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Flexural Behaviour and Durability of Self Compacting Concrete Mixed with SN-Based Corrosion Inhibitor

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ABSTRACT

The present study aimed to create a Self-Compacting Concrete (SCC) that possesses long-lasting properties and evaluate its fresh, mechanical, and durability properties by substituting 30% of the cement with class F fly ash. Furthermore, the performance of SCC that has been admixed with an SN-based corrosion inhibitor was investigated. Various factors such as the ratio of water to powder, fine aggregate, coarse aggregate (12mm downgraded), and the SN-based corrosion inhibitor were studied. The particle size distribution of the materials was analyzed using a sieve to achieve an even distribution of sizes, appropriate packing, and a lower void content. Multiple mixes were conducted, each with a unique combination of fine and coarse aggregate, as well as a water-to-powder ratio that was altered to optimize the mix percentage. Finally, controlled SCC (or mix M2) met the fresh property standards outlined in the EFNARC guidelines and specifications.

The mechanical and durability properties of control SCC and SCC admixed with an SN-based corrosion inhibitor were investigated. Results showed a significant improvement in the compressive strength, split tensile strength, and flexural behavior of Reinforced Cement Concrete (RCC) beams when control SCC was utilized. Furthermore, the SCC with 2% SN demonstrated superior performance in terms of chloride penetration compared to the control SCC. The flexural strength parameters of the SCC with 2% SN were comparable to those of the control SCC. Based on the study's findings, it can be concluded that the addition of inhibitors at a weight percentage of 2% of the cement supplied increased durability properties without affecting the strength properties of SCC. Therefore, the created durable SCC can be recommended for applications such as bridges, prefabricated constructions, and deck slabs which are densely crowded with steel rebars. The study's findings could contribute to the development of SCC with enhanced properties, which would lead to more durable and sustainable construction materials.

Keywords: Self compacting concrete, SN based corrosion inhibitor, Durability properties,Flexural strength.

I. INTRODUCTION

1.1 General

Concrete is one of the most commonly used man-made construction materials because it can be created with readily available raw materials in the surrounding area. This attribute contributes to concrete's popularity. Hydration of cement is the process by which cement undergoes a chemical reaction with water to grow harder over time. This reaction, which is known as hydration of cement, is a continuous process that makes concrete harder gradually. Because concrete is robust when compressed but fragile when stretched, it needs to be reinforced with other materials in order to improve its tensile strength. However, steel is very strong in tension; therefore, by combining steel reinforcement with concrete, the issue that arises from the tensile weakness of concrete can be solved.

One of the most common and widely used types of building framework are reinforced concrete constructions. Reinforcing bars made of steel are typically but not always used for the reinforcement. These bars are typically inserted in the concrete in a passive manner prior to the setting of the concrete. In general, reinforcing schemes are developed to withstand tensile stresses in certain sections of the concrete that have the potential to induce undesirable cracking and/or structural failure. Reinforcing elements in contemporary reinforced concrete may be fabricated from steel, polymers, or an assortment of other composite materials, and they may or may not be combined with rebar. It is also possible to permanently stress reinforced concrete by applying compression stresses, with the goal of improving the behaviour of the finished structure when subjected to working loads.

1.2 Objectives:

- Create a long-lasting Self-Compacting Concrete (SCC)
- Investigate the fresh, mechanical, and durability properties of SCC by substituting 30% of cement with class F fly ash and adding an SN-based corrosion inhibitor.
- Analyze the ratio of water to powder, fine aggregate, coarse aggregate, and corrosion inhibitor.
- Optimize the mix percentage by altering the water-to-powder ratio and using unique combinations of aggregates.
- Determine if the SCC satisfies the fresh property standards outlined in EFNARC guidelines and specifications.
- Compare the mechanical and durability features of control SCC and SCC with SN-based corrosion inhibitor.
- Determine if SCC with corrosion inhibitor performs better in terms of chloride penetration and flexural strength parameters.
- Conclude if the addition of corrosion inhibitors at 2% weight percentage of cement increases durability properties without affecting strength properties.
- Suggest potential applications for the durable SCC, such as bridges, prefabricated constructions, and deck slabs with densely crowded steel rebars.

II. LITERATURE REVIEW

B.H.V. Pai, M. Nandy, A. Krishnamoorthy, P.K. Sarkar, C. Pramukh Ganapathy (2021), "Experimental study on self-compacting concrete containing industrial by-products", European Scientific Journal. A performance analysis of fresh concrete properties and mechanical properties of both GGBS and SF based SCC mixes was conducted by them**.** The main focusof this study was to achieve SCC of M25 grade by the method proposed by Nan Su etal., which specifies the utilization of two powders, Fly Ash and GGBS, as thereplacement for cement in the same mix. When compared to the SF-based SCC, the results showed that the GGBS-based SCC possessed superior values of compressive strength, split tensile strength, and flexural strength. It is possible that the highpercentage of SF (50.19%) in the mix is to blame for the poor potency of the SF-basedSCC. When compared to SF, GGBS has a stronger pozzolonic activity than SF, whichmay be responsible for the strength gain of a combination that is based on GGBS.

O. S. Olafusi, A. P. Adewuyi, O. M. Sadiq, A. F. Adisa, O. S. Abiola (2021) Rheological and Mechanical Characteristics of Self-Compacting Concrete Containing Corncob Ash" Journal of Engineering Research, The V-funnel apparatus was used to evaluate the flowability and resistance to segregation of freshly mixed concrete specimens, while the L-box apparatus was used to investigate the characteristics of passing ability. The compressive strength of cylindrical concrete specimens of 100 millimeters in diameterand 200 millimeters in length was tested. Due to the different testing procedures and individual flow characteristics, the rheological properties of SCC cannot be comparedto those of normal concrete. This is because SCC has its own unique characteristics. In comparison to conventional cement concrete, the compressive strength results of hardened concrete showed that SCC gained strength more slowly than conventional cement concrete due to the presence of admixtures. The compressive strength of SCCafter 28 days is in the range of 85–95% of conventional cement concrete, but SCC eventually had potentials of higher strength beyond 90 days. When compared to conventional concrete, the influence of water-to-cement ratio on the plastic characteristics of self-compacting concrete was almost insignificant.

Madhavan V, Antony Jeyasehar C (2021) "Strength and durability studies on sodium nitrite inhibitor in ordinary and high performance concrete", International Journal of Engineering and Applied Science, The effect of using a sodium nitrite-based corrosion inhibitor in concrete was studied and the researchers employed several dosages of the sodium nitrite-based inhibitor, including 0.5%, 1%, 1.5%, and 2%. The comparative analysis of the mechanical qualities and durability properties of high-performance concrete and standard concrete, both with and without an inhibitor. The findings of thetests demonstrate that the compressive strength and split tensile strength of the concrete were raised when sodium nitrite was used as a corrosion inhibitor. This is in comparison to the concrete that did not have an SN-based corrosion inhibitor added. When compared to regular concrete with inhibitor, high performance concrete with inhibitor has a water absorption rate that is forty percent lower than that of conventional concrete with inhibitor. In high performance concrete with inhibitor, the presence of chloride ion permeability is very low (coulombs range: 142-93) when compared to ordinary concrete with inhibitor (coulombs range: 387-158) as thepercentage of dosages increases.

Yasar Arafat et.al (2021) "Influence of sodium nitrite and calcium nitrite based corrosion inhibitor on the durability properties of concrete", International Journal of Engineering and Applied Science, conducted research to investigate how the durability qualities of concrete are affected by the use of sodium nitrite and calcium nitrite-based corrosion inhibitors. In order to find the optimal value, sodium nitrite was mixed in at a rate of 1% and 2% by weight of cement, while calcium nitrite was mixed in at a rate of 1.5%, 2%, 3%, and 4% by weight of cement. Both of these rates were applied to the cement. In order to establish a benchmark for this value, a battery of durability experiments, including the Accelerated corrosion test, the Sorpitivity test, the Open circuit potential test, the Rapid chloride ion penetration test, and the chloride ion penetration test, were carried out. After adding 2% sodium nitrite, it was discovered that the concrete specimen demonstrated higher corrosion resistance across the board. This was the finding across all of the tests.

Dharmaraj, Malathy (2020) "Effect of Corrosion on Mechanical and Durability Properties of Reinforced Self-Compacting Concrete", Middle-East Journal of Scientific Research, conducted an experiment to investigate the strength and corrosion resistant properties of SCC along with sodium nitrite as a corrosion inhibiting admixture at the dosages of 1%, 2%, 3%, 4%, and 5% by weight of cementitious material. The dosages were determined based on the weight of the cementitious material. The findings of the strength and durability tests were analysed and compared to the results obtained from testing ordinary self-compacting concrete. According to the findings, the maximum value for compressive strength, split tensile test, and flexural strength can be achieved by adding 3% of the inhibitor to the SCC. Adding more inhibitor results in a reduction in strength due to a lower degree of hydration, so increasing the dosage has the opposite effect. The sorptivity test of the concrete reveals that SN3 specimens had much lower water penetration compared to the reference concrete.

R Dharmaraj, R Malathy (2021) "Flexural Behaviour of Reinforced Self- Compacting Concrete Containing Corrosion Inhibitors", International Journal of Advanced Engineering Technology, The authors of the study conducted an experiment to test the influence of hexamine as a corrosion inhibitor in self-compacting concrete on the properties of both fresh and hardened concrete. The optimal amount of corrosion inhibitor in concrete mix was determined to be 2%, and additional research examined the flexural behaviour of RCC beams with and without corrosion inhibitor (also knownas hexamine). The mechanical properties, such as compressive strength, split tensile test, flexural strength, and also the durability test, the prominent result has been obtained in H2% mix, and it was concluded that the further addition of corrosion inhibitor (Hexamine) leads to a decrease in strength. These tests were conducted on the material. In comparison to the behaviour of control SCC, the flexural behaviour ofRCC beams of SCC with 2% hexamine demonstrates a much-improved outcome.

III. STUDY ON MATERIAL PROPERTIES

3.1 General

This section includes specific information regarding the chemical and physical characteristics of the components that are utilised in the production of SCC. All tests were conducted as per the Bureau of Indian standard (BIS) and American standard fortesting materials (ASTM) code requirements.

3.2 Materials

The materials are used for the experimental study are listed in Table 1

Table 1: Materials used for the experimental study

S No.	Type of material	Purpose of using
1	Ordinary Portland cement	Binder material
2	Fly ash (Class F)	Filler material, increases propertyof flow
3	Fine aggregate (zone I)	Reduces shrinkage
4	Coarse aggregate (<20mm)	

5	Super plasticizer (PCE based)	Increases flow property and actsas water reducing agent
6	Potable Water	Hydration of cement

3.2.1 Cement

We utilised regular Portland cement with a grade of 53, as specified by the international standard IS 12269:1987 (Concrete mix proportioning – Guidelines). In accordance with the requirements of IS 4031:1988, the cement's physical properties were analysed (Methods of Physical Test for Hydraulic cement). The cement's physical characteristics are given in Table 2 below.

Table 2: Observation on physical properties of cement

Properties		Obtained values
Fineness (%)		5
Consistency (%)		28
Initial setting time (min)		50
Final setting time (min)		250
Specific gravity		3.02
Compressive strength (MPa)	3 days	39.99
	7 days	45.25
	28 days	55.75

3.2.2 Fine aggregate

The fine aggregate consisted primarily of manufactured sand. The nature of sand can be ascertained by carrying out tests in accordance with Indian Standard 2386. (part 1). Based on the findings of the sieve analysis, it has been determined that the sand is suitable for use in zone II of international standard 383-1970. The physical parametersof fine aggregate are displayed in Table 3 and Figure 1, respectively. Figure 1 also displays the particle size distribution of fine aggregate.

Table 3: Observation on properties of fine aggregate

Properties	Obtained values
Specific Gravity	2.34
% water absorption	0.386%
Bulk density (Kg/ m^3)	16.7
Particle size distribution	Well graded
Grading Zone	Zone II

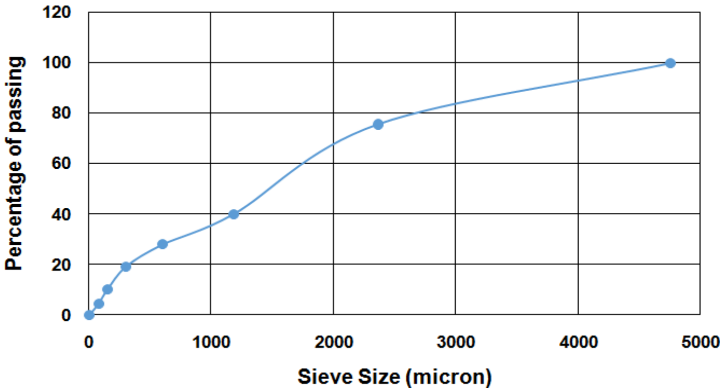


Figure 1: Observation on particle size distribution of fine aggregate

3.2.3 Coarse aggregate

This research made use of coarse particles with a reduced size of 12 millimeters for the production of self-compacting concrete. As a result of the fact that the form and the distribution of the particle size is very significant for the packing void content, thewater absorption, and the grading in order to manufacture SCC of high quality, Table 4 contains a listing of the characteristics that coarse aggregate possesses, including its specific gravity, water absorption, fineness modulus, and bulk density.

Table 4 : Observation on physical properties of coarse aggregate

Properties	Obtained values	Test procedure
Specific Gravity	2.77	IS: 2386:1963, Indian Standard Methods of test for Aggregates for concrete(Part-3) “Specific gravity, density, voids, absorption and bulking”
% water absorption	0.202%	
Bulk density (KN/ m^3)	16.74	

3.2.4 Fly ash

Pulverized fuel ash which is also known as fly ash is used as a filler material in proposed SCC. It was collected from Kothagudam Thermal Power Plant and the grade of fly ash used in the study is class F.

3.2.5 Super-plasticizer

In the chemical industry, super-plasticizers are referred to as chemical admixtures, and their primary function is to lower the amount of high-range water. In order to improve the flowability of the concrete, it is an essential component of the SCC system. The product that is utilised is known as Master Glenium Sky 8233, which was formerly known as Glenium B233. It is a high-performance super- plasticizer that is based on poly-carboxylic ether and is offered by Master Builders solutions, BASF India Ltd.

Corrosion inhibitor

In the investigation, a mixed inhibitor based on sodium nitrite that was commercially available was utilised. The liquid that acts as the corrosion inhibitor has a dark brown colour and is free flowing. To ensure that the inhibitor is dispersed evenly throughout the mortar matrix, it is first pre-mixed with the water that will be used in the preparation process.

Table 5: Observation on test properties of corrosion inhibitor

Test property	Test procedure	Sodium Nitrite based corrosion Inhibitor
pH	BIS 13435 part-4 (1992),” Determination of specific gravity and pHusing resistance method”	11.58
Specific gravity		1.182

3.2.6 Potable water

Ordinary Potable Water available in laboratory is used.

3.3 Methodology

The approach for evaluating the performance of control SCC and SCC with 1% & 2%SN is depicted in Figure 3.2, which provides an illustration of the different important actions that are included in the evaluation process. Rebar with a diameter of 12 millimeters, ordinary Portland cement, super plasticizer, and SN-based corrosion inhibitor are the components that make up the material. In this particular investigation, M-sand that was readily available on the market was utilised. The effectiveness of corrosion inhibitors that were mixed in with SCC was analysed by testing its fresh properties, strength characteristics, and toughened properties in accordance with the provisions of the relevant codes. For the purpose of providing steel bar with corrosionresistance, commercially available inhibitors are utilised. In addition to that, the trialson durability were carried out.

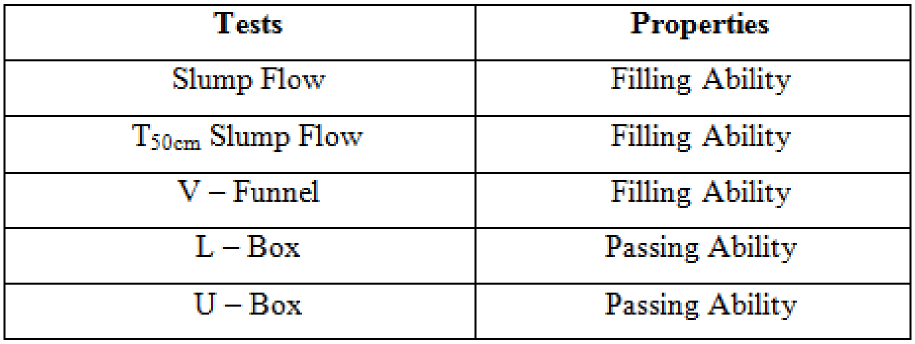
IV. TESTS ON CONCRETE

4.1 Fresh Concrete Properties:

4.1.1 General

The primary attributes of SCC qualities that are exhibited while it is in its fresh state The design of the mix is centred on the ability of the material to flow under its own weight without vibrating, to flow through heavily congested reinforcement under its own weight, and to preserve its homogeneity without separating into distinct components. Self-compacting concrete is a type of concrete mix that can only be classedas such if it possesses certain properties, including the ability to fill, the ability to pass, and the ability to segregate. Table 6 provides a comprehensive rundown of the many testing procedures that can be used to evaluate the workability qualities of SCC in its fresh stage.

Table 6: List of test for workability properties of SCC



Tests	Properties
Slump Flow	Filling Ability
T_{50cm} Slump Flow	Filling Ability
V – Funnel	Filling Ability
L – Box	Passing Ability
U – Box	Passing Ability

4.1.1.1 Slump flow test [IS 1199 – 2018 (Part 2)]

The slump test is seen in Figure 2; it is carried out for two distinct mixes, and it is carried out in accordance with EN 12350-2. The final spread diameter of the concreteand the amount of time it takes for a 500mm diameter spread are both noted. The acquired result can be found given in Table 7 below. When compared toSCC-M2, SCC-M1 has a lower slump flow, and it has been discovered that slump flow increaseswith both an increase in paste volume and an increase in the percentage of fines. Therefore, SCC-M2 possesses superior flow characteristics to those of SCC-M1. It can be concluded from this that SCC-M2 has a higher capacity for filling. As a result,we will refer to SCC-M1 as the control SCC. Additionally, the slump flow test was carried out for SCC with 1% and 2% SN.

Figure 2: View of concrete spreading after slump flow test

Table 7: Observation on slump test results

Fresh Concrete Properties	SCC-M1	SCC-M2	SCC with 1% SN	SCC with 2% SN	Specification as per EN 12350
Slump flow -T50(sec)	4	3	5	3	≤5sec
Slump Flow Final Spread (mm)	640	668	650	643	>600mm

4.1.1.2 V-Funnel Test [EN 12350 – 1]

In accordance with EN 12350-1, a test known as the V-funnel test is carried out to determine the filling and segregation properties of concrete. After approximately 12 litres of concrete have been poured into the funnel, the trap door can be opened. The amount of time that it takes for it to trickle down is recorded. The flow time for the V-funnel test should be between eight and twelve seconds. The results of this test, which is performed on the four mixes serving as controls (SCC-M1, SCC-M2, SCC, and SCC with 1% and 2% SN), are summarized in Table 8. When compared with the SCC- M2, the initial flow time of the SCC-M1 is significantly longer. In addition, a V-funneltest is performed on SCC samples with 1% and 2% SN. The correlation between the fine content and the flow time is illustrated in figure 3. Figure 4 depicts the test setup that is used for the V-funnel test.

Table 8: Observation on V-funnel test results

Fresh concrete properties	SCC-M_1	SCC-M_2	SCC with 1% SN	SCC with 2% SN	Specification as per EN 12350
V-Funnel flow time (sec)	15	11	9	7	≤12 sec

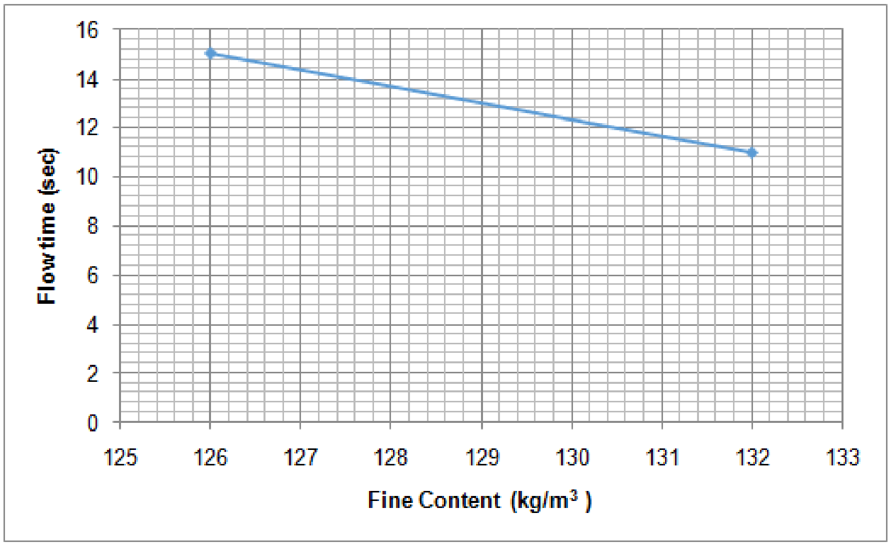


Figure 3: Relation between fine content and time of flow for SCC

Figure 4: V-funnel test

4.1.1.3 U- Box test [EN 12350 – 1]

The U-box test configuration is illustrated in figure 5. In accordance with EN12350- 1, this test is performed to evaluate the self-compacting concrete's capacity for filling spaces. The apparatus consists of a vessel that is partitioned into two separate compartments by a wall located in the center of the vessel. In between the two sections is a doorway that has a gate that can slide open and closed. At the gate, reinforcing barswith a nominal diameter of 13 millimeters and a center-to-center distance of 50 millimeters have been inserted. Because of this, there will be a distinct gap of 35 millimeters between the bars. The area on the left is given approximately 20 litres of concrete, which then flows into the section on the right.

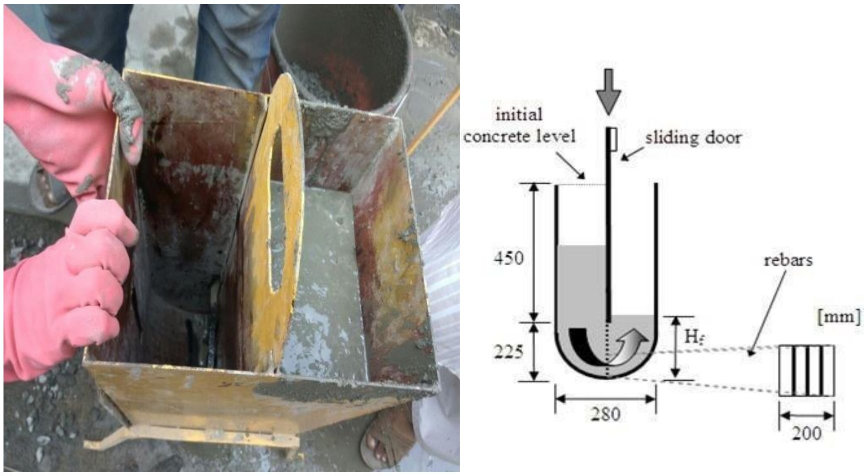


Figure 5: U-box test

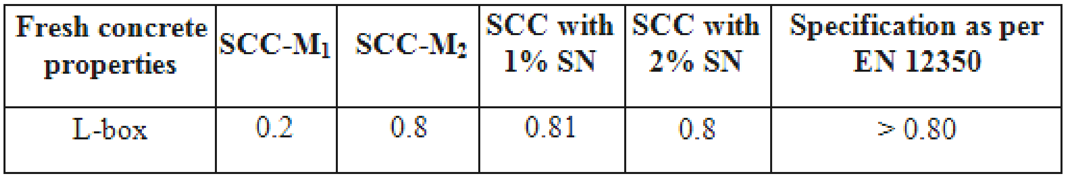
Table 9: Observation on U-box test results

Fresh concrete properties	**SCC-M1**	**SCC-M2**	**SCC with 1% SN**	**SCC with 2% SN**	**Specification as per EN 12350**
U-box	50	20	22	18	≤ 30mm

4.1.1.4 L-Box Test [BS EN 12350 – 10]

For this particular test, you will need around 14 litres of concrete. After the concrete has been poured into the vertical part, it is let to remain undisturbed for one minute. Thelift is put on the sliding gate, and concrete begins to pour out. The height of the concreteat both the beginning and the end is measured, giving heights H1 and H2 respectively. The blocking ratio can be calculated by dividing the height of the concrete at one end of a vertical section by the height of the concrete at the other end of the vertical sectionusing the formula H2 / H1. The entire exam must be completed within the allotted time frame of 5 minutes. The two different mixtures are put through a series of tests, and the results are summarized in Table 10. When compared to the result produced for the SCC M1, the result acquired for the SCC M2 satisfies the value of the L-box.

Table 10: Observation on L-box test results



Fresh concrete properties	SCC-M_1	SCC-M_2	SCC with 1% SN	SCC with 2% SN	Specification as per EN 12350
L-box	0.2	0.8	0.81	0.8	> 0.80

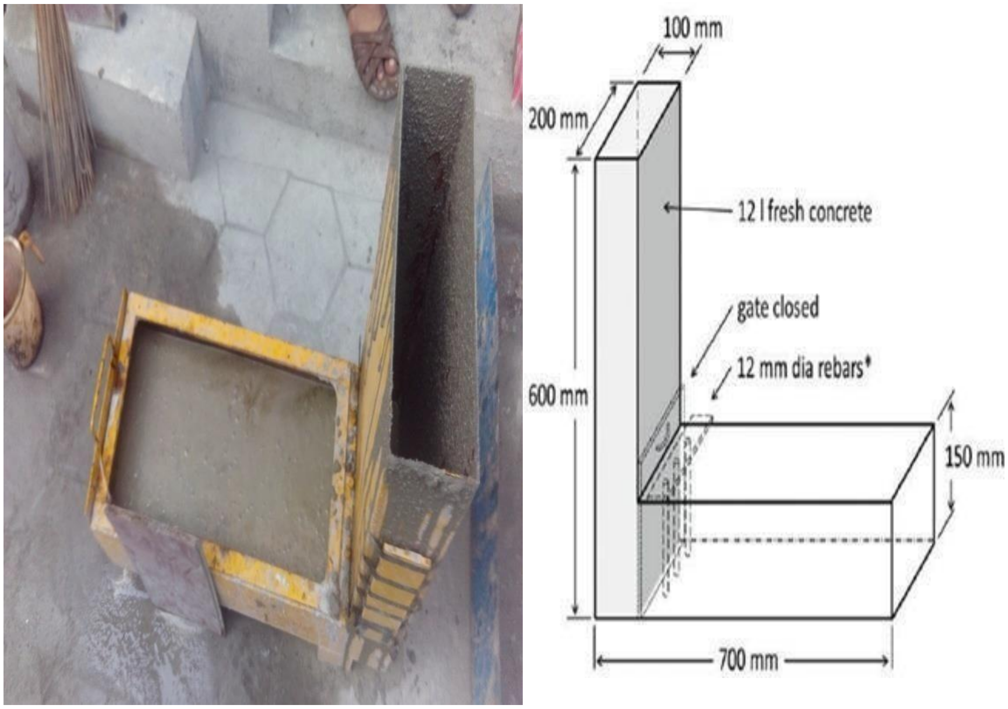


Figure 6: L-box test

4.2 Summary

The fact that SCC M1 does not satisfy the fresh concrete properties range values may be deduced from the findings of the fresh concrete properties of SCC M1 and SCC M2,which were presented before. Therefore, for the purpose of the current comparison investigation with the SCC admixed SN based corrosion inhibitor, the SCC M2 is being investigated for further research, both in terms of its toughened and durable property profiles. Therefore, we will choose SCC-M2 as our control SCC. Figure 7 displays a view of the cast and demoulded specimens, and Figure 8 illustrates the curing process being carried out on the specimens.

Figure 7: View of casted and demoulded specimens

Figure 8: Curing of specimens

V. EXPERIMENTAL INVESTIGATION

In this chapter, mechanical & durability properties of both conventional concrete andobtained self-compacting concrete are represented in addition to workability properties.

Mechanical strength related studies conducted includes: Compressive strength test, Split tensile strength test, Flexural Behaviour of RCC beams, Durability related studies conducted includes: Chloride penetration test,

Experimental Investigation On Mechanical Properties

5.1 Compressive strength test

Test procedure

Compressive testing machine with a 2000 KN capability is used for this evaluation. After waiting for a certain number of days for the concrete to cure out of the water, the cubes were taken out for testing. Specimens for display at the surface are cleaned,including the water gild and fins, and stored dry. After drying, the samples were placed symmetrically in the middle of the CTM loading plate. The load will be steadily increased by 3.5 kilo newtons per second until the system fails. An indication of the failure load and mode is provided. Many samples go through the same process repeatedly. This compressive test is depicted in Figure 9

Figure 9: Compressive strength test

5.2 Split tensile strength test

Test procedure

200-tonne (2000 KN) compression testing machine was used to measure the material's split tensile strength.

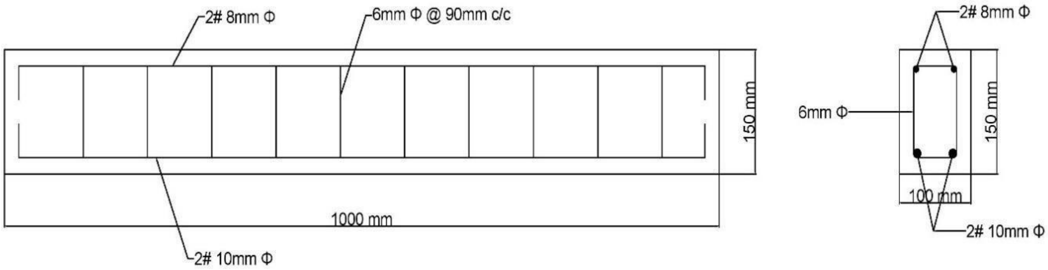
Thin bearing strips made of plywood are used to evenly distribute the stress supplied along the length of the specimen, and the cylinder specimen is placed in a particular fixture to do this. To apply force to the specimen, steel load bars are arranged as shown in Figure 10. Increases in pressure of 0.7 MPa/min to 1.4MPa/min are achieved in the loading process. The split tensile strength is obtained by splitting the specimen in half at the highest stress using the correct geometrical factor.

Figure 10: Split tensile strength test

5.3 Experimental Investigation On Flexural Behaviour Of RCCBeams

Categories of beams and details of specimens

Beams were cast into three distinct varieties. As reinforcement, HYSD bars were employed. Beams were tested with both untreated SCC and SCC that had been admixed with either 1% or 2% of a sodium nitrite-based corrosion inhibitor. The length of the specimens was 1000mm, width was 100mm, and depth was 150mm. There were two pieces of bottom reinforcement measuring 10mm in diameter, and two pieces of top reinforcement measuring 8mm in diameter. There were 6mm diameter vertical stirrups with a 90mm c-c distance between the legs. Schematic view and reinforcing detailing of beam shown in Figures 11 and 12.



5.3: Schematic view of reinforcement details of beam

Figure 12 : Tied reinforcement cage of beam

Casting and curing of beams

Beam dimensions are 100mm x 150mm x 1000mm. There were nine beams total, with three in each of three different types. Beams were cast with self- compacting concrete,thus no tamping is required. Pan mixers are used to make self- compacting concrete. After a day, all of the beams are broken down into their component parts. After beingcast, the beams soaked in water for 28 days to cure. Figure 13 depicts the process of casting beams.

Figure 13: Various stages involved in casting of beams

Test setup and instrumentation

After curing for the specified time, 28 days, the beam specimens were tested for flexural strength in accordance with IS 516-1959. A Universal Testing Machine with a 2T capacity was used for the evaluation.
In order to achieve basic bearing conditions, we place the beam over a supporting system that includes a roller with a diameter of 20 mm. The beam is subjected to a two-point load, applied via a centrally located setup. A highly sensitivedial gauge measures the deflection at two points on either side of the centre. To measure the beam's bending moment in the vicinity of the support, a dial gauge is set up at the beam's midpoint. The flexural strength test is depicted in Figure 14. Testing ultimate failure load, deflection at failure, fracture pattern, and load deflection behaviour are all important metrics to keep an eye on.

Figure 14: Flexural strength test

5.4 Experimental Investigation On Durability Properties

5.4.1 Chloride Penetration Test [ASTM C 1202]

Introduction

The purpose of the chloride penetration test is to determine how resistant concrete is to the movement of chloride ions through the material in the absence of any other external inciting agent. The samples were in the form of concrete cubes measuring 150millimeters on a side and 150 millimeters on each of the other three sides. In this investigation for the chloride penetration test, three specimens of each of the three mixtures being researched are analysed after a period of 28 days.

Test Procedure

For the chloride penetration test, a polymer-based water-proof coating is applied to four sides of a concrete cube measuring 100 mm by 100 mm, leaving the top and bottom exposed. After soaking for up to 20 days in a 3% NaCl solution, the specimens were cut in half and spliced together for the chloride penetration test. Spliced specimens are sprayed with a solution containing 0.1N silver nitrate and 0.1% sodium fluorescein. Only the area where chloride has penetrated the specimen retainsits original colour; the rest turns a rosy red. A chloride penetration test is shown in process in Figure 15.

Figure 15: Chloride penetration test

VI. RESULTS AND DISCUSSION

General

Both conventional concrete and self-compacting concrete were subjected to a variety of tests in order to ascertain the mechanical and durability performance of both types of concrete. These examinations of the materials were carried out in accordance with both the American standard and the Bureau of Indian Standards (BIS) (ASTM).

Mechanical Properties

6.1 Compressive strength of concrete

Table 11, 12 and 13 shows the observation on compressive strength of the mixes ofcontrol self-compacting concrete and SCC with 1% & 2% sodium nitrite-basedcorrosion inhibitor conducted at 7, 14, 28 and 56 days of curing respectively. It can be inferred that SCC with sodium nitrite-based corrosion inhibitor mix has a significant increase in compressive strength at all the tested ages as compared to control self- compacting concrete mix. The control SCC mix attained 90% of its strength at 7 days of curing, and 100% of its strength is attained at 14 days and 28 days of curing.

However, SCC with 1% & 2% SN based corrosion inhibitor achieved 49MPa& 52.5Mpa compressive strength in 28 days which is 45%& 50% more than the targetedgrade M35 respectively. These 1% SN and 2% SN mixes also attained 100%of its strength at 7 days curing, 120% and 115% of strength is attained at 14 days of curing and 145% and 150% of its strength is attained in 28 days of curing. Figure 16 shows the comparison of compressive strength between control SCC & SCC with1% and 2% SN based CI.

Table 11: Observation on compressive strength of control SCC

SI.No.	Type of Mix	Age	Ultimate load (kN)	Compressive strength (MPa)
1	Control SCC	7 days	317.5	31.75
2		14 days	386.5	38.65
3		28 days	460	46
4		56 days	625	62.5

Table 12: Observation on compressive strength of SCC with 1% SN based CI

SI.No.	Type of mix	Age	Ultimate load (KN)	Compressive Strength (MPa)
1	SCC with 1%SN based CI	7 days	356	35
2		14 days	419.5	42
3		28 days	490	49
4		56 days	521	52

Table 13: Observation on compressive strength of SCC with 2% SN based CI

SI.No.	Type of mix	Age	Ultimateload (KN)	Compressive strength (MPa)
1	SCC with 2%SN based CI	7 days	347	34.7
2		14 days	401.5	40.15
3		28 days	525	52.5
4		56 days	576	57.6

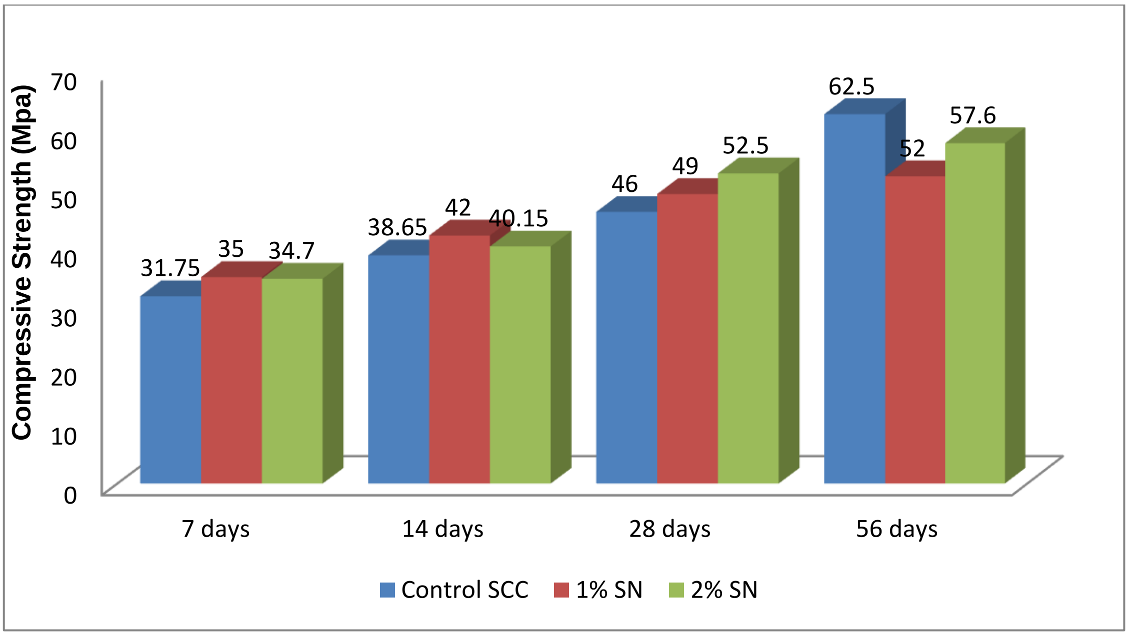


Figure 16: Comparison of compressive strength between control SCC & SCCwith 1% and 2% SN based CI

6.2 Split tensile strength test

Table 14 shows the observation of split tensile strength of control SCC and SCC with1% & 2% sodium nitrite-based corrosion inhibitor. The split tensile strength obtain for control self-compacting concrete is 2.78MPa. The split tensile strength obtains forSCC with 1% and 2% SN based CI is 3.84MPaand 2.8Mpa respectively which is more than the target average strength of the specimen size.

From this result it can be inferred that SCC with 1% and 2% SN based CI has good split tensile strength when compared to control self-compacting concrete. Figure 17 shows the comparison of split tensile strength of control SCC and SCC with 1% & 2%SN based CI.

Table 14: Observation on split tensile strength test

SI. No.	Type of mix	Age	Ultimateload (KN)	Split tensile strength (MPa)
1	Control SCC	28 days	206.01	2.78
2	SCC with 1% SN	28 days	276.67	3.84
3	SCC with 2% SN	28 days	201.67	2.8

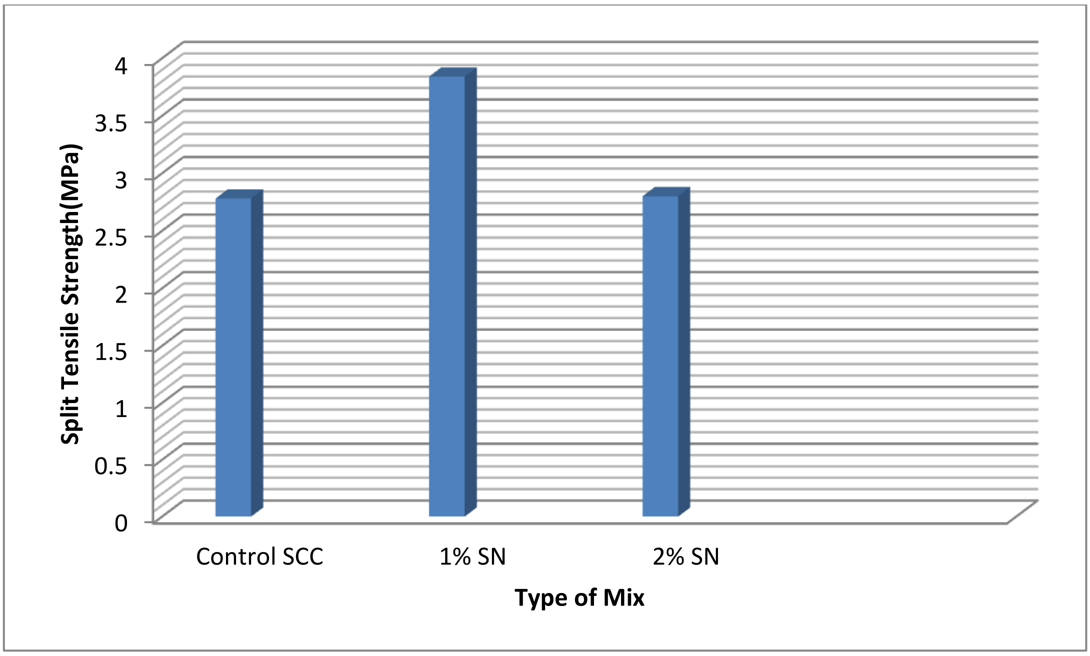


Figure 17: Comparison of split tensile strength of control SCC and SCC with1% & 2% SN based CI

6.3 Flexural Strength Test Of RCC Beams

General

Beams of 700mm x 150mm x 150mm were casted. The flexural performance of SCC beams was evaluated by comparing it with SCC with 1% & 2% SN based corrosion inhibitor. A total of 9 beams were cast and subjected to flexural test according to IS 516-1959 under two-point loading.

Flexural Strength Test

Table 15 shows the observation on flexural strength test and failure pattern. It can be observed that the control SCC beams offers first crack load and ultimate failure load as 57kN and 76kN respectively. The percentage increase in first crack load to failure load is 33.33%. For SCC beams with 1% SN offers 54kN as first crack load which is 5% less than for control beams and ultimate failure load as 74kN which is 2% less than for control beams. The percentage increase in first crack load to failure load is 37%. For SCC beams with 2% SN offers first crack load as 51kN which is 10% less than for control SCC beams and ultimate failure load as 73kN which is 4% less than for control beams. The percentage increase in first crack load to failure load is 43.13%. Failure pattern of beams revealed that all the beams of control SCC andSCC with 1% & 2% SN based CI specimens failed due to flexural crack.

Table 15: Observation on flexural strength and failure pattern

SI. No	Type of beam	First crack load (kN)	Ultimateload (kN)	Flexural strength (N/mm^2)	Failure pattern
1.	Control SCC	57	76	30.4	Flexural crack
2.	SCC with 1%SN based CI	54	74	29.6	Flexural crack
3.	SCC with 2%SN based CI	51	74	29.2	Flexural crack

Table 16 shows the observation on ultimate load and corresponding deflection. It canbe observed that SCC with

1% SN based CI specimens offers least deflection as compared to other beams. Whereas significant increase in deflection for control SCC and SCC with 2% SN based CI as compared to SCC with 1% SN based CI. The control SCC beams shows more deflection at center and at L/3 support when compared to other SCC with SN based CI beams.

Table 16: Observation on ultimate load and their deflection

Type of beam	**First crack load (kN)**	**Deflection at first crack load (mm)**		**Ultimate load (kN)**	**Deflection at ultimate load (mm)**	
		at center	**at L/3 support**		**at center**	**at L/3 support**
Control SCC	57	4.1	5.0	76	6.6	6.5
SCC with1% SN based CI	54	2.3	2.1	74	3.5	3.4
SCC with2% SN based CI	51	2.6	2.2	73	4.09	3.5

Table 17 shows the energy absorption offered by the tested beams. It is inferred that the energy absorption capacity is increased significantly for SCC with SN based CI beams.

Table 17: Observation On Energy Absorption

SI. No.	**Type of beam**	**Ultimate load (kN)**	**Area under P-Δcurve (kN-mm)**
1.	Control SCC	76	27.6
2.	SCC with 1% SN basedCI	74	9.14
3.	SCC with 2% SN basedCI	73	12.26

6.4 Failure Mode and Crack Pattern

Figure 18, 19 and 20 shows the crack pattern of beams for control SCC and SCC with 1% & 2% SN based CI. All the three categories of beams are failed under flexural failure. When compared to control SCC beams the crack width of SN admixed beams is less. The crack width of 2% SN admixed beams are very less when compared to control SCC and 1% SN admixed beams.

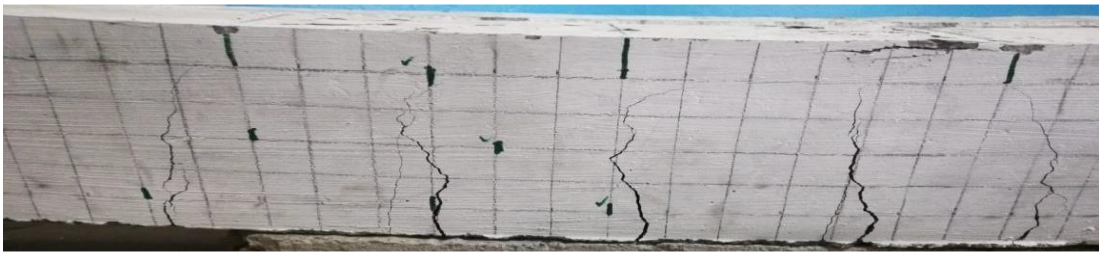


Figure Figure 18 : Crack pattern for control SCC beam

Figure 19: Crack pattern for SCC with 1% SN based CI beam

Figure 20: Crack pattern for SCC with 2% SN based CI beam

6.5 Durability Properties

6.5.1 Chloride Penetration Test

The Figure 21 shows the chloride penetrated part of the cubes. For the cubes of SCC mix shows the average chloride penetration depth 2.5 mm; 1.8mm depth for SCC with1% SN based CI and 1.5 mm depth for SCC with 2% SN based CI. The chloride penetrated portion will be light colour and the non-penetrated portion will be dark. The penetration level of chloride is merely less in SCC due to presence of finer material making it denser and less permeable.

Figure 21:Tested specimen of chloride penetration test

VII. CONCLUSIONS

7.1 General

Using class F fly ash as a replacement for 30% of the cement in the mix and an SN-based corrosion inhibitor as a comparison, this experiment seeks to develop a long-lasting Self-Compacting Concrete with improved fresh, mechanical, and durability properties. SCC optimization involved testing its fresh concrete properties such slump flow, V-funnel, L-box, and U-box. The strength and durability properties were evaluated on a total of 36 cubes, 9 cylinders, and 9 RCC beams that were cast, cured, and then tested. Tests including the compressivestrength test, the split tensile test, and the flexural behaviour of RCC beams are used to evaluate the concrete's strength, while the chloride penetration test is used to evaluate the concrete's durability. The experimental investigation's test results are summarized in this chapter, along with any conclusions that can be taken from them.

7.2 Summary & Conclusions

Based on the experimental test results obtained the following conclusions are drawn: -

- The developed control Self-Compacting Concrete (SCC) mix achieved its target mean compressive strength of 46 MPa in 28 days, while SCC mixes admixed with 1% and 2% S-N based corrosion inhibitor achieved mean strengths of 49 MPa and 52.5 MPa respectively.
- The split tensile strength of the control SCC is 3.8% higher than the average tensile strength as per IS 456. However, SCC mixes with 1% and 2% SN-based corrosion inhibitor achieved split tensile strengths that are 27.1% and 1% higher than the average tensile strength.
- In flexural strength tests, the control beam failed suddenly upon reaching the ultimate load, while SCC mixes with 1% and 2% SN-based CI beams deformed further, preventing sudden failure.
- The chloride permeability of SCC mix with 2% SN-based corrosion inhibitor is lower than that of control SCC and SCC mix with 1% SN.
- It can be concluded that the addition of inhibitors at a weight percentage of 2% of the cement supplied improved the durability properties of SCC without affecting its strength properties.
- It is recommended that the developed durable SCC can be used for special applications such as bridges, prefabricated structures, and deck slabs that have a high density of steel rebars.

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