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An Experimental Study on Mechanical Properties of Concrete by Using Polyvinyl Alcohol Fibers

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Abstract
This paper outlines an experimental study that measures the effects of polymer fiber on Mechanical properties of concrete. Polyvinyl alcohol (PVA) fiber is considered as one of the most suitable polymeric fibers to be used as the reinforcement of concrete. The present study was to evaluate the mechanical properties of concrete by using PVA fibers. Specimens were prepared with various combinations of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 % of Poly vinyl alcohol fibers by volume fraction for all proportions. This paper presents the experimental methodology and experimental result related to Compressive strength of cubes for 3 days, 7 days, and 28 days, 56 days, 90 days. Split tensile strength, flexural strength of Concrete at 28 days of curing was evaluated. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. FRP reinforcements offer a number of advantages such as corrosion resistance, non-magnetic properties, high tensile strength, lightweight and ease of handling.

Keywords: PVA FIBERS, Fiber-reinforced concrete (FRC), Fibre-reinforced polymer (FRP).

Introduction
Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail. Reinforced concrete adds steel reinforcing bars, steel fibers, polymer fibers, glass fibers, or plastic fibers to carry tensile loads. Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. While concrete brittleness to a large extent can be compensated with steel reinforcements on a structural scale in Fiber Reinforced Concrete resulting in improved structural durability, safety as well as improved performance in infrastructure sustainability.

Polyvinyl alcohol fibers
PVA fiber has suitable characteristics as reinforcing materials for cementitious composites. Polyvinyl alcohol fiber is an ideal environment-friendly cement reinforced material. which possesses alkali and weather resistance due to its unique molecular structure, so it Improve the frost and resistance of concrete.taking on good affinity to cement, effectively prevent and suppress the crack formation and development, improve bending strength, impact strength and crack strength, improve permeability, impact and seismic resistance of concrete.Increase toughness due to improve the brittleness, impact resistance and bending strength of concrete.One of the remarkable characteristics of PVA fiber is strong bonding with cement matrix.

Fig. 1: Sample of PVA Fiber

Methodology

The physical properties of materials used in the experiments are determined with the standard test procedures as per Indian Standard (IS) Codes. Test results are tabulated as given below,

Table 2.1: Properties of Cement

S.No	Property	Values
1	Fineness of Cement	225 m²/kg
2	Specific Gravity	3.11
3	Normal Consistency	33 %
4	Setting Time i) Initial Setting time ii) Final setting time	 40 minutes 6 hours

Table 2.2: Properties of Fine Aggregate

S.No	Property	Values
1	Specific Gravity	2.583
2	Fineness modulus	2.8
3	Bulk Density I. Loose State II. Compacted State	 17.9 KN/m³ 19.5 KN/m³
4	Grading of Sand	Zone – II

Table 2.3: Properties of Coarse Aggregate

S.No	Properties	Value
1	Specific Gravity	2.68
2	Bulk Density	14.13 KN/m³
3	Water Absorption	0.49%
4	Flakiness Index	13.19%
5	Elongation Index	20.49%
6	Crushing Value	14.72%
7	Impact Value	6.08%
8	Fineness Modulus	6.26

Table 2.4: Properties of Polyvinyl alcohol fibers

S.No	Properties	Value
1	Fiber Diameter	2.0 dtex (±)0.2 (15µm+3)
2	Tensile Strength	≥ 11cN/dtex (1500 MPa)
3	Young's modulus	≥ 290 cN/ dtex (35 GPa)
4	Elongation at break	6-8 %
5	Hot water resistance	≥ 98°C
6	Softening point	≥ 216°C
7	Length	6" 9" 12" 19"
8	Density	1.3 g/ cm ³

Based on these material properties, the Mix Design is prepared for Normal Concrete Mix IS: 10262-2009 method is used and the mix proportions and mix details are obtained as follows,

Table 2.5 Mix Proportion

	Water	Cement	Fine aggregate	Coarse aggregate
Proportion by Weight	160kg	400kg	661.51kg	1220.19kg
Proportion by Ratio	0.4	1	1.65	3.05

Cube, cylinder and beam specimen are cast as per IS: 516-1978. In this process, once the wet concrete mixture is prepared of required standard the concrete is filled in cube moulds (150X150X150 mm) for compressive strength test. For Tensile strength the cylinders (300X150 mm) were casted and also for flexural strength the prisms (750X150X150 mm) were casted.

The specimen are removed after 24 hours and immersed in water tank for 3, 7, 28, 56 and 90 days. Then the specimen were removed from curing tank and tested immediately under Compression Testing Machine / Flexural Testing Machine. The type and number of specimens cast are as shown in Table 2.6.

Table2.6: Number of Specimens Cast

S.No	Proportion	Cubes	Cylinders	Prisms
1	CC	15	3	3
2	0.6% PVA	15	3	3
3	0.8% PVA	15	3	3
4	1.0% PVA	15	3	3
5	1.2% PVA	15	3	3
6	1.5% PVA	15	3	3
7	2.0% PVA	15	3	3

Tests adopted for measurement of workability of the concrete mix in the present investigation are,

1. Slump Test,
2. Compacting Factor Test.

Table 2.7 Workability

CASES	SLUMP	COMPACTION FACTOR
CC	24mm	0.74
PVA Fibers	25mm	0.75

Results and Discussions

Compressive Strength:

The cube specimens were tested in Compression Testing Machine (CTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.**0** PVA fibers for conventional concrete mix (CC). The compressive strengths after respective curing periods are noted in Table 3.1.

Table 3.1: Compressive Strength Results

Composition	Compressive Strength (N/mm²)				
	3 Days	7 Days	28 Days	56 Days	90 Days
CC	22.66	30.81	58.22	64.14	67.11
0.6 % PVA	24.66	33.92	63.40	70.96	72.96
0.8 % PVA	25.11	34.96	63.70	71.55	73.40
1.0 % PVA	25.62	35.29	64.37	71.70	74.00
1.2 % PVA	26.00	35.77	66.44	73.70	74.88
1.5 % PVA	26.14	36.14	70.66	74.44	75.03
2.0% PVA	26.44	35.70	70.14	72.66	74.59

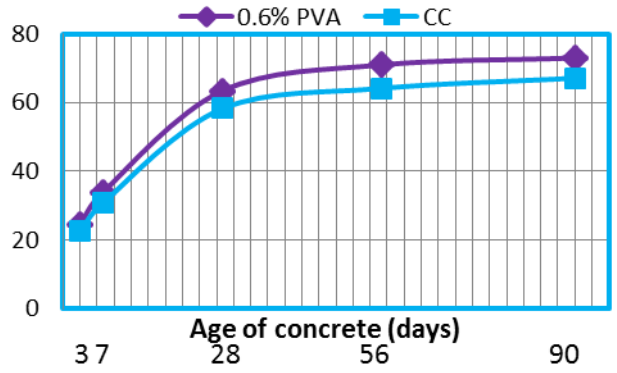

Fig. 3.1: Graph showing Compressive Strength Development of 0.6%PVA Fibers

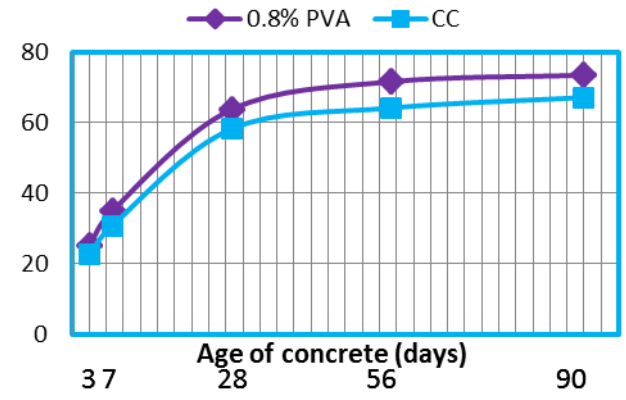

Fig. 3.2: Graph showing Compressive Strength Development of 0.8%PVA Fibers

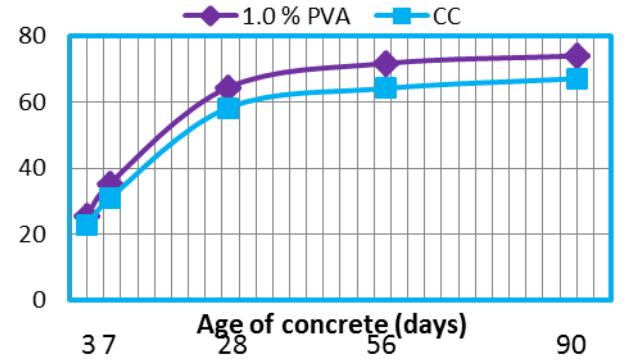

Fig. 3.3: Graph showing Compressive Strength Development of 1.0%PVA Fibers

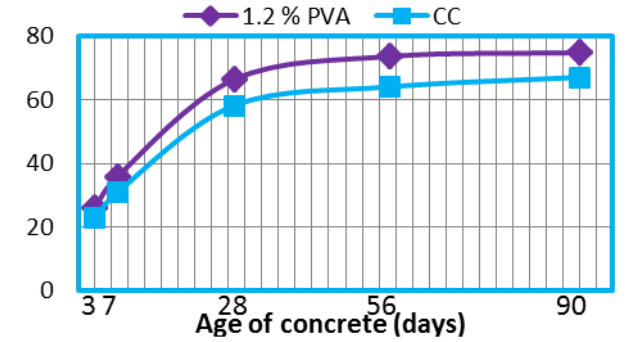

Fig. 3.4: Graph showing Compressive Strength Development of 1.2%PVA Fibers

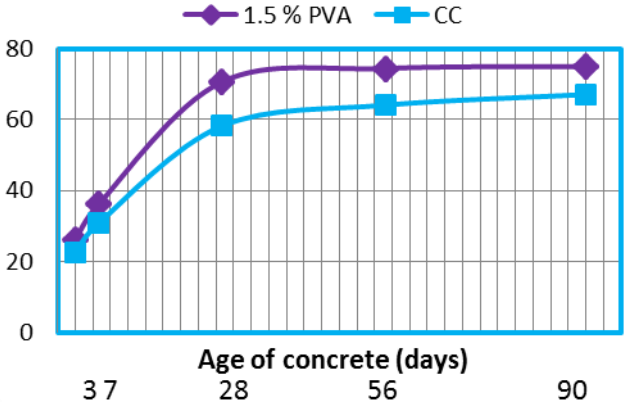

Fig. 3.5: Graph showing Compressive Strength Development of 1.5%PVA Fibers

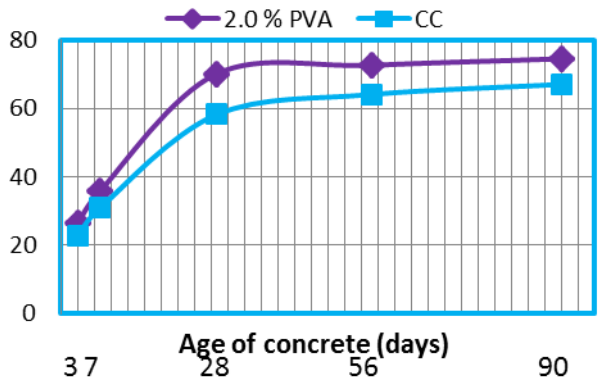

Fig. 3.6: Graph showing Compressive Strength Development of 2.0%PVA Fibers

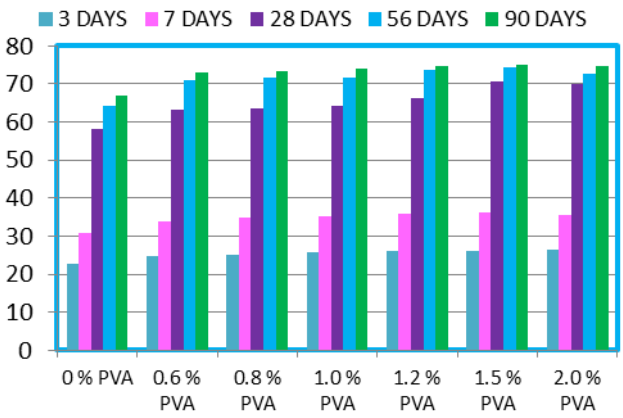

Fig. 3.7: Graph showing Compressive Strength Development of Different Mixes of PVA Fibers

Discussions on Compressive Strength Results

The compressive strength of specimen with 1.5 % PVA fibers is significant increasing in strength comparatively to other variations of PVA fibers. compressive strength of specimen with 1.5 % Polyvinyl alcohol fibres at 7,28,56,90 days is increased by 17.29 %, 21.36 %,16.05 %,11.80 % with 2.0 % PVA fibres at 3 days strength is increased by 16.68% when compared with Conventional concrete. Among all the variations of PVA fibers the percentage strength increased by 1.5 % PVA fibres is more because of more reinforcement strength when compared with others. After the 1.5 % Poly Vinyl Alcohol fibres, 1.2 % PVA fibers show favorable results.

Tensile Strength

The cylinder specimens were tested in Compression Testing Machine (CTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.**0** PVA fibers for conventional concrete mix (CC). The Tensile strengths after respective curing periods are noted in Table 3.2.

Table 3.2: Tensile Strength Results

Composition	Tensile Strength (N/mm^2)
	28 Days
CC	2.82
0.6 % PVA	3.46
0.8 % PVA	3.84
1.0 % PVA	3.91
1.2 % PVA	4.55
1.5 % PVA	4.81
2.0% PVA	4.29

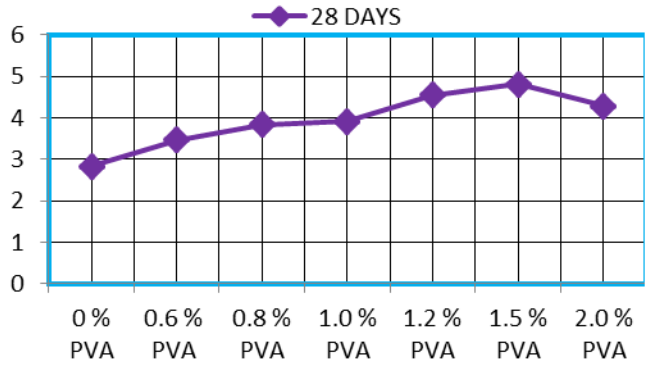

Fig. 3.2: Graph showing Tensile Strength Development of Different Mixes of PVA Fibers

Discussions on Tensile Strength Results

The Tensile strength of specimen with 1.5 % PVA fibers is significant increasing in strength comparatively to other variations of PVA fibers. Tensile strength of specimen with 1.5 % PVA fibres at 28 days is increased by 70.56%. Similarly by using 0.6%,0.8%,1.0%,1.2%,2,0% PVA fibres tensile strength increased by 22.69 %,36.17 %,38.65 %,61.34 %,52.12 % at 28 days strength is when compared with Conventional concrete. Among all the variations of PVA fibers the percentage tensile strength increased by 1.5 % PVA fibres is more because of more reinforcement strength when compared with others. After the 1.5 % PVA fibres, 1.2 % PVA fibers show favorable results.

Flexural Strength

The cube specimens were tested in Universal Testing Machine (UTM) after specified curing period for different percent of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.**0** PVA fibers for conventional concrete mix (CC). The flexural strengths after respective curing periods are noted in Table 3.3.

Table 3.3: Flexural Strength Results

Composition	Flexural Strength (N/mm^2)
	28 Days
CC	8.37
0.6 % PVA	9.32
0.8 % PVA	9.85
1.0 % PVA	10.47
1.2 % PVA	13.36
1.5 % PVA	14.35
2.0% PVA	14.85

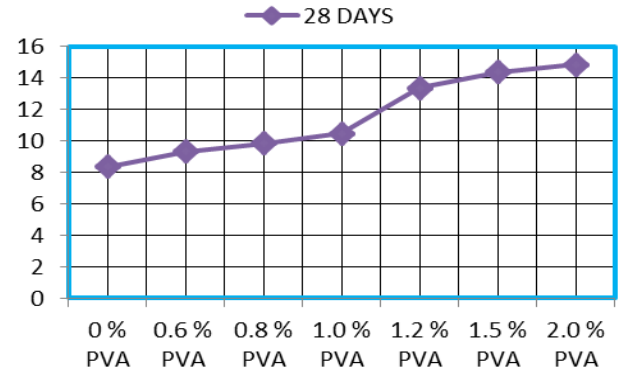

Fig. 3.3: Graph showing Flexural Strength Development of Different Mixes of PVA Fibers

Discussions on Flexural Strength Results

The Flexural strength of specimen with 2.0 % PVA fibers is significant increasing in strength comparatively to other variations of PVA fibers. Flexural strength of specimen with 2.0 % PVA fibres at 28 days is increased by 77.41%. Similarly by using 0.6%,0.8%,1.0%,1.2%,1.5% PVA fibres Flexural strength increased by 11.35 %,17.68 %,25.17 %,59.61 %,71.44 % at 28 days strength is when compared with Conventional concrete. Among all the variations of PVA fibers the percentage Flexural strength increased by2.0 % PVA fibres is more because of more reinforcement strength when compared with others. After the 2.0% PVA fibres, 1.5, 1.2 % PVA fibers show favorable results.

Conclusions

1. The Compressive strength of concrete is increased by 21.36 % with PVA fibers
2. The Tensile strength of concrete is increased by 70.34 % with PVA fibers
3. The flexural strength of concrete is increased by 77.41% with PVA fibers
4. There is significant change in the Tensile strength, Flexural strength with variation of PVA fibers when compared to Conventional concrete.
5. Among different various percentages of PVA fibers, 1.5% PVA fibers show good results to use with concrete.
6. Flexural strength of polymer fiber concrete is much higher than conventional concrete.
7. Bond strength between polymer fibers and concrete is high.
8. Polymer concrete is lighter in weight than conventional concrete.
9. Polymer fiber reinforced concrete is the most effective type of concrete withstands the adverse environmental conditions such as corrosion and other distress due to poor quality, execution and maintenance works.

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