

# Effect of Elevated Temperatures on Fiber Reinforced Self Compacting Concrete



V. Mallikarjuna reddy, S. Vasanthi

**ABSTRACT:** *The present investigation is mainly focused on study the temperature effects on SCC reinforced with steel fibers on M40 grade of concrete. The main objective of the investigation is inspired from the real world - to know the strength of a concrete after subjected to an elevated temperature. Steel fibres with an aspect ratio of 40 varied at a fibre dosage of 0, 1, and 1.5% by the weight of the cement used in this investigation. In this study concrete is exposed to five different residual conditions. In addition to the room temperature there are four different temperatures of 100°C, 300°C, 500°C and 800°C are considered at a retention period of 1, 2, 3 and 4 hours in muffle furnace. Compressive strength conducted after 28 days of curing. From the experimental results it is observed that SCC with steel fibres reduced the workability on the contrary there is increase in compressive strength observed with the addition of fibres. It is also observed that SCC with steel fibres has shown the better performance compared to control mix at elevated temperatures. This is mainly due to fibres are participated in delaying the cracks.*

**Keywords:** *Self compacting concrete, Steel fibres, High Temperatures.*

## I. INTRODUCTION

The difficulties in concreting at congested reinforcement areas can be achieved by self-compacting concrete (SCC) due to SCC has an ability to flow under its own weight [1]. SCC usually considered as high performance concrete due to its properties like low yield stress, high deformability, good segregation resistance and moderate viscosity [2]. Shortcoming of SCC like poor resistance to crack growth and spalling tendency under fire conditions are limiting the usages in structures like buildings, bridges and tunneling etc., [3]. These shortcomings can be achieved by the addition of polypropylene (PP) fibres to the concrete. Because of low reinforcing efficiency PP fibres can arrest the crack growth and spalling effect of concrete subjected to elevated temperatures [4]. SCC reinforced with PP fibres improve the

properties of concrete but the improvement is limited in extent. Because of low young's modulus and low tensile strength these fibers can only effective in low stress levels only [5].

Concrete reinforced with steel fibers known to improve the crack resistance and energy absorption capacity at pre-peak and post-peak portions of concrete [6]. But the effect of steel fibers at elevated temperature to be studied. since the most of the studies are conducted on SCC reinforced with PP fibers [7]. Thus the study is aimed to investigate the mechanical properties of SCC reinforced with steel fibers. Steel fibers of length 20mm and diameter 0.5mm used in this study.

## II. EXPERIMENTAL PROGRAM

### 2.1 Materials used for SCC

#### 2.1.1 Cement:

Ordinary Portland cement of 53 grade conforming to IS 12269 [8] is used for the entire work. Cement having a Specific gravity, fineness and normal consistency are 3.15, 7% and 28% respectively. Initial and final setting time is 35min and 450min

#### 2.1.2 Fly ash:

Ultra-fine pozzolana which is called as P500 is used as a mineral admixture shown in figure 1. Specific gravity of P500 is 2.18, mean particle size is 3.9-5.0, surface area is 13000sqcm/kg.



Fig.1 Ultra-fine pozzolana (P500)

#### 2.1.3 Aggregates:

Locally available Crushed angular aggregate conforming to IS 383 [9] of maximum size 12mm used as coarse aggregate. Natural river sand is used as fine aggregate which is confining to zone-2.



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Properties of fine and coarse aggregates represented in Table.1

**Table.1 properties of aggregates**

Property	Fine aggregate	Coarse aggregate
Bulk Density(kg/m <sup>3</sup> )	1560	1502
Specific gravity	2.7	2.6
Surface water (%)	0.5	0.5
Water adsorption (%)	0.4	0.2

All the above tests are conducted as per IS: 2386(part-3)1963 [10].

### 2.1.4 Chemical admixture:

Glaniom B-233 is used as super plasticizer to develop SCC Mix. which is having specific gravity of 1.1, density is 1090kg/m<sup>3</sup>. It is a product of BASF Company. It is in light brown color. It is a mixture of VMA (viscosity modifying agent) and plasticizer. For all the mixes water binder ratio fixed as 0.3 and the super plasticizer is fixed as 1% by the weight of cementitious material is used.



**Fig.2 Superplasticizer**

### 2.1.5 Fibres:

Steel fibres of length 20mm with a diameter of 0.5mm used as a reinforcing material to arrest the growth of micro and macro cracks. The percentage of steel fibre is considered as 0, 1 and 1.5% by the weight of cement.

### 2.1.6 Water:

Portable water is used for mixing of concrete which is free from impurities and having P<sup>H</sup> should not be less than 6, it should be satisfy the requirements as per IS:456-2000 [11].

### 2.1.7 Mix design

The mix design for M40 grade is obtained by using nansu method of mix design. The final mix is used as conventional mix (without fibres). By adding fibres of 1% and 1.5% by weight of cementitious material to the conventional mix to develop mix1 and mix2. Mix proportions are presented in table 2.

**Table.2 Mix proportions for M40 grade per cubic meter**

s.no	Material	Control Mix	MIX 1	MIX 2
1	Cement(kg/m <sup>3</sup> )	350	350	350
2	P500 (kg/m <sup>3</sup> )	120	120	120
3	F.A (kg/m <sup>3</sup> )	920	920	920
4	C.A (kg/m <sup>3</sup> )	808	808	808
5	Steel fibres(kg/m <sup>3</sup> )	0	4.7	7.05

## III. EXPERIMENT METHODOLOGY

### 3.1 Workability:

There are three properties to be achieved for SCC i.e., filling ability, passing ability, flowing ability as per the guidelines of AFNOR specifications. Different tests are conducted to determine the workability they are slump flow, L-box, V-funnel tests. It is observed that The addition of steel fibres to fresh SCC will slightly reduce the flow ability or workability.

### 3.2 Casting and specimens used

The 100×100mm cubes were used for the compressive tests. The fibres were added gradually to attain a uniform distribution with a mix. For three mixes total 153 specimens are used. Samples were demoulded after 24hrs and stored in a curing tank for 28 days. Finally, concrete samples were stored at room temperature to maintain humidness and temperature conditions until they were submitted to a testing.

### 3.3 Thermal treatment

The samples were weighted before placing in the furnace. The samples with and without fibres are tested. In addition to room temperature there are four different temperatures were considered namely 100<sup>0</sup>c, 300<sup>0</sup>c, 500<sup>0</sup>c and 800<sup>0</sup>c along with various intervals i.e., 1hr, 2hrs, 3hrs and 4hrs are tested. The rate heating maintained as 200c/min is shown in figure.3.



**Fig.3 Muffle Furnace**

### 3.4 Results and discussion:

#### Mass loss

The samples were weighted before and after subjected to elevated temperatures. Weight loss is calculated at 100<sup>0</sup>c, 300<sup>0</sup>c, 500<sup>0</sup>c and 800<sup>0</sup>c respectively. The weight loss of concrete mix is shown in table.3 and figure.4.

**Table.3: Mass loss in % for Various durations at different Temperatures**

Mix	Duration	Mass loss in %			
		100	300	500	800
C.M	1 Hour	1.74	4.43	4.87	5.8
	2 Hour	2.84	1.98	4.67	6.11
	3 Hour	2.56	4.31	4.69	5.9
	4 Hour	0.4	0.04	4.85	5.58
Mix-1	1 Hour	1.18	3.68	3.31	4.73
	2 Hour	1.5	4.03	3.59	5.21
	3 Hour	2.02	3.91	3.79	5.46
	4 Hour	2.38	4.12	4.28	4.82
Mix-2	1 Hour	0.62	3.53	4.43	4.31
	2 Hour	0.62	4.25	4.5	4.57

	3 Hour	1.44	4.25	4.63	6.68
	4 Hour	1.59	3.6	4.43	3.42

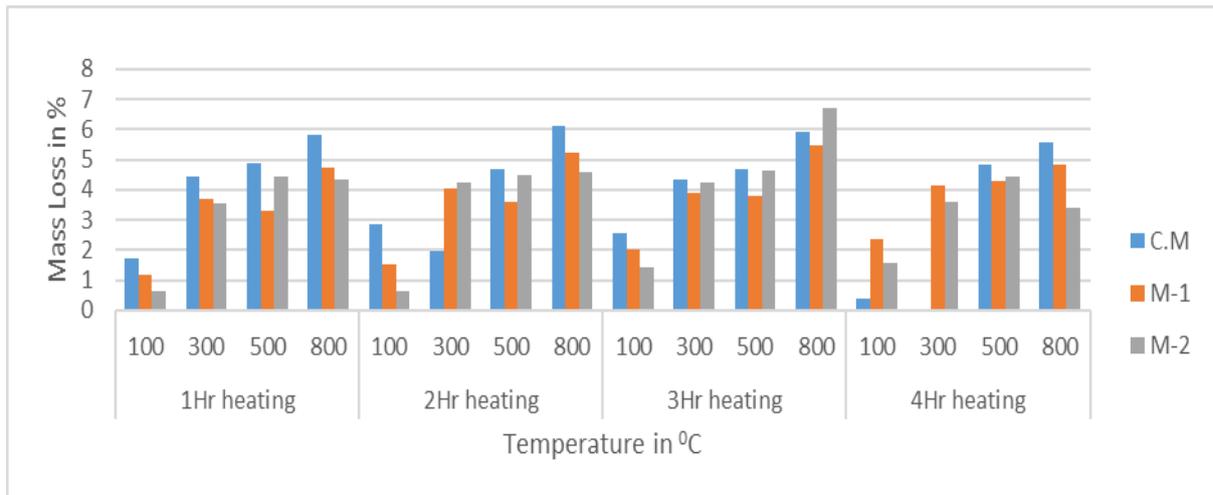


Fig.4 Mass loss in % for Various durations at different Temperatures

The experimental results show that mass loss in conventional mix is more than the other two mixes & mix-1 with 1% fibres having less variation in mass loss for varying high temperatures from 300<sup>0</sup>c and 800<sup>0</sup>c at any duration whereas mix-2 with 1.5% fibres having irregular variations.

**Strength loss**

For each mixture up to 300<sup>0</sup>c the strength loss of the specimen is decreasing. It is also observed that strength loss of a concrete mix is more when specimen is subjected elevated temperature greater than 300<sup>0</sup>c. If the exposure of the specimen is below 300<sup>0</sup>c then the preferable mixture is C.M and if it is exposed to more than 300<sup>0</sup>c the preferable mixture is M-2. Results are presented in figure 5 and table 4.

	2 Hour	3.97	7.94	0	82.54
	3 Hour	-3.97	-3.17	33.33	79.37
	4 Hour	-4.76	-11.11	0	76.19
Mix-1	1 Hour	7.69	-2.31	19.23	58.46
	2 Hour	3.85	4.62	11.54	63.08
	3 Hour	16.15	6.92	26.15	76.15
	4 Hour	-5.38	7.69	34.62	73.85
Mix-2	1 Hour	16.67	2.9	26.09	52.9
	2 Hour	21.01	-2.9	32.61	67.39
	3 Hour	25.36	-5.07	39.13	70.29
	4 Hour	8.7	-4.35	34.78	73.91

Table.4: Strength loss in % for Various durations at different Temperatures

Strength loss in %					
Mix	Duration	100	300	500	800
C.M	1 Hour	0.79	42.86	38.89	80.95

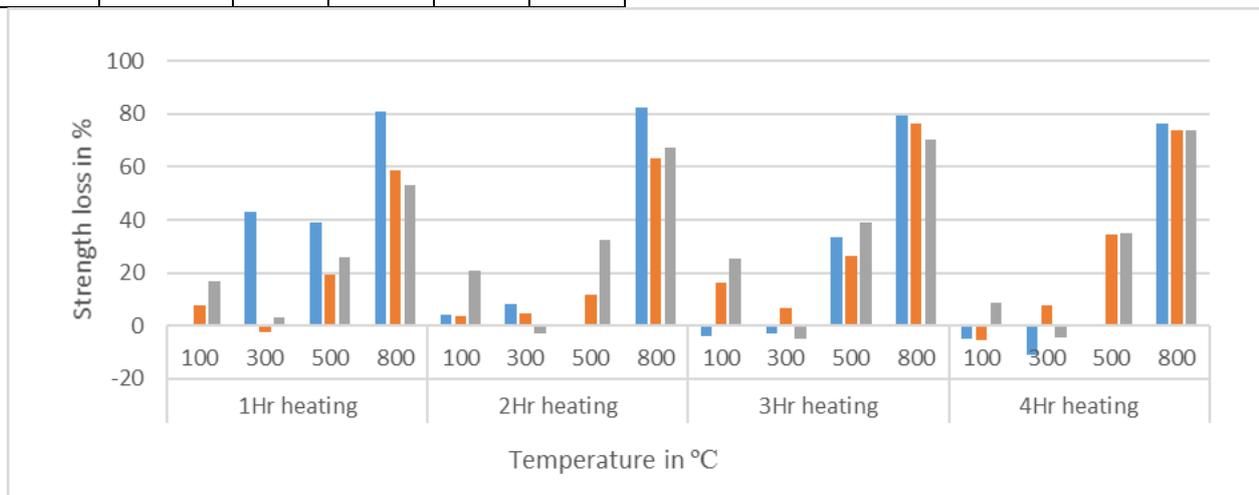


Fig.5 Strength loss in % for Various durations at different Temperature

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Up to 300<sup>0</sup>c Conventional Mix Strength is increasing with duration and further increasing in Temperature strength is decreasing drastically where as other two mixes losing their strengths gradually with increasing Temperature for each duration.

## IV. CONCLUSION

As per the study and the experiments conducted to know the compressive strength of fibre reinforced self-compacting concrete with respect to the elevated temperatures. The fibres are mixed at a rate of 0%,1%, and % with binder materials. Thus three mixtures are formed which are conventional mix, Mix-1 and Mix-2. When these three mixtures are exposed to elevated temperatures such as 100<sup>0</sup>c, 300<sup>0</sup>c, 500<sup>0</sup>c and 800<sup>0</sup>c at an interval of 1,2,3,4.

Upon the processing the same the conclusions regarding the weight loss and strength loss are- it is observed that the weight loss is relative with respect to the temperatures mentioned. Regarding compressive strength loss- strength loss is decreasing when the specimen is exposed to up to 300<sup>0</sup>C and increasing when the specimen is exposed to more than 300<sup>0</sup>C. And so the preferable mixtures would be varying with respect to the exposure.



**S. Vasanthi Reddy**, has completed engineering from VBIT college of Engineering, affiliated to JNTUH, Telangana in the batch of 2012-2016 with first class degree. Presently pursuing masters in Structural Engineering Gokaraju Rangaraju Institute of Engineering and Technology (Hyderabad) attentively interested to conduct a test on effect of elevated temperatures on fiber reinforced self compacting concrete.

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