Mechanical behaviour of self compacting concrete with hybrid fibres

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Abstract: Research lag on the stainless steel scrap (lathe waste) on the mechanical behaviour of self-compacting concrete was inferred. It is proposed to investigate the mechanical and flexural behaviour of self-compacting concrete completely under IS-10262:2019 (chapter 7: SCC). Here the effective utilization of materials namely steel fibre and lathe waste as an additive, cement is to be partially replaced with Ground Granulated Blast Furnace Slag (GGBS) along with High Range Water Reducers (ether-based superplasticizer) are to be compared with the control specimen of SCC. Adding fibre content to the volume of concrete by replacing 0%, 0.5%, 1.0%, 1.5% and 2.0% of steel fibre and constant replacing of 0.125% of stainless steel scrap with steel fibre and proceeds as a hybrid combination in SCC.

Keywords: Self-Compacting Concrete (S.C.C), Stainless Steel Scrap (Recycled Industrial Waste -Lathe waste), Mechanical Properties.

1. INTRODUCTION

The study of the impact resistance based on fibre dosage and improves the initial cracking. Among those fibres Mono-FRC group (SFRC and PFRC) are used to perform tests and show that SFRC improves 10 times impact resistant at SFRC dosage of 1.5%, and with Sisal fibres improves steps at 3.5 times of the same dosage of 1.50%. In the case of a hybrid combination of steel fibre and sisal fibre the minor improvement for the 1.50% of hybrid dosage [1].

The flexural analysis of stainless-steel provision, carbon reinforcement in concrete structures has augmented in the applications where oxidization and chemical conflict is desirable such as bridges, retaining walls and tunnels. The design of RC beams (M30) includes the common characteristic of stainless steel in the design of reinforced concrete beams. The result is compared with 4-Point loading and ANSYS [2].

Using coarse plastic, fine plastic waste and varied plastic waste the self-compaction properties have tested with different criteria such as slump flow, v-funnel flow, L-box and U-box for the study of fresh properties and for hard properties they considered compressive strength alone. From the results, inferred that we increase the size of the aggregates, a quantity of adding replacement based on coarse it will directly affect both fresh and harden property of the self-compacting concrete [3].

The paper shows the detailed investigation of using separate fibre types and combined fibre types. Study based on the impact resistance of the SCC using hooked end steel fibre, crimped steel fibres and a combination of both the fibres. The flexural behaviour of combined fibre shows at even distribution of adding fibres with their control specimens [4].
At the hybrid combination of polypropylene fibres, steel fibres and sisal fibres project the impact study on the concrete. Polypropylene fibre and steel fibre combination show a better cracking resistance of 1.50% while compared with their control specimens and other combinations of fibres. In the case of compression 1.25% of strength variation for polypropylene and steel fibre combinations [5].

To encounter workability goals, self-compacting concrete using high quantities of untreated rice husk ash as a fine aggregate essential huge quantities of water, primarily because of the enlarged volume fraction and surface area of the binder in the existence of RHA. In particular, the RHA-induced increase in binder surface area was extensive. The increased surface area adsorbs a larger amount of water, thus reducing the quantity of free water available in the mixture. The compressive strength of the specimens decreases due to the high water–binder ratio. Maintain regular flow ability, the addition of RHA alone required an increase in water–binder ratio. Combinations of RHA with LS decreased the water–powder ratio by higher than 28% [6].

To maintain or increase the flexural behaviour of the specimens using lathe waste taking some possibility as same as the steel fibre. The study centred on both the strength and flexural property of the concrete. As we know the 1.5% of steel fibre extends the compressive strength than other % of addition. They feed the data of lathe wastes are also to be used as the steel fibres. The discussion shows the more flexural behaviour of the lathe waste using reinforced concrete. Various studies for crack pattern identification, deflection, initial cracking, and shear cracking. All the practically obtained data are compared with ANSYS [7]. Similarly, many authors were reported their experimental investigations using steel fibres and basalt fibres in concrete materials and structural behaviour of beams [8-12].

2. MATERIAL AND METHODS

![Figure 1 Methodology]

From the Figure 1 predicted methodology, a part of the work has done for compressive strength analysis after attaining the strength criteria, the flexural part of the concrete will be analyzed.
2.1 Steel Fibre

Steel fibres are short ends strips of particularly manufactured steel as shown in Figure 2. Their presence in the concrete mends the mechanical properties of concrete significantly. As the most common matrix, which is today in use in the construction industry as Reinforced Cement Concrete. Reinforced cement concrete is a grouping of steel, cement, aggregates & water. Concrete performances as a compression member. It takes compressive forces resulting due to the functional load and self-load. The main problem in concrete is its fault in resisting tensile forces to respond partly against the brittle nature of the concrete.

2.2 Stainless Steel Scrap

Recycled industrial waste used as good standby for steel fibre and also act as fibres for reinforced concrete.

To improve the flexural and other uniqueness of concrete. The raw materials found from the lathe industries mentioned in Figure 3, the fibre leads three major roles such as to progress flexure of concrete, to confine the brittle nature and to reduce the volume changes resulting from the settling and hardening process. The density of lathe scrap is 7750 kg/m$^3$.

3. SELF-COMPACTING CONCRETE MIX DESIGN (IS-10262-2019)

When placing of SCC propagates the extreme or moderate fluidity within the boundary of formwork, can flow through obstructions, around corners shape and surface texture of a mold. These properties result in the casting of the concrete with less labour and high costed machines for pouring SCC. Once poured, SCC is usually similar to standard concrete in terms of its setting, curing time, and strength. SCC does not require high water to powder ratio to make the concrete fluidity SCC may contain low water/cement ratio with chemical admixtures than standard concretes.

Instead, SCC gains its fluid properties from the fineness offered by the admixtures, combined superplasticizers (improve workability), and viscosity-modifying admixtures (VMA) (additives reduces the segregation of concrete based on flowability).

Self-Compacting Concrete has extreme importance to the construction of the complex reinforced areas such as seismic prone area, beam-column joints, etc. Self- Compacting Concrete (SCC) can be defined as a high compaction factor of the mixture by adding required admixtures with it and giving additional qualities such as self-compaction with its dead weight. Using a Fine aggregate of size...
<0.125 mm (125 micron) achieves self-compaction. The main specialties of SCC are its faster building rates in construction and required skilled labour while mixing concrete and placing.

3.1. Target Strength

\[ f_{ck^*} = f_{ck} + 1.65s \]

Where  \( f_{ck^*} \) is targeting 28days average compressive strength, 
\( f_{ck} \) is characteristics compressive strength and is a standard deviation is 5.

Target strength = \( 30 + 1.65 \times 5 = 38.25 \text{ N/mm}^2 \).

3.2. Water/Cement Ratio

W/C ratios are taken from the IS-10262-2019 is 0.40, based on the Nominal mix. 0.40≤0.50. Calculations of cement and Chopped Glass Fibre content W/C ratios 0.40.

Superplasticizers 1% from cementitious material.

Water = 202.5 kg/m\(^3\), Reducing water of 18% for 1% of Superplasticizer.
Cement=202.5/0.4 =506.3 kg/m\(^3\)>450 kg/m\(^3\).

Replacing 30% of GGBS with cementitious material.

3.3. Powder Content

For Self-compacting concrete, the powder content lies between 400-600 kg/m\(^3\).
Here, 585 Kg/m\(^3\) is used to make the concrete at the better flow and with the consistency of the concrete.

3.4. Water/Powder ratio

As per the water/ powder ratio based on the total volume of the fine materials used are considered as a powder (0.1951m\(^3\)).
W/P= 0.1661/0.1951= 0.851
(W/P ratio between 0.85 and 1.10)

3.5. Trial Mix

Table 1 shows the trial mixes carried out in the laboratory.

| Trialno | Cement | GGBS | F.A | C.A | Water | SP dosage |
|---------|--------|------|-----|-----|-------|-----------|
| T1      | 0.7    | 0.3  | 1.82| 1.46| 0.4   | 0.6%      |
| T2      | 0.7    | 0.3  | 1.87| 1.43| 0.4   | 0.7%      |
| T3      | 0.7    | 0.3  | 1.94| 1.61| 0.4   | 1%        |

4. Test on Fresh Properties

4.1. Slump Flow & J-Ring Test

By checking the slump flow and v-funnel test for the different combinations at Table 1 concludes the following,

- For T1, the slump flow attains slump dia of 350 mm and initial slump SF1 ranges between 550 mm to 650 mm.
- For T2 & T3, the slump flow ranges 450mm to 610mm shown in Figure 4 & Figure 5. V-
Funnel Flow/ passing) ranges between V2- Class (8 to 25 Seconds) refer to Table 2.

- For T3-0.5% of Steel Fibre and T3-2.0% Steel Fibre having their slump flow between 570mm to 500mm. Hence the steel fibres act as flow controllers (flow restrictor) as shown in Figure 6 and Figure 7.
- Hence we increase the fibre content that will restrain the flow property of Self-Compacting Concrete as shown in Figure 8. If we require more flow means increasing the superplasticizer content and it will change the setting property of concrete.
- Figure 9 shows the flow comparison of the V-funnel test.

**Table 2** Slump Flow and Flow test

| Trial no | Steel Fibre | J- Ring & Slump Dia(mm) | V- Funnel Flow(seconds) |
|----------|-------------|-------------------------|-------------------------|
| T1       | 0%          | 350                     | V2-class-<20sec         |
| T2       | 0%          | 450                     | V2-class-18.4sec        |
| T3       | 0%          | 610                     | V1-class-7.4sec         |
| T3       | 0.5%        | 570                     | V1-class-7.8sec         |
| T3       | 1.0%        | 550                     | V2-class-8.5sec         |
| T3       | 1.5%        | 550                     | V2-class-8.7sec         |
| T3       | 2.0%        | 500                     | V2-class-9.5sec         |

![Figure 4](image4.png)
T2- Slump dia 450mm

![Figure 5](image5.png)
T3- Slump dia 610mm

![Figure 6](image6.png)
T3-0.5% SF Slump dia 570mm

![Figure 7](image7.png)
T3- 2.0% SF Slump dia 500mm
5. RESULTS AND DISCUSSION

5.1. Test on direct compression strength
5.1.1. 7 days of strength
Table 3. 7 Days Compressive Stress

| 7 Days  | Steel Fibre | 7 Days             | Steel Fibre + SS Scrap |
|---------|-------------|--------------------|------------------------|
| Mix ID  | Stress(MPa) | Mix ID             | Stress(MPa)            |
| T1-0    | 16.185     | T1-0               | -                      |
| T2-0    | 15.59      | T2-0               | -                      |
| **T3-0**| **19.79**  | **T3-0**           | **19.79**              |
| T3-0.5,7| 20.78      | T3-D               | 22.17                  |
| T3-1.0,7| 21.69      | T3-C               | 24.55                  |
| **T3-1.5,7**| **23.08**  | **T3-B**           | **28.4**               |
| T3-2.0,7| 19.53      | T3-A               | 20.77                  |

From the following results of Table 3, the compressive stress might have a slight increase in hybrid combination than the steel fibre combination. Hence the stress development attains the stress concentration at 0.125% of SS Scrap and 1.375% of Steel Fibre combination.

5.1.2. 28 days of strength

Table 4. 28 Days Compressive Stress

| 28 Days  | Steel Fibre | 28 Days             | Steel Fibre + SS Scrap |
|----------|-------------|--------------------|------------------------|
| Mix ID   | Stress(Mpa) | Mix ID             | Stress(MPa)            |
| T1-0     | 29.36       | T1-0               | -                      |
| T2-0     | 29.28       | T2-0               | -                      |
| **T3-0**| **33.4**    | **T3-0**           | **33.4**               |
| T3-0.5,28| 34.75       | T3-D               | 38.05                  |
| T3-1.0,28| 36.27       | T3-C               | 39.81                  |
| **T3-1.5,28**| **44.71**  | **T3-B**           | **47.76**              |
| T3-2.0,28| 35.34       | T3-A               | 40.1                   |

Results of Table 4, the compressive stress for T3-B increased up to 20% of hybrid combination even though the steel fibre enhanced up to 14.5% of stress for T3-1.5, 28 while compared with T3-0. The stress development may restrain the higher strength by partial replacement of steel fibre of 1.375% and 0.125% of SS Scrap of hybrid combination as shown in Figure 10.
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6. CONCLUSIONS

From the results of the compressive stress, the optimum content of 1.375% steel fibre and 0.125% of stainless steel scrap of hybrid combination has obtained 1.4 times (30.06%) of strength enriched (as partial replacement of steel fibre) than the steel fibre combination. The addition of steel fibres decreased the flow properties in SCC mixes and belongs to SF1 category. By combining the merits of optimum content of fibre and mineral admixture namely GGBS enhanced the mechanical properties in SCC.

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CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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