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# Experimental Investigation on Partial Replacement of E-Waste as Coarse Aggregate in Concrete

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**Abstract-** *Electronic waste is an emerging issue posing serious pollution problems to the human beings and to the environment. The rate of E-waste generation is increasing day by day in the modern world 80 % to 85% of different electronic items wastes disposed of in landfills or incinerators which can include or discharge certain lethal gases into air, it may influence environment and human being health conditions. The disposal which is becoming a challenging problem. For solving this process the removal of large amount of E-waste material, reuse of E waste in concrete industry is recommended as the most feasible application. Due to increase in cost of normal coarse aggregate it has forced the civil engineers to find out the suitable alternatives to it. E-waste is used as one of the alternative for coarse aggregate. Owing to less production of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was tried. The work was conducted on M25 grade mix. The replacement of coarse aggregate with E-waste in the range of 0%, 15%, 25%, and 35%. Finally the mechanical properties and the durability of concrete mix specimens obtained from the addition of these materials is compared with control concrete mix. The test results shows that a proper improvement in compressive strength was achieved in the E-waste concrete compared to conventional concrete and can be used effectively in concrete. The reuse of E-waste leads in waste reduction and resources conservation.*

***Key words: E-waste, Compressive strength, Split tensile strength, Flexural strength, Specific gravity.***

## 1. INTRODUCTION

E-wastes are one of the fast growing wastes in the world. It is a situation that prevails everywhere and it's hard to survive in this world without machines. Each year around 50 million ton of E-Waste are produced. Depending upon their nature of reaction, there are possibilities for dangers depending upon the situation. Discarded computers, mobile phones and other electrical and electronic wastes may results in unwanted results. So it's important to be aware of E-Waste in addition to the other physical wastes. Use of concrete is very large so the availability of natural material is reduced and there is no material which plays the role of this ideal material (concrete). To fulfill the requirement of industries, we have to replace E-waste partially. This paper is based on the review of literature which gives the idea about the possibility usage of E waste material in concrete.

Ten states generate 70% of the total E-waste generated in India. Because of the increment in cost of typical coarse aggregate it has constrained the civil engineers to discover appropriate other options to replace it. E-waste can be utilized as one of the options for coarse aggregate. Owing to shortage of coarse aggregate for the planning of solid, incomplete supplanting of E-waste with coarse aggregate was tried. The work was conducted on M25 mix ratio. The replacement of coarse aggregate with E-waste in the range of 0%, 15%, 25%, and 35%.

E-waste describes loosely discarded surplus, obsolete, broken, electrical or electronic devices. Rapid technology change, low initial cost has resulted in a fast growing surplus of electronic waste around the globe. Several tones of E-waste need to be disposed per year. E-waste contains numerous types of substances and chemicals creating serious human health and environment problems if not handled properly. Owing to the scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was attempted. The work was conducted on M25 grade mix. In this work, the percentage of various replacement levels of coarse aggregate with E-waste in the range of 0%, 15%, 25% and 35%. Finally the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials will be compared with that obtained by using control concrete mix.

## 2. METHODOLOGY

The research work was done before starting the work by reviewing the previous research topics papers published. The materials used are ordinary Portland cement of grade 43, natural sand is used as fine aggregate, natural crushed aggregate is used as a coarse aggregate and crushed & shredded e-waste of which is passed from 20 mm sieve and retained on 4.75 mm sieve is employed in this research project. The nature of the materials was tested by conducting tests namely specific gravity test, water absorption test, Impact value test. As per IS 10262:2009 mix design is done. Mix prepared which contain 0% to 35% electronic waste as partial replacement to coarse aggregate along with natural coarse aggregate with water cement ratio of 0.45 which is determined by conducting slump cone test for fresh concretes of every proportion of e-waste replaced specimens. Once design mix has been prepared, then 150X150X150mm cubes and 150X300 mm cylinders was prepared and casted for these mixes which is going to tested after 7,14 and 28 days of curing.

## 3. MATERIALS

### 3.1. Cement

Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Some tests were conducted such as consistency test, setting time test, specific gravity test.

**Table-1**: Physical properties of cement

| S.NO | PROPERTY | VALUE |
|---|---|---|
| 1. | Specific gravity | 3.14 |
| 2. | Consistency | 33% |
| 3. | Initial setting time | 30min |
| 4. | Final setting time | 300min |

### 3.2. Aggregate

Aggregates are materials added to cementitous mixtures to improve the strength of that mixture. The size of aggregates used is 20mm and the grain size of sand is used. The aggregate tests are performed and results are as follows.

(1)Fine aggregate
Aggregate is the granular materials used to produce concrete or mortar and when the particles of the granular material are so fine that they pass a 4.75mm sieve, it is called fine aggregate. It is widely used in the construction industry to increase the volume of concrete, thus it is a cost saving materials.

(2)Coarse aggregate:
Coarse-grained aggregate will not pass through a sieve with 4.75mm. Those particles that are predominantly retained on the 4.75mm sieve and will pass through 3-inch screen, are called coarse aggregate. It gives strength, hardness, durability in concrete.

**Table-2:** properties of fine aggregate and coarse aggregate

| S.NO | PROPERTY | FINE AGGREGATE | COARSE AGGREGATE |
|---|---|---|---|
| 1. | Fineness modulus | 2.64 | 4.16 |
| 2. | Specific gravity | 2.65 | 2.85 |
| 3. | Bulk density (kg/$m_3$] | 1810 | 1800 |
| 4. | Water absorption % | 0.55% | 0.65% |

### 3.3. Water

Water as a material to make any kind of cementitous paste. It is what helps initiate the hydration reaction of the cement to turn that slurry of the mix to act as a binder between all its constituents. Water influences the strength development and durability of concrete. Ordinary drinking water can be used for preparing concrete. Guidance of examine the suitability of the available water for construction can be obtained from the following specified data in IS 456-2000.The pH value of water should be generally not be less than 6.

### 3.4. E-waste

E-waste refers to electronic products nearing the end of their "useful life" for example, computers, televisions, VCRs, stereos, copiers, and fax machines. Many of these products can be reused, refurbished, or recycles. In this project these e-waste were crushed and used in the place of 20mm coarse aggregate.

**Fig-1**: E-waste

## 4. CONCRETE MIX

The mixes were designated with the grade of concrete and the type of fine aggregate used. IS method of concrete mix was used to achieve a mix with cube strength of 25 Mpa. Mix proportions were arrived and E-waste was added to the concrete mix with a w/c ratio 0.45. 0The percentage of E-waste added by weight was 0%, 15%,25% and 35%. Control mix concrete and modified concrete with varying percentage of E-waste and the percentage for various replacement levels.

**Table-3**: % of E-waste

| MIX SPECIFICATION | CONTROL MIX | MODIFIED MIX 1 | MODIFIED MIX 2 | MODIFIED MIX 3 |
|---|---|---|---|---|
| PROPORTION OF E-WASTE ADDED | 0% | 15% | 25% | 35% |

## 5. EXPERIMENTAL PROCEDURE

### 5.1 Preparation of Test Specimens

For the purpose of testing specimens, various concrete specimens were prepared for different mixes using rotating drum mixer. Preparation of concrete specimens aggregates, cement and E-waste was added. After thorough mixing,

water was added and the mixing was continued until a uniform mix was obtained. The concrete was then placed in to the moulds which were properly oiled. After placing of concrete in moulds, proper compaction was given using the table vibrator. For compressive strength test, cubes of size 150mmx150mmx150mm were cast. For splitting tensile strength test, cylinders of size 150mm diameter and 300mm height were cast and for flexural strength test, beams of size 150mmx100mmx100mm with and without reinforcement were cast. Specimens thus prepared were de-moulded -after 24 hours of casting and were kept in a curing tank for curing.

**Table-4:** size of specimens

| TEST DETAILS | SHAPE AND DIMENSION OF THE SPECIMENS |
|---|---|
| Compressive strength | Cube:150*150*150mm |
| Split tensile strength | Cylinder:150*300mm |
| Flexural strength | Beam:150*100*500mm |

## 6. TESTING OF SPECIMENS

### 6.1. .Compressive Strength

Cube specimens are used of size 150mmx150mmx150mm to determine compressive strength of mix design concrete no of cube casted for compressive strength is 12cubes with the addition of e-waste(0%,15%,25%,35%)for 7 days and 28 days under normal water curing

**Table-5:** Compression Tested Values

| S NO | % of e-waste added | 7days compressive strength (N/mm² ) | 28 days compressive strength (N/mm²) |
|---|---|---|---|
| 1 | 0% | 16.25 | 24.5 |
| 2 | 15% | 15.3 | 22.16 |
| 3 | 25% | 17.03 | 23.30 |
| 4 | 35% | 12.72 | 21.12 |

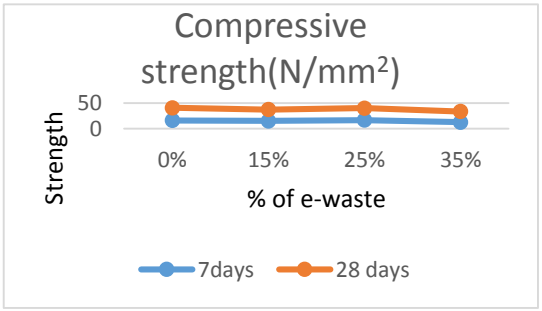


**Chart -1:** compressive strength on cube

### 6.2. Tensile Strength

Normal cylinders and e-waste concrete cylinder of size 150ϕ x300mm height are casted and cured. No of Specimens casted for Split tensile Strength is 12 cylinders with addition of e-waste (0%, 15%, 25%, 35%) for 28 days. the tensile strength test is calculated.

**Table-6:** Split tensile tested value

| S .NO | % of e-waste added | 7days split tensile strength (N/mm² ) | 28 days split tensile strength (N/mm²) |
|---|---|---|---|
| 1 | 0% | 2.62 | 3.85 |
| 2 | 15% | 2.10 | 2.8 |
| 3 | 25% | 2.9 | 3.20 |
| 4 | 35% | 3.1 | 3.75 |

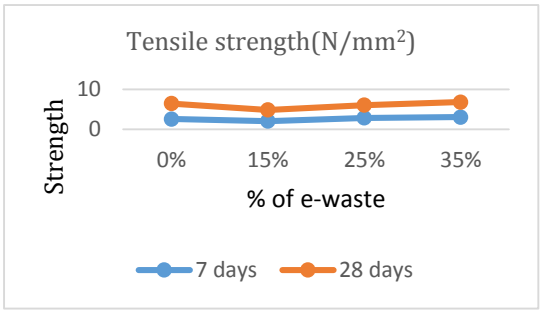


**Chart 2-**Tensile strength on cylinder

### 6.3. Flexural strength test

Normal mix concrete beams and addition of e-waste concrete mix beam size 150mmx150mmx500mm are used for flexural testing machine. No of Specimens casted for Flexural Strength is 12 beams with the addition of e-waste (0%, 15%, 25%, 35%) for 28 days.

**Table no-7:** Flexural Tested value

| S NO | % of e-waste added | 28 days flexural strength(N/mm²) |
|---|---|---|
| 1 | 0% | 3.43 |
| 2 | 15% | 3.6 |
| 3 | 25% | 3.9 |
| 4 | 35% | 3.2 |

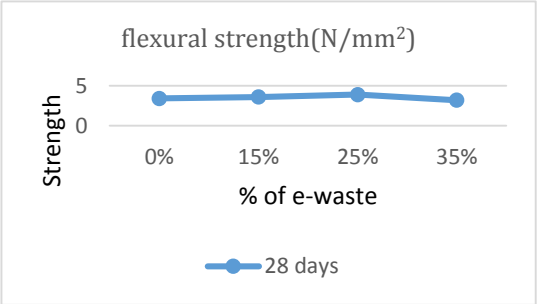


**Chart-3:** Flexural strength on prism

## 8. CONCLUSIONS

An experimental study has been done on concrete using e-waste as coarse aggregate and following points is observed from the study. They are

- It is identified that e-waste can be disposed by using them as construction materials.
- Since the e-waste is not suitable to replace fine aggregate it is better equipped to replace the coarse aggregate.
- The compressive strength and split tensile strength of concrete containing e-waste aggregate can be retained as in conventional concrete specimens.

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