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Mechanical and Durability Performance of Self-Compacting Concrete Incorporating Supplementary Cementitious Materials

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ABSTRACT

Self-Compacting Concrete (SCC) is a high-performance concrete capable of flowing under its own weight without external vibration. This study evaluates the mechanical and durability performance of SCC incorporating supplementary cementitious materials. Mechanical properties were assessed through compressive strength and split tensile strength tests at 7, 28, and 56 days. Durability characteristics were evaluated using Rapid Chloride Penetration Test (RCPT), sorptivity, water absorption, and acid attack resistance. Experimental results indicate that SCC exhibits superior mechanical strength and enhanced durability compared to conventional concrete. Reduced permeability, lower capillary absorption, and improved resistance to aggressive environments confirm the suitability of SCC for long-life infrastructure applications.

Keywords: Self-Compacting Concrete, Mechanical Properties, Durability, RCPT, Sorptivity, Acid Attack.

1. INTRODUCTION

Self-Compacting Concrete (SCC) was developed to address compaction-related problems in heavily reinforced and complex structural elements. Unlike conventional concrete, SCC flows under its own weight and achieves full compaction without vibration. Apart from construction advantages, SCC exhibits improved mechanical and durability performance due to its dense microstructure and optimized mix design.

Durability-related deterioration mechanisms such as chloride ingress, moisture penetration, and chemical attack significantly reduce the service life of concrete structures. Hence, evaluating durability along with mechanical performance is essential. This study investigates the combined mechanical and durability behavior of SCC and compares its performance with conventional concrete.

2. MATERIALS AND MIX PROPORTIONS

Ordinary Portland Cement (OPC 53 grade) was used as the primary binder. Fly ash or GGBS was used as partial replacement of cement. Natural river sand and crushed granite aggregates were used as fine and coarse aggregates, respectively. A polycarboxylate ether

(PCE)–based superplasticizer was used to achieve self-compacting properties.

The SCC mix was designed as per EFNARC guidelines with a water–binder ratio of 0.36 and a total binder content of 500 kg/m³.

Table 1. SCC Mix Proportions (per m³)

Material	Quantity
Cement	400 kg
Fly Ash / GGBS	100 kg
Fine Aggregate	850 kg
Coarse Aggregate	700 kg
Water	180 litres
Superplasticizer	1.0% of binder
Material	**Quantity**

3. EXPERIMENTAL PROGRAM

Fresh properties were evaluated using slump flow, T50 time, V-funnel, and L-box tests. Mechanical properties were evaluated using compressive strength and split tensile strength tests at 7, 28, and 56 days. Durability performance was assessed using RCPT, sorptivity, water absorption, and acid attack tests.

4. RESULTS AND DISCUSSION

4.1 Fresh Concrete Properties

The SCC mix satisfied all EFNARC requirements, confirming adequate filling ability, passing ability, and segregation resistance.

Table 2. Fresh Concrete Test Results

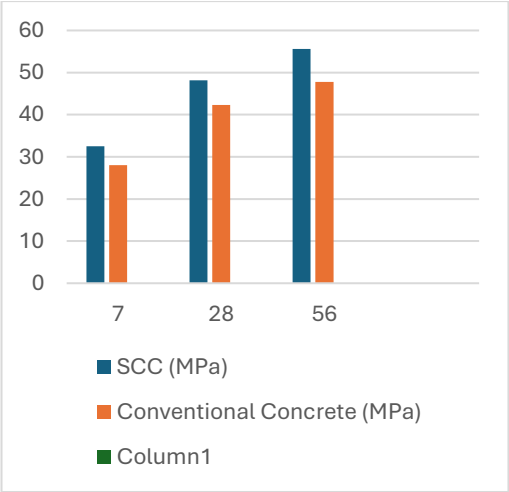
Test	Result	EFNARC Limit	Test
Slump Flow	710 mm	650–750 mm	Slump Flow
T50 Time	4.2 s	2–7 s	T50 Time
V-Funnel	8.5 s	6–12 s	V-Funnel
L-Box Ratio	0.89	≥ 0.80	L-Box Ratio

4.2 Mechanical Properties

Compressive Strength

Table 3. Compressive Strength Results

Age (Days)	SCC (MPa)	Conventional Concrete (MPa)
7	32.5	28.0
28	48.2	42.3
56	55.6	47.8

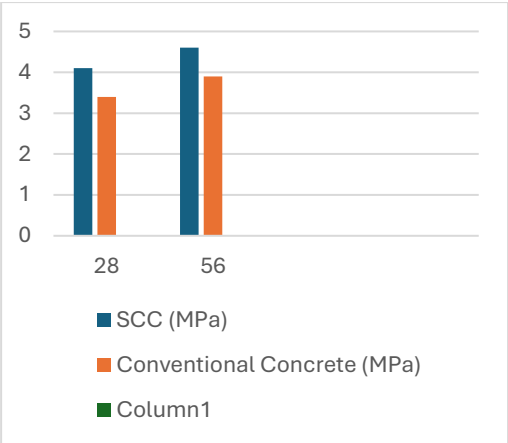


SCC exhibited higher compressive strength at all ages due to improved
compaction and continuous pozzolanic reactions.

Split Tensile Strength

Table 4. Split Tensile Strength Results

Age (Days)	SCC (MPa)	Conventional Concrete (MPa)
28	4.1	3.4
56	4.6	3.9



4.3 Durability Properties

Rapid Chloride Penetration Test (RCPT)

Table 5. RCPT Results

Mix	Charge Passed (Coulombs)
SCC	1450
Conventional Concrete	2850

Lower charge passed confirms superior chloride resistance of SCC.

Sorptivity Test

Table 6. Sorptivity Results

Mix	Sorptivity ($mm/min^{0.5}$)
SCC	0.095
Conventional Concrete	0.142

Water Absorption

Table 7. Water Absorption Results

Mix	Water Absorption (%)
SCC	1.8
Conventional Concrete	3.1

Acid Attack Resistance

Table 8. Acid Attack Results

Parameter	SCC
Weight Loss (%)	2.4
Strength Loss (%)	6.5

5. CONCLUSIONS

The study confirms that SCC exhibits superior mechanical and durability performance compared to conventional concrete. Reduced permeability, improved strength, and enhanced resistance to aggressive environments make SCC suitable for sustainable and long-life infrastructure.

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