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Review on use of waste plastic in concrete

Shubham Minhas, Ritesh Jain

Department of Civil Engineering, College of Agricultural Engineering and Technology, Punjab Agricultural University, Ludhiana 141004, India

Abstract- **Plastic waste has emerged as one of most difficult to tackle waste due to long life of plastics. Polyethylene terephthalate (PET) in one of major plastics which is used to make bottles for beverages and packaged drinking water. These bottles are mostly of single use and are needed to be disposed once used thus having a great environmental impact. On the other side concrete is a major construction material and raw material for making it are growing scarce. Finding alternative to the cement, fine aggregates and coarse aggregates for concrete is need of the situation. There have been many studies done for checking the effect of use of PET waste on mechanical strengths of concrete i.e. compressive strength, split tensile strength and flexural strength. This paper examines various literature reviews in which waste PET has been used as partial replacement in concrete.**

Keywords – **Plastic waste, Polyethylene terephthalate, strength, replacement.**

I. INTRODUCTION

With rapid industrial growth and urbanization there has been an unprecedented increase in amount of waste plastics produced every year. This plastic waste has far reaching impact on environment. Recycling is an option however there is only a small fraction that is recycled, rest ends up in landfills and poses serious environmental threats. So, coming up with an alternative approach can be quite beneficial in present condition. In construction industry concrete is major input which is made from cement, fine aggregates and coarse aggregates. These raw materials are becoming difficult to procure due to high demand and less availability. Thus, use of waste plastics in concrete as raw material can solve both problems to an extent. PET is one of major plastic among waste produced by single use plastic bottles used for beverages and packaged drinking water. It can be crushed to serve as fine aggregates and formed into strips/ fibres to replace coarse aggregates.

II. LITERATURE REVIEW

A large number of laboratory tests have been done to examine the effect of partial replacement of concrete inputs by PET on various properties of concrete. This paper is based on literature review which gives idea of various ways of use of PET in concrete.

Sanjay kumar and Daule (2017) studied effect of 0.5% to 2% with increment of 0.5% replacement of fine aggregates on properties of concrete. The water cement ratio was 0.40 for the test. They reported optimal strength at 1.5% replacement. There was increase of 4%, 8% and 59% in compressive strength, split tensile strength and flexural strength respectively.

Foti (2013) investigated use of different forms of reinforcements with pet bottle viz circular fibres, half bottles and rectangular strips. The tests resulted in high concrete PET adherence. Further, more ductile behaviour was observed when subjected to bending load.

Ramadevi and Manju (2012) examined the impact of 0.5%, 1%, 2%, 4% and 6% replacement of fine aggregates with ground pet fibres. Pet bottles were first shredded into flakes and subsequently ground. Optimal compressive strength, split tensile strength and flexural strength was recorded on 2% replacement.

Safinia and Alkalbani (2016) compared the compressive strength of concrete blocks with empty 500ml PET bottles placed in between to that of hollow concrete blocks procured from a local market. Concrete specimen with bottles resulted in an increase of 57% as compared to hollow concrete block from market.

Patil et al. (2016) tested concrete specimens with plastic waste fibres 1%, 2% and 3% of cement for compressive strength, split tensile strength and flexural strength. There was increase of 13% in compressive strength while split tensile and flexural strength increased by 38% and 65% respectively.

Asha and Resmi (2015) checked strength of concrete by replacing cement in dry mix by 0.5%, 1% and 1.5% plastic fibres. Straight and crimped fibres were used in different specimens. Both types of fibres gave optimal results at 1% fibre. For straight fibres compressive and tensile strength increased by 16% and 37% respectively on the other hand, for crimped fibres there was increase of 18% and 42% in compressive and split tensile strength.

Rinu Isah and shruthi (2017) compared non reinforced concrete beam with beams reinforced with hollow bars made of PET bottles and steel bars. The hollow bars where prepared by cutting PET bottles longitudinally then folding and pinning to form 48 cm long bars. Although steel reinforcement gave maximum flexural strength, for hollow PET bar reinforced beams the flexural strength almost doubled as compared to control beam with no reinforcement.

Pelisser et al. (2015) used PET fibres of different length replacing different volume fraction of concrete. The author found toughness index to increase for 0.18% and 0.3% with 28days curing. Although after 150 days of aging toughness index improvement was reported to be no longer present due to degradation of fibres in alkaline environment of concrete.

Tharini and Nishanthi (2018) experimented by replacing fine aggregate with 5% to 15% concrete with 2.5% increment with HDPE and LDPE along with replacement of cement with 2% polypropylene fibres. For 10% fine aggregate replacement maximum increase in compressive strength, split tensile strength and flexural strength was observed in both HDPE and LDPE.

Khatib et al. (2019) used waste plastic bottle caps by replacing them with coarse aggregates by volume. 10%, 15% and 20% by volume of coarse aggregates where exchanged with bottle caps. First crack was observed at a load which increased with increase of bottle cap percentage and attained maximum value at 20% replacement. There was an increase of 16% in compressive strength for 20% replacement as compared to control specimen.

Ananthi et al. (2017) tested concrete specimens for compressive strength and split tensile strength by 0.3%, 0.6%, 0.9% and 1.2% plastic fibres. Plastic fibres were made by hand cutting plastic cups into thin rectangular strips. For 0.9% plastic fibre maximum increase in strength was observed. Compressive strength was increased by 28.5% and split tensile strength increased by 54.4% after 28days of aging.

Irwan et al. (2013) prepared concrete specimens by adding 0.5%, 1% and 1.5% grinded PET fibres from waste PET bottles. For 1.5% PET fibres compressive strength decreased by 17.65% but split tensile strength was increased by 23.6% after 28days. Specimen containing 0.5% fibres had shown increase in compressive strength by 9%.

Raghatate (2012) investigated use of polyethylene bag pieces as plastic fibre in concrete. 0.2% to 1% of fibres was used in concrete specimens. For 0.8% fibre compressive strength decreased by 23% however split tensile strength was enhanced by 35% as compared to control specimen after 28days.

Ravikumar and Manjunath (2015) studied mechanical strength of concrete by 0% to 100% replacement of fine aggregates by manufactured sand along with 0.5% replacement of cement by low density polyethylene fibres. The experiment resulted in 10.38%, 19.52% and 14.24% increase in compressive strength, split tensile strength and flexural strength for 100% manufactured sand.

Akçaözog˘lu et al. (2010) tested concrete mixtures with and without granulated blast furnace slag (GBFS) and/or PET granules in different mixes. the compressive and flexural strength of the mortars containing PET and sand aggregates were greater as compared to the mortars containing only PET aggregates.

Ochi et al. (2007) produced plastic fibres using PET bottles as raw material. The process of manufacture of waste plastic fibres included extrusion of waste PET bottles. The monofilaments thus produced are indented using special apparatus to get desired roughness for preventing slippage of fibres in concrete. Three water to cement ratio of 0.65, 0.60 and 0.55 were tested. A maximum increase of bending strength of 36% was observed for 0.55 w/c ratio and 1.5% fibre on the other hand compressive strength had a maximum increase of 13% for 0.60 w/c for 1% fibre.

Malagavelli and Rao (2010) used high density polypropylene (HDPP) and polyethylene terephthalate (PET) with 1% and 2% fibres by concrete volume. There was increase in strength for both type of fibres for 1% fibre by volume of concrete. Ultimate load carrying capacity increased by 4.62% for HDPP fibres and by 9.11% for PET fibres. Similarly load carrying capacity under flexure also increased for 1% PET fibres by maximum extent.

Choi et al. (2005) used PET bottles to produce light weight aggregates by pouring cut bottle pieces in heated mixer and adding granulated blast furnace slag (GBFS) to solidify aggregate surface. Lightweight plastic aggregates were replaced with fine aggregates by 25%, 50% and 75%. Both compressive strength and split tensile strength were both reported to decrease with increase in percentage of waste plastic aggregates.

Albano et al. (2009) studied mechanical behaviour of concrete with water-cement ratio 0.5 and 0.6 along with 10% and 20% replacement of fine aggregates by volume. PET particles of 0.26cm, 1.14cm and 1:1 mix of both was tested by exposing specimens to 200^{o}C, 400^{o}C and 600^{o}C. Mechanical strengths decreased with addition of PET particles, best mechanical properties were observed for 10% small and 1:1 mix for both water-cement ratio as compared to higher percentage and bigger particles.

Kandasamy and Murugesan (2011) observed the effect of addition of 0.5% polythene fibre by weight of cement on compressive strength and split tensile strength of concrete. Compressive strength increased by 5.12% while split tensile strength increased by merely 1.63% as compared to control specimen of normal concrete.

IV.CONCLUSION

A large variety of experiments have been performed to check the sustainability of using plastic waste in general and PET waste in specific in concrete by different methods. Many studies have resulted in enhancement of mechanical properties of concrete which furthers the need and opportunity for the area for exploration. PET being one of major plastic in daily use is produced in huge quantity which means increased need for efforts to dispose the waste. Significant increase in strength of concrete have been observed by using waste plastics by just grinding and cutting of plastic waste. Based on current studies plastic added concrete can be used in utilities that require strength increase just between that of conventional concrete and steel reinforced concrete.

Plastics have varied properties depending upon their intended use this makes its use in concrete with complete confidence difficult. The review has proved that the addition of concrete increases the compressive strength and split strength. Thus, much effort is needed for developing method which can provide increase in mechanical strength with reliable value, besides decreasing environmental pollution in using waste plastics with partial replacement of ingredients in concrete

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