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# A STUDY ON FLOW PROPERTIES OF HYBRID FIBER REINFORCED SELF COMPACTING CONCRETE

Engineering

**KEYWORDS:** self-compacting concrete, fiber reinforced self-compacting concrete, hybrid steel fiber reinforced self-compacting concrete, steel fiber reinforced concrete.

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## ABSTRACT

This project deals with the study on flow properties of hybrid fiber reinforced self-compacting concrete. The mix design M30 used in this project was adopted from previous researchers, the fibers used in this project were steel crimped fibers and steel hooked end fibers which were added to control SCC mix in different proportions by keeping total fiber content constant as 2% by weight of cement. The properties studied were flow properties which include filling ability, passing ability and resistance to segregation.

## 1. INTRODUCTION

Self-compacting concrete was originally developed in Japan and Europe. "Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement."

### 1.1 Fiber reinforced self-compacting concrete

The main characteristics of SCC in the fresh state are filling ability, passing ability and segregation resistance. Fibers improve the performance (strength and toughness) of brittle cement-based materials by bridging cracks, transmitting stress across a crack and counteracting the crack growth.

### 1.2 Hybrid fiber reinforced self-compacting concrete (HFRSCC)

The combination or mixing of fibers is commonly termed as hybrid fibers .In a fiber reinforced self-compacting concrete if two or more fibers are added simultaneously then it is called as hybrid fiber reinforced self-compacting concrete Hybrid fiber reinforced self-compacting concrete gives the advantages of all the fibers which are added in self-compacting concrete .

## 2. OBJECTIVE

The main objective of this study is to study the fresh properties of hybrid fiber reinforced self-compacting concrete.

The fresh or flow properties includes

- Filling ability.
- Passing ability.
- Resistance to segregation.

## 3. METHODOLOGY

Self-compacting concrete mix of M30 grade is adopted from past researchers .The fiber reinforced self-compacting concrete and hybrid fiber reinforced self-compacting concrete mixes are obtained by adding fibers to SCC mix to get total fiber content as 2% by weight of cement. Flow properties are studied through

- Flow table test
- V-Funnel test
- L-Box test

## 4. MATERIALS

In these project materials like cement, Fly ash, river sand, Coarse Aggregates (CA), SP and water and steel fibers are used in this study. The description of each of the material is described in the following sections. The materials used in this study are tested to obtain their properties as per the relevant IS codes.

### 4.1 Cement

Cement used in this project is Ordinary Portland cement (OPC) of 53 grade manufactured by KCP company.

### 4.2 Fly ash

Fly ash obtained from Vijayawada thermal power plant (VTPS), Vijayawada, Andhra Pradesh, India was used in this study.

### 4.3 Fine aggregate

Natural river sand conforming to grading zone-II with specific gravity 2.62 and having fineness modulus as 2.72 is used as fine aggregate.

### 4.4 Coarse Aggregate (CA)

Maximum aggregate size should generally be limited to 10 – 12 mm.

### 4.5 Steel Fibers

Steel fibers greatly increase toughness of concrete, which primarily is used for crack and shrinkage controls, to serves as secondary reinforcement for pavements, slabs, pipes, channel and tunnels. In this study crimped steel fibers 0.4mm x 30 mm (aspect ratio 50)and steel hooked end fibers 0.5mm x 30mm are used.

### 4.6 Super plasticizer

Poly-carboxylic ether (Master Glenium 8650) type super plasticizer was used in mixes. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.

This type of super plasticizer is free of chloride & low alkali. It is compatible with all types of cements.

### 4.7 Water

Ordinary potable water available in laboratory was used.

## 5. TEST PROCEDURE

Required self-compacting concrete Mix proportion was obtained from past projects. The steel fibers were added to control mix SCC0 in different percentages by keeping total fiber content as 2% by weight of cement.

Mixes were designated as SCC0, SFRSCC2C, SFRSCC3C, SFRSCC2H, HFRSCC (0.5C+1.5H), HFRSCC (1.0C+1.0H) and HFRSCC (1.5C+0.5H) respectively. Mix with no fibers is designated as SCC0 which was the control mix.

### 5.1 Test on fresh concrete

After preparing every SCC mix, following flow tests were conducted to study the flow properties.

- Slump flow test
- V-funnel test
- L-box test

Slump flow test was conducted to assess the horizontal flow of the concrete in absence of obstruction. Slump flow test is a method to get flow-ability characteristics of self-compacting concrete without any segregation.

The V-funnel test is used to assess the viscosity and filling ability (flow ability) of self-compacting concrete with a maximum size of aggregate 20 mm size.

The L-box test is used to assess the passing ability of self-compacting concrete to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking.



**Figure 3** Slump flow test apparatus



**Figure 4** Measuring flow diameter



**Figure 5** V-funnel



**Figure 6** L-Box test apparatus

**Table 1**
Acceptance criteria for self-compacting concrete

| S.No | Method | Units | Typical range | |
|---|---|---|---|---|
| | | | Min | Max |
| 1. | Slump flow test | mm | 650 | 800 |
| 2. | T50 slump flow | sec | 2 | 5 |
| 3. | V-Funnel test | sec | 6 | 12 |
| 4. | L-Box test ( $H_2/H_1$) | | 0.8 | 1.0 |

**5.1 Test results of fresh concrete properties**

**Table 2**
Mix proportion used in this project

| C (kg) | F.A (kg) | F.agg (kg) | C.agg (kg) | W/C | SP (Ltr) |
|---|---|---|---|---|---|
| 425 | 119 | 957.95 | 666.825 | 0.54 | 85 |

C – Cement
F.A – fly ash
F.agg – fine aggregate
(Master Glenium Sky 8650)
C.agg – coarse aggregate
W – Water
SP – Super plasticizer

**Table 3**
Flow properties of self-compacting concrete mixes

| S. No | Mix designation | Flow diameter (cm) 65-80 | Flow time T50cm (sec) 2-5 | V-funnel time (sec) 6-12 | L-Box ($H^2/H^1$) 0.8-1.0 |
|---|---|---|---|---|---|
| 1 | SCC0 | 72 | 2.2 | 6 | 0.97 |
| 2 | SFRSCC2C | 69 | 3 | 7 | 0.82 |
| 3 | SFRSCC3C | 67.5 | 3.4 | 9.8 | 0.81 |
| 4 | SFRSCC2H | 68 | 3.2 | 8 | 0.814 |
| 5 | HFRSCC (0.5C+1.5H) | 70 | 3 | 6.5 | 0.923 |
| 6 | HFRSCC (1.0C+1.0H) | 68 | 3 | 7 | 0.85 |
| 7 | HFRSCC (1.5C+0.5H) | 70 | 3 | 6.5 | 0.928 |

**Table 4**
% change in the flow properties of FRSCC and HFRSCC mixes

| S. No | Mix designation | %Decrease in flow diameter | %Increase in flow time | %Increase in V funnel time | %Decrease in blocking ratio |
|---|---|---|---|---|---|
| 1 | SCC0 | ------- | ------- | ------ | ------- |
| 2 | SFRSCC2C | 4.17 | 36.36 | 16.67 | 15.46 |
| 3 | SFRSCC3C | 6.25 | 54.54 | 63.33 | 16.08 |
| 4 | SFRSCC2H | 5.55 | 45.45 | 33.33 | 16.08 |
| 5 | HFRSCC (0.5C+1.5H) | 2.78 | 36.36 | 8.33 | 4.84 |
| 6 | HFRSCC (1.0C+1.0H) | 5.55 | 36.36 | 16.67 | 12.37 |
| 7 | HFRSCC (1.5C+0.5H) | 2.78 | 36.36 | 8.33 | 4.33 |

SCC - self-compacting concrete
SCC0 - self-compacting concrete with 0 % fibers
SFRSCC2C- steel fiber reinforced SCC with 2% crimped fibers
SFRSCC3C - steel fiber reinforced SCC with 3% crimped fibers
SFRSCC2H - steel fiber reinforced SCC with 2% hooked fibers
HFRSCC (0.5C+1.5H) - hybrid fiber reinforced SCC with 0.5% crimped and 1.5% hooked fibers
HFRSCC (1.0C+1.0H) - hybrid fiber reinforced SCC with 1.0% crimped and 1.0% hooked fibers
HFRSCC (1.5C+0.5H) - hybrid fiber reinforced SCC with 1.5% crimped and 0.5% hooked fibers

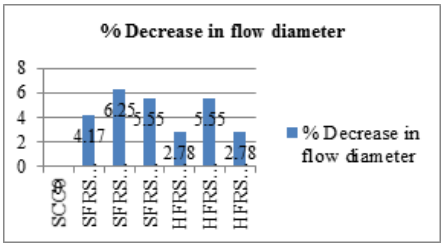


**Chart 1** % decrease in flow diameter

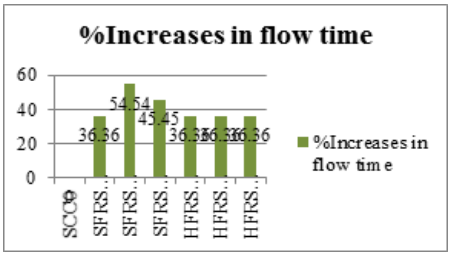

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**Chart 2**%increase in flow time $T_{50cm}$

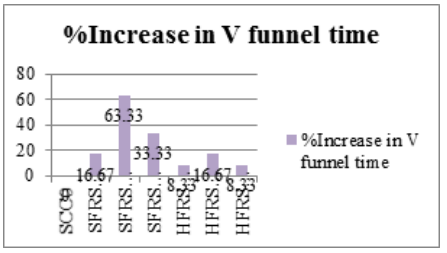


**Chart 3**%Increase in V funnel time

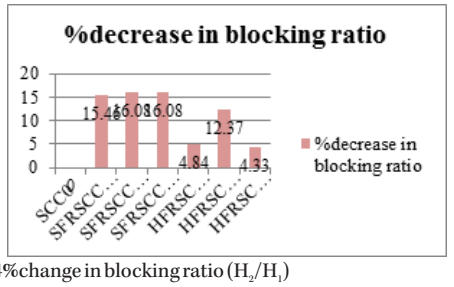


**Chart 4**%change in blocking ratio ($H_2/H_1$)

## 6. CONCLUSION

As there is increase in fiber content in the SCC mix the flow properties are adversely affected.

- **SFRSCC2Ccompared to control mix SCC0:** Slump flow is decreased by 4.17%.Slump flow time T50cm is increased by 36.36%.VFunnel time is increased by 16.67%.Blocking ratio is decreased by 15.46%.

- **SFRSCC3Ccompared to control mix SCC0:** Slump flow is decreased by 6.25%.Slump flow time T50cm is increased by 54.54.V- Funnel time is increased by 63.33%.Blocking ratio is decreased by 16.08%.

- **SFRSCC2Hcompared to control mix SCC0**: Slump flow is decreased by 5.55%.Slump flow time T50 is increased by 45.45%.V- Funnel time is increased by 33.33%.Blocking ratio is decreased by 16.08%.

- **HFRSCC (0.5C+1.5H) mix compared to control mix SCCM0:** Slump flow is decreased by 2.78%.Slump flow time T50 is increased by 36.36%.V- Funnel time is increased by 8.33%.Blocking ratio is decreased by 4.84%.

- **HFRSCC (1.0C+1.0H) mix compared to control mix SCC0:** Slump flow is decreased by 5.55%.Slump flow time T50 is increased by 36.36%.V- Funnel time is increased by 16.67%.Blocking ratio is decreased by 12.37%.

- **HFRSCC (1.5C+0.5H) mix compared to control mix SCC0S:** lump flow is decreased by 2.78%.Slump flow time T50 is increased by 36.36%. V- Funnel time is increased by 8.33%. Blocking ratio is decreased by 4.33%

Compared to single fiber reinforced SCC mixes hybrid steel fiber reinforced SCC mixes are giving better flow properties.

- **Compared with SFRSCC2C mix, HFRSCC (0.5C+1.5H) is giving the following improved flow properties:** Slump flow is increased by 1.45%.V funnel time is decreased by 7.14%.Blocking ratio is increased by 12.56%.

- **Compared with SFRSCC2C mix, HFRSCC (1.0C+1.0H) is giving the following flow properties:** Slump flow diameter is decreased by 1.45%.Blocking ratio is increased by 3.66%.

- **Compared with SFRSCC2C mix, HFRSCC (1.5C+0.5H) is giving the following flow properties:** Slump flow diameter is increased by 1.45%.V funnel time is decreased by 7.14%.Blocking ratio is increased by 13.17%.

- **Compared with SFRSCC2H mix, HFRSCC (0.5C+1.5H) is giving the following flow properties:** Slump flow diameter is increased by 2.94%.Flow time is decreased by 6.25%.V funnel time is decreased by 18.75%.Blocking ratio is increased by 13.39%.

- **Compared with SFRSCC2H mix, HFRSCC (1.0C+1.0H) is giving the following flow properties:** Slump flow time is decreased by 6.25%.V funnel time is decreased by 12.5%.Blocking ratio is increased by 4.42%.

- **Compared with SFRSCC2H mix, HFRSCC (1.5C+0.5H) is giving the following flow properties:** Slump flow is increased by 2.94%. Flow time is decreased by 6.25%.V funnel time is decreased by 23.08%.Blocking ratio is increased by 14%.

Addition of hybrid fibers in SCC mixes in combination as 0.5C+1.5H or 1.5C+0.5H is giving better flow properties than 1.0C+1.0H combination.

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