EXPERIMENTAL INVESTIGATIONS ON CONCRETE WITH e-PLASTIC WASTE

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Abstract*— Management and recycling of e-plastic waste is rapidly growing as it is a valuable resource of IT industries and it is very hazardous substances with low recycling rate. The use of e-plastic waste will reduces the aggregate cost, landfill cost and it is energy saving. An experimental study is made on utilization of e-plastic waste as coarse aggregate in concrete with partial replacement from 0% to 20%(by volume) on strength criteria of M20 concrete. Compressive strength of concrete at 7&28 days, and split tensile strength of concrete at 28 days were determined. The results indicate that replacing natural coarse aggregate with e-plastic waste doesn't affect workability significantly and compressive strength and split tensile strength of concrete was found to be marginally increased upto 10% partial replacement with natural aggregate.

***Keywords*—: e-plastic waste concrete, Compressive strength, Split Tensile strength.**

Introduction

In the present scenario, no construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability.

Today, the world is advancing too fast and our environment is changing progressively. Attention is being focused on the environment and safeguarding of natural resources and recycling of wastes materials. Electronic plastic or e-plastic waste describes plastics from old and discarded electronic devices such as televisions, computers, mobile phones, etc. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered as e-waste. Informal processing of electronic waste in developing countries may cause serious health and pollution problems. Land-filling of plastics is also dangerous due to its slow degradation rate and bulky nature. The waste mass may hinder the ground water flow and can also block the movement of roots. Plastic waste also contains various toxic elements especially cadmium and lead, which can mix with rain water and pollute soil and water. As plastic is a hydrocarbon-based material, its high calorific value can be used for incineration or in other high temperature processes. But, burning of plastics releases a variety of poisonous chemicals into the air, including dioxins, one of the most toxic substances.

One of the new waste materials used in the concrete industry is the e-plastic waste. For solving the disposal of large amount of plastic material, the reuse of plastic in concrete industry is considered as the most feasible application. Due to depletion of natural coarse aggregate, alternative suitable materials need to be found and e-plastic waste may be one of the alternative sources for coarse aggregate.

Several studies have been made on concrete with different types and forms of plastics. Some of those studies are discussed below:

Saikia and Brito[1] studied the concrete with plastics as flaky PET bottles, pallet PET plastics as fine aggregate and they revealed that incorporation of plastics produces concrete with high durability and longevity and it also gives better resistance to chemical attack. It was revealed that production of plastic aggregate results in comparatively lesser cost and lighter weight than competing materials and reducing fuel consumption during aggregate transportation.

Osifala, Salau et al.,[2] have carried out studies on concrete containing plastic shreds derived from waste plastics, rubbers as coarse aggregate. They concluded that the increase in percentage of plastic shreds in concrete mix leads to decrease in compressive strength when flaky plastic aggregate is used whereas concrete with pallet shaped aggregate gives little higher concrete strength than with flaky aggregate.

Lakshmi and Nagan[3] made a study on concrete with e-plastic waste as aggregate and fly ash as pozzolana. They revealed that compressive and split tensile strength of concrete with these materials are increased up to 20% replacement.

Borg, Baldacchino et al[5] have used untreated PET bottle fibres at various sizes in concrete and concluded that the concrete with small sized fibres shows better performance than longer fibres and plastic fibres shows higher flexural strength than control mix. Though the strength parameter shows small increase for particular proportion, poor workability and poor compaction make difficulties in production.

Nursyamsi and Zebua[6] have studied the compressive strength of concrete with treated PET plastic as coarse aggregate at various fineness and gives out the conclusion as the size of the coarse aggregate of PET waste can affect the compressive strength of structural light concrete. This is influenced by the coarse aggregate surface areas and densities of PET waste in concrete.

Hama and Hilal[7] studied SCC with plastic waste as partial replacement of sand at various sizes and various proportions and say that the fine aggregate replacement with plastic waste shows decreased compressive strength but increased workability.

Yang and Yue et al[8] have made a study on Self compacting lightweight concrete containing recycled plastic particles as fine aggregate replacement by volume. They concludes that the viscosity, elastic modulus and dry bulk density of SCLC decreases with an increase in sand replacement and compressive strength, split tensile and flexural strength are increased with the replacement level upto 15%.

Several studies have been made on concrete with plastics such as PET bottle, plastic shreds, plastic fibres and electronic wastes. But studies on using e-plastic waste as coarse aggregate in concrete is scarce and limited. In this study, strength properties of concrete with e-plastic waste as coarse aggregate in various proportions are investigated.

Experimental program

***Materials and mix proportions*:**

Ordinary Portland Cement-53 grade confirming to IS:12269, 1987 was used and its properties are given in Table 1. Locally available crushed granite stone aggregate and e-plastic waste of 20 mm (maximum) size was used as coarse aggregate. Locally available river sand was used as fine aggregate. Aggregates were tested as per IS: 2386, 1963 and its properties are tabulated in Table 2& 3. e-plastic waste was collected from discarded, surplus, obsolete, broken electrical or electronic devices from waste recyclers.Tests results indicate that bulk density and specific gravity of e-plastic waste was about 4.58 and 2.54 times lower than natural coarse aggregate respectively.

The mix proportions for concrete were done as per IS: 10262:2009. Cement content of 380kg/m^3; with water cement ratio of 0.53 was adopted based on various trail mixes to achieve medium degree of workability. The mix proportions are given in Table 4.

Table 1: Properties of Ordinary Portland Cement

Physical Property:		
Si.No	**Property**	**Result**
1	SPECIFIC GRAVITY	3.09
2	STANDARD CONSISTENCY (%)	29
3	INITIAL SETTING TIME (MINUTES)	120
4	FINAL SETTING TIME (MINUTES)	240

Table 2: Properties of Aggregates

SL.NO.	PHYSICAL PROPERTIES	FINE AGGREGATE (SAND)	COARSE AGGREGATE
1.	SPECIFIC GRAVITY	2.6	2.7
2.	WATER ABSORPTION(%)	1.67	1.67
3.	BULK DENSITY (kg/m^3)	1621	1413
4.	FINENESS MODULUS	2.74	7.95
5.	GRADATION	ZONE II	

Table 3: Physical characteristics of e-plastic waste

SL.NO.	PHYSICAL PROPERTIES	e-PLASTIC WASTE
1.	SPECIFIC GRAVITY	1.02
2.	WATER ABSORPTION (%)	0
3.	BULK DENSITY (kg/m^3)	3.08

Table 4:Mix proportions of concrete

Mix	**% of e-plastic waste**	**Cement (kg/m^3)**	**Sand (kg/m^3)**	**Coarse aggregate (kg/m^3)**	**e-plastic waste (kg/m^3)**
S1	0	380	665	1128	-
S2	10	380	665	1016	24
S3	20	380	665	902	49

Casting and Curing:

Concrete mixtures were proportioned with suitable quantity of fine and coarse aggregates based on chosen water-to-cement ratio and cement content based on trial mixes. Concrete mixtures were proportioned for M20 grade concrete with target strength of 26.6 MPa as per IS 10262-2009. Coarse aggregate was partially replaced by e-plastic waste aggregates in terms of 0%, 10% and 20% by volume. The water-to-cement ratio was maintained constant for all mixes. The materials were thoroughly hand mixed in a laboratory. After mixing, the concrete was then smoothly transferred into moulds in three stages and compacted with the help of a table vibrator and the top surface was levelled using trowel. The moulds were covered after casting with wet gunny bags for 24 hours. There upon, the specimens were de-moulded and cured in water until the day of testing.

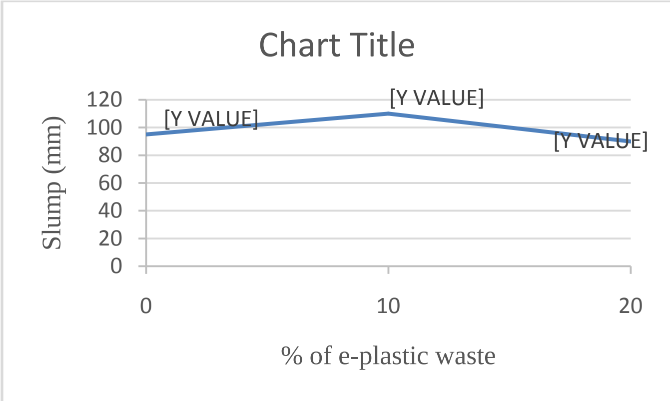
Tests conducted:

Compressive strength of e-plastic waste concrete cube specimens of size 10x10x10cm was determined at 7 and 28 days. At appropriate ages, three specimens exposed to various curing conditions were tested in accordance with IS: 516-1959[16] using 3000 kN compression testing machine. Three numbers of 100mm × 200mm cylinders were casted to determine splitting tensile strength of e-plastic waste concrete specimens at 28 days.

Results and discussions:

Workability test- Slump test was conducted on fresh concrete with varying percentage of e-plastic waste to determine the workability as per IS:1199(1989).It was noticed that incorporation e –plastic waste as coarse aggregate does not affect the workability of concrete significantly Fig 1. This may be due to smooth surface and the slippery surface texture of e-plastic aggregate, which decreases the inner friction between the mortar and the e-plastic waste aggregate. The increase of the slump of concrete mixes due to the incorporation of plastic aggregates is due to the presence of more free water in the mixes containing plastic than in the concrete mix containing natural aggregate since, unlike natural aggregate, plastic aggregates cannot absorb water during mixing[1].

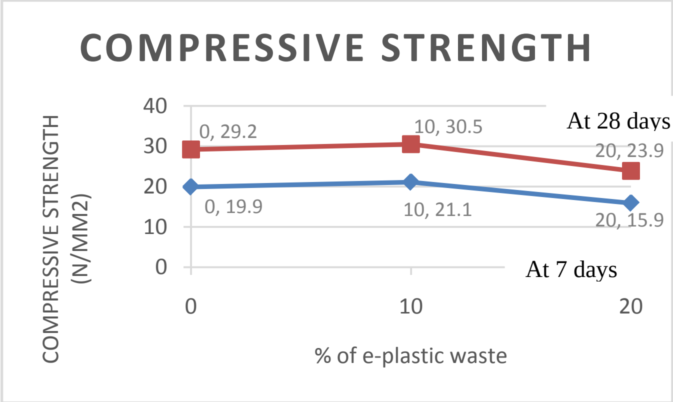
Fig 1:Slump Values



***Compressive strength*:**

Compressive strength of concrete determined at 7 and 28 days was tabulated in Fig 2.Compressive strength attained was varied from 16MPa to 31MPa at various ages. Test results indicate that compressive strength was marginally increased up to 10% of e-plastic waste and decreased at 20% of e-plastic waste. The above trend was same for all ages. At 7 and 28 days, percentage decrease in compressive strength was about 20% and 18% when compared to reference mixture. The factors that may be responsible for low compressive strength of concrete containing plastic aggregate are: (1) the very low bond strength between the surface of the plastic waste and the cement paste; (2) the hydrophobic nature of plastic waste, which can inhibit cement hydration reaction by restricting water movement[4].Concrete with 10% of e-plastic waste aggregate exhibits compressive strength that meets the target strength values for M20 grade concrete. Maximum compressive strength of about 31 MPa was attained at 10% e-plastic waste at 28 days.

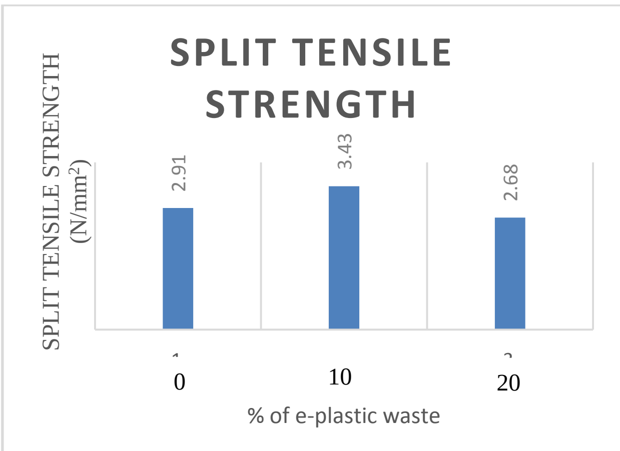
Table 6: Compressive Strength test values



***Splitting tensile strength*:**

Table 7 presents split tensile strength of concrete containing e-plastic waste aggregate up to 20% at 28 days. In general, splitting tensile strength of concrete varies from 2.68 MPa to 3.43MPa. Similar to the behaviour of compressive strength, incorporation of e-plastic waste slightly increases the splitting tensile of concrete up to 10% and decreases above 10%. The reason for the reduction observed in splitting tensile strength was similar to those explained in decrease in compressive strength of plastic aggregate concrete. According to researchers, the splitting tensile strength of concrete is influenced by the properties of the interfacial transition zone (ITZ) and therefore the smooth surface of the plastic particles and the free water accumulated at the surface of plastic aggregate could cause a weaker bonding between the PVC particles and the cement paste [4].

Table 7: Split tensile strength of concrete containing various % of e-plastic waste



Conclusions:

Based on the test results, the following conclusions are drawn:

- Incorporation of e-plastic waste as coarse aggregate does not affect the workability of concrete.
- For a given w/c, the use of e-plastic waste as coarse aggregate in the mix does not affect the compressive strength and tensile strength of concrete up to 10% replacement.
- e-plastic waste can be recommended as coarse aggregate for partial replacement up to 10%.
- The inclusion of waste e-plastic aggregates in the concrete of the buildings under investigation has been shown to be advantages from energy point of view and also environmental point of view.

Acknowledgments

The authors would like to thank the Principal and Head of Civil Engineering, Pondicherry Engineering College, Puducherry, for their unflinching support to carry out this research work.

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