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# A Review Study on Mechanical Properties and Fracture Behavior of Chopped Fiber Reinforced Self-Compacting Concrete

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**ABSTRACT:**

Self Compacting Concrete's rise to prominence in constructional represents a watershed moment in the industry's history. It has a number of advantages over traditional concrete, including increased productivity, lower labour and overall costs, and a high-quality end product with good mechanical reaction and durability. Fibres addition improves SCC characters, particularly those related to post-crack behaviour. As a result, the purpose behind this to compare mechanical properties of self-consolidating concrete reinforced with various types of fibres. Type and varied percentages of fibres in the study. The mechanical characteristics, toughness, fracture energy, and sorptivity of fresh SCC were investigated. The bond and hydrated structure formation of fibre with mixed are studied using a SEM to examine the microstructure of various mixes. carbon fibre, basalt fibre and 12 mm glass fibre were employed in the investigation. 0.0 percent, 0.1 percent, 0.15 percent, 0.2 percent, 0.25 percent, and 0.3 percent fibre volume fractions were used. There were two stages to the project. The first stage involved developing an M30 grade SCC mix design, and the second stage involved adding different fibres such as glass, basalt, and carbon fibres to the SCC mixes and determining and comparing their fresh and hardened properties. By incorporating fibres of various sorts and volume fractions into self-compacting concrete, the researchers were able to significantly improve all of its qualities. In the hardened condition, carbon FRSCC outperformed basalt FRSCC and glass FRSCC, but it performed poorly in freshen state due to its significant water absorption. Freshen state of concrete, Glass FRSCC performed best. According to the findings, Basalt Fiber is the greatest alternative for enhancing overall quality of self-compacting concrete in terms of overall performance, optimum dose, and cost.

**Keyword:** Self Compacting Concrete, Chopped Glass Fiber, Mechanical Properties, Microstructure, Carbon Fiber, Basalt Fiber.

## INTODUCTION:

Generally its developed in Japan and Europe. It's freely flowing or filled each section of formwork corner by itself, without the use of vibration or any other means of compaction, even when heavy reinforcement is present. Prof. H. Okamura's development of SCC in 1986 had a huge impact on the building industry by solving some of the issues associated with newly prepared concrete. The SCC, in its current form, details various challenges relating to worker skill, reinforcing density, structural section type and arrangement, pumpability, segregation resistance, and, most notably, compaction.. Self-Consolidating Concrete with a high fines concentration has been found to endure longer. It all began in Japan, where a number of studies on the global development of SCC, as well as its micro-social system and strong features, were published. BIS has not issued a standard mix method, a number of building systems and researchers have conducted extensive research to establish appropriate mix design trials. And its similar to conventional concrete in that it contains a binder, F.A., C.A. and water, fines, and admixtures. SCC should contain greater fines content, super plasticizers, and viscosity agents to some level to change SCC properties from regular concrete, which is a significant difference.

When compared to conventional concrete, the advantages of SCC include increased strength, similar tensile strength to non-SCC, slightly lower modulus of elasticity and better durability for better surface concrete.

With the inclusion of additional fines and high water lowering admixtures, SCC becomes more sensitive, and it is developed and designated by the concrete society, which is why it is utilised in the construction of pre-cast products, bridges, wall panels, and other structures in various countries.

Varied studies are however, to investigate the various features and structural uses of SCC. Because SCC has proven to be an effective material, it is necessary to provide guidance on the normalisation of self-consolidating properties and behaviour for use in various structural constructions, as well as its use in all risky and inaccessible project zones for higher quality control.

## FIBER REINFORCED SELF-COMPACTING CONCRETE

The availability of numerous grades of cements and mineral admixtures has resulted in an inventive revolution in concrete technology in recent years. Although significant progress, several difficulties have remained. These problems can be considered as drawbacks for this cementatious material, when it is compared to materials like steel. Concrete, a "quasi-fragile" substance with little tensile strength?

Fiber reinforced composites have been shown to be more efficient than other forms of composites in various studies. By bridging action during micro and macro cracking, the fiber's principal role is to regulate cracking and raise the fracture toughness of the brittle matrix. Debonding, sliding, and pulling influence bridging activity. At the start of macro cracking, fibre bridging activity prevents and controls crack opening and propagation. This mechanism raises the energy demand for the fracture to spread. Low volumetric fibre fractions have no meaningful effect on the matrix's linear elastic performance.

The use of fibres improves the properties of this special concrete both before and after it has set. As a result, scientists have focused to improving the effect of strength and durability of FRSCC.

1) Glass fibers
2) Carbon fibers
3) Basalt fibers
4) Polypropylene fibers etc.

Fibers used in this investigation are of glass, basalt & carbon, a brief report of these fibers is given below.

**Alkali Resistance Glass Fibers**

Glass fibres are made by drawing molten glass filaments in the shape of filaments. Typically, 204 filaments are drawn at the same time and cooled before being bundled together on a drum creating a strand including all 204 filaments. And these are treated with a sizing which protecting against weather and abrasion effects.

Glass fibres of many sorts, such as C-glass, E-glass, and S-glass AR-glass, for example, is made with various qualities and applications in mind. Because of their alkali resistance, fibres used for structural reinforcement are classified as E-glass, AR-glass, or S-glass. There are two types of E-glass fibres.

(1) Continuous

(2) Discontinuous fibers

Low costing, higher strengthening, easiest and safely handling, or rapidly and uniformly dispersion facilitate homogeneous mixtures, which in turn make durable concrete, are the main benefits. Poor abrasion resistance, which results in lower useable strength, poor adhesion to particular polymer matrix materials, and poor adhesion in humid settings are all drawbacks.

**Basalt Fibers**

Quarried basalt rock is melted at roughly 14000 degrees Celsius and extruded through small nozzles to produce continuous filaments of basalt fibres. Basalt fibres have a chemical makeup comparable to glass fibre, however they are stronger. It can withstand alkaline, acidic, and salt attacks, making it an excellent material for concrete, bridges, and coastal structures. It has more applications than carbon and aramid fibre, such as stronger oxidation resistance, a larger temperature range (-2690C to +6500C), higher shear and compressive strength, and so on. Basalt fibres particularly effective in improving the characteristics of conventional and SCC concrete mixes.

**Carbon Fibers**

Carbon fibres have a low density, great thermal conductivity, outstanding chemical stability, and exceptional abrasion resistance, making them ideal for reducing cracking and shrinkage. These fibres improve tensile and flexural strengthening, flexural toughness, and impact resistance, among other structural qualities. Carbon fibres also aid in the reduction of dry shrinkage and freeze-thaw durability. The electrical resistance is reduced when carbon fibres are added.

## LITERATURE REVIEW:

**M Ouchi, et al. (1997)** The author gave an outline of superplasticizer effect on the fresh characteristics of concrete based on the experimental findings. The author discovered that his research were quite useful in predicting the % of Plasticizer required to fresh qualities of concrete.

**GaoPeiwei., et al. (2000)** the authors has studied special type of concrete, like conventional concrete. Admixtures containing Viscosity Modifying Agents (VMA) are required to generate high-performance concrete. It reducing cement quantity used in HPC. The primary goal is to preserve precious natural resources, followed by cost and energy reductions, and last, long-term strength and durability.

**Neol P Mailvaganamet al. (2001)** The author looked at how admixtures interact with binding material molecules and affect the hydration process. The dosages are determined based on the performance of the admixtures with concrete, such as the type and dosage of admixtures, their composition, specific contact area of cement, type and amounts of various aggregates, and water/cement ratio.

**Raghu Prasad P.S. et al. (2004)**The authors discovered that when admixtures are used, both the initial and ultimate setting are delayed. This is happen because of delayed pozzolanic reaction affected by the addition of particular admixtures. This type of delayed setting property is occasionally helpful during the concreting in summer season. There will also significant strength gain for mixed cements and concretes after 28 days. Due to this reason concrete corrosion will beless.

**Lachemi M, et al.(2004)** Viscosity Modifying Agents showing particularly effective in achieving stable rheology of the SCC, according to the author. The suitability of 4 types of poly-carboxylic-based VMA SCC growth mixtures was investigated. In comparison to commercially available VMA, the author discovered that the novel type VMA is more suited mix. 0.04 percent of dose, according to the author, satisfies freshen and hardened qualities , less than 6 % commercially available VMA.

**M.Collepardi, et al. (2006)** The author investigated the impact of VMA in creating consistent SCC when chosen vol. range of 170-200 liters/m3 of B.M. (90m max. size) was unavailable, and discovered that the combination of VMA and no mineral filler was the most effective. In this case, a modest increase in VMA dose (for example, from 3 to 8 Kg/m3) is required to achieve an unsegregable SCC without mineral filler, as dictated by cement content. In summary, dosages are required to maintain the freshen and toughened features of SCC while also improving its durability.

**Okamura et al. (1995)** The inventor created a specific type of concrete that flows and compacts itself at every point of the formwork. It was previously utilised as an anti-washout concrete. They claim that using Super Plasticizer was required to get the ability to self-compact. The W.C.R. should be between 0.4 and 0.6. The material properties and mix proportions have the greatest impact on the concrete's self-compactability. To achieve self-compact ability, the author limited the C.A. is 60% of solid vol. and F.A.40%.

**Khayat K. H,et al. (1999)** The behaviour of VEA in cementitious materials was studied by the author. He realised that by appropriately changing the combinations of VEA and Higher Water Reducing agents, he could develop a fluid with no washout resistance, which would improve the qualities of underwater cast grouts, mortars, and concretes, as well as reduce turbidity and raise pH values in the surrounding waters.

**Yin-Wen Chan,et al. (1999)** The author created (ECC) and the treatment parameters, which control the rheological properties in the fresh state, by improving the micromechanical parameters that regulate composite qualities in the hardened state. Micromechanics was approved for the formation of self-compacting ECC to adequately select the matrix, fibre, and interface parameters in order to display strain hardening and varied cracking behaviour in the composites. The structured rheological features of fresh matrix were then used to explain ECC's ability to self-compact. with various ingredient materials, including deformability and flow rate Accepting an optimal mixture of super plasticizer and viscosity modifying agent resulted in self-compactability. ECC produced in this study has been confirmed to be self-compacting, according to new test results. It is unaffected by the highly applied consolidation during placement, according to flexural testing. This finding validates the self-compact ability's efficacy in maintaining structural element quality.

**Kung-Chung Hsu, et al. (2001)** The authors proposed a new SCC mix design technique, with a focus on using binder paste to fill holes in weakly packed aggregate. For aggregate, they learned about PF.The Packing Factor has a significant impact on the approach (PF). Because of the higher sand content, Its employed in the suggested method may be less by previous mix design methods. The aggregate content is influenced by the packing factor, which has an impact on the concrete's fresh qualities.

**M. Sonebi,et al. (2002)** This study exhibits the results of freshen SCC property and flow time assessed by slump flow apparatus, and plastic fresh properties measured by column apparatus. Its influenced by the water/binder ratio, sand type, and slump. The results of freshen and hardened tests, were comparing to 0 %. Increases in the water/binder ratio and sand nature improved the qualities of fresh SCC, while the volume of coarse aggregate and chemical admixture dosage remained similar.

**Hajime Okamura et al. (2003)** The authors argue that when self-compacting concrete is widely employed to the point that it is considered "Standard Concrete" rather than "Special Concrete," it will be successful in producing long-lasting and dependable concrete structures that require minimal maintenance.

**R.SriRavindrarajah, et al. (2003)** The features of flowing concrete and self-compacting concrete mix with varying percentages of high-water lowering super-plasticizer were investigated experimentally by the author. Drying shrinkage is influenced by superplasticizer dosage.

**ShettyR.G,et al. (2004)** Self consolidating concrete is appropriate for concreting in dense reinforcement structures, according to the authors, who also explained the methodology used to design and test SCC mixes, as well as the methods used to test the concreting walls.

**Frances Yang,et al. (2004)** The process for developing SCC, as well as its components and mix proportioning procedures, are done in this. It lists numerous advantages of adopting SCC techniques used to assess its features. The author proposes several model applications of SCC, such as Toronto International Airport, and it presents the preventive actions that should be implemented for creating and developing the mix. For the 68-story high-strength SCC was employed to produce compactly reinforced parts poured in below-freezing temperatures.

**Geert De Schutter,et al. (2005)** In this inquiry, the results of creep and shrinkage are given. When experimental data are compared to some traditional methods, the ACI model provides accurate predictions. The models proposed by "Delarrard" and "Model Code" lead to in underestimation of the deformations. The use of SCC needs no extra provisions taken for the structure.

**"The European Guidelines for SCC (2005)**The proposed specifications and associated test adopted for site-mixed concrete is offered aiming to facilitate standardization at European code.The method is to encourage increased adoption and use of SCC.The EFNARC defines SCC and many of the technological terms utilized to define its properties and function.They also present data on standards connecting to testing and to related constituent materials used in the manufacture of SCC.

**AnirwanSenguptha, et al. (2006)** According to the EFNARC 2005 code, the author discovered the best mixture for making SCC. The EFNARC criteria were met in all design mixtures, which showed good segregation resistance, passage ability, and filling ability. It was required to use a lot of powder in the design of SCC. The SCC has a higher powder content, which results in higher compressive strengths.

**G. Giri Prasad, et al. (2009)** For toughened qualities, the author constructed M60 grade SCC compared it to a routinely manufactured concrete mix. The collected experimental data were confirmed using analytical equations for the stress-strain curve presented by several authors. The values of stock at peak stress during axially compressioning for both concretes were found to be close to 0.002, as stated in IS:456-2000.

## MATERIAL

**Cement**

In the current research, Konark brand Portland slag cement from local market was employed. The experimentally determined physical parameters of PSC were confirmed according to IS: 455-1989.

**Coarse Aggregate**

The C.A. of 20 mm size and smaller than 10 mm were collected from Gwalior city.

**Fine Aggregate**

Natural river sand has been collected from Chambal River, Morena, Madhya pradesh and conforming to the Zone-III as per IS-383-1970.

**Silica Fume**

Elkem Micro Silica 920D is used as Silica fume. It's a pozzolanic materials to be used in concrete due to its fineness and pozzolanic responsiveness.

When it's added to concrete, it reduces porosity, permeability, and bleeding.

**Admixture**

SikaViscoCrete Premier is a plasticizer that having modifying viscosity additive that was used in this investigation.

**Water**

In the investigations, potable water was used.

**Glass Fiber**

The material utilised was alkali resistant glass fibre with a modulus of elasticity of 72 GPA and a length of 12mm.

**Basalt Fiber**

The experiments employed basalt fibre with a length of 12mm.

**Carbon Fiber**

The investigations employed carbon fibre with a length of 12mm..

**Table Mechanical Properties of Fibers**

| **Name** | **Length (mm)** | **Density ($g/cm^3$)** | **Elastic modulus(GPa)** | **Tensile strength(MPa)** | **Elong. at break(%)** | **Water absorption** |
|---|---|---|---|---|---|---|
| BASALT | 12 | 2.65 | 93-110 | 4100-4800 | 3.1-3.2 | <0.5 |
| GLASS | 12 | 2.53 | 43-50 | 1950-2050 | 7-9 | <0.1 |
| CARBON | 12 | 1.80 | 243 | 4600 | 1.7 | |

**(X)** **(Y)** **(Z)**

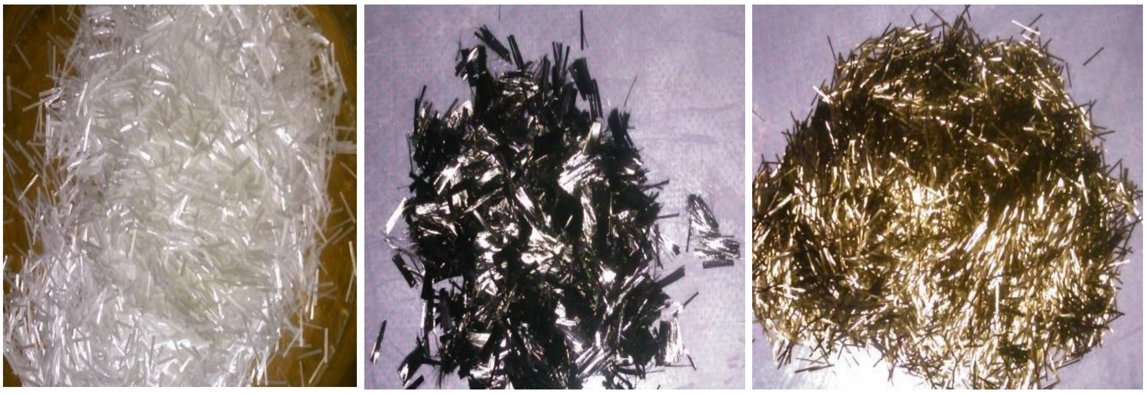

**Fig. (X) Glass Fiber (Y) Carbon Fiber (Z) Basalt Fiber**

## SUMMARY:

The following conclusions can be taken from this research:

1. Addition of fibers to self-compacting concrete causes loss of basic characteristics of SCC measured in terms of slump flow, etc.
2. 2. Carbon fibre had the greatest reduction in slump flow, followed by basalt and glass fibre. This is due to the fact that carbon fibres absorb more water than other materials, but glass absorbs less.
3. 3. Adding more than 2% carbon fibre to the mix rendered it harsh, and it failed to meet the requirements for self-compacting concrete, such as slump value and T50 test.
4. 4. Fibers added to self-compacting concrete improve mechanical qualities such as compressive strengthening, split tensile and flexural strengthening.
5. 5. An ideal % of each type of fibre was found to produce the greatest increase in SCC mechanical characteristics.

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**A. LIST OF IS CODES**


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3. IS: 4031-1988 Methods for Physical tests for Hydraulic Cements (All Parts)
4. IS:383-1970 Specification for Coarse and Fine Aggregate from Natural Sources forConcrete.
5. IS:2386-1963 Methods of tests for Aggregates for Concrete (All Parts)
6. IS: 9103-1999 Specification for admixtures for concrete
7. IS : 1199-1959 Methods for sampling and analysis of concrete
8. IS : 5816-1970 Methods of test for splitting tensile strength of concrete cylinders