

Experimental Investigation on the Effect of Superplasticizers and Retarders on Workability and Strength Properties of High Strength Concrete

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Abstract

High strength concrete (HSC) is widely used in modern construction due to its superior mechanical and durability properties. However, achieving adequate workability at low water-cement ratios remains a major challenge. This study investigates the effect of polycarboxylate ether (PCE) based superplasticizers and retarders on the workability, strength, and durability properties of M60 grade high strength concrete. Concrete mixes were prepared with varying dosages of superplasticizer (0.8%, 1.0%, and 1.2% by weight of cement) and combined dosages of superplasticizer with retarder (0.2% and 0.4%). Fresh concrete properties such as slump, slump retention, compaction factor, and setting time were evaluated. Hardened concrete properties including compressive strength, split tensile strength, flexural strength, and water absorption were assessed at 7, 28, and 56 days. The results indicate that superplasticizers significantly improve workability and strength, while the combined use of superplasticizer and retarder provides excellent workability retention without adversely affecting long-term strength and durability. The study demonstrates that an optimum combination of chemical admixtures is essential for the practical application of high strength concrete.

Keywords: High strength concrete, Superplasticizer, Retarder, Workability

retention, Compressive strength, Durability

1. Introduction

The demand for high strength concrete has increased significantly due to the growth of high-rise buildings, long-span bridges, and heavily loaded infrastructure. High strength concrete is typically produced using a low water-cement ratio, which results in reduced workability and rapid slump loss. Chemical admixtures such as superplasticizers and retarders play a crucial role in overcoming these limitations.

Superplasticizers improve workability by dispersing cement particles, while retarders delay hydration and enhance workability retention, particularly under hot weather and extended placement conditions. Although several studies have investigated the individual effects of these admixtures, limited experimental data are available on their combined influence on M60 grade high strength concrete under Indian conditions. This study aims to address this research gap.

2. Experimental Program

2.1 Materials

Ordinary Portland Cement (OPC) 53 grade conforming to IS 12269 was used. Natural river sand (Zone II) and crushed coarse aggregate of 20 mm nominal size were used. A PCE-based superplasticizer and a

commercially available retarder conforming to IS 9103 were incorporated. Potable water was used for mixing and curing.

2.2 Mix Proportions

The concrete mix was designed for M60 grade as per IS 10262:2019 with a constant water–cement ratio of 0.32. Six mixes were prepared: one control mix (CC), three mixes with varying superplasticizer dosages (SP1, SP2, SP3), and two mixes with combined superplasticizer and retarder dosages (SPR1, SPR2).

3. Test Results and Discussion

3.1 Fresh Concrete Properties

3.1.1 Slump Test Results Table 1 Slump Test Results

Mix ID	Slump (mm)
CC	65
SP1	95
SP2	120
SP3	145
SPR1	140

Discussion:

The control mix exhibited low workability due to the low water–cement ratio. Superplasticizer significantly improved slump, while the combination of superplasticizer and retarder resulted in maximum workability.

3.1.2 Slump Retention

Table 2 Slump Retention Results (mm)

Mix	0 min	30 min	60 min	90 min	120 min
CC	65	45	30	15	5
SP2	120	100	80	60	40
SPR1	140	125	110	95	80
SPR2	150	135	120	105	90

Discussion:

Rapid slump loss was observed in the control mix. Retarder-based mixes showed excellent workability retention up to 120 minutes, making them suitable for ready- mix applications.

3.2 Mechanical Properties

3.2.1 Compressive Strength

Table 3 Compressive Strength Results (MPa)

Mix	7 Days	28 Days	56 Days	Mix	7 Days
CC	42.5	61.2	65.8	CC	42.5
SP2	48.9	68.5	73.4	SP2	48.9
SP3	50.1	69.2	74.0	SP3	50.1

Discussion:

All mixes achieved M60 strength at 28 days. Superplasticizer enhanced strength due to improved particle packing. Slight reduction in early strength was observed in retarder-based mixes, but long-term strength was not adversely affected.

3.2.2 Split Tensile Strength

Table 4 Split Tensile Strength Results (MPa)

Mix	28 Days	56 Days
CC	4.2	4.5
SP3	4.9	5.3
SPR1	4.7	5.1

Discussion:

Modified mixes showed improved tensile strength due to enhanced bonding between paste and aggregates.

3.2.3 Flexural Strength

Table 5 Flexural Strength Results (MPa)

Mix	28 Days	56 Days
CC	6.0	6.4
SP3	7.0	7.4
SPR1	6.7	7.1

Discussion:

Flexural strength increased for admixture-modified mixes, indicating improved homogeneity and reduced microcracking.

3.3 Durability Properties

3.3.1 Water Absorption

Table 6 Water Absorption Results (%)

Mix	28 Days	56 Days
CC	2.4	2.1
SP3	1.7	1.4
SPR2	1.6	1.2

Discussion:

Lower water absorption values for modified mixes indicate denser concrete and improved durability.

4. Conclusions

1. Superplasticizers significantly enhance workability and strength of high strength concrete.
2. Retarders effectively improve workability retention without compromising long-term strength.
3. The combined use of superplasticizer and retarder provides an optimum balance between workability, strength, and durability.
4. All modified mixes achieved M60 grade strength at 28 days.
5. The study confirms the suitability of chemical admixtures for practical application of high strength concrete.

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