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# STUDY ON PROPERTIES OF CONCRETE WITH ELECTRONIC WASTE

**K. Karuna Devi, S. Arun Kumar, R. Balaraman**
Assistant Professor, Department of Civil Engineering,
Jerusalem College of Engineering, Chennai, Tamil Nadu, India

**ABSTRACT**

*Utilization of waste materials and by products is a partial solution to environmental and ecological problems. Use of these 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. Electronic waste, abbreviated as e waste, consists of discarded old computers, TVs, refrigerators, radios basically any electrical or electronic appliance that has reached its end of life. 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. An experimental study is made on the utilization of E waste. Particles as coarse aggregates in concrete with a percentage replacement ranging from 0 % to 20% 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.*

**Key words:** E waste, Compression test, Water absorption test.

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## 1. INTRODUCTION

All over the world, the quantity of electrical and electronic waste generated each year, especially computers and televisions, has assumed alarming proportions. Among the 10 largest e-wastes generating States Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. The main sources of electronic waste in India are the government, public and private (industrial) sectors, which account for almost 70 per cent of total waste generation. The contribution of individual households is relatively small at about 15 percent, the rest being contributed by manufacturers. Though individual households are not large contributors to waste generated by computers, they consume large quantities of consumer durables and therefore, potential creators of waste.

The processing of electronic waste in developing countries causes serious health and pollution Problems due to electronic equipment contains serious contaminants such as lead, Cadmium, Beryllium, Arsenic, Mercury, Nickel, Silver, Zinc .E Waste sources available in the form of loosely discarded , surplus, obsolete ,broken, electrical or electronic devices from commercial informal recyclers have been collected which were crushed and ground to the particle size as per requirement for coarse aggregate or fine aggregate.

Electronic waste is an emerging issue posing serious pollution problems to the human and the environment. The disposal of which is becoming a challenging problem. For solving the disposal of large amount of E-waste material, reuse of E-waste in concrete industry is considered as the most feasible application. Due to increase in cost of normal coarse aggregate it has forced the civil engineers to find out suitable alternatives to it. E-waste is used as one such alternative for coarse aggregate. Owing to scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was attempted. The work was conducted on M20 grade mix. The replacement of coarse aggregate with E-waste in the range of 0%, 5%, 10%, 15%, and 20%. Finally the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials is compared with control concrete mix. 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.

## 2. NEED FOR THE STUDY

- New waste management options are needed to divert End-Of-Life (EOL) electronics from landfills and incineration.
- .Increasing the need for landfills is a burden to our environment. Also with the storage of landfill capacity and an increased concern about environmental quality, newer waste treatment methods are desired.
- Incineration is the process of burning of the electronic wastes and converting them into ashes which makes it simple to dispose them of well in the natural resources
- Incineration may lead to air pollution due to uncontrolled burning of wastes and also when disposed of in natural resources it causes contamination of its quality which is a threat to environment
- Electronic product in construction industry is one of the environmentally friendly aspects.
- But it contains several toxic components in composition so it requires several treatment and processes to remove those components and make it feasible for useful purposes those are really effective
- The major objective of this project to reduce as far as possible the accumulation of used and discarded electronic and electrical equipments and transfer waste into socially and industrially beneficial raw material using simple, low cost and environmental friendly technology.
- The reuse of E-waste results in waste reduction and resources conservation.

### 2.1. E-Waste

Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered e-waste. Informal processing of electronic waste in developing countries may cause serious health and pollution problems, as these countries have limited regulatory oversight of e-waste processing.

E-waste encompasses ever growing range of obsolete electronic devices, such as computers, servers, main frames, monitors, TVs and display devices, cellular phones, calculators, audio and video devices, printers, scanners, copiers, refrigerators, air conditioners, washing machines, microwave ovens, electronic chips, processors, mother boards, printed circuit boards (PCBs), industrial electronics such as sensors, alarms etc.Electronic and electrical equipments are made up of several components, many of which contains toxic substance, like lead, chromium, mercury, beryllium, cadmium, acids and plastics etc. Monitors and televisions made with tubes (not flat panels) have between 4 and 8 pounds of lead in them. Most of the flat panel monitors and TV's being recycled now contain less lead, but more mercury, from their mercury lamps. About 40% of the heavy metals, including lead, mercury and cadmium, in landfills come from electronic equipment discards.

These toxic substances can have highly adverse impacts on human health and environment, if not handled properly. Often these hazards arise due to improper recycling and rudimentary processes used for disposal of E-waste. For example, improper breaking or burning of printed circuit boards (PCBs) and switches may lead to the release of mercury, cadmium and beryllium which are highly toxic to human health. Another dangerous process is the recycling of components containing hazardous compounds such as halogenated chlorides and bromides used as flame retardants in plastic, which form persistent dioxins and furans on combustion at low temperatures.

## 2.2. Composition of E-Waste

Electrical and Electronic equipment contains metallic and non metallic elements, alloys and compounds such as Copper, Aluminium, Gold, Silver, Palladium, Platinum, Nickel, Tin, Lead, Iron, Sulphur, Phosphorous, Arsenic etc. If discarded in the open, these metals can cause a severe environmental and health hazard.

## 2.3. Experimental Investigation

In order to achieve the objective, this project was explored with the previously done research by doing comprehensive literature reviews. The method consists of collection of required data, which interm will support in deciding the type and method of data collection and analysis. Different alternative data collection such as experiments, observations, etc. were examined and used during the exercise. Test results were presented in tabular and graphical forms and the analysis and discussions were also made on the research findings both qualitatively and quantitatively. Based on the final test result findings, conclusions and recommendations were forwarded.

Mix Design for M20

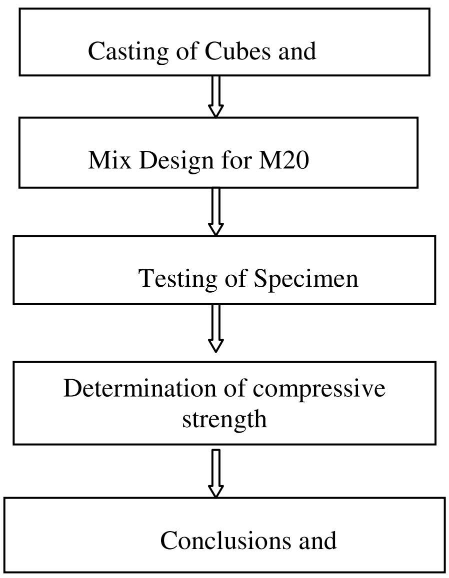


**Figure 1** Mix Design for M20

# 3. MATERIALS USED

- Portland Pozzolana cement
- Fine aggregates
- Coarse aggregates
- Water
- E-waste

## 3.1. Cement

Cement is used right from ancient periods in construction industry .The most commonly available Portland Pozzolana cement was selected for the investigation. The cement used was dry, powdery and free from lumps. All possible contact with moisture was avoided while storing cement. The Portland Pozzolana Cement is a kind of Blended Cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions. Portland pozzolana cement has spherical cement particles and they have higher fineness value. Due to the spherical shape concrete move more freely and more fineness of particles allows better filling of the pores. This type of cement also gives better cohesiveness to concrete. PPC cement also reduces the rate of slump loss of concrete as compared to concrete made with ordinary cement, particularly in hot weather condition. PPC cement reduces bleeding by providing greater fines volume and lower water content for a given workability. This also helps to block bleed water channels. PC cement slightly prolongs the setting time of concrete which helps the mason for good finishing of concrete or cement mortar. The cohesiveness of concrete mix helps for better finishing of concrete. The silicate formation of PPC continues even after the rate of hydration of ordinary cement slows down. This results in increased strength gain at later ages. This higher rate of strength gain will continue with time and result in higher later age strength. PPC in concrete helps to reduce drying shrinkage and plastic shrinkage.

## 3.2. Fine Aggregate

Aggregates comprise as much as 60% to 80% of a typical concrete mix, so they must be properly selected to be durable, blended for optimum efficiency, and properly controlled to produce consistent concrete strength, workability, finishability, and durability .Fine aggregates are the most important component of the concrete mix after the cement. Normally river sand is used as fine aggregates for preparing concrete. Aggregate most of which passes 2.36 mm IS sieve is used.

## 3.3. Coarse Aggregate

Ordinary crushed stone with size 20mm was used as coarse aggregate in concrete mixes. They generally possess all the essential qualities of a good stone showing very high crushing strength, low absorption value and least porosity. The high crushing strength of the coarse aggregates defines the capacity of the coarse aggregates in concrete which can bear a large amount of load to withstand the crushing effect caused by the different types of load. The low absorption value and porosity are determined to find the permeability of fluids through the coarse aggregates which may cause the cracks and other deformation which may lead to the collapse of the structure.

## 3.4. Water

Water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Hence locally available purified drinking water was used for the work.

## 3.5. E-Waste

E-waste is a popular, informal name for electronic products nearing the end of their useful life. Because technology advances at such a high rate, many electronic devices become "trash" after a few short years of use. Computers, televisions, VCRs, stereos, copiers, and fax machines are common electronic products. Many of these products can be reused, refurbished, or recycled.

**Figure 2** Electronic waste

**Figure 3** Coarse aggregate

## 3.6. Batching

Batching was done method of weight batching by using weighing balance having accuracy 0.001gm.

## 3.7. 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 20 Mpa. Mix proportions were arrived and E-waste was added to the concrete mix with a w/c ratio 0.5. the percentage of E-waste added by weight was 0, 5 ,10 ,15 and 20.

**Figure 4** Coarse aggregate

# 4. MATERIAL PROPERTIES

## 4.1. Specific Gravity Test

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity test helps in identification of stone. Specific gravity test is done using spring balance and Le chatelier's apparatus and kerosene for cement and the fine aggregates i.e. sand. Firstly, the empty weight of the apparatus is weighed and then the cement is taken into the apparatus as sample and then weighed. Then the apparatus is filled with kerosene and the weight is taken. Then the apparatus filled with the fine aggregate or cement then the rest is filled with the kerosene and the overall weight is taken. By subtracting the actual weight of the apparatus the specific gravity of the fine aggregate and cement is found. To determine the specific gravity of the coarse aggregates i.e. is gravel and e-waste the pyconometer apparatus is used. It follows the same principle as the fine aggregates. As the e-waste is replaced in the coarse aggregates the specific gravity of each particular percentage varies with the weight of e-waste. In the pyconometer apparatus the 200g of coarse aggregates are taken and their specific gravity is determined using water, then the e-waste is replaced in the coarse aggregate by percentage by percentage and then their corresponding specific gravity values are determined.

**Table 1** Specific gravity test of the materials

| **Material** | **Specific gravity values** | | |
|---|---|---|---|
| | **Trial 1** | **Trial 2** | **Mean** |
| Cement | 3.14 | 3.15 | 3.15 |
| Fine aggregate | 2.61 | 2.61 | 2.61 |
| Coarse aggregate | 2.65 | 2.65 | 2.65 |

Specific gravity for e-waste:

$W_1$ ,$W_2$,$W_3$,$W_4$ are the weights of the aggregates and water and the apparatus in the specific gravity test

For 0%

Specific gravity $= \frac{\text{Dry weight of aggregate}}{\text{weight of equal volume of water}}$

$= \frac{W_4}{W_3-(W_1-W_2)}$

$= \frac{0.2}{0.201-(1.098-0.972)}$ $= 2.65$

For 10%

Specific gravity $= \frac{\text{Dry weight of aggregate}}{\text{weight of equal volume of water}}$

$= \frac{W_4}{W_3-(W_1-W_2)}$

$= \frac{0.2}{0.203-(1.094-0.972)}$ $= 2.46$

For 15%

Specific gravity $= \frac{W_4}{W_3-(W_1-W_2)}$

$= \frac{0.2}{0.201-(1.103-0.972)}$ $= 2.86$

For 20%

Specific gravity $= \frac{W_4}{W_3-(W_1-W_2)}$

$= \frac{0.2}{0.205-(1.101-0.972)}$ $= 2.6$

**Table 2** Specific gravity test for e-waste

| Replacement of e-waste | Specific gravity |
|---|---|
| 0% | 2.65 |
| 10% | 2.46 |
| 15% | 2.86 |
| 20% | 2.6 |

## 4.2. Water Absorption Test

Water absorption gives an idea of strength of rock stones having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on the strength, impact and hardness tests.

For 0%,

Water absorption = Percent by weight absorbed in terms oven dried

weight of aggregrate= $\frac{(W_3-W_4)\times 100}{W_4}$

$= \frac{(0.201-0.2)\times 100}{0.2} = 0.5$

For 10%,

Water absorption = $\frac{(W_3-W_4)\times 100}{W_4}$

$= \frac{(0.203-0.2)\times 100}{0.2} = 1.5$

For 15%,

Water absorption $= \frac{(W_3-W_4)\times 100}{W_4}$

$$= \frac{(0.201-0.2)\times 100}{0.2} = 0.5$$

For 20%,

$$\text{Water absorption} = \frac{(W_3-W_4)\times 100}{W_4}$$

$$= \frac{(0.205-0.2)\times 100}{0.2} = 2.5$$

**Table 3** Absorption test for e-waste

| Replacement of e-waste | Absorption values |
|---|---|
| 0% | 0.5 |
| 10% | 1.5 |
| 15% | 0.5 |
| 20% | 2.5 |

## 4.3. Fineness Modulus

Aggregates in concrete provide the basic strength to it. Graded aggregates for the densest concrete and has effective workability with a minimum quantity of cement. Hence, the fineness modulus number is an essential criterion in the mix design of concrete. Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the sieves ranging from 80 mm to 150 micron and dividing this sum by 100. Fineness modulus is generally used to get an idea of how coarse or fine the aggregate is. More fineness modulus value indicates that the aggregate is coarser and small value of fineness modulus indicates that the aggregate is finer.

Fineness modulus is a numerical index, which gives an idea about the property and mean size of the particles in the entire body of the aggregates. It is obtained by adding the percentage weight of material retained on each of the standard set of sieves and dividing it by 100. Sieves of different sizes, lid and receiver ,sieve shaker, balance ,tray and stiff brush are used to find this analysis of fineness.

**Table 4** Limits of fineness moduli

| Maximum size of aggregate | Fineness Modulus |
|---|---|
| Fine aggregate | 4.84 |
| Coarse aggregate(20mm) | 9.04 |
| Coarse aggregate(20mm) | 7.35 |

**Table 5** Sieve analysis of fine aggregate

| S.no | Seive size | Weight retained (gm) | Percentage of weight retained % | Cumulative Percentage Retained % |
|---|---|---|---|---|
| 1 | 4.75mm | 20 | 4 | 4 |
| 2 | 2.36mm | 25 | 5 | 9 |
| 3 | 1.18mm | 130 | 26 | 35 |
| 4 | 600µ | 120 | 24 | 59 |
| 5 | 300 µ | 1.45 | 29 | 88 |
| 6 | 150 µ | 20 | 4 | 92 |
| 7 | 75 µ | 25 | 5 | 97 |
| 8 | Less than 150 µ | 15 | 3 | 100 |
| | | | TOTAL | 484 % |

Cumulative percentage of fine aggregate retained = 484%
Fineness modulus of fine aggregate = (Cumulative percentage retained )/100 = 4.84%

**Table 6** Sieve analysis of coarse aggregate

| S.no | Seive size | Weight retained (gm) | Percentage of weight retained % | Cumulative Percentage Retained % |
|---|---|---|---|---|
| 1 | 80mm | 0 | 0 | 0 |
| 2 | 40mm | 0 | 0 | 0 |
| 3 | 20mm | 17 | 17 | 17 |
| 4 | 10mm | 700 | 70 | 87 |
| 5 | 4.75mm | 130 | 13 | 100 |
| | | | TOTAL | 904 |

## 4.4. Other Properties

**Table 7**

| Properties | E- waste particle | Coarse aggregate |
|---|---|---|
| Colour | White and Dark | Dark |
| Shape | Angular | Angular |
| Crushing value | <2% | 15% |
| Impact value | <2% | 26% |

# 5. MIX DESIGN

The concrete mix is designed as per IS 10262 - 2009.

## 5.1. Mix Proportion for M20

***Determination of Water content***

Characteristic strength = 20 MPa
Specific gravity of sand = 2.6
Specific gravity of Cement = 3.15
Target strength = $f_{ck}$ + 1.65 x SD (S)
= 20 + 1.65 x 4
= 26.6 $N/mm^2$

(where $f_{ck}$ and SD are the compressive strength and standard deviation values )

***Selection of water cement ratio***

From Table 5 of IS 456, maximum water cement ratio = 0.5
Therefore Adopt w/c = 0.5

***Selection of water content***

From table 2,IS 10262
Maximum water content =186 l
Assuming slumpness below 25mm,
Estimated water content = $186(\frac{3}{100})\times186 = 191.58$ l

***Calculation of cement content***

Water Cement rati = 0.5

Cement content $= \frac{W}{0.5}$

Cement content = $\frac{191.58}{0.5}$ = 383.84 kg/m$^3$

Minimum cement content for M20 grade of 250 kg/m$^3$

Hence , safe.

***Proportion of volume of coarse aggregate and fine aggregate***

From Table 3 of IS 10262 - 2009, for 20mm aggregate, volume of coarse aggregate for water cement ratio = 0.5 is 0.6 and volume is reduced.

Volume of coarse aggregates= 0.6 m$^3$

Volume of fine aggregates $= 1 - 0.6$=0.4 m$^3$

## 5.2. Mix Calculation

Volume of concrete = 1 m$^3$

Volume of cement $= \frac{\text{Mass of cement}}{3.15} \times \frac{1}{1000} = \frac{383.16\times1}{3.15\times1000}$

=0.1216 m$^3$

Volume of water=$\frac{191.6\times1}{1\times1000}$ = 0.1916 m$^3$

Volume of all in aggregate = a-(b+c)

=1-(0.1216+0.1916)

= 0.6868 m$^3$

Mass of coarse aggregates= e×vol. of coarse agg.×sp. gravity of coarse agg.×1000

$0.6989\times0.54\times\frac{2.46+2.65}{2}\times1000$

= 964.27 kg/m$^3$

Mass of fine aggregates= e×volume of fine aggregates × specific gravity of fine aggrgates

= 0.6989×0.46×2.61×1000 = 839.09 kg/m$^3$

*For 6 cubes,*

Volume of 6 cubes $= 6 \times (0.15)^3$

= 0.02025 m$^3$

Cement weight = 0.02×344.84 = 6.89 kg

Water content = 0.5×6.896 = 3.45 l

Fine aggregates =0.02×839.09 = 16.78 kg

Total Coarse aggregates= .02×964.27 =19.29 kg

Replacing 10% of coarse aggregates by e waste

Coarse aggregates = 17.361 kg

E waste = 1.929 kg

*For 6 cylinders:*

Volume of 6 cylinders= $\frac{6\times\pi\times0.15^2\times0.3}{4}$ = 0.032 m$^3$

Weight of batch = 0.032×2400 = 76.34 kg

Total weight of batch= $76.34+\frac{76.34}{10}$ = 83.97 kg

Weight of cement = $83.97 \times \frac{1}{5.5}$ = 15.27 kg

Weight of fine aggregates= $83.97 \times \frac{1.5}{5.5}$ = 22.9 kg

Weight of coarse aggregate= $83.97 \times \frac{3}{5.5}$ = 45.80 kg

Weight of e waste = $\frac{10}{100} \times 45.80$= 4.58 kg

Weight of coarse aggregates= 45.8-4.58= 41.22 kg

w/c=0.5(w/c is the water cement ratio)

Water content = 0.5 x 15.27= 7.635 l

*Total quantity of materials required for 10 % content:*

Cement = 22.16 kg

Coarse aggregates = 58.58 kg

Fine aggregates = 39.68 kg

E waste = 6.51 kg

Water = 11.085 l

Similarly the quantities of materials required for 15% and 20% of e waste replacement in concrete is calculated

*15% mix calculation:*

For 6 cubes,

Cement weight = 6.89 kg

Water content = 3.45 l

Fine aggregates = 16.78 kg

After 15% replacement of e waste

Coarse aggregates = 17.67 kg

E waste = 3.119 kg

For 6 cylinders,

Cement weight = 15.27kg

Water content = 7.635 l

Fine aggregates = 22.9 kg

After 15% replacement of e waste

Coarse aggregates = 38.93 kg

E waste = 6.87 kg

*20% mix calculation:*

For 6 cubes,

Cement weight = 6.89 kg

Water content = 3.45 l

Fine aggregates = 16.78 kg

After 20% replacement of e waste

Coarse aggregates = 15.94 kg

E waste = 3.9854 kg

For 6 cylinders,

| | |
|---|---|
| Cement weight | = 15.27kg |
| Water content | = 7.635 l |
| Fine aggregates | = 22.9 kg |

After 20% replacement of e waste

| | |
|---|---|
| Coarse aggregates | = 36.64 kg |
| E waste | = 9.16 kg |

*Total quantity of materials required:*

| | |
|---|---|
| Cement weight | = 66.48 kg |
| Water content | = 33.255 l |
| Fine aggregates | = 119.04 kg |
| Coarse aggregates | = 167.76 kg |
| E waste | = 29.644 kg |

## 6. TESTS ON FRESH CONCRETE

### 6.1. Slump Test

Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. In this test fresh concrete is filled into a mould of specified shape and dimension and the settlement or slump is measured when supporting mould is removed. Slump increases as water content is increased. Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works.

The apparatus for conducting the slump test essentially consists of metallic mould in the form of a frustum of a cone having the internal dimensions under:

| | |
|---|---|
| Bottom diameter | : 20cm |
| Top diameter | : 10cm |
| Height | : 30cm |

The slump cone is cleaned and a light film of oil or grease is applied. The quantity of materials required for this test is calculated and it is mixed with water taking water-cement ratio of 0.5.theis placed on smooth horizontal non-absorbent surface or on a metal plate and the mould is held in position firmly. Now concrete is filled in the mould to one-fourth height and tamped with tamping rod 25 times uniformly over the full surface of the concrete. Then another one-fourth height is filled and tamped. Finally it is levelled with the top of the mould. Then the mould is raised. On raising the mould the concrete will subside height of the subside concrete heap is measured by steel rule immediately after removing the mould then difference in the height between the original height and subside heap of concrete will give like value of slump. Hence the slumps for water –cement ratio 0.5 are noted.

**Figure 5** Slump test

**Table 8** Slump test values for e-waste

| E waste replacement | Slump test values |
|---|---|
| 0 | 42.7 |
| 10 | 38 |
| 15 | 32.3 |
| 20 | 27.4 |

## 7. CASTING OF CUBES AND CYLINDERS

The moulds are cleaned and oil is applied lightly. The quantities of material required for casting the cubes and cylinders for designed mix is computed and weighted. First the materials are mixed in dry condition and then the water is added and mixed well. Now the mix is placed in the mould in 50mm layers of concrete and each layer is compacted 25 times with tamping rod uniformly.

**Figure 6** Concrete blocks

## 8. CURING OF THE CONCRETE BLOCKS

Water curing is the most effective method of curing. It produces the highest level of compressive strength .If a concrete is not well cured, it cannot gain the properties and durability to endure long life service. A proper curing greatly contributes to reduce the porosity and dry shrinkage of concrete and thus achieves higher strength and greater resistance to physical and chemical attacks in aggressive environments. With these results in mind, proper curing was done for specified days after the specimens are removed from the moulds.

**Figure 7** Curing of cubes and cylinders

## 9. TESTS ON HARDENED CONCRETE

The cube and cylinder specimens are casted and cured for 7 days and 28 days. The compression and split tensile tests are carried out as in the following section.

### 9.1. Compressive Strength

Compressive strength was determined using compression testing machine (CTM) of 2000 kN capacity. Compressive strength of concrete cubes and cylinders varies according to its grade of concrete. Water cement ratio and curing period are also taking the main role for improving the compressive strength. The test is conducted on concrete specimens of size 150mm x 150mm x 150mm . The cubes are removed from the moulds and placed inside the water and after 7 days and 28 days testing is done. Then after proper curing the cubes are taken and then water is wiped out. Then it is kept to dry for a few hours outside. The square plate is placed over the machine .The specimen is placed at the centre of the compressive testing machine platform and then circle plate is placed over it. The load is applied gradually till the specimen fails. The load at which the specimen fails is noted down and the compressive strength.

The compressive strength of the specimen are calculated as follows

Compressive Strength = $\frac{P}{A}$

Where, P - Load applied, N

A - Surface area of cube under loading, $mm^2$

**Figure 8** Testing machine

**Figure 9** Testing of cubes

### 9.2. Split Tensile Strength of Cylinders

The cylinders are cast using the cylinder moulds and used to determine the tensile strength of the concrete by splitting the cylinder. The cylinders are taken out of the curing chamber and then wiped out and kept to be dried in the atmospheric air. The cylinders are placed in the testing machine and the break point load is determined. This value is used to determine the tensile strength.

Tensile strength = $\frac{2P}{\pi DL}$

Where ,P – Load applied, N

D – Diameter of the cylinder , mm

L – Length of the cylinder ,mm

**Figure 10** Testing of cylinder

## 10. TEST RESULTS

### 10.1. Test Results of Cubes

The e-waste are replaced in different proportion to cast cubes and the ewaste volume showing average compressive strength. The test results shows the 7, 28 days compressive strength of e-waste and are partially mixed with coarse aggregate. From the results increase in strength has been obtained in e-waste in 15%.

**Table 9** Compressive test of cubes for 7 and 28 days

| SI.No | E-waste replacement | Compressive strength in N/mm$^2$ | |
|---|---|---|---|
| | | 7 days | 28 days |
| 1. | 0% | 13.94 | 24.74 |
| 2. | 10% | 14.22 | 25.8 |
| 3. | 15% | 17.68 | 29.31 |
| 4. | 20% | 13.36 | 21.06 |

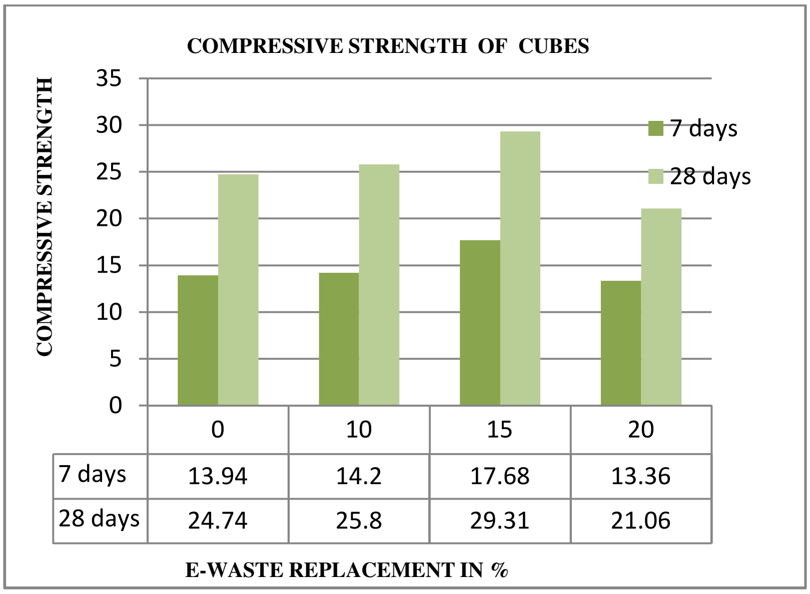


**Figure 11** Compressive strength of cubes for 7 days and 28 days

## 10.2. Test Results of Cylinders

The e-waste are replaced in different proportion to cast cubes and the e-waste volume showing average compressive strength. The test results shows the 7, 28 days compressive strength of e-waste

**Table 10** Split tensile test of cylinders for 7 and 28 days

| SI.No | E-waste replacement | Split tensile strength in N/mm$^2$ | |
|---|---|---|---|
| | | 7 days | 28 days |
| 1. | 0% | 1.18 | 2.74 |
| 2. | 10% | 1.76 | 3.02 |
| 3. | 15% | 2.41 | 3.36 |
| 4. | 20% | 1.13 | 1.46 |

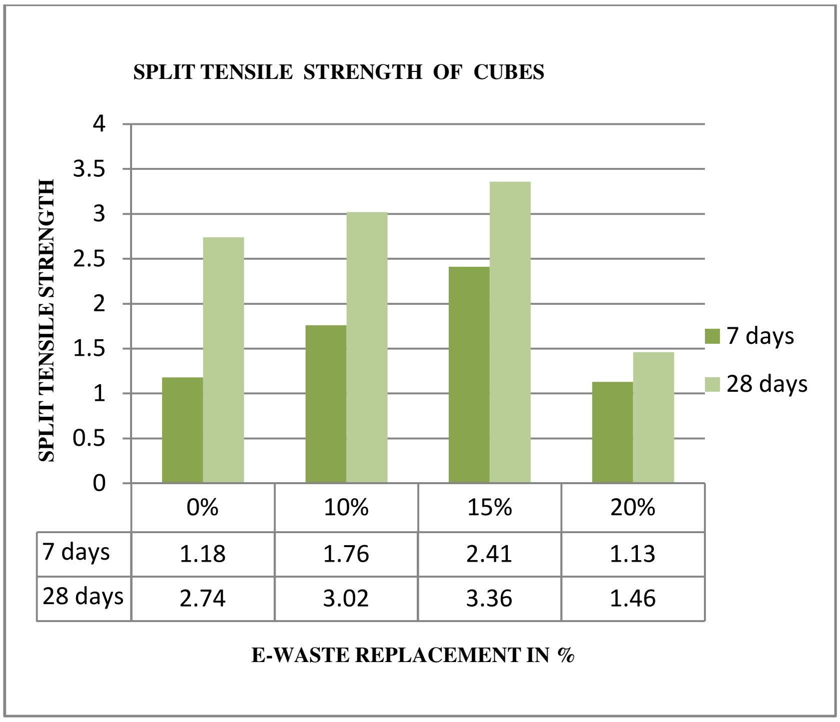


**Figure 12** Split strength tensile of cubes for 7 days and 28 days

## 11. CONCLUSIONS

This study helps to find the effective ways to utilize the electronic waste particle as the partial replacement of coarse aggregate. Analysis of the compressive strength gave the following results:

- The addition of E-waste attains optimum value in compressive strength in 15% replacement.
- The split tensile strength optimum strength in 15% replacement of the e waste.
- The compressive strength of concrete will gradually decrease when coarse aggregate are partially replaced beyond 15% with Electronic waste.
- From this study we can use Electronic waste in to the concrete by partial replacing the coarse aggregate.
- It is identified that the E- waste particles can be used as the construction material.
- The use of E-waste in concrete is possible to improve its mechanical properties and can be one of the economical ways for their disposal in environment friendly manner

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