japan pioneered the concept of Self-Compacting Concrete (SCC) to address the issue of inadequate compaction in highly reinforced concrete sections. The main motivation was to produce concrete that could flow under its own weight, filling formwork completely and achieving full compaction without any external vibration. They observed that poor compaction in conventional concrete was a major cause of durability issues and structural deficiencies. Their work ... The researchers identified the need for balance between flowability and segregation resistance. They proposed the inclusion of viscosity-modifying admixtures (VMA) to maintain homogeneity and prevent segregation during flow. The resulting SCC demonstrated high deformability, resistance to bleeding, and excellent surface finish. Their laboratory experiments confirmed that SCC can achieve both superior durability and high strength compared to conventional vibrated concrete. Okamura and Ouchi's research laid the foundation for all subsequent SCC developments, transforming the concrete industry by introducing the concept of a "vibration-free" casting process. Their work emphasized material optimization and control of rheological properties as key factors in producing successful SCC mixes.

Conclusion: The study concluded that SCC could eliminate the need for vibration, ensuring better quality and longer durability. It also provided the first comprehensive understanding of how mix proportioning and admixture selection affect flow and stability.

2.2 EFNARC (2002, 2005) – European Guidelines for SCC

The European Federation for Specialist Construction Chemicals and Concrete Systems (EFNARC) published the most influential guidelines for SCC in 2002 and 2005. These documents standardized testing procedures and performance classifications for SCC mixes. The EFNARC guidelines specify acceptable limits for flowability, passing ability, and segregation resistance using empirical tests such as the slump flow test, V-funnel test, and L-box test. These tests evaluate how SCC behaves under its own weight. The guidelines also define ranges for key properties like T50 flow time (2–5 seconds for high flow SCC), and J-ring difference (0–10 mm). EFNARC recommended the use of high-range water-reducing admixtures (HRWR) and VMAs to achieve a balance between fluidity and stability. Additionally, it introduced visual stability index (VSI) evaluation for segregation control. This framework has since become the global benchmark for SCC quality control and research consistency. By providing a unified reference, EFNARC allowed researchers and engineers worldwide to produce, test, and compare SCC mixes effectively. The guidelines continue to influence the development of sustainable and high-performance SCC for both precast and in-situ applications.

Conclusion: EFNARC's contribution provided international uniformity in SCC testing and performance evaluation. These standards are widely used in laboratories and construction sites, ensuring consistent quality and reliability in SCC production.

2.3 Domone (2007) – Hardened Properties of SCC.

Domone's research in 2007 analyzed the mechanical and durability properties of SCC in comparison with conventional vibrated concrete (CVC). Through an extensive review of experimental data, Domone found that SCC often achieved equal or superior compressive strength due to improved compaction and reduced air voids. The researcher highlighted that while SCC tends to have a higher paste content, its denser matrix results in enhanced durability properties such as reduced permeability and better resis... Domone also examined tensile

strength, modulus of elasticity, and shrinkage. The findings showed that SCC's mechanical performance depends strongly on the mix composition, particularly the type and amount of supplementary cementitious materials (SCMs) like fly ash, silica fume, and ground granulated blast furnace slag (GGBS). The researcher emphasized the need for long-term field studies to assess SCC's durability in real service environments, as laboratory performance may vary from site conditions. Overall, Domone's work provided a comprehensive understanding of SCC's hardened behaviour, contributing to the wider acceptance of SCC in structural and precast applications worldwide.

Conclusion: Domone concluded that SCC offers comparable or better mechanical performance than conventional concrete when properly designed and cured. His findings encouraged its adoption in critical structural components

2.4 Brouwers (2005) – Particle Packing and Mix Design

Brouwers introduced a theoretical framework for SCC mix design based on particle packing and rheology principles. The researcher proposed that the key to achieving both high flowability and stability lies in optimizing the gradation and packing density of solid particles. Using mathematical modeling, Brouwers demonstrated that a well-graded aggregate skeleton combined with sufficient paste volume can minimize voids, reduce segregation, and enhance mechanical strength. His research bridged the gap between empirical mix design and scientific modeling. By considering the interaction between paste viscosity, particle size distribution, and aggregate surface area, Brouwers' model provided precise control over the fresh and hardened properties of SCC. Experimental verification confirmed that particle packing models could produce mixes with excellent deformability and minimal bleeding. Brouwers' approach is still widely referenced in modern SCC design, particularly in sustainable concrete research where optimization of materials is crucial.

Conclusion: The study concluded that particle packing optimization ensures stable, dense, and highly workable SCC mixes. It set the foundation for performance-based SCC design approaches used today

OBJECTIVES

1. To develop a concrete mix that can flow under its own weight and completely fill the formwork without the need for mechanical vibration.
2. To ensure proper compaction of concrete in heavily reinforced and congested structural elements where conventional vibration is difficult or impossible.
3. To improve the quality and durability of concrete by eliminating defects such as honeycombing, voids, and segregation.
4. To reduce labour requirement, construction time, and dependence on skilled workers for vibration.

CHAPTER 4

METHODOLOGY

4.1 METHODOLOGY FLOWCHART

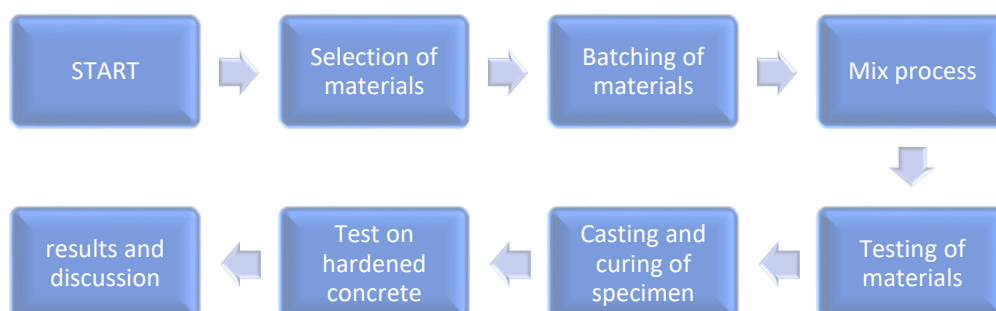


FIG:4.1: FLOWCHART

The methodology adopted in this study focuses on the systematic design, preparation, and evaluation of Self-Compacting Concrete (SCC) mixes to ensure compliance with performance requirements. The experimental program is carried out to assess both the fresh and hardened properties of SCC in accordance with established guidelines such as EFNARC and relevant Indian Standard (IS) codes. Emphasis is placed on achieving adequate flowability, passing ability, and segregation resistance without the application of external vibration.

The methodology involves careful selection and characterization of constituent materials, followed by SCC mix design through trial batches to achieve the desired workability parameters. Fresh concrete tests are conducted immediately after mixing to evaluate flow characteristics and stability. Concrete specimens are then cast without compaction, allowing the concrete to self-level under its own weight. After demoulding, specimens are subjected to controlled curing conditions to ensure proper hydration. Finally, hardened concrete tests are performed at different curing ages to evaluate strength development and overall performance. The results obtained are analyzed and compared with standard requirements to validate the suitability of the developed SCC mix for structural applications.

4.2 MATERIALS REQUIRED:

1. Cement (OPC 53 grade)
2. Fine Aggregate
3. Coarse aggregate
4. Fly Ash
5. Super plasticizer (Conplast SP 430)

4.7 MIX DESIGN

Mix proportioning for a concrete of M 40 grade using fly ash

1. Grade of concrete = M₄₀
2. Type of cement = opc43 Grade
3. Type of chemical admixture = Conplast SP430
4. Type of mineral admixture = Fly ash
5. Workability = 100mm
6. Maximum nominal size of aggregate = 20mm
7. Specific Gravity of cement = 3.15
8. Specific Gravity of Flyash = 2.2
9. Specific Gravity of fine aggregates = 2.62
10. Specific Gravity of coarse aggregate = 2.75

1. Target mean strength

$$f_{ck}^1 = f_{ck} + 1.65S$$

$$f_{ck}^1 = 40 + (1.65 \times 5)$$

$$f_{ck}^1 = 48.25/\text{mm}^2$$

2. Water cement ratio

$$\text{Maximum W/C} = .45$$

$$\text{Adopting W/C} = .4$$

3. Selection of water cement ratio

Table 2 of IS 10262 maximum water content is 186 Liters

Estimated water content for 100mm slump

$$= 186 + \left(\frac{6}{100} \times 186\right)$$

$$= 197 \text{ Liters}$$

As Super plasticizer is used, the water content is reduced up to 29%

$$= 197 \times .71$$

$$= 140 \text{ Liters}$$

4. Cement content

$$\text{Cement} = \left(\frac{140}{.4}\right)$$

$$= 350 \text{ Kg/m}^3$$

Since the Fly ash is not active as that of cement,

Increase cementitious material by 10%,

$$= 350 + \left(\frac{10}{100} \times 350\right)$$

$$= 385 \text{ Kg/m}^3$$

5. Proportion of volume of coarse aggregate and Fine aggregate

For W/C, .5=.6

.4=?

For, .4 W/C = .6+ (.01x2)

$$= .62$$

$$\text{Volume of C.A} = 0.62 \times 0.9 = 0.56$$

$$\text{Volume of F.A} = 1 - 0.56$$

$$= 0.44$$

6. Mix Calculations for 1m³:

$$\text{Volume of concrete} = 1 \text{ m}^3$$

$$\text{Volume of cement} = \left(\frac{\text{Mass}}{\text{Specific Gravity}} \times \frac{1}{1000}\right)$$

$$= \frac{270}{3.15} \times \frac{1}{1000}$$

$$= 0.086 \text{ m}^3 \text{ (a)}$$

$$\text{Volume of water} = \left(\frac{140}{1} \times \frac{1}{1000}\right) = 0.14 \text{ m}^3 \text{ (b)}$$

Volume of Chemical admixture = 2% of cementitious material

$$= \left(\frac{7}{1.145} \times \frac{1}{1000}\right)$$

$$= 0.007 \text{ m}^3 \text{ (c)}$$

$$\text{Volume of Fly ash} = \left(\frac{115}{1} \times \frac{1}{1000}\right)$$

$$= .052 \text{ m}^3 \text{ (d)}$$

$$\text{Volume of all in aggregate: } e = 1 - (a+b+c+d)$$

$$e = 1 - (0.086 + 0.14 + 0.007 + 0.052)$$

$$e = 0.715 \text{ m}^3$$

$$\begin{aligned} \text{Mass of C.A} &= e \times \text{Specific Gravity of C.A} \times \text{Volume of C.A} \times 1000 \\ &= 0.715 \times 2.74 \times 0.56 \times 1000 \end{aligned}$$

$$= 1097 \text{ Kg/m}^3$$

$$\begin{aligned} \text{Mass of F.A} &= e \times \text{Specific Gravity of F.A} \times \text{Volume of F.A} \times 1000 \\ &= 0.715 \times 2.74 \times 0.44 \times 1000 \end{aligned}$$

$$= 862 \text{ Kg/m}^3$$

$$\text{Cement} = 270 \text{ Kg/m}^3$$

$$\text{Fly Ash} = 115 \text{ Kg/m}^3$$

$$\text{Water} = 140 \text{ Kg/m}^3$$

$$\text{Fine aggregate} = 862 \text{ Kg/m}^3$$

$$\text{Coarse aggregate} = 1097 \text{ Kg/m}^3$$

$$\text{Chemical admixture} = 707 \text{ Kg/m}^3$$

4.8 CALCULATION FOR QUANTITY OF MATERIAL REQUIRED FOR 6 CONCRETE BLOCK:

For 6 cube of size (15x15x15cm)

- 1) Volume of 1 cube
 $= 15 \times 15 \times 15 \text{ cm}$
 $= 0.003375 \text{ m}^3$
- 2) Volume of 6 cubes
 $= 6 \times 0.003375$
 $= 0.02025 \text{ m}^3$
- 3) Multiply by (0.02025) m^3

Cement	270	0.02025	5.4675 kg
Fly Ash	115	0.02025	2.32 kg
Water	140	0.02025	2.835 kg
Fine aggregate	862	0.02025	17.455 kg
Coarse aggregate	1097	0.02025	22.214 kg
Chemical admixture	7.7	0.02025	0.155 kg

TABLE 4.81 materials required

Calculation of Concrete Volume for 6 Cylindrical Moulds

Formula:

$$\text{Volume of cylinder} = \frac{\pi}{4} \times d^2 \times h$$

$$\begin{aligned} \text{Volume of 1 cylindrical mould} \\ &= 3.142/4 \times (0.15)^2 \times 0.30 \\ &= 0.00530 \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Volume of 6 cylindrical mould} \\ &= 6 \times 0.00530 \\ &= 0.0318 \text{ m}^3 \end{aligned}$$

Cement	270	0.0318	8.586 kg
Fly Ash	115	0.0318	3.657 kg
Water	140	0.0318	4.452 kg

Fine aggregate	862	0.0318	27.411 kg
Corse aggregate	1097	0.0318	34.884 kg
Chemical admixture	7.7	0.0318	0.2448 kg

TABLE 4.82 materials required

CHAPTER 5

RESULTS AND DISCUSSION

TABLE 5.1 BASIC TESTS ON MATERIALS

SL NO.	TEST	RESULT OBTAINED	RANGE
1	Normal consistency	32%	26%-35%
2	Initial setting time of cement	30 Min	30 min
3	Final setting time of cement	310 min	4-5 hours
4	Specific gravity of cement	3.14 g/cc	3.1-3.16
5	Sieve analysis of fine aggregate	F.M= 4.37 kg/m ²	-
6	Specific gravity of fine aggregate	2.88	2.5-3.0
7	Sieve analysis of coarse aggregate	F.M-9.23mm	-
8	Specific gravity of Coarse aggregate	2.65	2.5-3.0
9	Flakiness index	14.2%	-
10	Elongation index	16%	-

5.1 COMPRESSION TEST:

TABLE 5.2 Compression Test on normal concrete:

SAMPLE	7 DAYS		21 DAYS	
	Load (KN)	Strength (Mpa)	Load (KN)	Strength (Mpa)
Cube 1	680	30.2	980	43.6

Cube 2	700	31.1	1000	44.4
Cube 3	670	29.8	960	42.7
Average	683	30.4	980	43.6

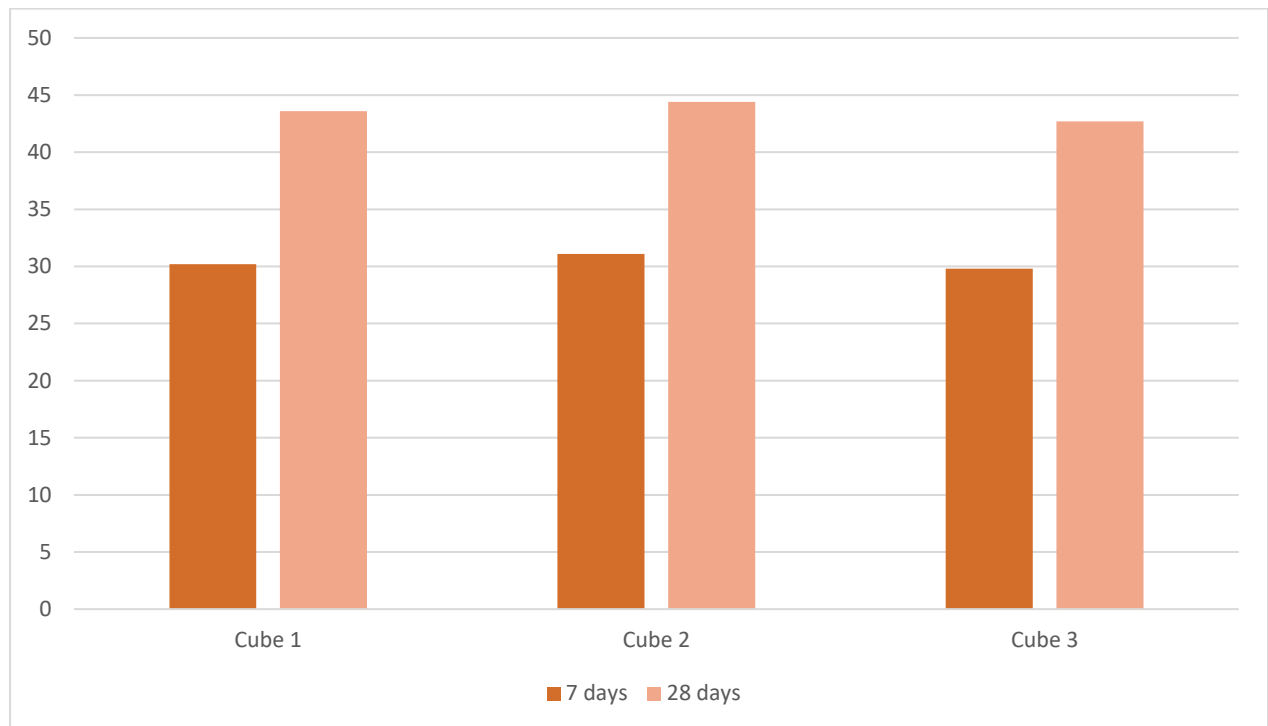


FIG 5.1 THE COMPRESSIVE STRENGTH FOR CONCRETE

TABLE 5.3 Compression Test on SCC concrete:

SAMPLE	7 DAYS		28 DAYS	
	Load (KN)	Strength (Mpa)	Load (KN)	Strength (Mpa)
Cube 1	720	32.0	1020	45.3
Cube 2	740	32.9	1040	46.2
Cube 3	710	31.6	1000	44.4
Average	723	32.2	1020	45.3

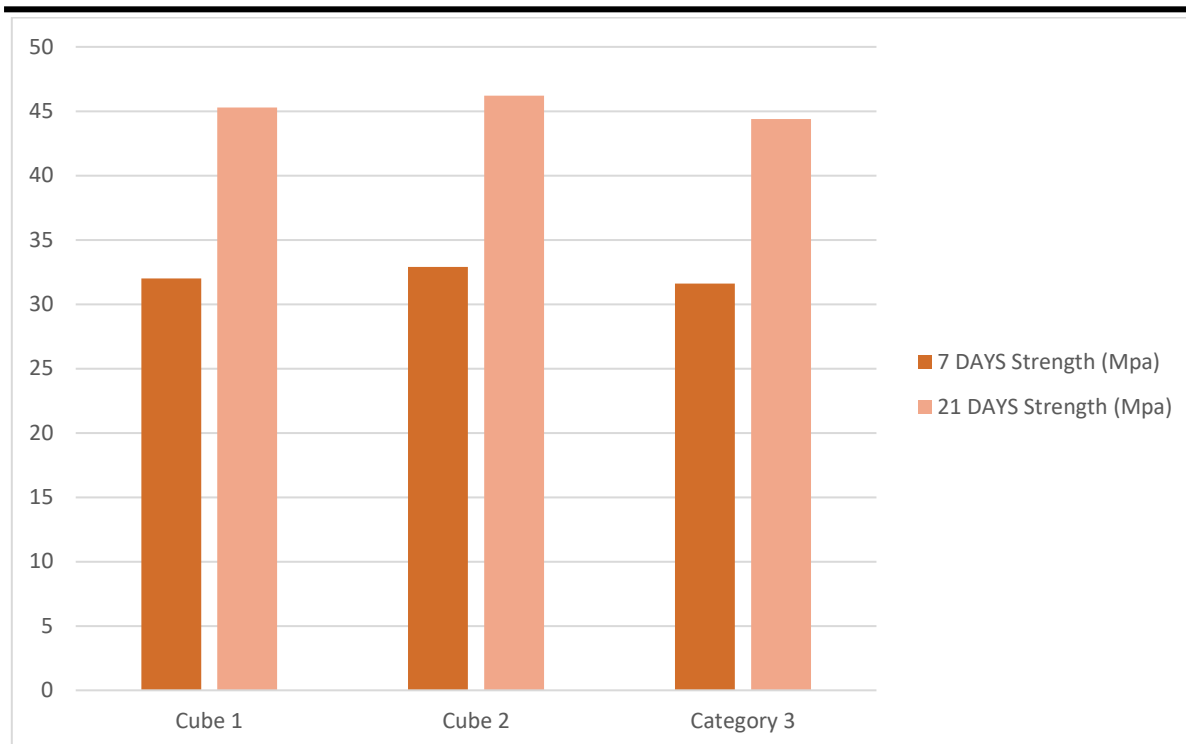


FIG 5.2 THE COMPRESSIVE STRENGTH FOR CONCRETE FOR SCC

TABLE 5.3 Compression Test on SCC Cylinders :

SAMPLE	7 DAYS		28 DAYS	
	Load (KN)	Strength (Mpa)	Load (KN)	Strength (Mpa)
Cylinder 1	480	27.2	710	40.2
Cylinder2	500	28.3	730	41.3
Cylinder 3	490	27.8	720	40.8
Average	490	27.8	720	40.8

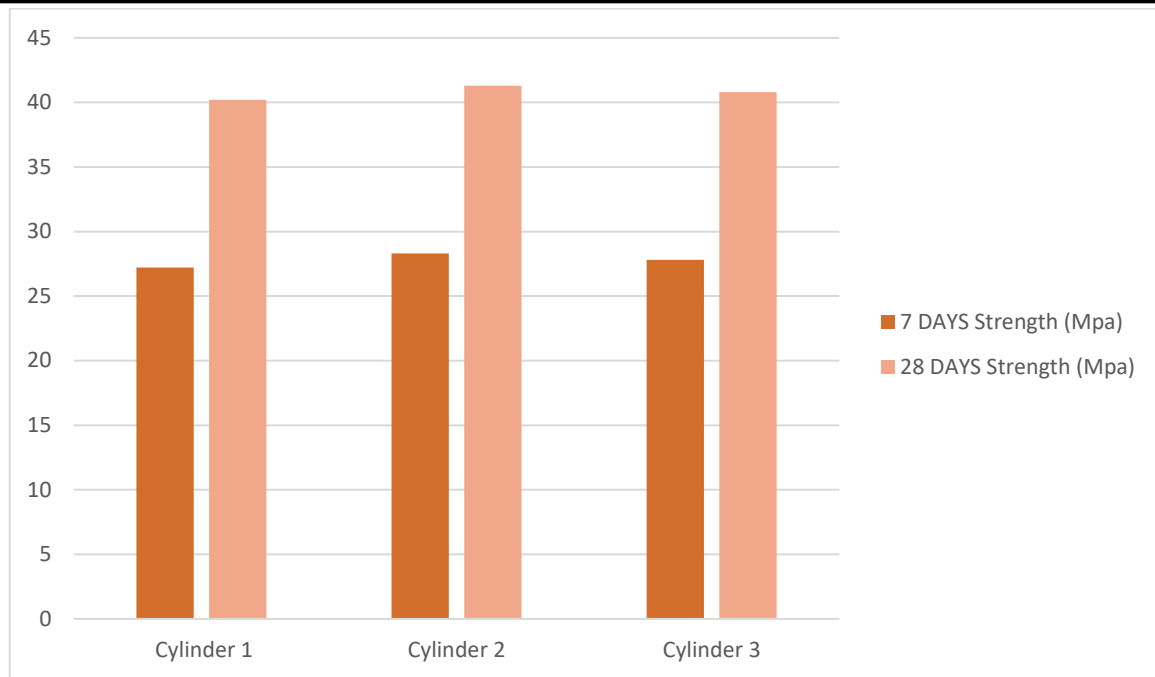


FIG 5.3 THE COMPRESSIVE STRENGTH FOR CONCRETE FOR SCC

CHAPTER 6

SCOPE OF STUDY

1. To evaluate the fresh properties of Self-Compacting Concrete (SCC) such as flowability, filling ability, passing ability, and segregation resistance using standard tests like slump flow, V-funnel, L-box, U-box, and J-ring.
2. To study the mechanical properties of SCC including compressive strength (cube and cylinder) at different curing ages of 7, 14, and 28 days.
3. To design and optimize an M40 grade SCC mix that satisfies EFNARC guidelines while maintaining adequate strength and self-compactability.
4. To observe the effect of mix composition and superplasticizer dosage on workability, stability, and strength characteristics of SCC.
5. To assess the durability performance of SCC, including water absorption, permeability, and resistance to environmental effects such as sulphate and chloride attack.
6. To study the quality of surface finish and homogeneity of SCC in comparison with conventional vibrated concrete.
7. To compare the performance of SCC with normal (conventional) concrete, highlighting improvements in workability, compaction, and strength behaviour.
8. To evaluate the use of supplementary cementitious materials (such as fly ash, GGBS, or zeolite) in SCC for improving sustainability and reducing cement consumption.
9. To assess the practical feasibility of SCC in construction, especially in structures with dense reinforcement and complex formwork.
10. To identify the suitability of SCC for structural and non-structural applications such as high-rise buildings, precast elements, bridge components, and infrastructure projects.
11. To study the effect of curing conditions on strength development of Self-Compacting Concrete at different ages and compare it with conventional concrete.
12. To evaluate the economic benefits of SCC, including reduction in labour, time of construction, and overall cost efficiency due to elimination of vibration and improved placing efficiency.

CONCLUSION

From the present experimental investigation on Self-Compacting Concrete (SCC), it can be concluded that SCC is an effective and reliable alternative to conventional vibrated concrete. The designed M40 grade SCC mix satisfied the self-compactability requirements as per EFNARC guidelines, exhibiting excellent flowability, filling ability, and passing ability without any signs of segregation or bleeding.

The results of the compressive strength tests indicated that SCC achieved and exceeded the target strength of M40 grade concrete at 28 days. The early-age strength development at 7 was also satisfactory, demonstrating the effectiveness of proper mix proportioning and admixture usage.

Compared to conventional concrete, SCC showed better compaction quality and surface finish, eliminating issues such as honeycombing and voids. The absence of vibration not only improved the homogeneity of concrete but also reduced labour requirement, construction time, and noise pollution at site.

The use of supplementary cementitious materials in SCC contributed to improved workability and sustainability by reducing cement content without compromising strength. This makes SCC an environmentally friendly and economical option for modern construction.

Overall, the study confirms that SCC is highly suitable for heavily reinforced structures, complex formwork, precast elements, and high-rise buildings, where conventional concrete faces practical difficulties. With proper mix design and quality control, SCC can significantly enhance construction efficiency, structural performance, and durability.

Hence, Self-Compacting Concrete can be confidently recommended for large-scale structural and infrastructure applications as a sustainable, efficient, and high-performance construction material.

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