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Comparitive Study of Steel fiber and Glass fiber Reinforced Concrete by Using Manufactured Sand (M-sand) as Fine Aggregate

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Abstract : In this paper fiber reinforced concrete is a two-phase material consisting of a matrix which is reinforced with randomly oriented small diameter fibers to improve the mechanical properties of the matrix. It increases the tensile strength of the concrete. Two types of fibers have been used in this paper i.e steel fiber and glass fiber. Steel fiber reinforced concrete is a homogeneous distribution of randomly oriented discontinuous and discrete steel fibers. It is available in the forms of Carbon steel or stainless steel. It has a high tensile and compressive strength. The Glass fibers are formed by drawing the molten material rapidly from a melted batch in a crucible or furnace. Glass fibers do not have a negative effect on the well-known high compressive strength of concrete. Thus, it shows that the fiber reinforced concrete is in good workable condition rather than without super plasticizer. The addition of 2% steel fiber and 0.5% - 1% of glass fiber in concrete is found to be optimum as well as effective and economical as it gives good compression, tensile, and flexural strength for the concrete.

Keywords: Glass fiber, Steel fiber, concrete strengthening, compressive strength.

I. INTRODUCTION

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water, with or without admixtures. Concrete is an ancient material of construction, which is first used during Roman Empire. Concrete is the second most consumed substance in the world after water. Concrete is the only major building material that can be delivered to the job site in a plastic state. This unique quality makes concrete desirable as a building material because it can be moulded to virtually any form or shape. Concrete is also designed to permit reliable and high quality fast-track construction. Structures built with concrete are more durable and can be engineered to withstand earthquakes, hurricanes, typhoons and tornadoes. Concrete is an incredibly useful and flexible building material without which modern architecture and construction would not be possible. Composed of cement, sand and coarser aggregates, concrete can easily be poured into forms and moulds to create any number of shapes, yet quickly hardens to become a durable stone-like material. It is used in buildings, foundations, bridges, footings, roads and in many other applications. . Concrete can continue to harden and gain strength over many years. Concrete is one of the most important materials among the building materials in all types of civil engineering works. Since the adaptation of concrete as a building material, lot of researches and studies has been made to improve the quality, strength and durability of it. There is a rapidly increasing concern that we can no longer continue to ignore the pollution problems on the one hand and the unrestricted depletion of natural resources on the other hand. A satisfactory solution is essential because, if unresolved, environmental pollution and depletion of natural resources present a clear threat to our standard of living, and more importantly, to the entire fabric of life support systems on which the planet earth is dependent. This answers the question of why the issue of sustainable development has great importance.

1.1. FIBER REINFORCED CONCRETE (FRC)

Fiber reinforced concrete is a two-phase material consisting of a matrix which is reinforced with randomly oriented small diameter fibers to improve the mechanical properties of the matrix. Durability of a material is defined as the service life of a material under given environmental conditions. The above definition holds good for all concrete and cementitious composites. Fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. Fibers have always been considered as promising as reinforcement of cement based matrices because of their availability and low consumption of energy. Short discrete vegetable fibers namely sisal, coir and jute have been examined for their suitability for incorporation in cement concrete. It increases the tensile strength of the concrete. It reduces the air voids and water voids the inherent porosity of gel. It increases the durability of the concrete. Therefore, the orientation and volume of fibers have a significant influence on the creep performance of rebar’s or tendons.

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II. STEEL FIBER AND GLASS FIBER REINFORCED CONCRETE (GFRC)

2.1 STEEL FIBER REINFORCED CONCRETE : Steel Fiber have been used in concrete since the early 1900s. Steel fiber reinforced concrete is a homogeneous distribution of randomly oriented discontinuous and discrete steel fibers. Steel fiber reinforced concrete is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages. Steel fiber-reinforced concrete is basically a cheaper and easier to use form of rebar reinforced concrete. It is available in the forms of Carbon steel or stainless steel. Its having length of 6.4 to 76 mm. The Diameter of fibre ranging between 0.25 to 0.75 mm. It has Tensile strength around 275-2757 Mpa. Its having an Ultimate Elongation of 0.5-35% and Modulus of elasticity of 200Gpa. Steel fiber-reinforced concrete uses thin steel wires mixed in with the cement. This imparts the concrete with greater structural strength, reduces cracking and helps protect against extreme cold. Steel fiber is often used in conjunction with rebar or one of the other fiber types.

2.2 GLASS FIBER REINFORCED CONCRETE (GFRC): The Glass fibres are formed by drawing the molten material rapidly from a melted batch in a crucible or furnace. They are manufactured as continuous filaments and are chopped to form short fibers. The thickness of Glass Fibre ranges from 0.005mm to 0.75mm& length ranges from 150mm to 6mm.The Glass fibre has a tensile strength over three times stronger than Steel fibre. GFRC is a composite material made up of Cement, Fine silica, Alkali resistant (AR) glass Fibre, Chemical Admixtures and Water. GFRC can be moulded to any shape, size or form colour and texture. Resistance to weather, corrosion, fire, abrasion, seismic shocks and termites. It is high density with low porosity. The strength of GFRC is determined by Glass content, Fiber size, Fiber compaction & distribution as well as degree of Cure.
The main advantage of GFRC is light Weight along with High Strength. Greater Durability as it is Corrosion Resistant and thermal and Sound insulation. Glass fibers do not have a negative effect on the well-known high compressive strength of concrete. GFRC products reduce loadings on buildings leading to significant savings in superstructure and foundations.

III. METHODOLOGY

The methodology explains about the step by step procedure that is going to be done in the project. The methodology is explained in the following flow chart:

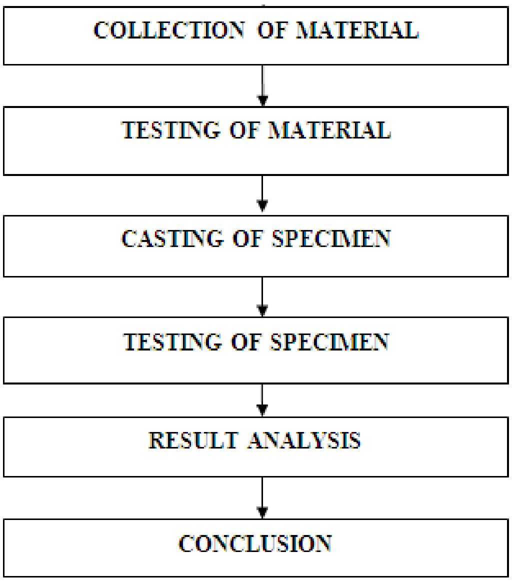

Figure 3.1: Flow Chart of Methodology

3.1 MATERIALS USED FOR THE STUDY

It is well known that strength of concrete is dependent on the properties of its ingredients. The materials used in present investigation are as follows: Portland Pozzolana Cement (PPC), M20 grade Concrete, Manufactured sand (4.75mm passing), Coarse Aggregate (20mm down size), different fibres and Water.

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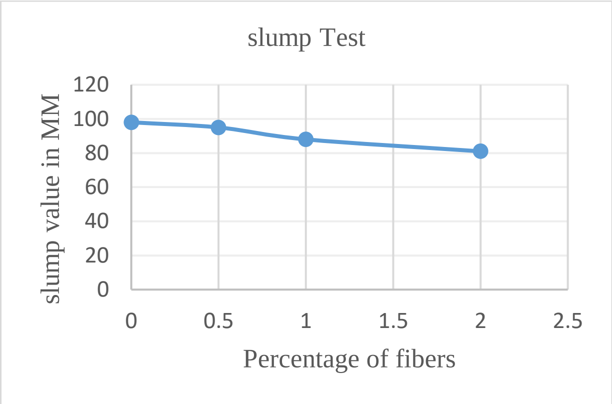
IV. RESULTS AND DISCUSSION

4.1 Slump Test Results

Graph 4.1 Slump Value for 0.5%, 1%, 2% of steel and glass Fiber Addition

Water cement ratio	% of Fiber	Slump (mm)
0.5	0	98
0.5	0.5	95
0.5	1.0	89
0.5	2.0	82

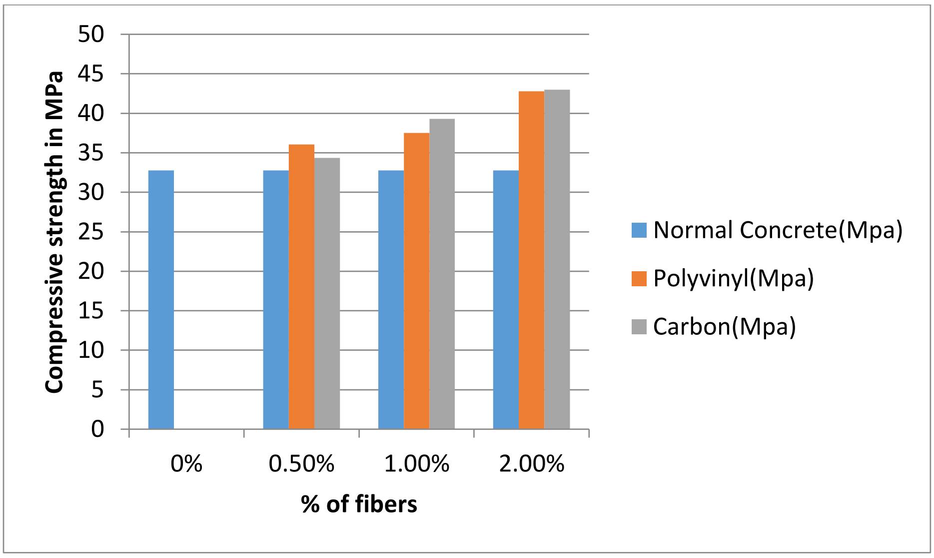


4.2 COMPRESSIVE STRENGTH , SPLIT TENSILE STRENGTH AND FLEXURAL STRENGTH :

The tabulations and graphical representation of the different specimens are as shown below.

Table 4.2.1: Comparison of Compressive Strength on normal concrete and different % of fibers (Steel and Glass) at room temperature:

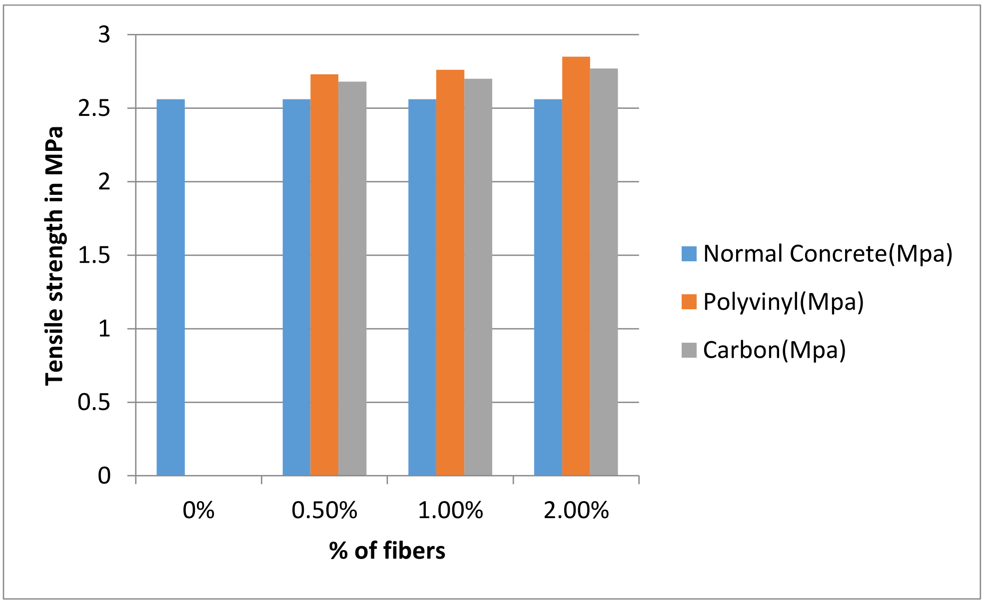
% Of Fibers	Normal Concrete (Mpa)	Steel (Mpa)	Glass (Mpa)
0%	32.76	0	0
0.50%	32.76	36.95	33.98
1.00%	32.76	37.41	35.87
2.00%	32.76	43.81	41.87



Graph 4.2.1: Comparison of Compressive Strength on normal concrete and different % of fibers (Steel and Glass)

Table 4.2.2: Comparison of Split tensile Strength on normal concrete and different % of fibers(Steel and Glass) at room temperature:

% of Fibers	Normal Concrete (Mpa)	Steel (Mpa)	Glass (Mpa)
0%	2.56	0	0
0.50%	2.56	4.13	4.98
1.00%	2.56	4.21	5.01
2.00%	2.56	4.85	5.17



Graph 4.2.2: Comparison of Split tensile Strength on normal concrete and different % of fibers(Steel and Glass):

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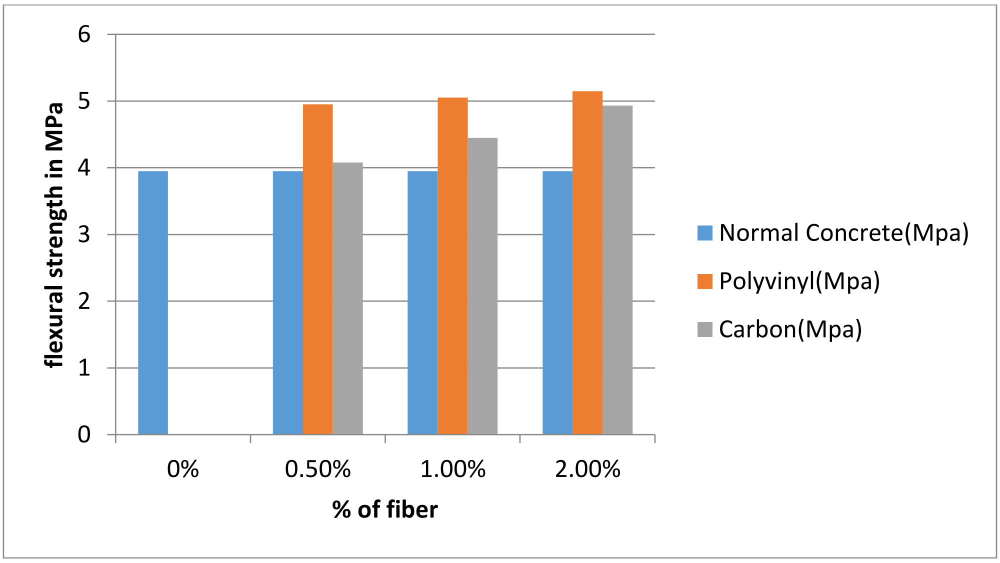
Table 4.2.3: Comparison of Flexural Strength on normal concrete and different % of fibers (Steel and Glass) at room temperature:

% Of Fibers	Normal Concrete(Mpa)	Steel(Mpa)	Glass(Mpa)
0%	3.95	0	0
0.50%	3.95	4.98	4.38
1.00%	3.95	5.07	4.58
2.00%	3.95	5.25	4.97



Graph 4.2.3: Comparison of Flexural Strength on normal concrete and different % of fibers (Steel and Glass):

Table 4.2.4: Comparison of Compressive Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Temperature ^{0}C	compressive strength (Mpa) for 0.5% fiber		
	Normal concrete	Steel	Glass
27	32.76	36.95	33.98
100	32.1	35.93	33.81
200	31.78	34.73	33.07
300	31.23	33.38	32.79
400	29.85	32.55	32.1
500	26.56	31.89	31.65

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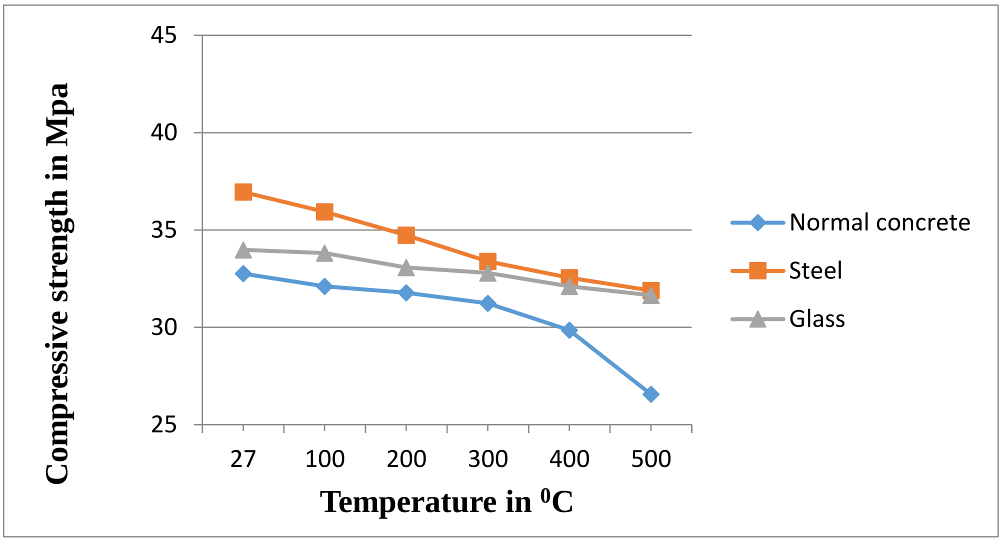
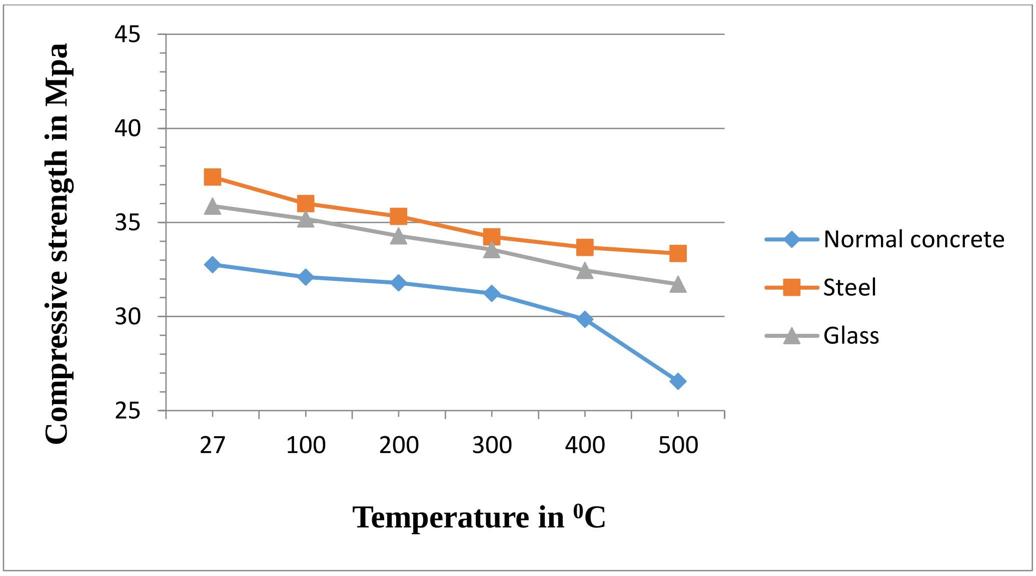


Graph 4.2.4: Comparison of Compressive Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Table 4.2.5: Comparison of Compressive Strength of normal concrete and different fibers for 1.0% (Steel and Glass)

Temperature ⁰C	compressive strength (Mpa) for 1.0% fiber		
	Normal concrete	Steel	Glass
27	32.76	37.41	35.87
100	32.1	36.01	35.18
200	31.78	35.32	34.29
300	31.23	34.23	33.55
400	29.85	33.68	32.45
500	26.56	33.35	31.72



Graph 4.2.5: Comparison of Compressive Strength of normal concrete and different fibers for 1%(Steel and Glass)

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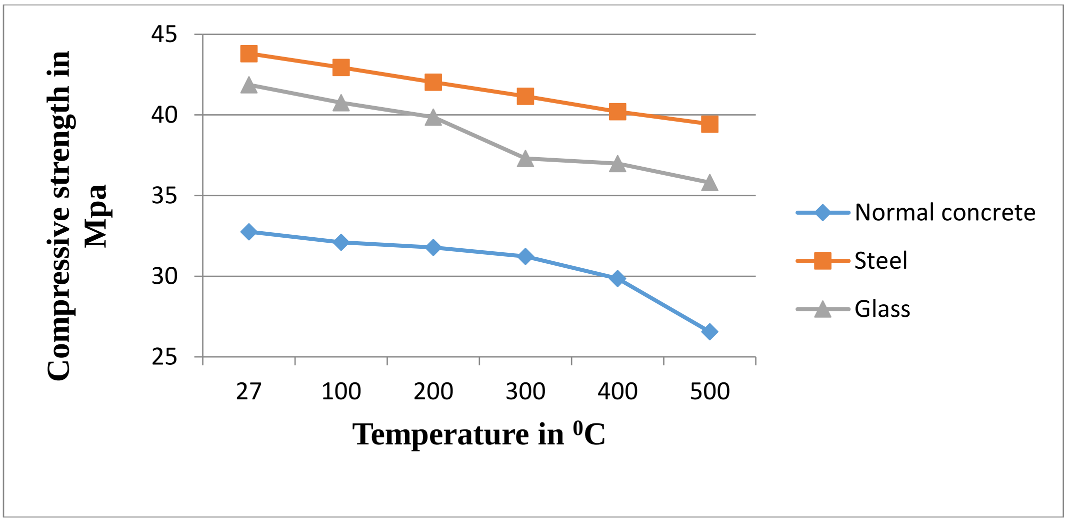
Table 4.2.6: Comparison of Compressive Strength of normal concrete and different fibers for 2% (Steel and Glass)

Temperature ^{0}C	compressive strength(Mpa) for 2.0% fiber		
	Normal concrete	Steel	Glass
27	32.76	43.81	41.87
100	32.1	42.95	40.77
200	31.78	42.03	39.86
300	31.23	41.15	37.31
400	29.85	40.21	36.99
500	26.56	39.44	35.81



Graph 4.2.6: Comparison of Compressive Strength of normal concrete and different fibers for 2% (Steel and Glass)

Table 4.2.7: Comparison of Split Tensile Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Temperature ^{0}C	Split tensile strength (Mpa) for 0.5% fiber		
	Normal concrete	Steel	Glass
27	2.56	4.13	4.98
100	2.24	4.03	4.61
200	2.19	3.93	4.46
300	2.15	3.54	4.25
400	2.11	3.45	4.11
500	1.95	2.92	3.74

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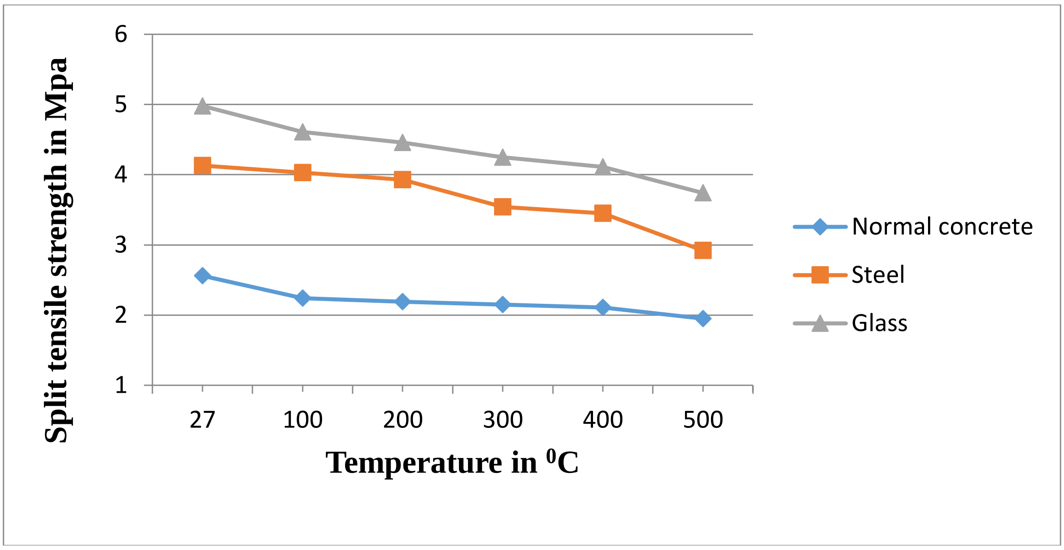
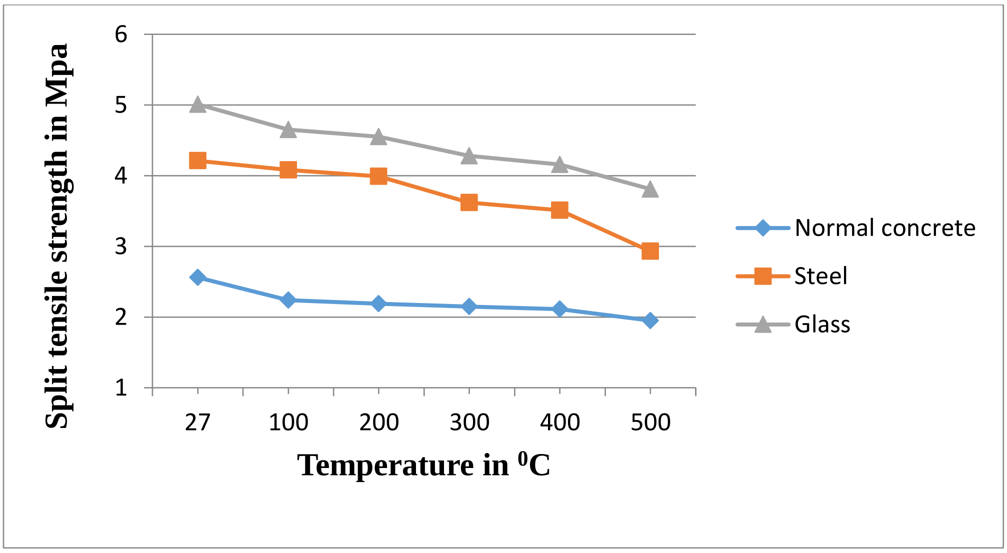


Graph 4.2.7: Comparison of Split Tensile Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Table 4.2.8: Comparison of Split Tensile Strength of normal concrete and different fibers for 1% (Steel and Glass)

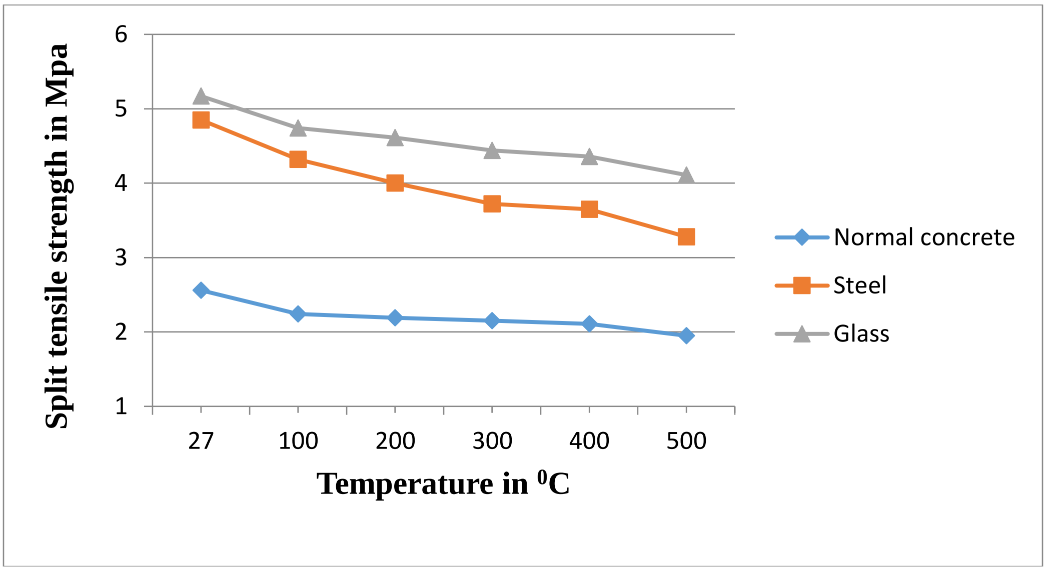
Temperature ^{0}C	Split tensile strength (Mpa) for 1.0% fiber		
	Normal concrete	Steel	Glass
27	2.56	4.21	5.01
100	2.24	4.08	4.65
200	2.19	3.99	4.55
300	2.15	3.62	4.28
400	2.11	3.51	4.16
500	1.95	2.93	3.81



Graph 4.2.8: Comparison of Split Tensile Strength of normal concrete and different fibers for 1% (Steel and Glass)

Table 4.2.9: Comparison of Split Tensile Strength of normal concrete and different fibers for 2% (Steel and Glass)

Temperature ^{0}C	Split tensile strength (Mpa) for 2.0% fiber		
	Normal concrete	Steel	Glass
27	2.56	4.85	5.17
100	2.24	4.32	4.74
200	2.19	4	4.61
300	2.15	3.72	4.44
400	2.11	3.65	4.36
500	1.95	3.28	4.11



Graph 4.2.9: Comparison of Split Tensile Strength of normal concrete and different fibers for 2% (Steel and Glass)

Table 4.2.10: Comparison of Flexural Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Temperature ^{0}C	Flexural strength (Mpa) for 0.5% fiber		
	Normal concrete	Steel	Glass
27	3.95	4.98	4.38
100	3.9	4.75	4.12
200	3.84	4.57	3.98
300	3.71	4.41	3.92
400	3.61	4.23	3.85
500	3.52	4.02	3.77

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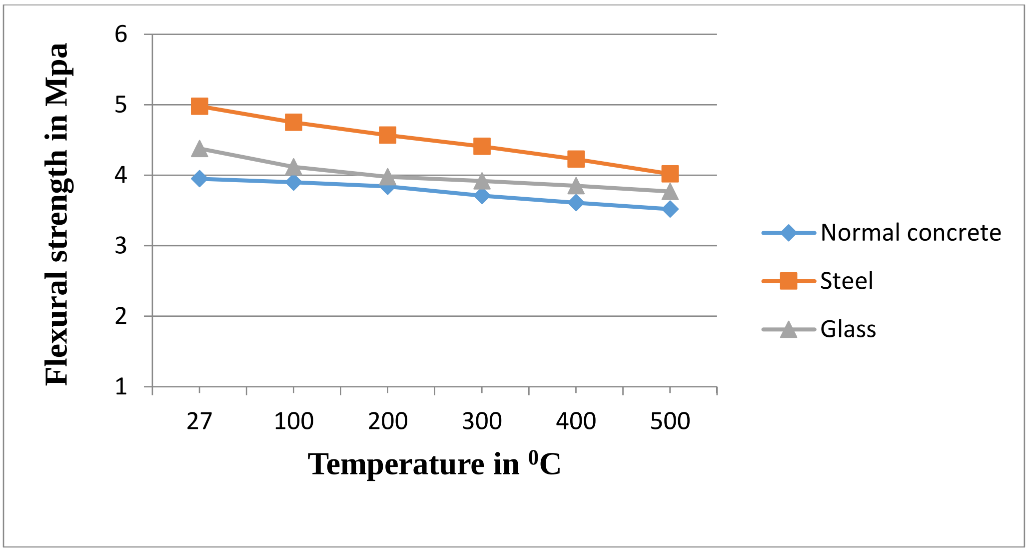
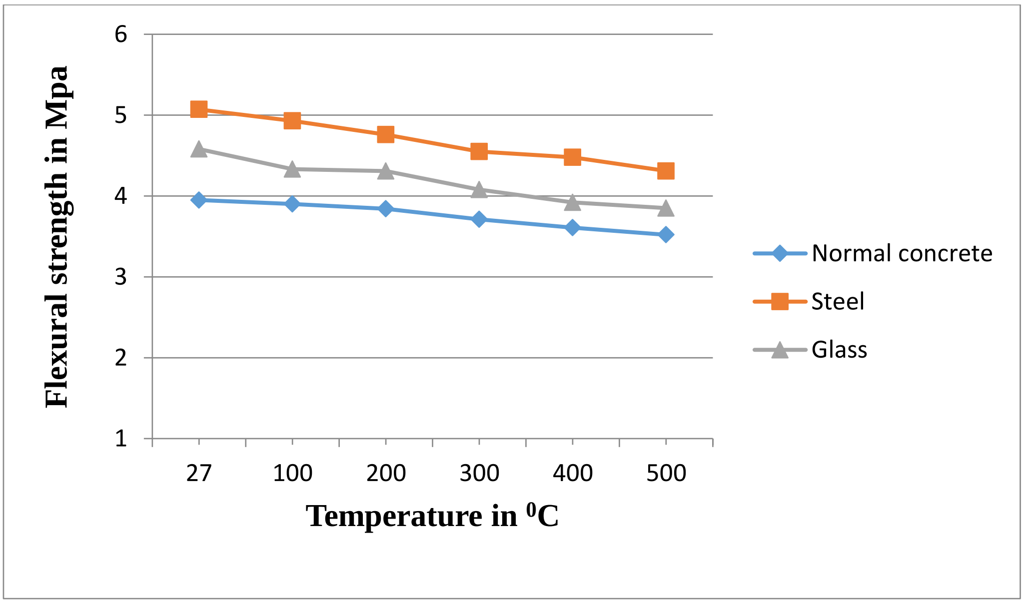


Graph 4.2.10: Comparison of Flexural Strength of normal concrete and different fibers for 0.5% (Steel and Glass)

Table 4.2.11: Comparison of Flexural Strength of normal concrete and different fibers for 1% (Steel and Glass)

Temperature ^0C	Flexural strength (Mpa) for 1.0% fiber		
	Normal concrete	Steel	Glass
27	3.95	5.07	4.58
100	3.9	4.93	4.33
200	3.84	4.76	4.31
300	3.71	4.55	4.08
400	3.61	4.48	3.92
500	3.52	4.31	3.85



Graph 4.2.11: Comparison of Flexural Strength of normal concrete and different fibers for 1% (Steel and Glass)

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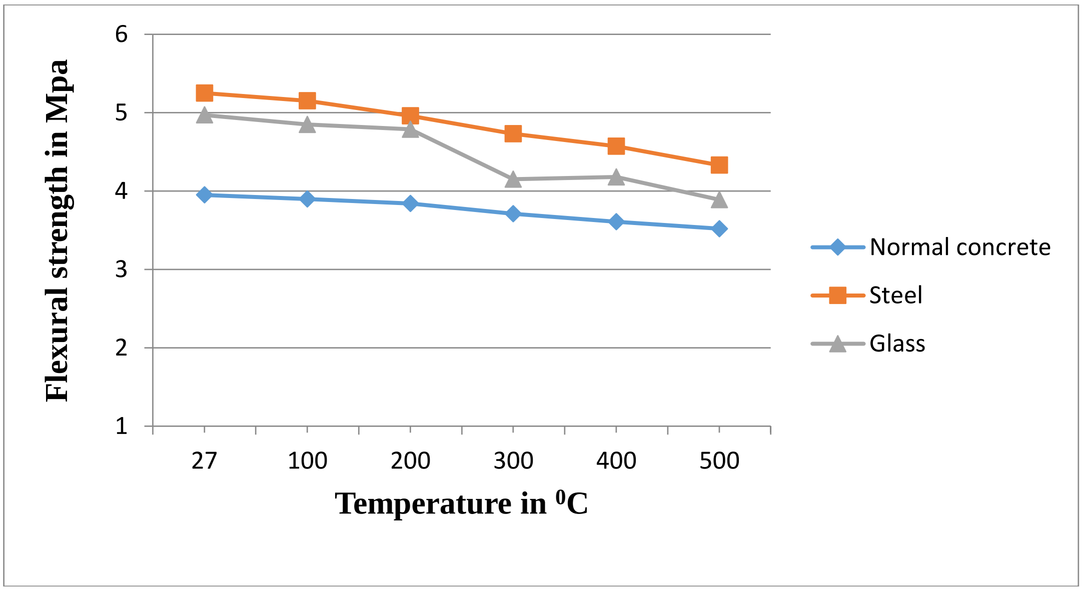
Table 4.2.12: Comparison of Flexural Strength of normal concrete and different fibers for 2% (Steel and Glass)

Temperature ^{0}C	Flexural strength (Mpa) for 2.0% fiber		
	Normal concrete	Steel	Glass
27	3.95	5.25	4.97
100	3.9	5.15	4.85
200	3.84	4.96	4.79
300	3.71	4.73	4.15
400	3.61	4.57	4.18
500	3.52	4.33	3.89



Graph 4.2.12: Comparison of Flexural Strength of normal concrete and different fibers for 2% (Steel and Glass)

V. CONCLUSION

From the present experimental investigation the following conclusion can be drawn.

- It shows that the fiber reinforced concrete is in good workable condition rather than without super plasticizer.
- Later, with increase in amount of steel and glass fibers, the slump value decreased.
- It was observed that the addition of fibers slightly increases the compressive strength of concrete than conventional one and the maximum compressive strength of concrete when 2% of steel and glass fibers added the maximum compressive strength obtained is 39.44 MPa and 35.81 MPa respectively.
- The addition of steel fiber will increase the tensile strength of concrete. The maximum strength of concrete when 2% of steel fibers the maximum tensile strength obtained is 3.28 MPa. Toughness of concrete also increases by the addition of fiber.
- The addition of glass fiber will increase the tensile strength of concrete. The strength of concrete when 0.5%, 1% and 2% of glass fibers added the tensile strength obtained are 3.74 MPa, 3.81 MPa and 4.11 MPa respectively at 500^{0}C.

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- As the percentage of steel fiber is increased by more than 2%, there will be increase in mechanical properties is observed.
- When the percentage of glass fiber is added between 0.5%-1.0% there will be increase in mechanical properties, but it was observed that reduction in mechanical properties when fiber content exceeds more than 1%.
- Addition of fibers not only increases tensile strength but also increases bond strength, decreases permeability. Also, it reduces the creep and shrinkage cracks developed in concrete.
- The brittleness of concrete could be improved with addition of steel fibers and not so much with glass fiber.
- Lastly, the addition of 2% steel fiber and 1% of glass fiber in concrete is found to be optimum as well as effective and economical as it gives good compression, tensile, and flexural strength for the concrete

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