Replacement of coarse aggregate by Polyethylene Terephthalate in Light Weight Concrete: A Review Paper

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Abstract - This study utilizes Polyethylene Terephthalate (PET) plastic waste which is light as coarse aggregate. The coarse aggregate from PET plastic waste is the result of the PET-heated to produce agglomeration and then it is cooled and crushed into aggregates that have variety of sizes with certain gradations. The purpose of this study is to determine the compressive strength of light concrete of PET plastic waste as coarse aggregate and influence of aggregate gradations towards the compressive strength of concrete that is produced. This work reviews several previous studies on the utilization and preparations of plastic materials and their effect on the physical and mechanical properties of concrete. The concrete with PET plastic waste can be used not only as an effective plastic waste management practice but also as an strategy to develop more economic and sustainable building materials in the future.

Keywords: Light concrete, PET plastic waste, coarse aggregate, fine aggregate, compressive strength.

I.INTRODUCTION

The use of Polyethylene Terephthalate (PET) for food or beverage packing is already familiar in public. After the contents are consumed, the PET plastic containers usually are directly discharged. Plastic is the most significant material in our life of the last century and today, it is available almost everywhere. Replacing or compensating for plastic and material is a practice that has become widespread of late, given the increasing trend of plastic waste build-up. The existence of such waste results in a negative environmental impact. Polyethylene Terephthalate (PET) is one of potential waste which could be used in various applications. Efforts have been made to explore their usage in concrete such as that of fiber on concrete performance. The development of new construction materials using recycled PET fiber is important to both the construction and PET recycling industries. Previous researchers revealed that PET waste fiber in concrete has significant role in terms of bonding and strength. PET waste has very weak bond with cement paste. PET fibers or synthetic fibers show most success in practical application and experiments as they have qualities that are unique compared to the ordinary fibers such as :

i) They are chemically inert.

ii) They do not corrode.

iii) They allow easy jetting of concrete.

iv) They are lighter than steel fibers of the same number.

v) They allow a better control of the plastic shrinkage cracking.

Hence, reusing of PET wastes in the building industry is an effective approach in both, preventing environmental pollution and designing economical buildings. The aim of this review paper is to summarize the previous studies on waste plastic material such as PET and investigations of fresh/hardened concrete characteristics and mix designs and applications.

II.MATERIALS

A. Cement: Ordinary Portland cement of 43-grade.

B.PET Plastic waste: PET is used as a raw material for making packing material such as bottle and containers for packing a wide range of food products and other consumer goods. Examples include soft drinks, alcoholic beverages, detergents, cosmetics, plastics .Polyethylene Terephthalate also can be used as main material in making paper.

C. Light Weight Aggregate: Readily release as needed for hydration or to replace moisture lost through supply an internal source of water.

D. Course Aggregate: Natural course aggregate passing though 20mm and retaining on 4.75mm sieve.

E. Fine Aggregate: Passing through 4.75 sieves.

III.TESTS

A .Compressive strength test: Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials ASTM C39/C39M provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

B. Split tensile strength: The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

C. Flexural strength: Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. A flexure test is more affordable than a tensile test and test results are slightly different. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails. The maximum recorded force is the flexural strength of that particular sample.

D. Ultrasonic pulse velocity: Structural defects cause serious damages and collapses. Ultrasonic testing provides information on the strength and uniformity of concrete, rock, composites, ceramics, wood, epoxy, refractory materials and can be used to detect and localize voids, pipes, cracks and defects. The ultrasonic pulse echo (UPE) technology extends ultrasonic pulse velocity (UPV) applications to objects where access is restricted to a single side. Proceed offers the most versatile range of ultrasonic testing instruments.

IV. STUDY RELATED TO POLYETHLENE TEREPHTALATE (PET)

Frigione et al.(2010) [1] investigated the effect of plastic aggregates on the bulk density of concrete. For this purpose, they made 12 concrete mixes with different w/c containing varying percentages (0%, 10%, 30%, and 50%) of plastic aggregates. Angular post-consumer plastic aggregates having a maximum size of 13 mm were used. They concluded that: (i) bulk density of concrete decreased with the increase in plastic aggregates content; (ii) reduction in bulk density was directly proportional to the plastic aggregates content; and (iii) density of concrete was reduced by 2.5%, 6%, and 13% for concrete containing 10%, 30%, and 50% plastic aggregates, respectively. Reduction in density was attributed to the lower unit weight of the plastics.

Choi et al. (2005) [2,3] studied the effects of polyethylene terephthalate (PET) bottles lightweight aggregate (WPLA) on the density of concrete. Mixture proportions of concrete were planned so that the water/cement ratios were 45%, 49%, and 53%, and the replacement ratios of WPLA were 0%, 25%, 50%, and 75% by volume of fine aggregate. Density of concrete mixtures decreased with the increase in WPLA content. In their study the influence of polyethylene terephthalate (PET) bottles lightweight aggregate (WPLA) on the splitting tensile strength of concrete was observed. Mixture proportions of concrete were planned. The water/cement they concluded that: (i) splitting tensile strength of concrete mixtures decreased by 19%, 31%, and 54% with the increase in PET aggregates by 25%, 50%, and 75% respectively; and (ii) for a particular PET aggregate content, splitting tensile strength increased with the reduction in w/cm ratio. Also the study investigated the effect of polyethylene terephthalate (PET) bottles lightweight aggregate (WPLA) on the modulus of elasticity of concrete. According to the authors, modulus of elasticity of concrete mixtures decreased with the increase in PET aggregates.

Kou et al. (2009) [4] investigated the fresh and hardened properties of lightweight aggregate concretes that are prepared with the use of recycled plastic waste sourced from scraped PVC pipes to replace river sand as fine aggregates. Concrete mixes were tested, in which river sand was partially replaced by PVC plastic waste granules in percentages of 0%, 5%, 15%, 30% and 45% by volume. Splitting tensile strength 28-day values are 3.06, 2.89, 2.82, 2.58 and 1.83 MPa, respectively.

Akçaözoglu et al. (2010) [5] carried out a study of using shredded waste PET bottles as aggregate in lightweight concrete. Investigation was carried out on two groups of mortar samples, one made with only PET aggregates and, second made with PET and sand aggregates together. The authors found average values of flexural strength similar to those of normal weight mortar.

Rahmani et al. (2013) [6] investigated the effects of replacing 5%, 10% and 15% substitution of sand with PET processed particles. To determine the effect of the percentage of sand replacement with PET on concrete flexural strength, some beam specimens with dimensions of 50 × 10 × 10 cm3were casted. 11 According to the authors, the flexural strength has an increasing trend at first when the amount of PET particles increases, but it drops after a while. For example, the 5% replacement of sand volume with PET particles with w/c ratios of 0.42 and 0.54 shows 6.71% and 8.02% increase in flexural strength, respectively. However, 15% substitution of PET particles with w/c ratio of 0.42 and 0.54 yielded 14.7% and 6.25% reduction in the flexural strength, respectively. Also the study observed the effects of PET particles on tensile strength. By replacing 15% of sand volume with PET particles.

V.CONCLUSION

Case studies based on researches, experimental works and scientific reports have proved that waste PET may be applied for the modification of concretes. The incorporation of PET bottle fibers as reinforcement in concrete has shown, on the basis of different tests on its mechanical properties, that there is a significant improvement in the modified concrete. The use of PET fibers as reinforcement of cement composites is a promising technique for developing sustainable materials to be applied in the civil construction industry and hence, concrete with waste PET bottle fiber can be used not only as an effective plastic waste management practice but also as a strategy to produce more economic and sustainable building materials in the future.

VI.REFERENCES

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