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# Destructive and Non-Destructive Tests on Steel Fiber Reinforced Self Compacting Concrete Exposed to Elevated temperature

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**Abstract -** *Self compacting concrete (SCC) has high flow ability and moderate viscosity and no bleeding occurs during flow. The fresh properties of SCC are characterised by EFNARC guide lines. Concrete generally exhibits good Fire resistance properties. The performance of concrete at elevated temperature deteriorates, which depends on the temperature and duration of exposure. The non-destructive tests such as rebound hammer and ultrasonic pulse velocity (UPV) help to estimate the compressive strength and quality of concrete without damaging the specimens or structures. The present work involves the effect of elevated temperature on weight loss, rebound number (RN) and ultrasonic pulse velocity (UPV)for SCC reinforced with crimped steel fibers of aspect ratio 50 at 0 to 1.5% at an interval of 0.5% in volume fraction. The exposure temperature were 400$^0$C, 600$^0$C and 800$^0$C for one hour duration. The results revealed the loss of weight and reduction in rebound number and ultrasonic pulse velocity.*

***Key Words***: Self compacting concrete, Fly ash, Steel fibers, M-sand, Destructive test, Non-destructive tests.

## 1.INTRODUCTION

SCC is a concrete of this generation and called as the special type of concrete as it is having special fresh properties which simplify the problems which could occur during casting. As name only indicates, this concrete does not require any compaction as it undergo compaction on its own weight without any segregation or bleeding. It has the ability to give proper filling at corners, passing through the congested reinforcement bars and good structural performance [1].
The use of the steel fibers along with the polypropylene fibers gives the positive results for the effect on post peak behaviour of SCHPC materials before and after exposed to the elevated temperatures. The steel strength help to the residual compressive strength and polypropylene fibers helps to resist the surface spalling of the concrete specimen [2].
Self compacting high strength concrete has shown more spalling than high strength normal concrete and decreased compressive strength by 41-48% when exposed to elevated temperature of 400$^0$C [3].
The polypropylene fibers increases the residual strength and fracture energy of concrete subjected to thermal shock. The specimens do not show any surface cracks at 200$^0$C both with and without fibers. But 600$^0$C for surface cracks found in both cases. And observed that, addition of 0.05% of polypropylene fibers gives the superior performance during heating [4].

## 2. METHODOLOGY

### 2.1 Mix design

Nan-Su method of mix design has been used to design M30 grade concrete satisfying EFNARC guidelines in fresh state.

### 2.2 Materials

The materials used in this project are
1. Cement: Ordinary Portland cement of grade 43 has been used in this project.

2. Fly ash: Fly ash is used as the filler material in this project and cement of 30% is replaced by fly ash.

3. Fine aggregates:
a) Natural sand: Locally available natural sand was used for the experimentation.

b) Manufactured sand: The rocks which are available locally are crushed for the production of Manufacture sand. It produces particles with similar size and shape.

*4. Coarse aggregates:* The coarse aggregates used in this project were locally available. The sizes of aggregates used are 12mm and 20mm.

5. Admixtures: The admixture conplast SP 430 was used in this project. Which confirms IS 4103:1999.

6. Water: Mixing and curing specimens was normal portable water.

### 2.3 Tests

1. In the present work involves conduct of tests, such as Slump flow test, T500 flow test, V-Funnel test, V-Funnel test, J-Ring test, L-Box test, U-Box test and Orimet test in fresh state.

2. Non-destructive tests

Two different non-destructive tests were conducted on self-compacting concrete cube specimens of size 150x150x150 mm were exposed to temperature 4000C, 6000C and 8000C after 28 days of curing and test were conducted before and after exposure to elevated exposure.

a. Rebound number (RN)

Rebound hammer test was conducted on a smooth surface in a horizontal position for cube specimens, which gives the rebound number RN which indirectly gives the compressive strength of concrete.

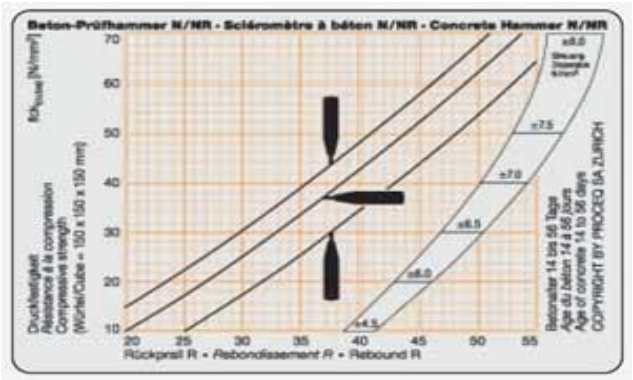


**Fig-1:** The chart gives the compressive strength by the rebound number

b. Ultrasonic pulse velocity test

The ultrasonic pulse device used to perform to obtain the ultrasonic pulse velocity (UPV). As per the IS 1311 (part 1): 1992 the quality of concrete will be assessed from the velocity obtained by the UPV test. Here in this study this test has been performed on the cube specimens before and after exposer to elevated temperature.

c. Destructive test

The compression test is performed on SCC before and after subjected to the temperature $400^0$, $600^0$ and $800^0$C for duration of one hour.

## 3. EXPERIMENTAL INVESTIGATION

### 3.1 Influence of steel fibers on weight

The weight loss obtained from the result is shown in table 1 for different percentage of steel fibers 0%, 0.5%, 1% and 1.5% in SCC. Chart -1 indicates the variation in weight loss before and after exposure for different percentage of steel fibers in SCC .The minimum loss occurred at 1% fiber content for $400^0$C and maximum at $800^0$C at 0.5% fiber content. The variation in weight loss is marginal compared with a concrete with 0% of steel fibers and for SCC with steel fibres for a given temperature.

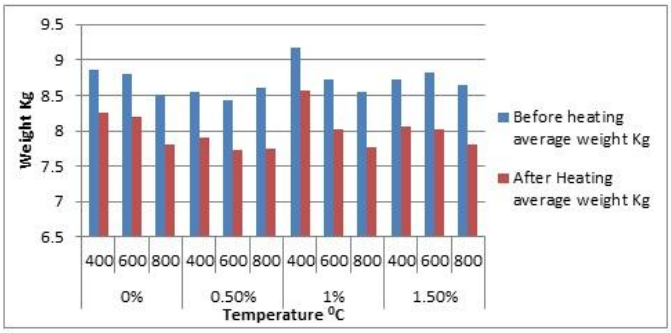


**Chart -1**: Weight v/s Temperature at 1hour duration before and after heating for steel fibers (0%, 0.5%, 1% and 1.5%)

### 3.2 Influence of steel fibers on Rebound number

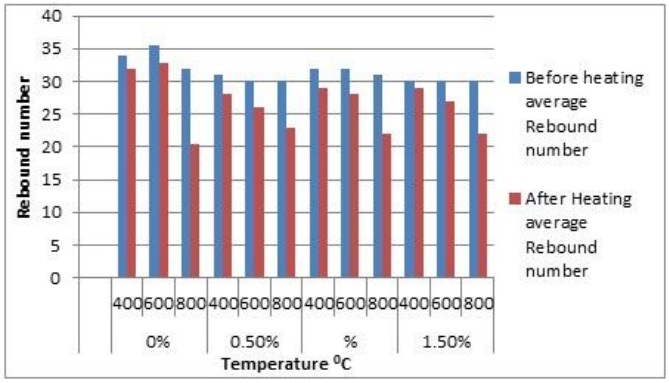


**Chart -2**: Rebound number v/s Temperature at 1hour duration before and after heating for steel fibers (0%, 0.5%, 1% and 1.5%)

Chart-2, which indicates the variations in RN before and after exposure to temperature. The reduction in RN after subjecting to the elevated temperature is being observed for the steel fiber reinforced self compacting concrete. The table 1, it is observed that for a given temperature of $400^0$C, and $800^0$C percentage variation in rebound number was less at 1.5% fiber content compared with normal SCC and SCC with other fiber contents. Indicating a better influence of fiber in compressive strength.

### 3.3 Influence of steel fibers on Ultrasonic pulse velocity

The chart-3 shows the variation of the pulse velocity for different percentage of steel fibers before and after heating with temperatures of self compacting concrete.

**Table -1**: The percentage variation in weight loss, rebound number, UPV and Compression strength for different percentage of steel fibers.

| Contents | Temperature for 1hour duration | Percentage Variation of weight | Percentage Variation of Rebound number | Percentage variation of Compressive strength by RN | Percentage Variation of UPV | Percentage Variation of Compressive strength |
|---|---|---|---|---|---|---|
| **Steel Fibers** | | | | | | |
| 0% | 400⁰C<br>600⁰C<br>800⁰C | -6.96<br>-7.02<br>-8.34 | -5.88<br>-7.64<br>-35.93 | -7.81<br>-14.28<br>-62.71 | -14.71<br>-24.90<br>-100 | 0<br>0<br>-72.48 |
| 0.5% | 400⁰C<br>600⁰C<br>800⁰C | -7.64<br>-8.42<br>-10 | -9.67<br>-13.33<br>-23.33 | -22.80<br>-26.92<br>-46.15 | -19.75<br>-33.74<br>-100 | -2.56<br>-17.67<br>-72.22 |
| 1% | 400⁰C<br>600⁰C<br>800⁰C | -6.48<br>-8.04<br>-9.23 | -9.37<br>-12.5<br>-29.03 | -18.64<br>-25.42<br>-54.38 | -27.20<br>-52.1<br>-68.87 | +10.87<br>+3.64<br>-54.42 |
| 1.5% | 400⁰C<br>600⁰C<br>800⁰C | -7.68<br>-8.94<br>-9.60 | -3.33<br>-10<br>-26.66 | -7.69<br>-19.23<br>-50 | -22.83<br>-55.93<br>-67.54 | +12.51<br>+6.16<br>-51.31 |

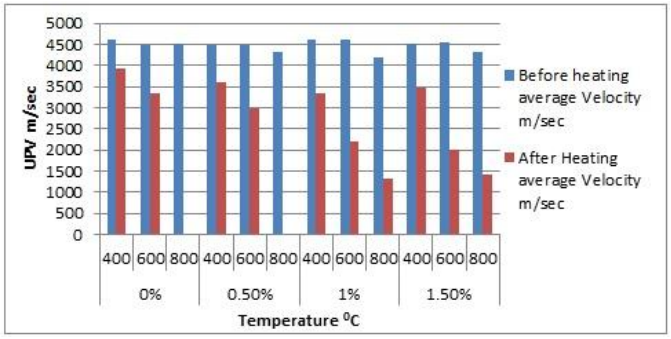


**Chart -3**: UPV v/s Temperature at 1hour duration before and after heating for steel fibers (0%, 0.5%, 1% and 1.5%)

The less reduction in UPV is observed in normal SCC compared to steel fiber reinforced self compacting concrete and is shown in chart-3. Compared to 600 and 800⁰C the less reduction in UPV was observed at 400⁰C for duration of one hour.

The decrease in UPV of SCC when subjected to elevated temperatures may due to the cracks formation.

### 3.4 Influence of steel fibers on compression strength

The steel fibers with different percentage in SCC, the variation in compressive strength before and after exposed to temperature is shown in chart-4.

The percentage loss of compressive strength was high in all percentage of steel fibers (0%, 0.5%, 1% and 1.5%) at 800⁰C for 1hour duration. The compressive strength was better in 1% and 1.5% of steel fibers at 400 and 600⁰C compared to normal SCC (0% of fibers).

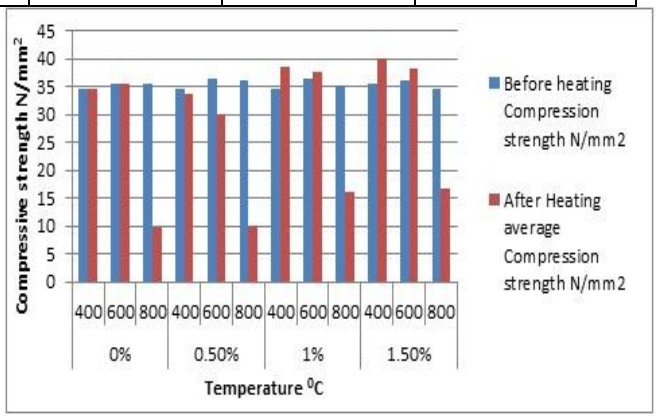


**Chart -4**: Compressive strength v/s Temperature at 1hour duration before and after heating for steel fibers (0%, 0.5%, 1% and 1.5%)

Non-destructive test show higher variation in compressive strength obtained by rebound number at higher temperature compared to destructive test and lower variations at lower temperature exposure of 400⁰C and 600⁰C.

## 4. CONCLUSIONS

1. Compressive strength was better in steel fibers of 1% and 1.5% compared to 0% of steel fibers.

2. The Ultrasonic pulse velocity was less at 400⁰C compared to the 600 and 800⁰C for 1hour duration. The small reduction in UPV was in normal SCC compared to steel fiber reinforced SCC.

3. The effect of weight loss for the steel fiber reinforced SCC has been found very less at 1% of fiber content at 400⁰C for 1hour duration. The variation in loss of weight is marginal compared with a self-compacting concrete with 0% of steel fibers.

4. The rebound number show higher reduction at higher elevation of 800⁰C, whereas show marginal reduction for 400⁰C and one hour when compared with normal SCC.

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