Experimental Investigation of Self-Consolidating Concrete with Micro Steel Fibres

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ABTRACT

One of the unique concretes that is highly valued in the modern construction industries is Self-Compacting Concrete (SCC). One of the main uses of SCC is that it may be filled without vibration or manual compaction in the formwork of a heavily reinforced structure. However, SCC lacks conventional mix design techniques and internationally recognised testing methods for the qualities of its fresh concrete. This limits SCC's growth in the construction industry. Additionally, SCC calls for higher amounts of fine aggregate and binder, which raises the price of concrete. The flexural properties are improved by the use of fibrous materials. Using steel fibres in normally vibrated concrete has a number of drawbacks (NVC). The density of steel fibres is larger than that of other composites found in the concrete, which might cause isolation of the steel fibres from other composites during incorrect vibration. This is one of the main disadvantages of employing steel fibres in NVC.

In phase-I the mix proportion was arrived for M50 grade of concrete using Nan-Su proposed mix design method.

Keywords: Self-compacting concrete; Nan Su, statistical study, optimization, micro steel fiber

1 Introduction

Self-Compacting Concrete SCC) is a highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without the need for mechanical vibration. This innovative material has revolutionized the construction industry by significantly reducing labor costs, enhancing surface finish quality, and improving the speed of construction. The ease of placement and superior workability make SCC particularly suitable for complex structures with densely packed reinforcement.

Despite its numerous advantages, SCC, like traditional concrete, is prone to cracking due to shrinkage and tensile stresses, which can compromise the durability and long-term performance of the structure. To address this limitation, researchers and engineers have explored various methods to enhance the mechanical properties and crack resistance of SCC. One promising approach is the incorporation of micro steel fibers into the SCC mix.

Micro steel fibers are small, discrete fibers, typically made of high-strength steel, that are added to concrete to improve its tensile strength, flexural strength, and resistance to cracking. When integrated into SCC, these fibers act as a form of reinforcement, providing better stress distribution and improving the overall toughness of the concrete. The addition of micro steel fibers also helps in controlling crack propagation, thereby enhancing the durability and service life of the concrete structure.

This study aims to investigate the effects of incorporating micro steel fibers into SCC, focusing on its impact on the mechanical properties, workability, and durability of the concrete. By understanding these effects, the research seeks to provide insights into the potential benefits and challenges of using micro steel fibers in SCC for various structural applications.

This introduction sets the context for the study, highlighting the significance of SCC, the challenges it faces, and the potential role of micro steel fibers in addressing those challenges.

2 Literature survey & background

Bicer (2018) This study examines an experimental method for analysing the different mechanical characteristics of concrete by mixing fly ash into the mixture. The study found that, up to a 50% rise in fly ash percentage, the density of the concrete composites increases linearly. The fly ash's density increased by 16.12% as its diameter shrank. The fly ash particles filled in the spaces in the concrete material because of their fineness and spherical form. The fly ash met the requirements of ASTM C-350.

Bagha Ghanooni (2016) The purpose of the study was to determine how mineral admixture affected the mechanical behaviour of SCC. Metakaolin (MK), fly ash (FA), silica fume (SF), lime stone powder (LS), and ground granulated blast furnace slag (GGBS) were the mineral admixtures employed in the study in place of cement

The Hai-Thong group (2016) The optimisation of water demand, which affects the rheological characteristics of self-compacting concrete, was the subject of the study. It has been determined that mixing time affects SCC, including water, performance.

Leung and associates (2016) According to the study, there are several uses for binary mineral admixtures, like fly ash and silica fume, in self-compacting concrete's mechanical qualities. It was found that the sorptivity and water absorption of concrete were decreased by the efficient use of fly ash and silica fume.

3. Objective

To create a mix design with a fixed target strength using the mix design procedure, and to use a statistical model to optimise the proportions in preparation for further SCC development in this area.

To achieve economic concrete by incorporating industrial by-products which decrease the cost of processing the industrial waste and also reduces the cost for procuring raw materials for the preparation of concrete

4. Result

Slump Flow test

Slump flow was conducted for all mixes (M1-M8) and the slump flow was calculated by taking the average of two perpendicular diameters of the flow across the spread of SCC ,

Table 1 Slump flow test

SN	Mix ID	Mix ID	Slump flow in mm
1	**M-1**	**FA-0.SF-0,SF -0**	710
2	**M-2**	**FA-30.SF-10,SF -0**	730
3	**M-3**	**FA-0.SF-0,SF -.25**	692
4	**M-4**	**FA-0.SF-0,SF -.50**	685

5	**M-5**	**FA-0.SF-0,SF -.75**	639
6	M-6	**FA-30.SF-10,SF -.25**	703
7	M-7	**FA-30.SF-10,SF -.50**	690
8	M-8	**FA-30.SF-10,SF -.75**	655

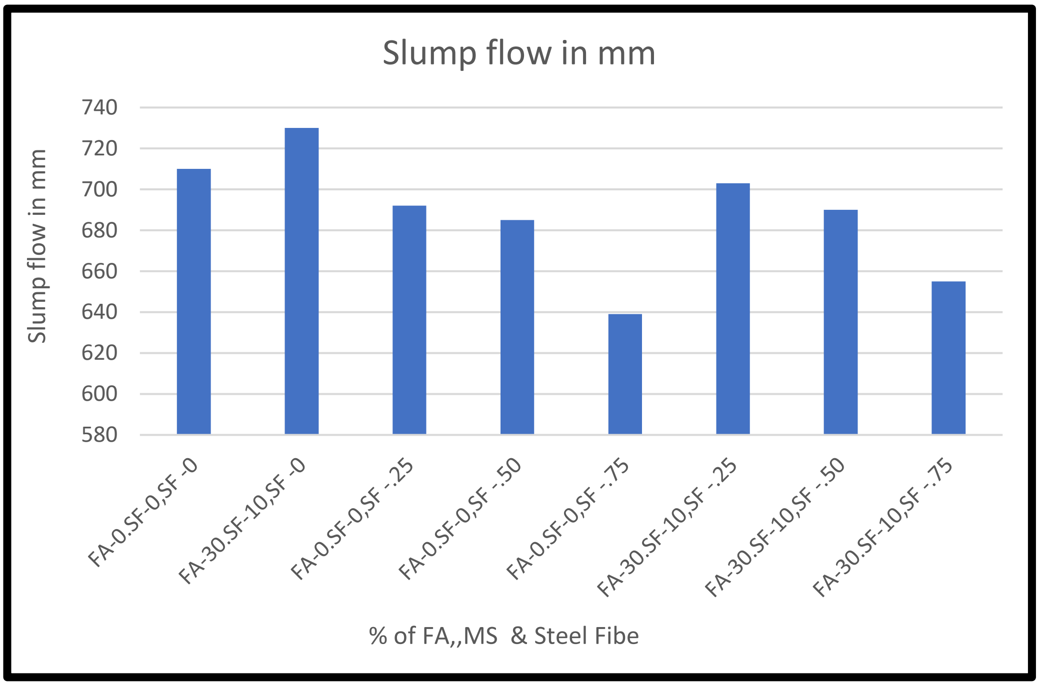

Figure 1 Slump flow in mm at different % of FA,,MS & Steel Fibe

According to the experimental results, mix batch M2, which has a 40% mineral admixture (fly ash at 30% and micro silica at 10%) has 2.75% higher rheological qualities than batch M1, which just has cement as a binder. The flowability of these three mixtures (M6, M7, and M8) was found to be superior to that of M3 (0.25%), M4 (0.5%), and M5 (0.75%). The addition of 0.75% microsteel fibres caused the slump flow to drastically decrease.

Mechanical properties

Mechanical properties such as, compressive strength, flexural strength and split tensile strength were evaluated to find the influence of mineral admixtures and micro steel fibres over conventional SCC. Composite matrix (concrete) was poured in mould with zero external compaction or vibration. The specimens were tested at surface dry condition for the curing period of 7 days, 21 days and 28 days, three cubes, two beam and two cylinder specimens from each batches were tested. The average strength of tested concrete specimens was taken for better comparison of compressive strength, flexural strength and split tensile strength given in Table

Table 2 Mechanical Properties

SN	Mix ID	Mix ID	Compressive Strength (MPa)		
			7 days	21 Days	28 Days
1	**M-1**	**FA-0.SF-0,SF -0**	36	29	57
2	**M-2**	**FA-30.SF-10,SF -0**	24.7	20	60
3	**M-3**	**FA-0.SF-0,SF -.25**	38	30.6	61
4	**M-4**	**FA-0.SF-0,SF -.50**	41	32.5	67
5	**M-5**	**FA-0.SF-0,SF -.75**	38	39	58
6	M-6	**FA-30.SF-10,SF -.25**	27	20	61
7	M-7	**FA-30.SF-10,SF -.50**	32	24.2	67
8	M-8	**FA-30.SF-10,SF -.75**	27	21	55

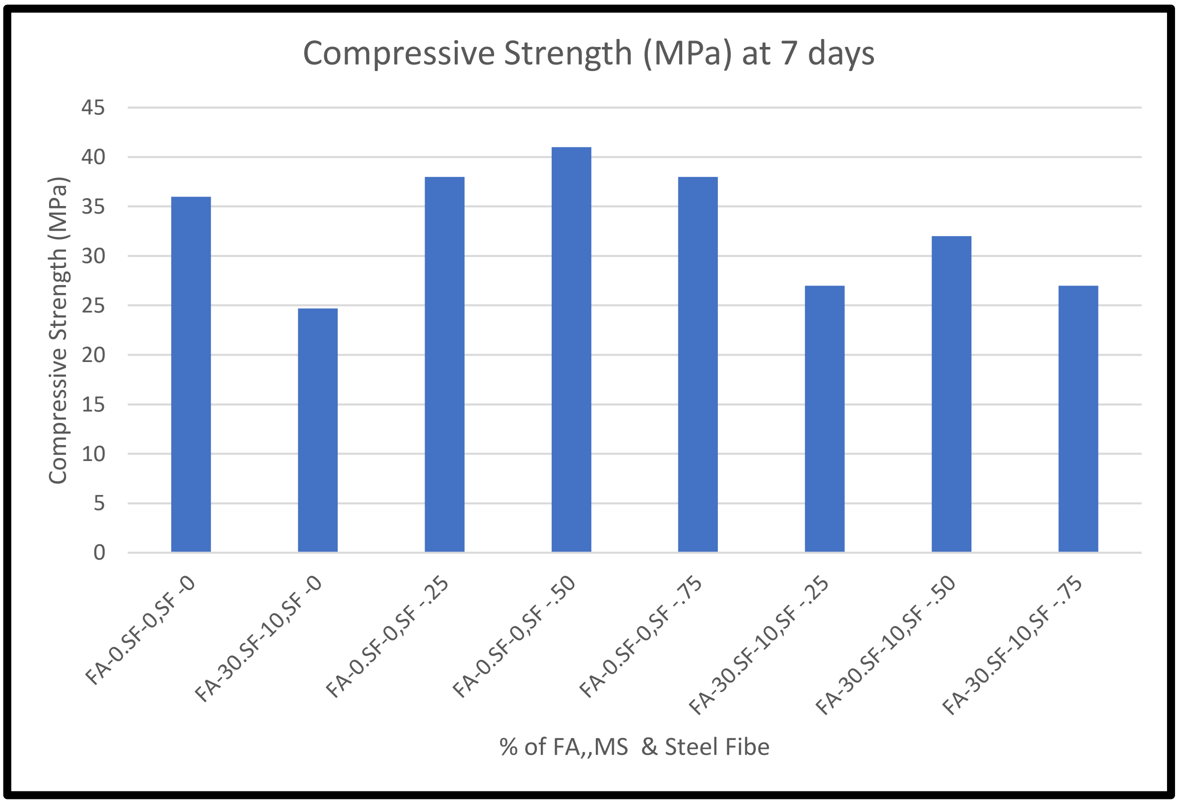

Figure 2 Compressive Strength (MPa) at 7 days

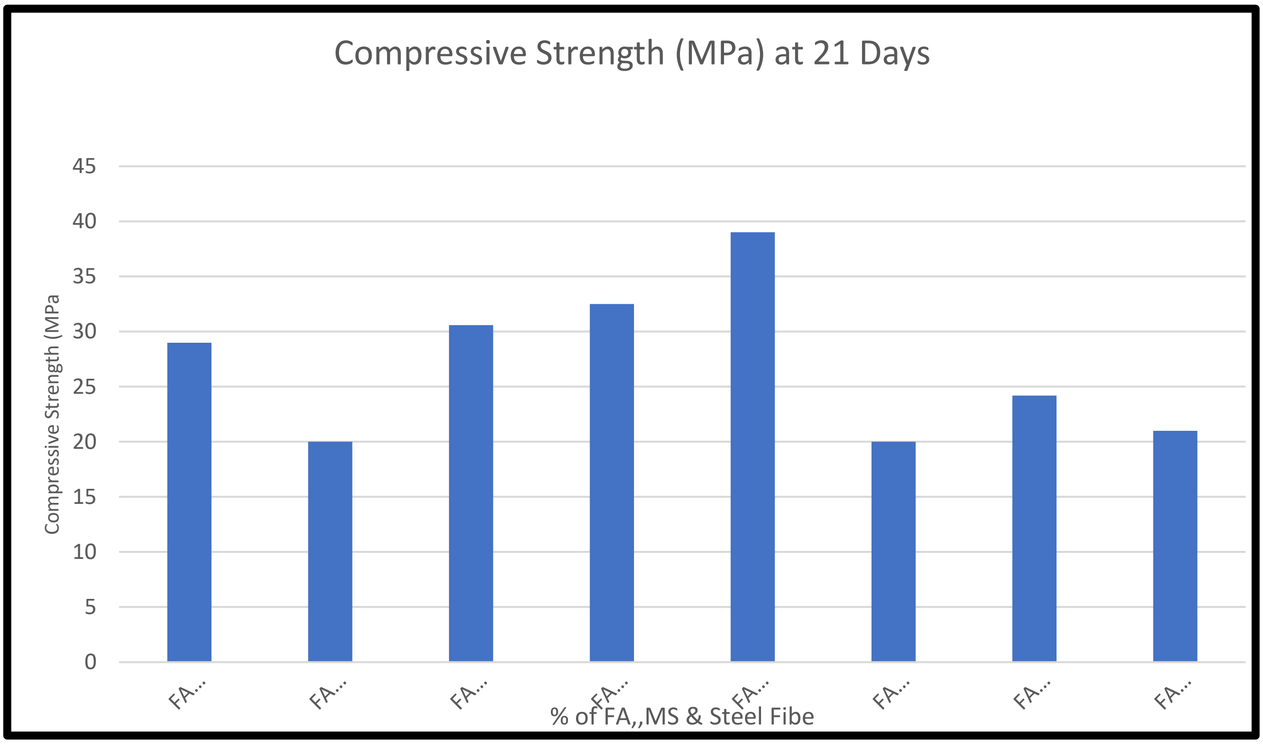

Figure 3 Compressive Strength (MPa) at 21 Days

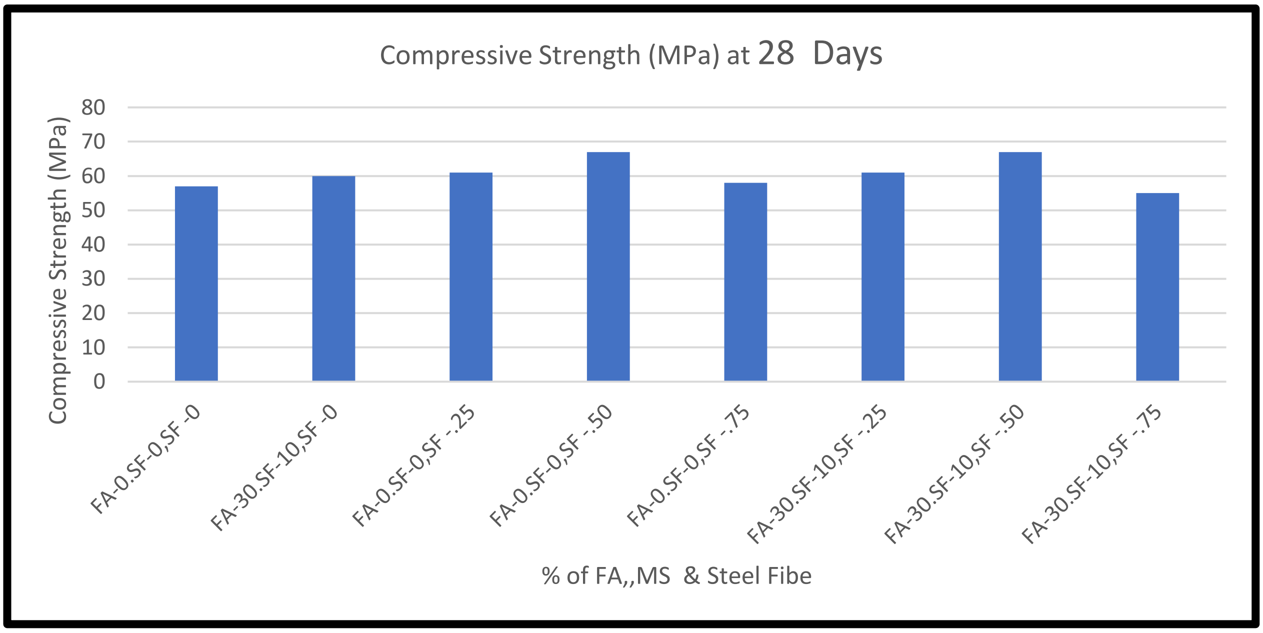

Figure 4 Compressive Strength (MPa) at 28Days

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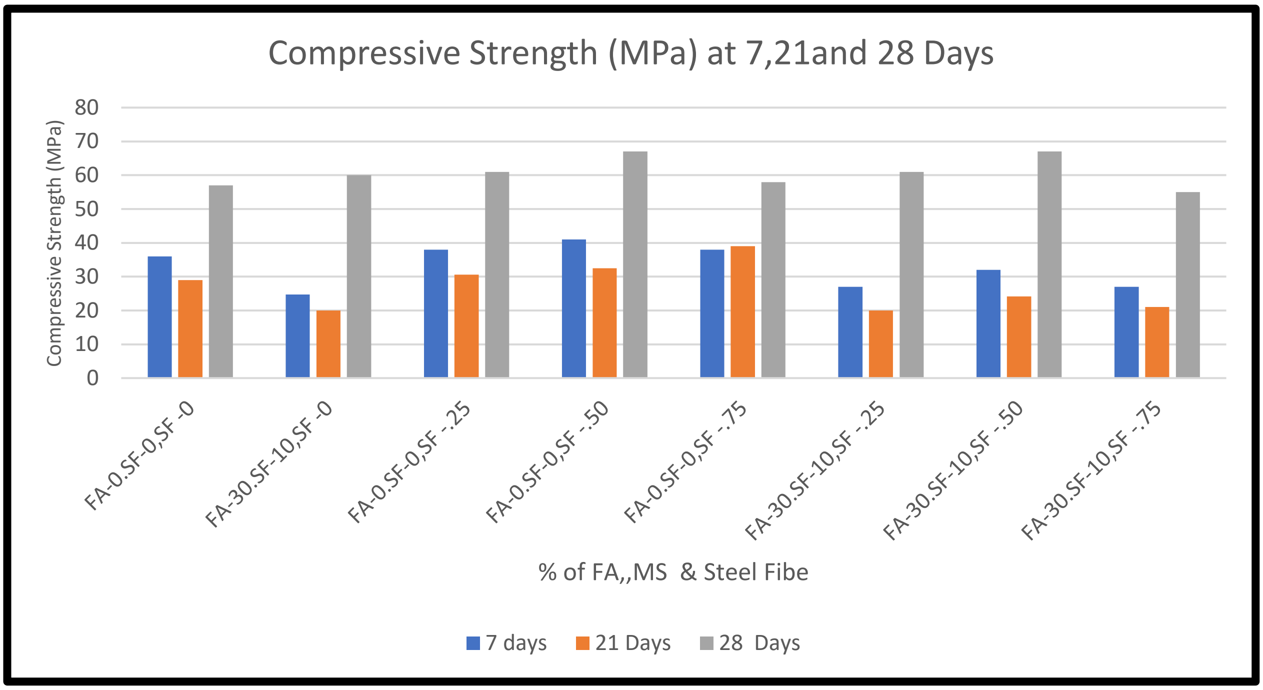

Fig. 5 Compressive Strength at different curing periods

Discussion - There was a decrease in the compressive strength of mixes M2, M6, M7 and M8 when compared with M1, M3, M4 and M5, respectively; during the early days (7days), when the total binder content was replaced with 30% of fly ash and 10% micro silica. This was due to the presence of fly ashThe compressive strength of mixtures M2, M6, M7, and M8 was found to be greater than that of mixes M1, M3, M4, and M5 after 56 days of curing, indicating that the hydration process continued beyond the standard 28-day curing period. A slight increase in strength, ranging from 5% to 9%, was observed on the 28th day for M3 and M4 compared to M1, and for M6 and M7 compared to M2.

The addition of micro steel fibres had a notable effect on compressive strength. A 0.25% fibre addition resulted in an 8% increase, while a 0.50% fibre addition showed a 16% increase in compressive strength compared to the mix without any fibres at 7, 21, and 28 days. However, mixes M5 and M8 showed a significant 10% drop in compressive strength at all curing stages when compared to M1 and M2, respectively.

5. Conclusion

This study aims to investigate the effects of incorporating micro steel fibers into SCC, focusing on its impact on the mechanical properties, workability, and durability of the concrete. By understanding these effects, the research seeks to provide insights into the potential benefits and challenges of using micro steel fibers in SCC for various structural applications.
The optimized mix proportions for M50 grade of self-compacting concrete has achieved the fixed slump flow of 710 mm and compressive strength of 58 MPa.

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