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Evaluation of Behavior of Mechanical Properties of Waste Polyethylene Terephthalate (PET) Bottle Fiber in Fiber Reinforced Concrete

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Abstract—*About 3591 ton of plastic waste is generated in Pakistan as per United Nations Environment Programme. Dumping of plastic bottles contaminates both sea water and human land. The main objective of this research is to study the effect of the addition of waste PET bottle fiber in concrete. Initial testing of all the materials was conducted and then concrete with PET fibers was made. Compressive strength was to be investigated. Addition of PET to concrete initially decreased the strength of concrete by 31% but after more addition strength increased and ended up almost same as standard strength for Aspect Ratio 10.*

Keywords*- Plastic Waste, PET bottle fiber, Compressive strength of PET Concrete*

I. INTRODUCTION

About 3591 tonne of plastic waste is generated in Pakistan as per United Nations Environment Programme [1]. World Bank in its report states that annual solid waste generation is about 1.3 billion tons. Most importantly by 2025, it will reach around 2.2 billion tons per year. This situation thus became a big problem to landfill. Plastic waste thus gives a big negative impact on the environment[2]. Moreover the disposal of waste plastic PET bottle is big problem to our environment as plastic is very difficult to biodegrade.

II. LITERATURE REVIEW

Teuten et al. (2009) worked in countries of Asia and found endocrine disrupting chemicals in plastic. He further stated that in Malaysia and Thailand BPA values were very high in landfill leachate. On the other hand lower BPA concentrations were found in less industrialized countries like Laos and Cambodia. More value of BPA is because of more plastic in landfills in industrialized countries [3].

Sea life as human life is not safe from plastic hazard. Million seabirds, countless fishes and about 100,000 sea mammals were dead because of plastic as reported by UNEP (2006) [4].

Phaiboon Panyakapo et al. added fly ash and Shredded plastic waste to find out correct mixing proportion of fly ash and Shredded plastic waste .[5]. In experiments cement, sand, plastic and fly ash percentage was changed. Best proportion selected was 1,0.8,0.9,0.3 for cement, sand, plastic and fly ash. Low strength and low dry density was achieved in by this mix dry density was noted as 1395 kg/m^3, while Compressive strength was recorded as 4.14 N/mm^2.

After Phaiboon Panyakapo et al, Zainab Z. Ismail et al.[6] used shredded plastic waste as replacement Of sand in concrete. Fresh density, slump, flexural strength, toughness indices, dry density and compressive strength tests were conducted. 3, 7, 14, and 28 days curing was done. In results production of micro crack was revealed hence reducing the strength of concrete. In the experiment alone 30 kg of plastic waste was used.

Albano et. al. (2009) [7] took the work further by adding plastic aggregates. Their size was investigated in the research. PET aggregates were chosen for research study. PET aggregates size and water/cement ratio were changed in different trials. In addition to this, degradation of PET 200, 400, 600^{o}c was also investigated. Results showed decrease in compressive strength and ultrasonic pulse velocity. Absorption on the contrary increased. Flexural strength was very dependent on temperature, the water/cement ratio and PET content.

Compression strength of concrete was improved by Vikrant S Vairagade et al [8] by adding 50 aspect ratio and alkali resistant glass fibers containing 0% and 0.25% by weight of cement of 12mm cut length and fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85mm length. Results showed good increase in compression and tensile strength.

An increase in compressive strength of concrete from 11% to 24% was observed by A.M. Shende et. al.[9]. Relationship between aspect ratio and tensile, splitting tensile and compressive strength was investigated. It was observed that 50 aspect ratio and 3% fibre gave the best results.

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III. METHODOLOGY

Waste was collected from various points in city. Waste was taken to the laboratory and separation of PET from all waste was done manually.

Figure 1 Shredded PET Fibres

Figure 2 Length of PET fiber

The following initial testing were conducted for selection of material

- Specific Gravity of Fine Aggregate
- Bulk Density of Coarse Aggregate
- Gradation of aggregates
- Loss Angeles abrasion value
- Impact value of aggregates
- Crushing value of aggregate

After necessary testing and confirmation that materials are of quality, mix proportions for 3000 psi concrete was calculated using ACI Mix Design method. Cubes were made with 0.6%, 1.2% and 1.8% pet fibers for aspect ratio 10. Total 21 No. of cubes were made. Following tests were conducted on concrete.

- Slump Test
- Compressive Strength Test of Concrete
- Splitting Tensile Strength Test
- Flexure Tensile Strength

Figure 3 Concrete cube Samples

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Figure 4 Concrete cubes Samples Testing

Figure 5 Testing of Samples for Splitting Tensile Strength

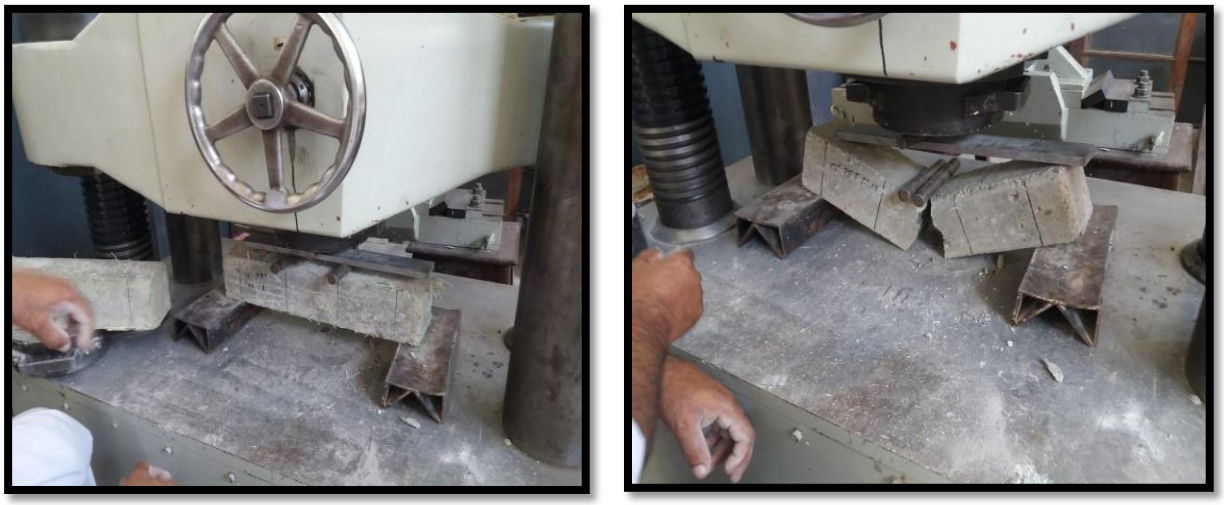

Figure 6 Testing of Samples for Flexure Tensile Strength Test

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IV. RESULTS & DATA ANALYSIS

Results obtained from testing are mentioned in Figure 7 to Figure 10.

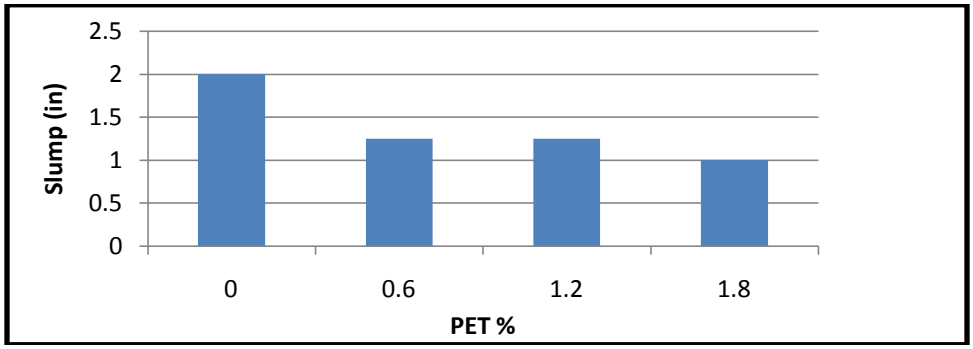

Figure 7 Slump Test results

Addition of PET fiber significantly decreased the slump. PET fibers 0.6% and 1.2% with Aspect ratio 10 decreased the slump upto 31% and 1.8 % decreased the slump upto 50 %. The slump reduced due to the induced friction b/w aggregates by the PET fiber.

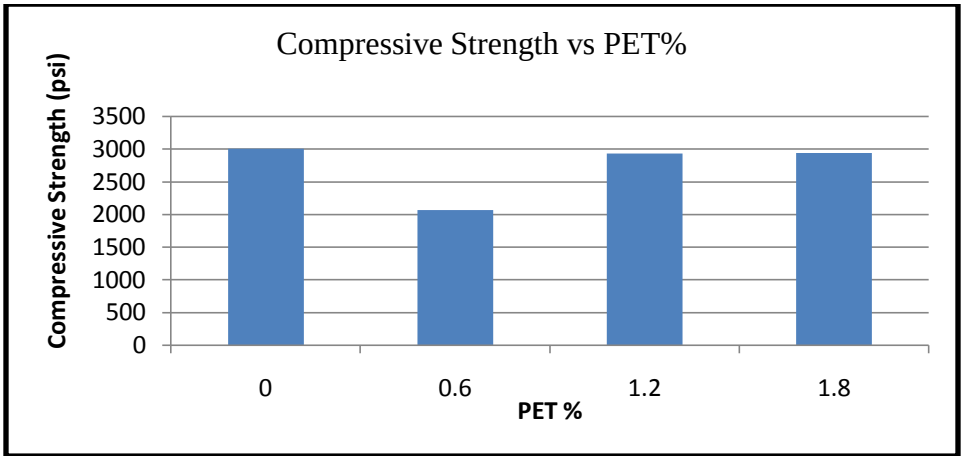

Figure 8 Compressive strengths

Addition of PET to concrete initially decreased the strength of concrete by 31% but after more addition strength increased and ended up almost same as standard strength for Aspect Ratio 10.

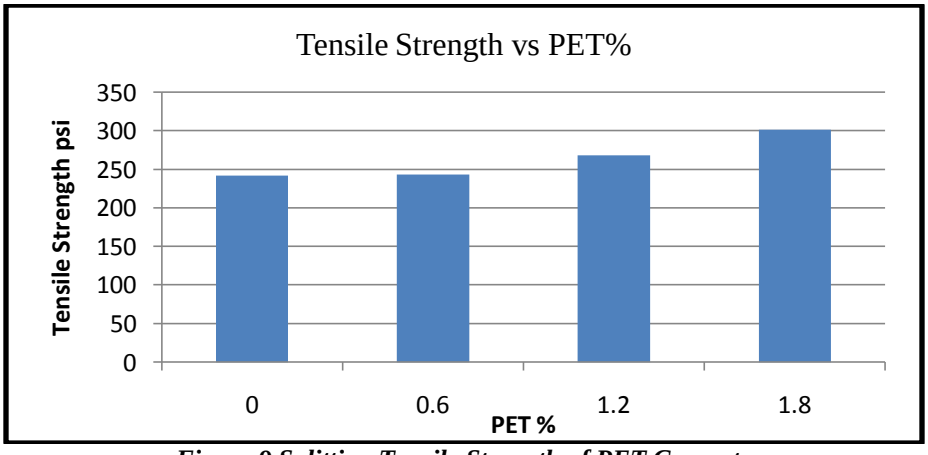

Figure 9 Splitting Tensile Strength of PET Concrete

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Addition of PET to concrete initially decreased the strength of concrete to a small extent then followed the ascending order till addition of 1.8% and ended up with 24% increase in tensile strength.

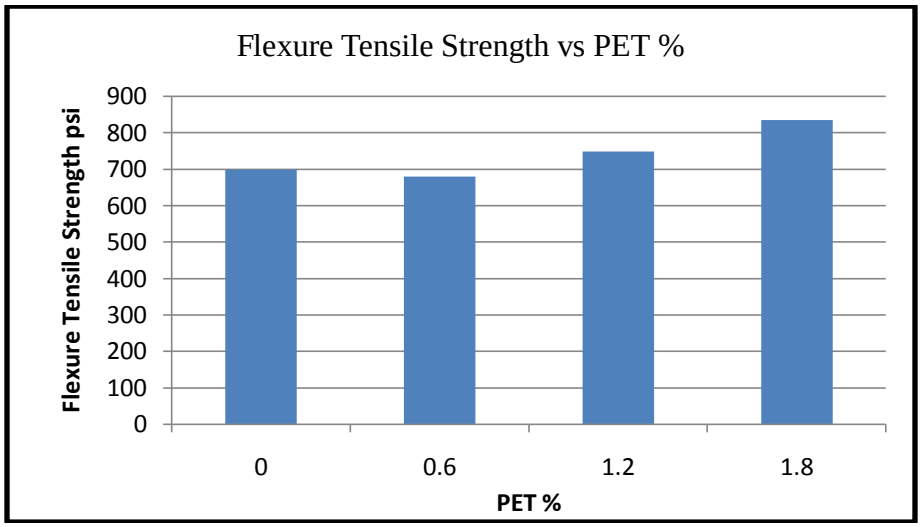

Figure 10 Flexure Tensile Strength of PET Concrete

Addition of PET to concrete initially decreased the strength of concrete by 2.8 % but after more addition strength increased. Aspect ratio 10 ended up with 19.20% in strength as standard strength. The Flexure tensile strength increased due to the better tensile properties of PET fiber and strong bond in Concrete Mix

V. CONCLUSION

After complete testing and result analysis it can be concluded that

- The slump values follow the descending order due to the imposed friction between aggregates.
- The compressive strength increased due to better bond between PET fibers and concrete Mix.
- PET Fiber Reinforced Concrete specimens did not suddenly break and failure was ductile. This is the main advantage of using PET fiber in concrete.
- The Flexure tensile strength increased due to the better tensile properties of PET fiber and strong bond of PET fibers in Concrete Mix.

VI. RECOMMENDATION

- Other sizes of PET fiber should be tried
- PET in powder form may also be examined.
- Other forms of plastic should be tried as fibers in concrete.
- Possibility of coating of aggregate with plastic can be viewed.

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