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COMPERATIVE EFFECT OF DIFFERENT TYPES OF FIBERS WITH SELF COMAPCTING CONCRETE

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Abstract - *In this study, the dynamic performance of various structural frame materials Reinforced Cement Concrete (RCC), steel, and composite was investigated to evaluate their behavior under earthquake and wind-induced loads. The research highlights the importance of material selection and bracing configuration in improving the stability and dynamic response of buildings. Finite element modeling and time-history analysis were performed using structural analysis software such as ETABS or ANSYS to simulate real-life loading conditions. The findings revealed that composite frames integrated with bracing systems exhibited superior performance compared to conventional RCC and steel frames. These systems demonstrated reduced displacement, higher energy dissipation, and improved damping capacity during dynamic events. In contrast, RCC frames, although strong, showed limited ductility, while steel frames experienced higher lateral sway when unbraced. Overall, the study concludes that composite frames with bracing provide an optimal balance of strength, flexibility, and lightness, making them a promising solution for achieving seismic resilience, cost efficiency, and enhanced structural stability in modern construction.*

Key Words: Composite Frames, Dynamic Analysis, Bracing Systems, Seismic Performance, Structural Stability, Finite Element Modeling, Earthquake Resistance, Energy Dissipation, Lightweight Construction, Material Optimization, Structural Dynamics, Cost-Effective Design, etc.

1. INTRODUCTION

Self-Compacting Concrete (SCC) is a revolutionary advancement in modern construction materials, designed to flow and compact under its own weight without the need for mechanical vibration. Developed in Japan during the 1980s by Prof. H. Okamura, SCC combines excellent workability, high strength, and superior durability, overcoming the limitations of traditional Normal Cement Concrete (NCC), which required intensive vibration for compaction. The inclusion of superplasticizers enhances its fluidity while maintaining strength, making SCC highly effective for structures with dense reinforcement, intricate formwork, or restricted access areas. Its use significantly reduces labor, noise, and construction time while improving surface finish and long-term durability. The development of Fiber-Reinforced Self-Compacting Concrete (FRSCC) further strengthens the material by incorporating steel, glass, or synthetic fibers to enhance tensile strength, ductility, and crack resistance. Widely applied in bridges, tunnels, precast elements, and complex infrastructures, SCC has transformed construction practices by ensuring faster, safer, and more efficient building with superior structural performance and aesthetic quality.

1.1 Aim & Objective

The aim of this study is to analyze the effect of different types of fibers on self-compacting concrete and investigate the behavior of steel and glass fibers in self-compacting concrete.

1) To improve the compressive strength of various grades of Self-Compacting Concrete through the addition of different types of fibers.
2) To enhance the tensile strength of various grades of Self-Compacting Concrete by incorporating different types of fibers.

2. LITERATURE REVIEW

Domone and His-Wen (1997) [1] stated that a slump test was conducted to evaluate the workability of high-workability concrete. The laboratory results revealed a positive correlation between the slump values and the concrete's flow characteristics. The study concluded that the concrete mix exhibited satisfactory slump flow, confirming its suitability for applications requiring self-compacting or high-flow concrete due to its excellent workability and flow consistency.

Bui et al. (2002) [2] explained that a rapid testing method was developed to evaluate the segregation resistance of Self-Compacting Concrete (SCC). Various influencing parameters such as water–binder ratio, paste volume, aggregate proportions, and mineral admixtures were investigated. The study introduced a testing apparatus capable of assessing segregation in both vertical and horizontal directions, providing an efficient and practical approach for ensuring SCC uniformity and durability during placement and curing.

Lachemi and Hossain (2004) [3] stated that their research examined the performance of four different Viscosity Modifying Agents (VMA) in the production of SCC, focusing on

both fresh and hardened properties. Using the V-funnel test, they found that all mixes maintained proper deformability with flow times below 6 seconds, showing no signs of segregation or aggregate blockage. The findings confirmed that VMAs effectively enhanced flowability and stability, making them ideal for producing high-quality SCC.

Ali R. Khaloo et al. (2005) [4] reported that the effects of fiber length and volumetric content on the energy absorption of steel fiber-reinforced concrete (SFRC) slabs were investigated. Testing of 28 slabs under flexural loading indicated that longer fibers and higher fiber content improved energy absorption capacity. Although theoretical models slightly overestimated results, the researchers proposed a reliable design approach based on allowable deflection, enabling accurate prediction of slab performance under flexural stresses.

Ferrara et al. (2006) [5] stated that their research assessed the fundamental properties of High-Performance Self-Compacting Concrete (HLSCC), such as flowability, filling ability, and segregation resistance. Through slump flow testing and evaluation of the time required to reach a 500 mm spread, all tested mixes demonstrated excellent flow characteristics and met the expected performance standards for high-quality SCC.

Kumar (2006) [6] discussed the development and testing methodologies of Self-Compacting Concrete (SCC), emphasizing its high flowability, resistance to segregation, and passing ability. The study highlighted the importance of mix design, material characteristics, and proportioning on SCC performance. Using tests such as the Orimet and J-ring combinations, the research confirmed their effectiveness in simulating real placement behavior, improving quality control and predictive accuracy for SCC applications in the construction industry.

Abbas Al-Ameeri (2013) [7] reported that the inclusion of steel fibers in SCC significantly influenced mechanical properties such as compressive, tensile, and flexural strengths. The study found that optimal performance was achieved at a steel fiber content between 0.75% and 1%. Fiber-reinforced mixes demonstrated higher tensile and flexural strengths at all curing stages, confirming that steel fibers enhance the concrete's resistance to cracking and improve its overall mechanical behavior.

Vennila et al. (2016) [8] stated that the growing use of SCC in congested reinforced structures faced challenges due to its high cost. To address this, the study explored the partial replacement of cement with fly ash and silica fume, along with foundry sand as a fine aggregate substitute, and the addition of glass fibers for tensile enhancement. The results showed improved performance, cost efficiency, and sustainability, demonstrating that eco-friendly and economical SCC can be achieved through material optimization.

Abhishek Sachdeva and Pankaj Singhal (2016) [9] explained that the effect of varying steel fiber content and different dosages of Viscosity Modifying Agents (VMA) in SCC was investigated. Tests such as slump flow, pipe flow, and L-box confirmed that increasing steel fiber content from 0.35% to 1% significantly enhanced compressive strength. The study concluded that higher fiber dosages resulted in improved mechanical properties without compromising workability.

Ravi Shankar Yadav and Juned Ahmad (2017) [10] stated that their study examined the workability and durability of SCC incorporating fly ash, VMA, and partial replacement of fine aggregates with demolished concrete. Glass fibers were added in varying proportions to enhance mechanical properties. The combination of 10% demolished concrete and 0.20% glass fiber yielded the best results, improving both strength and sustainability. The study demonstrated that such modified SCC mixes provide a balance between mechanical efficiency and environmental responsibility.

3. PROBLEM FORMULATION

3.1 General

This project aims to understand how varying the percentage of fibers affects the strength properties of self-compacting concrete (SCC). Specifically, it investigates the influence of steel fibers and glass fibers, added in different proportions, on both the compressive and flexural strength of SCC. The primary objective is to determine the optimum fiber content and to identify the most efficient type of fiber in enhancing concrete performance. By systematically analyzing the mechanical properties of SCC with different fiber types and percentages, the study seeks to provide practical insights for optimizing concrete mix designs. Ultimately, this research will contribute to improving construction practices, promoting material efficiency, and ensuring the long-term durability and structural safety of concrete elements.

3.2 Flow of Research Work:

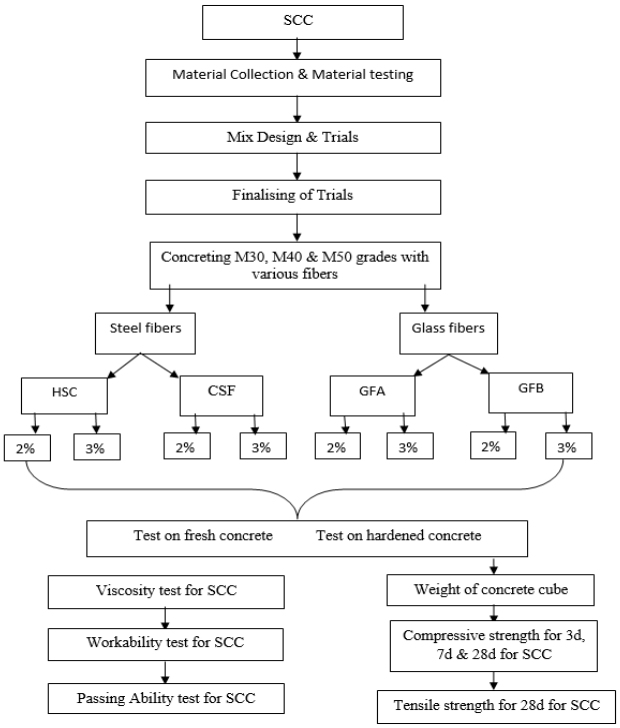


Figure No. 3.1 Flow of Research Work

3.3 Cases considered in project

This project focuses on investigating the effect of different types of fibers on the mechanical strength parameters of self-compacting concrete (SCC) across three different grades M30, M40, and M50. The aim is to assess the influence of fiber type, shape, and length on both the compressive and tensile strength of Fiber-Reinforced Self-Compacting Concrete (FRSCC).

Fiber Types and Mix Design

Four different types of fibers were selected for the study, each varying in length and longitudinal shape:

- Crimped steel fiber
- Hooked-end steel fiber
- 6 mm glass fiber
- 12 mm glass fiber

For each concrete grade (M30, M40, M50), eight different mix combinations were prepared, incorporating these fibers at two different volume fractions: 2% and 3% of the total concrete volume. These fiber dosages were selected to evaluate their effectiveness in improving the mechanical performance of SCC without compromising workability.

Compressive Strength Testing

The compressive strength of each FRSCC mix was tested at three curing intervals: 3 days, 7 days, and 28 days. For this purpose, concrete cubes were cast for each mix. The compressive strength test was conducted as per standard testing procedures, where each cube was subjected to axial loading using a compression testing machine until failure. The maximum load at failure was recorded and used to calculate the compressive strength of each sample.

Tensile Strength Testing

To evaluate the tensile performance of the FRSCC mixes, two types of specimens cylinders and beams were cast and tested:

Split Tensile Strength (Cylindrical Specimens):

Cylinders were prepared for each grade of concrete containing 3% fiber content of each fiber type. These specimens were cured for 28 days, after which the split tensile strength test was carried out. The maximum load at failure was recorded using the standard test setup for indirect tensile strength.

Flexural Strength (Beam Specimens):

To assess the flexural strength (a form of tensile strength), concrete beams were cast using two selected fiber types: hooked-end steel fiber and 12 mm glass fiber, each at 3% fiber content. Beams were tested after 28 days of curing using a universal testing machine (UTM) under a three-point bending setup. The maximum load at failure was recorded to determine the flexural strength of the specimens.

This section outlines the comprehensive experimental setup adopted for this study. It provides a comparative analysis of how different fibers and their dosages influence the strength development of SCC over time and across varying concrete grades. The results from this experimental investigation are expected to offer valuable insights into optimizing fiber-reinforced SCC mixes for enhanced durability and structural performance

4. EXPERIMENTAL STUDY

4.1 General:

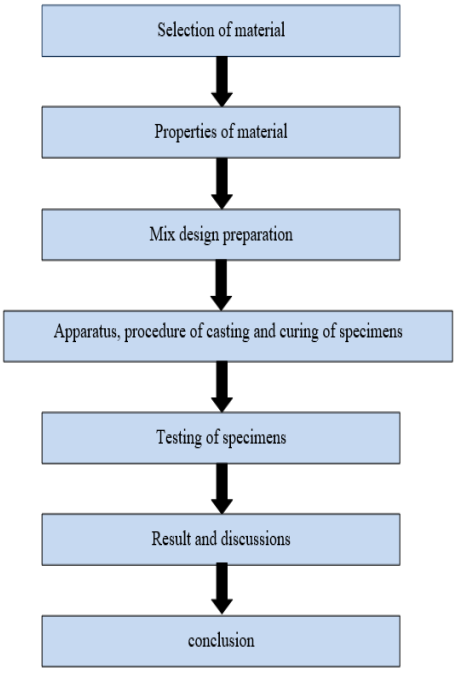
This experimental study aims to investigate the effects of different types and percentages of fibers on the properties of high-grade self-compacting concrete (SCC). The research focuses on evaluating both the fresh and hardened properties of SCC when reinforced with various fibers. The materials used in this study include M-sand as the fine aggregate, along with different types of fibers namely, hooked steel fiber, crimped steel fiber, 6 mm glass fiber, and

12 mm glass fiber added in varying proportions to enhance the mechanical properties of SCC. Concrete mixes will be designed for three different grades: M30, M40, and M50, based on relevant mix design standards. Concrete specimens will be prepared and cast in standardized cube molds to maintain uniformity in shape and size. Tests on fresh SCC, including flowability, viscosity, and passing ability, will be conducted to assess its self-compacting characteristics with the inclusion of fibers.

For hardened concrete, compressive strength tests will be carried out on cube specimens after 3, 7, and 28 days of curing using a compressive testing machine. The results for each grade will be recorded and compared to evaluate the effect of fiber type and dosage. Additionally, split tensile strength tests will be performed on cylindrical specimens after 28 days of curing to further assess the mechanical performance of the fiber-reinforced SCC.

4.2 Experimental study flow

The experimental study follows a systematic approach, beginning with the laboratory testing of materials to determine their physical and mechanical properties. This is followed by trial-and-error procedures to develop suitable mix designs for self-compacting concrete. Once the optimal mix proportions are finalized, the casting and curing of test specimens including cubes, cylinders, and beams are carried out. After the designated curing periods, compressive strength tests are performed on cube specimens, while flexural strength tests are conducted on beam specimens to evaluate the structural performance of the concrete.



4.3 Experimental Procedure

4.3.1 Selection of Materials

Material selection is the first and one of the most crucial steps in the experimental study. Proper selection ensures the quality and performance of the concrete. The materials used in this project include:

- **Cement**
- **Fine aggregate (M-sand)**
- **Coarse aggregate**
- **Superplasticizer (admixture)**
- **Fibers**: Crimped steel fiber, hooked steel fiber, 6 mm glass fiber, and 12 mm glass fiber.

All materials were procured in the required quantities after confirming their suitability through laboratory testing.

4.3.2 Properties of Materials

Determining the properties of materials is essential for developing a proper mix design. Accurate knowledge of these properties ensures the mix meets the required workability and strength characteristics of self-compacting concrete (SCC). The following tests were conducted:

- **Cement**:
  Fineness, specific gravity, standard consistency, initial and final setting time, soundness, and compressive strength.
- **M-sand(Fine Aggregate)**:
  Fineness modulus, specific gravity, moisture content, water absorption, and bulk density.
- **Coarse Aggregate**:
  Fineness modulus, specific gravity, moisture content, water absorption, and bulk density.
- **Superplasticizer (Admixture)**:
  Appearance, color, specific gravity, chloride content, and pH value.

4.3.3 Mix Design Preparation

Mix design is a critical step in ensuring the concrete achieves the desired strength and workability. The mix proportions were calculated based on standard SCC mix design procedures to determine the quantities of cement, water, M-sand, coarse aggregate, admixture, and fibers.

A trial-and-error method was adopted to refine the mix for different grades of concrete (M30, M40, and M50). The aim was to achieve the required flow characteristics and strength parameters of SCC by adjusting the mix components iteratively.

4.3.4 Casting and Curing of Specimens

After finalizing the mix design, concrete specimens were prepared accordingly:

- Specimens included **cubes**, **cylinders**, and **beams**.
- All specimens were cast under controlled conditions and given proper surface finishing.
- After 24 hours, the specimens were demolded and placed in a curing tank.
- Standard water curing was carried out for 28 days, in accordance with IS specifications.

4.3.5 Compressive Strength Testing

Compressive strength tests were carried out on cube specimens using a **Compression Testing Machine (CTM)** with a capacity of 3000 kN. Testing was performed in accordance with **BS EN 12390-3:2009**.

- Tests were conducted at **3 days**, **7 days**, and **28 days**.
- The compressive strength for each cube specimen was recorded and averaged.
- Results were analyzed to determine the influence of fiber type and dosage on strength development.

4.3.6 Flexural Strength Testing

Flexural strength testing was conducted to indirectly assess the tensile properties of the concrete. Beam specimens with dimensions **150 mm × 150 mm × 700 mm** were used.

- The **clear span** was set to **600 mm**, and the **loading span** was **200 mm**.
- Two **displacement transducers** were placed at both sides of the beam to measure mid-span deflection.
- Beams were tested at **28 days** of curing.
- Tests were conducted under standard procedures, and the **flexural strength** was calculated based on the recorded data.

5. RESULTS

5.1 General

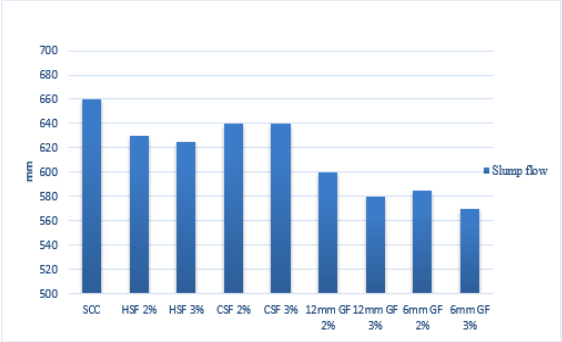
In this chapter, the experimental results obtained from the conducted tests on Fiber Reinforced Self-Compacting Concrete (FRSCC) are presented and discussed. The results are illustrated in both tabular and graphical forms to provide a clear comparison and analysis. The performance of FRSCC has been assessed in terms of its fresh properties (specifically flowability) and hardened properties (compressive strength at different curing periods 3, 7, and 28 days).

5.2 Results of M30 FRSCC

The results of M30 grade Fiber Reinforced Self-Compacting Concrete (FRSCC) are presented and discussed in this section. The fresh property of the concrete flowability was evaluated using the slump flow test and T50 slump flow time in accordance with standard procedures.

The compressive strength of the concrete was determined using a Compressive Testing Machine (CTM), while the flexural strength was measured using a Universal Testing Machine (UTM). All test results are compiled and discussed in the subsequent subsections, with appropriate tabular and graphical representations to facilitate comparison and interpretation.

5.2.1 Slump flow results of M30



Graph No. 1- Variation of flowability of M30 concrete against varies % of fibers

following are the observation has been discussed.

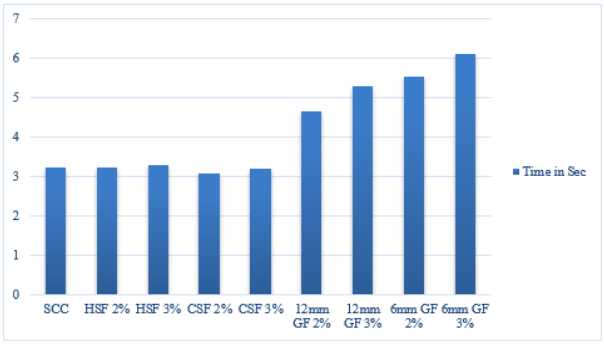
The control SCC mix exhibited the highest flow value of 660 mm, confirming its excellent workability.

The incorporation of fibers led to a reduction in flowability, with the extent of reduction depending on the type, size, and percentage of fibers used. Hooked steel fibers (HSF) showed slump flow values of 630 mm (2%) and 625 mm (3%), whereas crimped steel fibers (CSF) maintained relatively higher flowability with 640 mm for both 2% and 3%, indicating that fiber geometry influences workability.

In contrast, the addition of glass fibers (GF) caused a significant reduction in flow, particularly at higher dosages. For 12 mm GF, the slump flow dropped to 600 mm (2%) and 580 mm (3%), while 6 mm GF further reduced flowability to 590 mm (2%) and 570 mm (3%).

Overall, the results highlight that SCC without fibers provides maximum flowability, CSF is more favorable for maintaining workability compared to HSF, and glass fibers exhibit the most adverse effect on flow behavior.

5.2.2 T50 Slump flow results of M30



Graph no.2 Variation of T50 slump flow of M30 concrete against varies % of fibers

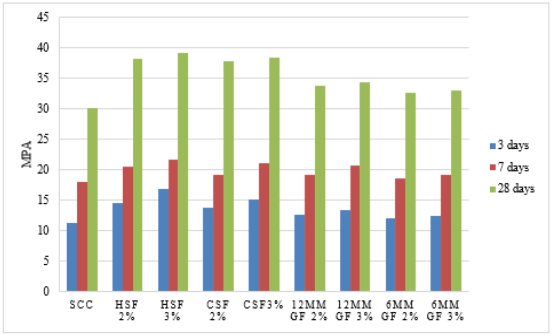
Following observations are noted indicate the filling ability and viscosity of different SCC mixes. The control SCC mix recorded the lowest time of 3.2 seconds, demonstrating excellent flowability with minimal resistance.

The addition of steel fibers (HSF and CSF) caused only a marginal increase in T_{50} time, with values ranging between 3.1 and 3.3 seconds, suggesting that steel fibers have a limited effect on the viscosity of SCC.

In contrast, the inclusion of glass fibers (GF) significantly increased the flow time, indicating reduced fluidity and higher internal resistance of the mix. For 12 mm GF, the T_{50} time increased to 4.6 seconds (2%) and 5.3 seconds (3%), while for 6 mm GF, the values further increased to 5.5 seconds (2%) and 6.1 seconds (3%).

These results confirm that glass fibers, particularly in higher dosages and shorter lengths, substantially reduce the flow rate of SCC due to their tendency to interlock and restrict particle movement. Overall, SCC without fibers offers the best flow characteristics, steel fibers show minimal adverse effects, while glass fibers significantly hinder flowability.

5.2.3 Compressive strength test results of M30



Graph no.3 Variation of Compressive strength results M30 concrete against varies % of fibers

Following observations are noted

The control SCC mix achieved strengths of 12 MPa, 18 MPa, and 30 MPa at 3, 7, and 28 days, respectively.

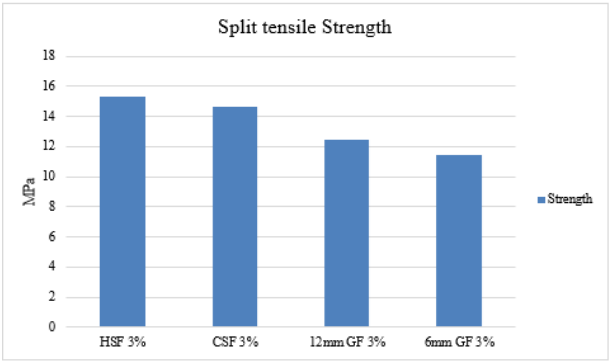
The incorporation of fibers significantly improved compressive strength, with the maximum enhancement observed for hooked steel fiber (HSF) mixes.

At 28 days, HSF 2% and HSF 3% achieved strengths of 38 MPa and 39 MPa, respectively, representing the highest values among all mixes. Crimped steel fibers (CSF) also improved strength, with 28-day values of 37.5 MPa (2%) and 38.5 MPa (3%), slightly lower than HSF but still considerably higher than plain SCC.

In comparison, glass fiber (GF) mixes exhibited moderate improvements, with 28-day compressive strengths ranging between 33–35 MPa for both 12 mm and 6 mm fibers at different dosages.

Overall, the results demonstrate that the addition of steel fibers, particularly hooked steel fibers, enhances compressive strength more effectively than glass fibers.

5.2.4 Split tensile strength results of M30



Graph no.4 Variation of Split tensile strength results M30 concrete against varies % of fibers

Following observations are noted

The variation of split tensile strength for different additives at 3% replacement levels. Among all the mixes, HSF (Hooked Steel Fibers) at 3% achieved the highest split tensile strength, approximately 15.4 MPa, followed closely by CSF (Crimped Steel Fibers) at 3%, which recorded about 14.6 MPa.

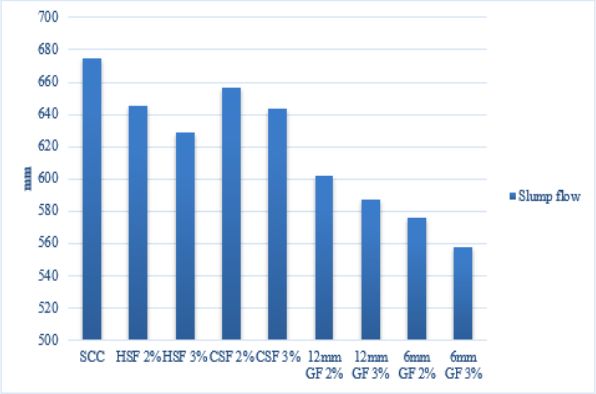
In comparison, the mixes incorporating glass fibers exhibited lower tensile strength values. The specimen with 12 mm glass fibers at 3% reached around 12.4 MPa, while the mix with 6 mm glass fibers at 3% showed the lowest strength, approximately 11.5 MPa.

These results indicate that steel fibers, particularly hooked steel fibers, are more effective in improving split tensile strength compared to glass fibers. The longer length of glass fibers (12 mm) contributed to slightly better performance than shorter fibers (6 mm), but both remained less effective than steel fibers. This demonstrates the superior crack-bridging and load-transfer capabilities of steel fibers in enhancing the tensile resistance of concrete.

5.3 Results of M40 FRSCC

The results of M40 fiber reinforced self-compacting concrete is observed and discussed bellow in which the fresh properties of self-compacting concrete, flowability is calculated by using slump flow test & T50 Slump flow. Compressive strength of concrete is calculated by using compressive testing machine (CTM) & flexural strength of concrete is calculated by using universal testing machine (UTM) and discussed below.

5.3.1 Slump flow results of M40



Graph no.5 Variation of Flowability results M40 concrete against varies % of fibers

Following observations are noted

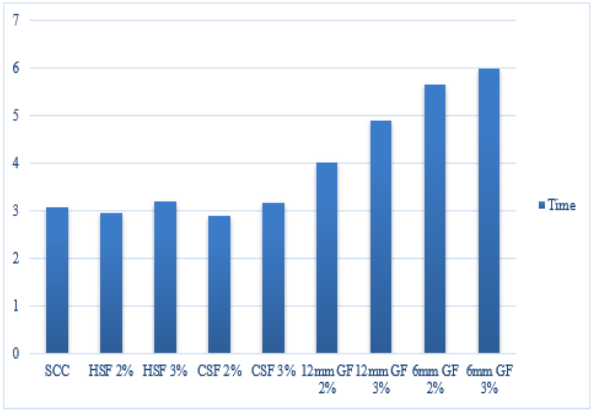
the slump flow values of different mixes, highlighting the effect of fiber type, percentage, and length on the flowability of self-compacting concrete (SCC). The control mix (SCC without fibers) exhibited the highest flowability with a slump flow of about 675 mm, confirming its superior workability.

The inclusion of fibers led to a noticeable reduction in slump flow. Among the steel fibers, CSF at 2% showed relatively higher flowability (~658 mm) compared to HSF 2% (~645 mm). However, increasing the fiber dosage to 3% resulted in further reduction, with HSF 3% (~630 mm) and CSF 3% (~645 mm), indicating that higher fiber content reduces workability due to increased interlocking and obstruction of flow.

In the case of glass fibers, the reduction in flowability was more pronounced. The mixes with 12 mm glass fibers recorded slump flows of approximately 605 mm (2%) and 590 mm (3%), whereas 6 mm glass fibers showed even lower values of about 575 mm (2%) and 555 mm (3%). This suggests that glass fibers, especially shorter ones, significantly hinder the flow of SCC due to higher surface area and tendency to form clusters.

Overall, the results indicate that while SCC without fibers provides maximum flowability, the addition of fibers decreases slump flow. Steel fibers are less detrimental to workability compared to glass fibers, and lower percentages (2%) are more favorable than higher dosages (3%) in maintaining the flow characteristics of SCC.

5.3.2 T_{50} Slump flow results of M40



Graph no.6 Variation of T_{50} Slump flow results M40 concrete against varies % of fibers

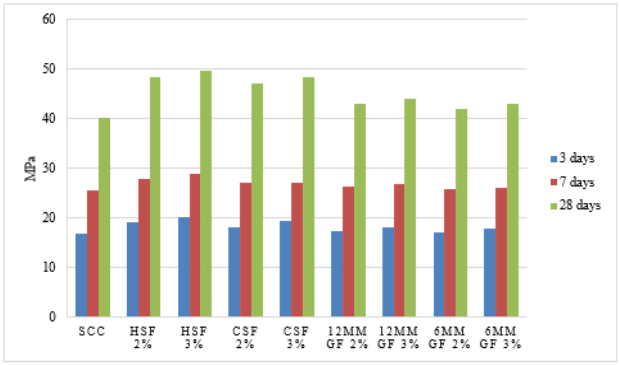
Following observations are noted

The influence of different fiber types, lengths, and dosages on the flow time of self-compacting concrete (SCC). The reference SCC exhibited a slump flow time of approximately 3.1 seconds, confirming its high flowability.

The incorporation of hooked steel fibers (HSF) at both 2% and 3% dosages showed negligible variation in T50 time, remaining close to the control mix, while crimped steel fibers (CSF) also had minimal effect, with a slight reduction at 2% and a marginal increase at 3%.

In contrast, the addition of glass fibers (GF) had a more pronounced impact. For 12 mm long glass fibers, the T50 time increased to about 4.0 seconds at 2% and further to 4.9 seconds at 3%, indicating a reduction in flowability with higher fiber content.

5.3.3 Compressive strength test results of M40



Graph no.7 Variation of Compressive strength results M40 concrete against varies % of fibers

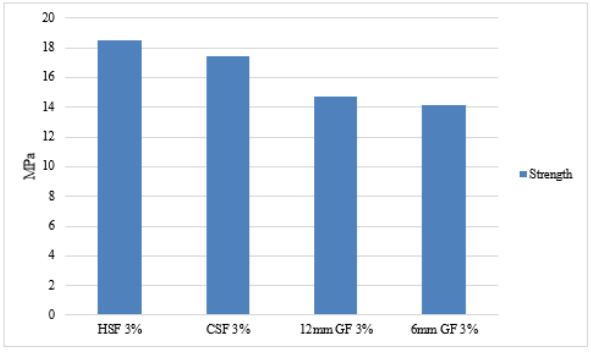
Following observations are noted

The variation in compressive strength of self-compacting concrete (SCC) with different fiber types, dosages, and lengths is illustrated in Figure X, evaluated at 3, 7, and 28 days. The reference SCC attained compressive strengths of 17.2 MPa, 25.8 MPa, and 40.6 MPa at 3, 7, and 28 days respectively.

The incorporation of hooked steel fibers (HSF) showed an improvement in compressive strength, with values reaching 19.1 MPa, 28.5 MPa, and 48.7 MPa at 2% dosage, and further increasing to 20.1 MPa, 29.3 MPa, and 49.6 MPa at 3% dosage.

The 6 mm GF mixes showed the least improvement, with compressive strengths stabilizing around 16.9–17.4 MPa, 25.5–26.3 MPa, and 41.9–43.3 MPa at 3, 7, and 28 days. Overall, the results indicate that the inclusion of steel fibers, particularly at higher dosages, significantly improves compressive strength, while the use of glass fibers has a comparatively lesser impact, with shorter fibers showing minimal contribution to strength gain.

5.3.3 Split tensile strength results of M40



Graph no.8 Variation of Split tensile strength results M40 concrete against varies % of fibers

Following observations are noted

The split tensile strength results of self-compacting concrete (SCC) with 3% fiber addition are presented in Figure X. Among the different fiber types, hooked steel fibers (HSF) at 3% dosage exhibited the highest split tensile strength of 18.5 MPa,

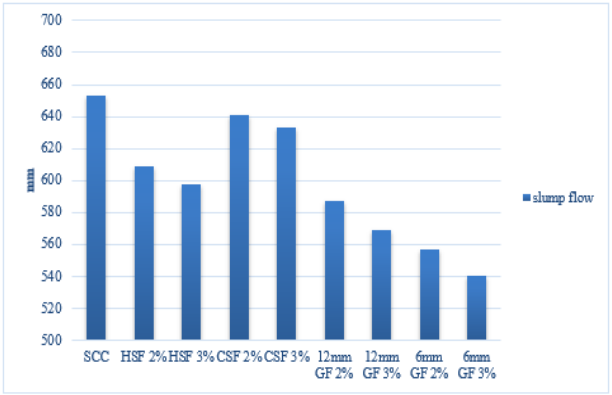
followed closely by crimped steel fibers (CSF) at 3%, which achieved 17.4 MPa. In comparison, the mixes containing glass fibers (GF) showed lower tensile strength values. For 12 mm glass fibers at 3% dosage, the split tensile strength was recorded as 14.8 MPa, while the lowest value of 14.1 MPa was observed for 6 mm glass fibers at the same dosage.

These results clearly demonstrate that steel fibers, especially hooked types, significantly enhance the tensile performance of SCC due to their better anchorage and stress transfer characteristics. On the other hand, glass fibers contribute to some improvement but are less effective compared to steel fibers, with shorter lengths providing the least enhancement in tensile resistance.

5.4 Results of M50 FRSCC

The results of M50 fiber reinforced self-compacting concrete is observed and discussed below in which the fresh properties of self-compacting concrete, flowability is calculated by using slump flow test & T_{50} Slump flow. Compressive strength of concrete is calculated by using compressive testing machine (CTM) & flexural strength of concrete is calculated by using universal testing machine (UTM) and discussed below,

5.4.1 Slump flow test results of M50



Graph no.9 Variation of Flowability results M50 concrete against varies % of fibers

Following observations are noted

The bar chart represents the variation in slump flow values for different concrete mixes. From the graph, it is observed that the reference Self-Compacting Concrete (SCC) exhibited

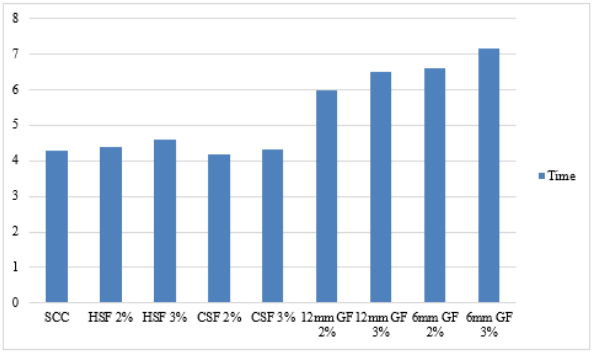
the highest slump flow value of around 650 mm, indicating excellent workability.

When Hybrid Steel Fibers (HSF) were added, a reduction in slump flow was noticed, with values dropping to approximately 610 mm for 2% HSF and 600 mm for 3% HSF. On the other hand, the incorporation of Crimped Steel Fibers (CSF) showed relatively higher slump flow values compared to HSF, with 640 mm at 2% and 630 mm at 3%, suggesting that CSF has less impact on reducing flowability than HSF.

In contrast, the addition of Glass Fibers (GF), both 12 mm and 6 mm lengths, significantly reduced slump flow. For 12 mm GF, the values decreased to about 590 mm at 2% and 570 mm at 3%, while for 6 mm GF, the slump flow was further reduced to around 560 mm at 2% and 540 mm at 3%.

Overall, the results indicate that the inclusion of fibers in SCC reduces slump flow, with glass fibers showing the most pronounced effect, while crimped steel fibers had the least effect on flowability. This trend highlights the trade-off between fiber reinforcement and workability in fiber-reinforced self-compacting concrete.

5.4.2 T_{50} Slump flow test results of M50



Graph no.10 Variation of T_{50} Slump flow results M50 concrete against varies % of fibers.

Following observations are noted

The bar chart illustrates the T50 slump flow time for different concrete mixes. The reference SCC mix shows a T50 time of about 4.3 seconds, indicating good flowability and viscosity balance.

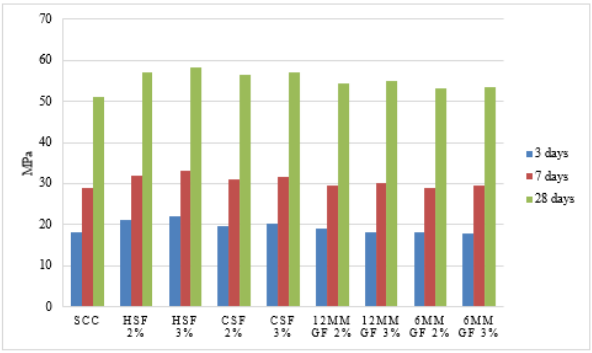
The addition of Hybrid Steel Fibers (HSF) slightly increased the T50 time to around 4.4 seconds (2% HSF) and 4.6 seconds (3% HSF), while Crimped Steel Fibers (CSF) maintained relatively lower values of about 4.2 seconds (2% CSF) and 4.3 seconds (3% CSF). This indicates that CSF has minimal impact on flow resistance compared to HSF.

On the other hand, the inclusion of Glass Fibers (GF) caused a significant increase in T50 time, demonstrating reduced flowability and higher resistance to deformation.

For 12 mm GF, the T50 time rose to 6.0 seconds at 2% and 6.5 seconds at 3%, while for 6 mm GF, it increased further to 6.6 seconds at 2% and peaked at about 7.2 seconds at 3%. These results show that shorter glass fibers (6 mm) at higher content substantially increase flow resistance.

Overall, the findings highlight that while steel fibers (especially CSF) have a limited effect on T50 time, glass fibers considerably reduce the flowability of SCC, with the impact being more severe at higher fiber content and shorter fiber length.

5.4.3 Compressive strength results of M50



Graph no.11 Variation of Compressive strength results M50 concrete against varies % of fibers

Following observations are noted

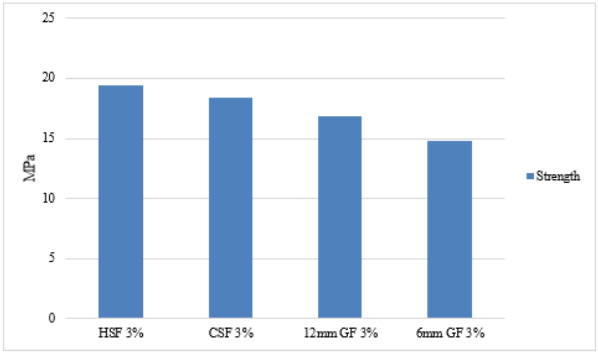
The compressive strength (in MPa) of various concrete mixes measured at 3, 7, and 28 days. The mixes include a control mix (SCC) and several modified mixes containing different percentages of hybrid steel fibers (HSF), copper slag fibers (CSF), and glass fibers (GF) at two lengths (12 mm and 6 mm) and concentrations (2% and 3%).

Across all mixes, compressive strength increased with curing time, showing the highest values at 28 days. Among the modified mixes, the HSF 3% mix exhibited the highest 28-day compressive strength, followed closely by the HSF 2% and CSF 3% mixes.

Generally, fiber incorporation enhanced compressive strength compared to the control mix (SCC), particularly at later curing ages. However, the variation between different fiber types and dosages suggests that while all fibers contribute to strength gain, their effectiveness depends on both type and proportion.

The results highlight the potential of fiber-reinforced concrete in improving long-term strength performance.

5.4.3 Split tensile strength results of M50



Graph no.12 Variation of split tensile strength results M50 concrete against varies % of fibers

Following observations are noted

The split tensile strength of various concrete mixes incorporating 3% of different fibers: hybrid steel fibers (HSF), copper slag fibers (CSF), and glass fibers (GF) of lengths 12 mm and 6 mm.

Among all fiber-reinforced mixes, the HSF 3% mix exhibited the highest split tensile strength, followed closely by the CSF 3% mix. The mixes with glass fibers showed comparatively lower strength values, with the 12 mm GF mix outperforming the 6 mm GF mix. This trend indicates that both the type and length of fibers significantly influence tensile performance.

Steel and copper slag fibers, due to their higher stiffness and bonding characteristics, appear to contribute more effectively to tensile strength improvement than glass fibers. Additionally, the longer glass fibers (12 mm) provided better performance than the shorter ones (6 mm), suggesting that fiber length plays a key role in bridging cracks and enhancing tensile capacity.

6. CONCLUSIONS

From this study, it can be concluded that the developed Fiber-Reinforced Self-Compacting Concrete (FRSCC) mix successfully achieved self-compaction without the need for vibration, exhibiting satisfactory results in flowability, passing ability, and viscosity tests. The inclusion of fibers influenced both workability and strength characteristics of SCC. Crimped steel fibers caused a slight reduction in flowability (1.5–3%), while glass fibers showed a higher decrease (3–4%) at similar fiber content. However, both fiber types enhanced mechanical properties, with hooked steel fibers at 3% providing the maximum compressive and tensile strength, improving load transfer and crack resistance. Glass fibers, though less effective, still contributed to moderate strength enhancement. The optimum fiber content for achieving a balance between workability and strength was found to be 3%, making hooked steel fiber–reinforced SCC the most efficient mix for superior performance and durability in structural applications.

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