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E-Waste in Concrete-A Review

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Abstract—*Concrete is a composite material of fine aggregate, coarse aggregate, cement and water with or without admixture which is widely used in construction industry. However, production of concrete is energy intensive and efforts have been made to substitute the conventional components of concrete by other alternatives. Electronic waste (E-wastes) are one of the fast growing wastes in the world with an estimated growth rate going from 3% up to 5% per year. E-waste consists of discarded old computers, TVs, fridge or electronic device that has reached its end of life. Utilization of e-waste in concrete could be a partial solution to environmental and ecological problems caused by e waste. It will also reduce the landfill cost and help in disposal of E-waste, which is a major problem in India as no proper treatment areas are established.*

The objective of this study is to determine the mechanical and chemical properties of E-waste concrete. The researches were carried out using different parts i.e. plastic and metallic parts of E-waste in different grades (M20, M25, M30) of concrete. E-waste were used to replace both fine and coarse aggregates. The replacement of fine aggregate was made with 5%, 10%, 15% and 20% (by weight) and replacement of coarse aggregate ranges from 0% to 30% (by weight) with or without fly ash. The results of workability, durability and compressive strength performed after 7 days, 14 days and 28 days for both conventional concrete and e-waste concrete were highlighted. The review concludes with the future direction of studies that need to be undertaken to explore further application of e-waste in construction industry.

1. INTRODUCTION

Concrete is the first choice for the construction in many countries today. This has led to the fast vanishing of natural resources. On the other hand new electrical and electronic products have become an integral part of daily lives providing us with more comfort, security, easy, and faster acquisition. Nowadays people prefer to buy a new appliance rather than taking the pains to get the older one repaired. Such a trend not only leads to increase in volume of electrical and electronic waste but also poses serious threat to public health and environment. Due to technological growth, there is a high rate of obsolescence in the electronic equipment which leads to one of the fastest growing waste stream in the world.

Technically, electronic waste is only a subset of WEEE (Waste Electrical and Electronic Equipment). According to the Organization for Economic Co-operation and Development (OECD) any appliance using an electronic power supply that has reached its End –of life would come under WEEE.

In India, e-waste is mostly generated in large cities like Delhi, Mumbai and Bangalore. Sixty five cities in India generate more than 60% of the total e waste generated in India. Ten states generate 70% of the total e-waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra of e-waste generating states in India. Among top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur. There are two small WEEE/E-waste dismantling facilities are functioning in Chennai and Bangalore. There is no large scale organized e-waste recycling facility in India and the entire recycling exists in unorganized sector.

So to avoid pollution and protect environment there is a need to utilize the waste in various purpose. One of the best way is the application of E-waste in concrete as partial replacement of aggregates.

2. MATERIALS USED

The materials used in different experiments by different researchers are as follows-

-E-waste: metallic parts and plastic components.

- Cement: OPC grade 43 and 53.

- Fine aggregate: River sand.

- Coarse aggregate: Ranges from 20mm to 12.5mm.

- Water: Potable water.

-Accelerators:Potassium Carbonate, Sodium Triosulfate and Triethanolamine.

3. FINDINGS OF VARIOUS RESEARCHERS

Lakshmi.R et.al. [1] experimented on utilization of E-waste particle as coarse aggregate in M20 grade concrete with percentage replacement of 0%, 4%, 8%, 12%, 16%, 20%, 25% and addition of 10% fly ash. Compressive strength, tensile strength and flexural strength of concrete with and without E-waste as aggregates was observed. Ultrasonic test on strength properties were executed and the feasibility of utilizing E-waste as coarse aggregate replacement is discussed on their paper.

D.W.Gawatre et.al.[2] experimented the use of E-waste particles as substitute of fine aggregates and remaining mix ratio as the same with conventional mix in the concrete mixes to achieve suitable compressive strength and workability of M30 grade concrete. Fine aggregates were replaced with 0%, 7.5%, 15%, 21.5% proportion of E-plastic waste.

Ashwini Manjunath B T [3] compare the properties of concrete with and without plastics, used as coarse aggregates. The technique adopted for this study was Hand mixing and by using concrete mixer for the mix proportion of 1:1.4:2.4:0.5 with w/c ratio 0.5. The E-plastic aggregates are added in amount of 0%, 10%, 20% and 30% by the weight of cement in mixed .The cubes of standard mould size of 150x150x150 mm, 150 X 300 mm cylinders and beams of 150 X 150 X 300 mm are used to prepare the specimen.

A.A. Dhanraj et.al. [4] focuses on the performance of M30 concrete prepared with E-plastic waste (PCB cutting waste) as part of the fine aggregate to find the thermal and ultrasonic properties. An experimental study had been carried out to analyze the thermal and ultrasonic properties of conventional concrete by casting the cube specimen. The compressive strength test was conducted using casting slab panels of 1'x1' with various thicknesses like 2", 4", 6", 8" and different temperatures in a closed chamber. A replacement of cement with fly ash (10% by weight) can be used effectively in concrete.

Prakash et.al. [5] presented an experimental work done to determine the effects of recycled concrete aggregate (RCA) under the curing conditions of 2.1 pH in sulphuric acid (H_2SO_4) and 0.5 N in Hydrochloric Acid (HCl) severally. The replacement percentages of RCA were 0%, 5%, 10% and 15% respectively. The partial replacement of RCA to achieve the mechanical properties (compressive and flexural strength) and chemical properties (corrosion resistance and alkali attack) of concrete by utilizing E–waste as compared with the ordinary conventional concrete. The present study aspire that the major work has been replacing of E–waste in the production of low cost concrete in civil engineering society.

Rasika shirgaonkar et.al. [6] study the effect of variation in percentage electronic waste plastic as a filter material on the strength of M20 grade concrete. The compressive strength of concrete with different percentage of plastic i.e.,0.72%, 1.44%, 2.16%, 2.88% was carried out at the edge of 3 days, 7 days and 28 days. The plastic which has been partially replaced by fine aggregate in the project is Acrylonitrile butadiene styrene (ABS).

Sunil Ahirwar et.al. [7] experimented using OPC of grade 43, natural sand from river Narmada is used as fine aggregate, natural crushed aggregate is used as a coarse aggregate and crushed plastic waste of which is passed from 20 mm sieve and retained on 4.75 mm sieve is employed in this research project. Mix is prepared with 0% to 30% electronic waste as partial replacement to coarse aggregate along with this 10% to 30%fly ash as a partial replacement of fine aggregate. 150*150*150mm cubes is casted for these mixes which is going to tested after 7,14 and 28 days of curing . Series of test were carried out on material, green & hardened concrete to obtain the workability strength characteristics of Electronic waste for potential application as structural concrete.

P.Krishna Prasanna et.al. [8] prepare specimens by utilizing E-waste particles (hard plastic) as coarse aggregates in concrete with percentage replacement from 0% to 20%.They also prepare conventional specimens of M30 grade concrete without using E-waste as aggregate.

Gaurav Awasthi et.al. [9] presents the effect of accelerators on compressive strength and flexural strength of concrete. OPC was used to produce M20 and M30 grade concrete. Three accelerators Potassium Carbonate, Sodium Triosulfate and Triethanolamine were used. Results were observed on 7,14 and 28 days. The test result revealed that yhe maximum percentage gain was for Triethanolamine accelerator out of the three at 1,3,7,14 and 28 days.

4. RESULTS AND DISCUSSION

Addition of fly ash in the mix improve the compressive strength and flexural strength of 20% and 25% mix to nearly 50% more compared to other E-waste mix without fly ash. However strength noticeably decreased when E-plastic content was more than 20%. 28 days result of UPV test confirmed the quality criteria of E-plastic concrete as good.It is concluded that 20% of E-waste aggregate can be replaced as coarse aggregate without any long term detrimental effects and with acceptable strength development properties[1].

The compressive strength of E-waste concrete is reduced by 52.98% when fine aggregate is replaced by 21.5%.The compressive strength of concrete is found optimum when fine aggregate are replaced by 7.5% with E-waste. Since fine aggregate can be replaced upto 7.5% successfully it can be used as construction material and thus decrease the project cost indirectly[2].

Workability increases upto 10% replacement and then decreases with increase in percentage of E-waste.Comparing the results with conventional concrete at 28 days the compressive strength, split tensile strength and flexural strength of concrete is reduced by 52.98% when coarse aggregate is replaced by 20% of E-waste. Thus the strength of concrete gets reduced when fine aggregate are replaced by E-waste. Plastics can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This is useful in applications requiring non-bearing lightweight concrete, such as concrete panels used in facades. Introduction of plastics in concrete tends to make concrete ductile, hence increasing the ability of concrete to significantly deform before failure. This characteristic makes the concrete useful in situations where it will be subjected to harsh weather such as expansion and contraction, or freeze and thaw[3].

E-waste concrete U factor values are more than the conventional concrete slab with the same area and different thickness. It shows that the R value (heat resistance) for e-waste concrete is lesser than the conventional concrete and the energy stored in the body of e-waste concrete is also lesser than the conventional concrete. So we can prefer e-waste by replacing with fine aggregation portion by 5%. By adding FR-4 to the fine aggregate, it decreases the weight of the concrete and it can provide fine strength and durability like conventional concrete.

UPVT also shows that the e-waste performs better. Hence, e-waste can be used as an alternative for the fine aggregate portion of conventional concrete [4].

The maximum compressive strength is obtained by replacing 15% of coarse aggregate by E–waste in concrete.The flexural strength is maximum when replacing 15% of coarse aggregate by E–waste in concrete .E–waste materials in the concrete does not influenced by sulphate under the curing condition of 2.1 N of H_2SO_4 for 28 days.Alkali reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete. It cause serious expansion and cracking in concrete, resulting in major structural problems and sometimes necessitating demolition. E-waste concrete exhibits the beam cause without any damage and cracks under the curing conditions of 0.5 pH of HCL for 28 days[5].

There is decreased in strength of concrete with 1.44 % (1kg) of plastic granules than 0.72% (500g) of plastic granules. With 2.16% (1.5kg) plastic granules increase in strength is found. However further increase in granules i.e. with 2.66% (2kg), reduction in strength at 3,7 and 28 days is observed. Thus e-waste mix concrete prepared with 2.16% (1.5kg) plastic granules is found to give maximum compressive strength compared to other concrete mixes. From the failure pattern of concrete cubes in compression it was found that, the failure was because crushing of cement paste rather than crushing of aggregate. It is difficult to ensure uniform dispersion of plastic granules throughout the mass of concrete. Further it is observed that some of the plastic fibres were found to be floating on the surface of cube due to load density of plastic .with increase in percentage of plastic granules concrete was found to loose cohesiveness[6].

Workability of the concrete increases when percentage of the electronic waste increases. Workability of fly ash with electronic waste concrete is even more than conventional and electronic waste concrete. Compressive strength of electronic waste concrete decreases with increase in the percentage of e-waste. Cement replacement of 30% by fly ash along with electronic waste gives best result. Electronic waste can replace coarse aggregate upto 10% or 20%. It is also concluded that electronic waste can replace coarse aggregate upto 30% in concrete when 30% fly ash is replaced by cement[7].

The strength of concrete was reduced by 33.75 when coarse aggregate is replaced by 20% of E-waste.

It was reduced by 16.86% when coarse aggregate was replaced by 20% of E-waste +10% fly ash. Compressive strength decrease beyond 15% e-waste[8].

More than 90% of target compressive strength was achieved at 7 days for M20 grade concrete with accelerators Sodium Triosulfate and Triethanolamine. For three accelerators, percentage increase in 1 and 3 days compressive strength is more for M20 grade concrete as compared to M30 grade concrete. Maximum percentage gain was observed for triethanolamine accelerator out of all accelerators at 1,3,7,14 and 28 days flexural strength for both M20 and M30 grade concrete[9].

5. CONCLUSION

The literature surveyed has listed the strength gain at early ages by using accelerators with E-waste and fly ash in concrete at different proportions. From the results of the literature review, it is evident that E-waste can be used in concrete as aggregate both fine and coarse. Increase in percentage of E-Waste leads to reduction in the self-weight of concrete. Workability of concrete decreases when percentage of the E-Waste is increased. Mechanical properties of concrete with E-Waste as aggregate shows slightly lesser strength than the controlled mix. It is also observed that the compressive strength of concrete is found to be optimum when coarse aggregate is replaced by 15% with E-Waste.

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