Behavior of steel reinforced ternary blended concrete subjected to elevated temperature

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ABSTRACT

Concrete is one of the most widely used constriction material in world. Strength of the concrete depends upon the physical properties of the concrete materials and mix design of concrete. Ternary blended concrete mix consisting of three different three cementitious materials. In this study along with cement I used fly ash and micro silica as secondary and ternary materials. The partial replacement of weight of cement at various percentages ranging between 5%-15% with steel fibers having aspect ratio of 50. In this research steel fibers are added at 0.0%, 0.5%, 1.0%, 1.5% of steel fibers as total fibers percentages. The workability is measured for its consistency using slump cone test compaction factor method.

The main aim of the present study is to find the compressive, split tensile and flexural strength of ternary blended concrete subjected to elevated temperature of 200^{0}C, 300^{O}C, 500^{O}C the comparison made for 7, 14 and 28 days curing of the cube, cylinder and prism specimens for finding the optimal value of strength.

Key words: Concrete, fly ash, micro silica, workability, compressive strength, split tensile strength, flexural strength.

1. INTRODUCTION

Concrete is the mixing of cementitious material, coarse aggregates, and fine aggregates and with addition of this materials suitable quantity of water is one of most important material. Ternary concrete mixtures include three different cementitious materials. This report addresses those combinations of Portland cement, slag cement, and a third cementitious material. The mixing of these three cementitious materials in concrete mix is generally known as ternary blended concrete. For this study the cement is used as primary material, fly ash is used as secondary material, micro silica is used as the ternary material the mixing of this constituent materials with proper mix design will make as ternary blended concrete.

Strength of concrete can be find out with the help of compressive test, tensile test and flexural strength test. The strength of the concrete can be increased by using the steel fibers with suitable percentages of addition of steel fibers for the specified grade of concrete. With the use of steel fibers the cracks in concrete reduces. The strength may increases or decreases with increasing the percentages of steel fibers. In the present experimental study I was used steel fibers of 0%, 0.5%, 1%, 1.5%, and 2% of steel fibers with temperature of 200^{0}C, 300^{O}C, 500^{O}C in ternary blended concrete.

2. Methodology

In this present experimental study workability, strength of concrete can be done for ternary blended concrete. Casting of cubes, cylinders and prism specimens were done to check the compressive strength, split tensile strength, flexural strength and durability of ternary blended concrete with the help of elevated temperatures of 200^0C, 300^OC, 500^OC.

Collection of materials

The project materials like cement, fly ash, micro silica, fine aggregates, coarse aggregates were collected from various locations depending upon the availability. After collecting the materials we need to determine the material properties for calculating the trial mixes.

Batching: In batching process, concrete mix ingredients are processed either by mass or by volume and and then added to the mixture. Usually batching is considered by volume but now mass mix is regarded as more accurate and also is preferred for accurate mixes. Batching when done correctly affects workability by reducing the bleeding and segregation in the mix. It also provides a smooth surface of the concrete. It helps in speedy construction and decreases the wastage of material. Hence, batching is considered as an essential step while preparing concrete mix.

Mixing of concrete: Measured quantities of coarse aggregate, fine aggregate and cement were spread out over an impervious concrete floor. Fly ash aggregates were added randomly while mixing the concrete. The mixture was rolled over and over until uniformity of color was achieved the time of mixing was between 10 15 minutes.

Casting of the specimens

Specimens casting process is done in order to find the compressive strength, split tensile strength and flexural strength of concrete for cube specimens we need calculate the compressive strength, for cylindrical specimens and beam specimens were casted for flexural strength under different elevated temperatures.

Placing and compacting: The mould sections were coated with oil and a thin coating of oil was applied between the contact surfaces of the bottom of the moulds and the base plate to create a water tight boundary. Then the concrete is filled in the moulds layer wise by proper compaction. And finally the moulds were leveled once they fully filled the slurry paste was applied to remove any voids

Workability of concrete

Workability of the concrete was determined by using slump cone test and compaction factor test with different percentages of steel fibers under different elevated temperatures.

Curing: The specimens namely cubes, prisms and cylinders were stored on the platform such that it was away from any vibrations, and at a temperature of 27 ± 2c and at 90% of relative humidity in moist air for 24 hours ± ½ hour from the time of mixing of water to the dry constituents. Then the concrete cubes, prisms and cylinders are removed from moulds and placed for curing for 7 , 14 , and 28 days.

3. RESULTS AND ANALYSIS

Slump cone test: In this test we measure the behavior of a inverted cone that is compacted concrete under self weight due to gravity. The slump test was done with increasing the percentage of steel fibers from 0% to 2% taking an interval of 0.5% for 200 degrees elevated temperature, 300 degrees elevated temperature and 500 degrees elevated temperature. The results were tabulated and a bar chart was plotted.

S. No	% Steel fibers	Slump in mm for 200 degrees elevated temperature	Slump in mm for 300 degrees elevated temperature	Slump in mm for 500 degrees elevated temperature
1	0%	75	70	60
2	0.50%	65	60	50
3	1.00%	65	60	50
4	1.50%	50	50	40
5	2.00%	25	25	25

Table 1: Slump test of concrete

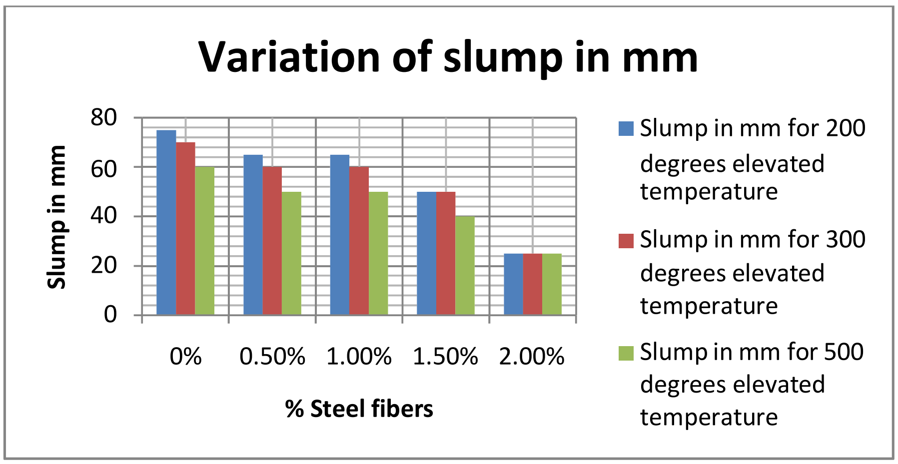
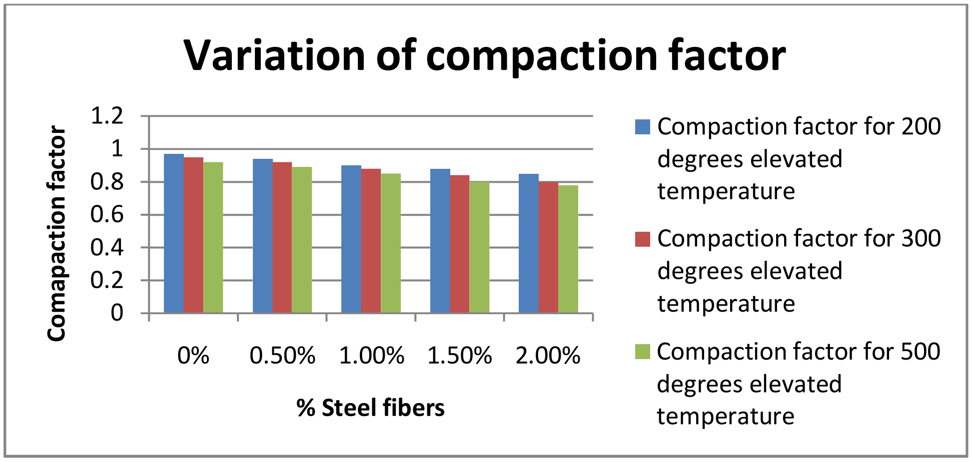


Fig 1: Slump test of concrete

Compaction factor test: It is the ratio of weight of a partially compacted concrete mix to fully compacted concrete mix. The test was conducted with increasing the percentage of steel fibers from 0% to 2% taking an interval of 0.5% for 200 degrees elevated temperature, 300 degrees elevated temperature and 500 degrees elevated temperature. The results were tabulated and a bar chart was plotted.

S. No	% Steel fibers	Compaction factor for 200 degrees elevated temperature	Compaction factor for 300 degrees elevated temperature	Compaction factor for 500 degrees elevated temperature
1	0%	0.97	0.95	0.92
2	0.50%	0.94	0.92	0.89
3	1.00%	0.9	0.88	0.85
4	1.50%	0.88	0.84	0.8
5	2.00%	0.85	0.8	0.78

Table 2: compaction test of concrete



Tests on Strength of concrete:

Compressive strength: In this test the cubes were casted of dimensions 150mm× $150mm \times 150mm$ and checked for compressive strength at intervals of 7, 14 and 28 days. Cubes were casted with increasing the percentage of steel fibers from 0% to 2% taking an interval of 0.5% for 200 degrees elevated temperature, 300 degrees elevated temperature and 500 degrees elevated temperature. The results were tabulated and also in the form of bar chart separately for intervals of 7, 14 and 28 days.

S. No	% Steel fibers	7 days compressive strength for 200 degrees elevated temperature	7 days compressive strength for 300 degrees elevated temperature	7 days compressive strength for 500 degrees elevated temperature
1	0%	19.5	19.72	19.88
2	0.50%	20.06	20.14	20.68
3	1.00%	20.44	21.04	21.72
4	1.50%	21.04	20.84	21.48
5	2.00%	20.98	20.42	20.98

Table 3: 7 days compressive strength

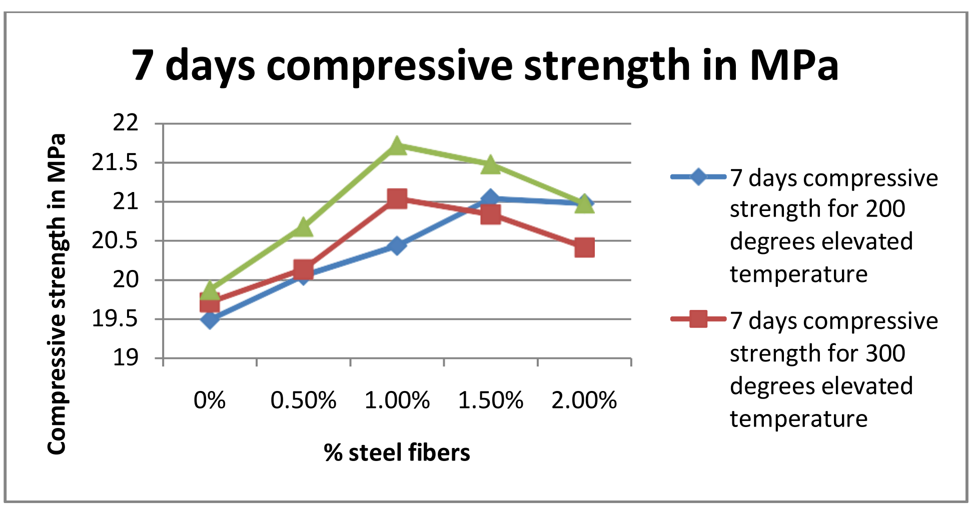
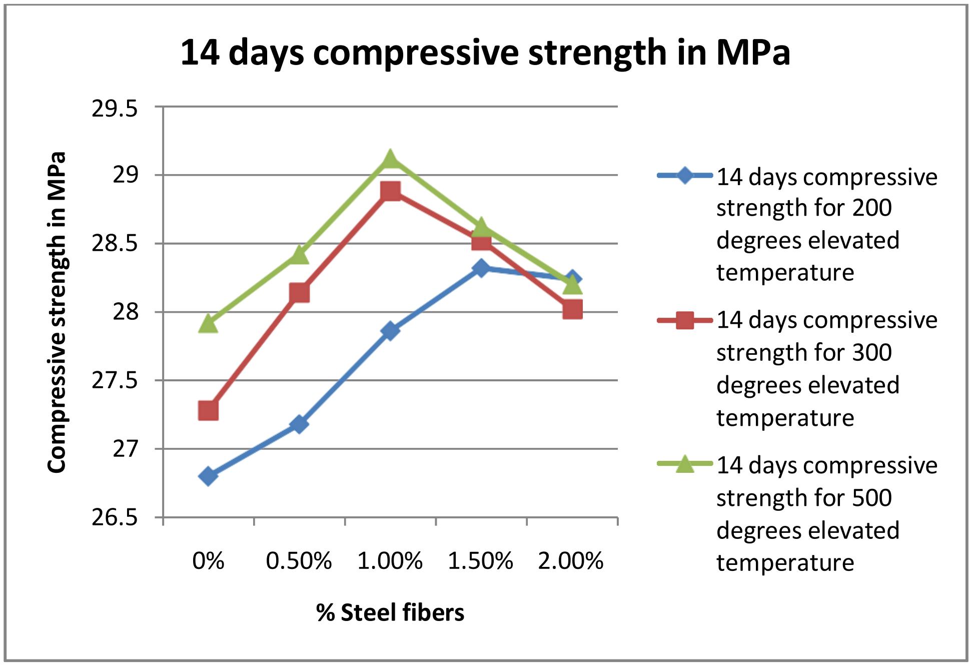


Fig 3: 7 days compressive strength

S. No	% Steel fibers	14 days compressive strength for 200 degrees elevated temperature	14 days compressive strength for 300 degrees elevated temperature	14 days compressive strength for 500 degrees elevated temperature
1	0%	26.8	27.28	27.92
2	0.50%	27.18	28.14	28.42
3	1.00%	27.86	28.88	29.12
4	1.50%	28.32	28.52	28.62
5	2.00%	28.24	28.02	28.2

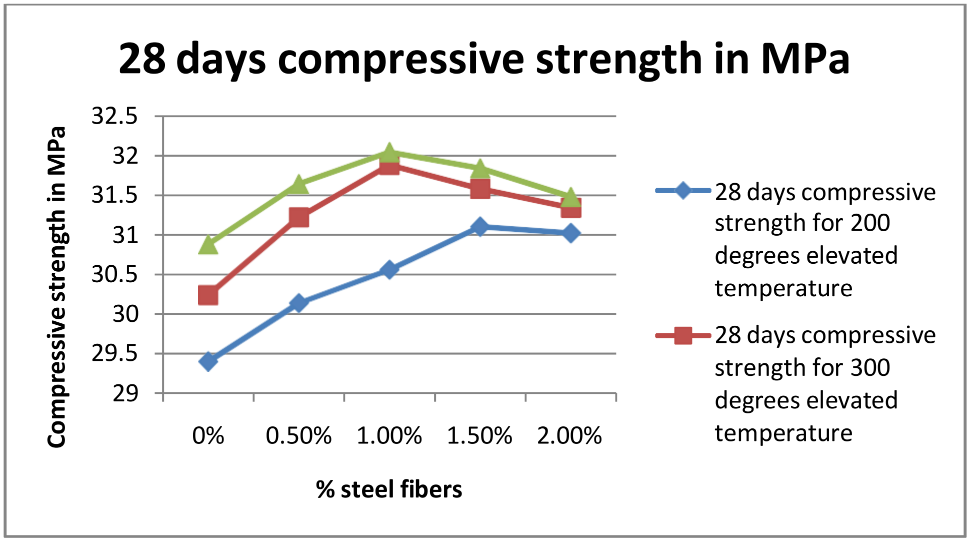
14 days compressive strength



14 days compressive strength

S. No	% Steel fibers	28 days compressive strength for 200 degrees elevated temperature	28 days compressive strength for 300 degrees elevated temperature	28 days compressive strength for 500 degrees elevated temperature
1	0%	29.4	30.24	30.88
2	0.50%	30.14	31.22	31.64
3	1.00%	30.56	31.88	32.04
4	1.50%	31.1	31.58	31.84
5	2.00%	31.02	31.34	31.48

28 days compressive strength

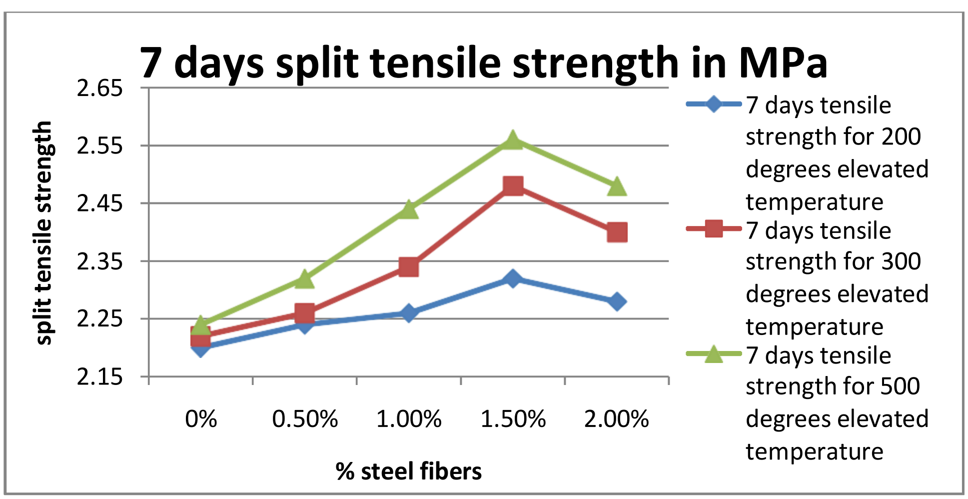


28 days compressive strength

Spilt tensile strength: The concretes compatibility to withstand the pulling force (Tensile Stress) without breaking is called the Tensile Strength of concrete. Its unit is (N/Sqmm or Mpa). The split tensile strength is calculated as loading condition such that the load is applied on top and bottom of the cylinder on its lateral surface, to the area equal to the lateral surface area of the cylinder. The split tensile strength = ($2P/\pi dl$) N/mm2. The split test was done on cylinders with dimensions 300mm height and 150mm diameter.

S. No	% Steel fibers	7 days tensile strength for 200 degrees elevated temperature	7 days tensile strength for 300 degrees elevated temperature	7 days tensile strength for 500 degrees elevated temperature
1	0%	2.2	2.22	2.24
2	0.50%	2.24	2.26	2.32
3	1.00%	2.26	2.34	2.44
4	1.50%	2.32	2.48	2.56
5	2.00%	2.28	2.4	2.48

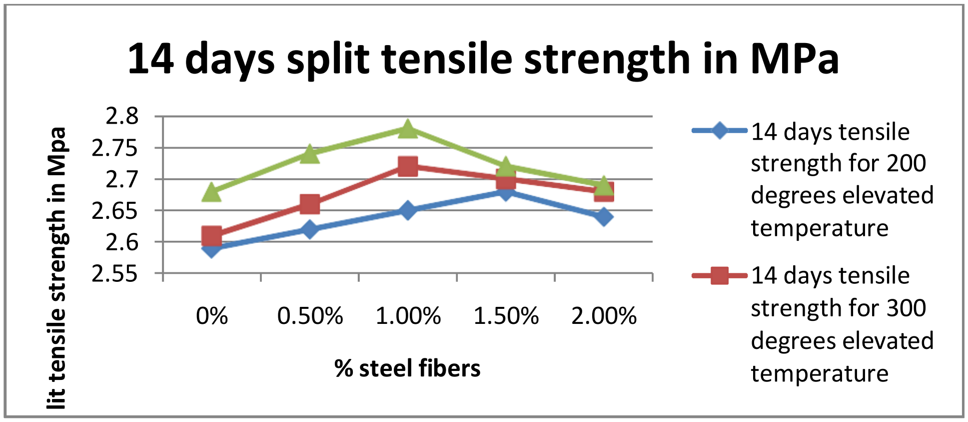
7 days split tensile strength



7 days split tensile strength

S. No	% Steel fibers	14 days tensile strength for 200 degrees elevated temperature	14 days tensile strength for 300 degrees elevated temperature	14 days tensile strength for 500 degrees elevated temperature
1	0%	2.59	2.61	2.68
2	0.50%	2.62	2.66	2.74
3	1.00%	2.65	2.72	2.78
4	1.50%	2.68	2.7	2.72
5	2.00%	2.64	2.68	2.69

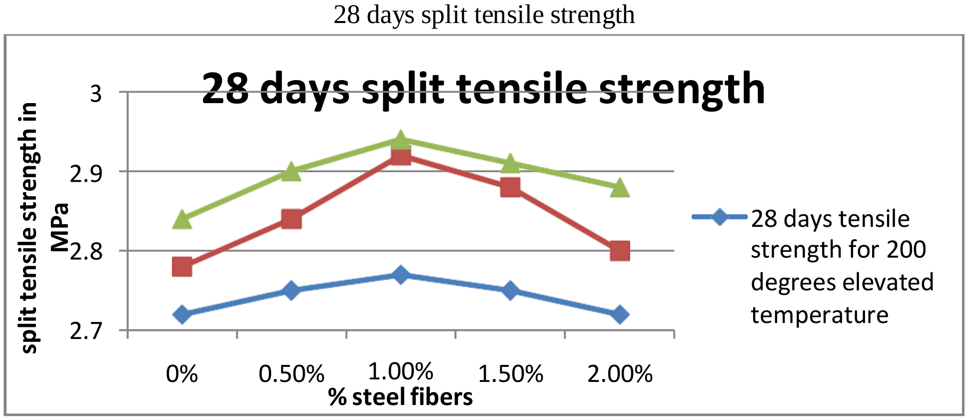
14 days split tensile strength



14 days split tensile strength

S. No	% Steel fibers	28 days tensile strength for 200 degrees elevated temperature	28 days tensile strength for 300 degrees elevated temperature	28 days tensile strength for 500 degrees elevated temperature
1	0%	2.72	2.78	2.84
2	0.50%	2.75	2.84	2.9
3	1.00%	2.77	2.92	2.94
4	1.50%	2.75	2.88	2.91
5	2.00%	2.72	2.8	2.88

28 days split tensile strength

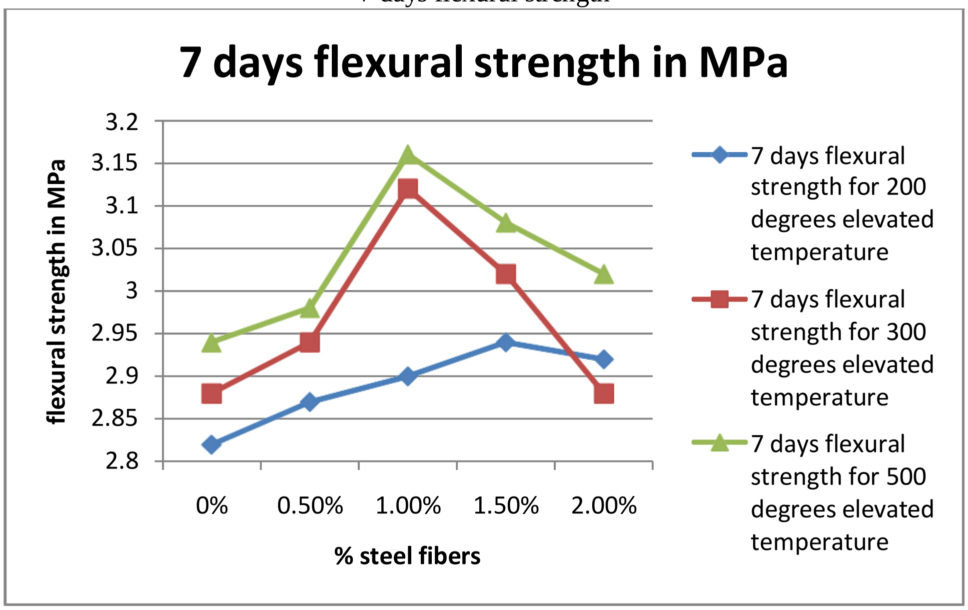


28 days split tensile strength

Flexural strength of concrete

S. No	% Steel fibers	7 days flexural strength for 200 degrees elevated temperature	7 days flexural strength for 300 degrees elevated temperature	7 days flexural strength for 500 degrees elevated temperature
1	0%	2.82	2.88	2.94
2	0.50%	2.87	2.94	2.98
3	1.00%	2.9	3.12	3.16
4	1.50%	2.94	3.02	3.08
5	2.00%	2.92	2.88	3.02

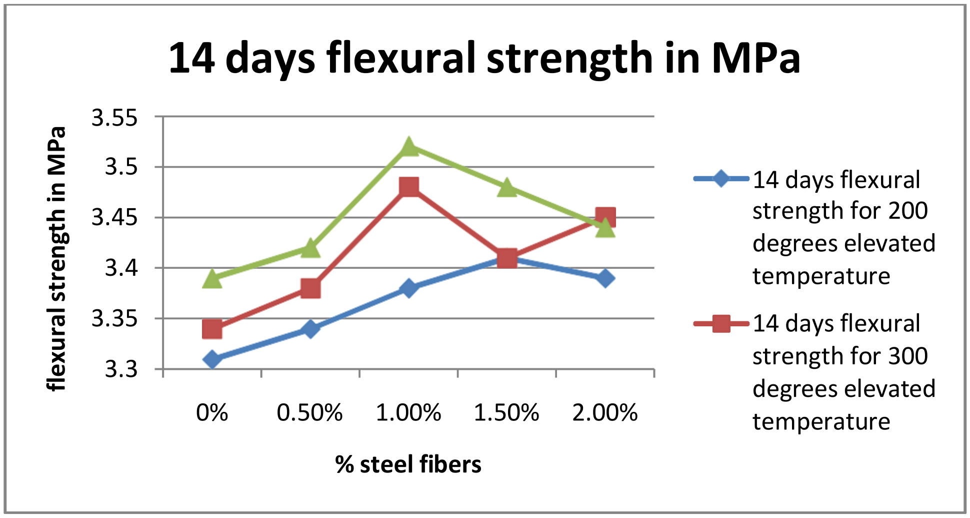
7 days flexural strength



7 days flexural strength

S. No	% Steel fibers	14 days flexural strength for 200 degrees elevated temperature	14 days flexural strength for 300 degrees elevated temperature	14 days flexural strength for 500 degrees elevated temperature
1	0%	3.31	3.34	3.39
2	0.50%	3.34	3.38	3.42
3	1.00%	3.38	3.48	3.52
4	1.50%	3.41	3.41	3.48
5	2.00%	3.39	3.45	3.44

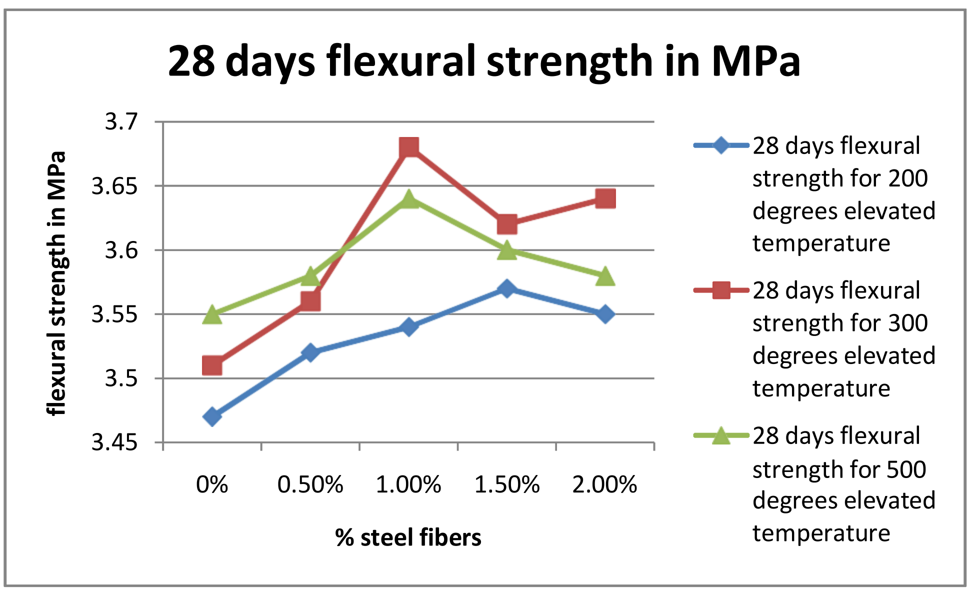
14 days flexural strength



14 days flexural strength

S. No	% Steel fibers	28 days flexural strength for 200 degrees elevated temperature	28 days flexural strength for 300 degrees elevated temperature	28 days flexural strength for 500 degrees elevated temperature
1	0%	3.47	3.51	3.55
2	0.50%	3.52	3.56	3.58
3	1.00%	3.54	3.68	3.64
4	1.50%	3.57	3.62	3.6
5	2.00%	3.55	3.64	3.58

28 days flexural strength



28 days flexural strength

4. CONCLUSIONS

The Following Conclusions are drawn from the Experimental Investigation in present study

1. An effective and efficient triple blended concrete mix can be prepared with the addition of condensed fly ash and micro silica to OPC.
2. This triple blended mix is not only cost effective also it renders the concrete to achieve several beneficial properties.
3. The value of slump cone and compaction factor test decreases with increasing the percentage of fibers.
4. The optimal value of compressive strength was observed for 7days, 14 days and 28 days at 1% steel fibers for 300^{O}C, 500^{O}C and 1.5% fibers for 200^{o}C.
5. The optimal value of split tensile strength was observed at 1% steel fibers for 300^{O}C, 500^{O}C and 1.5% fibers for 200^{o}C for 7days, 14days and 28 days curing.
6. The optimal value of flexural strength was observed at 1% steel fibers for 300^{O}C, 500^{O}C and 1.5% fibers for 200^{o}C for 7days, 14days and 28 days curing.

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