Effect of PET Fibers on Mechanical Properties of Concrete: A Review

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Abstract : The concrete is the most significant material which is almost used in every form of civil engineering construction. The efficiency of the concrete at the construction level is mainly enhanced by some of its properties such as good compressive strength, durability, specific gravity etc. but at same time as every material or system possess some limitations so does concrete which namely comprise of brittleness, low tensile strength, low impact strength, 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. Management and disposal of waste at proper designated places is one of the major challenges, as a result of which there is considerable implications on the environment. Thus waste utilization in civil engineering construction is considered as appropriate and attractive alternative for disposal and shielding environmental degradation. The paper provides a comprehensive summary of experimental approaches used by various authors to add PET shredders as replacement of coarse aggregate, fine aggregate and also are used as fibers in concrete in order to enhance the mechanical properties of concrete which not only are eco-friendly but at the same time approach is techno-economical for the commercial use.

***IndexTerms* – PET, coarse aggregate, concrete, environmental degradation, mechanical properties.**

I. INTRODUCTION

Due to the increased use of PET bottles the amount of waste is going to grow by leaps and bonds. The capacity for recycling in India is around 145,000 TPA, so such quantity of waste needs a large landfill to dump. Now a day the recycling rate of PET bottles is very less than the cost of virgin PET production for common use. This gap is drastically increasing and constraining to find a solution of the problem.

These advantages have forced civil engineers to add something to concrete so that the mechanical properties can be enhanced. Till date so many materials have been utilized to overcome the limitations of concrete such as steel, glass and plastic fibers which have shown satisfactory laboratory results to improve the durability aspects of concrete. The use of industrial by-products such as flyash, silica fume, blast furnace slag, glass culets etc. are used in the concrete to modify the properties of concrete and for the safe disposal of these products.

Plastics can be divided in two types.

Thermoplastic: This type of plastic can be melted for recycling in the plastic industry such plastics are polyethylene, polypropylene, polymoid, polytetrafluorethene, polyetheleneterephthalete and polyoxymethylene.

Thermosetting: This plastic can not really be heat-melted; phenolic, melamine, unsaturated polymer, epoxy resin, etc.

It has many advantages such as high compressive power, endurance, specific gravity etc. due to which it is most frequently used in construction material throughout the world. It features some bitter properties such as fragility, poor tensile strength , low fracture toughness, super heavyweight etc. These advantages have forced civil engineers to add something to concrete so that the mechanical properties can be enhanced. In the concrete, the use of manufacturing by-products such as flyash, silica fume, blast furnace slag, glass culets etc. is used to change the properties of concrete and to ensure the safe handling of these materials. The use of fiber in the cement base matrix serves as an unnecessary arrester for micro cracks. Preventing crack prorogation during load will lead to improved static and dynamic characteristics of cement - based materials matrix. The serviceability of fiber reinforced cement concrete is also enhanced due to restricting entry of water and other contaminants through micro cracks which causes corrosion to steel reinforcement. Waste is the one of the main challenges to dispose and manage. It has become one of the major environmental, economic and social issues. Recycling is the most promising waste management process for disposal of waste materials. The waste utilization in civil engineering construction has become an attractive alternative for disposal and the Polyethylene (PET) bottles are available without any cost as these are waste products and can be economically shredded. The fibers of these shredded bottles are added to the normal concrete for making it as an alternative material for construction, dispose off the non-biodegradable waste with eco-friendly process and then making it techno-economical for the commercial use.

Plastic shredders are gaining widespread recognition in the manufacturing industry as their advantages produce the desired results at an economical cost.

II. LITERATURE REVIEW

The various researchers have used the experimental and analytical approaches to add or replace ingredients of concrete by using PET fibers and from the research it has been established that various mechanical properties such as compressive strength, tensile strength, and flexural strength, etc are influenced to a reasonable extend. The following summary of various authors, clearly provide the effectiveness with which the properties are enhanced or degraded.

Research group led by Nibudey R.N has utilized 0-3 % shredded PET fibers by weight of cement in M20, and M30 grades of concrete with size 25mm*1mm and an aspect ratio of 35 and 50 . It was concluded from the study that dry density was reduced in PFRC which is beneficial in reducing dead weight of concrete. For experimental observations author has made use of cubical and cylindrical samples to ascertain effectiveness on compressive strength , it was further established that strength remain intact

without forming any definite pattern, which in turn revealed that the samples with PET fibers have shown ductile behavior, which is an added advantage to enhance the life of concrete using shredded PET fibers. While as the samples without PET fibers broke abruptly into the pieces and the behavior was contrary to the ductility.

Dora Foti and his group used 0.26% PET to weight of concrete with a size of 32mm*5mm, after the experimental analysis it was found that by the use of PET fibers concrete attained ductility, reduced the shrinkage cracks of concrete and acquired the alkali resistance, it further enhanced the compressive strength of concrete to a considerable amount. The addition of PET fiber in concrete reduced the propagation of water into the concrete and also reduced the sorptivity, which is a tendency of material to absorb and transmit water by the phenomenon of capillarity. There was a little improvement in the compressive strength of PFRC, the percentage of improvement was observed from 0 to 1% volume fraction of PET, it was further analyzed that sorptivity of PFRC is decreased at 1% fiber volume fraction and increased at higher volume fraction in different grades of concrete viz.M20 and M30 when aspect ratio was between 35 and 50.

T. Senthil Vadivel,…… et@ In their research authors used 1, 2, and 3% of PET fibers which were added to the concrete and found a clear impact on its mechanical properities. It was clearly revealed that after every percentage increase in PET fiber, compressive strength was increased. From the experimental results it was also observed that 3% addition of fiber provide 12.5% increase in compressive strength when compared with conventional concrete.The experimental results also revealed that there was an increase of 9% in tensile strength and 8.12% in flexure strength when the strength of PFRC with 3% fibers was compared with conventional concrete. It was further analyzed that PET fibers acted as crack arresters, hence prevented shrinkage cracks, this property increased with the increase in the addition of quantity of some PET fibers. The experimental observations revealed that there was a definite enhancement in mechanical properties of concrete when it was amalgamated with PET fibers.

Md. Jahidul Islam,……et@ author investigated the study by replacing the course and fine aggregates (by volume) with the PET . The study was carried forward by producing PFA concrete (PFC),50% of sand (by volume) was replaced by PFA and in PCA concrete (PCC) 50% of the brick chips (by volume) where replaced with (PCA) at the same time for the experimental investigations different water cement ratio Viz. 0.42, 0.48 and 0.5 where used. The relationship between workability and replacement of course and fine aggregate showed a considerable increased in workability with the replacement of course aggregate by PCA and keeping the same water cement ratio when compared with NAC. The result was contrary in view of lower slump values which mean lower workability was obtained for PFC. In both PCC and PFC the compressive strength showed a variation with varied water cement ratios. With this replacement a lower density was achieved for PCC and PFC as compared to NAC.

Ms K. Ramadevi et@ author elucidated the experimental and research work to replacement of PET fibers in the concrete with the ratio of 1%, 2%, 4%, 6% as fine aggregate and were compared with the normal concrete. The experimental investigation revealed that the concrete mixed with PET fibers reduced the weight of concrete. Inclusion of plastic fibers effectively made concrete light based on unit weight. It was further observed that the compressive strength, split tensile and flexural strength increased when 2% of fine aggregates were replaced with the PET fibers and it subsequently decreased for 4% and 6% replacements of fine aggregate and as consequence the 2% replacement yielded good results.

Mohd. Irvwan jaki et@ author describes the investigation to formulate the design of concrete mix nomograph for concrete, with PET as fine aggregate. The various physical and mechanical properties where ascertained by using the mix proportions containing 25%, 50% and 75% of PET with water cement ratio of 0.45, 0.55 and 0.05. To be more precise the material which was used for experimental work was waste PET bottles which were processed by plastic granulator machine. The above ingredients achieved low density. PET aggregates compared to fine aggregates of conventional concrete led to the reduction of concrete density. The higher water cement ratio formed pore spaces of water that did not participate in water-binder reaction and hence resulted in small diameter of capillary channels and with the experimental analysis the compressive strength of concrete mixed with 25% replacement ratio of PET aggregate appropriately obtained design strengths mix 25 Mpa. While with the inclusion of PET aggregate the split tensile strength also reduced in similar fashion as compressive strength. From the experimental investigations it clearly revealed that with increasing percentage of PET aggregate in concrete the mechanical properties of concrete such as compressive strength,split tensile and MOE reduced considerably.

Saini Verma, et al the author had experimentally used waste crushed PET bottles of suitable size in concrete with partial replacement of fine aggregates as it has potential of dispersing the waste which otherwise has hazardous effects on the eco-system. The analytical observations bring out the comparison of compressive strength of conventional concrete with concrete formed by appropriate substitution of aggregates with the help of PET fibers. Form the experimental results it was established that compressive strength of concrete with the substitution of PET fibers was better in compression to the normal concrete. From the observational studies it was calculated that with the replacement of fine aggregate with PET fibers the compressive strength increased up to 2 percent replacements which leads to 12 percent increase in compressive strengths and there is a definite pattern in decrease of compressive strengths for further increase beyond 2 percent of PET fibers. From the environmental aspect and global echo system PET are echo friendly with concrete mix and are non hazardous as they are easily dispersed in concrete mix.

III. CONCLUSION

After doing analysis of literature it is found that with increase in percentage of PET fibre, the various properties changes. With increase in PET percentage, strength increases but after a certain percentage most of the time 3-4 %, it starts decreasing.

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