International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET2310330

Experimental Investigation on E-Waste Concrete with Silicafume

***Narayanamma Velpula, Thulasirajan Krishnan, A. Anil**
Department of Civil Engineering, Annamacharya Institute of Technology and Sciences, Tirupati, India

ARTICLEINFO

Article History:

Accepted: 20 April 2023
Published: 11 May 2023

Publication Issue
Volume 10, Issue 3
May-June-2023

Page Number
74-81

ABSTRACT

Electronic waste, commonly referred to as "E-waste," is any electronic device that is no longer useful or has reached the end of its useful life. This can include computers, smartphones, tablets, televisions, refrigerators, and other household appliances, as well as industrial equipment and medical devices. Many electronic devices contain hazardous materials such as lead, mercury, cadmium, and brominated flame retardants, which can be harmful to human health and the environment if not disposed of properly. Improper disposal of e-waste can lead to environmental pollution, as well as health problems for those who are exposed to the hazardous materials and is passing severe toxic waste issues to the human beings and the environment. E-waste is a growing problem worldwide, as electronic devices become more common and quickly become obsolete due to advances in technology. Recycling and proper disposal of e-waste is becoming increasingly important as more electronic devices.

From then literature review it is inferred that the E waste was added to the concrete by partial replacement of Fine Aggregates. Recommended dosage of E waste as partial replacement of coarse aggregate was 10 % concrete. Minimum studies were carried out as a partial replacement of fine aggregates. To recommend the optimum percentage of E waste as replacement of fine aggregate. No effective method to prevent the leaching of toxic components from E waste concrete. The Compressive Strength, Split-Tensile strength, Rebound Number, UPV test and Durability tests was carried.

Therefore, by incorporation of Silica Fume the mechanical properties such as Compressive strength and Tensile strength are improved. The increase in the % of E- waste decreases the density and hence E-waste concrete can be adopted for light weight construction. The quality of E-waste concrete improved by the incorporation of Silica Fume. which is evident from the rebound hammer and Ultrasonic Pulse velocity results. And also Durability Test results. The Optimum % of E-waste was found to be 5%.

Overall, the combination of E-waste and Undensified Silica Fume develop a sustainable concrete which can prevent the unnecessary dumping of E-waste and act as a light weight concrete.

Keywords : Cement, Fine aggregate, E-Waste, Undensified Silica Fume.

I. INTRODUCTION

Electronic technology is the dominant field in the current rapid world. The consumption of electrical and electronic devices, such as cell phones, computers, smart televisions, and other electronic devices, is also a larger part of modern people's lifestyles. Old, damaged, or end-of-life electronics will eventually turn into so-called "waste" or "electronic waste". However, the life cycles of the electronic devices were short. The hazardous materials found in electronic waste have an adverse effect on living things. Electronics' toxic materials are released when they are not properly disposed of and end up in landfills, thereby affect the environment and finally the human health. Globally, electronic waste of 7.3 kg was produced per person on average, and it is estimated to rise up to 65.3 million tonnes by 2025.

E-waste or electronic waste is created when an electronic product is discarded after the end of its useful life. By weight, small equipment account for the largest share of e-waste produced and included product such as microwaves, vacuum cleaners and kettles. More then 50 million metric turns of e-waste generated globally every year, averaging some seven kilograms of e-waste for capita. According to CPCB, the generation of plastic waste per year is increasing by 3%, and the generation of e-waste is even higher, with e-waste is produced totally 7.1 lakhs tonnes in 2018-19 and 10.14 lakhs tonnes in 2019-20. In 2020-21, India is produced 3.4 lakhs tonnes of e-waste. Every year, there is a 31% increase.

1.2 Harmful charactericties : Under the harmful waste (special criminal provision) act “harmful waste “was defined to “mean any injurious, poisonous toxic or waste-emitting radioactive substance if the waste is in such quality, whether with any order consignment of the same or different substance, as to subject any person to the risk of death, fatal injury or incurable impairment of physical and mental health; and the fact that the harmful waste is placed in a container shell not by itself be taken to exclude any risk which might be expected to rise from the harmful waste. the harmful waste act was enacted with the specific aim of prohibiting the carrying, depositing and dumping of hazardous waste on not just land but territorial (and non-territorial) waters and other matters relating thereto.

Electronic waste contains toxic components that are dangerous to human health, such as mercury, lead, cadmium, polybrominated flame retardance, barium and lithium. The negative health effects of these toxins on humans include brain, heart, liver, kidney and skeletal system damage. The processing of electronic waste in developing countries cause serious health and pollution problems due to electronic equipment contains serious contaminants such as lead, cadmium, beryllium, arsenic, mercury, nickel, silver, zinc, copper, chrome, cobalt etc. pollutants or toxins in e-waste are typically concentrated in circuit boards, batteries, plastics and LCDs (liquid crystal displays).

COMPONENTS OF E-WASTE

Components	Percentage (%)
Metal	25%
Plastic	63%
Rubber	0%
Glass	4%
Metal and plastic	8%
Metal and rubber	0%
Iron and steel	48%

1.3Objectives:

The objective of the present research work is to find out the different properties of Electronic waste. To reduce the utilization of fine aggregate by partial replacement of E-Waste with silica fume. To enhance the best environmental alternate for cement.

1. To check the Workability of the conventional concrete to that of E-waste concrete.
2. To check the behavior of E-waste concrete under Compression, Split Tensile, UPV Test for 28 days.
3. To investigate the effect of acid on the behavior of E-Waste concrete.

4. This will explore the mechanical properties of Electronic Waste Concrete (EWC) with partial replacement of Fine aggregate with electronic waste in 5% and 15%, 5% of silica fume

II. Material

The following sections discuss constituent materials is used for manufacturing of concrete specimens of different grades. Physical and chemical properties of the constituent materials are presented in this section.

2.1 Cement:

Portland pozzolana cement is a type of blended cement. It consists of 15-35% pozzolanic material, 4%of gypsum and the rest in clinker. PPC as per BIS code is equivalent to that of 53 grade. The various properties of cement are shown in the below.

Table : 2.1 - Properties of cement

S.NO	PROPERTIES	RESULT
1	Specific gravity	3.15
2	Standard consistency	33.5%
3	Fineness modulus	5.0%
4	Specific Area	$3250cm^2/gm$

2.2 Fine aggregate:

Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are 4.75mm or smaller as per IS:383-1970 was used for all the specimens. Test conducted on fine aggregate are specific gravity using pycnometer, fineness modulus by sieve analysis.

2.3 Coarse aggregate:

Coarse aggregate with specific gravity of 2.67 and retained on 20mm and 10mm sieve and as given in IS:383-1970 is used for all the specimens. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the reminder.

2.4 E-Waste:

E-Waste is a popular, informal name for electronic products nearing the end of their useful life. Computers, Televisions, VCRs, Stereos, Copiers and fax machines are common electronic products. Then specific gravity is 1.87 and fineness modulus is 3.51.

2.5 Silica Fume:

Silica fume is a byproduct of astrra chemicals, 11, Moores road, Thousand lights, Chennai. Then chemical, physical properties are presented in the below.

Table:2.2 Physical properties of silica fume

S.NO	PHYSICAL PROPERTIES	RESULT
1.	Specific gravity	2.2
2.	Size	0.1 microns
3.	Surface area	$3000kg/m^2$
4.	Physical state	Micronized powder
5.	Colour	Grey

Table:2.3 chemical properties of silica fume

S.NO	CHEMICAL PROPERTIES	RESULT
1.	SiO_2	90.26%
2.	Al_2O_3	05.84%
3.	Fe_2O_3	01.11%
4.	Moisture	02.20%

Figure 2.1. Silica fume (Gray)

III. Methodology

The research work was done before starting the work by reviewing the previous research papers published. Concrete tests are performed for the investigation and partial substitution of E-waste for fine aggregate. In this experiment, the materials used are PPC grade 53, natural sand as fine aggregate, natural aggregate as coarse aggregate, Polypropylene fiber of 12 mm and crushed 20 mm retained e-waste was used in this investigation project.

E-waste is replaced partially in the percentage of 0%, 5%,10% and 15% with fine aggregate in the fibrous concrete mix. Polypropylene fiber is used in the range of 0% to 5%. The partially replaced fibrous e-waste concrete is with and without silica fume.

M20 mix design of 1:2.01:2.85 proportions with 0.5 water cement ratio was used to prepare entire specimens. Then Specimens were taken out from the curing tank after 28 days to perform various tests. Hardened properties were found out by carrying out the investigational work on cubes and cylinders which were casted in laboratory and their behaviour under test were observed at 28 days for compressive strength, rebound hammer, ultrasonic pulse velocity, split tensile strength tests and Durability tests are conducted.

IV. Test Methods

4.1 Compressive strength test:

Compressive strength test was conducted on the cubical specimens for all the mixes after 28days of curing as per IS: 516-1959. Compression test machine of 2000KN capacity is used to examine the compression strength of concrete. The compression test is conducted on fibrous concrete specimen of size of (15X15X15) cm with various ratio of e-waste 0%,5%,10% and 15%. The compressive strength (fc) of concrete can be calculated by ratio of the maximum load applied to the specimen to the cross-sectional area of the specimen. The mixing, tamping, and casting of specimens is shown in the below.

Figure : 4.1 Compressive strength test

4.2 Split tensile strength test:

Split tensile strength (STS) test was conducted on the specimens for all mixes after 28 days of curing as per IS 5816(1999). Three cylindrical specimens of size of (10X20) cm were cast and tested for each age and each mix. The load was applied gradually till the failure of the specimen occurs. The maximum load applied was then noted. Length and cross-section of the specimens was measured.

The split tensile strength (fct) was calculated as follows

$$Fct = \frac{2P}{\pi LD}$$

Where,

Fct=splitting tensile strength of concrete (N/mm^2)

P=maximum load applied to the specimen (in Newton)

L=length of the specimen (in mm)

D=cross-sectional diameter of the specimen (in mm)

Figure : 4.2 Split tensile test

4.3 Ultrasonic pulse velocity test:

The ultrasonic pulse velocity (UPV) test is an in-situ, non-destructive test to check the quality of concrete and natural rocks. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural rock formation.

Ultrasonic testing equipment includes a pulse generation circuit, consisting of electronic circuit for generating pulses and a transducer for transforming electronic pulse into mechanical pulse having an oscillation frequency in range of 40 kHz to 50 kHz, and a pulse reception circuit that receives the signal. A procedure for ultrasonic testing is outlined in ASTM C597 - 09. In India, ultrasonic testing is conducted according to IS 13311-1992. This test indicates the quality of workmanship and to find the cracks and defects in concrete.

Figure : 4.3 UPV test

4.4 Water absorption test:

Water absorption (WA) tests were carried out on 150 mm cube specimens at the age of 28 day curing as per ASTM C 642. The specimens were weighed before drying. The drying was carried out in a hot air oven at a temperature of 105C. The drying process was continued, until the difference in mass between two successive measurements at 24 hours interval agreed closely.

The dried specimens were cooled at room temperature and then immersed in water. The specimens were taken out at regular intervals of time, surface dried and weighed. This process was continued till the weights became constant (fully saturated).

The difference between the measured water saturated mass and oven dried mass expressed as a percentage of oven dry mass gives the WA.

Figure: 4.4 Water absorption test

4.5 Acid attack test:

The concrete cubes of conventional and E-plastic were immersed in the sulphuric acid solution of 5%concentration in accordance to the procedure given in ASTMC 642. A 5% (by mass) sulphuric acid solution was directly diluted from 98% concentrated sulphuric acid with tap water. The specimens were immersed in solution after the normal curing of the concrete specimens. The cubes were fully immersed in the solution kept in plastic containers. The containers were covered in order to minimize the evaporation rate and to avoid falling of the dust in the containers. The pH of the solution was maintained throughout the study period. The compressive strength and change in mass of the concrete cylinders were observed on first and fourth week after immersion into the solution and reading were noted. The surfaces were cleaned and oven dried at 100^0c for 24 hours. The oven dried cylinders were weighed.

Figure : 4.5 Acid test

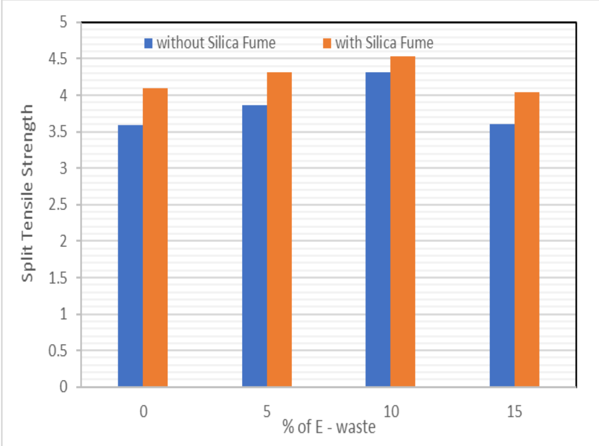

Figure : 5.2 Split tensile strength result

V. Result and Discussion

5.1 Compressive Strength Test:

The Compressive Strength of concrete increases by 0.97%, 0.91%, 1.13% for 5%, 10%, 15% of E-waste respectively for without silica fume. The Compressive Strength of concrete increases by:0.92%, 0.97%, 1.138% for 5%, 10%, 15% of E-waste respectively for with silica fume.

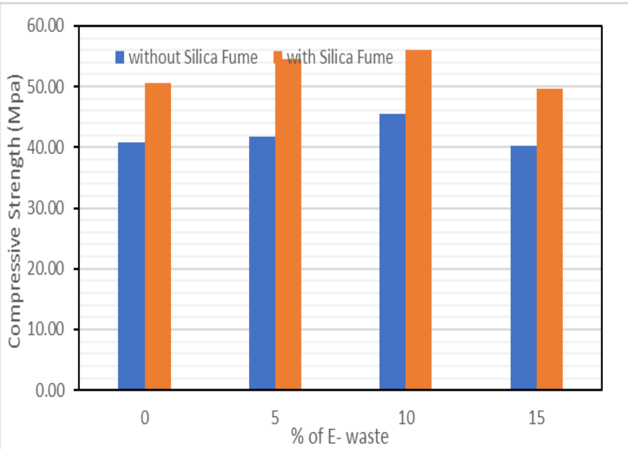

Figure:5.1Compressive strength result

5.2 Split tensile strength test: The Split tensile Strength of concrete increases by 0.92%, 0.89%, 1.196% for 5%, 10%, 15% of E-waste respectively for without silica fume. The Compressive Strength of concrete increases by:0.94%, 0.95%, 1.123% for 5%, 10%, 15% of E-waste respectively for with silica fume.

5.3 Ultrasonic pulse Velocity Test:

The Ultrasonic pulse velocity of concrete increases by 0.97%, 0.96%, 1.012% for 5%, 10%, 15% of E-waste respectively for without silica fume. The Compressive Strength of concrete increases by:0.98%, 0.97%, 0.56% for 5%, 10%, 15% of E-waste respectively for with silica fume.

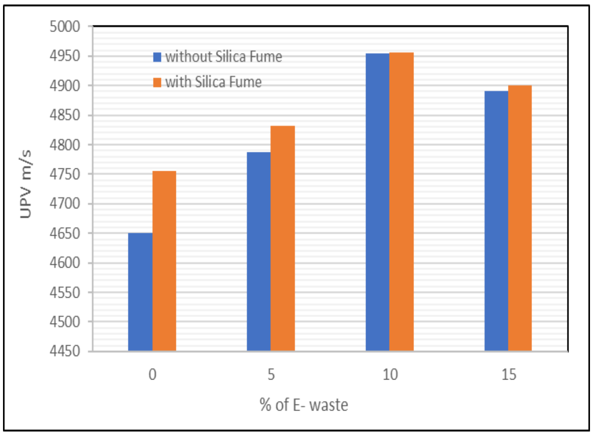

Figure : 5.3 Ultrasonic pulse velocity result

5.4 Water absorption test:

This section describes water absorption result of E-Waste concrete with and without silica fume specimens. These values and graphs are tabulated in below.

Table : 5.4 Water absorption result

% of E-Waste	Water absorption test	
	Without Silica Fume	With Silica Fume
0	1.23	1.13
5	1.29	1.21
10	1.34	1.28
15	1.43	1.32

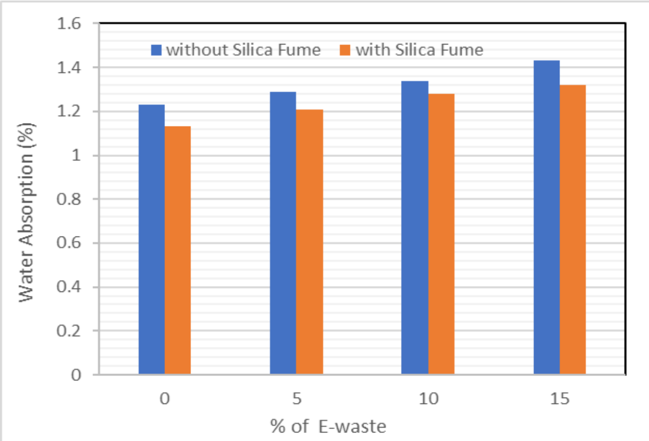

Figure : 5.4 Water absorption result

5.5 Acid attack test:

This section describes Acid attack result of E-Waste concrete with and without silica fume specimens. These values and graphs are tabulated in below.

% of E-Waste	Acid test	
	Without Silica Fume	With Silica Fume
0	8.14	6.18
5	3.43	2.36
10	4.32	2.85
15	4.95	3.94

Table : 5.5 Acid attack result

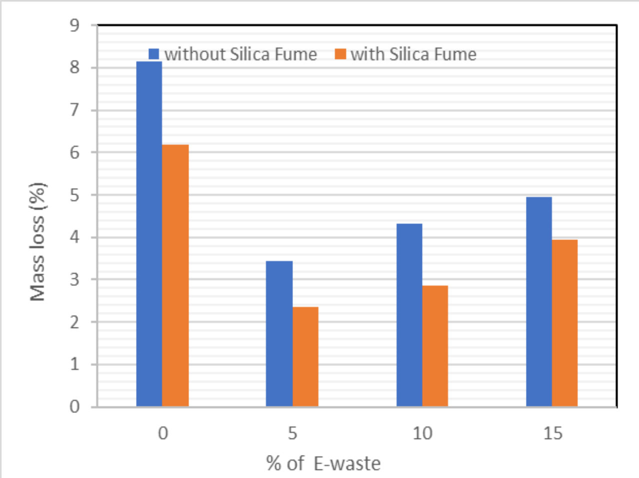

Figure : 5.5 Acid attack result

Figure : 5.1 After Acid attack specimens

VI. CONCLUSION

Based on the test results, the following conclusions are drawn:

- Optimum percentage of E-Waste is found to be is 10% for M35 grade concrete.
- By incorporation of silica fume the mechanical properties such as compressive strength and tensile strength are improved.
- The increase in the % of E-waste decreases the density and hence E-waste concrete can be adopted for light weight construction.
- The quality of E-waste concrete improved by the incorporation of silica fume, which is evident from the rebound hammer and ultrasonic pulse velocity results.
- The acid resistance of the E waste concrete is improved by the incorporation of silica fume.

Over all the combination of E-waste and silica fume develop a Sustainable Concrete and can prevent the unnecessary dumping of E-waste.

VII. REFERENCES

[1]. ACI committee 544. 1982. State-of-the-report on silica fume reinforced concrete, (ACI 544.1R-82), Concrete International: Design and Construction. 4(5): 9-30, American Concrete Institute, Detroit, Michigan, USA.

[2]. ACI Committee 544. 1989. Measurement of properties silica fumes reinforced concrete, (ACI 544.2R-889). American Concrete Institute, Detroit, Michigan, USA.

[3]. Ahirwar et al.2016 – Ahirwar, s., Malviya, P., Patidar, V. and singh, V. k. 2016). An Experimental study on Concrete by using E-Waste as Partial Replacement for Course Aggregate. IJSTE-International Journal of Science Technology & Engineering 3(04), pp. 7–13.

[4]. Alagusankareswari et al. 2016 – Alagusankareswari, k., kumar, s.s., Vignesh, k.b. and niyas, A.H. 2016. An Experimental study on E-Waste Concrete. Indian Journal of Science and Technology 9(2), pp. 1–5.

[5]. Arora, A. and Dave, U.V. 2013. Utilization of e-waste and plastic bottle waste in concrete. International Journal of Students' Research in Technology & Management 1(4), pp. 398–406.

[6]. Jaidev K, Biswal M, Mohanty S and Nayak S K 2021 Sustainable Waste Management of Engineering Plastics Generated from E-Waste: A Critical Evaluation of Mechanical, Thermal and Morphological Properties J. Polym. Environ. 29 1763–76.

Cite this article as :

Narayanamma Velpula, Thulasirajan Krishnan, A. Anil , "Experimental Investigation on E-Waste Concrete with Silicafume", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 10 Issue 3, pp. 74-81, May-June 2023. Available at doi : https://doi.org/10.32628/IJSRSET2310330

Journal URL : https://ijsrset.com/IJSRSET2310330