Experimental Investigation of E-Waste based Concrete

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Abstract— **At present the demand of coarse aggregate is increased day by day in the world. 85 to 90% of electronic waste is disposed on landfills may dumped in environment and affects human health conditions. For the recovery of very serious issue in the world to overcome this rapid emerging problem is being questioned. In 2018 only 8.5% of E-waste are re used. Most innovative proposal to dispose E-waste as partial replacement for coarse aggregate in concrete and it also reduces cost of concrete. Effort has been made in concrete industry to eliminate the concrete material inadequacy problem which is currently going on in construction industry. Concrete mixes with various percentages of E-waste were casted. It has been decided to make of control mix specimens with partial replacement of E-waste on a percentage of 10%, 20%, and 30% to coarse aggregate in M30 grade of concrete with water cement ratio of 0.40. Control mix specimens are also prepared for same grade of concrete. And further it is studied and analyzed by comparison criteria.**

Keywords – E-Waste, Partial Replacement, Mechanical Properties.

I. INTRODUCTION

E-waste encompasses a board and growing range of electronic devices ranges from large household devices and etc. It is defined as "Any appliance sings an electric power supply that has reached its end of its life". It is roughly calculated that 50 million tonnes of E-waste will be increased globally in 2020. From this only 20 percent of world E-waste is recycled every year, which means that 50 million tons of e-waste is kept in landfill, burned or illegally exported and treated in an unsound way. This is despite 66 percent of the world's population being covered by e-waste legislation. In India, the lack of inventory in E-waste generated makes it difficult to quantify the recycled and disposed materials. According to the Central Pollution Control Board's inventory from 2005, India is to generate 0.8 million tons of E-waste by 2019. . Moreover, less independent studies suggest that the generation of E-waste could be much higher. The Global E-Waste Monitor, 2017 published by the United Nations University estimated that India generates about 2 million metric tons of E-waste (2018) annually. India is ranked 5th in the world among top e-waste producing countries-USA, China, Japan and Germany. "The large increase (in total E-waste generation of the world) was mainly attributed to India", Electronic Waste Management in India identified computer equipment make for almost 70 percent of E-waste, followed by telecommunication equipment-phones (12 per cent), electrical equipment (8 per cent) and medical equipment (7 per cent) with remaining from household E-waste. It is growing at a compound annual growth rate (CAGR) of about 30% in the country. Assocham estimated that e-waste generation was 1.8 million metric tonnes (MT) per annum in 2016 and would reach 5.2 million metric tonnes per annum by 2020.The work was conducted on M30 mix ratio. The replacement of coarse aggregate with E-waste percentage is 0%, 10%, 20%, and 30%. At last the mechanical properties of these concrete specimens were compared with control concrete specimens. The comparative study and tests results were demonstrated that a huge variation in compressive strength was accomplished in the E- waste concrete and can be utilized adequately in concrete.

Figure. 1 E-waste

II. LITERATURE REVIEW

Many report on the addition of E-waste mixed with the concrete has been published which gives a valuable information on the use of E-waste in concrete**.** Partial replacement of aggregate by e-waste has been experimentally carried out. The use of e-waste, we can overcome many environmental problems as it reduces the landfill due to e-waste and reduced the use of natural resources like aggregates. The 15% replacement of aggregates gives the optimum results for compressive strength test. It can be dispose in concrete as a coarse aggregate. Split tensile strength is maximum up to 15% replacement of coarse aggregate by e-waste. This replacement gives the sustainable approach. It is found that the workability decreases with the increase in the percentage of e-waste in concrete. It is due to the rough, irregular shape of e-waste aggregate as compared to the natural aggregates. These aggregates are flaky in shape and of rough texture so the internal friction is very high between these aggregates and results in reduced workability [1-3].

The E-waste concrete and comparing with conventional concrete is carried out experimentally. The E–waste is added by 0%, 5%, 10% and 15% with a w/c ration of 0.5%.Thus compressive, flexural, corrosion resistance, alkali attack, and durability test has been conducted. The test has been done for 7days and 28 days .Corrosion test is influenced by sulphate under the curing condition of 2.1 N of H2SO4 for 28 days. Alkali attack test is under 0.5 pH curing conditions of Hcl. Utilization of partial replacement of E–waste as a coarse aggregate is the best alternative for the conventional concrete.

The result shows that the good strength, greater durability and addition of E–waste exhibits increase in compressive strength up to 15% replacement. The corrosion resistance reaction shows that the EWC does not tempted by sulphur fewer than 2.1 N curing conditions of H_2SO_4[4].

The 28 mix prepared which contain 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. Tested after 7, 14 and 28 days of curing i.e. total 252 cubes are casted. At the same time 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. It has been observed that when we replace cement by fly ash in concrete along with electronic waste as a coarse aggregate compressive strength increases. Cement replacement of 30% by fly ash along with electronic waste gives best result. Current study concluded that Electronic waste can replace coarse aggregate up to 10% or 20%.Current study also concluded that electronic waste can replace coarse aggregate up to 30% in concrete when 30% fly ash is replaced by cement[5-6].

The E–waste is added by 0%, 2.5%,5%,7.5% and tested after 7,14,28 days. Thus compressive, flexural, corrosion resistance, alkali attack, durability test has been conducted. By comparing the result with conventional concrete at 28 days strength we found out that the compressive strength is first increasing by 3.6% and 4.8% for 2.5% of e-waste replacement respectively. And it is decreasing by 4.2% for 7.5% of e-waste replacement which is within the permissible limit of target mean strength value .Same is happening with the result of flexural strength and tensile strength. Hence we get that optimum percentage up to which we can introduce e-waste in concrete as coarse aggregate is 5% (increase in strength) to 7.5%.The E – waste concrete and comparing with conventional concrete is carried out experimentally. The E–waste is added by 0%, 5%, 10% and 15% with a w/c ration of 0.5%.The test has been done for 7days and 28 days [7-9].

III. MATERIALS AND ITS TEST RESULTS

A. Material Properties

Cement

Ordinary Portland cement of 53 grade locally available is used in this investigation. The cement is tested for various properties as per the code IS: 4031-1988 and it is found to be conforming to various specification of IS: 12269-1987 having specific gravity of 3.1.

Table. 1 Properties of Cement

Sl. No	Property	Result
1	Specific gravity	3.1
2	Standard consistency	32.5%
3	Initial setting time	31minutes
4	Final setting time	596 minutes

Fine Aggregate

The sand used for this experimental program was locally available and conformed to grading Zone I as per IS: 383-1970. The sand was first sieved through 4.75mm sieve and having specific gravity of 2.67.

Coarse Aggregate

Coarse aggregates which were locally available having the size of 20mm were used in the experimental work. Testing of coarse aggregate was done as per IS: 383-1970. The specific gravity of coarse aggregate is 2.87.

Table. 2 Properties of Fine Aggregate and coarse aggregate

Sl. No	Property	Result
1	Specific gravity of fine aggregate	2.67
2	Specific gravity of coarse aggregate	2.78
3	Water absorption	0.51%

E-waste

The E-waste which is collected from locally available having the size of 20mm was used in the experimental work. Testing of E-waste was done as per IS: 383-1970. The specific gravity of coarse aggregate is 1.20

Table. 3 Properties of E-waste

Sl. No	Property	Result
1	Specific gravity of E-waste	1.20
2	Water absorption	0.04%

Water

Water is a main ingredient of concrete, as it actively participates in the chemical reactions with cement to form the hydration product such as C-S-H gel. A higher water cement ratio will results in decreases of strength, durability etc. Addition of excess water ends in formation of undesirable voids in hardened cement paste of concrete. The pH value of water lies between 6 & 8 and it should be free from organic matter, acids and other suspended solids. Locally available water conforming to standard specified in IS: 456-2000 is used.

IV. EXPERIMENTAL PROGRAM

The compressive strength, Split tensile strength and flexural strength for M_{30} grade of concrete were investigated. The cube of 150x150x150mm, cylinder of 150mm dia & 300mm height and prism of 100x100x500mm were used. The test should be carried out as per code provision IS: 516-1959.

Compressive strength test

Compressive strength test was carried out on the specimens after 7 ,14 and 28 days of curing by compression testing machine. The test should be carried out as per code provision IS: 516-1959. Totally 12 cubes were casted. The compressive strength is calculated as,

$F_{ck}=P/A$

Where,

F_{ck}= Compressive strength (N/mm^2)

P = Ultimate load (N)

A = Loaded area (mm^2)

Split tensile strength test

The test is carried out by placing cylindrical specimens horizontally between the loading surfaces of a compressive testing machine and the load is applied until failure of cylindrical specimen. The test should be carried out as per code provision IS: 516-1959. Totally 12 cylinders were casted. The split tensile strength is calculated by

$F=2P/\pi DL$ N/mm^2

Where,

P= applied load

D= dia of cylinder

L= Length of cylinder

Flexural strength test

The test should be carried out as per the code IS: 516-1959. Flexural strength is calculated by,

Flexural strength= PL/bd^2

Where,

P=applied load

b= breadth of prism

d=depth of prism

l= c/c distance between the supports

Mix Proportion and Mix Details

The Mix proportion for the ordinary grade concrete and standard concrete is designed using IS: 10262-2009. Material required for 1 cubic meter of concrete in ordinary grade concrete $M_{30}$is

Table. 4 Mix Proportion

Volume of Concrete	*Cement*	*Water*	*Fine Aggregate*	*Coarse Aggregate*	*Super Plasticizer*
By Weight (kg/m^3)	*385*	*140*	*901*	*1194*	*3.5*
By Volume	*1*	*0.40*	*2.34*	*3.1*	*1% of cement*

V. RESULTS AND DISCUSSION

A. Compressive strength test result

Compressive strength test results after 7 ,14, 28 days are given in table. The result shows that the strength gets increases at 20% replacement of E-waste.

Table. 5 Compressive strength tests

S. No	Percentage of E-waste Added	Average Compressive Strength (N/mm^2)		
		7 days	14 days	28 days
1	Control Mix	21.4	29	35.3
2	10 %	19	27.6	31.5
3	**20 %**	**20.6**	**28.6**	**34.7**
4	30 %	18.3	26.2	30.2

The results showed that at early ages the strength was comparable, while at the age of 14, 28 days, 20% E-Waste concrete exhibited higher strength than the normal concrete. This is illustrated in fig.3.1.

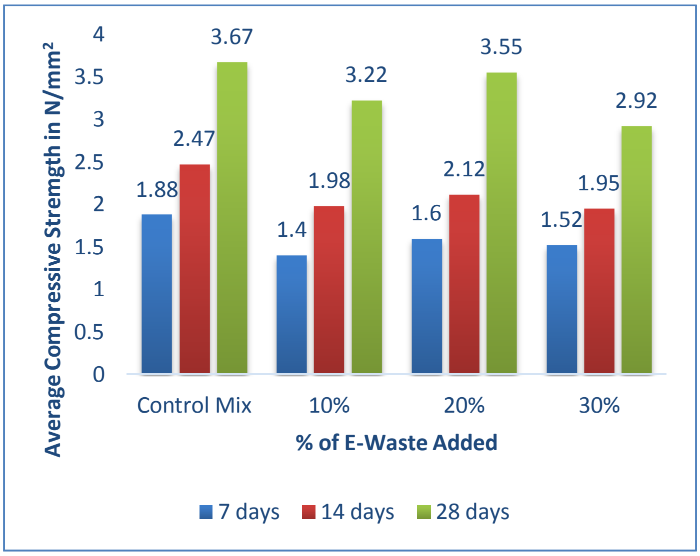

Fig. 3.1. Average compressive strength for $M_{30\ grade}$ of concrete

B. Split Tensile Strength Test result

Split tensile strength test results after 7 days,14days and 28 days are given in table. The result shows that the strength gets increases at 20% replacement of E-waste.

Table. 6 Split tensile strength test

S. No	Percentage of E-waste Added	Average Split Tensile Strength (N/mm^2)		
		7 days	14 days	28 days
1	Control Mix	1.88	2.47	3.67
2	10 %	1.4	1.92	3.22
3	**20 %**	**1.6**	**2.12**	**3.55**
4	30 %	1.52	1.95	2.92

The Tensile strength properties of E-Waste concrete was investigated in the laboratory, the results of this investigation are presented in table 6. There is improved strength at 7 days, 14 days and 28 days test by replacement of E-waste as coarse aggregate. But after 28 days 20% replacement of E-waste gives a minimum increased strength moreover equal to the normal concrete. This is illustrated in fig.3.2.

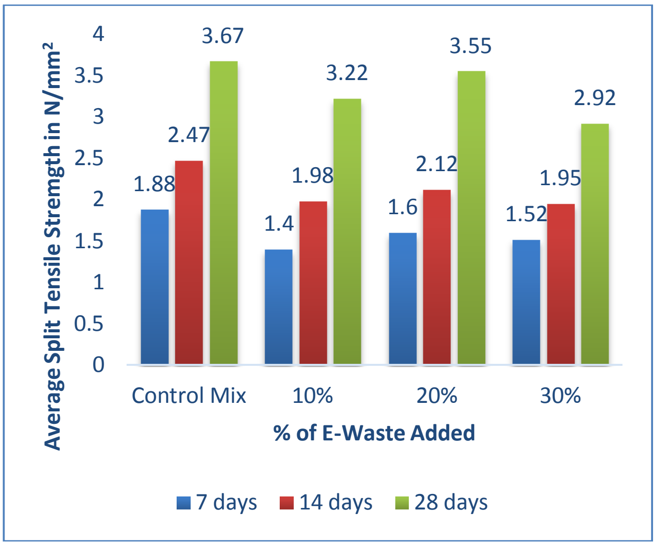

Fig. 3.2. Average split tensile strength for $M_{30\ grade}$ of concrete

VI. CONCLUSIONS

The study has been done on concrete using e-waste as partial replacement in coarse aggregate and it is notified from the study.

1. It is proved from the experimental that the E-waste can be disposed as a coarse aggregate in construction materials. The compressive strength and split tensile strength of concrete containing e-waste aggregate can be retained as in conventional concrete specimens.
2. However, strength noticeably decreased when the e-waste content was more than 20%.
3. It can be concluded that 20% of E-waste aggregate can be replaced as coarse aggregate replacement in concrete without any long-term effect sand with acceptable strength development properties.
4. From the test results it can be concluded E-waste is not suitable for replacement of fine aggregate.
5. As the E-waste as a waste material, it reduces the cost of construction.

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