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# Experimental Study on Electrical Waste and Plastic Waste in Stabilizing Concrete

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Abstract

Nowadays with the increasing population usage of electronic applications increased and once the device is used it is either refurbished, reused, or discarded. The discarded electrical waste turns to be called E-Waste whose disposal is very difficult. This waste grows annually at a rate of 3-4% and in which 15% is only been recycled. According to the data around 2021, we will generate 52.2 million tonnes per annum of E-Waste. E-waste recycling becomes difficult due to the Presence of flame retarder and around 20% of plastic material in it.The current review helps to understand how this hard to recycle E-waste can be used in stabilizing and strengtheningconcrete and finding compressive and tensile strength of E-Waste reinforced concrete.

Key Words- E-waste, stabilization, strengthening, compressive and Tensile

## I.INTRODUCTION

Researchers worldwide are conducting different types of experimental studies to find different kinds of benefits and effects of using electrical waste in concrete. Studies provide that utilization of E-waste in construction work as well as in making the construction economical. It also reduces the disposal issues of E-waste like landfilling, dumping into oceans, and saving energy. The replacement of nonbiodegradable bio-waste like E-waste in concrete was a result of finding the best disposal method for E-waste instead of landfilling and creating pollution. Therefore, effective waste management methods were considered. E-waste is used in the replacement of cement; coarse and fine aggregates and the latest research states the different advantages of using E-waste in the construction industry which we will see in the present review.

**E-Waste –** The waste generated when we discard useless electrical appliances like CPUs, smartphones contain destructive materials like lead, brominated flame retardants, or beryllium which makes disposal and recycling of E-waste risky. One of the U.S.A agency EPA classified E-waste into 10 different categories varying from large to small household appliances, IT equipment, consumer products like T.V, Lamps, toys, Tools, etc and medical instruments, automatic dispensers.

E-waste must be recycled before using in concrete as a partial replacement of fine aggregate. The recycling process can be done in two sectors one is the Formal sector and the other one is the Informal sector. In the formal sector recycling unit is set up the same as any other industry where formal recyclers will be responsible for environmental problems and permissions regarding environmental pollution. These recycling units are committed to CSR(corporate socialresponsibility).

In India most of the E-waste recycling is done by the informal sector it's a widespread sector with a lot of workforces where manual dismantling without machinery is done. It is not the same method of recycling because health and environmental protection are taken. Recycling is done in five steps as follows manual separation, shredding, pulverization, density separation, and ball-milling. After converting it into a fine powder it is used in replacement of fine aggregate to increase the strength of concrete specimens.

## II. Types of Electrical Waste

Electrical waste is nothing but discarded and used electronic devices which can be reused, recycled, and refurbished.This waste consists of pollutant materials like lead, cadmium,brominated flame retardants, and beryllium which will become a risk when gets into contact with the human being. There are many hazardous and non-hazardousmaterials present in E-Waste some of thefollowings areHazardous waste materials we get when E-Waste is discarded are Lead,Americium, cadmium, Mercury, Hexavalent chromium, Sulphur, Beryllium Oxide, and PVC. Non-Hazardous components that can be recycled are Aluminium, Copper, Germanium, Gold, Lithium, Nickel, Silicon, Tin, and Zinc.

In research work done till now, we can see E-waste is used after incineration in the form of ashes. Waste ash consolidated with concrete helped in developing the flexural strength of concrete roads. The addition of electronic waste in concrete decreased the specific gravity of the specimen.

It can also be seen that replacement of coarse aggregate with electronic waste help to enhancethe stability of the specimen. E-waste helped to increase were has plastic waste helped to increase flexibility and durability of specimens and the addition of these waste materials in the making of bituminous roads gave satisfying results. And helped to reduce the harmful effects of E-Waste and Plastic waste making it economical.

We can also add waste generated from the television and automobile sector many of the products from these industries can be recycled, reused, and refurbished. We can discard them into small pieces and use them in the form of aggregates or can convert it into fine ashes burning the E-Waste and using 10 to 15% of it in road constructionsto increase the stability of bituminous roads and reduce cost.

The use of plastic waste in road construction also helped ineffective waste management and economicconstruction.
Studies are done by using small plastic shredded waste spread all over the hot aggregate layer that helps in melting and form a thin coat of molten plastic has plastic shows adhesion properties in a molten state and helps to develop the melting point of bitumenand it helps to increase the life span of roads by decreasingthe formation of potholes, ruts and develop havoc.
Use of waste rubber tires and waste glass in making asphalt pavements. Many other materials like coal fly ash, blast furnace slag, bottom ash, boiler slag, steel slagis been used in making road constructions and proved to be reclaimed paving materials over conventional materials.
Use of fly ash generated from burning of electrical waste and plastic waste, cement kiln dust, and Phosphor'sgypsumis reused in the construction of highways it is converted into stacksthis industrial wastepossess disposal problems but when used in construction field they help in developing the strength, stability, and durability of the structure.

## III. Literature

Chanda Jithendra Sai Raja et.al(1), A Review on the use of Plastic in Construction of Roads. In the present study plastic waste is converted into powder, mixed in a crusher,and used with aggregate and bitumen mixes by heating processes. Polymer coated aggregate and bitumen mix show high strength, better binding property, stability development against wear and tear of roads, better durability. It also helps in recycling plastic waste effectively.
Ahmed Trimbakwala (2),a detailed study on the use of waste plastic in road construction. It provides that the use of plastic waste after proper processing will improve the life of the road. In the present study waste,the plastic material was treated and converted into powder form and 3 to 4% of it was mixed in the bitumen.It helped in improving the surface-initiated cracking, aging, oxidation resistance, resistance towards rutting due to higher viscosity and softening points. It also concluded that using plastic waste as an additive helped in lower pavement maintenance costs, Eco-friendly method of construction, and helps in maintaining environmental conditions.
Huda Shafiq(3), In the present study non-biodegradable plastic waste to construct plastic roads. Using plastic waste also helps to eliminate plastic disposal into landfills. Plastic-coatedaggregates have proved to offer better abrasion, wear and tear.It was shown that the bond between plastic coated aggregates and bitumen is also very strong due to the increased contact area between plastic and bitumen. Adding plastic waste to aggregates increased the performance and life span of roads. Molten plastic is coated at 140c to 160c and spread throughout aggregate
Aniket Ravindra Ingole et al(4), In the present study on the use of electronic waste concrete for road construction, have used ashes of electronic waste in different volume ratios starting from 0.1 $m^3$ to 1 $m^3$. Results show that compared to plain cement concrete roads E-Waste ash concrete roads have better specific gravity, flexural strength, and compressive strength. It demonstrated that E-Waste fiery remains are utilized regularlyas material in concrete road pavement.
Anjali Deshmukh et al (5), in the present study on the performance of E-Waste and polymer, modified bituminous mix in flexible pavement. E-Waste is used as a partial replacement of coarse aggregate. For polymer modified bitumen they have used the wet process by shredding plastic waste and mixing with bitumen and in E-Waste partial replacement of coarse aggregate with e-waste is done. The portions were mixed in percentages starting from 0% to 1% for plastic and 0% to 20% for E-Waste. Results show that 15% E-waste replacement with coarse aggregate gave better results in Marshall Stability testand Flow Value test compared to plain cement concrete and other percentages. In terms of density plain cement concrete has more compared to E-Waste concrete.
S.Sabarai Mani et al (6), the study on the bituminous pavement by using E-Wastefly ash shows that bituminous concrete mixed with 10 to 15% of E-Waste gave optimal results compared to plain cement concrete. Fly ash mixed as filler increasedthe stability of bituminous roads. E-waste reduces the cost of constructionand contributes tothe efficient management of waste.
D.D. Adegoke et al(7), the application of recycled waste materials for highway construction and their prospect and challenges. It gives the significance of different waste materials that can be used in construction work and help to develop stability and strength of the construction. They have done studies on different materials like plastic waste, slag, waste tires, waste glass, demolition wastes, geopolymers, mill tailings, and shingles. Conventional constructionmaterials are still in use to date and continuously used will start developing negative impact on the environment. so, use waste materials that have befit of providing strength and at the same time reduce the environmental effects of incinerating the E-waste. Despite the drawbacks withthe use of materials with improvement in technology, sustainability is ensured.
A.S. Sandbhor and J.K. Patil(8), the present study on the use of plastic waste in construction of roads shows that using VG 30 bitumen with different percentages of fibers like 1% to 9% and comparing the results with plain cement concrete for different properties like penetration, ductility, softening point and viscosity at 60 degrees. different percentages of fibers show different strength properties like 9% bitumen shows higher viscosity and softening point compared to otherswhereas0% fibers showed better ductility and penetration values.
S.Suchithra, V.S. Indu (9), In the present study E-Waste is replaced with coarse aggregate in the range of 0%, 5%, 10%, 15%, and 20%. The durability and mechanical properties are tested and compared with the control concrete mix. Results show that the replacement of 15% E-Waste shows the increase in compressive strengthand flexural strength test.
Ashish B.Tone et. Al(10), In the present study on the use of E-Waste in the construction industry they used E-waste has the partial replacement of aggregate in different percentages of 0%,5%, 10%, and 15% and the form of Fibers in the percentages of 0%, 0.5%, 1%,2%, and 3% was added in an amount of cement. Results show that the compressive strength of E-Wate cement concrete is similar to that of plain cement concrete. The addition of 15% E-Waste in replacement of aggregategave better results and the addition of 0.5% in the form of fiber gave the highest split tensile strength compared to plain cement concrete.

## IV. Materials and Methods

**Aggregates**

The concrete matrix is made up of cement, coarse aggregate, fine aggregates, and water. Aggregates take up 65-80% of concrete volume. The strength of aggregates does not affect the strength of concrete in the case of low-strength concrete.it also reduces the cost. Reduces thermal and shrinkage cracking. It also imparts unit weight to concrete.

**Coarse aggregate,** these are large-size filler materials in the concrete matrix. Generally, coarse aggregates are the materials like brick chips, gravels, pebbles, clinkers, stone chips, etc; they come from the crushing of huge rocks, natural disintegration of rocks, crushed gravels. The stones retained on a 4.75mm sieve are called coarse aggregates. Their surface area is smaller than fine aggregate materials. These are mainly used in preparing concrete blocks, railway track ballast, etc.in sieve analysis. These aggregates are passed from 5 wire mesh sieves of 80mmto 4.75mm (80mm,40mm,20mm,10mm,4.7
5mm). This procedure is noted in IS2386(part-1). The fineness modulus of coarse sand is 2.9-3.2. In the present study, we considered 10mm aggregates from the building site and conducted sieve analysis, and used aggregates retained on a 10mm sieve. The different testswere conducted on coarse aggregates before using them and their results are as shown in Table - 3 **Table – 3 Test results of coarse aggregates**

| Properties | Results |
|---|---|
| Fineness modulus of coarse aggregates | **7.2** |
| The specific gravity of coarse aggregates | **2.6** |
| Water absorption coarse of aggregates | **0.49%** |
| Shape test<br>Elongation index<br>Flakiness index | <br>**9.45%**<br>**8.55%** |
| Toughness index | **13.6%** |

**Fine aggregates** are small-size filler materials in the concrete matrix. Generally, these are the materials like sand, fly ash, fine cinder, burnt clay, etc; they are found on river sand or machine sand. it is also obtained when stone and gravel are crushed. The particle which passes from the 4.75 mm sieve and retains on a 0.075 mm sieve is considered fine aggregates. Their surface area is higher than coarse aggregates. They are used to fill up the gaps or voids between coarse aggregates. These aggregates are used for plastering, mortar, and filling road pavements. The sieve analysis procedure is taken as per IS-2386(part-1) the aggregates are passed from 6standard sieves from 4.75mm to 150µm (4.75mm,2.36mm,1.18mm,600µ m,300µm,150µm). the fineness modulus of fine aggregate is 2.2-2.6. the fine aggregate is also collected from the building site and done sieve analysis fine aggregates which were retaining on 150µm sieve were used. These aggregates were used to have proper bonding between fibers. The different tests conducted on fine aggregates before using them and their results are as shown in Table - 4

Table-4 Properties of Fine Aggregates

| S.NO | TEST | NATURAL SAND |
|---|---|---|
| **1.** | **Sieve analysis** | **Zone – II** |
| **2.** | **Fineness modulus** | **2.60** |
| **3.** | **Specific gravity** | **2.7** |
| **4.** | **Water absorption** | **0.9%** |

**Cement**

It is a very important binding material in civil engineering. It is used to combine all the materials like fine aggregates, coarse aggregates, and fibers together. It creates a better bonding between concrete matrix materials without voids. There are different grades of cement depending on the nature of construction and area of construction we can consider the type of cement to be used. Cement has different physical and chemical properties and different tests are conducted to find them. Test success fineness, soundness, consistency, setting time, the heat of hydration, etc come under physical properties. It has chemicals like tricalcium aluminate, tricalcium silicate, dicalcium silicate, ferrite, alkalis, free lime, alumina, etc are its chemical properties.A different field test conducted on cement-like specific gravity test, consistency of cement paste, fineness of cement, initial and final setting time of cement are conducted on cement paste and results are noted done are shown in Table - 5

**Table- 5Properties of Cement**

| S.NO | TEST CONDUCTED | RESULT |
|---|---|---|
| 1. | **The specific gravity of cement** | **3.15** |
| 2. | **Normal consistency of cement** | **31.22%** |
| 3. | **Fineness of cement** | **97%** |
| 4. | **Initial setting time of cement** | **45mins** |
| 5. | **Final setting time of cement** | **475mins** |

**E-WASTE**

The E-Waste used is collected from nearby electronic waste shops and Copper is collected from all the electronic waste is broken again into small one to two-inch strips and properties of E-Waste like specific gravity, Water Absorption, and Impact value are tested and results are as follows shown in Table-6

**Table-6 Properties of E-Waste**

| S.No | TEST | RESULTS |
|---|---|---|
| 1 | Specific Gravity | 1.8 |
| 2 | Water Absorption | 0.6% |
| 3 | Shape | Irregular |
| 4 | Crushing Value | <2 |
| 5 | Impact Value | <2 |

**Method of Mixing**

The present study done using E-Waste has a partial replacement of aggregate in concrete so that we can develop eco-friendly concrete by reducing the E-Waste in landfills and developing strength properties of concrete. Themix of M25 is designed as per the IS- Code method and E-Waste is added in 3 different percentages like 5%,10%, and 15%. Add to the concrete mix with a water-cement ratio of 0.5 and a control mix was made to compare the strength and durability properties with E-Waste concrete specimens.

First, the cubes are prepared. The control specimen is prepared by first dry mixing of sand and coarse aggregates in a portable mixer for 2mins and then adding cement and mixing it for 2mins more. Then add 60% of 750ml water and mix it for 3mins and then add the rest 40% of 750ml water and mix thoroughly for 5mins. The procedure of E-Waste concrete specimen preparation is first to dry mix the fine aggregates and coarse aggregates for 2mins in the portable mixer.

Then E-Waste is mixed with dry materialsaccording to the percentage of replacement of coarse aggregates added and dry mixed thoroughly for 2mins. Then 60% of 750ml water is added and mixed for 3mins and then the rest 40% of 750ml water is added and mixed thoroughly for 5mins. Then fresh properties of concrete are tested of all the different mixes. The concrete is filled in molded properly and left for curing in water and after 7days, 14days, and 28days specimens are taken out and tested for compressive strength. It is considered has to average of 3 test results.

Second cylinders are prepared. The control specimen is prepared by first dry mixing of sand and coarse aggregates in a portable mixer for 2mins and then adding cement and mixing it for 2mins more. Then add 60% of 350ml water and mix it for 3mins and then add the rest 40% of 350ml water and mix thoroughly for 5mins.

The procedure of E-Waste concrete specimen preparation is first to dry mix the fine aggregates and coarse aggregates for 2mins in a portable mixer. Then the electrical waste is dry mixed thoroughly for 2mins. Then 60% of 350ml water is added and mixed for 3mins and then the rest of 40% of350ml water is added and mixed thoroughly for 5mins. Then fresh properties of concrete are tested and a tensile strength test is conducted for 7days, 14days, and 28days after curing and the average of three test samples is considered to find the strength of the mixes.

Quantity of cement, 20mm aggregate and M-Sand for each mix used like control concrete specimen and 5%,10%, and 15% E-waste concrete specimens are shown in Table-7 and Table-8. The quantities used in making cubes to test the compressive strength of concrete mixes are given in the table as well as quantities used in making cylindersare also mentioned in the table.

**Table-7 Quantities of Materialper cube preparation**

| S.No | Specimens | C | C.A | F.A | E-WASTE |
|---|---|---|---|---|---|
| 1 | Control Mix | 1.35kg | 2kg | 2.3kg | - |
| 2 | 5% E-Waste | 1.35kg | 1.8kg | 2.3kg | 0.05kg |
| 3 | 10% E-Waste | 1.35kg | 1.7kg | 2.3kg | 0.1kg |
| 4 | 15% E-Waste | 1.35kg | 1.6kg | 2.3kg | 0.15kg |

**Table-8 Quantities of Material per cylinder preparation**

| S.No | Specimens | C | C.A | F.A | E-WASTE |
|---|---|---|---|---|---|
| 1 | Control Mix | 0.628kg | 0.935kg | 1.10kg | - |
| 2 | 5% E-Waste | 0.628kg | 0.87kg | 1.10kg | 0.05kg |
| 3 | 10% E-Waste | 0.628kg | 0.735kg | 1.10kg | 0.1kg |
| 4 | 15% E-Waste | 0.628kg | 0.365kg | 1.10kg | 0.15kg |

## V TEST AND RESULTS

**Fresh properties of concrete**

**Slump test**

The fresh properties of concrete are tested immediately after mixing to find the workability of the mix. Workability in simple words we can say ease to place or flow of the mix. Workability is tested by slump test of concrete mix. The slump test of fresh concrete with E-Waste mixed is tested to find the change workability of the mix due to electronic waste. The test is performed in the concrete laboratory of the civil engineering department, G.N.I.T Test is conducted as per codes specified in IS – 456 and IS 10262 – 2019. The slump value of control plain concrete and E-Waste reinforced concrete are tested and results are discussed below in Table- 9. slump values of the different mixes are shown in fig -1.

Table-9 Slump value of control specimen and E-Waste reinforced concrete specimens

| S. No | Specimen | Slump value (mm) |
|---|---|---|
| 1 | Control Mix | 75 |
| 2 | 5% E-Waste | 65 |
| 3 | 10% E-Waste | 55 |
| 4 | 15% E-Waste | 50 |

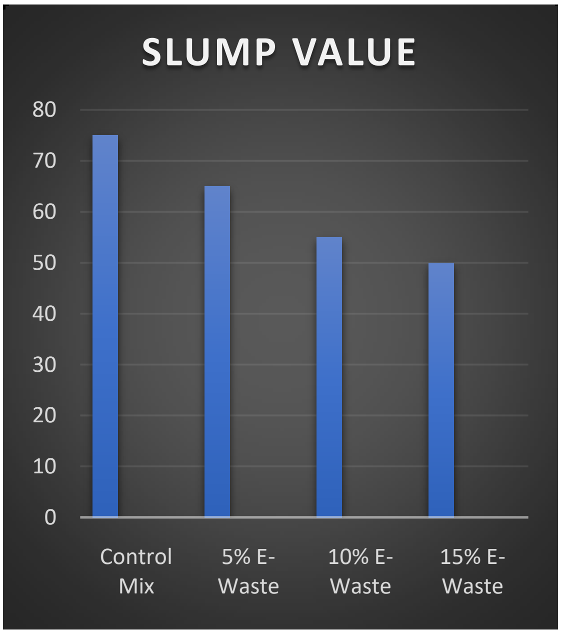



Fig-1 Graphical representation of Slump Value of different mixes.

***Hardened properties of concrete***

**Compression strength test on concrete**

The compression strength test is performed to find the characteristic compressive strength of the mix after 28days of curing on 150mm$^3$ specimens on the compression testing machine as per IS-516-1959. The compressive strength of each specimen on 7days, 14days, and 28days curing on standard loading. The test is performed on control concrete specimens and E-Waste reinforced concrete specimens. The load on the cube at constant stress is equal to 200kpa/sec to 400kpa/sec. The compression strength of each specimen is calculated and for each different specimen, the compressive strength is taken as the average of 3 same specimens. The compressive strength is generally found by stress developed due to the compressive load on it. The compressive load of different specimens on 7days curing, 14days curing and 28days curing is shown in fig -2,Stress can be calculated as

Stress $=\overline{A}$

Were P = load in kpa

A = Area in mm$^2$

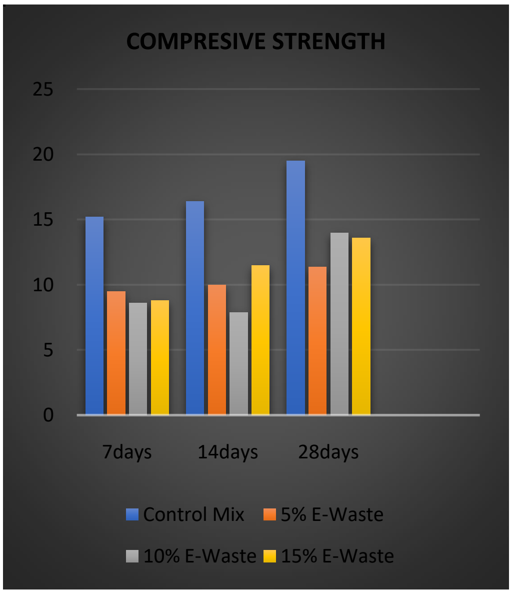



Fig-2 Graphical representation of Compressive strength of different mixes

**Split tensile strength test on concrete**

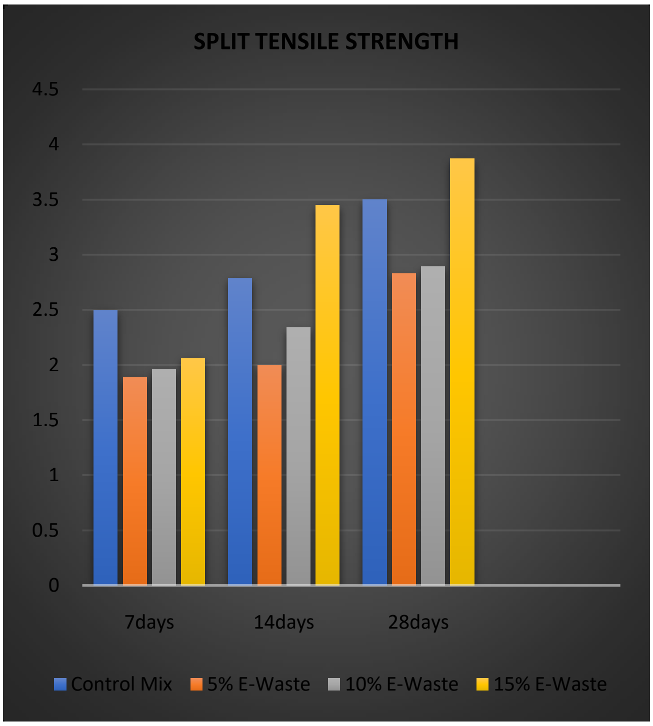
The tensile strength test is performed on cylindrical specimens. It is conducted as per the specified code IS-516-1959 to get the tensile strength of the concrete specimens. The test is conducted on a cylindrical specimen of 150×300mm on each specimen of control concrete specimen and E-Waste reinforced concrete. The average of three specimens is considered as the tensile strength of that mix. The test is conducted perpendicular to the loading axis of the compression testing machine. The compressive force is applied along its length direction. The load is uniformly distributed due to plywood placed on the loading plates of the machine. The load is applied till a crack in the vertical direction is observed. The constant load is applied in a range of 40kpa/sec to 60kpa/sec initially and keeps on increasing the rate of loading at ±1 until a crack is observed. The tensile strength can be determined by considering the load applied per area of the specimen. The tensile strength of different specimens is shown in fig-3with different curing periods. It can be calculated as follows

$$T = \frac{2P}{\pi DL}$$

Were P = load kpa

D = diameter of the cylinder = 100mm

L = length of the cylinder = 300mm




## VI.CONCLUSION

A review of different forms of E-Waste and plastic waste that can be used in the construction of cement concrete and bituminous roads has been discussed in the present paper. Use of different kinds of E-waste in the form of fly ash generated after burning, use of polymers,and use of plastic waste in replacement to coarse aggregate, in the formof shredded pieces whichhelp stabilize the bituminous roads. In present paper helps to review different kinds of waste materials that are been used in combination with concrete and bituminous works that not only helps to stabilize the structure but also helps in making cost-effectiveconstructionsby reducing the waste content and global warming.

- The results show that the slump value of the control specimen is more compared to 5%, 10%, and 15% of E-Waste reinforced concrete specimen.
- So, to develop the workability of concrete mix we can use a plasticizer which will help to increase the flowability of concrete mix.
- We can see compressive strength of control concrete specimen is higher than 5%, 10%, and 15% E-Waste reinforced concrete specimensafter different curing periods.
- Here we can also see that compressive strength of E-Waste concrete specimens kept on increasing with increases in the percentage of E-Waste in concrete mix
- We can also say that the strength decreases due tothe formation of cavities due to improper distribution of copper strips and tapping of the mix.
- The tensile strength of the controlconcrete mix is higher than 5%, 10%, and 15% E-Waste reinforced concrete specimens after a 7days curing period.

- The tensile strength of 15% E-Waste concrete specimen is higher than that of control concrete specimen after 14days and 28days of curing period.
- It can also be seen that initially, the bond between concrete and E-Waste is weak than final bonding after 14days and 28days of curing.
- We can see that using E-Waste has a better impact on the tensile strength of the concrete specimen compared to the compressive strength of concrete specimens.
- In the upcoming study we can use different Electrical waste or plastic waste that will help in enhancing the strength properties of concrete mix.
- The flexural strength test and Non-destructive strength test can be performed in future studies.

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