

Recycle of E-Waste in Concrete

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Abstract: Disposal of E-waste is a typical task faced in many regions across the globe. Computer wastes that are land filled produces contaminated leachates, which eventually pollute the groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil. Utilization of E- waste is a partial solution to environmental and ecological problems. In this work printed circuit board is used as E-waste material. This paper aims to minimize the dangers to human health and the environment that disposed and dismantled electronics can create. Benefits of recycling are extended when responsible recycling methods are used. Concrete mixes with different percentages of E-waste were casted. It has been decided to make three different types of conventional specimens with partial replacement of E-waste on a percentage of 10%, 20%, and 30% to coarse aggregate with water cement ratio of 0.45. For conventional specimens are also prepared for M20 Concrete without using E- waste aggregates. The effect of physical, and mechanical properties of the concrete were studied.

Keywords: E-waste; hazardous waste; concrete; Coarse aggregate; Printed circuit board

1. Introduction

Research concerning the use of Electronic waste to augment the properties of concrete has been going on for recent years. Waste Electronic and Electrical Equipment (WEEE) is diverse and complex in terms of materials and components as well as the manufacturing process. Non recycling Waste materials are posing serious pollution problems to the human and the environment. So, new effective waste management options need to be considered. Efforts have been made in the concrete industry to use non-biodegradable components of E-waste as a partial replacement of the coarse or fine aggregates. In the recent decades, the efforts have been made to use electronic waste from various sources in concrete for the replacement of cement, fine and coarse aggregate. The use of these materials in concrete come from the environmental constraints in the safe disposal of these products. Use of E-waste materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects.

Recently researchers have started to consider an alternative source for aggregate in concrete by using the waste material as building material, printed circuit board increases air content, improves the water retention property of fresh mortar and decrease the bulk density of hardened mortar.

2. E-waste an Overview

Millions of tons of electronic waste from obsolete computers and other electronic articles are being generated every year. E-waste contains numerous types (more than 1000 different) of substances and chemicals creating serious human health and environment problems if not handled properly. E-waste also includes many toxic substances viz heavy Metals like lead, cadmium, mercury, arsenic, selenium, hexavalent chromium etc. About 70% of the heavy metals (mercury &

cadmium) in landfills come from electronic waste. Consumer electronic is the root cause for the presence of about 40% of the lead in landfills. These toxins can cause brain damage, allergic reactions and cancer. E-waste also contains considerable quantities of valuable materials like gold, copper and other ordinary metals.



Figure 1: Printed circuit board

3. Recycling of E-Waste

E-waste is a popular, informal name for electronic products coming to the end of their “useful life”. As per the Hazardous Wastes Management and Handling Rules, 2003, e-waste can be defined as “Waste Electrical and Electronic Equipment including all components, sub-assemblies. Electronic waste, abbreviated as E-waste, consists of discarded old computers, TVs, refrigerators, radios –basically any electrical or electronic appliance that has reached its end of life. An estimated 50 million tons of E-waste are produced each year worldwide. The total E-waste generated in India is about 1, 46,180 tons per year. The environmental protection agency estimates that only 15-20% of E-waste is recycled, the rest of these electronics go directly into landfills and incinerators. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains serious contaminants such as lead, cadmium, Beryllium etc.

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Figure 2: Crushed E-waste

4. Experimental Details

4.1. Materials

The potential applications of industry products in concrete are to be partial aggregate replacement or partial cementitious materials depending on their chemical composition and grain size. Recent studies have shown that reuse of very finely grounded e-waste in concrete has economical and technical advantages for solving the disposal of large amount of e-waste, reuse in complete industry may be the most feasible application. E-waste particles can be used as coarse aggregate, fine aggregate, fine filler in concrete depending on its chemical composition and particle size. E-Waste in the form of loosely discarded, surplus, obsolete, broken, electrical or electronic devices from commercial informal recyclers have been collected which were crushed and ground to the particle size.

Table 1: Physical and mechanical properties of aggregates

Aggregate Property	Aggregate type		
	Coarse aggregate	Fine aggregate	E-waste
Specific gravity	2.67	2.64	1.44
Bulk density (kg/m ³)	1624	1656	650
Fineness modulus	5.6	3.37	3.08
Water absorption (%)	0.64	1.0	Nil

5. Concrete Mixes

Control mix concrete and concrete modified with various E-plastic waste contents listed in Table 2 were prepared. By considering the use of E-waste in the mixes as much as possible was attempted and strength criteria of Grade M20 concrete mix was analyzed.

Table 2: Mix specifications

Mix specifications	Conventional mix	X1	X2	X3
Proportion of E-waste	0%	10%	20%	30%

6. Tests

6.1 Compressive strength test

Out of various test carried out on concrete, this is the utmost important which gives an idea about various characteristic of concrete. Based on this test one judge that whether concreting has done properly or not. It was conducted to evaluate the strength development of concrete containing various E-waste contents at the age of 7, 14, 28 days respectively.

Table 3: Compressive strength test results in N/mm²

Mix Specification	Conventional mix	X1	X2	X3
Proportion of E-waste	0%	10%	20%	30%
7 Days	20.85	23.35	13.3	12.5
14 Days	34.2	26.7	15.4	13.2
28 Days	42.52	29.4	20.8	14.5

Table 4: Specimen details

Specimen	Specimen age (days)	Number of specimens				cast for W/C ratio	total
		0%	10%	20%	30%		
Cube (150 x 150 mm)	7	3	3	3	3	12	36
	14	3	3	3	3	12	
	28	3	3	3	3	12	
Cylinder (150 x 300 mm)	7	3	3	3	3	12	36
	14	3	3	3	3	12	
	28	3	3	3	3	12	

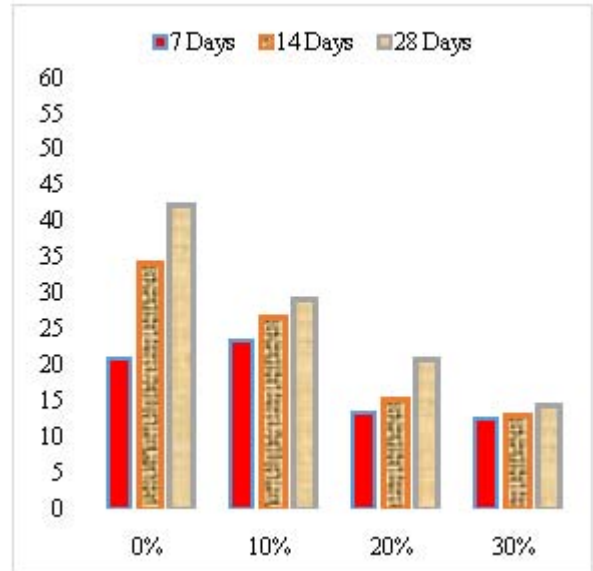


Figure 4: Split tensile Strength Results

6.2 Split Tensile Strength

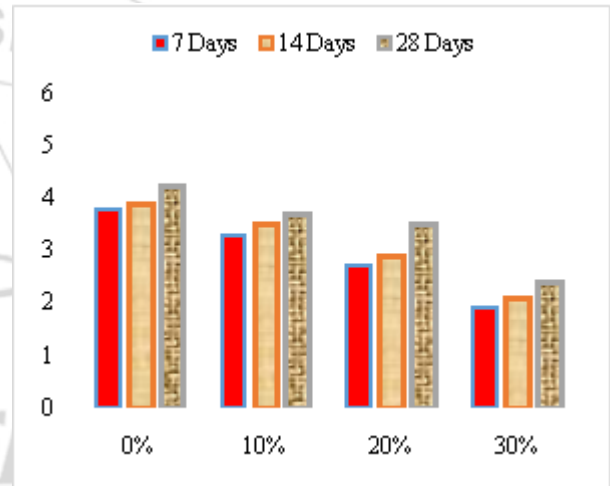
The split tensile strength of concrete is one of the basic and important properties. This test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle in nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Table 5: Tensile strength test results in N/mm^2

Mix specification	Conventional Mix	X1	X2	X3
Proportion of E-waste	0%	10%	20%	30%
7 Days	3.77	3.3	2.7	1.91
14 Days	3.9	3.5	2.9	2.25
28 Days	4.25	3.7	3.5	2.37



Figure 3: Compressive strength results



7. Results and Discussions

An analysis was made on the strength characteristics by conducting the tests on e-waste Concrete with E-waste and the results revealed that upto 20% replacement e-waste for coarse aggregate in concrete shows improvement in compressive & Tensile strength. By comparing the results with conventional concrete at 28 days strength it is observed that the strength of concrete is reduced by 30.7% when coarse aggregate is replaced beyond 20 % of E- waste.

8. Conclusion

This study intended to find the effective ways to reutilize the hard plastic waste particles as coarse aggregate. It is also observed that the compressive strength of concrete is found to be optimum when coarse aggregate is replaced by 20% with E-Waste. Beyond it the compressive strength is decreasing. The following results are

- 1) It is identified that e-waste can be disposed by using them as construction materials.
- 2) Since the e-waste is not suitable to replace fine aggregate it is used to replace the coarse aggregate.
- 3) The compressive strength and split tensile strength of concrete containing e plastic aggregate is retained more

or less in comparison with controlled concrete specimens. However strength noticeably decreased when the e plastic content was more than 20%.

- 4) It can be concluded, 20% of E-waste aggregate can be replaced as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

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