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Experimental Investigation Study on Polypropylene Fibre Reinforced Concrete with Mineral Admixtures

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ABSTRACT

This project is deals with the strength of the concrete by adding polypropylene with mineral admixtures in the concrete. Here we should indicate that admixtures are almost always used in modern practice and thus become an essential component of modern concrete. The widespread use of admixture is mainly due to the many benefits made possible by their application. For instance, chemical admixtures can modify the setting and hardening characteristic of cement paste by influencing the rate of cement hydration. Three major components: water, aggregate and cement. Comparing with steel, plastic and polymer, they are the most inexpensive materials and available in every corner of the world. The Polypropylene fibre reinforced concrete (PFRC) contains randomly distributed short discrete Polypropylene fibres which act as internal reinforcement so as to enhance the properties of the cementitious composite (concrete). The principal reason for incorporating the Polypropylene fibres into a cement matrix is to reduce cracking in the elastic range, and to increase the tensile strength and deformation capacity and increase the flexural strength of the resultant concrete.

Keywords: Experimental, Investigation, polypropylene fiber With Mineral admixture

1. INTRODUCTION

1.1.Concrete: Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. Concrete as a composite material that consists of a binding medium within which are embedded particles or fragments of aggregates. The simplest representation of concrete is:

Concrete = Filler + Binder.

According to the type of binder used, there are many different kinds of concrete. For instance, Portland cement concrete, asphalt concrete, and epoxy concrete. In concrete construction, the Portland cement concrete is utilized the most. Thus, in our course, the term concrete usually refers to Portland cement concrete. For this kind of concrete, the composition can be presented as follows Here we should indicate that admixtures are almost always used in modern practice and thus become an essential component of modern concrete. Admixtures are defined as materials other than aggregate (fine and coarse), water, fibre and cement, which are added into concrete batch immediately before or during mixing. The widespread use of admixture is mainly due to the many benefits made possible by their application. For instance, chemical admixtures can modify the setting and hardening characteristic of cement paste by influencing the rate of cement hydration. Water-reducing admixture can plasticize fresh concrete mixtures by reducing surface tension of water, air-entraining

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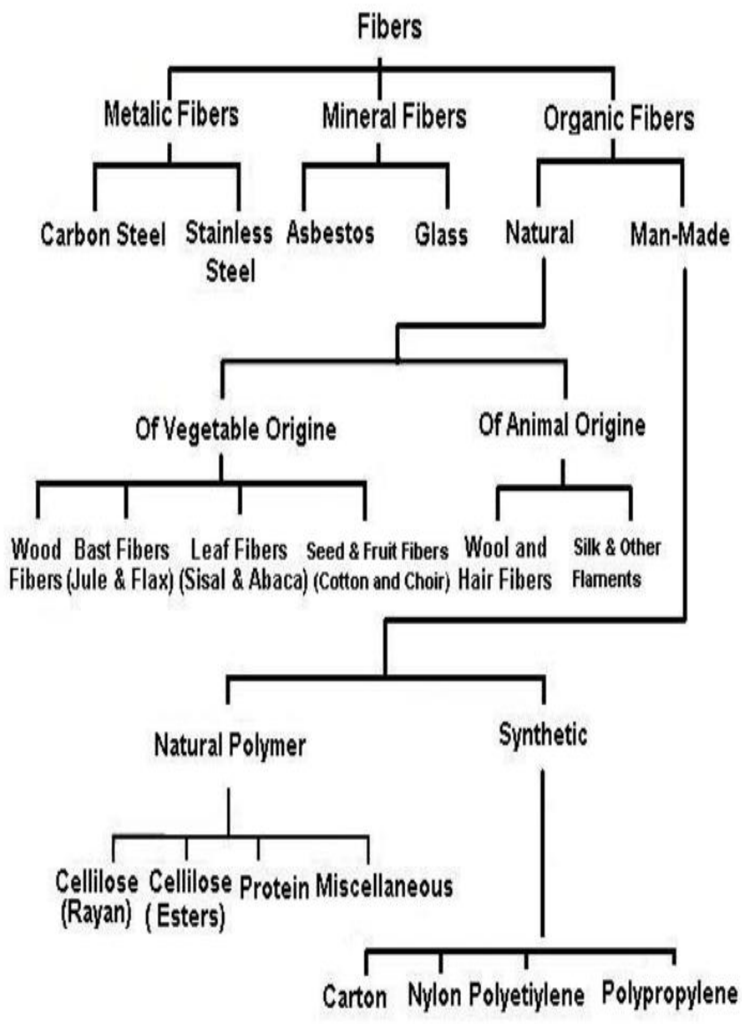
admixtures can improve the durability of concrete, and mineral admixtures such as pozzolans (materials containing reactive silica) can reduce thermal cracking. Advantages and limitations Concrete is the most widely used construction material in the world. It is used in many different structures such as dam, pavement, building frame or bridge. Also, it is the most widely used material in the world, far exceeding other materials. Its worldwide production exceeds that of steel by a factor of 10 in tonnage and by more than a factor of 30 in volume. The present consumption of concrete is over 10 billion tons a year, that is, each person on earth consumes more than 1.7 ton of concrete per year. It is more than 10 times of the consumption by weight of steel. Concrete is neither as strong nor as tough as steel, so why is concrete so popular

1.2. LIMITATIONS:

a) **Quasi-brittle failure mode**: Concrete is a type of quasi-brittle material. (Solution: Reinforced concrete)

b) **Low tensile strength**: About 1/10 of its compressive strength. (Improvements: Fiber reinforced concrete; polymer concrete)



1.3 Types of Polypropylene Fibre

c) **Low toughness**: The ability to absorb energy is low. (Improvements: Fiber reinforced concrete)

d) **Low strength/BSG ratio (specific strength)**: Steel (300-600)/7.8. Normal concrete (35-60)/2.3. Limited to middle-rise buildings. (Improvements: Lightweight concrete; high strength concrete)

e) **Formwork is needed**: Formwork fabrication is labour intensive and time consuming, hence costly (Improvement: Precast concrete)
f) **Long curing time**: Full strength development needs a month. (Improvements: Steam curing)
g) **Working with cracks**: Most reinforced concrete structures have cracks under service load. (Improvements : Prestressed concrete).

2. MATERIAL COLLECTION

2.1 Cement

Ordinary Portland cement, 53Grade conforming to IS: 269 – 1976.Ordinary Portland cement, 53Gradewas used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

2.2 Fine Aggregate
The sand is of river sand screened and washed to remove all the organic and inorganic compounds that are likely to present in it. Sand has been sieved through sieve IS 4.75mm passing through Sieve will be used for casting all the specimens

2.3 Coarse Aggregate
The material which is retained on BIS test sieve 4.75mm is termed as a coarse aggregate. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used in our work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per Indian Standard Specifications IS: 2386-1963.

2.4 SUPERPLASTICIZER
A super plasticizer (SP) based on a modified polycarboxylate was employed to obtain a satisfactory workability of fresh concrete for the different mixes. Properties of the mixture were presented. In usually a

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new generation polycarboxylic and conplast SP430 based super plasticizers are used together with either some chemical or mineral admixtures that provide the appropriate viscosity range.

2.5 SILICAFUME

It is a product of the manufacture of silicon and ferrosilicon alloys from high purity quartz and coal in a submerged arc electric furnace the escaping gaseous oxides condenses in the form of extremely fine spherical particles of amorphous silica called silica fume. Silica in the form of glass (amorphous) is highly reactive and the fineness and spherical shape of particle speeds up the reaction with the calcium hydroxide produced by hydration of Portland cement. The very small particle of silica fume can enter the space between the particles of cement and thus improves packing it also improves workability of mix. silica fume may be added to improve the mechanical properties of PFRC.

2.6 POLYPROPYLENE

The principal reason for incorporating the Polypropylene fibres into a cement matrix is to reduce cracking in the elastic range, and to increase the tensile strength and deformation capacity and increase the flexural strength of the resultant concrete. These properties of PFRC primarily depend upon length and volume of propylene fibres (PPF) used in the concrete mixture.Therefore there is a need to develop information on the properties of Polypropylene Fibre Reinforced Concrete (PPFRC) in which indigenous polypropylene fibres are used in the concrete mixture.An experimental study was undertaken. For the study, fibrillated polypropylene fibres of lengths (lf) of 25 mm (1.00 in) with 0.2%, 0.4%, 0.6%, 0.8% and 1.0% volume fractions (Vf) of were used.

2.7 Water

Casting and curing of specimens were done with the portable water that is available in the college premises.

3. MATERIAL PROPERTIY

3.1. Physical Properties of Cement

Ordinary Portland cement, 53Grade was used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete..

3.1.1 Specific Gravity

The density bottle was used to determine the specific gravity of cement. The bottle was cleaned and dried. The weight of empty bottle with brass cap and washerW_1 was taken. Then bottle was filled by 200 to 400g of dry cement and weighed as W_2.The bottle was filled with kerosene and stirred thoroughly for removing the entrapped air which was weighed as W_3.It was emptied, cleaned well, filled with kerosene and weighed as W_4.

3.1.2 Fineness (By Sieve Analysis)

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster development of strength.

100 grams of cement was taken on a standard IS Sieve No.9 (90 microns). The air-set lumps in the sample were broken with fingers. The sample was continuously sieved giving circular and vertical motion for 15 minutes. The residue left on the sieve was weighed.

3.1.3 Consistency

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency. 500 grams of cement was taken and made into a paste with a weighed quantity of water (% by weight of cement) for the first trial. The paste was prepared in a standard manner and filled into the vicat mould plunger, 10mm diameter, 50mm long and was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was noted. Similarly trials were conducted with higher water cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35mm from the top is known as the percentage of water required to produce a cement paste of standard consistency.

3.1.4 Initial Setting Time

The needle of the Vicat apparatus was lowed gently and brought in contact with the surface of the test block and quickly released. It was allowed to penetrate into the test block. In the beginning, the needle completely pierced through the test block. But after sometime when the paste starts losing its plasticity, the needle penetrated only to a depth of 33-35mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taken as the initial setting time.

3.2 Property of Fine Aggregate

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

3.2.1 Absorption, Porosity, and Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption relates to the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

3.2.2 Surface Texture

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and a cementing material. A rough surface texture gives the cementing material something to grip, producing a stronger bond, and thus creating a stronger hot mix asphalt or portland cement concrete. Surface texture also affects the workability of hot mix asphalt, the asphalt requirements of hot mix asphalt, and the water requirements of portland cement concrete. Some aggregates may initially have good surface texture, but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category.

3.2.3 Strength and Elasticity

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for Portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

3.2.4 Hardness

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness. Weak particles have poor cementation. Neither type is acceptable. The Mohs Hardness Scale is frequently used for determination of mineral hardness.

3.3 Property of Coarse Aggregate

Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability. 20mm down size aggregate was used.

3.3.1 Specific Gravity

A pycnometer was used to find out the specific gravity of coarse aggregate. The empty dry pycnometer was weighed and taken as W_1. Then the pycnometer is filled
with 2/3 of coarse aggregate and it was weighed as W_2. Then the pycnometer was filled with part of coarse aggregate and water and it weighed as W_3. The pycnometer was filled up to the top of the bottle with water and weighed it as W_4.

3.3.2 Bulk Density

Bulk density is the weight of a material in a given volume. It is expressed in Kg/m^3.A cylindrical measure of nominal diameter 250mm and height 300mm was used. The cylinder has the capacity of 1.5 liters with the thickness of 4mm. The cylindrical measure was filled about 1/3 each time with thoroughly mixed aggregate and tampered with 25 strokes. The measure was carefully struck off level using tamping rod as straight edge. The net weight of aggregate in the measure was determined. Bulk density was calculated as follows.

Bulk density = (Net weight of coarse aggregate in Kg)/ (Volume)

3.3.3 Water Absorption

100g of nominal coarse aggregate was taken and their weight was determined, say W_1. The sample was then immersed in water for 24 hours. It was then taken out, drained and its weight was determined, says W_2. The difference between W_1 and W_2 gives the water absorption of the sample.

3.3.4 Fineness Modulus

The sample was brought to an air-dry condition by drying at room temperature. The required quantity of the sample was taken (3Kg). Sieving was done for 10 minutes. The material retained on each sieve after shaking, represents the fraction of the aggregate coarser then the sieve considered and finer than the sieve above. The weight of aggregate retained in each sieve was measured and converted to a total sample. Fineness modulus was determined as the ratio of summation of cumulative percentage weight retained (F) to 100.

3.4 Properties of Water

Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

3.5 Polypropylene Fibre Properties

PROPERTIES	THICK FIBER	FINE FIBER
Nominal diameter (mm)	0.98	0.022
Tensile strength (Mpa)	240	400
Density (gr/cm3)	0.88-0.92	0.91
Elastic modulus (MPa)	5100	8500
Elongation (%)	24.4	12
Shape	Wavy	Flat

3.6 Fresh Concrete Properties

3.6.1 Workability

With the addition of furnace slag, the slump loss with time is directly proportional to increase in the slag content due to the introduction of large surface area in

the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.

3.6.2 Segregation and Bleeding

Furnace slag reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the furnace slag and hence the free water left in the mix for bleeding also decreases. Furnace slag also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

3.7 Hardened Concrete Properties

3.7.1 Compression Test on Concrete Cubes

The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm^2. This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either 15cm cubes or 15cm diameter used. At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under. Minimum cylinder compressive strength = 0.8 x compressive strength cube (10 cm x 10 cm) The concrete specimens are generally tested at ages 7 days and 28 days.

3.7.2 Split Tensile Test on Cylinder

Concrete is strong in compression but weak in tension. Tension stresses are likely to develop in concrete due to drying shrinkage, rusting of reinforcement, temperature gradient etc. In concrete road slab this tensile stresses are developed due to wheel loaded and volume changes in concrete are available to determine this. Split test is one of the indirect methods available to find out the tensile strength

3.7.3 Flexural Test on Beams

It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 6x6 inch concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as “Modulus of Rupture” (MR) in psi. Flexural MR is about 12 to 20 percent of compressive strength.

4. MIX DESIGN

4.1 Definition

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

4.2 Objective Of Mix Design

The objective of concrete mix design as follows.

The first objective is to achieve the stipulated minimum strength.
The second objective is to make the concrete in the most economical Manner. Cost wise all concrete’s depends primarily on two factors, namely cost of material and cost of labour. Labor cost, by way of formwork, batching, mixing, transporting and curing is namely same for good concrete.

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4.3 Factors To Be Considered In Mix Design

1.Grade& type of concrete

2.Type & size of aggregate
3.Type of mixing & curing

4.Water /cement ratio

5.Degree of workability

6.Density of concrete

7.Air content

5. TESTING PROCEDURE

5.1 Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula When a specimen of material is loaded in such a way that it extends it is said to be in tension (Figure.5.1) On the other hand if the material compresses and shortens it is said to be in compression.

Compressive Strength = Load / Area

Size of the test specimen=150mm x 150mm x 150mm

Figure 5.1 Compression Test

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5.2 Split Tensile Test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.

Split tensile strength = 2P/ µdl

Figure.5.2 Split Tensile Test

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the Determination of tensile strength of concrete is necessary to determine the load at which the concrete members may Crack. The cracking is a form of tension failure. Figure.5.2 Shows Split Tensile Test

5.3 Flexural Strength Test

Figure 5.3 Flexural Test

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During the testing, the beam specimens of size 1500mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. The flexural strength was obtained using the formula (R) Flexural strength, also known as modulus of rupture, bend strength, or fracture strength,[a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibres are at the largest stress so, if those fibres are free from defects, the flexural strength will be controlled by the strength of those intact 'fibres'. However, if the same material was subjected to only tensile forces then all the fibres in the material are at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress.

Therefore it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength. If we don't take into account defects of any kind, it is clear that the material will fail under a bending force which is smaller than the corresponding tensile force. Figure 5.3 shows Flexural Strength Test

6. TEST RESULT

6.1 For M35 Grade

RATIO –I

Polypropylene Fibre – 0% addition of fiber
Silica fume – 0% by replacement of cement

RATIO – II
Polypropylene Fibre – 0.2% addition of fiber

Silica fume – 5% by replacement of cement
RATIO – III:
Polypropylene Fibre – 0.6% addition of fiber

Silica fume – 10% by replacement of cement
RATIO – IV
Polypropylene Fibre – 1.0% addition of fiber

Silica fume – 11% by replacement of cement

RATIO – V
Polypropylene Fibre – 1.2% addition of fiber

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Silica fume – 12% by replacement of cement
Above all ingredients are added by weight of cement

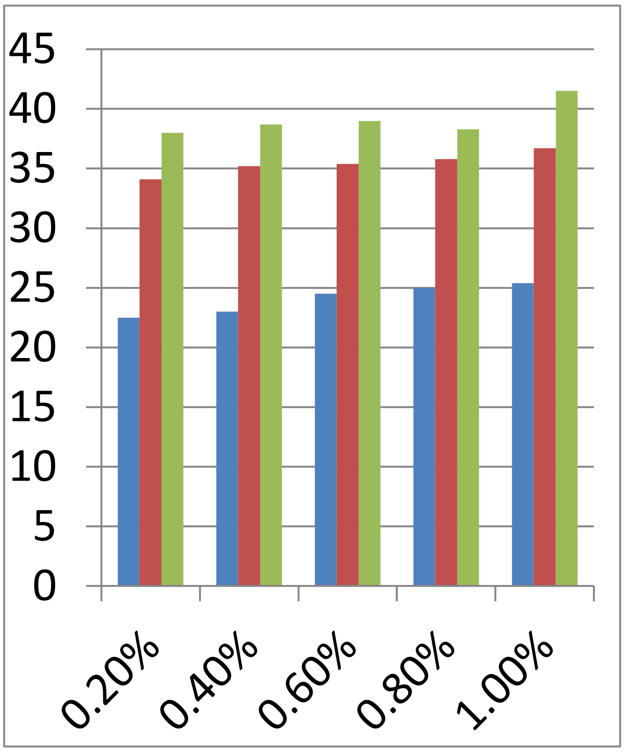
Table 6.1 shown Compressive Test on Cube,
Table 6.2 shown Split Tensile Strength of Cylinder and

.Table 6.1 Compressive strength for addition of polypropylene

Percentage of p/f	0.2 %	0.4%	0.6%	0.8%	1.0%	1.2%
7 days	22.5	23	24.5	25	25.4	25.2
14 days	34.1	35.2	35.4	35.8	36.5	35.6
28 days	38	38.7	39	38.3	41.5	40.8
Avg	31.5	32.3	32.96	33.03	34.5	33.86

The optimum value of addition of polypropylene fibre to the addition of cement is and 1.0%

Figure.6.1 shows Compression Test Graph Result,



Percentage of p/f	0.2 %	0.4 %	0.6%	0.8%	1.0%	1.2%
7 days	2.6	2.65	2.8	2.84	3.0	2.95
14 days	2.6	2.65	2.8	2.84	3.0	2.96
28 days	2.85	2.9	3.0	3.15	3.4	3.35

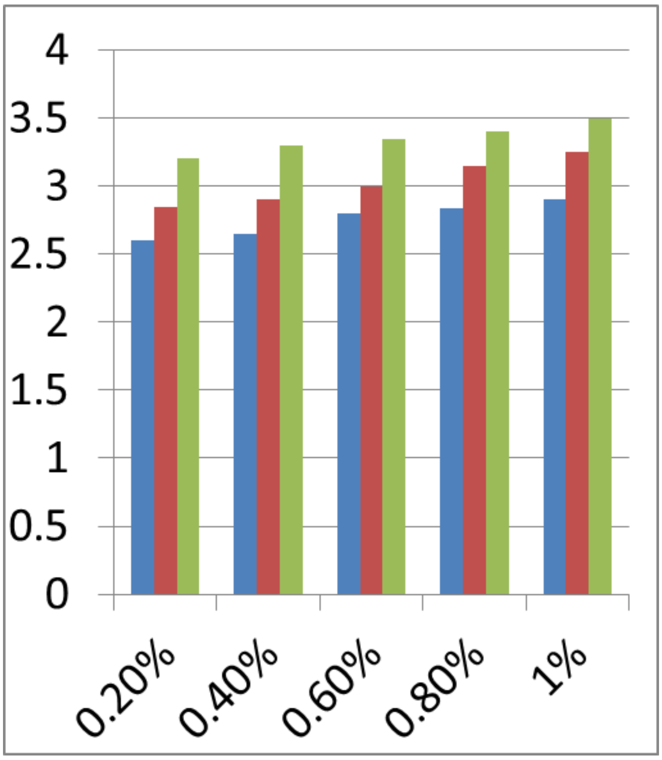


Figure.6.2 shows Split Tensile Test Graph Result

7. CONCLUSION

The conclusions drawn from these experimental investigations are as follows.There was an increase of 6.31 percent in the 28 day compressive strength of PFRC concrete over the control concrete with the replacement of silica fume and the addition percentage of polypropylene fiber. And also 10 percentage of increase in split tensile strength for PRFC concrete over control specimen with the replacement and addition percentages Addition of fibres (1.0% of polypropylene) Flexural Strength increased in 22% by comparing the conventional concrete. And also the PFRC beam did not go for any deflection in intial load. So this concrete reinforced beam can be suggest for taking impact load structures like workshop and it can also can be used for water retaining structures.Due to less weight of these concrete, the total dead load of the building will be reduced. The silica fume is increased the flexural strength of the concrete beam is 38 kn and slica fume and polypropylene fiber reinforcement concrete beam is increased strength is 44kn.

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