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EXPERIMENTAL STUDY ON THE USAGE OF PLASTIC E- WASTE AS FINE AGGREGATE IN CEMENT MORTAR

[1]Tadaboina ManojKumar, [2]Dr. Joshi Sreenivasa Prasad, [3]Mr. K. Hajarath

[1]Post Graduate Student, [2]Assistant Professor, [3]Assistant Professor
Department of Civil Engineering,
Anurag University, Ghatkesar, Hyderabad, Telangana, India

Abstract: Construction or civil Engineering represents one of the oldest branches of engineering, and practises that were used at the time were outdated. E-Waste is one of the fastest-growing waste streams in the world due to the current technology boom, technological advancements, and the electronics manufacturing sector. But, when the globe was facing severe environmental issues, civil engineering developed a number of innovative solutions. converting waste materials and other environmentally harmful elements into environmentally friendly products. Yet, E-waste is now becoming a significant issue. When left untreated, E-waste contains materials like plastic and PVC that pose a serious hazard to the environment. It is posing a major danger to the planet's landfills, and groundwater, which is steadily turning poisoned. E-waste was taken into consideration as a source of building to address this landfill issue and stop groundwater from becoming poisonous. Electronic garbage that is damaging to the environment includes mobile phones, iPods, refrigerators, computers, printers, washing machines, and televisions. India produces over 2 million TPA of E-waste (tonnes per annum). As a civil engineer, we took advantage of the situation and substituted e-waste for aggregate. Because of this, e-waste mortar has grown in a way that makes it lighter and more flexible. E-waste as a substitute for coarse, fine, or both types of aggregate produced remarkable results. This present study includes partial replacement of E-waste as fine aggregate in cement mortar. The E-waste is replaced in different proportions like 0%,10%,20%,30%,40%50%. The specimens are cured and tested for 7days, 14days and 28days. When the replacement ratio of E-waste increases the strength decreases. The compressive strength, the durability strength results of the cement mortar are found out in this investigation.

Index Terms **- E-waste replacement, Cement mortar, Mechanical properties, Durability properties.**

I. INTRODUCTION

Electronic waste recycling Global E-Waste Monitor 2020 states that 2019 had a global production of 53.6 million Tons of electronic garbage, of which only 17.4% was recycled. In India 3.2 MT of electronic garbage were produced after China and the United States. Electronic sources like IT and telecom equipment, large and small appliances, consumer and lighting products, electrical and electronic tools, toys and sports equipment, medical devices, monitoring and control instruments, and other technological advancements that have accelerated technological advancement.

It contains numerous dangerous heavy metals, acids, toxic compounds, and non-biodegradable polymers, among other things. The purpose of about 75% of electronic wastes is unknown, however there are ways to utilize them, such as refurbishing, remanufacturing, and using their parts for repairs, etc., Due to their access to inexpensive labour, the majority of E-recyclers exported hazardous products like leaded glass and mercury lamps to poor nations. The dismantling procedure requires a lot of labour. Dismantling involves not just unscrewing but also tearing, burning, and shredding. To find precious metals like gold, platinum, cadmium, etc., circuits are burned. Nevertheless, the wire coat of those is made of PVC, which can emit dangerous smoke and carbon particles and cause skin and lung cancer.

Electronic-environmental waste's impact is a new concern that poses serious pollution issues for people and the environment. Solutions need to be developed, especially in terms of recycling approaches. Fast technological advancement and low initial costs have led to a rapidly expanding global surplus of e-waste.

Instead of depleting natural resources for construction industry it is an alternative to replace the construction materials like fine aggregate, coarse aggregate and binder. E-waste aggregate as a partial replacement for natural sand in mortar in the current circumstances due to the lack of available natural sand for the preparation of mortar. One of the newest wastes used in the concrete industry is e-waste. One of the fastest-growing waste streams in the world is e-waste.

E-waste has increased the strength qualities, greater workability, and high resistance to chemical acid assaults when utilised in part to replace natural aggregates (coarse aggregates and fine aggregates).
E-waste provides concrete with superior strength qualities, good resistance to chemical acid attacks, greater workability, and an easy production process when used in place of natural aggregates. It is also employed in marine environments and offers affordable and secure E-waste disposal.

In this study, primarily focuses on to develop the cement mortar using E-Waste. The E-Waste used as partial replacement of fine aggregate at various replacement levels in cement mortar. And also, to study the mechanical properties, durability properties. Finally developed the optimum dosage of E-waste when partially replaced as fine aggregate in the cement mortar.

1.2 RESEARCH OBJECTIVES

The following specific objectives framed based on research gaps:

1. To study the mechanical properties of optimized dosage of E-waste plastics in cement mortar.
2. To determine the optimum dosage of E-waste plastics in cement mortar.
3. To determine the durability properties of E-waste plastics in cement mortar.

II. Materials And Methodology

2.1 Materials

The following are the materials used in the project work and each is explained in detail. They are as follows:

- Ordinary Portland Cement 53 grade
- Fine aggregate (River sand)
- Electronic waste(E-Waste)

2.1.1 Ordinary Portland cement (OPC 53 grade)

Ordinary portland cement (OPC 53 grade) conforming to BIS 12269-1987 (BIS 1987) was used in all mortar mixtures. The cement was tested for its physical requirements such as Fineness, Normal consistency, Soundness, specific gravity and Initial and Final setting time of cement in accordance with IS codes.

Fig. 1: OPC 53 Grade

2.1.2 Fine aggregate (River sand)

The fine aggregate used were locally available river sand without any organic impurities and conforming to IS: 383 – 1970 [Methods of physical tests for hydraulic cement]. The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386 – 1963 [Methods of test for aggregate for concrete] and is shown in table. The sand was surface dried before use.

Fig. 2: Fine aggregate (River sand)

2.1.3 E-waste

The size of E-waste materials used in this project are less than 4.75mm. The tests conducted on E-waste materials are Fineness, Specific Gravity, Water Absorption, Initial and Final setting time as per codal provisons.

Fig. 3: Electronic waste

III. Experimental Work

3.1 Collection of E-waste

The following procedure have been adopted to collect the Electronic waste to produce the required size of fine aggregate. This material is procured from the waste processing industries from various suppliers.

3.2 Mix Proportions for Cement Mortar

There were 6 mix proportions for the cement mortars were proposed to obtain the physical and mechanical properties, electronic waste replaced as fine aggregate 0% to 50% at 10% replacement levels, the mix proportions were designated as CM0 to CM50. The mix proportion for the cement mortar tabulated in Table 1.

Table 1: Mix Proportions of Cement mortar for cumec.

S.No	Mix Id	Binder (Kg)	% of Fine aggregate (Kg)	% of E-waste (Kg)	Water (Kg)
1	CM0	1100	1100	0	252
2	CM10	1100	990	110	252
3	CM20	1100	880	220	252
4	CM30	1100	770	330	252
5	CM40	1100	660	440	252
6	CM50	1100	550	550	252

In this research, the fine aggregate is partially replaced with E-waste and cement is used as binder material. E-waste is replaced up to 0% to 50% with 10% interval each in natural fine aggregate. 1:1 Mix proportion is used. The size of specimens are 10*10*10 cm. The Cement mortar samples are casted, cured and tested for 7 days, 14 days and 28 days. Acid curing is done for all samples for 28 days and 56 days and tested. The acid used for the durability test is Hydrochloric acid.

IV. Results And Discussion

4.1 Physical Properties of River sand

The physical properties of fine aggregate like specific gravity, Bulk density, Fineness modulus, bulking of sand are determined and tabulated in Table 2.

Table 2: Physical Properties of River sand

S.NO	Property	Fine Aggregate
1	Specific gravity	2.84
2	Bulk density(compact)	1711Kg/cum
3	Bulk density(loose)	1631Kg/cum
4	Fineness modulus	2.64
5	Bulking of sand	4% wc
6	Grading	Zone -II

4.2 Electronic Waste (E-waste)

The physical properties of Electronic Waste (E-waste) like fineness, consistency, specific gravity, initial setting time were determined and tabulated in Table 3. The chemical composition consists of copper, zinc, Aluminium, plastics, glass, lead, steel and others are 7%, 3%, 10%, 19%, 22%, 8%, 29% and 3% respectively.

Table 3: Physical properties of E-waste

S.No	Type	Properties
1	Maximum Size	4.75 mm
2	Shape	Angular
3	Colour	Green and dark
4	Specific Gravity	2.6
5	Water Absorption	Less than 0.2%

4.3 Compressive strength of Cement mortar

The compressive strength results were determined for samples. The compressive strength results before acid curing and after acid curing are shown below. Before acid curing the samples of Cement Mortar i.e, CM are tested for 7 days, 14 days and 28 days. After acid curing the samples of CM are tested for 28 days and 56 days.

4.4 Compressive strength before acid curing

The CM samples are tested for compressive strength before acid curing at 7 days, 14 days, and 28 days.

1:1 Mix proportion, Natural sand partially replaced with E-waste, cement as binder material.

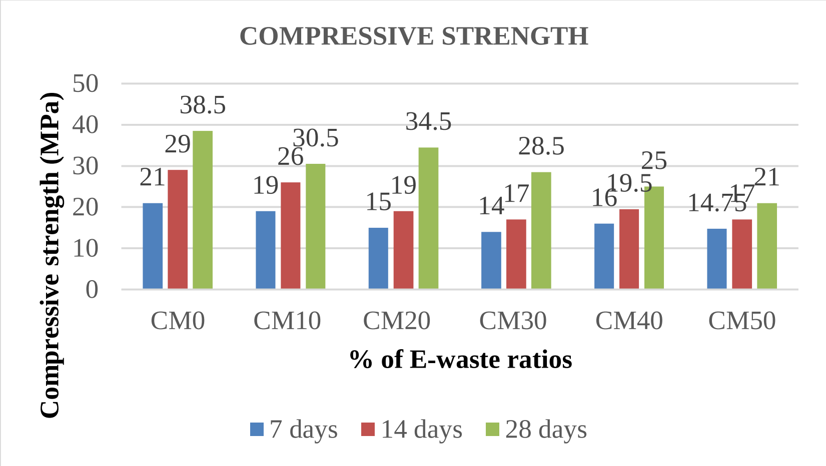

Fig. 4: Compressive strength results of CM samples

This graph tells us about the compressive strength results of the cement mortar samples at 7, 14, and 28 days. In this research, the fine aggregate is replaced with E-waste and cement is used as a binder material. E-waste is replaced up to 0% to 50% with 10% interval each in natural fine aggregate. Mix proportion is 1:1. The size of the specimens are 10*10*10 cm. The samples are kept in water curing.

The maximum compressive strength obtained at 20% replacement i.e, 34.5 Mpa at 28 days.

The minimum compressive strength obtained at 30% replacement i.e, 14 Mpa at 7 days.

4.5 After Acid Curing

The CM samples are tested for compressive strength after acid curing at 28 days and 56 days.

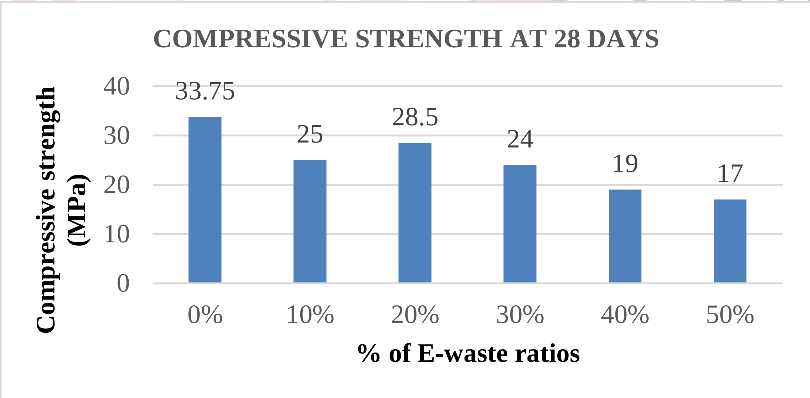

Fig. 5: Compressive strength results of CM samples for 28 days in Sulphuric acid

This graph tells us about the durability results of the samples which are placed in sulphuric acid for 28 days.

The maximum compressive strength obtained at 20% replacement i.e, 28.5Mpa.

The minimum compressive strength obtained at 50% replacement i.e, 17Mpa.

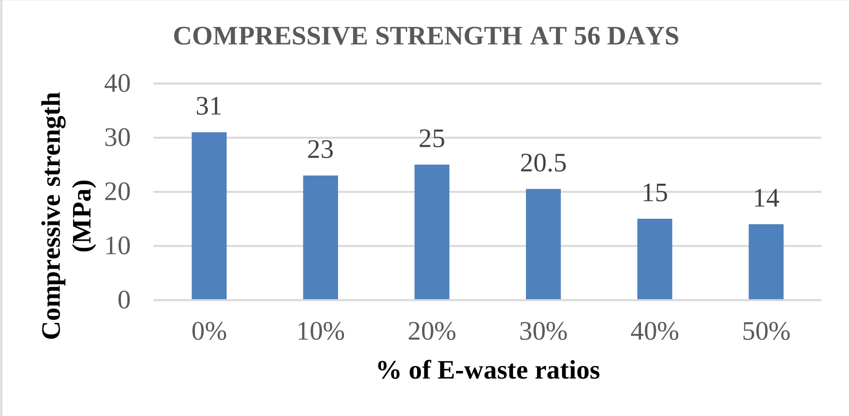

Fig. 6: Compressive strength results of CM samples for 56 days in Sulphuric acid

This graph tells us about the durability results of the samples which are placed in sulphuric acid for 56 days.
The maximum compressive strength obtained at 20% replacement i.e, 25Mpa.
The minimum compressive strength obtained at 50% replacement i.e, 14Mpa.

V. CONCLUSIONS

The behaviour of E-waste when partially replaced in fine aggregate in cement mortar with different ratios are determined and the results are compared in this study. The following are the conclusions which are drawn from the results:

1. The addition of E-waste as a partial replacement in the fine aggregate in cement mortar has a positive effect on mechanical properties.
2. The optimum dosage of the E-waste replacement percentage is 20%.
3. The compressive strength of CM20 achieved high strength.
4. The compressive strength decreases when the ratio of E-waste increases.
5. In the point of durability criteria, Cement mortar samples are immersed in Sulphuric acid for 28 days and 56 days.
6. In Sulphuric acid cured samples, it is observed that the loss of weight for CM20 at 28 days and 56 days is 17.4% and 27.6% respectively.
7. After 28 days of acid curing the compressive strength results of cement mortar at CM15 shows good results.
8. After 56 days of acid curing the compressive strength results of cement mortar at CM15 shows satisfactory results.

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