

FLEXURAL STRENGTH OF SELF COMPACTING CONCRETE AT ELEVATED TEMPERATURE

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Abstract: Self Compacting Concrete (SCC) is high performance concrete which compacts on its own weight without any vibration. The normal concrete is weak in initial shrinkage where as introduction of Fibres to concrete decreases its initial shrinkage and also imparts strength to concrete later on stage. In this project a study has been done on the effect of Polypropylene Fibres on both the fresh and hardened properties of SCC like flexural strength when specimen expose to elevated temperature for the duration of (30⁰, 100⁰, 200⁰, 400⁰, 600⁰, 800⁰ 900⁰) 2 and 4 hours. The SCC is made with percentage of polypropylene fiber 0.2% to the total volume of concrete along with addition of super plasticizer 1.15% of the volume of cement for M20 and M30 grade of concrete. Results from these test shows that the flexural strength decreased with increasing temperature and addition of fibers reduces the spalling in concrete

Keywords: SCC, Polypropylene Fibres, Super plasticizer, Flexural Strength

1. Introduction

Self-compacting concrete, a concrete with high flow ability that can be placed and compacted under its own weight without any external vibration, allows complete filling of formworks along with the complete covering of the reinforcing bars in compact matrix structure. SCC has many advantages that include faster construction, better surface finishes, easier placing, reduction in noise levels and improved durability but it affects when exposed to fire and loses its strength. The efficiency of SCC can be increase by introducing of fibers like polypropylene fibers, steel fibers and glass fibers, further enhance their toughness, tensile strength, resistance to crack propagation thereby improving the durability properties. The effects of fibers were qualified based on the fiber volume, length, and its aspect ratio, other properties of fibers such as shape and surface roughness are also found to be important. Mounir M. Kamal et al.[1] developed

SCC with steel and polypropylene fibres and effect of these with compressive and flexural strength, the result shows that, the optimum dosage of steel and polypropylene fibres was 0.75% and 1.0% of the cement content, respectively. Sayeed ahmad et al [2] developed concrete with addition of various proportions of polypropylene fibres result shows there is notable increase in flexural, tensile, and shear strength was found.

Self-compacting mixes are designed to have fresh properties that have a higher degree of workability than convectional concrete. Workability is a way of describing the performance of concrete in the plastic state and for SCC, workability is often characterized by the following properties, 1. Filling ability: ability to fill formwork under its own weight, 2. Passing ability: ability to overcome obstacles like reinforcement and 3.Stability: homogeneous composition of concrete during and after placing concrete.

2. Experimental Details

2.1 Material Properties

The materials used in the manufacture of self compacting concrete are Cement, Fine aggregate, Coarse aggregate, Polypropylene fibres and Superplasticizer.

Fine aggregate: River sand confirming to IS: 2386-1963[3] is used. Results showed that the specific gravity 2.68, Fineness modulus 2.72, and a bulk density of 1715 Kg/m³.

Coarse aggregate: Crushed coarse aggregate of 12mm to 20mm down size is used which is confirming to IS: 2386-1963[3].Results showed that the specific gravity 2.72, Fineness modulus 5.4 and a bulk density of 1545 Kg/m³.

Polypropylene fibres: In figure 1, Polypropylene fibres obtained from Ms. Reliance Industries Ltd. which confirms to ASTM C 1116 type 3[4]. The fibres are triangular cross section of cut length 12mm having

effective diameter 25-40 microns and specific gravity in ranges of 0.90-0.91.



Figure 1. Polypropylene fiber

Super plasticizer: A new generation Conplast SP 430[5] is used as a Super plasticizer having relative density 1.08 ± 0.001 at 250°C , and $\text{pH} > 6$, which also ensures the rheoplastic properties of concrete in excess of 45 minutes at 250°C .

Water: Potable water is used.

Cement: ordinary Portland cement of 53 grade cement is used confirming to various specifications as per IS: 12269-1987[6]. Results showed that specific gravity 3.12 and Normal consistency 31%.

Table 1. Chemical composition of ordinary Portland cement

Chemical component	Percentage
SiO_2	28.7
Al_2O_3	13.5
CaO	53.6
MgO	2.21
Fe_2O_3	2.27
SO_3	2.9
Chloride content	0.07
Insoluble residue	4.1
Loss on ignition	2.05
Total alkalis	0.59

2.2 Mix Proportion:

Table 2. mix proportion were adopted during the execution, obtained by Nan Su method [7]

Material	Cement	Sand (fa)	Aggregate (ca)	Water
Kg/m^3	620	977	562	252
Ratio	1	1.57	0.9	0.40

2.3 Performance Analysis:

In order to study effect of sustained elevated temperature on the flexural strength, of self compacting concrete, a total number 72 specimens of SCC beams ($100\text{mm} \times 100\text{mm} \times 600\text{mm}$). Ingredients of the mix were taken as per the mix proportion, for SCC (M20 & M30 Grade) by Nan-Su method [7]. Concrete was filled in three layers. The top surface of the specimens was hand troweled. The moulds were stripped after 24 hrs. The specimens were cured by placing them in curing tank for 28 days. After curing, the specimens were taken out & dried for one day in shed. The specimens were kept in muffle furnace, at required temperature (30° , 200° , 400° , 600° , 800° , 900°) for the duration of 2 and 4 hours.

The SCC is made with percentage of polypropylene fiber 0.2% to the total volume of concrete along with addition of super plasticizer 1.15% of the volume of cement for M20 and M30 grade of concrete. After heating, the specimens were taken out and cooled by water quenching and air cooling regime, then tested for their flexural strength test.

3. Result and Discussion

Table 3. Flexural strength of concrete with 0.1% of polypropylene fiber for 2 hour duration

Sr. No	Temperature ($^{\circ}\text{C}$)	Type of cooling	Flexural strength	
			M20	M30
1	30°	Water	4.51	6.21
		Air	4.68	6.43
2	100°	Water	4.48	6.10
		Air	4.61	6.25
3	200°	Water	4.29	5.75
		Air	4.40	5.95
4	400°	Water	4.21	5.54
		Air	4.35	5.81
5	600°	Water	3.98	5.27
		Air	3.97	5.42
6	800°	Water	3.11	4.54
		Air	3.48	4.79
7	900°	Water	2.54	3.85
		Air	2.65	3.98

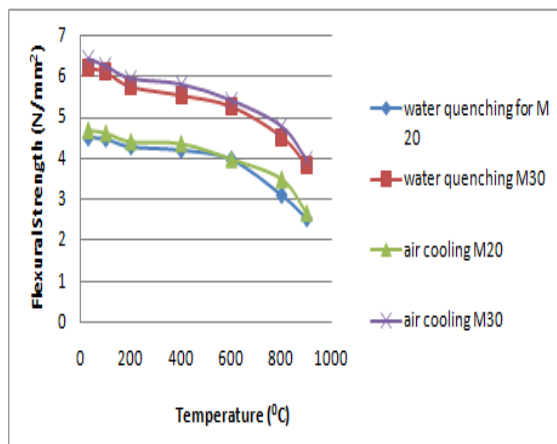


Figure 2. Flexural strength of concrete with 0.1% of polypropylene fiber for 2 hour duration

In figure 2, the reduction in flexural strength from room temperature 30°C to 400°C was 7% for water quenching and 6% for air cooling respectively but after that the strength get reduced 900°C upto 44% for water quenching and 43% for air cooling respectively.

Table 4. Flexural strength of concrete with 0.2% of polypropylene fiber for 2 hour duration

Sr No	Temperature (°C)	Type of cooling	Flexural strength	
			M20 Grade	M30 Grade
1	30 ⁰	Water	4.13	5.76
		Air	4.3	5.98
2	100 ⁰	Water	4.1	5.65
		Air	4.23	5.8
3	200 ⁰	Water	3.91	5.3
		Air	4.02	5.5
4	400 ⁰	Water	3.83	5.09
		Air	3.97	5.36
5	600 ⁰	Water	3.6	4.82
		Air	3.59	4.97
6	800 ⁰	Water	2.73	4.09
		Air	3.1	4.34
7	900 ⁰	Water	1.16	2.4
		Air	1.27	2.53

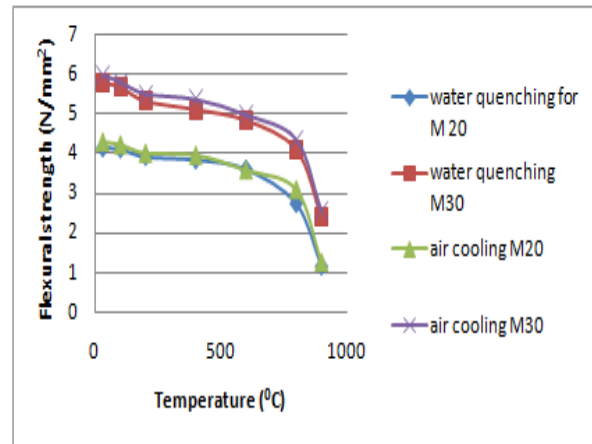


Figure 3. Flexural strength of concrete with 0.2% of polypropylene fiber for 2 hour duration

In figure 3, the reduction in flexural strength from room temperature 30°C to 400°C was 8% for water quenching and 6% for air cooling respectively but after that the strength get reduced 900°C upto 73% for water quenching and 70% for air cooling respectively. The addition of 0.2% of polypropylene fiber decreases the strength

Table 5. Flexural strength of concrete with 0.1% of polypropylene fiber for 4 hour duration

Sr.	Temperature (°C)	Type of cooling	Flexural strength	
			M20	M30
1	30 ⁰	Water	4.10	5.76
		Air	4.3	5.98
2	100 ⁰	Water	4.18	5.67
		Air	4.98	5.87
3	200 ⁰	Water	3.78	5.87
		Air	4.52	5.58
4	400 ⁰	Water	3.60	5.10
		Air	3.97	5.36
5	600 ⁰	Water	3.87	4.22
		Air	3.99	4.97
6	800 ⁰	Water	2.23	4.09
		Air	3.0	4.13
7	900 ⁰	Water	1.16	2.97
		Air	2.00	3.12

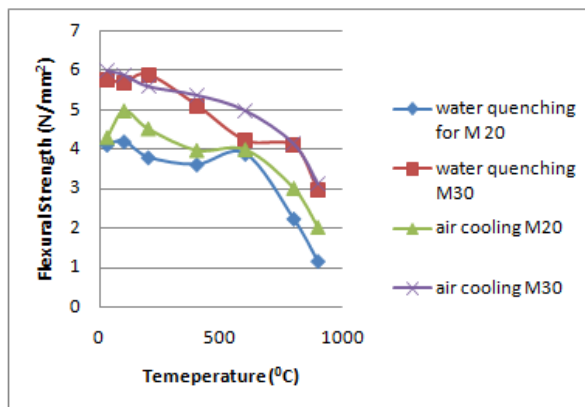


Figure 4. Flexural strength of concrete with 0.1% of polypropylene fiber for 4 hour duration

In figure 4, the reduction in flexural strength from room temperature 30°C to 400°C was 13% for water quenching and 8% for air cooling respectively but after that the strength get reduced upto 72% for water quenching and 52% for air cooling respectively. The proper percentage of polypropylene fiber reduced the spalling and increases the strength

Table 6. Flexural strength of concrete with 0.2% of polypropylene fiber for 4 hour duration

Sr.No No	Temperature ($^{\circ}\text{C}$)	Type of cooling	Flexural strength	
			M20	M30
1	30°	Water	4	5.44
		Air	4.16	5.76
2	100°	Water	3.83	4.98
		Air	3.96	5.53
3	200°	Water	3.82	4.9
		Air	3.92	5.4
4	400°	Water	2.83	4.56
		Air	3	5.09
5	600°	Water	1.77	3.69
		Air	2.2	4.14
6	800°	Water	0.83	3
		Air	1.07	3.13
7	900°	Water	0.16	2.26
		Air	0.72	2.53

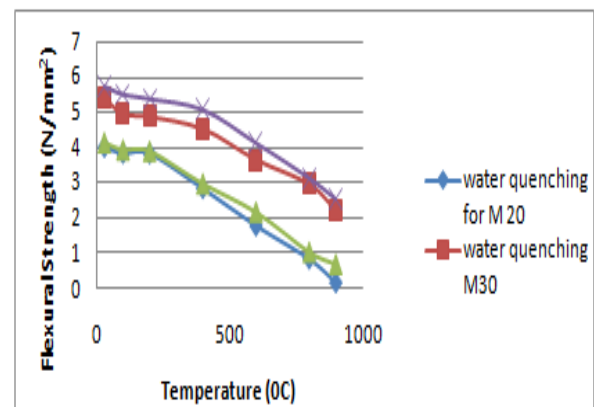


Figure 5. Flexural strength of concrete with 0.2% of polypropylene fiber for 4 hour duration

In figure 5, the reduction in flexural strength from room temperature 30°C to 400°C was 30% for water quenching and 26% for air cooling respectively but after that the strength get reduced up to 96% for water quenching and 83% for air cooling respectively.

4. Conclusion

Following conclusions can be drawn from the study work performed experimentally on M20 and M30 grade of SCC exposed to elevated temperature from 30°C to 900°C with polypropylene fibers.

1. The reduction in flexural strength from room temperature 30°C to 400°C was 13% for water quenching and 8% for air cooling respectively but after that the strength get reduced up to 72% for water quenching and 52% for air cooling respectively. The proper percentage of polypropylene fiber reduced the spalling and increases the strength
2. Addition of fibers to self-compacting concrete improves compressive strength of the mix. It provides channels for moisture movement within the concrete, thus increasing permeability and reducing the risk of spalling.
3. Flexural strength decreases after 400°C temperature

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