

EVALUATION OF HNO₃ CHEMICAL ATTACK AND ITS EFFECTIVENESS AGAINST SCC WITH HYBRID FIBER

Abstract

A self-compacting concrete mixture was made using OPC grade 53, 5% silica fumes, 25% GGBS, fine aggregate, coarse aggregate, micro steel fibers, macro wavy fibers, and super plasticizers. There were six different cement weight combinations that were used to make SCC mixes: N, 0%, 0.5%, 1%, 1.5%, and 2%. Every cube combination's compression strength is assessed. Three cube combinations are cast, and each combination is given a 3, 28-day curing period. After the strength test is finished, the cubes with the longest curing periods produce the strongest results. In this paper, several chemical resistance tests are discussed for self-compacting concrete made with different amounts of steel fibers, waved microfibers, without FIBRE and with GGBS, silica fume admixtures, and without admixtures. Six potential mix designs are expressed in order to run this test. The cubes are cast, allowed to dry for 28 days in clean water, and then immersed in chemical solutions (10% and 12%) for intervals of 3, 7, or 14 days each. After the 3, 7-day period, the percentage of weight loss in chemical assaults such nitric acid assault is found. The test findings show that the specimens were submerged in 12% nitric acid. Significant damage had occurred to 7days submerged. Loss of weight was noticed after being submerged in nitric acid.

Keywords: Self Compacting Concrete, Hybrid Fibers, Compression Strength, HNO₃ Nitric Acid, Weight Loss of Cubes.

Authors

Maneeth .P .D

Assistant Professor
Department of Civil Engineering
Visvesvaraya Technological University
Belagavi, Kalaburagi, Karnataka, India.

Dr. Shreenivasreddy Shahapur

Professor
Department of Civil Engineering
Visvesvaraya Technological University
Belagavi, Kalaburagi, Karnataka, India.

Neha Dama

PG Student
Department of Civil Engineering
Visvesvaraya Technological University
Belagavi, Kalaburagi, Karnataka, India.

I. INTRODUCTION

The technology for concrete has advanced dramatically in the last decades. Concrete is not simply just cement, aggregate, water, and additive; it is now an engineering substance containing a number of additional ingredients [1]. Today's building materials can meet most specified criteria under a variety of exposure situations. Today's concrete can meet almost every precise need under most exposure conditions. As a result, there is an ongoing need for study and research field of concrete technology [3]. According to the United States Concrete Association (ACI), exceptional performance concrete is "concrete that fits the criteria performance and consistency standards that are not constantly met using common ingredients, regular mixing procedures, and standard curing operations [2]. As a result, concrete with superior performance should contain at least one Excellent properties include compression capacity, great flexibility, and improved resilience to biological or physical stressors, as well as decreased penetration and lifespan[4]. The purpose of concrete movement, i.e. compression of fresh building materials, is to minimize honeycomb structures and cavities, which reduce the hardness and longevity of the material. Special usage, such as underwater the pouring process, always necessitates the use of fresh concrete that must be poured with no compaction [5]. Shaking is simply not conceivable in these situations. Designers and scientists have developed mechanical methods for compacting new concrete. Fortunately there have some drawbacks. to these approaches, such as vibration noise and insufficient consolidation[6]. These methods cannot be applied in structures with an abundance of stabilizers. Self Compacting Concrete (SCC) was created to address the issues connected with the compaction of concrete utilizing motion methods. Okamura (1988) popularized it in Japan [7]. The shortage of building laborers in Japan was the impetus for the invention of SCC, and this remains a major reason in its ongoing deployment [7].

- 1. Background on Self-Compacting Concrete:** Since mortar-derived products are the most widely available of all artificially manufactured commodities, they are very significant designer goods and are very likely to continue to be so old the same value in the future [8]. These aesthetic and anatomical products must, however, satisfy newer and more pressing needs. When faced with production, financial, operational, and environmental concerns, weatherproof materials adopt different decorative elements like vinyl, materials, and wood. Self-compressing concrete (SCC), an improved material that moves and consolidates itself by its weight without the need for additional compaction energy, is one route in this evolution [9] [10].
- 2. Reason for the Development of SCC:** The primary variables for the growth of the SCC are to accomplish high resilient, moveable, feasible and self-compressing of building materials and to resolve the weak characteristics of building materials as we understand the building materials a weak matter alongside low tension courage, volume stability, minimal elasticity and minimal power to the weight proportion [11]. Nevertheless SCC is distinguished because of it is additionally construction of homogeneous concrete SCC is a new form of concrete material that can increase the fluidity and functionality of regular concrete. Increasing the mortar content, on the other hand, might make the concrete brittle, resulting in collapse and higher expenses for production. Metal fibres can improve the stiffness, physical properties, and lifespan of buildings made of concrete when included with SCC-containing substitute cement products (CRMs). Cementing materials with the same qualities as cement can substitute at least part of the cement, lowering total

cost. It has been discovered that strengthened fibre improves the bending and shear rigidity, toughness, and hardness of cementitious substitute composites. By inserting fibres across cracks in concrete, fibres can improve compressive and flexural resilience, and manage masonry fractures, and varied activity. Someone additionally, bridging fractured areas and postponing regional fracture progression [12]. The mix with steel fibre reinforcement is mostly used in components that undergo harmful fluid and focused load. It's used in a variety of commercial and architectural applications, including commercial floors, airline pavements, overlays in its entirety and pipe coating. Fibers, on the other hand, can produce clogging and prove challenging to get apart while mixing [13]. CRMs including fly ash are used in concrete mixtures to improve SCC qualities such as functionality. Several replacements derived from flying ash ratios have been investigated to discover the greatest amount of enhancement and appropriate substitution ratio. The goal of this investigation is to improve the toughness and lifespan of self-compacting concrete by incorporating steel fibers into the substitute for cement components. Four distinct CRM-containing self-compacting blends of concrete. The effects of various CRMs on the new and exciting physical characteristics of SFR-SCC mixes were investigated. The ultimate goal was to discover optimal fraction of metallic filaments which will be incorporated into a building material to enhance it qualities. [2]

Kim et al. [2] investigated the mechanical characteristics of polypropylene (PP) fibre-reinforced lightweight concrete (FRLC) using lightweight clay particle that has been stretched (LECA). The findings revealed that the crushing toughness and flexible modulus of concrete sample are unaffected by temperature. Minor fiber content. The hardness of the concrete samples rose as the PP fiber concentration increased. Maza Heripour et al. [3] investigated the impact of investigated the impact of PP fibres on SCLC. They looked into rheological and toughened crushing toughness, breaking strength of tensile material, and other properties elastic modulus, and deflection. The findings show revealed the PP fiber didn't enhance the SCLC compression toughness or modulus of elasticity, but that additional 0.3% PP fibers increased the SCLC breakup yield toughness by 14%. [3]

II. METHODOLOGY AND OBJECTIVES

1. Objectives

- Evaluation of hybrid fibre Reinforce self-compacting Concrete.
- To study the SCC made with replacement partially by Micro Silica fume and GGBS.
- To determine properties of fresh characteristics in addition the Harden characteristics of mix design.
- Exploration as well as the outcome of HNO₃ on the characteristics of hybrid fibre Reinforce self compacting concrete.

2. The Materials Employed Are: In current study mix design [23] [30] in accordance with IS: 10262: 2019 codes containing OPC Cement 53 grade, CA of 10mm, FA confirming to zone II, and water was considered. Further 25% by weight of cement GGBS was adopted, 5% silica fume replacement by weight of cement was inducted, crimped steel fibers, polypropylene waved fibers [33] varied in percentage from 0% to 2% at equal quantity

was added and 1.6% by weight of cement poly-carboxylic ether, VMA were utilized. Additionally, chemical acid HNO₃ was utilized to evaluate the durability characteristic of design specimen. [34]

Table 1: Tests on Cement OPC 53 Grade

Sl.No.	Test Name		Result
1.	Cement fineness		4.6%
2.	Consistency (normal)		28ml water added 35mm penetration
3.	Time set	Initial	5mm at 45mins on every 5mins interval
4.		Final	360mins at every 60mins interval
5.	Specific gravity		3.1

Table 2: Tests of Sand

Sl.No.	Test Name	Result
1	Sand Specific gravity	2.61
2	Sand Fineness modulus	2.75
3	Sand Zone	II

Test on Coarse Aggregate

Table 3: Specific Gravity Test of Coarse Aggregate

Sl.No.	Test Name		Result
1.	Specific Gravity		2.61
2.	Bulk Density (kg/m ³)	Loose	1.4
		Compacted	1.5
3.	Water Absorption		0.5%

Tests on GGBS

Table 4: Tests on GGBS

Sl. No.	Test Name		Result
1.	Specific Gravity		2.77
	Bulk	Loose	1000-1100

2.	Density (kg/m ³)	Vibrated	1200-1300
3.	Fineness		>350m ² /kg

Table 5: Tests On White Micro Silica Fume

Sl. No.	Test Name		Result
1.	Specific Gravity		2.58
2.	Bulk Density kg/m ³	Un-densified	150 - 300
		Densified	600 - 700
3.	Fineness		0.1micron

3. Mixture Proportioning: For the test, A Self-Compacting Concrete Mixture Was Collected of OPC Grade 53, silica fume, fine aggregate, GGBS, coarse aggregate, micro steel fibers, macro waved fibers and super plasticizers. There Are Six Mixes Were Prepared.[22,23,24,25]

Table No.6: Percentage of Admixtures

Sl. No.	Mix Id	% of Silica Fume	% of GGBS	% of Steel Fibers	% of Waved Fibers
1	N	0	0	0	0
2	D0%	5%	25%	0	0
3	D0.5%	5%	25%	0.25%	0.25%
4	D1%	5%	25%	0.5%	0.5%
5	D1.5%	5%	25%	0.75%	0.75%
6	D2%	5%	25%	1%	1%

Mix Proportions

Table No 7: Mix Proportion for SCC

Cement kg/m ³	Mineral Admixture kg/m ³	FA kg/m ³	CA kg/m ³	Chemical Admixture kg/m ³	Water kg/m ³
319	136	860	830	2.71	190
1	0.43	2.708	2.59	0.0085	0.599

III.RESULT AND DISCUSSION

Flow Table Test Result

Table No 8: Flow Table Result

Slump value in (mm)	315	345	375	410	440	475
Mix ID	N	D _{0%}	D _{0.5%}	D _{1%}	D _{1.5%}	D _{2%}

With the mineral admixtures, the slump flow increases. Hybrid Fibers create concrete particle jamming and this has an influence on the flow rate. [27, 28, 29]

Tests on Compression Power

Compressive Power Test for Normal Mix



Figure 1:
Fresh State of Cube Casted



Figure 2 :
After De-moulding Cubes



Figure 3 :
Curing of Moulds



Figure. 4 :
Weight of Cube After 28days Curing Normal



Figure 5 :
Compression Strength Test Result



Figure 6 :
Breakage of Cubes



Figure 7 :
Super Plasticizers Mixing in Dry State of Concrete

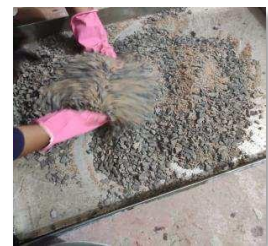
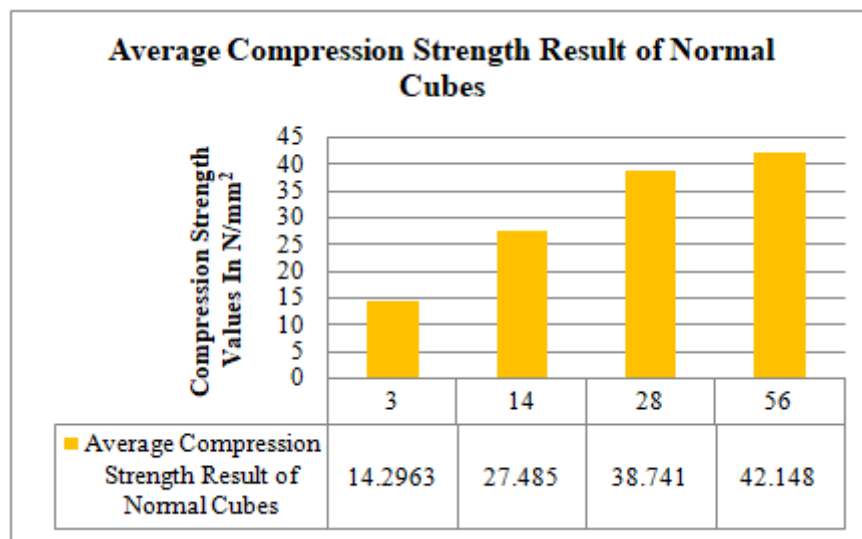


Figure 8:
Dry Mixing of Concrete

Table No 9: Compression Strength Test for Specimens of 150x150x150 mm For Normal Mix

Sl. No.	Identification Mark	Actual age of the specimens in days	Average Compression Strength in N/mm ²
1	N	3	14.29
2	N	14	27.48
3	N	28	38.74
4	N	56	42.14

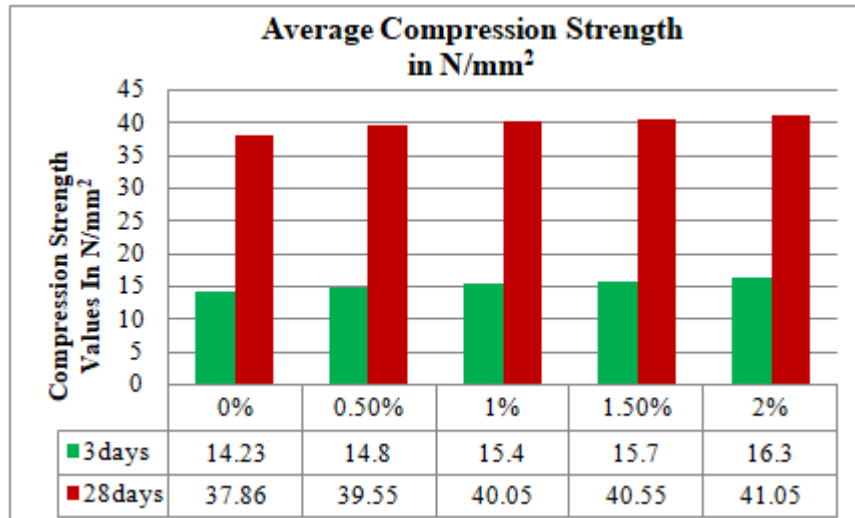


Graph No.1 Normal Specimen Average Compression Strength Result

Table No 10: Design Mix Average Compression Strength

Test at 3days and 28 days for Specimens of 150x150x150 mm

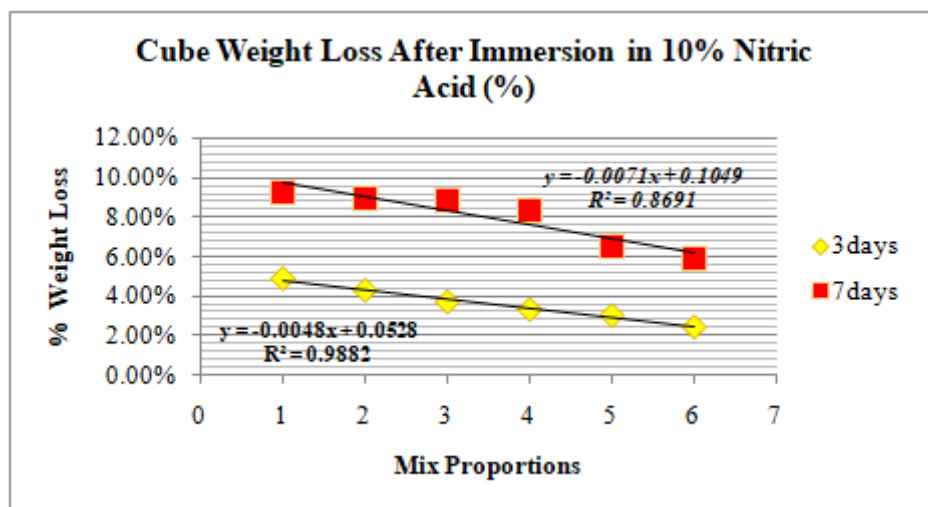
Sl. No.	Mix ID	Average Compression Strength Result in N/mm ²	
		3days	28days
1.	D 0%	14.23	37.86
2.	D 0.5%	14.80	39.55
3.	D 1%	15.40	40.05
4.	D 1.5%	15.70	40.55
5.	D 2%	16.30	41.05



Graph No. 2: Average Design Mix Compression Strength Result

Table No. 11:- 10% Nitric Acid Attack For 3, 7 Days Immersion of Cubes Result

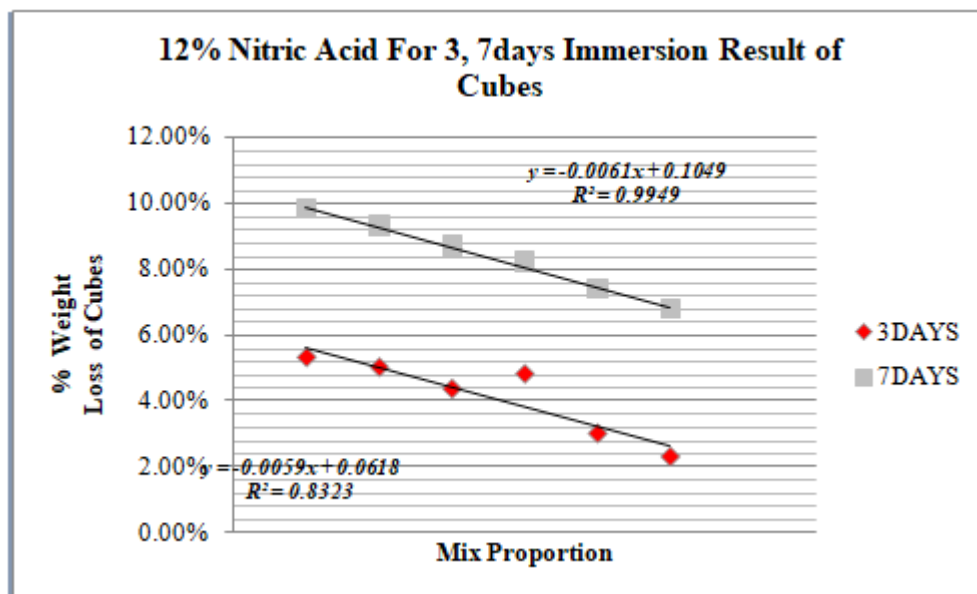
Sl. No.	Mix ID	Cube Weight Loss After Immersion in 10% Nitric Acid (%)	
		3days	7days
1	N	4.90%	9.30%
2	D _{0%}	4.30%	9.00%
3	D _{0.5%}	3.70%	8.85%
4	D _{1%}	3.30%	8.40%
5	D _{1.5%}	3.00%	6.50%
6	D _{2%}	2.40%	5.90%



Graph No. 3: 10% Nitric Acid for 3, 7days Immersion Result of Cubes

Table No. 12:- 12% Nitric Acid Attack For 3, 7 Days Immersion of Cubes Result

Sl. No.	Mix ID	Cubes Lose Weight After Immersion In 12% Nitric Acid (%)	
		3days	7days
1	N	5.30%	9.80%
2	D _{0%}	5.00%	9.30%
3	D _{0.5%}	4.35%	8.70%
4	D _{1%}	4.80%	8.20%
5	D _{1.5%}	3.00%	7.40%
6	D _{2%}	2.30%	6.80%



Graph No.4: 12% Nitric Acid for 3, 7days Immersion Result of Cubes

IV. CONCLUSION

1. Slump flow table test of hybrid fibre reinforced with self-compacting concrete shows increase in slump flow value.
2. From all mixes of said study, 2% mix shows the better slump flow value. This enhances the flow rate at this proportion.
3. Design mix Self-compacting concrete pertaining to 2% of hybrid fibre maximizes strength 28 days.
4. With hybrid fibers and additives like Silica fume, GGBS adds up together in increasing the compression strength.
5. The water's tint changes as concrete cubes inserted in Nitric acid solution.
6. More impact of nitric acid on cement, GGBS, as well as silica fume.
7. Less impact on sand and coarse aggregate.
8. When Specimens are allowed exposed at 10% and 12% respectively nitric acid it will

lose as significant amount of weight.

9. Design mix of SCC samples have various additives involved has shown enhanced chemical resistance, especially against nitric acid (HNO₃)
10. The weight of the cube following three consecutive days of curing 10% nitric acid is observed around 0.15% weight have decreased.
11. The cube lost around 0.35% of its weight 7 days followed curing with 10% nitric acid.
12. The cube's weight after three days of curing in 12% nitric acid is observed around 0.18% weight have decreased.
13. The cube lost around 0.42% of its weight 7 days following curing with 12% nitric acid.
14. 12% nitric acid shows the more a loss of weight cubes than 10% nitric acid solution.

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