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Mechanical Properties of Poly Propylene Concrete

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INTRODUCTION

Conventional concrete:

The history of cementing material is as old as the history of engineering construction. Concrete is a manmade building material that looks like stone, with a combination of cement with aggregate and by using sufficient water, concrete can be prepared. The strength and durability of concrete can be changed by making appropriate changes in its ingredients. Concrete has strength, durability, versatility, and economy and it can be placed or molded into virtually any shape and reproduce any surface texture.

Concrete where cement is used as binding material is called as cement concrete. It is one of the seemingly simple but actually complex materials. Though speedy advances were created throughout previous few decades within the usage and information of concrete, the improved methods of mix design; inspection and testing are probably resulting in control of qualities of concrete with in more and more defined limits as per the requirement on the specified job.

Some cementitious materials were used by Egyptians, Romans in their ancient constructions and it is believed that the early Egyptians used gypsum as cement where as Greeks and Romans used lime which was prepared by heating limestone.From12,000,000 BC, concrete was started using for the constructions. In 3000 BC, Egyptians have the habit to use the mud mixed with straw to bind the dried bricks. Further they discovered lime and gypsum mortar as a binding agent for building the Pyramids.

Advantages of concrete are

- Concrete is economical when all the materials are readily available.
- Concrete has long life and it relatively requires low maintenance increase its economic benefits.
- It is not as likely as to rot, corrode, or decay as other building materials.
- Concrete has the ability that it can be moulded or cast into any desired shape.
- Concrete is a non-combustible material and it helps the building to protect from fire-safe and it can be able to withstand in high temperatures.
- It is resistant over wind, water, rodents, and insects. Hence, concrete is often used for storm shelters.

Although concrete offers numerous advantages, it has inherent disadvantages. Some of the disadvantages of the conventional concrete are

- Low tensile strength
- Low post cracking capability
- Brittleness and low ductility
- Limited fatigue life
- Low impact strength

The brittle material is strong in compression but weak in tension. Due to weakness at tensile end, the structures get cracks. These cracks gradually propagate to the compression end and finally member breaks. Sometimes members may also fail due to drying shrinkage. These cracks are basically minor cracks. These cracks increase in size and magnitude as the time elapses and eventually makes the concrete to fail.

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The formation of cracks is that the main reason for the failure of the concrete.

Many researchers have been made many attempts to increase the tensile strength of concrete. To increase the tensile strength of concrete a new technique, i.e.., introduction of fibres in concrete is being used. The fibres act as crack arrestors and it prevents the member from failure. These fibres are uniformly distributed as well as randomly arranged. This type of concrete is named as Fibre Reinforced Concrete (FRC).

Addition of fibres helps in improving post cracking response of concrete, energy absorption capacity and apparent ductility. Also, it helps to maintain structural integrity and cohesiveness in the material.

In this investigation comparison between plain concrete and fibre reinforced concrete are studied. The tests conducted are Compression test, Split tensile test, Flexural test. Different Specimens are casted by using Steel fibres with different fibre volume contents.

FIBRE REINFORCED CONCRETE (FRC)

Concrete has little ability to resist tensile stresses and strains due to its brittle behavior. Conventional steel reinforced concrete is often sensitive to cracking, and these cracks could be the result of early age shrinkage. Cracks can cause the corrosion of steel reinforcements and thereby reducing the lifetime of concrete structures. Attempts to overcome these deficiencies have resulted in the development of Fibre Reinforced Concrete (FRC).

Fibres primarily control the propagation of cracks and limit the crack width. The fibres improve the ductility of the material or more properly, its energy absorption capacity. FRC is made with cement and aggregates of various sizes, incorporating discrete, discontinuous fibres. Conventional fibres such as steel and glass, synthetic fibres such as polypropylene, nylon etc. or natural fibres such as cellulose, sisal, jute etc. are used in FRC. These types of fibres vary considerably both in properties, effectiveness and cost.

Fibre reinforced concrete is concrete made from hydraulic cements with or without aggregates of various sizes and incorporating discrete fibre reinforcements. If aggregates are not incorporated the materials is called Fibre cement in analogy to the well-framed 'asbestos cement'. The utilization of fibre reinforcement imparts improvements within the modulus of rupture, impact and fatigue strengths and toughness, among different things. Asbestos, glass, steel and carbon fibres can be used to reinforce cement matrices.

Some of the practical applications of Fibre- reinforced composites include manhole covers, grain silos, containers, building components, cladding panels, permanent formwork, etc., These are besides special situations such as pile shells, tunnel and sewer linings and stabilisation of rock slopes. Structural Engineering Research centre, Chennai, has developed the know-how for the production of light, medium and heavy-duty fibre reinforced manhole covers.

The durability of steel fibres in cement composites is good, even though surface rusting and straining occur in the concrete. E-glass fibres are attacked by the alkaline, and cement matrix and alkali resistant glass fibres must be used. The use of pozzolanas is found to improve the performance.

Fibre being used in concrete:

Various fibres are being used in concrete to enhance the desired engineering properties. Fibre could be metallic synthetic or natural fibres are shown fig1.

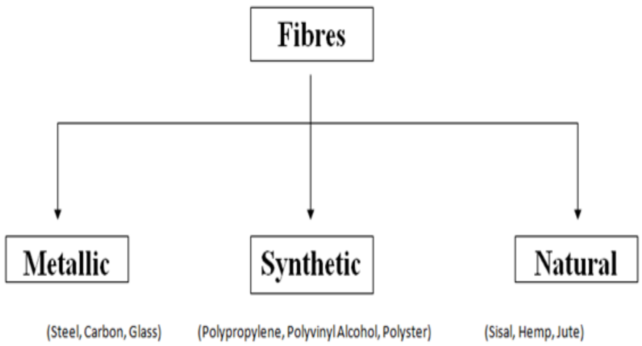

Fig 1. Various types of fibres being used

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Metallic fibres include Steel, Carbon, and Glass etc. Synthetic fibres include Polypropylene, Polyvinyl Alcohol, Polyester etc. and Natural fibres include Banana, Hemp, Jute, Sisal, coconut coir etc.

The addition of non-metallic fibres such as glass, polyester, polypropylene etc. results in good fresh concrete properties and reduced early age cracking. The beneficial effects of non-metallic fibres could be attributed to their high aspect ratios and increased fibre availability at a given volume fraction. Polypropylene (PP) fibres are produced from homopolymer PP resin in a variety of shapes and sizes, and with differing properties. The main advantages of these fibres are their alkali resistance, relatively high melting point (165 0C) and the low price of the material.

Table 1: Properties of various fibres

Fibre	Diameter (μm)	Specific Gravity	Modulus of Elasticity (GPa)	Tensile Strength (GPa)	Elongation at break (%)
Steel	5-500	7.84	200	0.5-2.0	0.5-3.5
Glass	9-15	2.6	70-80	2-4	2-3.5
Asbestos					
Crocidolite	0.02-0.4	3.4	196	3.5	2.0-3.0
Chrysolite	0.02-0.4	2.6	164	3.1	2.0-3.0
Polypropylene	**20-400**	**0.9-0.95**	**3.5-10**	**0.45-0.76**	**15-25**
Aramid (kevlar)	10-12	1.44	63-120	2.3-3.5	2-4.5
Carbon (high strength)	8-9	1.6-1.7	230-380	2.5-4.0	0.5-1.5
Nylon	23-400	1.14	4.1-5.2	0.75-1.0	16-20
Cellulose	-	1.2	10	0.3-0.5	-
Acrylic	18	1.18	14-19.5	0.4-1.0	3
Polyethylene	25-1000	0.92-0.96	5	0.08-0.60	3-100
Wood fibre	-	1.5	71	0.9	-
Sisal	10-50	1.5	-	0.8	3
Cement matrix (for comparison)	-	1.5-2.5	10-45	0.003-0.007	0.02

Role of fibres in concrete:

Properties of concrete are affected by several factors like properties of cement, fine aggregate, coarse aggregate. Aside from this, the fibre reinforced concrete is affected by following factors:

- Type of fibre
- Aspect ratio
- Quantity of fibre
- Orientation of fiber
- Workability of fiber

Aspect ratio:

Aspect ratio is defined as the ratio of length to width of the fibre. The value of aspect ratio varies from 30 to 150. Usually the increase in aspect ratio will increase the strength and toughness until the aspect ratio of 100. Above that the strength of concrete decreases, in view of decreased workability and reduced compaction. From investigations it usually discovered that good results are obtained at an aspect ratio around 80 for PP fibres. Keeping that in view we have considered PP fibres of length 12 mm with aspect ratio of 80 (Length 12 mm and Diameter 0.75 mm).

Fibre quantity:

Generally quantity of fibres is measured as volume of concrete. As the volume of fibres increase, there should be increase in strength and toughness of concrete. Concerning our fibre, we tend to hope that there will be a rise in strength, with increase in fibre content.

Orientation of fibre:

The orientations of fibres play a key role in deciding the capacity of concrete. In RCC the reinforcements are placed in desired direction. But in FRC, the fibres will be placed in random direction. The FRC will have most resistance when fibres are oriented parallel to the load applied.

Workability of fibers

When fibers are added to PCC mixture, decrease in the slump was noticed. Length of the fibres do play a significant role in affecting the workability of the PFRC. Lower fibre dosages did not show much impact on the workability. However, at higher volume level fiber, water reducing admixture and air entraining admixtures enhance workability and provide protections against freeze-thaw cycles (frost action).

Applications of Fibre Reinforced Concrete:

The uniform dispersion of fibres throughout the concrete mix provides isotropic properties are not common to conventionally reinforced concrete. The applications of fibres in concrete industries depend upon the designer and builder in taking advantage of the static and dynamic characteristics of this new material. The main area of FRC applications are:

Runway, Aircraft Parking, and Pavements

For constant wheel load FRC slabs may be regarding one half the thickness of plain concrete slab. Compared to a 375mm thickness of conventionally reinforced concrete slab, a 150mm thick crimped-end FRC slab was used to overlay an existing asphaltic-paved aircraft parking area

Tunnel Lining and Slope Stabilization

Fibre reinforced shortcrete (FRS) are being utilized to line underground opening sand rock slope stabilization. It eliminates the need for mesh reinforcement and Scaffolding.

Thin Shell, Walls, Pipes, and Manholes

Fibrous concrete permits the usage of thinner flat and curved structural elements. In the construction of hemispherical domes, Steel fibrous shortcrete is employed, with the help of using the inflated membrane method. By the addition of Steel and glass fibres in concrete pipes and manholes improves strength, reduces thickness, and diminishes handling damages.

Dams and Hydraulic Structures

FRC is being employed for the development and repair works of dams and other hydraulic structures and to provide resistance to cavitations and severe erosion caused by the impact of large waterborne debris.

Mix proportions for FRC

Computed quantities of cement, fine aggregate and coarse aggregate were mixed thoroughly in a drum type mixer for 2 min. 50% of calculated water was added, mixed thoroughly and rest 50% of water along with appropriate dosages of super plasticizer was added to maintain the workability. PP fibres were manually dispersed into concrete for uniform distribution of fibres and continued mixing for 5 min. Balling effect was observed for fibre dosages of 1.25% and 1.50% in the absence of superplasticizer.

Table 2: Content of mix proportions used

Constituents	Content KG/ m^3 of concrete
Cement	394.32
Fine aggregate	623.45
Coarse aggregate	1097.81
Water content	197.16
Fiber dosage	
0.5%	11.56
1%	23.12
1.5%	34.69
Super plasticizer	9.38

Details of specimen preparation

Cubes of size 150 mm were used to evaluate the compressiev strength and bond strength of PFRC. Cylinders of size 150 mm x 300 mm were used to determine the split tensile strength. Flexural strength of PFRC was evaluated using 100 mm x 100 mm x 500 mm beams. Steel moulds were used for casting the specimens. Concrete was poured in mould in 3 layers and each layer was vibrated for 15 s after placing it on the vibrating table for proper compaction. Smooth surface was ensured by properly levelling the surface of the specimen. Specimens were removed from the moulds after 24 hrs of casting and immersed in clean water for 28 days. Specimens were prepared for fibre dosages of 0.50%, 1.00% and 1.50% of volume of concrete in addition to samples of control mix. Three

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specimens were prepared for each test and average value was obtained.

RESULTS AND DISCUSSION

1. Compressive strength:

Compressive strength is the capacity of material to with stand loads tending to reduce size. The compressive strength of concrete cube of size (15cmx15cmx15cm) for dosage of fibre 0-.5%,1%,1.5% is given by following table 2 for the curing period of 28 days and 56 days.

Table 3: Compressive strength of PFRC at different ages

Fibre dosage (%)	Compressive strength after 28 days	% Growth	Compressive strength after 56 days	% Growth
PCC	39.53	-	40.32	-
0.50%	39.64	0.28	40.56	0.60
1.00%	40.73	3.04	41.54	3.03
1.50%	41.04	3.82	41.88	3.87

Split tensile strength:

Split tensile strength of concrete is one of the method to estimate tensile strength of concrete at which the concrete gets crack after application of load and it is measured by cylindrical specimen which gets the longitudinal cracks after application of load and the test results are given in table3 for a curing period of 28days and 56 days at dosage of fibre content 0.5%,1.0% and 1.5%.

Table4: Split tensile strengthof PFRC at different ages

Fibre dosage (%)	Split tensile strength after 28 days	% Growth	Split tensile strength after 56 days	% Growth
PCC	3.06	-	3.21	-
0.50%	3.12	1.96	3.26	1.56
1.00%	3.21	4.90	3.37	4.98
1.50%	3.31	8.17	3.48	8.41

Flexural strength:

Split tensile strength of concrete is one of the methods to estimate tensile strength of concrete. It is the measure of an unreinforced concrete beam or slab to resist failure in bending. Flexural strength is expressed as modulus of rupture. Flexural strength results are given in table4 for a curing period of 28days and 56 days at dosage of fibre content 0.5%,1.0%&1.5% .

Table5: Flexural Strengthof PFRC at different ages

Fibre dosage (%)	Flexural strength after 28 days	% Growth	Flexural strength after 56 days	% Growth
PCC	4.16	-	4.31	-
0.50%	4.23	1.68	4.36	1.16
1.00%	4.26	2.40	4.43	2.78
1.50%	4.37	5.05	4.65	7.89

Bond strength:

Bond strength is the measure of amount of adhesion between concrete and steel. It measures stress needed to separate the bonded layers each other. Bond strength results are given in table5 for a curing period of 28days and 56 days at dosage of fibre content 0.5%,1.0%&1.5%

Table6: Bond strengthof PFRC at different ages

Fibre dosage (%)	Bond strength after 28 days	% Growth	Bond strength after 56 days	% Growth
PCC	10.02	-	10.14	-
0.50%	10.03	0.10	10.22	0.79
1.00%	10.06	0.40	10.23	0.89
1.50%	9.93	-0.90	10.07	-0.69

Correlation among strength properties:

In this section we are correlating the strength properties those are compressive strength vs split tensile strength, compressive strength vs flexural strength and split tensile strength vs flexural strength for the polypropylene fibre reinforced concrete which we got from laboratory test.

1. Compressive strength Vs Split tensile strength

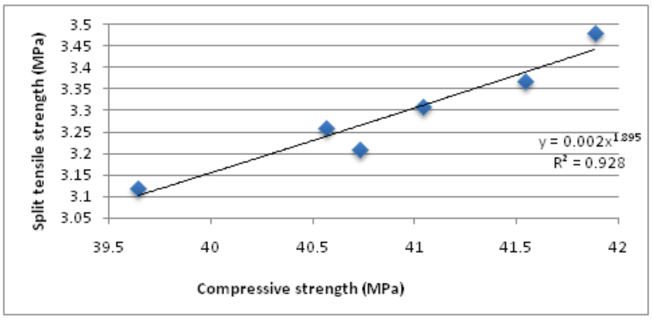

Fig15. Correlation between compressive and split tensile strength

From the chart we can say, that there is a linear relationship exist between compressive strength and split tensile strength that is when compressive stress increases then split tensile is also increase so split tensile strength depends on compressive strength of concrete.

Split tensile strength of concrete = 6 to 8 X square root of compressive strength of concrete.

fst = (6 to 8) *√fc 5

2. Compressive strength Vs Flexural strength

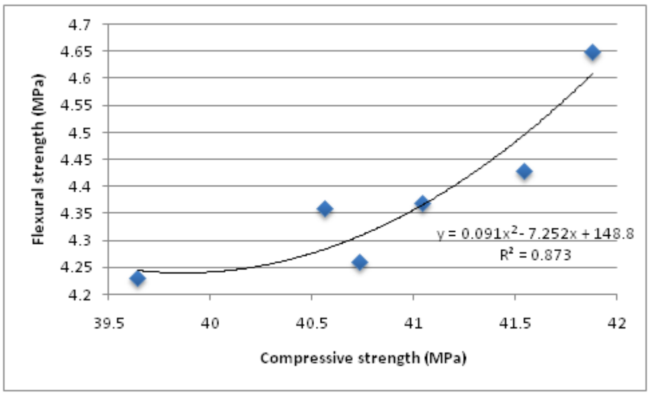

Fig16. Correlation between compressive and flexural strength

From the chart it is clear that flexural strength of concrete increases with compressive strength of concrete upto certain limted conditions only and there is no linear ship between compressive strength and flexural strength of concrete.

Flexural strength of concrete = k X (compressive strength of concrete)n`

fsc = k * (fc)n 6

K,n are coefficents varies from 0.12 to 0.3 and 0.5 to K,n are coefficents varies from 0.12 to 0.3 and 0.5 to 0.75.

3. Split tensile strength Vs Flexural strength

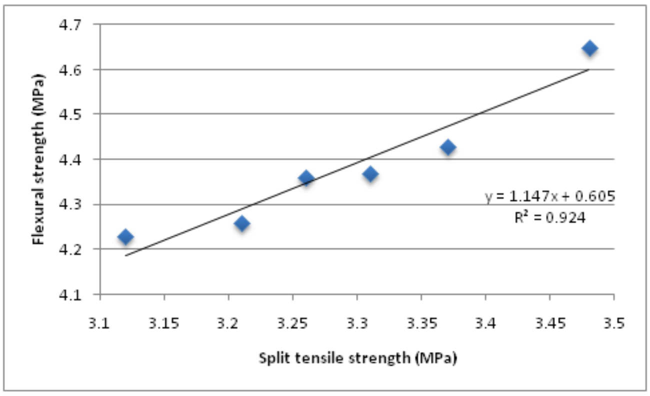

Fig17. Correlation between split tensile and flexural strength

From the chat we can say that there is a linear relationship exist between split tensile strength and flexural strength of concrete that is split tensile strength of concrete influence the flexural strength of concretre and it increses with increse in split tensile strength of concrete.

Fexural srength of cocrete = 0.901 X split tensile strength of concrete + 1.650

fsc = 0.901 * fst +1.650.................7

CONCLUSIONS

Based on the results of this experimental investigation, the following conclusions can be drawn:

1. Polypropylene fibers were found to be effective in improving compressive strength, split tensile strength, flexural strength and bond of the concrete compared to OPC.

2. Compressive strength of concrete increased with increase in fiber dosage and the maximum strength attained for a fiber dosage of 1.50%.

3. Tensile strength of concrete slightly increased with increase in fiber dosage and the maximum Flexural& split tensile strength attained for a fiber dosage of 1.50%.
4. Bond strength of concrete increased with increase in fiber dosage and the maximum strength attained for a fiber dosage of 1.0%.
5. Good correlation was found between compressive strength and Flexural strength of concrete.
6. Flexural strength of concrete increases with increase in compressive of concrete.
7. Bond strength of concrete increases limited dosage of polypropylene fiber.
8. Good correlation was found between split tensile strength and flexural strength of concrete.
9. Equations to predict the Tensile strength of concrete based on compressive strength for PFRC are proposed.

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