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EXPERIMENTAL STUDY ON DIFFERENT PROPORTION OF POLYPROPYLENE FIBER IN HIGH STRENGTH CONCRETE

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Abstract - The present day world is witnessing the construction of very challenging and difficult civil engineering structures. Concrete made with Portland cement has strong compressive strength but it has weak tensile strength and it tends to be brittle. Also cracks start to develop as soon as concrete is placed and before it has properly hardened which may lead to weakening of concrete structures, fracture and failure and general lack of durability. Thus this Project is aimed at reducing the aforementioned shortcomings of concrete to increase its applicability and performance. Addition of fibers also leads to a reduction in shrinkage cracking. We have used Polypropylene as the fiber. Polypropylene fiber, also known as polypropylene or PP, is a synthetic fiber, transformed from 85% propylene and used in a variety of application. It is used in many different industries, Polypropylene Fiber Reinforced Concrete is an embryonic construction material which can be described as a concrete having high mechanical strength, stiffness and durability. Polypropylene fiber reduce the plastic shrinkage crack area due to their flexibility and ability to conform to form. The addition of 0.1% by volume of fibers is found effective in reducing the extent of cracking by a factor of 5-10. The extent of crack reduction is proportional to the fiber content in the concrete. But in this project for phase I study conventional concrete grade of M30. Each series consists of cubes, cylinders and prisms as per IS standard. A series of tests were carried out to find out the compressive strength at the age of 28 days.

Key Words: Polypropylene fiber, Compressive strength, flexural strength, spilt tensile strength etc.

INTRODUCTION

1.1 General

Cement plays the vital role in construction industry. Cement act as a binding material in all concrete structures. The Major problem in concrete structure is minor cracks. These cracks are formed due to overloading, improper design, unskilled labors, quality of materials etc. The cracks that formed that allow unwanted pollutants to penetrate inside the concrete structure which leads to steel corrosion and also the production of cement emits equal tonnage of carbon dioxide(co_2) into the atmosphere and leads to ozone depletion. In this study, We are going to reduce the production of cement which used for repair &maintenance work with use of polypropylene fiber. The purpose of Polypropylene fiber in cement is to reduce water loss from the concrete as well as enhance its structure integrity.

1.2 OBJECTIVES

- The aim of the study was to achieve the maximum strength of concrete by using optimum weight of polypropylene fibers.
- The optimum percentage of polypropylene fiber was obtained to be 1.5% of cement by volume .
- The addition of small amount of polypropylene improved the mechanical properties of concrete

1.3 SCOPE

- This project is used to increase the strength of the concrete
- It used to reduce the high cost of the concrete
- To know the purpose of the polypropylene fiber with cement

2. LITERATURE REVIEW

Saman Khan [1]et.al, represents comparative experimental study on mechanical performance of polypropylene fiber reinforced concrete (PFRC) under compression and split tensile loading. The cube compressive strength and cylinder split tensile strength of conventional concrete and polypropylene fiber reinforced concrete were determined in the laboratory. The M25 and M30 grades of concrete mixes and polypropylene mono-filament macro-fibers of length 35 mm at volume fractions of 0.0%, 0.5%. 1.0%, 1.5%, 2.0%, 2.5% and 3.0% were used in the research. All specimens were tested at curing age of 28 days. In this paper the relationship between cube compressive strength and cylinder split tensile strength for conventional and polypropylene fibre reinforced concrete were established and compared with standards. The study suggested the significant improvement in compressive and tensile strength for concrete mixes reinforced with polypropylene fibres. The samples with added polypropylene fibres of 1% and 1.5% showed better results in comparison with the others.

Priti A. Patel[1] , Dr. Atul K. Desai[2] and Dr. Jatin A. Desai[3][2]Polypropylene fibres dose not disperse properly in the mixing water. Addition of fibres to dry mix was found to be more practical. The presence of fibres in concrete alerts the failure mode of material. It is found that the failure mode of plain concrete is mainly due to spalling, while the failure mode of fibre concrete is bulging in transverse directions. Compressive strength of material increases with increasing fibre content. Strength enhancement ranges from 8% to 16% for PFRC. Strength enhancement in splitting tensile strength due to polypropylene fibre addition varies from 5% to 23%. Split tensile strength at 28'days is approximately 50% higher than 7 day's strength. During the test it was visually observed that the PFRC specimen has grater crack control as demonstrated by reduction in crack widths and crack spacing. The flexural strength increases with increasing fibre content. The maximum increase in flexural strength of PFRC is 36%. The percentage increase in shear strength of the polypropylene fibre mix varies from 23% to 47%. This is because of fibers enhances the load carrying capacity of mix.

Milind V. Mohod[1]etl., [3] It have done different test on concrete for different conditions like control curing & irregular condition, from this it has been seen that for the irregular condition initially have more compressive strength than control curing condition but as the days advances it loses its strength or do not give satisfactory strength as compare to curing condition . Hence for a better strength it may conclude that the curing is an essential parameter. The polypropylene fibers (PPF) reduce early age shrinkage and moisture loss of the concrete mix even when low volume fractions of PPF are used. It was concluded that the increasing percentage volume of fiber added into the concrete would lead the workability decreased. High volume dosage rate above 1.0% showed that the concrete was significantly stiff and difficult to compact. However it also reduced the bleeding and segregation in the concrete mixture. It was also seen that the loss in weight and loss/gain in compressive strength of the cube specimens improved with age. Compressive strength of concrete increases with increase in fiber dosage up to 0.5%, then it starts decreasing. So the optimum percentage fiber found from research is found out to be 0.5%. In splitting tensile strength test, it was found that tensile strength was significantly improved only for 0.5% of fiber dosage and as the percentage of fiber volume dosage increases a continues drop of strength was observed. In flexure strength the improvement in the behavior due to the addition of the PPF is the similar to that in tensile strength. Hence we may conclude that the optimum value of fibre content is 0.5% for both tensile strength and flexural strength. As per the current demand of construction industry new types of concrete are to be invented, which will satisfy the problems observed in traditional concrete. In this approach PPFRC will be a good substitute to meet the present demand of construction industry.

Imtiaz Ahmed Memon a , [4] et.al.,Through the last hundred years, Concrete has established itself as one of the major construction and building materials. This has been mainly due to its excellent durability and availability and ease of molding concrete into any desired shape. Though concrete has various advantages, it is known to strong under compression but relatively weak under tensile stresses. Concrete possesses limited ductility while offering little resistance to abrasion and cracking . Therefore, over the years, researchers have used various materials to reinforce the concrete to withstand such tensile stresses. Civil engineering structures such as houses, bridges, storage tanks, dams, etc. utilize Reinforced Concrete (RC). RC is a type of concrete in which steel bars are used to reinforce the concrete. Steel bars offer concrete to resist the tensile stresses. RC with steel bars has led to reduction in tensile stresses and improvement in behaviour of RC but it also leads to increased self-weight load on the structure due to the use of steel bars to reinforce concrete. Another disadvantage of steel bars in concrete is it can easily be affected by corrosion, causing the steel bars to loss its strength. Composite materials have gained much popularity due to their ductility and strain hardening properties and the disadvantages related to use of steel bars to reinforce concrete. Reinforcement is necessary due to brittle behaviour of concrete; therefore, researchers have turned to the use of fibres, as reinforcement material, which provides ductility to the concrete. The studies conducted on the effect of fibres in concrete has provided an understanding that fibres when used to develop fibre reinforced concrete (FRC) resist the development and propagation of cracks but also improve the tensile strength and enhance the toughness of concrete. Though these are additional benefits, since the fundamental advantage of addition of fibres is to provide crack bridging. In composites materials, fibres are the major reason for the strength, whereas matrices maintain the bonding between the fibres and prevent from external harm. Over the years, many fibres have been developed and utilized in FRC which have been used in the construction of highway pavements and airports, foundations and tunnels. In recent years the polypropylene (PP) fibres have become widely used in various industries. This is due to PP fibres relatively low cost, ease in splitting into finer sizes, are durable in the environment of cement matrix and they are rust-free. Therefore, in this research work, two different fibre lengths at three various dosages were used to study their effect on the strength performance of PP fibre reinforced.

Ahsanafathima K M[1]&Shibi varghese[2],[5] Concrete is by far the most widely used construction material today. It is versatile, has desirable engineering properties, can

be moulded into any shapes and more importantly is produced with cost-effective materials. There is an old saying that broken stone, sand, and cement make good concrete. But the same proportion of broken stone, sand and cement also make bad concrete. To make good concrete now variety of innovative materials such as fibres, admixtures and construction chemicals, pozzolanas and different concrete making techniques are adopted in present day construction. In recent years, intensive research has resulted in advances and innovation in the technology of fibres such as glass, polypropylene, carbon etc., and more basic knowledge has been gained on the behaviors of cement concrete containing these fibres. Concrete containing hydraulic cement, water, aggregate, and discontinuous discrete fibres is called fibre-reinforced concrete. The incorporation of short discrete fibres (steel, polypropylene, glass, carbon) can lead to useful improvements in the mechanical behaviour of tension weak concrete. The steel fibre reinforced concrete yield higher compressive strength with addition of 0.75% steel fibre by volume of concrete. Fibre reinforced concrete with crimped steel fibre of 25mm length with aspect ratio 50 yields better compressive strength than hooked end steel fibre of 30mm length with aspect ratio 50. The steel fibre reinforced concrete yield higher splitting tensile strength with addition of 0.75% steel fibre by volume of concrete. The polypropylene fibre reinforced concrete yield higher splitting tensile strength .

Amsa M[1], Ariyannan P[2],[6] The use of polypropylene fibers, increase in bond strength especially for the mixtures with 8% silica fume. The slump flow of concrete is decreases, when use of 0.3% and 0.5% polypropylene fiber in concrete. Reduced slump flow for 0.3% and 0.5% of fiber usage is 100 mm, and 80 mm, respectively.

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Kolli.Ramujee[7]According to the researches, the increase of formability and bending strength are the extra advantages of adding the fibers to the concrete. Two kinds of fiber that very often used in the concrete are: steel fiber and polypropylene fiber [2]. The evaporation of concrete surface water is a factor in creating the contract paste fracture in concrete which leads to the formation of tension stress since the concrete starts to strengthen [3]. Zeiml et al. [4] mentioned that using polypropylene fibers can improve spalling behavior of concrete. The paste fractures are formed when the acceleration of water evaporation is more than the movement of concrete emulsion to the surface. Here, the negative pressure is generated in the capillaries through which the concrete paste flows and proportionately the tension stress is formed. Such stress is developed during the concrete strengthening and the concrete is cracked where the stress is more than the concrete strength. The cracks caused by paste contracting in the concrete are formed in the first hours after pouring the concrete in the frames and before the concrete reaches its initial strength. Such cracks create critical points in the concrete sensitivity for attaching harmful materials to internal parts of concrete that finally can lead to corrosion and damaging the material in the concrete

M. Najimi, F.M. Farahani and A.R. Pourkhorshidi[8]Concrete is considered to be a relatively brittle material, so it is prone to cracking. Many investigations have been carried out in order to overcome this problem. The inclusion of adequate fibers improves tensile strength and provides ductility [1-3]. There are more investigations on the effects of different fibers on concrete properties [4-9]. Some of the important effects of fibers in concrete are: increasing the tensile strength, preventing the crack development and increasing the toughness of concrete.

Salahaldein Alsadey[1] , Muhsen Salem[2][9]The concrete is one of the most widely used construction material in developed and developing countries. The performance of concrete depends on its ingredients. It is well known that plain concrete is brittle and weak in tension. One of the objectionable characteristics of the concrete as a brittle material is its low tensile strength, and strain capacity. Therefore it requires reinforcement in order to be used as the most widely construction material. Conventionally, this reinforcement is in the form of continuous steel bars placed in the concrete structure in the appropriate positions to withstand the imposed tensile and shear stresses. Fibers, on the other hand, are generally short, discontinuous, and randomly distributed throughout the concrete member to produce a composite construction material known as fiber reinforced concrete (FRC).

M. A. Mashrei, Ali A. Sultan, Alaa M. Mahdi[10]Concrete material is strong in compression while it is very weak in tension so, it tends to be brittle material. Using steel reinforcement and/or a sufficient amount of fibers, the weakness in tension can be resolved. Using of fibers also leads to change the behavior of concrete members after it has been cracked, thereby improving its toughness. Nowadays, many types of fiber, such as carbon, glass, steel and polypropylene fibers are frequently used in many projects such as high buildings, prestressed and precast concrete elements, bridges, dams, etc. The fibers can influence the properties of concrete both in fresh and hardened forms. The term “fiber reinforced concrete” is defined by ACI Committee 544 as a cement material mixed with aggregate and discontinuous discrete fibers [1].

Concrete is the most widely structural material used worldwide.

3.POLYPROPYLENE FIBER

The fiber dispersion into concrete is one of the technique to improve the building properties of concrete. Polypropylene fibers are synthetic fibers obtained as a by-product from textile industry. These are available in different aspect ratios and are cheap in cost. Polypropylene fibers are characterized by low specific gravity and low cost. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking. It provides reinforcement and protects damage of concrete structure and prevents spalling in case of fire. The fibers are manufactured either by the pulling wire procedure with circular cross section or by extruding the plastic film with rectangular cross-section. They appear either as fibrillated bundles, mono filament. The fibrillated polypropylene fibers are formed by expansion of a plastic film, which is separated into strips and then slit. The fiber bundles are cut into specified lengths and fibrillated. In monofilament fibers, the addition of buttons at the ends of the fiber increases the pull out load. Cracks play an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. If these cracks do not exceed a certain width, they are neither harmful to a structure nor to its serviceability. Therefore, it is important to reduce the crack width and this can be achieved by adding polypropylene fibers to concrete. Thus addition of fibers in cement concrete matrix bridges these cracks and restrains them from further opening. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibers. 2 This process, apart from preserving the integrity of concrete, improves the load carrying capacity of structural member beyond cracking. In this project polypropylene fibers of blended (24mm, 40mm, 55mm) type is used.

3.1. CHARCTERISTICS OF POLYPROPYLENE FIBER

Polypropylene (PP) is the first stereo regular polymer to have reached industrial importance. It is a **thermoplastic**, meaning that it becomes pliable or moldable at a certain elevated temperature and solidifies upon cooling. Polypropylene is processed into film for packaging and into fibers for carpets and clothing. PP belongs to the group of polyolefin and is partially crystalline and non-polar. It has similar properties as polyethylene, but it is harder and more heat resistant. It is a white rugged material with a high chemical resistance. Poly propylene is the second-most widely produced commodity plastic (after polyethylene) and it is often used for product packaging and labeling.

Polypropylene chips can be converted to fiber/filament by traditional melt spinning process**.** The first fibres from polypropylene were introduced to the textile industry in the 1970s and have become an important member on the synthetic fibres market.

Polypropylene fiber displays **good heat insulating properties** and is **highly resistant to acids, alkalies, and organic solvents**. The fiber is sensitive to heat and light, but the resistance to these agents can be influenced by added stabilizers. Filaments and monofilaments are used in the manufacture of cables, nets, filter fabrics and upholstery. In staple form, the fiber is used in carpeting, blankets, outerwear fabrics, knitwear, and filter fabrics. Textured polypropylene fiber is mostly used for carpet manufacturing. Growth in demand of PP is very high, and it is mainly due to its distinct technical features:

- light weight
- strong
- hydrophobic
- flexible
- has low thermal conductivity etc.

Because of all this, it is widely used to make undergarments, jackets for outerwear, swimming suits, filters, bags and diapers.

3.1.1.Properties of Polypropylene Fiber

1) Fiber Structure and Characteristics

PP fibers are composed of crystalline and non-crystalline regions. Each crystal is surrounded by non-crystalline material. Fiber spinning and drawing may influence the orientation of both crystalline and amorphous regions.

The degree of **crystallinity** of polypropylene fiber is between 50-65% in general, depending on the processing conditions. Crystallization occurs between glass transition temperature and the equilibrium melting point of PP. The crystallization rate is faster at low temperatures.

In general, polypropylene fiber has excellent chemical resistance to acids and alkalis, high abrasion resistance and resistance to insects and pests. PP fiber is also easy to process and inexpensive compared to other synthetic fibers. It also has low moisture absorption.

Some of the **main PP fiber characteristics**:

- gives good bulk and cover
- resistant to abrasion, deteriorations from chemicals, mildew, perspiration, rot, stain, soil and weather conditions
- resistant to bacteria and micro-organisms
- colorfast
- quick drying
- anti-static behavior
- thermally bondable
- strong
- dry hand
- comfortable and lightweight

Because of its low specific gravity, polypropylene yields the greatest volume of fibre for a given weight. This high yield means that polypropylene fibre provides good bulk and cover, while being lighter in weight. Polypropylene is the lightest of all fibers (for example, it is 34% lighter than

polyester and 20% lighter than nylon), even lighter than water.Polypropylene fibre is easy to process in factories and the production is inexpensive.

3.1.2 PHYSICAL PROPERTIES

Lime hardens much more slowly than cement-containing mortars, making it much more workable. Lime is also less brittle and less prone to cracking, and any cracked areas can absorb carbon dioxide and mend over time. Cement hardens very quickly, but may be too strong for some applications, e.g., working with old bricks. Cement is also prone to cracking as a structure settles, and may eventually require repair.

4.MATERIALS

4.1 CEMENT

Cement is a binding material which possess very good adhesive and cohesive properties which makes PPC of 53 grades in one lot was procured and stored in air tight container. The cement used was fresh i.e. used within three months of manufacture. It should satisfy requirement of IS12262.

4.2 FINE AGGREGATE

A fine aggregate obtained from the river is used for experimental purpose. The less amount of clay and silt (<3% by weight). The hire from silt, clay, salt and organic material and it was clean and dry. It is of size retained in 1.19 micron sieve. The coarse aggregate is strongest and porous component of concrete. Presence of coarse aggregate reduces the drying. shrinkage and other dimensional changes occurring on account of movement of moisture. The coarse aggregate used passes in 19 mm and retained in 11.4mm sieve. It is well graded (should of different particle size and maximum dry packing density and minimum voids) and cubical in shape.

5.Mix Design:

The target mean strength was 30 MPa for the OPC control mixture the total binder content, fine aggregate and coarse aggregate is taken listed in table 6.1 and the water to binder ratio was kept constant as 0.4 and the maintain a slump of (50-100 mm) for all mixtures. Experimental investigation of fresh mix Properties of conventional concrete were conducted based on IS: 516 - 1959 using a slump cone. Compressive and Flexural strength of each specimen was determined using IS: 516 – 1959 and splitting tensile strength of each specimen was determined using IS: 5816 - 1959.Length change was measured according to IS: 516 - 1959.

Table.1 Mix Design(Cement;Sand;Aggregate)

CEMENT	SAND	AGGREGATE
1	2.6	3.66
367	645.54	1264.038

6 Casting & Curing:

Casting of Cubes of 150 x 150 x 150 mm cast in cast iron mould for compression strength testing. Prisms are cast in 500 x 100 x 100 mm mould size for the flexural strength testing and Cylinders of 150mm diameter and 300mm height of mould for split tensile strength testing. Fresh concrete was placed into the moulds and compacted using vibrator table for 30Seconds. Curing of specimen After 24 hours of casting, the specimens were de-moulded and placed in water tank and allowed for curing. Curing is an important process to prevent the concrete specimens from losing of moisture while it is gaining strength. After 7 days, 14 days and 28 days of curing, the specimens were taken out from water and allowed it for drying and hardened properties test of M40 conventional concrete were carried out.

7.Testing

7.1TESTS ON HARDENED CONCRETE

The mechanical properties related tests were carried out on hardened concrete at the age of 7 days, 14 days, and 28 days to ascertain the cube compressive strength, cylinder Split Tensile strength and prism Flexural strength.

7.2 Compressive Strength: Compressive strength of concrete is tested on cube (150×150×150) at different percentage of polypropylene and Coir fiber and Silica fume content in concrete. The strength of concrete has been tested on cube at 28 days. 28 days test gives the data of final strength of Concrete at 28 days curing. This will produce internal voids in concrete mix which leads to decrease the total density of mix and thereby decrease the compressive strength of the mix. Compression testing machine is used for testing the compressive strength test on concrete.

At the time of testing the cube is taken out of water and dried and then tested keeping the smooth faces in upper and lower part. The strength of concrete is very much dependant up on the hydration reaction.

8 RESULT AND DISCUSSION

8.1 COMPRESSIVE STRENGTH OF CONCRETE

For cubes, compressive strength test was conducted at the curing age of 7 and 28 days, the cubes are casted with different proportions on combined Polypropylene addition to weight of cement.

Table.2 Compressive Strength of Concrete

S.No	Proportional	7 days	28 days
1	Conventional	23.25	32.58
2	0.4%	16.62	29.18
3	0.6%	23.99	34.66
4	0.8%	25.62	37.62
5	1.0%	23.25	32.29

9 CONCLUSION

Based on the experiment conducted the following observation were made Compressive strength properties of polypropylene fiber reinforced concrete increase as the percentage of polypropylene fiber increase up to 0.80% increasing strength.

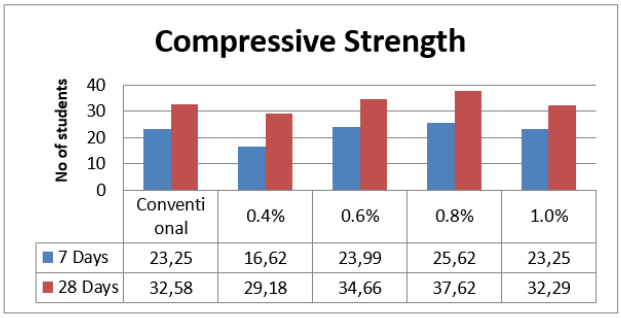

Figure.1

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