Effect of Steel and PET Fibers on Properties of Concrete: A Review

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Abstract : In any type of civil engineering construction, concrete is the most critical material used. Some of its properties, such as durability, strong compressive strength, specific gravity, etc. primarily increase the performance of the concrete at the construction stage. Since every material or system has some cons so does concrete. Concrete structures possess low impact strength, low tensile strength, brittleness, heavy weight, etc. Since it possess greater number of advantages, therefore it become mandatory to add a suitable material which in turn can enhance its mechanical properties. One of the main issues is the treatment and recycling of waste at appropriately defined sites, which has important environmental consequences. The use of waste in civil engineering construction is also considered an appropriate and desirable option for the recycling and preservation of environmental degradation. The paper offers a detailed overview of experimental methods used by different scholars to add PET shredders as a substitute for coarse aggregate, fine aggregate and often used as concrete fibres to strengthen the mechanical properties of concrete that is not just eco-friendly but also techno-economical for industrial usage at the same time.

***IndexTerms* – Properties of concrete, PET, coarse aggregate, environmental degradation.**

I. Introduction

Huge amount of waste generation has been observed due to the increased use of PET bottles. The Indian recycling capacity is around 147,000 TPA which is huge and requires large dumping landfills. Now-a-days the cost of virgin PET production for general use has exceeded the recycling cost of PET bottles. To find a solution to the dilemma, this distance is dramatically growing and constraining.

The advantages of concrete have led to the need of searching a substitute that can be added to concrete to enhance it's mechanical properties. So far, many materials such as plastic fibres, glass and steel have been utilized to overcome the limitations of concrete. These materials have shown satisfactory laboratory results in improving the durability aspects of concrete. To modify concrete properties several industrial by-products such as blast furnace slag, silica fumes, fly ash, glass culets etc. have been used.

Plastics are of two types- Thermoplastics and Thermosettings.

Thermoplastic: Thermoplastics such as polytetrafluorethene, polyoxymethylene , polymoid, polyethylene, polypropylene and polyetheleneterephthalete Thermoplastics can be heat- melted for recycling in the plastic industry.

Thermosetting: Thermosettings such as unsaturated polymer, phenolic, epoxy resin and melamine cannot be heat-melted.

Advantages such as endurance, high compressive power, specific gravity etc. have increased its frequency of being used as a construction material throughout the globe. But like every other construction material it too has some cons such as low fracture toughness, fragility, super heavyweight, poor tensile strength, etc. These benefits have forced the civil engineers to add something to concrete in order to enhance it's mechanical properties. To alter concrete properties and to ensure it's safe handling, construction by-products like glass culets, silica fumes, fly ash, , blast furnace slag, etc. are used. The use of fibre as an unwanted arrester for micro cracks in the cement base matrix is of great importance. It will contribute to improved static and dynamic properties of the cement-based materials matrix to avoid crack prorogation during charging. The flexibility of fibre reinforced cement concrete is also strengthened by reducing the entrance of water and other pollutants by micro cracks that induce steel reinforcement corrosion. Handling and disposing waste is one of the major concerns. It has been one of the big issues of cultural , economic and social significance. The most promising waste treatment method for waste material disposal is recycling. The use of waste in structural engineering construction has become an appealing choice for recycling and bottles of polyethylene (PET) are available at no cost because they are waste materials and can be shredded economically. To make it an alternate material for building, the fibres of these twisted bottles are applied to the usual concrete to dispose of the eco-friendly method of non-biodegradable waste and then make it techno-economical for industrial use. In the manufacturing industry, plastic shredders are widely recognised because their advantages produce the desired results economically.

Literature Review

By using PET fibres, various studies have used experimental and computational techniques to incorporate or eliminate concrete ingredients and the study has shown that different mechanical properties such as compressive strength , tensile strength, flexural strength, etc. are impaired to a fair degree. The accompanying description of the separate scholars explicitly provides the potency by which the concrete properties are improved or deteriorated.

The study group headed by Nibudey R.N used 0-3 percent by weight of cement shredded PET fibres in M20 and M30 concrete grades with a scale of 25 mm*1 mm and an aspect ratio of 35 and 50 mm. The study concluded that dry density was decreased in PFRC, which is helpful in reducing concrete dead weight. For experimental observations, the author used cubical and cylindrical samples to assess compressive strength effectiveness. It was further concluded that the strength remains intact without any definite trend, which in turn revealed that the PET fibre samples have shown ductile behaviour, which is an added bonus to enhance concrete life using shredded PET fibre. On contrary to this, the samples without PET fibres broke into the parts abruptly and the conduct was contrary to the ductility

Dora Foti and his group used 0.26 percent PET to concrete by weight of cement with a scale of 32mm*5 mm. It was observed during the experimental study that ductility was obtained through the use of PET fibres concrete, concrete shrinkage cracks decreased and the concrete acquired alkali resistance, which increased concrete compressive strength to a large level.
The inclusion of concrete PET fibre minimised the distribution of water through the concrete and also decreased the sorptivity, which is a propensity of the substance to absorb and transfer water via the capillarity effect. The compressive strength of PFRC was significantly improved, the percentage of improvement was observed from 0 to 1 percent volume fraction of PET, it was further evaluated that PFRC sorptivity decreases at 1 percent volume fraction of fibre and rises at higher volume fraction in various grades of concrete viz. M20 and M30 when aspect ratio was between 35 and 50.

T. Senthil Vadivel in his study used 1, 2, and 3% of PET fibres that were applied to the concrete and observed a strong effect on its mechanical properties. It was specifically revealed that compressive strength improved for any percentage rise in PET fibre. It was also reported from the experimental findings that 3% fibre addition produces a 12.5% improvement in compressive strength relative to standard concrete. The experimental findings also showed that when the strength of PFRC with 3% fibres was compared with standard concrete, there was an improvement of 9 percent in tensile strength and 8.12 percent in flexure strength. It was further studied that PET fibres behaved as crack arresters, thereby preventing shrinkage cracks, raising this property with the addition of certain PET fibres in quantity. The experimental tests found that when it was blended with PET fibres, there was a definite change in the mechanical properties of concrete.

Md. JahidulIslam et@ author carried out the analysis by substituting the course and fine aggregates (by volume) with the PET.The analysis was carried out by manufacturing PFA concrete (PFC) by replacing 50 percent of sand (by volume) by PFA and by replacing 50 percent of brick chips (by volume) by (PCA) in PCA concrete (PCC) at the same time for different water cement ratio Viz. for experimental investigations. 0.42, 0.48 and 0.5 respectively were included. The association between workability and replacement of fine aggregate and coarse aggregate demonstrated a substantial improvement in operability with the PCA replacement of course aggregate and the preservation of the same water cement ratio relative to NAC. In view of lower slump values, which implies better workability for PFC, the outcome was opposite. The compressive strength indicated a difference in broad water cement ratios in both PCC and PFC. With this substitution, a lower density relative to NAC for PCC and PFC was obtained.

Ms K. Ramadevi et@ author conducted the experimental and research work on the replacement of PET fibres in the concrete with a ratio of 1 % , 2%, 4%, 6% as fine aggregate and compared to normal concrete. The experimental investigation showed that the concrete combined with PET fibres decreased the concrete 's weight. Inclusion of plastic fibres created light weight concrete effectively on the basis of unit weight. It was also found that when 2 percent of fine aggregates were replaced with the PET fibres, the compressive strength, split tensile strength and flexural strength improved and consequently decreased for 4 percent and 6 percent fine aggregate replacements, resulting in positive results for 2 percent substitution.

Mohd. Irvwan jaki et@ author in his study formulated the concept of concrete mix nomography for concrete, with PET as a fine aggregate. By using the mix ratios of 25 percent, 50 percent and 75 percent of PET with water cement ratios of 0.45, 0.55 and 0.05, the different physical and mechanical properties were determined. To be more specific, waste PET bottles recycled by the plastic granulator system were the material used for experimental work. Low density was achieved by the ingredients above. Compared with fine aggregates of traditional concrete, PET aggregates contributed to a drop of concrete mass. The higher water cement ratio created pore water spaces that did not participate in the water-binder reaction and therefore resulted in small capillary channel diameters and the compressive strength of concrete mixed with 25 percent replacement ratio of PET aggregate properly obtained design strengths mix 25 Mpa with experimental analysis. The split tensile strength often declined in the same way as compressive strength with the addition of PET aggregate. It was clearly seen from the experiments that the mechanical properties of concrete such split tensile strength, compressive strength and MOE decreased drastically with an increasing percentage of PET aggregate in concrete.

Saini Verma, et @ author used waste crushed PET bottles of sufficient size in concrete experimentally with partial substitution of fine aggregates as it has the potential to disperse waste that otherwise has negative effects on the eco-system. Analytical findings indicate that the compressive strength of traditional concrete is comparable with that of concrete produced by sufficient aggregate replacement with the help of PET fibres. It was determined that the compressive strength of concrete with the replacement of PET fibres was better than the usual concrete compression. It was estimated from the observational studies that the compressive strength improved by up to 2 percent replacements with the substitution of fine aggregate with PET fibres, which leads to a 12 percent rise in compressive strengths and there is a significant trend of decrease in compressive strengths with a further rise beyond 2 percent of PET fibres. PET is eco-friendly with the concrete mix from the environmental perspective and global eco system and is non-hazardous since they are readily spread in the concrete mix.

Conclusion

Since reviewing the literature, it is observed that the different properties change with an improvement in PET fibre percentage. Strength increases with an increase in the percentage of PET, but it tends to decline after a certain number, most of the time 3-4 percent.

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