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Comparitive Study of Carbon fiber and PVA fiber Reinforced Concrete at Elevated Temperatures

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Abstract : In this paper Carbon fiber is composed of carbon atoms bonded together to form a long chain. The fibers are extremely stiff, strong, and light, and are used in many processes to create excellent building materials. Carbon fiber material comes in a variety of "raw" building-blocks, including yarns, uni-directional, weaves, braids, and several others, which are in turn used to create composite parts. The properties of a carbon fiber part are close to that of steel and the weight is close to that of plastic. Thus, the strength to weight of a carbon fiber part is much higher than either steel or plastic (Polyvinyl alcohol) (PVA) is well known as a synthetic biodegradable polymer and possesses excellent mechanical properties. PVA “displays strong interaction with carbon nanotubes” (CNTs), resulting in exceptional properties that are not found in another polymer

Keywords: Carbon fiber, Polyvinyl alcohol, concrete strengthening, compressive strength, comparative study.

I. INTRODUCTION

Concrete is a very strong and versatile moldable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. 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. By the same time efforts are also being made to economize concrete construction compared to other materials. Plain concrete is good in compression but weak in tensile strength with very limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to propagation of such micro cracks, eventually leading to brittle fracture of concrete.

II. CARBON AND POLYVINYL FIBRE

2.1 CARBON FIBRE: It is type of concrete that is reinforced with carbon fibers is known as carbon reinforced concrete. It is new highly stress able light weight composite construction that combines special fine grain ultrahigh strength concrete and carbon fibers. It has higher strength then steel with quarter of its weight. For construction carbon fibers are mostly used for repair purposes of old structural element against shear and flexure failure. Carbon fibers are fiber about 5-10 micrometers in diameter and composed mostly of carbon atoms. Carbon fiber have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in a, civil engineering, military and motorsports along with other competition sports. However, they are relatively expensive when compared with similar fiber, such as glass fibers or plastic fiber.

2.2 POLYVINYL ALCOHOL FIBRE: Polyvinyl Alcohol (PVA) are high performance reinforcement fiber for concrete and mortar. These are monofilament fibers that are available in 3 different deniers (diameter of the fiber- 7,15, and 100. The ¼” (PVA15), and ½” (PVA100). Due to the fine nature of these fibers, and the fact that they disperse into monofilament fibers, they are less likely to be visible in finished surface. How visible they are in relation to each other is in direct proportion to their various diameter (7 is least visible, 100 is most visible). Equally true, the small the fiber, the more fibers there are for any given unit of measure, the more likely they are to choke mixes at higher dosage rates. This is why the PVA100 are dosed at higher rates in the more flow able mixes than are the PVA15. At the first, PVA fiber has high tenacity and modulus of elasticity compare with other general organic fiber. Second, bonding strength

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between fiber and cement matrix is strong. Also it is possible to control bonding strength by surface treatment. At lastly, good durability has been proved by long terms field cement slate.

III. METHODOLOGY

3. The various ingredients that are used for the mix design, viz., cement, fine aggregates and coarse aggregates were tested for, before using them for the same. The tests conducted are such that they indicate changes in properties such as compressive strength, split tensile and flexural strength. The residual properties were measured in terms of compressive strength, spilt tensile and flexural strength.

The specimens that were casted varied in terms of percentage fiber reinforcement in which three numbers of each Normal concrete, concrete with carbon fibers with 0.5%, 1%, 2% and concrete with PVA fibers with 0.5%, 1% and 2% resulting in 21 number of cubes, 21 number of beams, 21 number of cylinders in total.

IV. RESULTS AND DISCUSSION

4.1 PHYSICAL OBSERVATION: The physical observation made on Polyvinyl &Carbon concrete specimens regarding the propagation of cracks and spalling after loading the specimens to maximum loading are reported below.

4.1.1: Spalling: Spalling was observed in all the specimens which were subjected to different loadings. This is because of the formation of the micro cracks which is seen on the specimens.

4.1.2: Cracks: The appearance of cracks can be attributed to the contraction of mortar due to water evaporation.

3.1 MATERIALS USED FOR THE STUDY

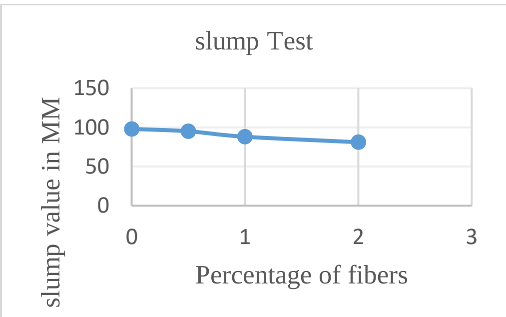
It is well known that strength of concrete is dependent on the properties of its ingredients. The materials used in present investigation are as follows: Portland Pozzolana Cement (PPC), M20 grade Concrete, Manufactured sand (4.75mm passing), Coarse Aggregate (20mm down size), different fibres and Water.

V. 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



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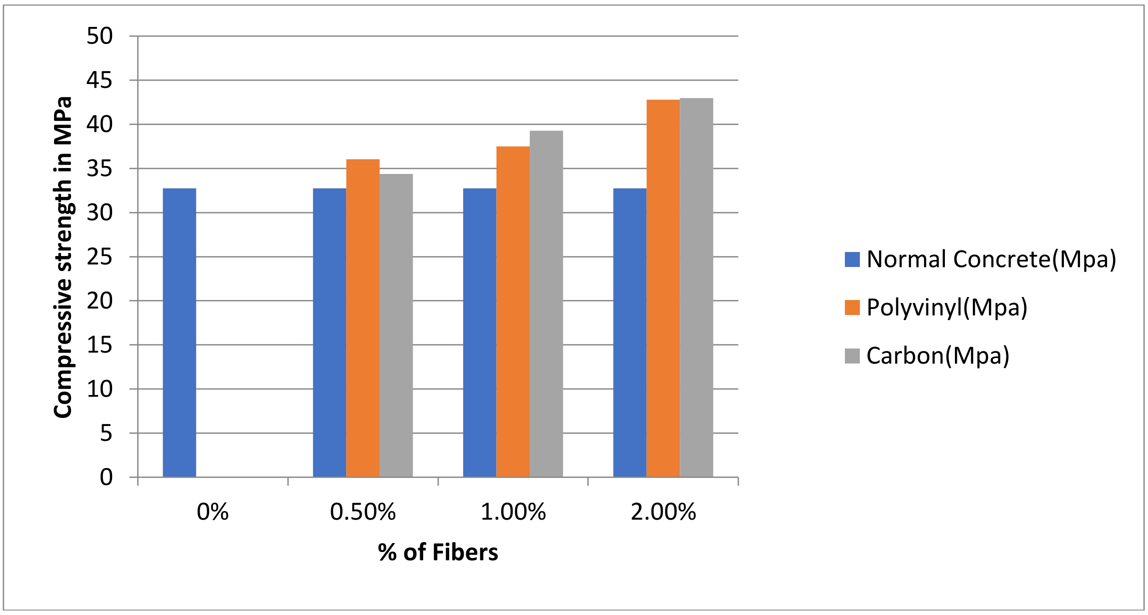
4.2 COMPRESSIVE STRENGTH , SPLIT TENSILE STRENGTH AND FLEXURAL STRENGTH :

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 (PVA and Carbon) at room temperature:

% of Fibers	Normal Concrete(Mpa)	Polyvinyl(Mpa)	Percentage Increased	Carbon(Mpa)	Percentage Increased
0%	32.76	0		0	
0.50%	32.76	36.05	10..04	34.36	4.8
1.00%	32.76	37.51	14.49	39.29	19.93
2.00%	32.76	42.8	30.64	42.98	31.19



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

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

% of Fibers	Normal Concrete(Mpa)	Polyvinyl(Mpa)	Percentage Increased	Carbon(Mpa)	Percentage Increased
0%	2.56	0	0	0	0
0.50%	2.56	2.73	6.64	2.68	4.68
1.00%	2.56	2.76	7.81	2.7	5.46
2.00%	2.56	2.85	11.32	2.77	8.20

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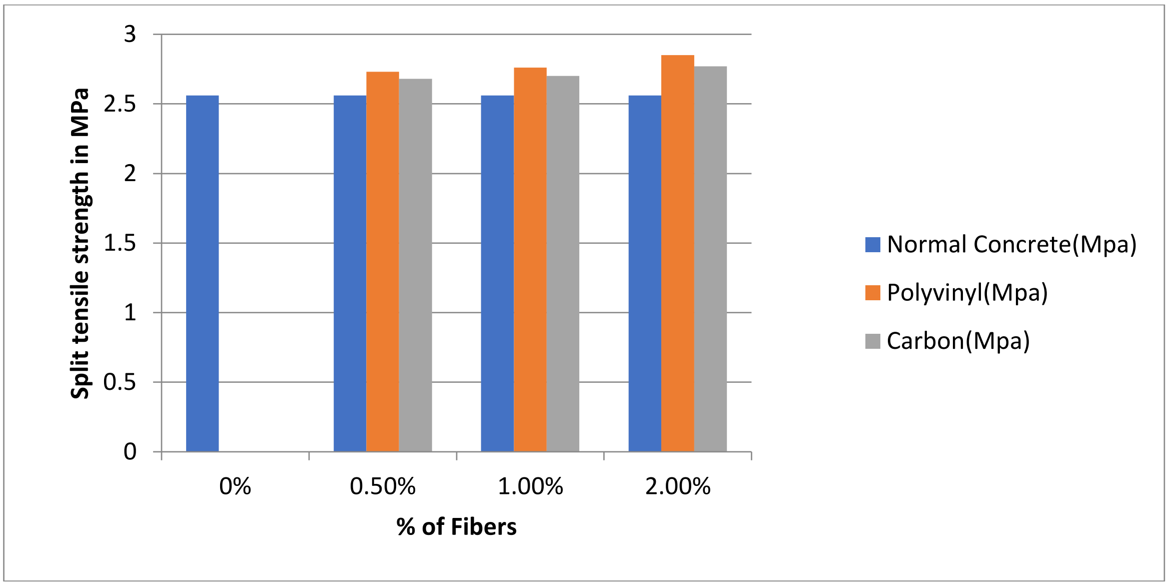
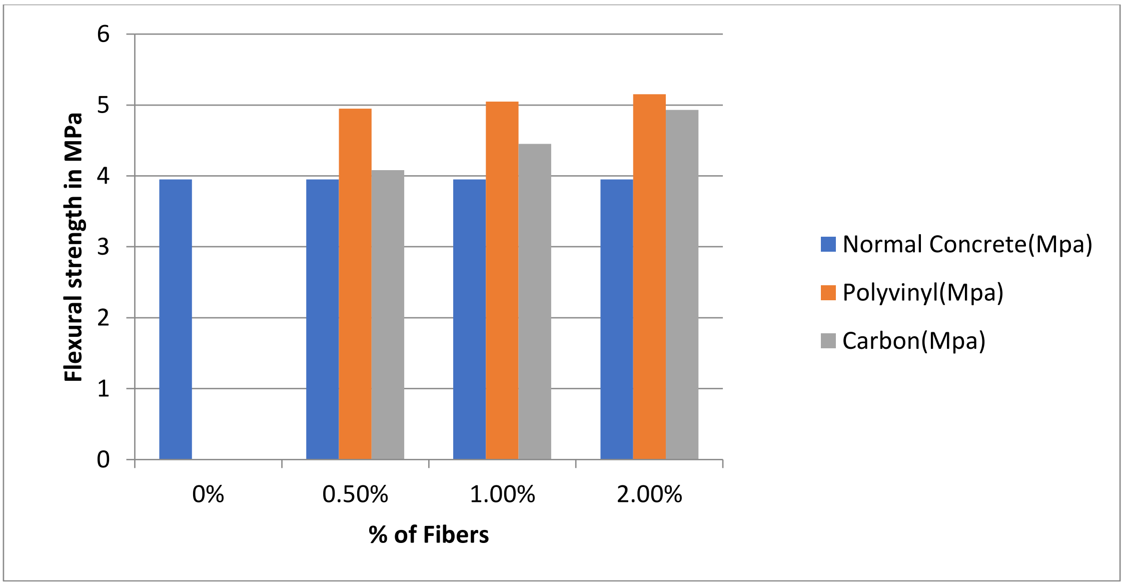


Graph 5.2.2: Comparison of Split tensile Strength on normal concrete and different % of fibers (PVA and Carbon)

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

% of Fibers	Normal Concrete(Mpa)	Polyvinyl(Mpa)	Percentage Increased	Carbon(Mpa)	Percentage Increased
0%	3.95	0	0	0	0
0.50%	3.95	4.95	25.31	4.08	3.29
1.00%	3.95	5.05	27.84	4.45	12.65
2.00%	3.95	5.15	30.37	4.93	24.81

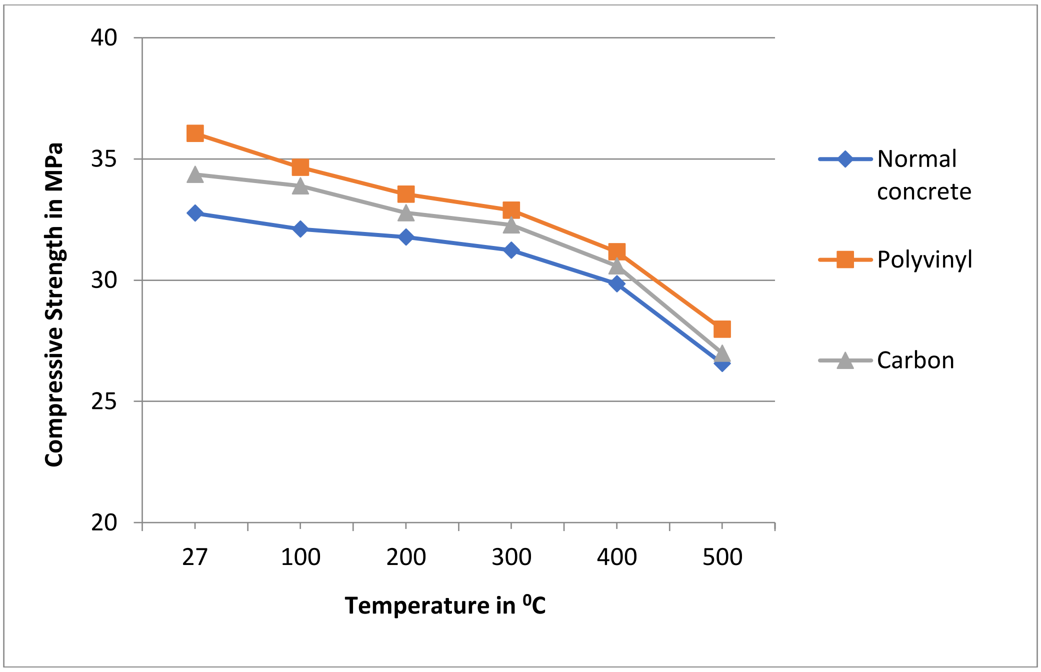


Graph 4.2.3: Comparison of Flexural Strength on normal concrete and different % of fibers (PVA and Carbon)

Results on fibers of Cube:

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

Temperature ^{0}C	Compressive strength(Mpa) for 0.5% fiber		
	Normal concrete	Polyvinyl	Carbon
27	32.76	36.05	34.36
100	32.1	34.66	33.89
200	31.78	33.54	32.78
300	31.23	32.89	32.28
400	29.85	31.17	30.59
500	26.56	27.98	26.99



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

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

Temperature ^{0}C	Compressive strength(Mpa) for 1.0% fiber		
	Normal concrete	Polyvinyl	Carbon
27	32.76	37.51	35.87
100	32.1	36.98	34.98
200	31.78	35.01	33.66
300	31.23	34.23	32.99
400	29.85	33.98	31.23
500	26.56	33.1	30.22

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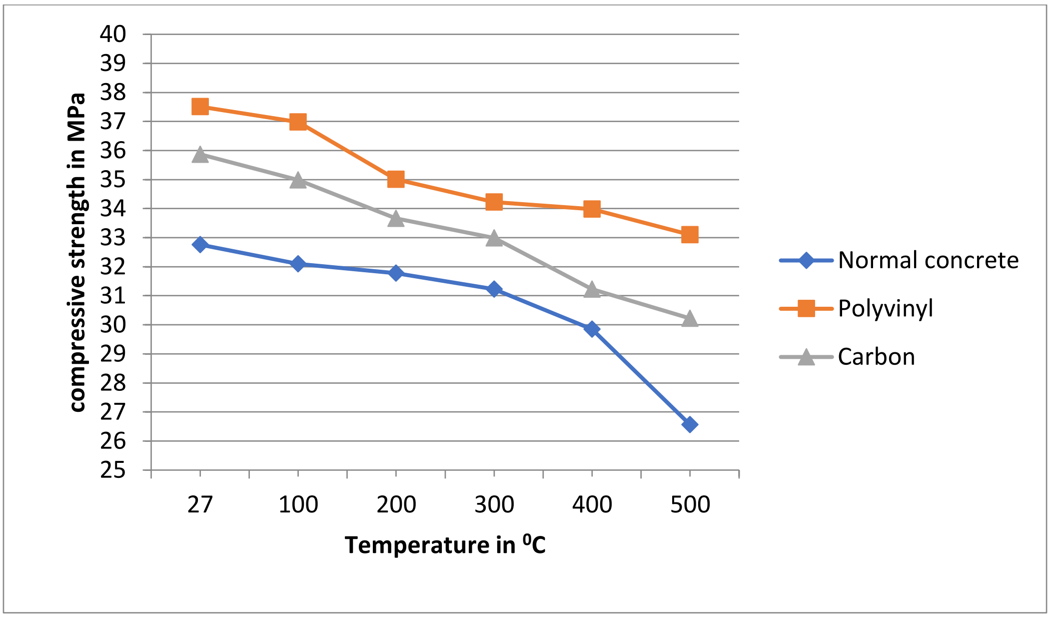
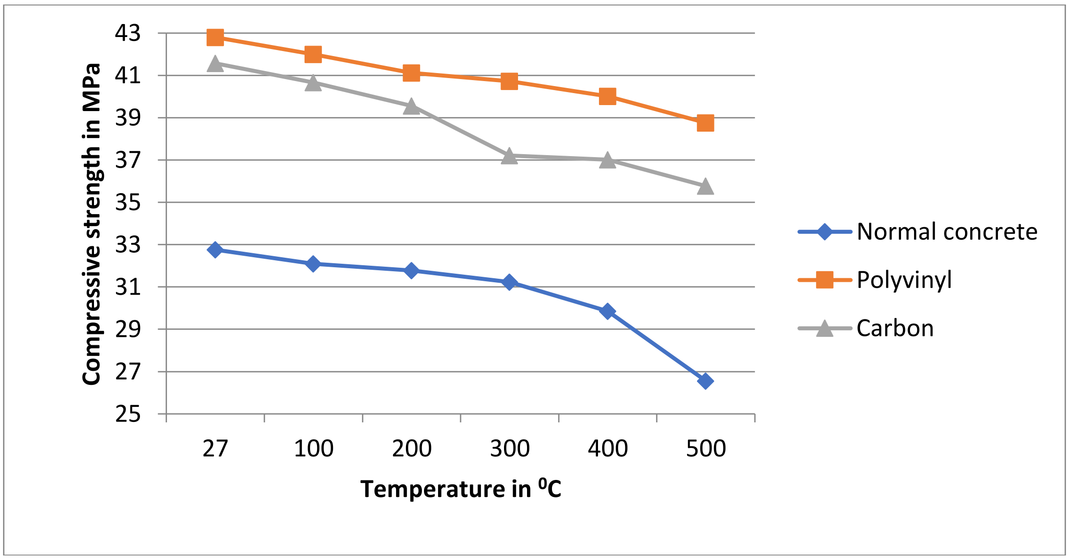


Graph 4.2.5: Comparison of Compressive Strength of normal concrete and different fibers for 1% (PVA and Carbon)

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

Temperature ^{0}C	Compressive strength(Mpa) for 2.0% fiber		
	Normal concrete	Polyvinyl	Carbon
27	32.76	42.8	41.57
100	32.1	41.99	40.67
200	31.78	41.12	39.56
300	31.23	40.73	37.22
400	29.85	40.01	37.01
500	26.56	38.76	35.77



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

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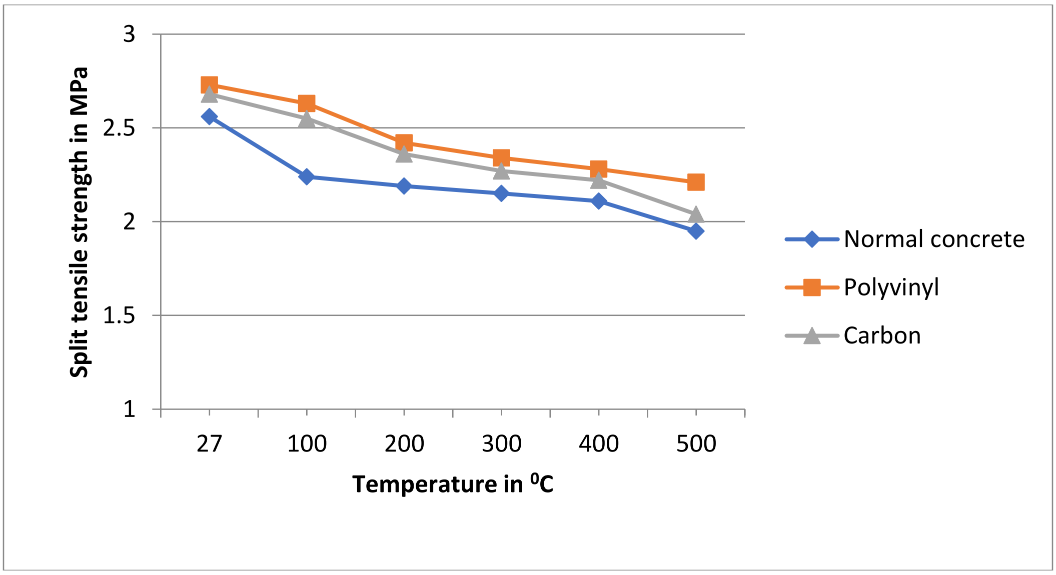
Results on fibers of Cylinder:

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

Temperature ^{0}C	Split tensile strength(Mpa) for 0.5% fiber		
	Normal concrete	Polyvinyl	Carbon
27	2.56	2.73	2.68
100	2.24	2.63	2.55
200	2.19	2.42	2.36
300	2.15	2.34	2.27
400	2.11	2.28	2.22
500	1.95	2.21	2.04



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

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

Temperature ^{0}C	Split tensile strength(Mpa) for 1.0% fiber		
	Normal concrete	Polyvinyl	Carbon
27	2.56	2.76	2.7
100	2.24	2.69	2.59
200	2.19	2.58	2.43
300	2.15	2.49	2.32
400	2.11	2.39	2.28
500	1.95	2.23	2.05

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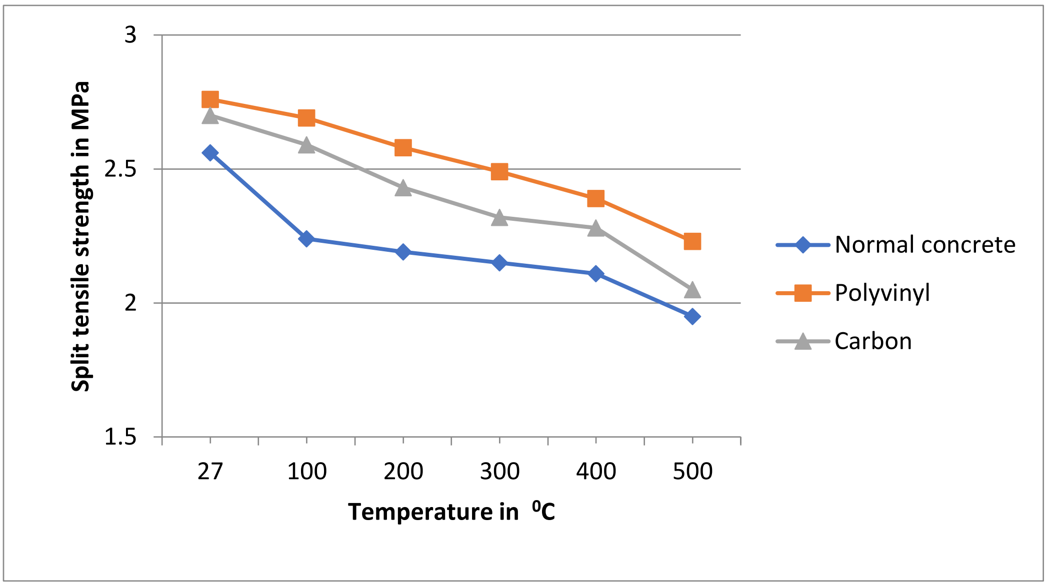
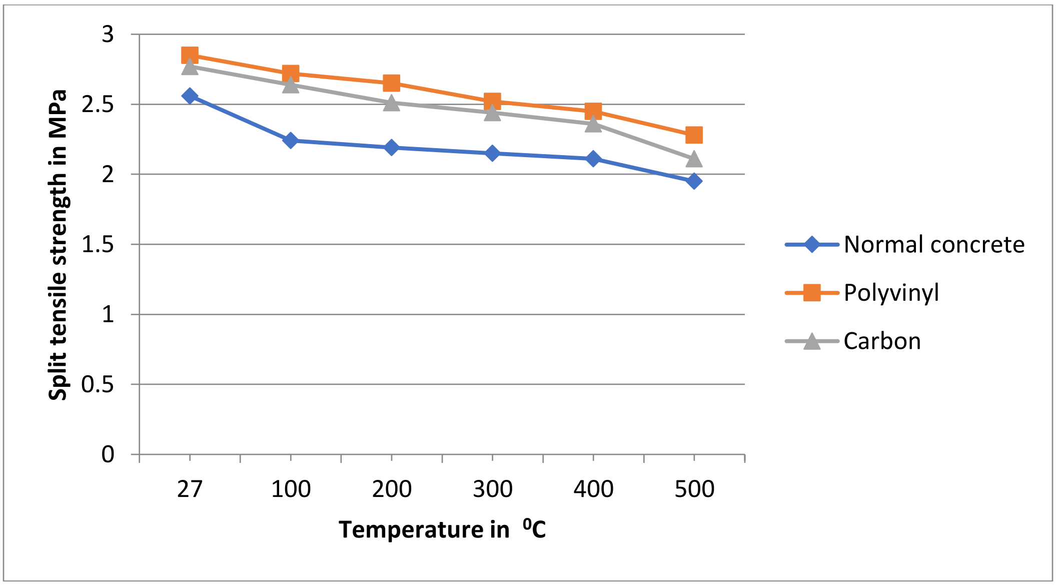


Graph 4.2.8: Comparison of Split Tensile Strength of normal concrete and different fibers for 1% (PVA and Carbon)

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

Temperature ^{0}C	Split tensile strength(MPa) for 2.0% fiber		
	Normal concrete	**Polyvinyl**	**Carbon**
27	2.56	2.85	2.77
100	2.39	2.72	2.64
200	2.27	2.65	2.51
300	2.15	2.52	2.44
400	2.11	2.45	2.36
500	1.95	2.28	2.11



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

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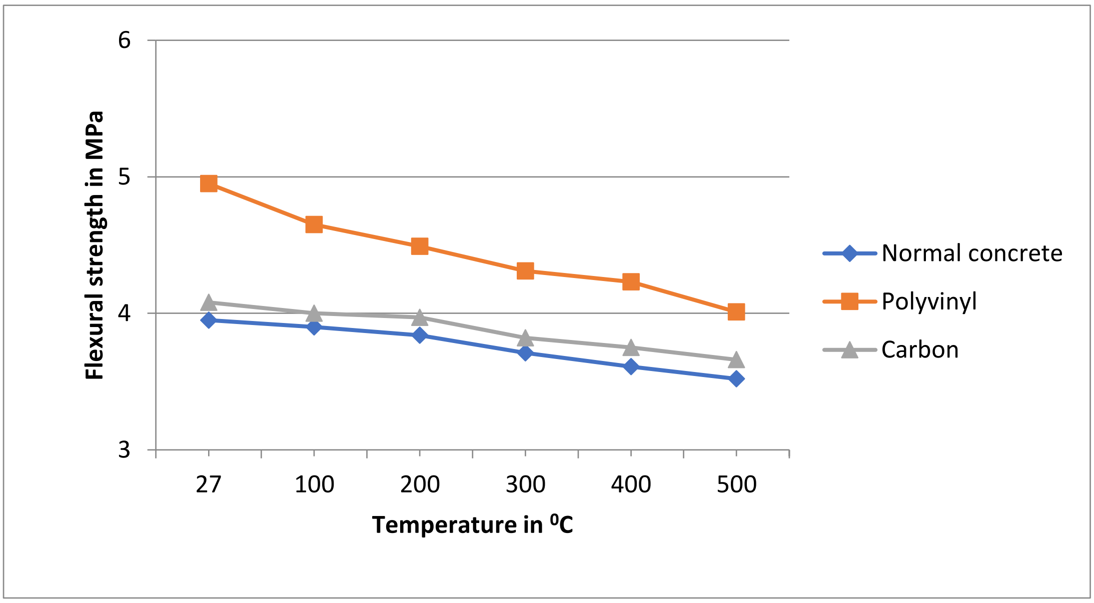
Results on fibers of Beam:

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

Temperature ^{0}C	Flexural strength(Mpa) for 0.5% fiber		
	Normal concrete	Polyvinyl	Carbon
27	3.95	4.95	4.08
100	3.9	4.65	4.0
200	3.84	4.49	3.97
300	3.71	4.31	3.28
400	3.61	4.23	3.75
500	3.52	4.01	3.66



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

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

Temperature ^{0}C	Flexural strength(Mpa) for 1.0% fiber		
	Normal concrete	Polyvinyl	Carbon
27	3.95	5.05	4.45
100	3.9	4.88	4.23
200	3.84	4.69	4.11
300	3.71	4.51	3.98
400	3.61	4.39	3.82
500	3.52	4.14	3.76

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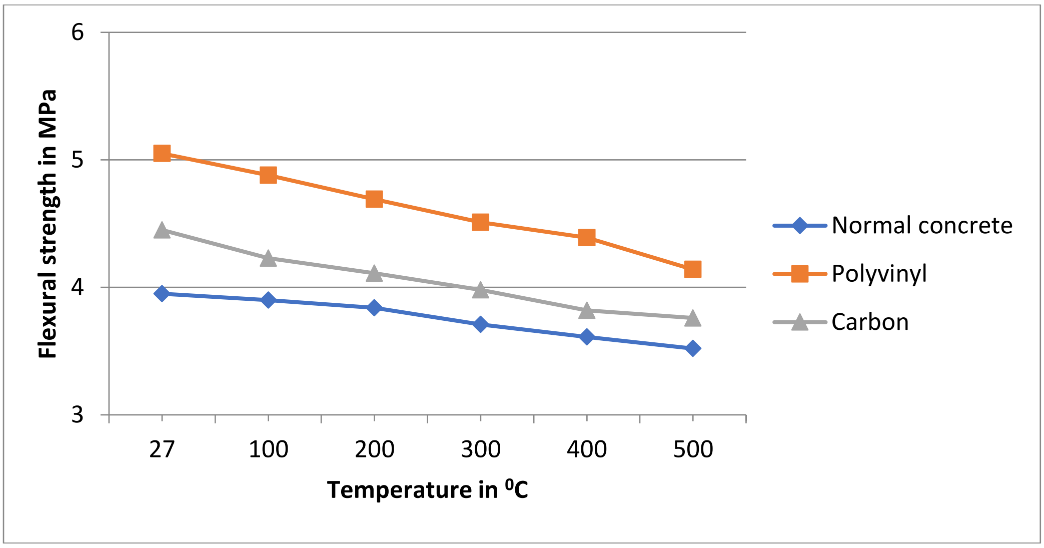
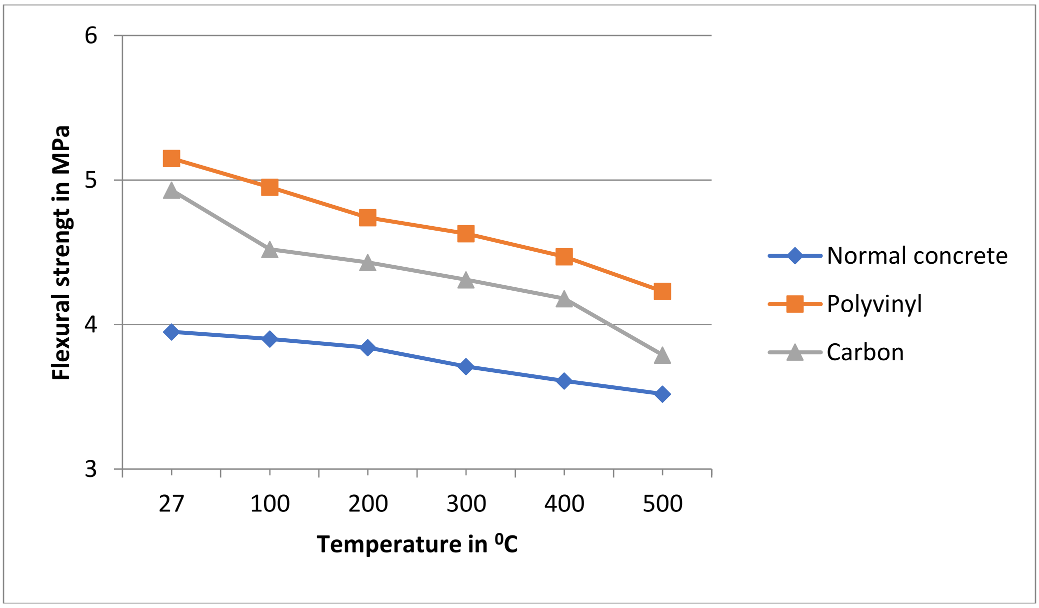


Graph 4.2.11:Comparison of Flexural Strength of normal concrete and different fibers for 1% (PVA and Carbon)

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

Temperature ^{0}C	Flexural strength(Mpa) for 2.0% fiber		
	Normal concrete	Polyvinyl	Carbon
27	3.95	5.15	4.93
100	3.9	4.95	4.52
200	3.84	4.74	4.43
300	3.71	4.63	4.31
400	3.61	4.47	4.18
500	3.52	4.23	3.79



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

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VI. CONCLUSION

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

The physical observations such as the effect on the spalling effect, cracks on surfaces can give valuable information regarding the load resisting of PVA and Carbon fibre reinforced concrete. From the results of different loads for some durations studies, it can be concluded that the compressive strength increases by adding carbon fibre to conventional concrete compared to PVA fibre. The results show that the compressive strength of the concrete increases as the percentage of fibres added increases. From the results of different loads for some durations studies, it can be concluded that the split tensile strength increases by adding PVA fibre to conventional concrete compared to Carbon fibre. The results show that the split tensile strength of the concrete increases as the percentage of fibres added increases. From the results of different loads for some durations studies, it can be concluded that the flexural strength increases by adding PVA fibre to conventional concrete compared to Carbon fibre. The results show that the flexural strength of the concrete increases as the percentage of fibres added increases. The graphs of the test shows that the specimens with fibres show good load taking capacity and the specimens containing 0.5%, 1.0% and 2.0% fibres show good deflection compared to that of the no fibre specimens.

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