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RESEARCH ARTICLE

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A COMPARATIVE STUDY ON MECHANICAL PROPERTIES AND LOAD DEFLECTION PARAMETERS OF R.C. BEAMS WITH THE ADDITION OF PVA, PE AND GLASS FIBERS

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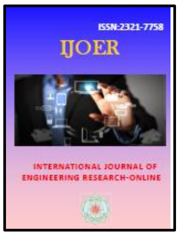

ABSTRACT

In India the concrete is the most widely using material for construction work and also the materials, for the production of the concrete is also available plenty in many areas and several locally available materials also proved as a best one for the production of the concrete. And also in present situations the researchers are also keeping interest on the improvement of concrete properties by adopting the various techniques in curing, compaction, and usage of admixture and fibers. With a connection to above discussed researches it has been carried a study on the flexural properties of the fibers incorporated concrete. As a part of this, it has been adopted the poly vinyl alcohol (PVA) fibers, polyethelene fibers and glass fibers as the additive to the concrete. The reason behind the PVA fibers and polyethelene fibers usage is that, in recent years it's usage in research is increasing significantly especially in china and japan countries. And it is found that, in India the research work was limited to some extent because of its high cost of fibers. Generally PVA and PE fibers are found to be alkali resistant and the similar properties was found in the glass fibers with this connection it has been chosen the PVA fibers polyethelene fibers and glass fibers in this research work.

In this study, the experimental work is done by finding the optimum percentage of the PVA fibers, polyethelene fibers and glass fibers as well, By testing the specimens for compressive, split tensile strength and flexural strength and by considering the various percentages of fibre content viz.0%,0.25%,0.5%,0.75% and 1%. And comparing the mechanical properties and load deflection parameters like load at first crack, maximum deflection, toughness and ultimate load with the conventional concrete, here the conventional concrete is designed for M25 grade. After finding the results variation of compressive strength split tensile strength and flexural strength of beam were observed and load at first crack, maximum deflection, toughness and ultimate loadwas found for RC beams and conclusions were made.

1. INTRODUCTION

Concrete is considered a construction material with strong Heterogeneous behaviour, with a good compressive strength and a low tensile strength. Moreover, concrete has a low strain capacity and is brittle in fracture. The use of fibre reinforced concrete is currently of particular interest, especially in structures with high standards of performance and durability. The behaviour of these concretes is mainly conditioned by the binding matrix properties and by its interaction with the reinforcing fibres. The most common fibres capable of improving the properties of plain concrete are made of steel, glass or poly vinyl alcohol. During the middle age history, extensive research was in progress for the use of composite materials for concrete reinforcement. After, the use of asbestos for concrete reinforcement was discrete due to the detection of health risks. New materials like steel, glass, and synthetic fibers were replaced by asbestos for reinforcement. Active research is still in progress on this important technology. Fiber Reinforced Concrete is considered to be one of the greatest advancements in the construction engineering. It is an advantage of increased tensile strength and better fatigue strength.In hardened stage the fibers contribute to reducing the bleeding in fresh concrete & make the concrete more impermeable. Addition of some amount of % of fibers in concrete towards flexural strength is smaller compared to the strength given by the reinforcements. Generally fiber restricts the magnification of crack under load thereby arresting ultimate cracking load. Alkali-resistant glass fibers and synthetic fibers provide resistance against chemicals. Reinforcing capacity of fibers is based on length of fibers, diameter of fibers, the percentage of fibers and condition of mixing, orientation of fibers and aspect ratio are non-metallic materials. Aspect ratio is ratio of length of fibers to its diameter which plays an important role in the process of reinforcement.

2. LITERATUER REVIEW

G. Jyothi Kumari, et al[2] was studied the behavior of reinforced concrete beams with glass fiber reinforced polymer flats and it was observed that beams with silica coated Glass fiber reinforced polymer (GFRP) flats shear reinforcement have shown higher failure loads. KavitaKene, et al[1],was conducted experimental study on behaviour of steel and glass Fiber Reinforced Concrete. In this study it was conducted on Fiber Reinforced concrete with steel fibers of different percentages like 0% and 0.5% volume fractions of concrete and alkali resistant glass fibers with 0% and 25% by weight of cement of 12 mm cut length, compared the result. Durability studies on glass fiber reinforced concrete. Conducted by Dr. P. Srinivasa Rao, et al.[3] S. H. Alsayed, et al[4] studied the performances of glass fiber reinforced plastic bars using as a reinforcing material for concrete structures. The study showed that the flexural load carrying capacity of concrete beams reinforced by GFRP bars can be estimated accurately using Review on the Performance of Glass Fiber Reinforced Concrete the ultimate design theory. The study also showed that as G.F.R.P bars having low modulus of elasticity. Deflection criteria were also controlled the design of intermediate and long beams reinforced with F.D.R.P bars. Yogesh Murthy, et al[5] studied the performance of G.F.R.C. The study showed that the usage of glass fiber in concrete not only improves the properties of concrete and a small cost cutting but also provides easy outlet to dispose the glass as environmental waste from the industry. Romualdi and Batson (1963)[6] published their classical paper on 'Mechanics of crack arrest in concrete'. They concluded that application of linear elastic fracture mechanics to reinforced concrete indicates that the relatively low tensile strength of concrete is not inherent to the material and can be avoided with suitable reinforcement arrangement. Gopalaratnam and shah (1986)[7] discussed the effect of strain rate on the flexure behaviour of unreinforced matrix and three different fibre reinforced concrete mixes. It was concluded that FRC is more sensitive than plain matrix and showing improvement in flexural strengths of 79, 99 and 111 percent over respective static flexural strengths for the 0.5, 1.0 and 1.5 percent (fibre volume content) composites (aspect ratio of 62.5) at identical loading rates. Also they have developed modified charpy instrument to conduct impact tests and results obtained by them were found to vary with conventional impact tests. Antonio Nanni (1988)[8] concluded that the splitting –tension test could be used to determine the tensile strength of fibre reinforced concrete commonly obtained with static flexural test. Also it was concluded that computation of first crack and ultimate crack is more convenient than that of flexural or direct tension test. Balaguru and Ramakrishnan(1988)[9] concluded that initial and final setting times of plain and fibre reinforced concretes were the same. Fibre concrete had lower slump & air- content and the rate of loss of these parameters with time was also higher. It was also observed that shrinkage of fibre concrete was slightly less but it underwent slightly more creep deformations. Bentur (1989)[10] reported that the use of alkali resistant glass fibres with silica fume was effective in improving durability performance of alkali resistant glass fibre reinforced cement composites (GFRC). Kavita Kene,[10] et al conducted experimental study on behavior of steel and glass Fiber Reinforced Concrete Composites. The study conducted on Fiber Reinforced concrete with steel fibers of 0% and 0.5% volume fraction and alkali resistant glass fibers containing 0% and 25% by weight of cement of 12 mm cut length, compared the result. G. Jyothi Kumari[11], et al studied behavior of concrete beams reinforced with and observed that beams with silica coated Glass fiber reinforced polymer (GFRP) flats shear reinforcement have shown failure at higher loads.

3. MATERIALS AND METHODS

3.1. Ordinary Portland cement.

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in the mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials in a kiln to form what is called clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available with the most common being called ordinary Portland cement (OPC) which is grey in color, but white Portland cement is also available.

3.2 Sand.

Fine aggregate / natural sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds.

3.3. PVA fibers.

Table 1. Properties of PVA fibres

Type	PVA
Density	1.26
Length(mm)	12
Modulus of elasticity	42.8
Reduction in water	<2
Breaking elongation	<7-15
Normal strength	1620

polyvinyl alcohol, were developed some 20 years ago by Kuraray, a Japanese company. When added to concrete or mortar, the fibers develop a molecular and chemical bond with the cement during hydration and curing. .Generally the fiber used in ECC is PVA, One of the remarkable characteristics of this fiber is capable of strong bonding with cement matrix. The layer of $Ca(OH)_2$ called as Interfacial transition zone is formed round PVA fiber It is known PVA makes complex cluster with the metal hydroxide of cement matrix. It is pursued that Ca+ and OH- two different ions in the cement slurry are attracted by PVA fibers and makes layer of $Ca(OH)_2$ around the fibers and hence the $Ca(OH)_2$ layer plays an important role for bonding strength between the fiber and the matrix

3.4 Polyethylene fiber

Polyethylene is a polymer. Many no. of ethylene monomers join with each in the synthesis of polyethylene polymer. Polyethylene is a hard, stiff, strong and a dimensionally stable material that absorbs very little water. It has good gas barrier properties and good chemical resistance against acids, greases and oils. It can be highly transparent and colorless but thicker sections are usually opaque and off-white. Polyethylene also has good self-extinguishing properties and resistance against ultra violet. Polyethylene is obtained by the polymerization of ethane. Cationic coordination polymerization, anionic addition polymerization, radical polymerization and ion polymerization are the different methods by which polyethylene can be produced. Every method gives different types of polyethylene. Mechanical properties of Polyethylene depend on the molecular weight, crystal grouping and branching.

Polyethylene is a neutral environment-friendly cement reinforced material, due to its

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unique molecular structure it processes alkali and weather resistance. It prevents and minimizes the crack formation which in turn improves bending strength, impact strength and crack strength, improves permeability, impact and seismic resistance for concrete. This product can be used in industrial and civil constructions like walls, roofing, flooring and roads, bridges, tunnels, reinforcement for slopes.

Currently, in cement concrete engineering sector, due to Polyethylene fibres unique properties, with a broad prospect for its future in the engineering, Polyethylene fibre is a novel product ideal to completely replace the asbestos in the production of fibre cement corrugate sheet.

3.5. Coarse aggregate.

Coarse aggregate of size less than 10 mm i.e., passed through 10mm sieve and retained on 6.3mm sieve are taken. Because, if we add aggregate of larger size, then the crack width of concrete specimen increases and it cannot heal the cracks in presence of moisture. Two single sized crushed stone aggregates ranging from 12.5mm to 2.36 mm and 20 mm to 4.75 mm (10mm and 20mmsizes) were used in respective proportions in concrete mixes.

Table 2: Properties of Polyethylene fibres

Physical Properties	Recommended values by Supplier
Specific gravity	0.92
Softening range	Deg C- 85-90
Elongation at break %	45-50
Tensile strength psi	15000

3.6. Glass Fibre

The glass fibers with the designation "Cem-Cem-Fil Anti-Crack, HD-12mm, Alkali Resistant glass fibres"were used throughout in this experimental work. The specifications of these fibres are presented in Table.

Table 3. Properties of Glass fibres

Physical Properties	Recommended values by the supplier
Specific gravity	2.68
Elastic Modulus (Gpa)	72
Tensile Strength (Mpa)	1700
Length (mm)	12

The current experimental study was carries by conducting Preliminary tests for mix design of concrete and the for M25 grade concrete. And the mix proportion is shown in table.

Table 4. Mix proportion of M25 grade concrete.

ingredients	quantities	proportion
Water	191.6 lit	0.45
cement	425.78kg	1
fine aggregate	607.48kg	1.42
coarse aggregate	1182.586 kg	2.78

Then cubes of size 150mmx150mmx150mm are casted and tested for compressive strength. Similarly the cylinders of height 30 cm and 15 cm in diameter were casted and tested for the split tensile strength. And then RC beams of size 700mmx150mmx150mm were casted and tested for flexural strength for different percentages of the PVA and glass fibre content viz. 0%, 1%, 2%, 3%, 4% and 5% after 28 days curing. Observing the effect of PVA fibre in various aspects on the concrete properties and determining the optimum % of PVA fibre content and glass fibre content. Examining the results obtained from compressive strength test split tensile strength test and flexural strength test.

4. RESULTS

The tests were conducted and the results were tabulated and the same are represented in the graphical form

The table shows the variation of compressive strength of concrete specimens with all the three kinds of fibers at various percentages. The variation shown in the graphical form

Table 5 Comparison of compressive strength

Sl.no	% of fibre	Glass fibre	PVA fibre	PE Fibre
1	0	27.5	27.5	27.5
2	0.25	28.8	28.45	28.55
3	0.5	29.98	30.09	30.65
4	0.75	31.01	30.25	31.28
5	1	27.65	29.9	30.55

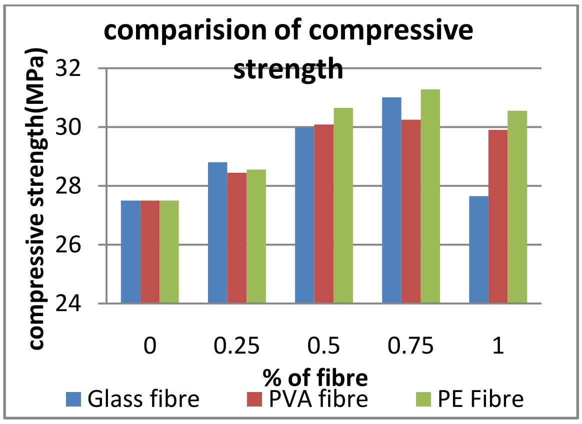

Figure 1. Variation of compressive strength

The table shows the variation of split tensile strength of concrete specimens with all the three kinds of fibers at various percentages. The variation shown in the graphical form

Table 6 Comparison of split tensile strength

Sl.no	% of fibre	Glass fibre	PVA fibre	PE Fibre
1	0	3.2	3.2	3.2
2	0.25	3.39	3.3	3.35
3	0.5	3.44	3.35	3.42
4	0.75	3.56	3.47	3.58
5	1	3.35	3.4	3.42

The table shows the variation of flexural strength of concrete specimens with all the three kinds of fibers at various percentages. The variation shown in the graphical form

Table 7 Comparison of flexural strength

Sl.no	% of fibre	Glass fibre	PVA fibre	PE Fibre
1	0	2.8	2.8	2.8
2	0.25	2.3	2.7	2.8
3	0.5	3	3.28	3.3
4	0.75	4.03	4.2	4.4
5	1	2.3	3.6	3.2

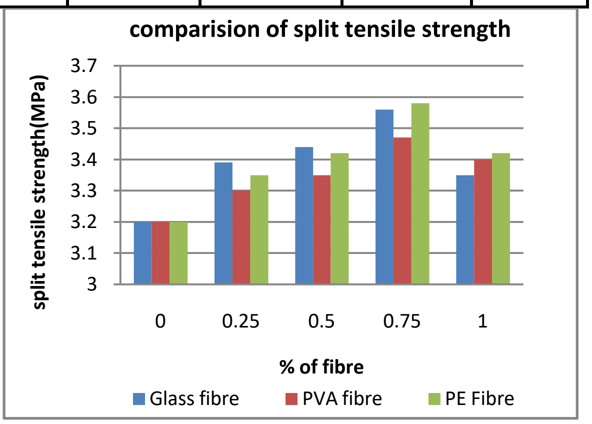

Figure 2. Variation of split tensile strength

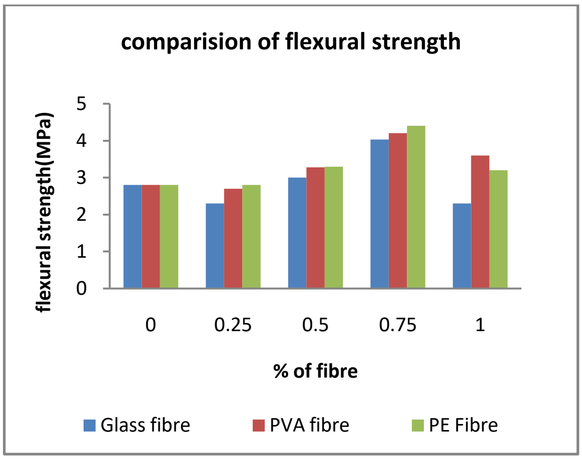

Figure 3.variation of flexural strength

Then load deflection studies were carried on RC beams an found the parameters like load at first crack, maximum deflection, toughness and ultimate load and the comparisons were made.

The fallowing figure shows the load deflection curves for various % of PVA fibers

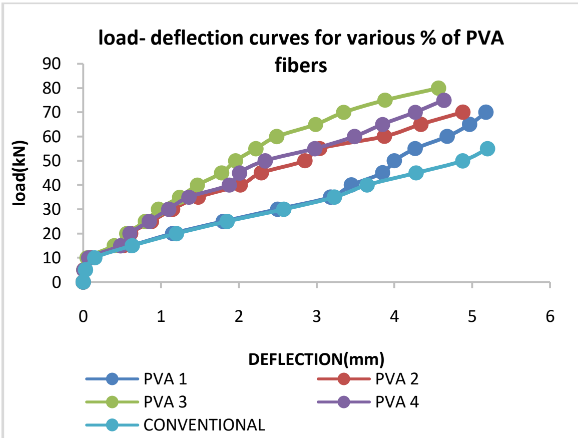

Figure 4. load- deflection curves for various % of PVA fibers

The fallowing figure shows the load deflection curves for various % of glass fibers

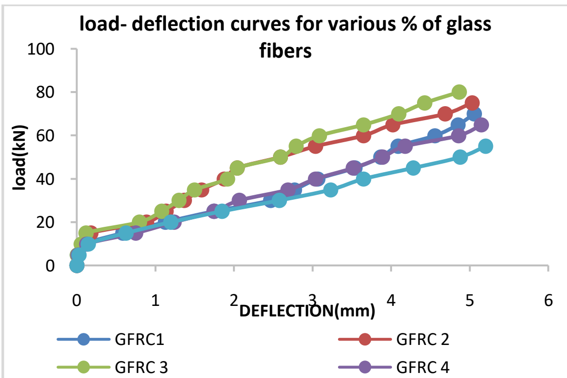

Figure 5.load- deflection curves for various % of glass fibers

The fallowing figure shows the load deflection curves for various % of PE fibers.

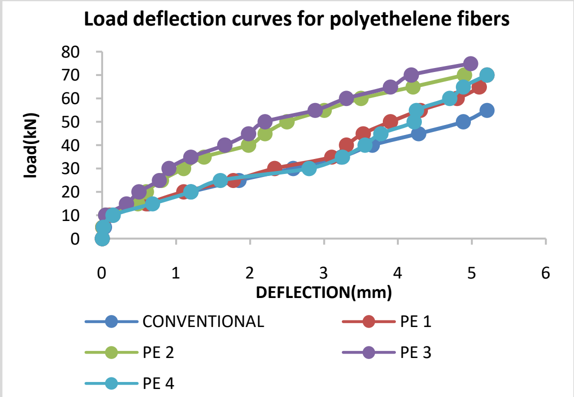

Figure 6. Load deflection curves for polyethelene fibers with % of fibers

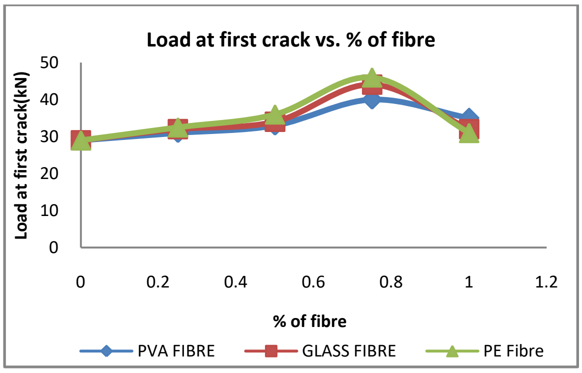

Figure 7 Variation of load at first crack values with percentage of fibers

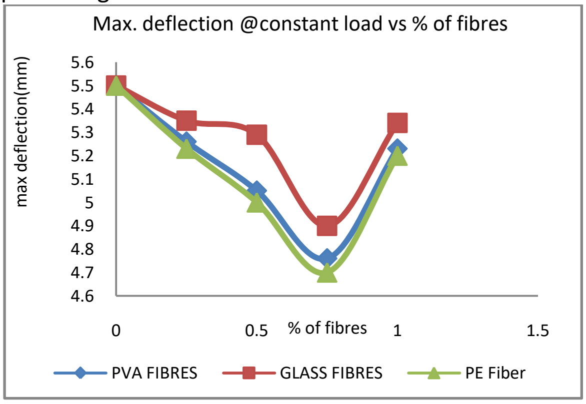

Figure 8. Graph showing Max. Deflection @constant load vs % of fibres

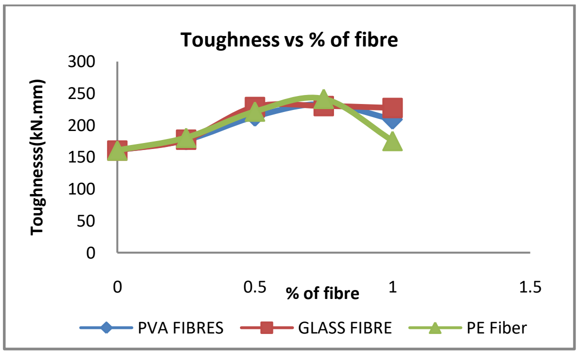

Figure 9. Graph showing Toughness vs % of fibre

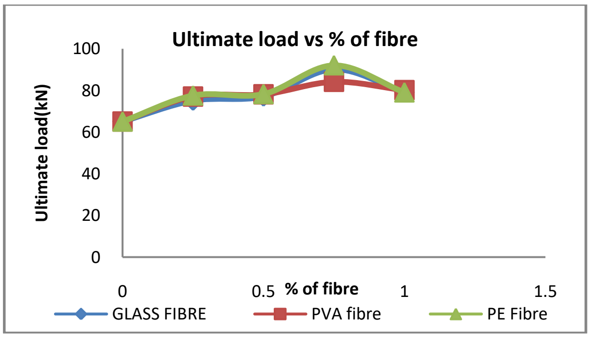

Figure 10. Graph showing Ultimate load vs % of fibre

5. DISCUSSIONS

From the above results the fallowing discussions were made The compressive strength of concrete is increased by 4.72% for 0.25% addition of glass fiber, 9.01% for 0.5% addition of glass fiber, 12.76% for 0.75% addition of glass fiber and 0.54% for 1% addition of glass fibers than conventional concrete.

1. The split tensile strength of concrete is increased by 5.93% for 0.25% addition of glass fiber, 7.5% for 0.5% addition of glass fiber, 11.25% for 0.75% addition of glass fiber and 4.68 % for 1% addition of glass fibers than conventional concrete.
2. The flexural strength of concrete is decreased by 21.7% for 0.25% addition of glass fiber, 7.14 % increased for 0.5% addition of glass fiber, 43.9 % increased for 0.75% addition of glass fiber and 21.7% decreased for 1% addition of glass fibers than conventional concrete.
3. The compressive strength of concrete is increased by 3.45%for 0.25% addition of PVA fiber, 9.41% for 0.5% addition of PVA fiber, 10% for 0.75% addition of PVA fiber

and 8.72% for 1% addition of PVA fibers than conventional concrete.

4. The split tensile strength of concrete is increased by 3.125% for 0.25% addition of PVA fiber, 4.68% for 0.5% addition of PVA fiber, 8.43% for 0.75% addition of PVA fiber and 6.25% for 1% addition of PVA fibers than conventional concrete.
5. The flexural strength of concrete is decreased by 3.7 %for 0.25% addition of PVA fiber, increased by 17.14 % for 0.5% addition of PVA fiber, increased by 50% for 0.75% addition of PVA fiber and increased by 28.57% for 1% addition of PVA fibers than conventional concrete.
6. The compressive strength of concrete is increased by 3.81%for 0.25% addition of PE fiber, 11.45% for 0.5% addition of PE fiber, 13.74% for 0.75% addition of PE fiber and 11.09 % for 1% addition of PE fibers than conventional concrete.
7. The split tensile strength of concrete is increased by 4.68% for 0.25% addition of PE fiber, 6.8% for 0.5% addition of PE fiber, 11.8% for 0.75% addition of PE fiber and 6.8% for 1% addition of PVA fibers than conventional concrete.
8. The flexural strength of concrete is decreased by 0%for 0.25% addition of PE fiber, increased by 17.85 % for 0.5% addition of PE fiber, increased by 57.14% for 0.75% addition of PE fiber and increased by 14.28 % for 1% addition of PVA fibers than conventional concrete.
9. The load at first crack of concrete is increased by 10.34% for 0.25% addition of glass fiber, 17.24% for 0.5% addition of glass fiber, 51.72% for 0.75% addition of glass fiber and 10.34% for 1% addition of glass fibers than conventional concrete.
10. The toughness of concrete is increased by 10.55% for 0.25% addition of glass fiber, 42.41% for 0.5% addition of glass fiber, 43.22% for 0.75% addition of glass fiber and 41.42% for 1% addition of glass fibers than conventional concrete.
11. The maximum deflection value of concrete is decreased by 2.8% for 0.25% addition of glass fiber, 3.96% for 0.5% addition of glass fiber, 12.24% for 0.75% addition of glass fiber and 2.99% for 1% addition of glass fibers than conventional concrete.
12. The ultimate load of concrete is increased by 15.38% for 0.25% addition of glass fiber, 18.46% for 0.5% addition of glass fiber, 38.46% for 0.75% addition of glass fiber and 21.53% for 1% addition of glass fibers than conventional concrete.
13. The load at first crack of concrete is increased by 6.89% for 0.25% addition of PVA fiber, 13.79% for 0.5% addition of PVA fiber, 37.93% for 0.75% addition of PVA fiber and 20.68% for 1% addition of PVA fiber than conventional concrete.
14. The toughness of concrete is increased by 9.99% for 0.25% addition of PVA fiber, 33.06% for 0.5% addition of PVA fiber, 45.28% for 0.75% addition of PVA fiber and 30.21% for 1% addition of PVA fiber than conventional concrete.
15. The maximum deflection value of concrete is decreased by 4.56% for 0.25% addition of PVA fiber, 8.91% for 0.5% addition of PVA fiber, 15.54% for 0.75% addition of PVA fiber and 5.16% for 1% addition of PVA fiber than conventional concrete.
16. The ultimate load of concrete is increased by 18.46% for 0.25% addition of PVA fiber, 20% for 0.5% addition of PVA fiber, 29.23% for 0.75% addition of PVA fiber and 23.07 % for 1% addition of PVA fiber than conventional concrete.
17. The load at first crack of concrete is increased by 12.06% for 0.25% addition of PE fiber, 24.13% for 0.5% addition of PE fiber, 58.62% for 0.75% addition of PE fiber and 6.89% for 1% addition of PE fiber than conventional concrete.
18. The toughness of concrete is increased by 12.46% for 0.25% addition of PE fiber, 38.07% for 0.5% addition of PE fiber, 50.49% for 0.75% addition of PE fiber and

9.37% for 1% addition of PE fiber than conventional concrete.

19. The maximum deflection value at constant load of concrete is decreased by 5.16%for 0.25% addition of PE fiber, 10% for 0.5% addition of PE fiber, 17.02% for 0.75% addition of PE fiber and 5.76% for 1% addition of PE fiber than conventional concrete.

20. Ultimate load of concrete is increased by 19.23% for 0.25% addition of PE fiber, 20.30% for 0.5% addition of PE fiber, 41.53% for 0.75% addition of PE fiber and 21.53% for 1% addition of PE fiber than conventional concrete.

6. CONCLUSIONS

1) For the addition of glass fibers, the compressive strength of concrete is increased for a maximum of **12.76%** when compared with conventional concrete.
2) For the addition of glass fibers, the split tensile strength of concrete is increased for a maximum of **11.25%** when compared with conventional concrete.
3) For the addition of glass fibers, the flexural strength of concrete is increased for a maximum of **43.9%** when compared with conventional concrete.
4) For the addition of PVA fibers, the compressive strength of concrete is increased for a maximum of **10%** when compared with conventional concrete.
5) For the addition of PVA fibers, the split tensile strength of concrete is increased for a maximum of **8.43%** when compared with conventional concrete.
6) For the addition of PVA fibers, the flexural strength of concrete is increased for a maximum of **50%** when compared with conventional concrete.
7) At **0.75%** fiber content, the deflection parameters like load at first crack, toughness, an ultimate load were obtained maximum. These parameters are obtained maximum for glass fibers when compared with PVA fibers.
8) The maximum deflection was also decreased at **0.75%** of fiber content for all the three fibers and better result were observed in the case of polyethylene fiber from this polyethylene fibers are capable of resistant the higher central deflection under load.
9) From the toughness comparisons it can be concluded that the energy absorbing capacity is almost same for all the three fibers as well at optimum fiber content i.e., at **0.75%**.
10) From ultimate load comparisons all the three fibers serves as the better ones for the increment of ultimate load carrying capacity. And this is obtained maximum for the polyethelene fibers than PVA&glass fibers.
11) The usage of fiber in the concrete matrix gives the better performance in all aspects due to the bridging action and high tensile properties of fiber.
12) The reduction in the result with the further increment of the fibre may be due to balling effect.
13) From my experiments I can conclude that the usage of polyethelene fibers may be useful for the better performance of concrete in all aspects like availability, effectiveness and production.

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