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Experimental investigation on high performance concrete with partially replaced e-waste materials by coarse aggregates

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Keywords

E-waste,
Compressive Strength,
Split tensile strength,
Flexural strength.

Abstract

In this present work the compressive strength, flexural strength test and split tensile strength of M30 concrete containing E-waste aggregate is retained more or less in comparison with controlled concrete specimens. The most realistic use for disposing of significant amounts of E-waste material is reuse of E-waste in the concrete industry. In the range of 0%, 5%, 10%, 15%, 20%, and 50%, coarse aggregate is replaced by E-waste. The workability of the M30 concrete increases as the percentage of replacement of coarse aggregates with E-waste increases.

1. Introduction

The electronics and electrical industries have witnessed a marked increase with the rise in urbanization [1-5]. The paradox of such exponential growth, however, is the ongoing global electronic waste (e-waste) crisis. As greater numbers of electronic equipment become obsolete and no longer provide value to their owners, consumers must make decisions concerning how or even whether to dispose of such devices [6]. E-waste is increasing drastically, with a growth rate of 20-25% annually. The cumulative market-diffusion, replacement-market, and high-obsolescence-rate make e-waste the fastest developing waste stream. Pollution prevention covers the methods that help to diminish the usage of hazardous and non-hazardous materials, equipment, energy, etc. [7,8]. Effective waste management can decrease criminal and civil liability risks, operation costs, and the need for transport and disposal. It is a multifaceted waste stream comprising of both scarce and economically valued constituents [9]. In India, e-waste is estimated to comprise computer accessories (68%), telecommunication equipment (12%), electrical apparatus (8%), health apparatus (7%), and 'household e-scrap' (5%.) The commoditization of e-waste to recover precious metals such as lanthanum, neodymium, silver, gold, palladium, platinum, etc., is also highlighted [10]. Improper handling of e-waste leads to several deleterious effects on the environment like degradation and pollution of soil, contamination of water sources and release of toxic fumes (from e-waste combustion) directly affects the health of living organisms [11]. Currently, a number of studies are being focused on the various aspect of e-waste beginning from womb to tomb in different parts of the world [12-17]. However, there are continuous issues that have been occurring related to e-waste, such as incessant increasing the e-waste quantity, development of various physicochemical and biological metal recovery methods, trans boundary movement issues among countries, regular amendment of law and order and penetration of toxic metal into the ecosystem.

In this present work we have done compressive strength, flexural strength test and split tensile strength of M30 concrete containing E-waste aggregate is retained more or less in comparison with controlled concrete specimens. The workability of the M30 concrete increases as the percentage of replacement of coarse aggregates with E-waste increases.

2. Experimental details

2.1 Materials used

(i) Cement

Cement is one of the binding materials in this project. Cement is the important building material in today's construction world 53 grade Ordinary Portland Cement conforming to IS: 8112-1989. The properties of cement used given in Table 1.

Table 1. Properties of cement.

Description of test	Test results obtained	Requirements of IS: 8112 1989
Initial setting time	65 minutes	Min. 30minutes
Final setting time	270 minutes	Max. 600minutes
Fineness (specific surface by Blaine's air permeability test)	412.92 m^2/kg	Min. 225 m^2/kg

Figure 1. Properties of cement.

(ii) Physical properties of cement

Ordinary Portland cement, 53Grade conforming to IS: 269-1976. Ordinary Portland cement, 53 Grade was used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence.

(iii) Fine aggregate

Natural river sand is used as fine aggregate. As per IS: 2386 (Part III)-1963. Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The fine aggregates of soil are shown in Figure 2. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The Properties fine aggregates of soil are given in Table 2.

Table 2. Properties Fine aggregates of soil.

S.No.	Properties	Value
1	Specific Gravity	2.65
2	Fineness Modulus	2.25
3	Water absorption	1.5%

Figure 2. Fine aggregates of soil.

(iii) Coarse aggregate

Crushed stones of maximum size 20 mm are used as coarse aggregate. As per IS: 2386 (Part III)-1963. Aggregate in concrete is structural filler. The coarse aggregate is depicted Figure 3. Test results of coarse aggregate. The experimental data of coarse aggregate is given in Table 3.

Table 3. The experimental data of coarse aggregate.

S.No.	Properties	Value
1	Specific Gravity	2.68
2	Size of Aggregates	20mm
3	Fineness Modulus	5.96
4	Water absorption	2.0%
5	Impact Test	15.2%
6	Crushing Test	22.5%

Figure 3. Coarse aggregate.

(iv) Property of coarse aggregate

Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite.

(iv) E-waste

The E-waste materials are shown in Figure 4. E-waste comprises of wastes generated from used electronic devices and house hold appliances which are not fit for their original intended use and are destined for recovery, recycling or disposal. The properties of E-waste particle are given in Table 4.

Table 4. The properties of E-waste particle.

Properties	E-waste particle
Specific gravity	1.01
Absorption	<0.2
Color	White and dark
Shape	Angular
Crushing value	<2%
Impact value	<2%

Figure 4. E-waste materials.

3. Physical characterization of materials

3.1. Compressive strength test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. In the study of strength of materials, the compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. The compressive strength test of cube is depicted in Figure 6. The compressive strength of materials can be measured by using following relation.

Compressive Strength = Load / Area
Size of the test specimen=150mm x 150mm x 150mm

3.2. Split tensile test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The Split tensile test of cylinder is shown in Figure 7.

As there are many difficulties associated with the direct tension test, a number of indirect methods have been developed to determine the tensile strength.

3.3. Flexural strength test

During the testing, the beam specimens of size 7000 mm x 150 mm x 150 mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. The flexural strength test of beam is given in Figure 8.

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three-point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture.

4. Results and Discussion

4.1 Compression, flexural and Split tensile test results

Compressive strength of cube increases with increase in days for E-waste when compared to CC, which is due to addition of E-waste. Split tensile strength of cylinder increases with increase in days for E-waste when compared to CC, which is due to addition of E-waste.

Flexural strength of beam increases with increase in days for E-waste when compared to CC, which is due to addition of E-waste. The data of Compressive strength of cube, Split tensile strength of cylinder and Flexural strength of beam are given in Table 5. Compressive strength of cube, Split tensile strength of cylinder and Flexural strength of beam increases, which are due to addition of E-waste materials. All the information are confirmed by both data and bar graph.

Table 5. Compression, Flexural and Split tensile test results.

S. NO	NAME OF THE TEST	SPECIMEN	DAYS	LOAD IN (kN)		STRENGTH IN (N/mm^2)	
				CC	50% E-Waste	CC	50% E-Waste
1	Compression	Cube	7	416.2	441.0	18.5	19.6
			14	634.5	663.7	28.2	29.5
2	Split Tensile	Cylinder	7	134.3	148.4	1.9	2.1
			14	197.9	212.0	2.8	3.0
3	flexural	Beam	7	14.94	16.8	3.1	3.5
			14	24.1	25.5	5.0	5.3

5. Conclusion

The compressive strength, flexural strength test and split tensile strength of concrete containing e plastic aggregate is retained more or less in comparison with controlled concrete specimens. The maximum compressive strength was achieved at 50% E-waste. Optimum level of compressive strength is 29.5 n/mm^2. The flexural strength achieved for all the mix is more than the control mix and all these values are more than specified values. The maximum flexural strength was achieved 14 days of result at 10 % e-waste. The workability of the M30 concrete increases as the percentage of replacement of coarse aggregates with E-waste increases.

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