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# Use Of E-Waste as A Partial Replacement of Fine Aggregate in Cement Concrete Pavement

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***Abstract***
*The rapid growth of the electrical and electronics sector has led to the generation of a massive volume of discarded materials or that have reached the end of their useful life are commonly referred to as electronic waste (e-waste). India ranks as the third-largest producer of e-waste globally. The electronics sector has witnessed rapid growth, primarily driven by continuous technological advancements and the frequent introduction of new innovations. This surge has simultaneously contributed to a significant increase in one of the fastest-growing categories of solid waste globally—electronic waste (E-waste). Concurrently, the boom in construction activities across the country has led to a substantial demand for aggregates in concrete production, resulting in the depletion of natural resources and negative environmental impacts. Moreover, the rapid pace of infrastructure development has caused a shortage of natural sand. This study investigates the experimental use of electronic waste (E-waste) as a partial replacement for fine aggregates in concrete. Compressive strength, flexural strength and split tensile strength tests were performed on the hardened concrete samples. The results indicate that incorporating E-waste partially as a fine aggregate enhances the strength and it produces a less dense concrete. The study presents a sustainable, economical, and environmentally friendly approach to E-waste management by repurposing it in concrete production.*
***Keywords:*** *E-waste, concrete, fine aggregate, sustainability.*

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## I. INTRODUCTION

With the rapid growth of electrical and electronic industries the e-waste is growing with fastest rate.India stands 3rd in the world in generating e-waste according to the "global e-waste-statistics". Disposal of e-waste is not only a big problem but it is hazardous and very dangerous to the health of human as well as the animals ,because it may contain corrosive ,reactive, toxic and volatile substances.

The concrete industry is also growing very fast which utilizes cement, coarse sand and stone grit as raw material. The fast growth of concrete industry is a threat to the rate of extraction of natural sand i.e. fine aggregate. An experimental study has been done to utilize e-waste as fine aggregate in M-35 grade concrete with a partial replacement of natural fine aggregate i.e. coarse sand in concrete production with a replacement ranging from 0,3,6,9,12 and 15 percent fine e-waste. It has been observed that the strength increases upto the replacement of 6% fine aggregate as optimum level successfully.

### 1.1 LITERATURE REVIEW

Arjun and Senthil (2016) [1] have explored the use of e-waste fibers in M-30 concrete by hand-cutting of electrical wire and replacing the fine aggregate at 0.6%, 0.8% and 1% respectively to find out optimum percentage fiber. They concluded that upto 0.8% addition of e-waste fiber showed increasing trend in the compressive strength, whereas at 1% addition, the strength decreased.

Mehboob et al (2016) [2] utilized manufactured sand and electronic waste as partial replacement for fine aggregate in the range of 10%,20%,30%,40% and 50% and found that the strength increases with increase in percentage of M-sand, whereas the strength of the concrete increased upto the level of 20% e-waste replacement.

Asha (2015) [3] conducted an experiment using PCB particles smaller than 1mm as fine aggregate in concrete, with a range of 10-30%. She found that as e-waste content increases, the strength of the concrete decreases. She concluded that e-waste is a good alternative material for fine aggregate in concrete because of its lightweight. She also noted that e-waste can be used in concrete where higher strength is not needed and for non-structural applications.

Harish More and Arwind Sagar B (2016) [4] has found that compressive strength of e-waste concrete having 5% e-waste as a partial replacement of fine aggregate shows a significant increase in comparison to conventional concrete. They have also found that the e-waste concrete offers more resistance to the chemicals resulting more durability.

Suchitra S and Indu V S (2015) [5] have replaced coarse aggregate with e-waste in the range of 0%, 5%, 10%,15% and 20% and found that a significant improvement in compressive strength was achieved in the e-waste concrete compared to conventional concrete which can be used effectively in concrete.

### 1.2 SIGNIFICANCE OF THE PRESENT RESEARCH

1. The review of literature done on utilization of e-waste in concrete shows that most of the researches have been done to replace coarse aggregate with partial replacement and very few researchers have experimented the partial replacement of fine aggregate with e-waste.
2. Most of the researches were carried out for M-20, M-25 and M-30 grade with normal water content.
3. The present research involves studying the compressive, flexural and split tensile strength of the e-waste concrete utilizing as partial replacement of fine aggregate for a target strength of M-35 grade concrete with reduced water-cement ratio.

### 1.3 OBJECTIVE OF THE STUDY

1. To procure and convert the e-waste material into e-waste fine aggregate by grinding the e-waste chips to the required grain size.
2. To produce e-waste concrete of M-35 grade and compare with that of conventional concrete of the said grade.

## II. METHODOLOGY

1. The e-waste chips were collected from the local e-waste dismantling vendor and it was converted into fine aggregate by grinding the chips.
2. The coarse and fine aggregate were procured from local market.
3. PPC grade cement of good quality was procured from local market.
4. Dr. Fixit Pidicrete CF-205 was used as superplasticizer containing sulfonated naphthalene formaldehyde for water reduction at the rate 100ml per 50kg cement.
5. Mix design was done for M-35 grade of concrete as per IS 10262-2019.
6. Different mixes were casted for different proportions of e-waste as partial replacement in fine aggregate.
7. The water-cement ratio, cement content and coarse aggregates were kept constant for all proportions.
8. Testing of compressing strength, flexural strength and split tensile strength of samples were conducted after 7 and 28days curing.

**Table 1: The Dimensions of Specimen used for the study are produced here under**

| Test Details | Shape | Dimensions of specimen (mm) |
|---|---|---|
| Compressive Strength | Cube | 150x150x150 |
| Flexural Strength | Beam | 100x100x500 |
| Split Tensile Strength | Cylinder | 150x300 |

## III. EXPERIMENTAL INVESTIGATION

**Table 2: The physical properties of constituents are given in table number 2 as under:**

| Properties | Fine Aggregate | Coarse aggregate | E-waste | Cement-PPC | Admixture |
|---|---|---|---|---|---|
| Specific gravity | 2.62 | 2.74 | 1.90 | 2.90 | 1.21 |
| Water absorption | 1% | 0.5% | 0.2% | - | - |
| Bulk density | 1600kg/cum | 1500kg/cum | 550kg/cum | 1440kg/cum | - |
| Shape | - | Angular | - | - | - |

## IV. TEST RESULTS AND DISCUSSION

### 4.1 Compressive Strength

The compressive strength test results are summarized in table given as under. The concrete cubes were tested using compression testing machine with a capacity of 2000KN. The maximum compressive strength observed after 28days of curing reached 42MPa for the fine e-waste concrete mix where 6% of the fine aggregate were replaced with fine e-waste particles which is 5.26% higher than conventional concrete of M35 grade.

**Table 3: Showing Compressive Strength**

| Fine E-waste in Mix (%) | 7 Days Compressive Strength (Mpa) | 28 Days Compressive Strength (Mpa) |
|---|---|---|
| 0 | 27.93 | 39.90 |
| 3 | 27.85 | 40.95 |
| 6 | 28.14 | 42.00 |
| 9 | 24.62 | 36.75 |
| 12 | 22.63 | 34.30 |
| 15 | 21.48 | 32.55 |

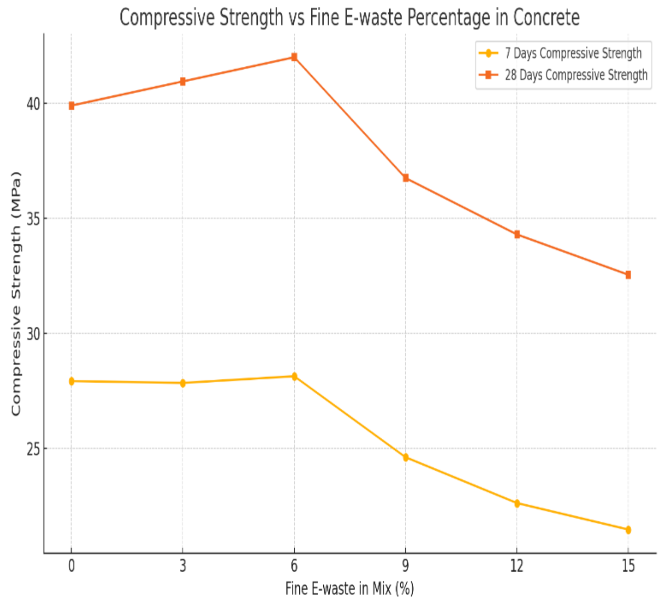


Figure 1: Effect of e-waste on compressive strength

### 4.2 Flexural Strength

The flexural strength test results are summarized in table given as under. The table shows that replacing 6% of fine aggregate with e-waste yielded optimum results with flexural strength of 5.21MPa which is 4.62% higher than conventional concrete of M35 grade at 28days curing.

**Table 4: Showing Flexural Strength**

| Fine E-waste in Mix (%) | 7 days flexural strength (MPa) | 28days flexural strength (MPa) |
|---|---|---|
| 0 | 3.49 | 4.98 |
| 3 | 3.55 | 5.08 |
| 6 | 3.65 | 5.21 |
| 9 | 3.12 | 4.52 |
| 12 | 2.80 | 4.12 |
| 15 | 2.61 | 3.90 |

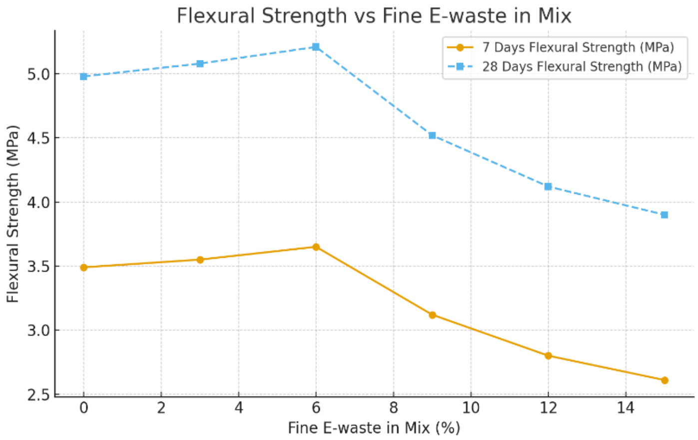


Figure 2: Effect of e-waste on flexural strength

### 4.3 Split tensile strength

The results of split tensile strength are produced in table given as under. The results of split tensile strength test performed over cylindrical specimens of 150mm dia and 300mm length shows that the optimum level of replacement of fine aggregate by e-waste is 6% at which the split tensile strength was found as 3.53MPa at 28days curing which is 4.13% higher than the respective grade of conventional M35 grade cement concrete.

**Table 5: Showing Split Tensile Strength**

| Fine E-waste in Mix (%) | 7 Days Split tensile strength (MPa) | 28 Days Split tensile Strength (MPa) |
|---|---|---|
| 0 | 2.27 | 3.39 |
| 3 | 2.33 | 3.48 |
| 6 | 2.40 | 3.53 |
| 9 | 1.96 | 2.94 |
| 12 | 1.88 | 2.81 |
| 15 | 1.78 | 2.66 |

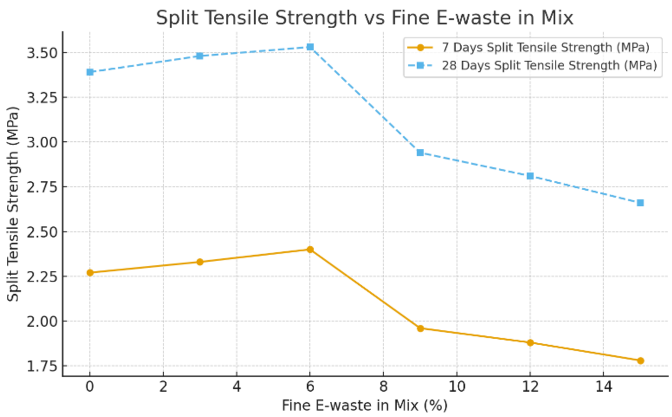


**Figure 3: Effect of e-waste on split tensile strength**

## V. CONCLUSION

The analysis of strength characteristics of M35 grade concrete with partial replacement of coarse aggregate by e-waste led to the following conclusion:

1. Compressive Strength: The compressive strength of concrete increased with the replacement of fine aggregate by e-waste reaching a peak at 6% replacement beyond which the rate of strength gain declines.
2. Flexural Strength: The flexural strength at 6% replacement of fine aggregate with e-waste after 28days curing increased by 4.62% as compared to standard concrete.
3. Split Tensile Strength: At 6% replacement of fine aggregate with e-waste the split tensile strength reached 3.53MPa which is 4.13% higher than conventional concrete of M35grade.
4. Environmental benefits: the reuse of e-waste in concrete contributes to waste reduction, natural resource conservation and environmental protection offering a sustainable approach to construction.

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