# Experimental Investigation on Utilization of E-Waste in Concrete-Taguchi's Approach

**Vivek Pratap Maurya[1], Mr. Rajneesh Kumar[2]**

[1]*Master of Technology in Civil Engineering, Lucknow Institute of Technology, Lucknow, India*
[2]*Assistant Professor, Civil Engineering, Lucknow Institute of Technology, Lucknow, India*

---------------------------------------------------------------------***---------------------------------------------------------------------

**Abstract -** *E trash, often referred to as electronic waste, is the term used to describe electronic equipment that has become outdated and has been discarded. These include, in variable amounts, waste products manufactured of plastic as well as waste products made of metal. Recycling trash that is made of metal, as opposed to recycling waste that is made of plastic, is a little bit less complicated and also results in less pollution than recycling waste that is made of plastic. Therefore, in order to lessen the amount of air pollution that is caused by the recycling of plastic garbage and electronic waste, we need to devise a different and more practical method of reusing it in its original form. This is necessary in order to reduce the amount of plastic garbage and electronic waste that is recycled. It is believed that each year, countries all around the globe create anywhere between 20 and 25 metric tonnes of electronic waste. This article discusses the findings of an experiment that was carried out to determine how the incorporation of plastic e-waste into concrete would affect the qualities of the concrete. The experiment was carried out to study the influence that such an incorporation might have. During the course of this research project, plastic from electronic waste was combined with M25 concrete by replacing the fine aggregate at the rates of 10 percent, 20 percent, and 30 percent by weight and also by replacing the coarse aggregate at the rates of 5 percent, 10 percent, 15 percent, 20 percent, and 25 percent by weight. This was done in order to determine the effects of combining the two materials. After seven and twenty-eight days, compressive strength was evaluated. The findings of the study showed that increasing the quantity of plastic e-waste that was mixed into the concrete resulted in a decrease in the material's compressive strength. This was proved by the findings of the study.*

***Key Words***: Plastic e-waste, concrete, compressive strength, tensile strength, Split tensile test.

## 1. INTRODUCTION

Due to the fact that electronic garbage is both long-lasting and non-biodegradable, disposing of it may be a very challenging task. Getting rid of this electronic garbage by dumping it in a landfill or piling it up in stockpiles is not an environmentally sound approach. We are up against a significant challenge in determining how to recycle the E garbage that cannot be thrown away. This issue may be remedied by including e-waste into the composition of concrete in a limited capacity such that it can partially take the place of both fine and coarse aggregate. India is a country that is expanding at a rapid rate and is now in the process of transitioning from a developing nation to a developed one. Therefore, in order to become a developed country, one's infrastructure has to reach world-class levels. According to the findings of a research, the concrete sector in India is now using 370 million cum of concrete per year, and it is anticipated that this number would rise by 30 million cum every year (1). An further fact about this country is the rapidly expanding amount of electronic garbage. According to a study report titled "E-waste in India" (4) that was given in the Rajya Sabha in 2011, the amount of electronic garbage created in India in 2010 was around 4 lakh tonnes, which is an increase from the 1.47 lakh tonnes generated in 2005. The most significant amounts of electronic trash are produced in the metropolitan areas of India's largest cities, such as Delhi, Mumbai, and Bangalore. More than sixty-five cities in India are responsible for producing more than sixty percent of the country's total electronic trash. Seventy percent of the country's total e-waste is produced in only ten of India's states: Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh, and Punjab. These states are listed in alphabetical order. Top 10 cities creating e-waste include Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur. "polychlorinated biphenyls, chlorofluorocarbons, polyvinyl chloride are some of the halogenic compounds and heavy metals like arsenic, barium, beryllium, cadmium, chromium VI, lead, lithium, mercury nickel are typically present," according to the Environmental Protection Agency. E-waste also contains heavy metals such as nickel, lithium, and mercury. The purpose of this piece is to investigate whether or not e-waste may be repurposed into a material that represents optimism for the twenty first century. The current effort is a component of a larger programme that includes experimental studies that have been carried out to evaluate the impact of replacing an expensive material with a less expensive alternative, in this case electronic trash, on the strength of concrete. In the course of this research, cubes were produced by casting replacements for fine and coarse aggregates using electronic trash. It was found that the compressive strength of concrete made from electronic trash was equivalent to that of natural concrete. In order to carry out this comparative study, cubes were cast with either 0 percent, 10 percent, 20 percent, or 30 percent of the fine aggregate replaced by e-waste, and either 5 percent, 10 percent, 15 percent, 20 percent, or 25 percent of the coarse aggregate replaced with e-waste. Both types of aggregate were then compared to one another. After 7 and 28 days, these cubes were examined for quality. During the tests, a design mix with the proportions 1:1.65:3 (where 3 is the percentage of 10mm and 20mm size aggregate) was used in order to determine compressive strength at a water cement ratio of 0.46.

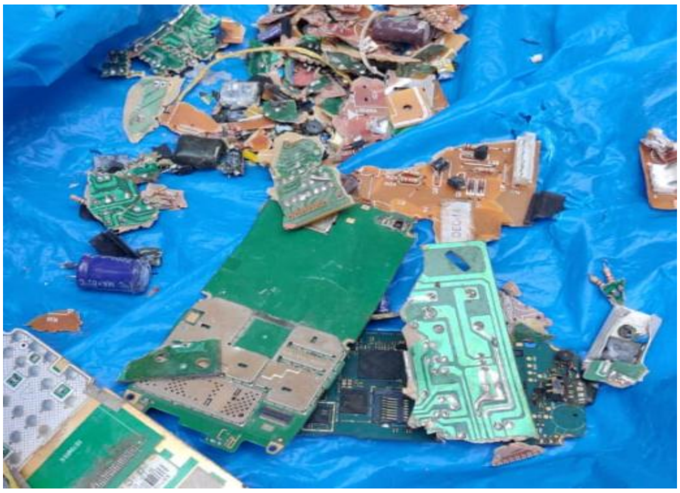


**Figure-1: E Waste**

### 1.1. Materials and Methods

The goal of this study is to determine how the strength of concrete is impacted when electronic waste is used to partially replace fine aggregate and coarse aggregate in the mixture that goes into making concrete. To get an idea of the optimal percentage of e-waste that does not significantly affect the strength of non-conventional concrete, an attempt has been made here to get the strength of cubes made up with different percentages of ewaste to the respective strength of conventional concrete at the end of 7, 28 days of moist curing. This was done in order to determine the optimal percentage of e-waste. Casting the cubes required a design mix of (1:1.65:3.00), where 3.00 refers to the proportion of 10mm to 20mm aggregate. Cubes with a measurement of 100 mm A. Cement The material that was employed in this experiment was generated by using individual batches of Pozzolana Portland Cement (PPC) of the Prism brand during the length of the inquiry. In most cases, the Portland cement that we work with is composed of an argillaceous component and a calcareous component as its principal constituents. The findings of the examination of the PPC's physical features are shown in the table labelled "Table 1." The cement satisfies the prerequisites outlined in the Indian Standard 1489:1991 (IS 1489:1991). On the other hand, Ankit et al. [2014] reported material characteristics that were very close.

**Table-1: Properties of Pozzolana Portland cement (PPC)**

| S. No. | Properties | Experimental | Codal requirement (IS 1489 (Pt-1)-1991) |
|---|---|---|---|
| 1 | Normal Consistency% | 31.5% | |
| 2 | Initial setting time | 165min | (Not less than 30 min) |
| 3 | Final setting time | 215min | (Not more than 600 min) |
| 4 | Soundness of Cement (Le chatelier expansion) | 0.75mm | (Not more than 10 mm) |
| 5 | Fineness of Cement (%age retained on 90 micron IS sieve) | 3.77% | 10% |
| 6 | Specific gravity of Cement | 2.60 | 3.15 |
| 7 | Compressive Strength | | |
| a | 7 Days | 23.45 | 23.45 $N/mm^2$(min) |
| b | 28 Days | 33.5 | 33 $N/mm^2$(min) |

## 2. COARSE AGGREGATE

The coarse aggregate was obtained from a quarry that was located in an area that offered convenient access. The quarry produced coarse aggregate in two distinct sizes; one fraction was able to pass through a sieve with a diameter of 20 millimetres, while the other portion was able to pass through a sieve with a diameter of 10 millimetres. Both fractions have a specific gravity of 2.77, which is typical of coarse aggregate. This property is shared by both fractions. The grading of coarse aggregate with diameters of 10 millimetres and 20 millimetres, respectively, is provided in both table 3 and table 4. It was found that the percentage of aggregate with a size of 20 millimetres is sixty percent, while the proportion of aggregate with a size of 10 millimetres was discovered to be forty percent. On the other hand, Manish and colleagues [2014] discovered that the material had a great deal of similarities in its properties.

**Table-2: Sieve Analysis of Coarse Aggregate (10mm Size)**

| S. No. | Sieve Size | Weight Retained (gm) | Cumulative Weight Retained | Cumulative % Weight Retained | Passing % |
|---|---|---|---|---|---|
| 1 | 20mm | 0.018 | 0.018 | 0.36 | 99.64 |
| 2 | 10mm | 3.490 | 3.508 | 70.16 | 29.84 |
| 3 | 4.75 mm | 1.456 | 4.963 | 99.26 | 0.74 |
| 4 | 2.36 mm | 0.025 | 4.989 | 99.78 | 0.22 |
| 5 | 1.18mm | 0.011 | 5.000 | 100 | 0 |
| 6 | 600 µm | | | 100 | 0 |
| 7 | 300 µm | | | 100 | 0 |
| 8 | 150 µm | | | 100 | 0 |
| | | | | Total=669.56 | |

## 3. WATER

Both the mixing process and the curing process need the use of drinkable water. The water-to-cement ratio (w/c) that should be used is 0.46, as found by the investigation. In this particular experiment, a kind of concrete with the designation M 25 was used, and the volume of fine aggregate as a fraction of the total volume of aggregate was kept at a constant proportion of fifty percent. The mix that was produced had a water-to-cement ratio of 0.46, a total of 380 kg/m3 of cement, and a cement-to-fine-aggregate-to-coarse-aggregate ratio of 1:1.65:3.00 (where 3.00 is the proportion of 10mm and 20mm size aggregate). Additionally, the mix had a cement-to-fine-aggregate-to-coarse-aggregate ratio of 1:1.65:3.00. It was determined that the ratio of fine aggregate to coarse aggregate should be 1:1.65:3.00.

## 4. E- WASTE

Sources of electronic trash were gathered from professional recyclers in the form of electronic or electrical equipment that had been abandoned in a disorganised manner, was in excess, was no longer in use, or was damaged in some way. This equipment might also have been in some way damaged. After that, every metal that had been physically linked to the PCB was first severed from it, then pulverised into very small fragments, and finally thrown away. When broken down into individual particles, it has been shown that the diameter of waste E-plastic particles may vary anywhere from 1.18 millimetres to 2.36 millimetres. [Citation needed]

**Table-3: Properties of E-Waste**

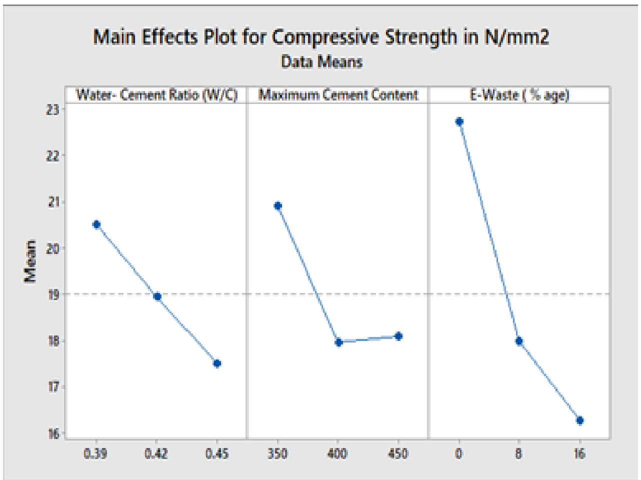
| Physical Properties | Observations |
|---|---|
| Specific Gravity | 1.03 |
| Absorption (%) | < 0.2 |
| Crushing value | < 2% |
| Impact value | < 2 % |

## 5. RESULT AND DISCUSSION

In addition to the compressive strength of E-waste concrete, the compressive strength of referral concrete was measured for partial replacement of fine aggregate in table 6, and for partial replacement of coarse material in table 6. As can be seen from the comparison table, the replacement concrete's strength is comparable to the strength of the reference concrete up to a percentage of twenty percent. However, beyond that proportion, the replacement concrete's strength dramatically decreases as a result of the addition of electronic trash. This is due to the nature of the waste. The difference in compressive strength that results from using a variable percentage of e-waste as a partial replacement for fine aggregate as opposed to utilising e-waste as a partial replacement for coarse material. The compressive strength of concrete with and without an addition as a function of the amount of time it is allowed to cure as a function of the amount of time it is allowed to cure. After seven days, the compressive strength of PPC is 23.45 kN/mm2 when the ratio of water to cement is 0.46; after 28 days, this value climbs to 33.5 kN/mm2.

### 5.1. Compressive Strength Test Results N/mm$^2$ at 28 days

When determining a material's compressive strength, one of the parameters that is taken into account is the capacity of the material to survive failure in the form of cracks and fissures. This is because cracks and fissures indicate that the material has been compromised. During this particular test, the push force that is applied to both of the faces of the concrete specimen is measured, in addition to the maximum compression that the concrete can withstand before it cracks. Both of these forces are applied to the concrete specimen in order to determine its strength. The concrete specimen is subjected to both of these forces so that the strength of the concrete may be evaluated.

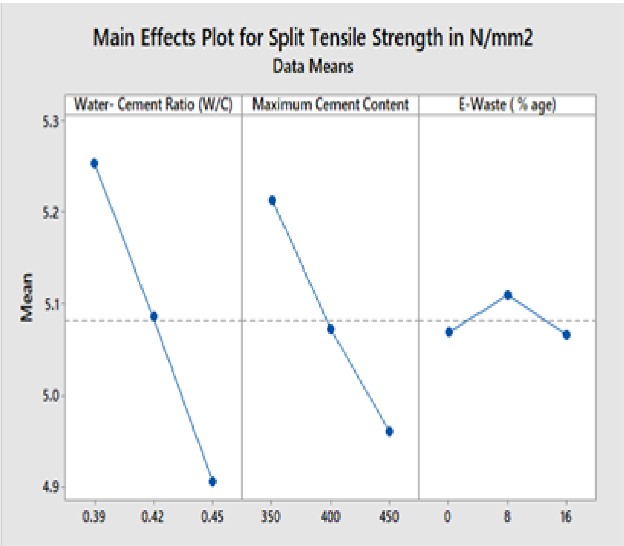



**Graph-1: Main Effect Plot for Compressive Strength**

The use of means of response at each level of the parameter is necessary in order to generate main effects plots for compressive strength, as is seen from graph-1. This is because the parameter may take on a variety of values. Completing this step is necessary in order to determine which affects will be the most significant. It is possible to establish that an increase in the water-to-cement ratio, cement content, or E-wastes causes a decline in concrete's capacity to fulfil the function for which it was built and manufactured. This may be done via the use of a number of different tests. One strategy for achieving this objective is to make use of the evidence that may be gathered through scientific study. It has been shown that the amount of impact that E garbage has on the potency of the concrete is rather minimal, and this is something that should be taken into mind as it is something that has to be taken into account. Research led to the unveiling of this previously unknown information, which had been concealed from public view up until this point.

### 5.2. Split Tensile Strength Test Results N/mm² at 28 days

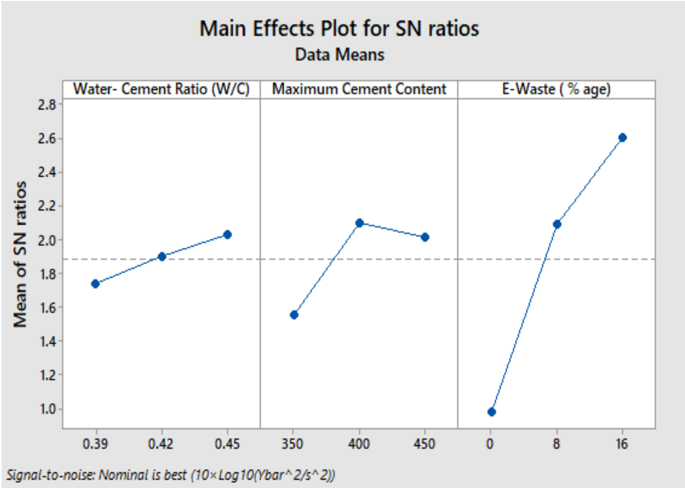
An examination of the means of response at each level of the parameters is one of the many stages that must be taken in order to complete the process of creating major effect plots for split tensile strength. This step is one of a number of required processes in the process. The analysis is shown in graph-2 for your viewing pleasure. The plots are the outcome of carrying out this operation in its entirety as described in the previous sentence. It has been discovered that either increasing the water-to-cement ratio or the cement content results in a drop in the split tensile strength of the material. [Citation needed] This is the case irrespective of whether or not the variable is altered. The fact that the variable is being made more important does not change the fact that this is the case. On the other hand, the influence of the E waste on the split tensile strength of the material is the largest.




**Graph-2: Main Effect Plot for Split Tensile Strength**

### 5.3. SN Ratio

Illustrations of the most significant adverse reactions to SN in the form of diagrams When selecting how to plot the ratio of nominal to best, it is important to take into consideration the plethora of components that are present at each level in order to arrive at an accurate result. It is vital to bear in mind that an increase in the values of the parameters will, as a consequence, result in an increase in the strength of the concrete. This is because an increase in the strength of the concrete has a direct correlation to the values of the parameters. In order to provide a basis for ranking each of the parameters, the difference in mean values that are obtained between the many levels of component levels is computed and used in the process. To calculate the delta, first determine the mean with the greatest possible value and then take that number and subtract the mean with the lowest possible value. It makes sense for the items that carry the most weight to be in the most prominent place.




**Graph-3: Main Effects Plot for SN Ratio**

## 6. CONCLUSIONS

In order to provide an explanation for the impact that the use of electronic waste has on concrete, the following points, which can be summed up based on the inquiry, may be employed. The informal recycling practises in India are being negatively impacted by the invasion of e-waste coming from the interior of the country as well as illicit imports from industrialised nations. The management of solid waste in India is already a challenging undertaking due to the environment in the country. This is because electronic garbage, often known as e-waste, may be recycled using a variety of various methods. It is needed to construct a comprehensive assessment system of the current and future state of e-waste, and it is also essential to develop model facilities with environmentally friendly ways for the treatment of e-waste. Both of these things are essential. In the past, studies have been carried out to evaluate the viability of utilising recycled glass and plastic as an aggregate in concrete. In line with this specific aspect, it was realised that electronic trash may be disposed of by employing it as a building material in some capacity. This was done in order to remain with the theme of this particular feature. Depending on the size of the E-waste particles, they could be appropriate for use as a non-active filler component in concrete. This would depend on the size of the particles.

The outcomes of the investigation on the manageability of concrete manufactured from e-waste indicated that increasing quantities of e-waste material in the concrete did not significantly affect the slump of the concrete. On the other hand, the probability of slumping increases in conjunction with an increase in the waist-to-hip ratio.

## REFERENCE


1. Murthi, P. and Sivakumar, V. "Strength-porosity relationship for ternary blended concrete", The Indian Concrete Journal, Vol. 82, No. 7, pp. 35-41, 2008

2. Alireza Mokhtarzadeh, and Catherine French, "Machanical Properties of High-Strength Concrete with Consideration for Precast Applications", ACI Materials Journal, Vol. 97, No.2, pp. 136-147, 2000.

3. Manikandan, R. and Ramamurthy, K. "Swelling Characteristic of Bentonite on Pettetization and Properties of Fly-ash Aggregates", Journal of Materials in Civil Engineering, Vol. 21, No. 10, pp. 578-586, 2009.

4. Bibra Gorai, Jana, R.K. and Premchand, "Characteristics and utilization of copper slag-a review", Resources, Conservation and Recycling, Vol. 39, pp. 299-313, 2002.

5. Christian Meyer, and Ali Behnood, "Utilization of copper slag in cement and concrete", Resources, Conservation and Recycling, Vol.52, pp.1115-1120, 2008.

6. Johnson Alengaram, U., Mohd Zamin Jumaat, and Hilmi Mahmud, "Comparison of Mechanical Properties and Structural Behaviour of Palm Kernel Shell Concrete (PKSC) Beams with Normal Weight Concrete (NWC) Beams", 10th NCB International Seminar on Cement and Building Materials, pp. 21- 26, 200

7. Rashid, M.A., Tanvir Hossain, and Ariful Islam, M. "Higher strength concrete using crushed brick as coarse aggregate", The Indian Concrete Journal, Vol.10, pp. 18-23, 2008.

8. Evangelista, L. and de Brito, J. "Mechanical behavior concrete made with fine recycled concrete aggregates, Cement and Concrete Composites, Vol. 29, pp. 397-401, 2007.

9. Khatib, J.M. "Properties of concrete incorporating fine recycled aggregate", Cement and Concrete Research, Vol. 35, pp.763-769, 2005.

10. Lilian Ribeiro de Rezende, and Jose Camapum de Carvalho, "The use of quarry waste in pavement construction", Resources, Conservation & Recycling, Vol. 39, pp. 91-105, 2003.

11. Reindl, J. Report by recycling manager, Dane county, Department of public works, Madison, 1998.

12. Caijun Shi, "Corrosion of Glasses and Expansion Mechanism of Concrete Containing Waste Glasses as Aggregate", Journal of Materials in Civil Engineering, Vol. 21, No. 10, pp. 529-534, 2009.

13. Bashar Taha, and Ghassan Nounu, "Utilizing Waste Recycled Glass as Sand/Cement Replacement in Concrete", ASCE Journal of Materials in Civil Engineering , Vol. 21, No. 12, pp. 709-721, 2009.

14. Srinivasa Rao, P., Seshadri Sekhar, T. and Sravana, P. "Durability studies on glass fibre SCC", The Indian Concrete Journal, Vol.10, pp. 44-52, 2009.

15. Seung-Bum Park, and Bong Chun Lee, "Studies on expansion properties in mortar containing waste glass and fibers" Cement and Concrete Research, Vol. 34, pp. 1145-1152, 2004.

16. Alhozaimy, A.M., Shannag, M.J. "Performance of concretes reinforced with recycled plastic fibres", Magazine of Concrete Research, Vol. 61, No. 4, pp. 293-298, 2009.

17. Elzafraney, M., Soroushian, P. and Deru, M. "Development of EnergyEfficient Concrete Buildings Using Recycled Plastic Aggregates", Journal of Architectural Engineering Vol. 11, No. 4, pp. 122-130, 2005.

18. Shweta Goyal, Maneek Kumar, and Bhattacharjee, B. "Potential benefits of incorporating fly-ash in silica-fume concrete", The Indian Concrete Journal, Vol. 82, No. 8, pp. 38-46, 2008