Journal of Advances in Science and Technology
Vol. 13, Issue No. 2, March-2017, ISSN 2230-9659

# Experimental Study on Effect of E-Waste on Properties of $M_{30}$ Grade Concrete

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***Abstract – Rapid growth of technology, advancement in technical innovations and a high rate of obsolescence in the electronics industry have led to one of the fastest growing Waste streams in the world, called E-waste. Several tones of E-waste need to be disposed per year. Non recycling Waste materials such as E-Waste, fly ash, silica fume etc are posing serious pollution problems to the human and the environment. Use of these materials in cement, concrete and other construction materials helps in getting them utilized. it also helps in reducing the cost of cement, concrete manufacturing and numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effect.***

***An experimental study is made on the utilization of E-Waste particles as coarse aggregate in concrete with a percentage replacement ranging from 0% to 30% and 15% of constant fly ash replacement in cement (0%+0%, 5%+15%, 10%+15%, 15%+15%, 20%+15%, 25%+15%, 30%+15%) on strength criteria of M30 grade concrete.***

***Keywords –Coarse Aggregate, E-Waste Aggregate, Fly Ash, Partial Replacement, Compressive strength.***

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## 1. INTRODUCTION

Up gradation in the field of science and technology brought industrial revolution, In the 20th Century, the information and communication revolution has brought massive changes in the way we organize our lives, our economies, industries and institutions. These amazing developments in modern times have truly boosted the quality of our lives. At the same time, these resulted in multiple problems including the problem of massive amount of hazardous waste and other wastes generated from electric/electronic products. Both developed countries and developing countries like India face the problem of e-waste management. E-Waste is one of the rapidly growing waste streams in the world which consist of end of life electrical and electronic equipment products. E-wastes material like PCBs contains around 30% metals and 70% non-metals. These hazardous and other wastes pose a great threat to the human health and environment. The proper management of wastes is the critical issue for the protection of livelihood, health and environment, so the efforts are needed to address it for achieving sustainable development.

**Figure 1.1 E-Wastes Coarse Aggregate (EWCA)**

Construction industry plays a primary role in the developing countries like India. In construction industry cement mortar and concrete are the most generally used construction material. Use of E-waste materials in cement, concrete and other construction materials, helps in getting them employed**,** reduces the cost of cement and concrete manufacturing and also has numerous indirect benefits such as saving in energy, reduction in landfill cost, and protecting the environment from possible pollution effects. To overcome impact on ecological imbalance of nature and to get economy in construction, in this project an attempt has been made to replace coarse aggregate with "E-waste particles" at different proportion for cement concrete of M-30 grade. Fly ash which is also a by-product from various industries and residue left from burning coal is a group of materials that can vary extremely in composition. In this paper, 15% of fly ash has recycled in cement which helped in increasing the ultimate compressive strength and workability, reduced sulphate attack, reduced efflorescence, reduced shrinkage, reduced heat of hydration, reduced alkali silica reactivity of fresh concrete.

**Figure1.2 Fly Ash (FA)**

Comparative experimental work is carried out to study the compressive strength of concrete of M-30 grade in laboratory after 7, 14 and 28 days by adding E-Waste in coarse aggregates with a percentage replacement ranging from 0% to 30% and 15% of constant fly ash replacing in cement.

## 2. E-WASTE AN OVERVIEW

Technically, electronic waste is only a subset of WEEE (Waste Electrical and Electronic Equipment). According to the Organization for Economic Co-operation and Development (OECD) any appliance using an electronic power supply that has reached its End –of life would come under WEEE.

Millions of tons of electronic waste from unusable computers and other electronic equipments are being generated every year. E-waste contains multiple types (more than 1000 different) of substances and chemicals which causes serious human health and environment problems if not handled properly. E-waste also includes many toxic substances viz heavy metals like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium etc. electronic waste is the reason for 70% of the heavy metals (mercury & cadmium) in landfills. Consumer electronic is the main source for the presence of about 40% of the lead in landfills. These toxins can cause brain damage, allergic reactions and cancer.

The constituents and their components of WEEE are given in Table 2.1

| Constituents | Components in % |
|---|---|
| Iron and Steel | 47.9 |
| Non flame retarded plastic | 15.3 |
| Copper | 7.0 |
| Flame retarded plastic | 5.3 |
| Aluminum | 4.7 |
| Printed circuit boards | 3.1 |
| Wood and plywood | 2.6 |
| Concrete & ceramics | 2.0 |
| Other metals (non-ferrous ) | 1.0 |
| Rubber | 0.9 |
| Others | 4.6 |

**Table 2.1: WEEE material composition**

There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India 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. Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur. Fig.2.1 shows the State wise E-Waste generation in India (Tones/year). 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.



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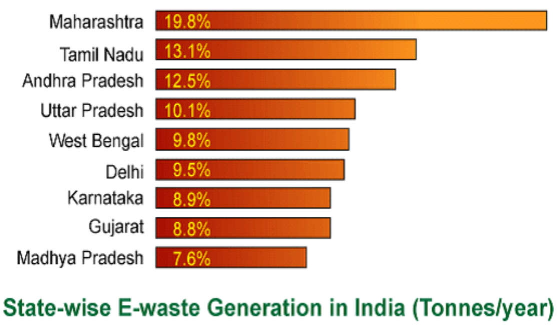


**Fig.2.1 State wise E-Waste generation in India (Tones/year)**

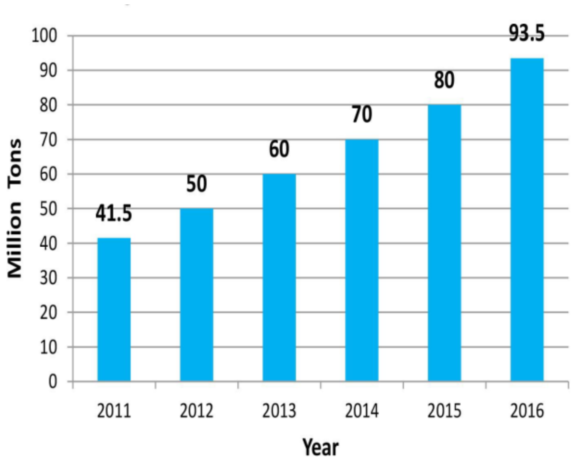


**Fig.2.2 E-Waste volume growth in last few years**

## 3. MATERIALS USED

- Cement
- Fine Aggregate (FA)
- Coarse Aggregate (CA)
- E-Waste coarse Aggregate (EWCA)
- Fly ash (FA)

### Cement

Cement is the primary building material in today's construction world. In this project 53grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989 is used.

Specific gravity of cement = 3.15

| Description of test | Test results obtained | Requirements of IS: 8112 1989 |
|---|---|---|
| Initial setting time | 60 minutes | Min. 30minutes |
| Final setting time | 300 minutes | Max. 600minutes |

**Table 3.1 physical properties of cement**

### Fine Aggregate

Locally available clean and dry manair river sand conforming to Grading zone II of IS: 383 –1970 has been used. The sand passing through IS 4.75mm Sieve has been used for casting all the specimens.

The specific gravity= (w2-w1)/ (w2-w1)-(w3-w4) = 2.61

Water absorption =0.82%

### Coarse Aggregate

The crushed 20 mm size aggregate were used.

| S.no. | Property | Value |
|---|---|---|
| 1 | The specific gravity | 2.6-2.8 |
| 2 | Water absorption | 0.19% |
| 3 | Fineness modulus | 3.12 |

**Table 3.2 properties of coarse aggregate**

### E-Waste Coarse Aggregate (EWCA)

E-Waste collected from the disposal area was collected and sorted to get the superior one. These were crushed into small pieces and then they are sieved to get 20mm size E-Waste coarse aggregate.

**Figure 3.1 Crushed EWCA**

### Properties of E-Waste

According to the Indian standard specifications the property of aggregates such as specific gravity,


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aggregate crushing value and density were determined. From Table 2.3 comparing the properties of aggregate for both NCA and EWCA, it is observed that the specific gravity and bulk density for EWCA is much lower than NCA which offers a light weight concrete.

| Property | EWCA | NCA |
|---|---|---|
| Specific gravity | 1.1 | 2.6-2.8 |
| Water absorption | <0.2% | 0.64% |
| Crushing value | <2% | 21% |
| Bulk Density(kg/m3) | 650 | 1624 |
| Impact value | <2% | 17% |

**Table 3.3 Properties of EWCA and NCA**

**Fly ash (FA)**

The fly ash waste available in thermal power station by burning coal has been collected and 15% of Fly ash is used in cement.

**Properties of Fly ash**

| S. No | Property | Fly Ash |
|---|---|---|
| 1. | Specific gravity | 2.1-2.3 |
| 2. | Bulk Density (gm/cc) | 0.9-1.3 |
| 3. | Porosity (percent) | 30-65 |

**Table 3.4 physical properties of fly ash**

| Chemical compound | Pozzolan type | | | Cement |
|---|---|---|---|---|
| | CLASS F | CLASS C | CLASS N | |
| SiO | 54.90 | 39.90 | 58.20 | 22.60 |
| AL2O3 | 25.80 | 16.70 | 18.40 | 4.30 |
| Fe2O3 | 6.90 | 5.80 | 9.30 | 2.40 |
| CaO | 8.70 | 24.30 | 3.30 | 64.40 |
| MgO | 1.80 | 4.60 | 3.90 | 2.10 |
| SO3 | 0.60 | 3.30 | 1.10 | 2.30 |
| Na2O & K2O | 0.60 | 1.30 | 1.10 | 0.60 |

**Table.3.5 Chemical Composition of Fly Ash and Cement**

## 4. EXPERIMENTAL PROCEDURE

In the present experimental work, first, the waste recycling material fly ash and e-waste have collected from disposal area and e-waste have crushed into the small 20mm particle size. Various tests have conducted to find the mix proportions of M30 Grade. According to the mix proportions the concrete mix was prepared and 3 specimens have prepared for each percentage of e-waste so that total 21cubes have moulded for different e-waste percentages ranging from 0% to 30% and 15% of constant fly ash than the casting is done by filling the concrete in to well-oiled moulds, as concrete have become dried, cubes were demoulded and placed for curing in curing tank. For every 7, 14, 28 days the compression test is performed and values are noted.

**Mix Design**

The concrete mix design was proposed by using Indian Standard for control concrete.M30 Grade concrete is been used and 21 cubes were casted using E-Waste particles as coarse aggregate in concrete with a percentage replacement ranging from 0% to 30% and 15% of constant fly ash replacing in cement. Different mixing ratios are given in Table3.1

| S.No | FA | EWCA |
|---|---|---|
| 1 | 0% | 0% |
| 2 | 15% | 5% |
| 3 | 15% | 10% |
| 4 | 15% | 15% |
| 5 | 15% | 20% |
| 6 | 15% | 25% |
| 7 | 15% | 30% |

**Table 4.1 Different mixing ratios**

## 5. TESTING PROCEDURE

**Compressive strength test**

Out of various test carried out on concrete, this is the most important test which gives an idea about various characteristic of concrete. Compressive strength test was conducted to evaluate the strength development of concrete containing various E- waste contents and fly ash at the age of 7, 14, 28 days respectively. At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block has been noted. From the noted values, the compressive strength has been calculated by using formula:

Compressive Strength = Load / Area

Size of the test specimen = 150mm x 150mm x 150mm

Figure 5.1 Compressive Strength Test

## 6. TEST RESULT

**Compressive strength:**

| S. No | % Replacement | | Compressive Strength N/MM$^2$ | | |
|---|---|---|---|---|---|
| | FA | EW | 7 Days | 14 Days | 28 Days |
| 1 | 0% | 0% | 20.41 | 27.22 | 35.17 |
| 2 | 15% | 5% | 19.21 | 24.3 | 29.6 |
| 3 | 15% | 10% | 19.81 | 26.84 | 32.89 |
| 4 | 15% | 15% | 18.12 | 25.17 | 28.43 |
| 5 | 15% | 20% | 16.77 | 22.82 | 26.67 |
| 6 | 15% | 25% | 15.89 | 22.41 | 25.12 |
| 7 | 15% | 30% | 14.73 | 20.42 | 23.81 |

Table 6.1 Compressive Strength Test Result

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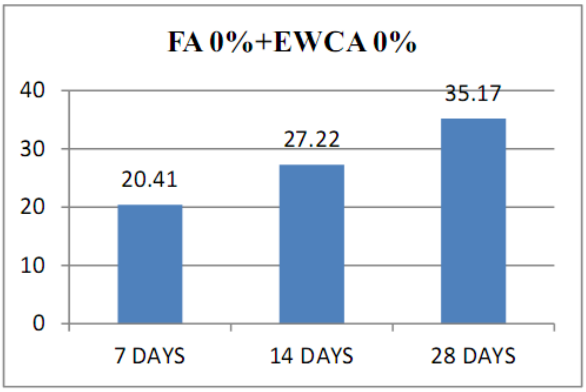
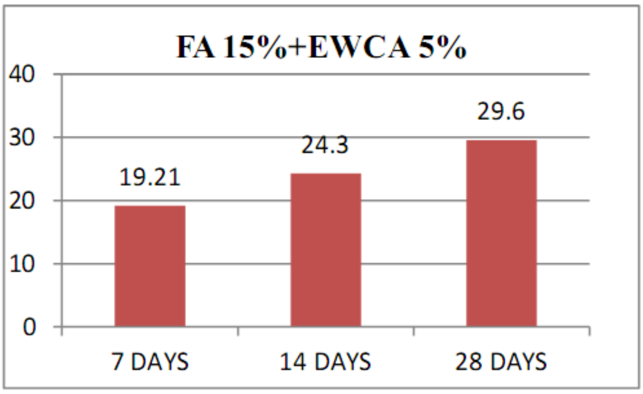
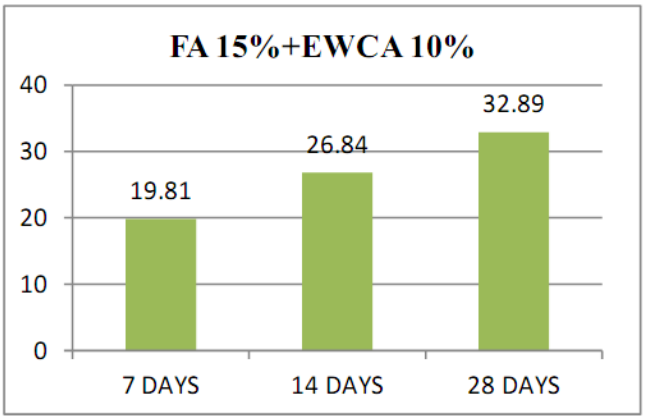


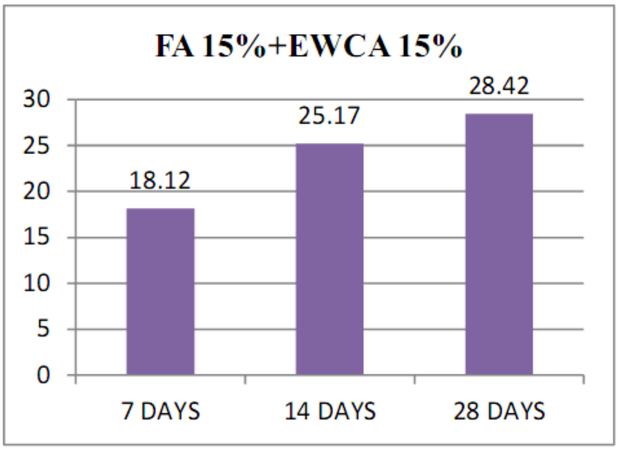

Compressive strength for FA 0%+EWCA 0%



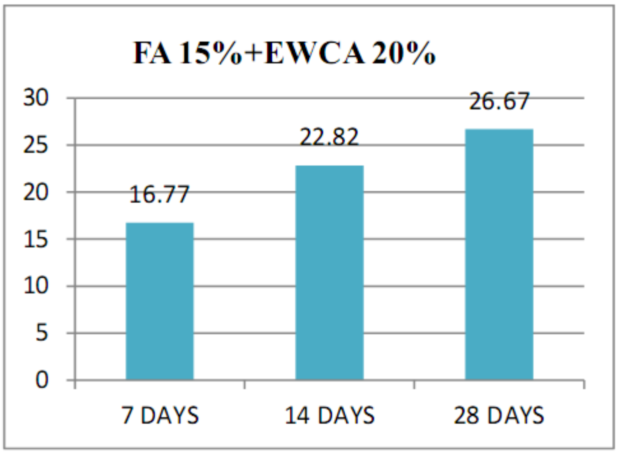

Compressive strength for FA 15%EWCA 5%



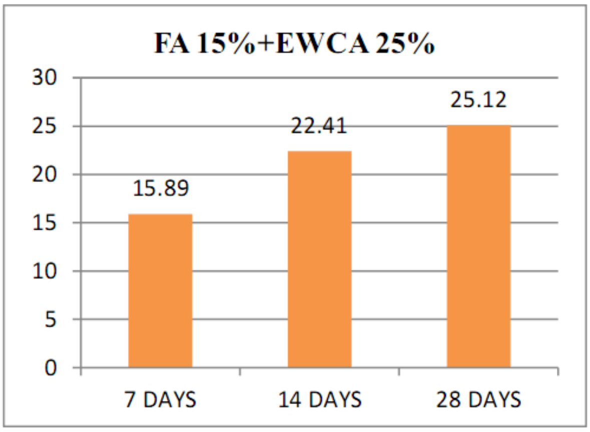

Compressive strength for FA 15%+EWCA 10%



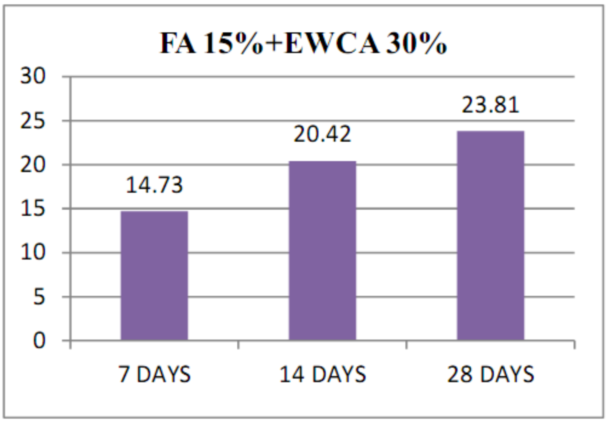

Compressive strength for FA 15%+EWCA 15%



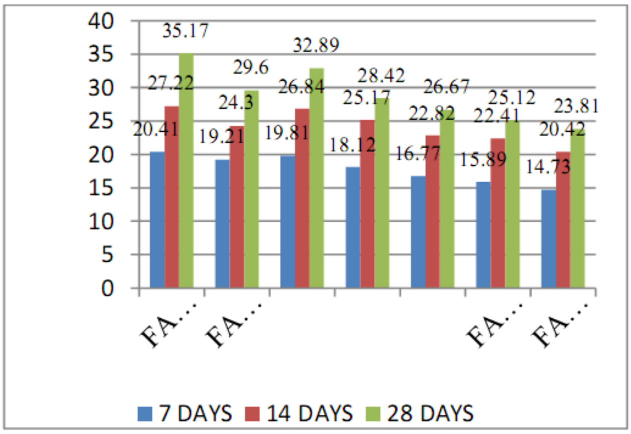

**Compressive strength for FA 15%+EWCA 20%**




**Compressive strength for FA 15%+EWCA 25%**




**Compressive strength for FA 15%+EWCA 30%**




**All percentages with final results**

## CONCLUSION

In this Study we have casted M30 Grade concrete replacing partially the cement with 15% fly ash and a coarse E-Waste aggregate at various percentages (0%+0%, 15% +5% , 15%+10% , 15%+ 15% , 15% +20% , 15%+25% , 15%+30%). The percentage substitution that gave higher compressive strength has been noted after testing M30 grade concrete samples under compressive condition.

This study intended to find the effective ways to reutilize the E-Waste particles as coarse aggregate. It is also observed that the compressive strength of concrete is found to be optimum when coarse aggregate is replaced up to 10% with E-Waste.

Beyond it the compressive strength is decreasing. The following results are

1) It is identified that e-waste can be disposed by using them as construction materials.

2) It can be concluded; up to 10% of E-waste aggregate can be replaced as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

3) Increasing the recycled coarse aggregate percentage resulted in decreases of concrete strength.

4) The workability of the concrete with waste did not show appreciable changes as compared to the control mix.

5) Although recycled aggregate can be applied in the high strength structure, but one issue must not be neglected as recycled aggregate with reduce water content would have low workability. Whenever recycled aggregate is applied, water content in the concrete mix has to be monitored carefully due to the water

absorption capacity varying quantity of recycled aggregate.

6) Addition of fly ash in the mix considerably improves strength index of control mix as well as e waste concrete.

Thus it is concluded that the use of E- waste in concrete can be possible to increase the compressive strength up to 10% e-waste replacement and then results in decrease of strength in concrete and it can also be one of the economical ways for their disposal in an environment friendly manner.

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