International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 9 (2015) pp. 22835-22842

http://www.ripublication.com

An Experimental Study on Partial Replacement of Fine Aggregate With E-Waste Material (Fr-4) In M_{30} Grade of Concrete

[1]A. A. Dhanraj and [2]Dr. C. Selvamony

[1-]Research scholar, Sathyabama University, Tamilnadu, India.
[2-]Professor, Department of Civil Engineering, PSN College of Engineering , Tirunelveli, Tamilnadu, India

Abstract

Electronic waste or waste electronic and electrical equipment is an emerging issue posing serious pollution problems to the human and the environment. New effective waste management options need to be considered especially on recycling concepts. This research presents the results of an investigation to study the performance of M_{30} concrete prepared with E-plastic waste (PCB cutting waste) as part of fine aggregate. A detailed experimental study has been done to analyze the durability characteristics of conventional concrete by casting the specimen such as Cubes, Cylinder and Beams. Also the tested were conducted such as Compressive strength test, Split tensile test and Flexural test. From the results we had found that the E-waste aggregate up to 5% weight of the fine aggregate and replacement of cement with fly ash (10% by weight) can be used effectively in concrete and thus results in waste reduction and resources conservation.
Keywords: Waste management; E-waste; compressive strength; PCB Cutting waste; Compressive strength, Split tensile, Flexural strength.

Introduction

Electronic and Electrical waste, popularly known as e-waste products, do not decompose or rot away. The information and communication technology (ICT) sector in the last twenty years or so in India has revolutionized life of one and all, ratcheting a viral effect on electronic manufacturing industries leading to phenomenal growth in terms of both, volume and applications. Digital development has become the new mantra having its all engulfing footprints everywhere. The booming usage of electronic and electrical equipment has created a new but very dangerous stream of waste, called “electronic-waste”, or simply known as e-waste. With the presence of deadly chemicals and toxic substances in the electronic gadgets, disposal of e-waste is becoming an environmental and health nightmare. E-waste is now one of the fastest growing waste streams. Every year, hundreds of thousands of old computers, mobile phones, television sets and radio equipment are discarded, most of which either end up in landfills or unauthorized recycling yards.

E-Waste An Overall View

According to a report of Confederation of Indian Industries, the total waste generated by obsolete or broken down electronic and electrical equipment in India has been estimated to be 1,46,000 tons per year (CII, 2006). The results of a field survey conducted in the Chennai, a metropolitan city of India to assess the average usage and life of the personal computers (PCs), television (TV) and mobile phone showed that the average household usage of the PC ranges from 0.39 to 1.70 depending on the income class (Shobbana Ramesh and Kurian Joseph, 2006). In the case of TV it varied from 1.07 to 1.78 and for mobile phones it varied from 0.88 to 1.70. The low-income households use the PC for 5.94 years, TV for 8.16 years and the mobile phones for 2.34 years while, the

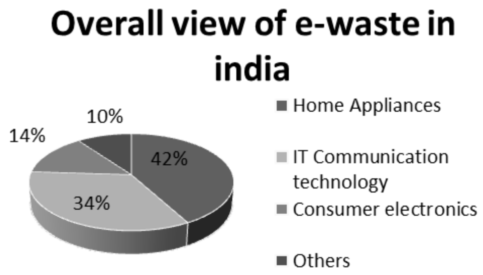

Figure 1: Overall View of E-Waste In India

Upper income class uses the PC for 3.21 years, TV for 5.13 years and mobile phones for 1.63 years. Although the per-capita waste production in India is still relatively small, the total absolute Volume of wastes generated will be huge. Further, it is growing at a faster rate. The growth rate of the mobile phones (80%) is very high compared to that of PC (20%) and TV (18%).

Impacts of E-Wastes

Although it is hardly known, e-waste contains toxic substances such as Lead and Cadmium in circuit boards; lead oxide and Cadmium in monitor Cathode Ray Tubes (CRTs); Mercury in switches and flat screen monitors; Cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and polyvinyl chloride (PVC) cable insulation that releases highly toxic dioxins and furans when burned to retrieve Copper from the wires. All electronic equipment contain printed circuit boards which are hazardous because of their content of lead (in solder), brominated flame retardants (typically 5-10 % by weight) and antimony oxide, which is also present as a flame retardant (typically 1-2% by weight) (Devi et al, 2004). Invisible to state scrutiny because they border on the informal economy and are therefore not included in official statistics.

Experimental Details

Materials

➢ **Cement:**

43 grade of Ordinary Portland cement was used. The property of the Cement is as show in table 1..

Table 1: Properties of 43 grade Cement

Physical Properties	**Obtained values**
Compressive strength	43 Mpa
Fineness	5%
Initial setting time	30 minutes
Final setting time	600 minutes
Standard consistency	29 %

➢ **Fine aggregate:**

- **River sand:**

River sand was used as fine aggregate. The size of the aggregate is 4.75 mm and lower. The property of the river sand is as show in table 2.

Figure 2: Fine Aggregate

Table 2: Properties of Fine aggregate

Physical Properties	**Obtained values**
Size	Passing through 4.75mm
Bulk density	1721 kg/ m^3
Fineness modulus	2.9
Specific gravity	2.65

- **E-waste:**

In our experimental study we have decided to use PCB cutting waste (FR-4) as a fine aggregate (partial replacement). FR4 is a grade designation assigned to glass-reinforced epoxy laminate sheets, tubes, rods and printed circuit boards (PCB). FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant (self-extinguishing). "FR" stands for flame retardant, and denotes that safety of flammability of FR-4 is in compliance with the standard UL94V-0. FR-4 is created from the constituent materials (epoxy resin, woven glass fabric reinforcement, brominated flame retardant, etc.) by NEMA in 1968. FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios.

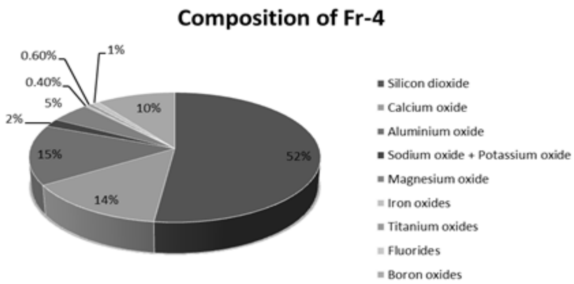

Figure 3: Composition of Fr-4

Figure 4: FR-4

Table 3: Properties of e-waste (FR-4)

Parameter	**Value**
Specific gravity/density	1,850 kg/m^3 (3,120 lb/cu yd)
Water absorption	−0.125 in < 0.10%
Temperature index	140 °C (284 °F)
Rockwell hardness	110 M scale
Compressive strength – flatwise	> 415 MPa (60,200 psi)

➢ **Coarse aggregate:**

Crushed Blue metals obtained from a local quarry were used as Coarse aggregate. The properties of the coarse aggregate are shown in table 4.

Table 4: Properties of Coarse aggregate

Physical Properties	Obtained values
Size	Passing through
Water absorption	0.45
Fineness modulus	7.6
Specific gravity	2.68
Impact value	14.5
Crushing value	19

Control Mix and Mix Proportion

Mix design for M_{30} grade concrete according to BIS method (IS 10262:2009). The mix proportion for concrete is shown in the table 5.

Table 5: Control mix

Cement kg	Fine Aggregate kg	Coarse Aggregate kg	Water
413	706	1117	186
1	1.71	2.70	0.45

Mix Specification

The control mix were prepared for the M_{30} grade of concrete and E- waste is added in various percentage of combination along with the fine aggregate and it is tabulated in table 6.

Table 6: Mix Specification

Mix proportion	Control mix					
	A	B	C	D	E	F
Proportion of E-waste + 10% of fly ash	0%	5%	10%	15%	20%	25%

Mix proportion	Control mix				
	G	H	I	J	K
Proportion of E-waste + 10% of fly ash	30%	35%	40%	45%	50%

Tests on Concrete

From the above observation and results of materials such as cement, Fine aggregate, e-waste, coarse aggregate and water the required design mix was prepared and the final ratio was 1:1.71:2.70 with the water cement ratio of 0.44. Then the specimens such as Cubes (150mm x 150mm x150mm), Cylinder (150mm diameter & 300mm length) and Beam (100mm x 100mm x 500mm) was casted to evaluate the Compressive strength , Split tensile strength and Flexural strength of the concrete.

Figure 5: Casted Specimen

Compressive Strength
To evaluate the Compressive strength of the concrete we have casted 9 cubes for each percentage of e-waste with aggregate. Therefore totally 66 cubes was caste and allowed for curing process.. Then the cubes are tested for the compressive strength using CTM machines. The average values of samples from 7 days, 14 days and 28 day are tabulated in table

Split Tensile Test
To determine the Split tensile of the concrete we have casted 33 numbers of cylinders of 300mm length and 150mm diameter

Flexural Strength Test
To evaluate the flexural strength we have casted 33 numbers of beams of size 100mm x 100mm x 500mm and allowed for curing of 7 days, 14 days and 28 days.

Results and Conclusion
Table7 and Figure 6 represent the compressive strength of the respective specimens. The maximum strength of the specimen was identified and it was 10% of E-waste in Fine aggregate when compared to the 0% E-waste. And also we have observed that when increasing the FR-4 in fine aggregate upto 25% the overall concrete mixture absorbs excess than the calculated value. An important thing is the gradual increase of FR-4 in fine aggregate decrease weight of the Concrete i.e. Light weight concrete.

Table 7: Compressive Strength of The Control Mix M30 Grade Concrete Specimen

MIX PROPORTION	**CONTROL MIX**					
	A	**B**	**C**	**D**	**E**	**F**
Proportion of E-waste + 10% Fly ash	0%	5%	10%	15%	20%	25%
7 DAYS	21.11	14.44	13.33	14.44	12.22	14.44
14 DAYS	25.56	26.67	18.89	25.56	17.56	25.56
28 DAYS	36.67	38.87	25.56	24.44	21.11	23.33

MIX PROPORTION	**CONTROL MIX**				
	G	H	I	J	K
Proportion of E-waste + 10% Fly ash	30%	35%	40%	45%	50%
7 DAYS	5.56	10	7.78	6.67	5.56
14 DAYS	10	15.78	12.22	10	13.11
28 DAYS	14.44	16.67	13.33	12.22	14.44

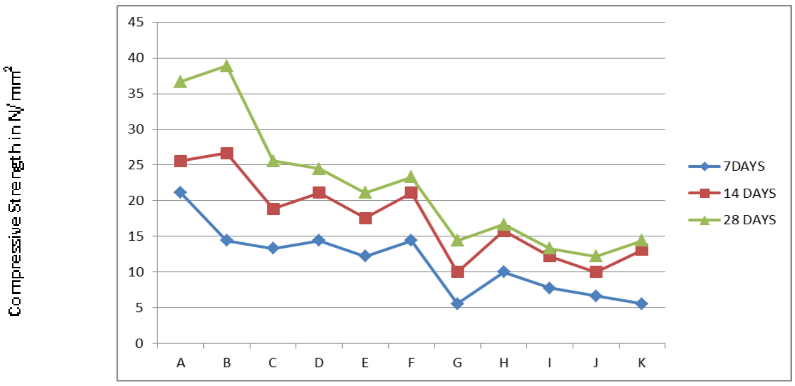

Fig.6. compressive strength chart.

Reference

[1] R. Lakshmia and S. Naganb, INVESTIGATIONS ON DURABILITY CHARACTERISTICS OF E-PLASTIC WASTE INCORPORATED CONCRETE, Asian journal of civil engineering (building and housing) vol. 12, no. 6 (2011) PAGES 773-787.

[2] Lakshmi.R and Nagan.S, STUDIES ON CONCRETE CONTAINING E PLASTIC WASTE, INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES Volume 1, No 3, 2010, PAGES 270-280.

[3] Kurian Joseph, ELECTRONIC WASTE MANAGEMENT IN INDIA– ISSUES AND STRATEGIES KURIAN JOSEPH, Centre for

Environmental Studies, Anna University, Chennai, India, Sardinia 2007, Eleventh International Waste Management and Landfill Symposium.

[4] Ajeet Saoji, E-WASTE MANAGEMENT: AN EMERGING ENVIRONMENTAL AND HEALTH ISSUE IN INDIA, National Journal of Medical Research, Volume 2 Issue 1 Jan – March 2012 ISSN 2249 4995. PAGES 107-110.