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Effects of Partial Replacement of Sand by Crushed E-Waste on Mechanical Properties of Concrete

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Abstract: Electronic waste is an increasing issue and a serious pollution problem for the environment and human life. The disposal of electronic waste is becoming a serious problem. The main potential for addressing the disposal of large amounts of electronic waste material is in the construction industry. The excess cost of coarse aggregate has forced civil engineers to find out an alternative solution for the construction materials. So, we can use e-waste as a partial replacement for coarse aggregate. Using electronic waste in construction will not only reduce the waste materials like electronic waste from the earth but also reduce the construction material(concrete) that will lead to economic construction. for Concrete mixes, different rate percentages of E-waste were selected and three different types of conventional and standard specimens have been decided to be partly replaced by E-waste at a percentage rate of 10%, 20%, and 30% for a coarse aggregate. M25 Concrete is usually prepared for conventional specimens without using E-waste aggregates. The results and effectiveness of concrete with e-waste replacement and the physical and mechanical properties of the following have been studied in this paper.
Keywords: Concrete, E-Waste, Flexural Strength, Compressive Strength, Economic construction.

I. INTRODUCTION

Concrete is the most widely used construction material and is applied in public infrastructure/buildings. Cracks in concrete are one of the inherent weaknesses of concrete. Based on the continuous research carried out around the world, various advancements have been made from time to time to overcome the deficiencies of cement concrete. The ongoing research in the field of concrete technology has led to the development of special concretes considering the speed of construction the strength of concrete the durability of concrete & the environmental friendliness with the use of industrial materials like fly ash, blast furnace slag, silica fume, etc. Recently, it has been found that E-waste is also used as construction material in alternative methods.

Electronic waste or e-waste defines rejected electrical or electronic devices. Secondhand electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste. Electronic waste is an emerging concern posing serious health and hazardous problems to humans and the environment. E-waste disposal is a difficult task for whole over the world. Utilization of E-waste materials is a restricted solution to environmental and ecological problems. The estimated annual generation of electronic waste is 4,00,000 tons which is (10-15%) approximately. The wastes generated from the top cities such as Mumbai, New Delhi, Bangalore and Chennai were calculated to be 10,000 tons, 9,000 tons, 8,000 tons and 6,000 tons respectively. But from these sources, only 4% of it is recycled. Due to the large amount of concrete used as the construction material availability of raw materials is being questioned. Therefore, other replacement materials are needed to be finding out. E-waste is used as one such alternative for concrete materials in concrete. The use of E-waste in concrete on the basis of different researchers and marches strong possibility of E-waste being used as a construction material as well as environmental impact. The use of natural sand in concrete will decrease if different types of by-products are used in concrete as a substitute material. And it is more important to reuse the waste material.

II. SCOPE OF INVESTIGATION

New waste management options require a shift from landfills and incineration to end-of-life (EOL) electronics. The growing need for landfills is a burden for our environment. In addition, with the possibility of disposal and increasing concern for the quality of the environment, new disposal methods are needed. To be successful, it must be based on the fact of its financial stability, performance and social support. The reuse of EOL electricity in the construction industry is one of the environmentalists.

Using e-waste in concrete is not only a good method of disposal but also helps to reduce the cost of construction. In addition, it has many benefits such as reducing waste costs, preventing threats to the environment, saving energy, and protecting the environment from pollution. Therefore, this study, it is aimed to use e-wastes in concrete and to determine the electrical properties of e-materials added to concrete. E-waste is a suitable substitute for coarse aggregate in concrete.

Using e-waste i.e. For example, high-impact polystyrene, makes concrete weaker and less degradable than coarse aggregate. Tests to determine the best e-waste quality that can be added to the M25 concrete class hardened concrete were observed to study the strength parameters of concrete.

III. MATERIALS

A. Cement

Ordinary Portland cement of 53 grade UltraTech brand was selected for the casting of specimens. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for the chemical requirement in accordance IS 4032-1988.
The cement used was dry, fine and did not have any lumps. The following tests were conducted on cement and the results are shown in Table I.

Table I: Properties of cement

Sr.no	Characteristics	Experimental value
1.	Consistency of Cement (%)	33 %
2.	Specific gravity	3.15
3.	Initial setting time (In minutes)	39
4.	Final setting time (In minutes)	520
6.	Soundness (mm)	2.1
7.	Fineness of cement	2.5%

B. Fine Aggregate

The fine aggregate was brought from a locally available source and then gradation of natural fine aggregate was obtained by sieving. The physical properties of fine aggregate are given below in Table II.

TABLE II: - PROPERTIES OF FINE AGGREGATE

Sr. No	Characteristics	Values obtained
1	Fineness Modulus	2.78
2	Specific gravity	2.66
3	Grading zone	Zone II
4	Free moisture	1%

C. Coarse Aggregate

Locally available crushed granite stone was used as coarse aggregate of size not more than 20mm. the following tests were performed on the coarse aggregate and the results are given below in Table III.

TABLE III: - PROPERTIES OF COARSE AGGREGATE

Sr. No	Characteristics	Values obtained
1	Maximum size	20mm
2	Specific gravity	2.66
3	Total water absorption	1%
4	Fineness modulus	7.54
5	Impact value	12%
6	Crushing value	9.21%

D. Water
Locally available impurities-free, clean and potable water was used for casting the specimens and also for curing.

E. E-Waste
E-waste is used as sand, so it is very important that to find out the zone of that material, and the testing is done as per IS. The E-waste used is of zone-1.

F. Mix Design
Mix design for M25 grade concrete was done by IS Code method and concrete cube specimens were cast for trial mixes using e-waste as replacement. The mix proportions adopted are shown in Table IV.

TABLE IV: - MIX DESIGN PROPORTIONS FOR M25 GRADE CONCRETE

Types of concrete	Concrete mix				
	Cement (Kg)	Sand (Kg)	Aggregate (Kg)		E-waste In (Kg)
			10mm	20mm	
Nominal	15.54	31.54	11.00	25.67	00
E-10%	15.54	28.39	11.00	25.67	3.15kg
E-20%	15.54	25.23	11.00	25.67	6.31kg
E-30%	15.54	22.08	11.00	25.67	9.46kg

IV. EXPERIMENTAL PROCEDURE

A. Casting of specimens
To the above concrete mixes various percentages of E-waste was added as a partial replacement for sand. Cubes of 150mm x 150mm x 150mm were cast using moulds.

B. Testing of specimen
The specimens were tested for the compressive and flexural strength of concrete.

1) Compressive Strength
As per IS: 516-1959 (reaffirmed 2004), the compressive strength was tested on the concrete specimens which were cast and curated for 7, 14 and 28 days. The compressive strength of various proportionate mixes were determined by using a digital compression machine. The capacity of the compression testing machine was 2000kN and the specimens were tested at a loading rate of 2.5 KN/s. The dimensions of the cube are maintained as 150x150x150 mm. The results are shown in Table V and Fig 1.

2) Flexural Strength
The cylinders of 150mm x 300mm of were cast with the above mix proportion and tested for 7 and 14-days strength. Also, specimens were cast with coarse aggregate replacement by e-waste in various percentages and tested. The test results are shown in Table VI and Fig 2.

V. RESULTS

TABLE V: - COMPRESSIVE STRENGTH OF M25 MIX

Type of concrete	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
Nominal	15.27	21.77	24.71

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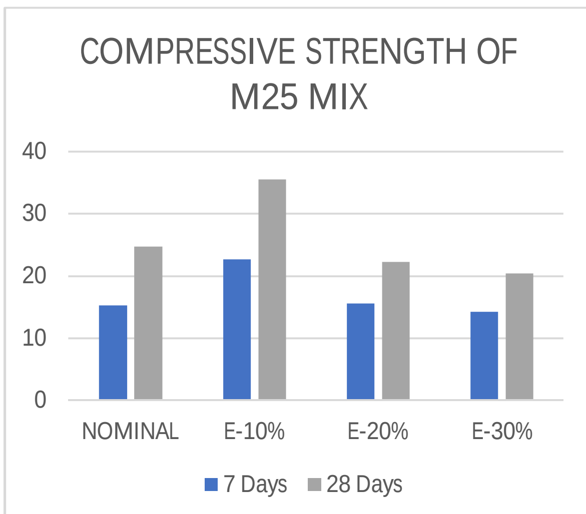
E-10%	22.67	28.22	35.55
E-20%	15.56	19.11	22.22
E-30%	14.27	17.77	20.44

TABLE V: - FLEXURAL STRENGTH OF M25 MIX

Type of concrete	7 days (N/mm^2)	28 days (N/mm^2)
Nominal	2.96	3.88
E-10%	3.10	3.91
E-20%	1.97	2.98
E-30%	1.7	2.3



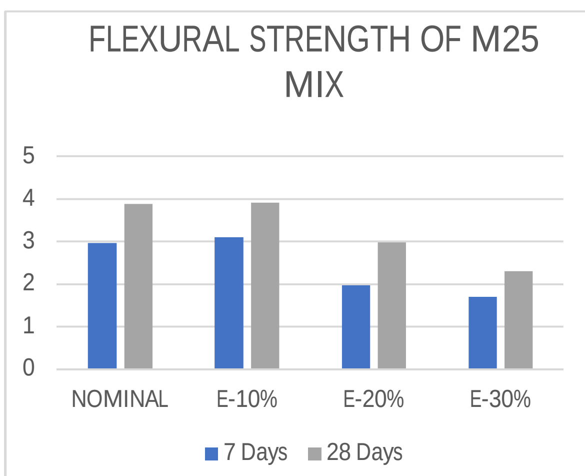


Fig2: - Compressive strength of M25 mix

VI. CONCLUSION & DISCUSSION

1) The cost of crushed E-waste is comparatively equal to that of river sand, sometimes it is cheaper than river sand (depending on the availability of E-waste).
2) By replacing the natural sand with E-sand or crushed E-waste results in a decrease in the weight of the concrete. It also increases the volume of concrete.
3) It is observed that after placing concrete the concrete releases water, so take precautions while adding water to concrete.
4) The mechanical properties of concrete could be maintained by using e-waste up to a certain quantity and can be one of the economical ways for their disposal in an environment-friendly manner.

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