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A Review on E-waste as construction material

KEYWORDS: E-waste, Compressive strength, Durability.

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ABSTRACT A substantial growth in the consumption of electronic equipments is observed all over the world in twenty-first century, which has led to huge quantities of e-waste. This review paper seeks to study the use of plastic components of E-waste in construction applications. This is an alternative solution to administer the growing quantity of the E-waste, due to its economic and ecological advantages. The replacement of coarse aggregate by some percent E-plastic waste can be possible to produce green concrete. The physical properties, strength properties and durability properties of E-waste containing concrete studied. The data presented in past research papers showed that there is great potential for the utilization of waste e-plastic in concrete

I.INTRODUCTION

Conservation of waste materials and by products is a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in concrete and other construction materials, it helps in reducing the cost of concrete manufacturing, but also has several indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Electronic waste consists of discarded old computers, TVs, mobile phones and washing machine, refrigerators, radios – basically any electrical or electronic appliance that has reached its end of life. Several tonnes of E-waste need to be disposed per year. Waste generated from the waste electronic equipments is a major problem for disposal. 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.

India, with a population of over 1 billion, is a rapidly growing economy and showing increased rate in electronic appliances consumption. A joint study on electronic waste generation was carried out in India under an EU Asia Pro Eco Project in 2007, by the Manufacturers Association of Information Technology (MAIT) and Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ). The estimated generation of electronic waste was approximately 400,000 tonnes of waste annually (from computers, mobile phones and television sets only), which is expected to grow at a rate of 10–15 % per year [3]. According to StEP(Solving the E-Waste Problem Initiative) report, E waste generation in India for the year 2012 is 2751.84 metric-kilotonnes.[1]. Based on report of StEP, experts predict that by 2017, the total annual volume of e-waste will rise by 33 percent to 65.4 million tons, the weight equivalent to almost 200 Empire State Buildings or 11 Great Pyramids of Giza. [2] In India, sixty five cities in India generate more than 60% of the total e waste generated in India. Ten states generate 70% of the total e-waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of e-waste generating states in India. Among top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur.[4]

II. E-WASTE AN OVERVIEW

Electronic waste comprises of different materials and chemicals such as lead, cadmium, mercury, beryllium, brominated flame-retardants and plastics including polychlorinated biphenyls, poly vinyl chloride, and polystyrene, many of which are toxic and are likely to create serious problems for the environment and human health if not handled properly. These electronic wastes require intense care in its disposal; otherwise, it can cause serious health problems to human beings. These necessitate a large collection network, recycling infrastructure, sound technology for handling and disposal of electronic waste. The globalized trade of this complex and toxic electronic waste poses a challenging task for its management and causes hazardous environmental concerns in both developed and developing nations [3].



Fig 1: Components of E-waste (source:[10])

According to the definitions in the directive of the Parliament and European Union council on waste electronic and electrical equipment(WEEE), E-waste can be subdivided into ten different categories as large household appliances, small household appliances, IT and telecommunication equipment, consumer equipment, lighting equipment, electrical and electronic tools, toys, leisure and sports equipment, medical devices (with the exception of the infected devices), monitoring and control instruments, automatic dispensers. Iron and steel are the most common materials found in electrical and electronic equipment and amounts to nearly half of the total weight of WEEE. Plastic are the second largest component by weight representing approximately 21% of WEEE. Non ferrous metals represent approximately 13% of WEEE (With copper accounting for 7%). The constituents and their components of WEEE are given in Table 1.[4]

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Table 1: WEEE material composition

Constituents	Components in %
Iron and Steel	47.9
Non flame retarded plastic	15.3
Copper	7.0
Glass	5.4
Flame retarded plastic	5.3
Aluminium	4.7
Printed circuit boards	3.1
Wood and plywood	2.6
Concrete & ceramics	2.0
Other metals (non-ferrous)	1.0
Rubber	.9
Others	4.6

Methods of disposal of E-waste

The E-waste that generated is usually disposed of in the following ways.

1) Land Fill

In land filling, trenches are made on the flat surfaces. Soil is excavated from the trenches and waste material is buried in it, which is covered by a thick layer of soil. Over time, the e-waste leads to certain amount of chemical and metal teaching. This can very often lead to ground water contamination.

2)Incineration

It is a controlled and complete combustion process, in which the waste material is burned in specially designed incinerators at a high temperature (900-1000o C). This process release harmful toxic gases, which escape to the atmosphere and contaminate it.

3) Reuse

It constitutes direct second hand use or use after slight modifications to the original functioning equipment like computers, cell phones etc. About 3%-5% of the computers that have been surplus by their users are reused.

4) Recycling

Recycling means that the old raw materials are reclaimed to be made of in making new products. However, the costs of recycling are high. The existing dumping grounds in India are full and overflowing beyond capacity and it is difficult to get new dumping sites due to scarcity of land. Therefore recycling is the best possible option for the management of e-waste.

Environment Impact of E-waste recycling

The most common method of managing e-waste is land filling and the waste includes heavy metals, glass, plastics, ferrous and Non ferrous metals and toxic matters also, which are very dangerous. Hence it is important to adopt reduce, reuse, recover and recycle in minimizing the E-waste hazards. The current practice is still landfill; however landfills do not provide an environment friendly solution. As a result there is a strong need to utilize waste glass and plastic components of e-waste.

II. PHYSICAL PROPERTIES OF E-WASTE PLASTIC

The fineness modulus of coarse aggregate with various E-waste content is between 1.86 and 2.78.

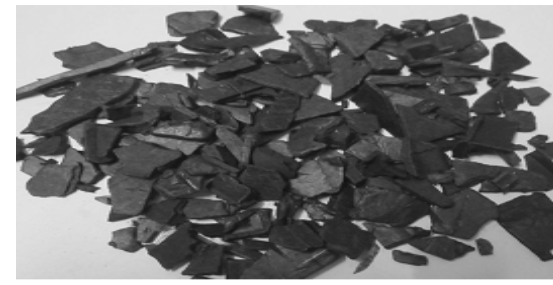


Fig 2: E-plastic aggregates
(K. Senthil et al. 2014 [7])

The E-plastic waste particles can be considered as partial coarse aggregate substitute retaining the mix ratio as the same. The divided particle size is assumed to be between 1.18mm–2.36mm.[5]

Table 2: Physical properties of E-waste particles and coarse aggregate

Properties	E-waste particle	Coarse aggregate
Specific gravity	1.01	2.65
Absorption (%)	<0.2	0.5
Color	White and dark	Dark
Shape	Angular	Angular
Crushing value	<2%	27.2%
Impact value	<2%	24.73%

I. STRENGTH PROPERTIES

The compressive strength of concrete is an elementary property that is thoroughly studied in almost all research works related to e-plastic aggregate. In all of these studies it was found that the incorporation of e-plastic as aggregate decreased the compressive strength. The factors that may be responsible for low compressive strength of concrete containing e-plastic aggregate are: (1) the very low bond strength between the surface of the e-plastic waste and the concrete constitutes; (2) the hydrophobic nature of e-plastic waste, which can inhibit cement hydration reaction by



Fig 3: Compression test on Concrete cube
(Iftekar Gull et al. 2014 [8])

Similarly to the behavior of compressive strength, the incorporation of e-plastic aggregate lowers the splitting tensile strength of concrete. The causes for the reductions observed in splitting tensile strength similar to those used to explain the decrease in compressive strength due to the incorporation of e-plastic aggregate.

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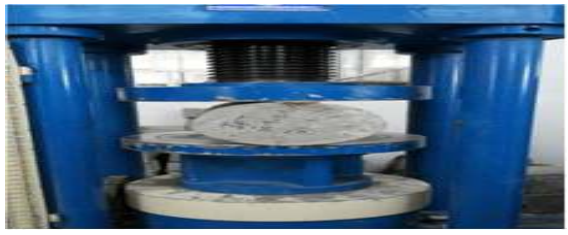


Fig 4: Tensile strength test on Concrete cylinders (Iftekar Gull et al. 2014 [8]

Flexural strength is defined as the material's ability to resist deformation under flexural load and is measured in terms of stress. It represents the highest stress experienced within the material at the collapse load. The transverse bending test is most frequently employed, in which a specimen with either a circular or rectangular cross-section is bent until fracture using a three or four point flexural test technique.

R. Lakshmi et al. [4-6], have carried out an experimental study on utilization of e-waste particles as coarse aggregate in concrete with a percentage replacement ranging from 0% to 30% on strength criteria of M20 concrete. It conclude that E waste can be disposed by using as construction materials. Compressive strength and spilt tensile strength of concrete containing e- waste is retained little less with compared to conventional concrete. In addition of fly ash compressive and spilt strength can be improved. It has been concluded 20% E waste aggregate can be replace as coarse aggregate in concrete without any long term detrimental effects and acceptable strength development properties.

K. Senthil et al. [7], have carried out an experimental study in that coarse aggregate was replaced with different percentages (10,20,30,40,50%) of E-plastic by volume. Compression test, spilt tensile strength, flexural strength test were performed for properties of concrete at different ages such as 7 and 28 days. Compressive, splitting tensile and flexural strength were reduced with increase in E-plastic. The E-plastic aggregates have poor shape and surface texture is smooth which greatly influenced the fresh and hardened properties of concrete. It is recommended that up to 30 % replacement by volume can be done; up to this limit, the characteristic strength of M25 concrete was achieved. It is recommended that 40 and 50 % replacement by volume can be used for non-structural lightweight elements.

Iftekar Gull et al.[8], worked to optimize the benefits of using e-plastic waste in the fiber form in concrete. In this study, e-plastic waste (insulation wires) is shredded into fibers of specific size (3cm, 4cm, 5cm) and shape. Several design concrete mixes with different percentages of waste plastic fibers for three aspect ratios, are casted into desire shape and size as per requirement of tests and cured for 7,14,28 days. Workability, compression and spilt tensile test were carried out. It concludes that, it has been confirmed that no major changes are found in compressive strength of concrete with the presence of E plastic. When 1% of e-plastic for 5 cm is added, compressive strength gets reduced by 2.59% compared to conventional concrete. With addition of e-plastic – 4cm and 3cm the comp. strength gets increased up to maximum of 5.9% and 10.6% respectively compared to conventional concrete. It has been confirmed that increase in tensile strength is found with presence of E plastic. When 1% of e-plastic for 5cm and 4cm are added, tensile strength gets increased by 2.3% and 4.6% compared to conventional concrete. When e-plastic for 3cm is added, tensile strength initially gets increased by 4.6% and then gets decrease with increase in percentage.

I. DURABILITY PROPERTIES

Several durability factors are evaluated for concrete containing e-plastic as aggregate. These include water absorption and sorptivity, shrinkage, carbonation resistance, chloride ion permeation and resistance against freezing and thawing. However, compared to the available information on mechanical performance of concrete containing e-plastic aggregate, there is less information on the durability behavior of concrete of this type of concrete.

The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality, and serviceability when exposed to its environment. R. Lakshmi et al.[5], carried out an experimental investigation of E-plastic waste replace coarse aggregate with 0% to 30% in concrete and compressive strength and durability test like chloride attack test, sulphate attack test, permeability test etc. From this research, following conclusions were drawn. In general strength gain of e-plastic concrete is satisfactory and 12% e-plastic particles can be incorporated without any long term detrimental effect. Observation of Chloride test, Sulphate test show that e-plastic concrete could result in dense matrix. Study of permeability parameters (saturated water absorption, porosity and sorptivity) also confirmed that durability of e-plastic concrete is acceptable, but little lower than conventional concrete.

II. CONCLUSION

A few works has been done on the use of various types of e-plastic waste as aggregate in concrete. The findings from these studies indicated that e-plastic waste can be used as a partial replacement of natural aggregate. From the results obtained from these studies the following conclusions can be drawn.

E-plastic can be use to replace coarse aggregate in concrete by volume up to 50%. The compressive, splitting tensile and flexural strength were reduced with increase in E-plastic. It is recommended that up to 30% replacement by volume can be done; up to this limit, the characteristic strength of concrete was achieved.[7] The reduction in tensile splitting strength and flexural strength were relatively less prominent than the reduction in compressive strength of concrete due to the incorporation of e-plastic aggregate. Durability parameters of concrete also affect while replacement of coarse aggregate by e-waste plastic in concrete. Not much has been reported on the durability performance of concrete containing e-plastic aggregates. However, existing data indicate that permeability parameters also confirmed that durability of E-plastic concrete is acceptable, though slightly lower than that of conventional concrete. Shrinkage is considerably increased due to the incorporation of various types of e-plastic aggregates. Observation of chloride attack test, sulphate attack tests shown that, e-plastic concrete could result in a dense matrix with the incorporation of fly ash in e-plastic concrete. E-waste plastic can be use to replace coarse aggregate in concrete with different admixtures like fly ash, silica fume etc. to develop or gain effective strength as well as durability properties.

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