Utilisation of E-waste in Concrete - An Experimental Investigation

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Abstract **- E waste or electronic waste are discarded electronic appliances. These contain some parts of plastic and some parts of metallic waste. Recycling of these metallic waste of e-waste is a bit easier than plastic and also is less polluting. So to reduce the air pollution during recycling of plastic waste of e-waste we need another suitable option of reusing it in its original state. The estimated production of e-waste is approximately 20 to 25 tons per year globally. In this paper result of experimental data have been discussed for the study of the effect of adding plastic e-waste on the property of concrete. In this investigation plastic e-waste were added by replacing the fine aggregate at the rate of 10%, 20% and 30% by weight and also replacing coarse aggregate at the rate of 5%, 10%, 15%, 20% and 25% by weight in M25 concrete and compressive strength were determined for 7 and 28 days. The test result showed that the compressive strength were decreased by increasing the quantity of plastic e-waste in the concrete.**

Keywords- Plastic e-waste, concrete, compressive strength.

I. INTRODUCTION

Now a days the disposal of E-waste is very difficult as it is durable and non-biodegradable. These e-waste are disposed by landfill or stock pile method is not an environmental friendly solution. We face a serious problem that how to reuse the non-disposable E waste. This problem can be solved by the partial utilization of e-waste in the concrete as partial replacement of fine and coarse aggregate.

India is a fast growing nation which is going through a transition state from developing nation to developed nation. So to become a developed nation infrastructure is needed to become world class. From a study it is revelled that concrete industry of India is using concrete at the rate of 370 million cum per year and also it is expected to increase at 30 million cum per year (1).

Another truth of this nation is fast growing e-waste. According to a research paper titled 'E-waste in India' (4) presented in the Rajya Sabha in 2011 India had generated around 4 lakh tonnes of electronic waste in 2010, up from 1.47 lakh tonnes in 2005. In India, major amount of e-waste is mostly generated in metropolitan 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 (Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab) generate 70% of the total e-waste generated in India. Top ten cities generating e-waste are Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur.

E-waste contains some of the most harmful chemicals and metals like "polychlorinated biphenyls, chlorofluorocarbons, polyvinyl chloride are some of the halogenic compounds and heavy metals like arsenic, barium, beryllium, cadmium, chromium VI, lead, lithium, mercury nickel are typically present."

The present work is an attempt to explore the possibility of using E-waste as a material of hope for twenty first century. The present work is a part of comprehensive program where in experimental investigations have been carried out to assess the effect of replacement of regular material by a cheaper substitute i.e. E-waste on strength of concrete. For this study cubes were cast by replacing fine aggregate and coarse aggregate replacement by E-waste. Compressive strength of E-waste concrete were observed comparable with those of natural concrete. To achieve this comparative study cubes were cast replacing fine aggregate by 0%, 10%, 20% and 30% with E-waste and replacing coarse aggregate by 5%, 10%, 15%, 20% and 25% with E-waste. These cubes were tested after 7 and 28. To identify compressive strength a design mix 1:1.65:3(where 3 is proportion of 10mm and 20mm size aggregate) were used during the investigations at water cement ratio 0.46.

Lakshmi.R and Nagan.S [2010] has made an experimental study on the utilization of E-waste particles as coarse aggregates in concrete with a percentage replacement ranging from 0 % to 30% on the strength criteria of M20 Concrete. Compressive strength, Tensile strength and Flexural strength of Concrete with and without E-waste as aggregates was observed which exhibits a good strength gain. Ultrasonic tests on strength properties were executed and the feasibility of utilizing E plastic particles as partial replacement of coarse aggregate has been presented. Lakshmi.R and Nagan.S [2011] reported a significant improvement in compressive strength was achieved in the E-plastic concrete compared to conventional concrete. The tests were also designed to evaluate the internal pore structure, its chemical resistance to environmental agents and reactivity with some components of the cement. The results indicated that the E-plastic aggregate up to 15% weight of the coarse aggregate and replacement of cement with fly ash (10% by weight) can be used effectively in concrete and thus results in waste reduction and resources conservation. P.Krishna Prasanna and M.Kanta Rao [2014] has made an experimental study by utilizing E- waste particles as coarse aggregates in concrete with a percentage replacement from 0% to 20% i.e. (5%, 10%, 15%, and 20%). And Conventional specimens are also prepared for M30 grade Concrete without using E- waste aggregates. By conducting

tests for both the specimens the hardened properties of concrete are studied. It is found that use of E- waste aggregates results in the formation of concrete which has lesser weight than that of conventional concrete. This study ensures that reusing of E- waste as coarse aggregate substitutes in concrete gives a good approach to reduce cost of materials and solve solid waste problems posed by E-waste.

II. MATERIALS AND METHODS

In order to study the effect of e-waste as partial replacement of fine aggregate and coarse aggregate on the strength of concrete. Cubes (100mm×100mm×100mm) were cast using a design mix of (1:1.65:3.00), where 3.00 is the proportion of 10mm 20mm aggregate), an effort has been made here to get the strength of cubes made up with different percentage of e-waste to the respective strength of conventional concrete at the end of 7, 28 days of moist curing and to have an idea about the optimum percentage of e-waste which does not affect the strength of non-conventional concrete considerably.

A. Cement

In this work, Pozzolana Portland Cement (PPC) of Prism brand obtained from single batches throughout the investigation was used. The Portland cement content mainly two basic ingredient namely argillaceous and calcareous. The physical properties of PPC as determined are given in table 1. The cement satisfies the requirement of IS: 1489:1991. However, similar material properties were reported by Ankit et al [2014].

TABLE I. PROPERTIES OF POZZOLANA PORTLAND CEMENT (PPC)

S. No.	Properties	Experimental	Codal requirement (IS 1489 (Pt-1)-1991)
1	Normal Consistency%	31.5%	
2	Initial setting time	165min	(Not less than 30 min)
3	Final setting time	215min	(Not more than 600 min)
4	Soundness of Cement (Le chatelier expansion)	0.75mm	(Not more than 10 mm)
5	Fineness of Cement (%age retained on 90 micron IS sieve)	3.77%	10%
6	Specific gravity of Cement	2.60	3.15
7	Compressive Strength		
a	7 Days	23.45	23.45 N/mm^2(min)
b	28 Days	33.5	33 N/mm^2(min)

B. Fine Aggregate (500 gm)

TABLE II. TABLE II SIEVE ANALYSIS OF FINE AGGREGATE

S. NO.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %	Standard % Weight Passing for Zone II
1	10 mm	0	0	0	100	100
2	4.75 mm	6	6	1.2	98.8	100
3	2.36 mm	32	38	7.6	92.4	75-100
4	1.18mm	68	106	21.2	78.8	55-90
5	600 µm	106	212	42.4	57.6	35-59
6	300 µm	190	402	80.4	19.2	8-30
7	150 µm	94	496	99.2	0.8	0-10
8	Pan	4	500	0	0	0
				Total = 252		

FINENESS Modulus = 252/100= 2.52

The fine aggregate was locally available river sand which is passed through 4.75 mm sieve. The specific gravity of fine aggregate is 2.56 and fineness modulus of fine aggregate is 2.52 Result of sieve analysis is given in table 2. However, similar material properties were reported by Manish et al [2014].

C. Coarse Aggregate

The coarse aggregate was locally available quarry having two different sizes, one fraction is passing through 20mm sieve and another fraction passing through 10mm sieve. The specific gravity of coarse aggregate is 2.77 for both fractions. The grading of coarse aggregate of 10mm and 20mm size are given in table-3 & 4. Proportion of 20mm and 10mm size aggregate was taken as 60% and 40% respectively. However, similar material properties were reported by Manish et al [2014].

TABLE III. SIEVE ANALYSIS OF COARSE AGGREGATE (10MM SIZE)

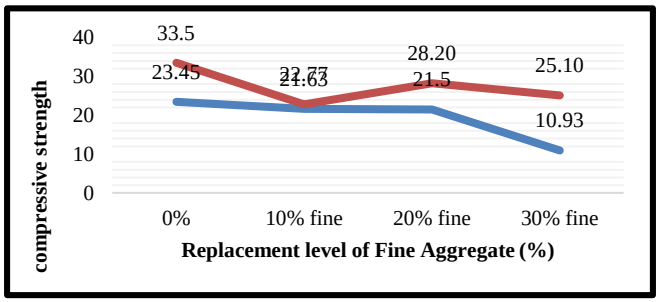
S. No.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	20mm	0.018	0.018	0.36	99.64
2	10mm	3.490	3.508	70.16	29.84
3	4.75 mm	1.456	4.963	99.26	0.74
4	2.36 mm	0.025	4.989	99.78	0.22
5	1.18mm	0.011	5.000	100	0
6	600 µm			100	0
7	300 µm			100	0
8	150 µm			100	0
				Total=669.56	

FINENESS MODULUS = 669.56/100=6.69

TABLE IV. SIEVE ANALYSIS OF COARSE AGGREGATE (20MM SIZE)

S. No.	Sieve Size	Weight Retained (gm)	Cumulative Weight Retained	Cumulative % Weight Retained	Passing %
1	40mm	0	0	0	100
2	20mm	4.444	4.444	44.44	55.55
3	10mm	5.531	9.975	99.75	0.25
4	4.75 mm	0.025	10.00	100	0
5	2.36 mm			100	0
6	1.18mm			100	0
7	600 µm			100	0
8	300 µm			100	0
9	150 µm			100	0
				Total= 744.19	

FINENESS MODULUS = 744.19/100=7.44



D. Water

Potable water is used for mixing and curing. The water cement ratio (w/c) of 0.46 has been used.

M 25 grade of concrete was used in this investigation and fine aggregate was kept as 50% of the total volume of aggregate. The resulting mix proportion of cement: fine aggregate: coarse aggregate was taken as 1:1.65:3.00(Where 3.00 is the proportion of 10mm and 20mm size aggregate) with water cement ratio of 0.46 and the quantity of cement is 380 kg/m^3.

III. RESULT AND DISCUSSION

A. Compressive Strength

The compressive strength of referral concrete as well as E-waste concrete are given in in table 5 for partial replacement of fine aggregate and in table 6 for partial replacement of coarse aggregate. It is evident from this table that up to 20 % of replacement the strength is comparable to the referral concrete however, beyond 20% strength substantially decreases with the addition of E-waste. The variation of compressive strength with different percentage of E-waste for partial replacement of fine aggregate is shown in figure 1 and for partial replacement of coarse aggregate in figure 2. This figure shows that the compressive strength of concrete with and without as function of curing time. The compressive strength of PPC is 23.45kN/mm^2 when water/cement ratio is 0.46 for 7 days and 33.5kN/mm^2 for 28 days curing.

1) Compressive strength of concrete at different replacement levels of fine aggregate

It is observed that at 7days curing strength of E-waste concrete decreased with increase in replacement level. It was observed that at 10% replacement of sand with E-waste the compressive strength at 7days curing is decreased by 7.76% which is comparable to the referral concretes. Decrease in strength at 7days curing was 8.32% and 49.16% at replacement level of 20% and 30% respectively. It showed that increase in E-waste content in concrete reduced the rate of strength gain at early ages due to slow hydration process. At 28days curing strength of E-waste concrete decreased with increase in replacement level. At 20% replacement of sand with E-waste the compressive strength at 28days curing is decreased to 28.20kN/mm^2 which is comparable to the referral concretes. Decreased strength at 28days curing was 22.77kN/mm^2 and 25.10kN/mm^2 at replacement level of 10% and 30% respectively. Compressive strength of concrete at different replacement levels of fine aggregate is shown in table no 5.

TABLE V. COMPRESSIVE STRENGTH OF CONCRETE AT DIFFERENT REPLACEMENT LEVELS OF FINE AGGREGATE

Cube designation	%age replacement of fine aggregate	Compressive strength 7 Days	Compressive strength 28 Days
A1	0%	23.45	33.5
A2	10%	21.63	22.77
A3	20%	21.5	28.20
A4	30%	10.93	25.10

Fig .1 Variation of Compressive Strength with replacement of fine Aggregate

2) Compressive Strength of Concrete at different Replacement levels of Coarse Aggregate

It was observed that at 7days curing strength of E-waste concrete decreased with increase in replacement level. It was observed that at 5% replacement of 10mm coarse aggregate with E-waste the compressive strength at 7days curing is marginally decreased by 6.61% which is comparable to the referral concretes. Decrease in strength at 7days curing was 12.01%, 14.43%, 31.77% and 31.91% at replacement level of 10%, 15%, 20% and 25% respectively. It showed that increase in E-waste content in concrete reduced the rate of strength gain at early ages due to slow hydration process. At 28days curing strength of E-waste concrete is initially increasing and then decreasing with increase in replacement level. It was observed that at 5% replacement of 10mm coarse aggregate with E-waste the compressive strength at 7days curing is increased to 37.10kN/mm^2 which is appreciable. Decreased strength at 28days curing was 32.70kN/mm^2, 32.50kN/mm^2, 28.10kN/mm^2 and 29.73kn/mm^2 at replacement level of 10%, 15%, 20% and 25% respectively. It showed that increase in E-waste content in concrete reduced the rate of strength gain at early ages due to slow hydration process. Compressive strength of concrete

at different replacement levels of coarse aggregate is shown in table no 6.

TABLE VI COMPRESSIVE STRENGTH OF CONCRETE AT DIFFERENT REPLACEMENT LEVELS OF COARSE AGGREGATE

Cube designation	%age replacement of coarse aggregate	Compressive strength 7 Days	Compressive strength 28 Days
B1	0%	23.45	33.5
B2	5%	21.90	37.10
B3	10%	20.63	32.70
B4	15%	20.07	32.50
B5	20%	16.00	28.10
B6	25%	15.97	29.73

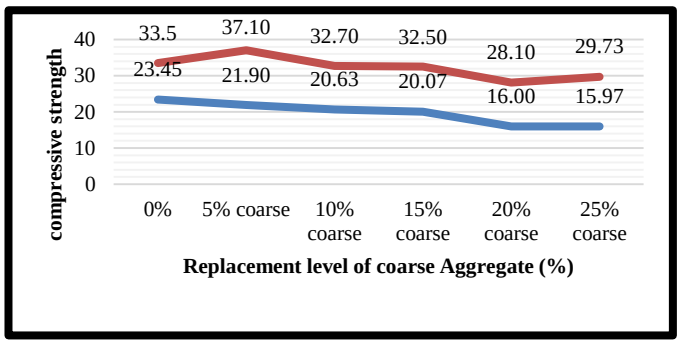


Fig 2 Variation of Compressive Strength with replacement of coarse Aggregate

IV. CONCLUSIONS

From the above study following conclusions are drawn-

1. The compressive strength of E-waste concrete up-to 20% replacement level as fine aggregate is comparable to referral concrete both at 7 and 28 days.
2. The Compressive Strength of E-waste concrete at 5% replacement as coarse aggregate is higher than that of referral concrete.
3. The compressive strength of E-waste concrete up-to 20% replacement level as coarse aggregate is comparable to referral concrete both at 7 and 28 days.
4. E- waste can effectively been used as construction materials.

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