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Experimental Study on Concrete Containing Electronic Waste (E-Concrete)

Mohammed Ihsaanul Haque[1], G. N. Shete[2]
[1]M.E. Student, Department of Civil Engineering, M. S. Bidve Engineering College, Latur, India
[2]Assistant Professor, Department of Civil Engineering, M. S. Bidve Engineering College, Latur, India

***Abstract*: Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability. Rapid growth of world population and wide spread urbanization has remarkably increased the development of the construction industry which caused a huge demand for sand and gravels. Environmental problems occur when the rate of extraction of sand, gravels, and other materials exceeds the rate of generation of natural resources. E-waste is nothing but discarded electronics and electrical equipment.80 to 85% of various electronic products discarded in landfills or incinerators which can involve or release certain toxics gases into air, may affect human health and environment. The extreme amount of lead in electronics alone causes damage in the central and peripheral nervous system, the blood and kidneys of human being. Only 12.5% of e-waste is currently recycled also Storage of waste is a big problem in India. In this paper an attempt is made experimentally to investigate the strength behavior of concrete with the use of electronic waste. The work was conducted on M30 grade mix. The replacement of coarse aggregate with E-waste in the range of 0%, 5%, 10%, and 15%. Various test such as compressive strength, tensile strength and flexural strength are investigated and these values are compared with conventional concrete. The test results showed that a significant improvement in compressive strength was achieved in the E-waste concrete compared to conventional concrete and can be used effectively in concrete.**

***Keywords*: E-waste, workability, compressive strength, tensile strength, flexural strength**

1. Introduction

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. The Waste materials Utilization of construction industry by-products is a sustainable solution to ecological and environmental problems. Use of such waste materials makes their reutilization in cement-concrete, RCC and other construction materials, and also the cost of cement and concrete manufacturing is reduces.

Research concerning the use of Electronic waste to augment the properties of concrete has been going on for recent years. Non recycling Waste materials are posing serious pollution problems to the human and the environment. So, new effective waste management options need to be considered. Efforts have been made in the concrete industry to use non-biodegradable components of E-waste as a partial replacement of the coarse or fine aggregates. In the recent decades, the efforts have been made to use electronic waste from various sources in concrete for the replacement of cement, fine and coarse aggregate. The use of these materials in concrete come from the environmental constraints in the safe disposal of these products. Use of E-waste materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects.

A. *Why e-waste?*

Now-a-days, electronic products have become an integral part of daily life which provides more comfort, security, and ease of exchange of information. These electronic waste (E-Waste) materials have serious human health concerns and require extreme care in its disposal to avoid any adverse impacts. Disposal or dumping of these E-Wastes also causes major issues because it is highly complex to handle and often contains highly toxic chemicals such as lead, cadmium, mercury, beryllium, brominates flame retardants (BFRs), polyvinyl chloride (PVC), and phosphorus compounds. India, which has emerged as the world's second largest mobile market, is also the fifth largest producer of e-waste, discarding roughly 18.5 lakh tones of electronic waste year, a study says.

2. Material properties

A. *Cement*

Portland pozzolona cement of ultra tech brand was used and it was conforming to IS 1489-1991properties of cement are tabulated in Table 1.

Table 1
Physical properties of cement

S. No	Property	Test results
1	Normal consistency	28.25%
2	Specific gravity	3.15
3	Initial setting time	170 minutes
4	Final setting time	250 minutes
5	Soundness test	0.5

B. *Fine aggregate*

Fine aggregate includes the particles that all passes through 4.75 mm sieve and retain on 0.075 mm sieve. Locally available river sand will be used as fine aggregate. The sand will first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then washed to remove the dust.

Properties of fine aggregate are tabulated in Table 2.

Table 2
Physical properties of fine aggregate

S. No	Property	Results
1	Specific Gravity	2.63
2	Fineness modulus	3.75
3	Grading zone	II
4	Bulk Density	
	1. Loose	1450 kg/m^3
	2.Compacted	1710 kg/m^3

C. *Coarse aggregate*

The broken stone is generally used as a coarse aggregate. Aggregate occupies most of the volume of the concrete. Locally available coarse aggregate having nominal size 20 mm was used. The aggregates were washed to remove dust and dirt. Physical properties of coarse aggregate are tabulated in Table 3.

Table 3
Physical properties of fine aggregate

S. No	Property	Results
1	Size	20mm
2	Specific gravity	2.68
3	Fineness modulus	7.20
4	shape	angular
5	Bulk Density	
	1. Loose	1350 kg/m^3
	2.Compacted	1600 kg/m^3

D. *Water*

Water is used for mixing, curing purpose should be clean, portable, and fresh and free from any bacteria. Water is a key ingredient in the manufacture of concrete.

E. *Electronic waste*

Electronic waste can be used as coarse aggregate, fine aggregate I concrete depending on particle size. In this experiment E-waste is crushed into 20mm size. Physical properties of e-waste are tabulated in Table 4.

Table 4
Physical properties of e-waste

S. No	Property	Results
1	Size	20mm
2	Specific gravity	1.5
3	Fineness modulus	7.20
4	Shape	Angular

3. Experimental programme and setup

The main aim of this experimentation is to study the effect of partial replacement of course aggregate by Electronic waste on the properties of concrete and check it,s compressive strength, flexural strength and workability of concrete. The experimental programme is divided in four phases.

1. Concrete mix design is done as per IS 10262-2009 for M30.
2. Casting of cubes and beams.
3. Curing of cubes and beams for 7 days and 28 days.
4. Testing of cube in compression testing machine and Beam are tested in flexural testing machine.

Each test result plotted in the Figures or given in the Tables is the mean value of results obtained from at least three specimens.

4. Mix design

Concrete mix design is done as per IS 10262-2009 for M30 grade of concrete. Material quantity required for 1m3 volume of work are tabulated in Table 5.

Table 5
Material quantity

Water	Cement	Fine. Agg.	Coarse agg.
186	413	610	1154
0.45	1	1.47	2.79
22.5	50	73.5	139.5

5. Methodology

A. *Workability*

The workability tests were performed using standard size of slump moulds as per IS; 1199-1999.slump test was performed for each percentage of replacement i.e. 5%, 10%, and for 15%.

B. *Compressive strength*

The cube specimen of the size 150 x 150 x 150 mm were tested after curing for period of 7 and 28 days. Compressive strength is determine by using compression testing machine (CTM) of capacity 2000KN.

C. *Tensile strength*

The tensile strength of concrete is tested by using test specimens 150 x 150 x 150 mm. Tensile strength is determine by using compression testing machine.

D. *Flexural strength*

The flexural strength test was determined according to I.S. 516:1959, 150 x 150 x 700 mm specimens were tested.

6. Result and discussion

A. *Effect of e-waste on the workability of concrete*

Table 6
Slump value

% of coarse aggregate replaced by electronic waste	Slump value (mm)
0%	47
5%	53
10%	50
15%	44

It is observed that with increase in percentage of e-waste workability decreases.

Obtained results are tabulated in Table 6 and also in graph format.

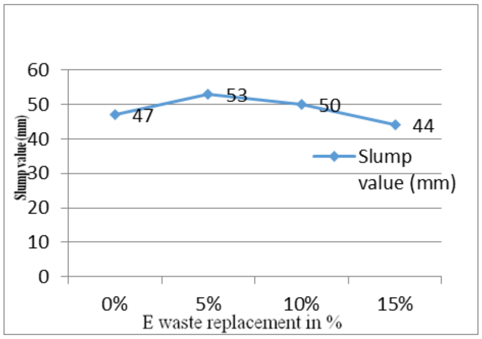

Fig. 1. Effect of e-waste on the workability of concrete

B. *Compressive strength*

The result of compressive strength after 7 days and 28 days are recorded. Result indicate that 10.9% and 5.9% increment in the compressive strength is found for 5% to 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 7% when the 15 % of coarse aggregate is replaced by e-waste.

Table 7
Compressive strength after 7 days and 28 days

S. No.	% of e-waste added	Compressive strength in N/mm^2	
		7 days	28 days
1	0%	19.53	31.80
2	5%	21.28	35.29
3	10%	20.5	33.70
4	15%	18.74	29.57

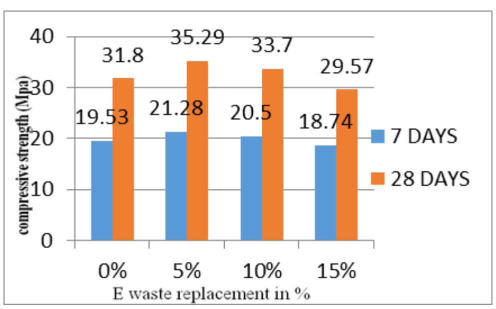

Fig. 2. Compressive strength after 7 days and 28 days

C. *Tensile strength*

Results obtained are tabulated in Table 8. 10.9% and 5.9% increment in the tensile strength is found for 5% and 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 7% when the 15 % of coarse aggregate is replaced by e-waste.

Table 8
Tensile strength after 7 days and 28 days

S. No.	% of e-waste added	Tensile strength in N/mm^2	
		7 days	28 days
1	0%	12.53	20.41
2	5%	13.65	22.65
3	10%	13.15	21.63
4	15%	12.02	18.98

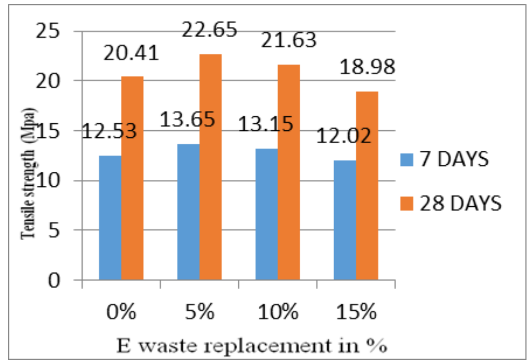

Fig. 3. Tensile strength after 7 days and 28 days

D. *Flexural strength*

The result of flexural strength were plotted in below table for 28 days. Result indicate that 13.3% and 6.8% increment in the flexural strength is found for 5% and 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 16% when the 15 % of coarse aggregate is replaced by e-waste.

Table 9
Flexural strength for 28 days

S. No.	% of e-waste added	Flexural strength in N/mm^2
		28 days
1	0%	3.8
2	5%	4.4
3	10%	4.1
4	15%	3..03

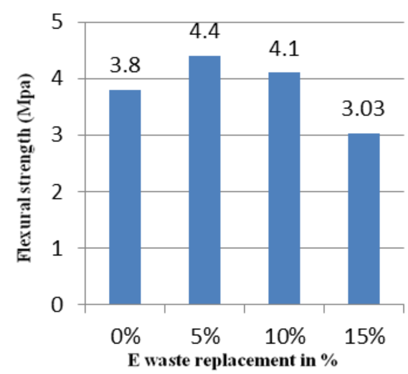

Fig. 4. Flexural strength for 28 days

7. Conclusion

Based on results and observation made in experimental research study. The following conclusions are drawn.

- Recycling of E-Waste is not just a viable solution to eliminate the harmful effects of disposal, but a sound business proposition in itself.
- Disposal of untreated E-Waste in landfills causes major health and environment hazards. Therefore, recycling of E-Waste becomes a major beneficial effect.

- It is observed that with increase in percentage of e-waste workability decreases.
- E-concrete is cheaper than conventional concrete.
- Current study concluded that Electronic waste can replace coarse aggregate upto 10%.
- 10.9% and 5.9% increment in the compressive strength is found for 5% to 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 7% when the 15 % of coarse aggregate is replaced by e-waste, by using aggregate cement ratio (A/C) is 4.2 and water cement ratio (W/C) is 0.45.
- 10.9% and 5.9% increment in the tensile strength is found for 5% and 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 7% when the 15 % of coarse aggregate is replaced by e-waste, by using aggregate cement ratio (A/C) is 4.2 and water cement ratio (W/C) is 0.45.
- 15.7% and 7.8% increment in the flexural strength is found for 5% and 10% replacement of coarse aggregate by e-waste respectively and the strength decreases by 20% when the 15 % of coarse aggregate is replaced by e-waste, by using aggregate cement ratio (A/C) is 4.2 and water cement ratio (W/C) is 0.45.
- The use of e-waste in concrete is possible to improve it's compressive strength, tensile strength and flexural strength and can be one of the economical ways for their disposal in environment friendly manner.

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