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Experimental Investigation of Concrete Using Polypropylene As An Admixture : A Review

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ABSTRACT

A composite material that consists essentially of a binding medium, such as a mixture of Portland cement and water, within which are embedded particles or fragments, usually a combination of fine and coarse aggregate. The tensile strength of concrete is much lower than its compressive strength, it is typically reinforced with steel bars; reinforced concrete. Concrete has better resistance in compression while steel has more resistance in tension. Conventional concrete has limited ductility, low impact and abrasion resistance and little resistance to cracking. Good concrete must possess high strength and low permeability. Hence, alternative Composite materials are gaining popularity because of ductility and strain hardening. To improve the post-cracking behaviour, short discontinuous and discrete fibres are added to the plain concrete. The addition of fibres improves the post-peak ductility performance, pre-crack tensile strength, fracture strength, toughness, impact resistance, flexural strength resistance, fatigue performance etc. The ductility of fibre-reinforced concrete depends on the ability of the fibres to bridge cracks at high levels of strain.

This paper presents review of literature related to advance concrete technology

Keywords : Concrete, Polypropelenefibre, Glass Fibre, Compressive Strength, Flexural Strength.

I. INTRODUCTION

Polypropylene fibres are new-generation chemical fibres. They are manufactured on large scale and have the fourth-largest volume in production after polyesters, polyamides and acrylics. About 4 million tons of polypropylene fibres are produced in the world in a year. Polypropylene fibres are hydrophobic, that is they do not absorb water. Therefore, when placed in a concrete matrix they need only be mixed long enough to insure dispersion in the concrete mixture. Polypropylene fibres are thermoplastics produced from Propylene gas. Propylene gas is obtained from the petroleum byproducts or cracking of natural gas feedstocks. Propylene polymerizes to form a long polymer chain under high temperature and pressure. However, polypropylene fibres with controlled configurations

of molecules can be made only using special catalysts. Polypropylene fibres were formerly known as Stealth. These are micro reinforcement fibres and are 100% virgin homopolymer, polypropylene graded monofilament fibres. They contain no reprocessed Olefin materials.

The research papers from different authors are summarized below which states the characteristics and specific properties of different fibres acting on the concrete properties and valuated their results through strength check.

II. Literature Review

In the research paper, Liu Lei et.al (2021), polypropylene fiber-reinforced high-performance concrete was developed and a series of tests were carried out to obtain its mechanical and thermal properties. Low-strength HPC—i.e., C30, C40, and C50—was instigated in research, and the split Hopkinson pressure bar (SHPB) was employed to carry out the dynamic tests of the HPC under various loading rates and the principles of the SHPB were introduced in detail. The polypropylene fibre-reinforced HPCs were heated to multiple high temperatures and measures were taken to keep the temperatures relatively constant.

It was found that at temperatures lower than 100 ◦C, the specimen could still be kept in its entirety, although many fractures were produced in the HPC specimen under dynamic loading conditions. However, it was found that at temperatures higher than 200 ◦C, all the HPC samples were smashed into fragments. In addition, the HPC's compressive strength was found to be significantly influenced by the temperature. At temperatures lower than 300 ◦C, the HPC's compressive strength was found to increase with increases in temperature. At temperatures higher than 300 ◦C, the HPC's compressive strength was found to decrease with increases in temperature.

K.L Ravisankar and K.Jeevanantham (2021) the primary objective of the research paper was to achieve the maximum strength of concrete by using optimum weight of polypropylene fibers. 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.

Results stated that compressive strength properties of polypropylene fiber reinforced concrete increase as the percentage of polypropylene fiber increase up to 0.80% increasing strength.

Mehul J.Patel and S.M. Kulkarni (2020) research paper dealt with the effects of the addition of various proportions of polypropylene fibres on the properties of High strength concrete. The primary aim was to prepare the strength of concrete of grade M40 with locally available ingredient and then to study the effect of different proportion of Polypropylene fiber in the mix and to find optimum range of Polypropylene fiber content is 0.5%,1.0%,1.5% in the mix. The concrete specimens were tested at different age level for mechanical properties of concrete, namely, cube compressive strength, split tensile strength, flexural strength and other test were conducted for cement, chemical admixture, coarse aggregate & fine aggregate.

Results stated that compressive strength increases with the increase in the percentage of Fly ash and Polypropylene fibre up to addition of Cement in Concrete for different mix proportions. Polypropylene fibre can be used with admixtures, plasticizers, and super plasticizers, for increasing the strength of concrete with partial replacement of cement. The workability of Polypropylene fibre concrete has been found to decrease with increase in Polypropylene fibre content replacement.

Polypropylene fibre is Reduce number of joints And Reduce repair due to subsequent damage.

P. Amsayazhi, et.al (2019) aim of the research paper was to analysis the effect of Polypropylene fiber (0% , 1%,1.5%, 2%) and glass fiber (0% , 1%,1.5%, 2%) and glass and polypropylene combined (0.5%+1.5%), (1.5%+0.5%), (1%+1%) mix by varying content and discovering the optimum fiber content that shows better durability. The specimens were investigated at different age levels for durability.

Results stated that the inclusion of polypropylene and glass fibers improved durability of concrete. The increase or decrease in compressive strength of the concrete specimens enhanced with time. The compressive strength of the concrete decreases with the increase in the fiber content amount subjected to acid curing and normal curing. If high durability is exhibited by the concrete specimens it establishes a good property for the structure. The polypropylene and glass fibers reduce the cracks by filling the gap with fibers and minimize interconnecting voids.

P. Akhil Kumar et.al (2019) primary objective of the research paper was to investigate the influence of widely used steel fibers and polypropylene fibers on the concrete. Five concrete mixes were made with steel fiber in dosages of 2.5%, 2%, 1.5%, 1% and polypropylene fibers are in dosage 0%, 0.5%, 1%, 1.5% of the weight of concrete mix. The specimens were casted and all the specimens are tested for 7days and 28 days strength.

Results depict that 4.2%, increase in its strength for mix1 (0.5%polypropylene fibers + 2.5% steel fibers), 9.12%, increase in its strength for mix2 (1%polypropylene fibers + 2% steel fibers), 18.04%, increase in its strength for mix3 (1.5%polypropylene fibers + 1.5% steel fibers) and 21.99%, increase in its strength for mix4 (2%polypropylene fibers + 1% steel fibers) in comparison to conventional concrete.

Arumugam .V et.al (2018) in the research paper, polypropylene fibers were added to Geopolymer Concrete (GPC) so as to improve the mechanical properties in different percentage. Geopolymer Concrete (GPC) is manufactured by alkali activation on dry mix which contains fly ash, coarse and fine aggregates. Sodium hydroxide and Sodium silicate were used as an alkali activator solution and super plasticizer was added to improve the workability of GPC. GGBS, a by-product from steel industries, was used to replace flyash at the rate of 10% to avoid heat curing of Geopolymer concrete in the investigation. The mixture was investigated for compressive strength, split tensile strength and flexural strength.

Test results stated that PP fibers at 2.5% resulted in 73.47% increase in compressive strength, 13.40% increase split tensile and 44.24% increase flexural strength compared to other combinations. It was concluded that the polypropylene fibers at 2.5% can be used as a promising additive to the geopolymer concrete to enhance the properties of geopolymer concrete.

Rasheed Abdulwahab et.al (2018) objective of the research paper was to complement the deficiency in the tensile zone using polypropylene. A concrete grade (M20) was batched, synthetic fibre (polypropylene) was used, and two categories of concrete specimens; with and without propylene fibre. The fibre was introduced in varying percentages (0.2%, 0.4%, and 0.6%) by weight of concrete.

Results stated that the compressive strength of concrete containing 0.4% polypropylene fibre at 28 days has the highest value of 32.22N/mm2 as compared to 30.22N/mm2, 30.49N/mm2 and 30.39N/mm2 for 0%, 0.2%, and 0.6% respectively. The splitting tensile strength at 7 days increases from 6.176 N/mm2 to 8.386 N/mm2 as the percentage of fibre increases from 0% to 0.4%.

Ahmed Mohamed Korany et.al (2017) research paper investigated the effect of the addition of steel and polypropylene fibers on the mechanical properties of high-strength concrete (HSC). Straight steel fibers (ST) with a 63mm length and 0.9 mm diameter, and Polypropylene fibers (PP) with a 12-mm length and

0.018 mm diameter were used. Each type separate and three mixtures were produced with the combination of steel and polypropylene fibers at (0.25% ST +0.75PP), (0. 5% ST +0. 5 PP) and (0.75% ST +0.25 PP). Slump, Compressive strength, split tensile strength, and flexural strength tests were performed and results were analyzed to associate with fiber combinations.

The best performance was attained by a mixture that contained 0.75% ST and 0.25% PP. The results stated that introducing fibers to concrete resulted in increase in Compressive strength, split tensile strength, and flexural strength and depending on the fibers ratio used, compared to the mixture of plain concrete.

Vinodh Kumar Balaji and Chinnakotti Sasidhar (2017) research paper outlined an experimental study that measures the effects of polymer fiber on Mechanical properties of concrete. Aim was to evaluate the mechanical properties of concrete by using PP fibers. Specimens were prepared with various combinations of 0.6%, 0.8 %, 1.0 %, 1.2 %, 1.5 %, and 2.0 % of Polypropylene fibers by volume fraction for all proportions. The experimental methodology and experimental result related to Compressive strength of cubes for 3 days, 7 days, and 28 days, 56 days, 90 days was presented. Split tensile strength, flexural strength of Concrete at 28 days of curing was evaluated.

Results stated that the compressive strength of concrete increased by 20.85 % with PP fibers. The Tensile strength of concrete increased by 27.74 % with PP fibers and the flexural strength of concrete increased by 73.33 % with PP fibres. Conclusion stated that Polymer fiber reinforced concrete is the most effective type of concrete withstands the adverse environmental conditions such as corrosion and other distress due to poor quality, execution and maintenance works. Use of polypropylene fiber concrete composites increases the structural stability of a structure due to better flexural, bond, and compressive strengths.

Divya S Dharan and Aswathy Lal (2016) in the research paper, polypropylene fibers of blended (24mm, 40mm, 55mm) type was used where the experimental program dealt with the effects of addition of various proportions of polypropylene fiber on the properties of concrete in fresh and hardened state so as to explore its effects on workability, compressive, flexural, split tensile strength and modulus of elasticity of concrete. Polypropylene fibers of different percentage (0.5%, 1%, 1.5%, and 2%) added with optimum replacement of steel slag for the fine aggregate in concrete was used.

Results stated that compressive strength of 1.5% of blended length polypropylene fiber reinforced concrete has found to be 21% increase in strength, when compared to that of Conventional concrete. Strength enhancement in split tensile strength is 26%, flexural strength is 29%and modulus of elasticity is 15% compared to that of Conventional concrete. 30% of steel slag with 1.5% fiber in concrete yields max. strength.

Ferhat Bingöl and Majid Atashafrazeh (2015) research paper investigated the strength of polypropylene fiber on fire resistance in concrete. Therefore concrete mixtures are prepared by using different amount of polypropylene; 0, 300, 600 and 900g by volume. In order to consider the test result's accuracy, three specimens were prepared from each group of the concrete mixes. All of them were kept under curing standards for 28 days. After curing period of the specimens, each group were exposed to 23, 300 and 750°C for 2 hours. Then the compressive strengths of the specimens were determined. The maximum compressive strength at 23°C was determined for the group of 300g polypropylene fibers concrete and this increase was about 5.6% in compare with the control specimens (control specimens: concrete without any polypropylene fiber)

but the maximum strength was determined for the group of 600g polypropylene fibers concrete at 300°C and its increase was 10.1% in comparison with the control specimens.

In the compressive strength test, the maximum strength has been obtained for the concrete by mixing 600 g/m3 woolen polypropylene fiber at 300°C. The strength increasing is about 10.1% in comparing with the control specimens and the minimum strength has been obtained for the concrete by mixing in 900 g/m3 woolen polypropylene fiber at 750°C. It was concluded that the relative compressive strengths of specimens containing some polypropylene fibers were higher than control specimens. Furthermore, it can be concluded that concrete specimens with 300g polypropylene fibers can significantly promote the residual compressive strength during the high temperature. That is because of the melting of the polymers which causes concrete to change to a porous material and prevent explosion of the concrete at high temperatures.

Milind V. Mohod (2015) research paper dealt with the effects of the addition of various proportions of polypropylene fibres on the properties of High strength concrete (M30and M40 mixes). An experimental program was carried out to explore its effects on compressive, tensile, and flexural strength under different curing conditions. The main aim of the investigation program is to study the effect of Polypropylene fiber mix by varying content such as 0% ,0.5%,1%,1.5% & 2% and finding the optimum Polypropylene fibre content. The concrete specimens were tested at different age level for mechanical properties of concrete, namely, cube compressive strength, split tensile strength, flexural strength. A detailed study was carried out for curing conditions. Half of the concrete specimens were left exposed to the surroundings to cure by themselves and the remaining half were cured in a curing tank.

Results stated that the use of fiber in the concrete decreases the workability of the fresh concrete Evidence of low workability was shown through the results of workability test obtained in the standard slump test. It was concluded that the increasing percentage volume of fibre 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. Compressive strength of concrete increases with an increase in fiber dosage up to 0.5%, then it starts decreasing. So the optimum percentage fiber found from research was found out to be 0.5%. In the splitting tensile strength test, it was found that tensile strength was significantly improved only for 0.5% of fibre dosage and as the percentage of fibre volume dosage increases a continuous drop of strength was observed. In flexure strength, the improvement in the behaviour due to the addition of the PPF is 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.

Saman Khan et.al (2015) research paper presented comparative experimental study on mechanical performance of polypropylene fibre reinforced concrete (PFRC) under compression and split tensile loading. The cube compressive strength and cylinder split tensile strength of conventional concrete and polypropylene fibre reinforced concrete were determined in the laboratory. The M25 and M30 grades of concrete mixes and polypropylene mono-filament macro-fibres 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 and the relationship between cube compressive strength and cylinder split tensile strength for conventional and polypropylene fibre reinforced concrete were established and compared with standards.

Results stated that Inter comparison of compressive strength and tensile strength with fibre the maximum

strength is achieved in M20 mix. On an average to gain maximum compressive and tensile strength with mono-filament macro fibre the optimum dosage be limited 1%to 1.5%, after further increase these strength properties decreases. The comparison of compressive strength concludes that with increase in cement content the strength gain due to percentage of fibre decreases. The increase in cement content with increased percentage of fibre caused loss of strength even greater.

Vahid Afroughsabet and Togay Ozbakkaloglu (2015) research paper investigated the effect of the addition of steel and polypropylene fibers on the mechanical and some durability properties of high-strength concrete (HSC). Hooked-end steel fibers with a 60-mm length were used at four different fiber volume fractions of 0.25%, 0.50%, 0.75%, and 1.0%. Polypropylene fibers with a 12-mm length were used at the content of 0.15%, 0.30%, and 0.45%. Some mixtures were produced with the combination of steel and polypropylene fibers at a total fiber volume fraction of 1.0% by volume of concrete, in order to study the effect of fiber hybridization. All the fiber-reinforced concretes contained 10% silica fume as a cement replacement. The compressive strength, splitting tensile strength, flexural strength, electrical resistivity, and water absorption of the concrete mixes were examined.

Results of the experimental study indicated that addition of silica fume improves both mechanical and durability properties of plain concrete. Incorporation of steel and polypropylene fibers improved the mechanical properties of HSC at each volume fraction considered in this study. It was observed that the addition of 1% steel fiber significantly enhanced the splitting tensile strength and flexural strength of concrete. Among different combinations of steel and polypropylene fibers investigated, the best performance was attained by a mixture that contained 0.85% steel and 0.15% polypropylene fiber. Introducing fibers to concrete resulted in a decrease in water absorption and, depending on the type of fibers, significant or slight reduction in the electrical resistivity of concrete compared to those of the companion plain concrete.

Seyed Hamed Ahmadipourinaeim and Younes Saberi (2014) research paper investigated the effect of polypropylene fibers on the compressive strength and heat resistance of concrete with high strength. Polypropylene fibers with different lengths, including 5, 10, 15 20 and 25 mm and different weight, including 0.5, 0.8, 1.3 and 1.7 kg/m was 3 used in the concrete.

The results indicated that the strength and heat resistance of the concrete have increased with the use of polypropylene fibers

Priti A. Patel et.al (2012) research paper explored properties such as compressive strength, flexural strength, split tensile strength and shear strength of polypropylene fibre reinforced concrete. The objective of the experiemntal study was to determine the properties of the fresh concrete mixtures using fiber and investigate and compare the properties of hardened concrete for control and various PFRC mixes so as to observe the difference between failure patterns of plain and PFRC specimens.

Results stated that 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. 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% as fibres enhance the load carrying capacity of mix.

III. CONCLUSION

The inclusion of polypropylene and glass fibres improved durability of concrete. The increase or decrease in compressive strength of the concrete specimens enhanced with time. The compressive strength of the concrete decreases with the increase in the fibre content amount subjected to acid curing and normal curing. If high durability is exhibited by the concrete specimens it establishes a good property for the structure. The polypropylene and glass fibres reduce.

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