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E-Waste: Utilization in Civil Engineering

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Abstract-One of the major problems in all the countries across the globe is the e-waste which is also called electronic waste. Rapid growth of technology, upgradation of technical innovations, and a high rate of obsolescence in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life electrical and electronic equipment's. It is estimated that more than 50 MT E-Waste is generated globally every year. E-Waste from discarded mobile phones would be about seven times higher than 2007 levels in China and in India 18 timers higher by 2020. The materials are complex and have been found to be difficult to recycle in an environmentally sustainable manner causing health hazard. The result of the careless dumping of these hazardous materials is very severe, and these materials cause fatal diseases to human beings as well as to environment. In the present scenario, no construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability. One of the new waste materials used in the concrete industry is E-waste. For solving the disposal of large amount of E-waste material, reuse of E-waste in concrete industry is considered as the most feasible application. E-waste is one of the fastest growing waste streams in the world.

Keywords –E-waste, recycled, concrete, electrical waste.

I. INTRODUCTION

The E-Waste is one of the fastest growing environmental problems of the world, as there is a lack of awareness among people about its treatment and serious impacts. E-waste needs to be treated as a hazardous waste. E-waste is any refuse created by discarded electronic devices and components as well as substances involved in their manufacture or use. The disposal of electronics is a growing problem because electronic equipment frequently contains hazardous substances. In a personal computer, for example, there may be lead in the cathode ray tube and soldering compound, mercury in switches and housing, and cobalt in steel components, among other equally toxic substances. E-waste is different from municipal and industrial wastes and requires special handling procedures due to the presence of both valuable and expensive materials. Estimates indicate that about 40 million tons of this waste are generated each year, or approximately 5 % of all solid waste generated in the world. Another study, from Greenpeace, estimated that globally 20–50 million tons of WEEE (waste electrical and electronic equipment) are discarded annually, with Asian countries disposing up to 12 million tones. It is estimated that computers, mobile phones and television sets alone would correspond to 5.5 million tons of electronic waste generated on a H.M. global scale in 2010. India has emerged as fifth largest Electronic waste producer in world. Computer devices account for nearly 70% of e-waste, with the contribution of telecom sector being 12%, medical equipment being 8%, and electric equipment's being 7% of the annual e-waste production. The Government, public sector companies, and private sector companies generate nearly 75% of electronic waste; with the contribution of individual household being only 16%. City-wise, Mumbai tops the list in producing electronic waste, followed by New Delhi, Bangalore and Chennai. Electronic waste account for 40% of lead and 70% of heavy metals found in landfills. State-wise Maharashtra ranks first in generation of electronic waste, followed by Tamil Nadu and Uttar Pradesh

II. DISCUSSION

2.1. Sources of e-waste

Sources of e-waste includes IT equipment such as computers, laptops, networking devices, cables, power adapters; household appliances like televisions, telephones, mobile phones, calculators, fridge, air conditioners, washing machines, microwaves, gaming consoles; electrical and electronic devices such as tube lights, bulbs, LED lights, remote controls, electronic toys, treadmill; medical devices such as monitoring and control equipment, ultrasound testing machines, x-ray, stabilizers etc. Composition of various electronic equipment-0-10% monitors and televisions are generated.10-15%-Computers, telephones, Radio, etc. 20-30% Washing machines. Dryers, Coffee Machines, irons etc.

Fig.2.1 Growth of E-waste in India

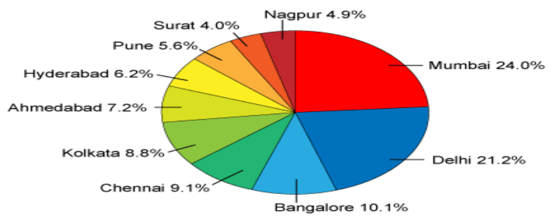

Fig.2.2 City-wise E-waste generation in India (Tones/year)

2.2. Hazardous elements of E-Waste & their impact on Human Being: -

landfills, it ultimately causes negative effects to nearlyevery system in the human body. Mobile phones contain harmful toxins including lead, mercury,arsenic, cadmium, chlorine and bromine, which can leak into groundwater and bio accumulate inthe food chain causing detrimental damage to the soil,water supply, vegetation, animals and humans.

Cadmium sulfide are used in interior surface of the CRT screens to produce illumination. Antimony is used in semiconductors, flame retardant formulations in plastics, also used in lead acid starter batteries and electrical solders. Air of the e-waste combusting region may have oxides of these heavy metals. Mercury is found in printed circuit boards, relays and switches, chromium is used as corrosion protectant in galvanized steel parts, Barium is found in CRT monitors, Beryllium is commonly found in circuit mother boards. Free Carbon radicles from toners of printers also another form of e-waste. These pollutants are responsible for groundwater contamination, air pollution and soil acidification. The Ministry of Environment, Forest and Climate Change has notified E-Waste (Management) Rules, 2016. The rules - for the first time in India - introduced Extended Producer Responsibility (EPR). EPR stipulates for collection 30% waste in first two years and up to 70% in seven years. According to ASSOCHAM, an industrial body in India the, Compound Annual Growth Rate (CAGR) of electronic waste is 30%. Nearly 95% of processing of electronic waste is carried out by the unskilled informal sector.

2.3. E-Waste impact on Human Being: -

When cell phones are improperly recycled or end up in landfills, it ultimately causes negative effects to nearly every system in the human body. Mobile phones contain harmful toxins including lead, mercury, arsenic, cadmium, chlorine and bromine, which can leak into the groundwater and bio accumulate in the food chain causing detrimental damage to the soil, water supply, vegetation, animals and humans: -

1. Electronic waste account for 40% of lead and 60% of heavy metals found in landfills. These pollutants are responsible for groundwater contamination, air pollution and soil acidification

2. The processes of dismantling and disposing of electronic waste in developing countries led to a number of environmental impacts as illustrated in the graphic.

3. Cathode ray tubes (used in TVs, computer monitors, ATM, video cameras, and more) through the process of breaking and removal of yoke, then dumping due to the presence of heavy metal it causes the toxicity of ground water.

4. Liquid and atmospheric releases end up in bodies of water, groundwater, soil, and air and therefore in land and sea animals – both domesticated and wild, in crops eaten by both animals and human, and in drinking water.

Table-1: E-waste generation in top ten cities in India

City	WEEE tones per year
Mumbai	11017.1
Delhi	9790.3
Bangalore	4648.4
Chennai	4132.2
Kolkata	4025.3
Ahmedabad	3287.5
Hyderabad	2833.5
Pune	2584.2
Surat	1836.5
Nagpur	3000

III. MANAGEMENT OF E-WASTE REUSING IN CONCRETE

The disposal of which is becoming a challenging problem. For solving the disposal of large amount of E-waste material, reuse of E-waste in concrete industry is considered as the most feasible application. Due to increase in cost of normal coarse aggregate it has forced the civil engineers to find out suitable alternatives to it. E-waste is used as one such alternative for coarse aggregate. Owing to scarcity of coarse aggregate for the preparation of concrete, partial addition of E-waste with coarse aggregate was attempted.

3.1. Preparation of Concrete cubes

• Crushing of E-Waste

• Sieving of coarse Aggregate

• Dry mixing

• Wet mixing

• Moulding

• Compaction

• Curing

• Compressive strength testing

3.2. Crushing of E-Waste

As e-waste is in different form the pure electronic waste is circuit board, IC’S, Condensers etc. so the e-waste is crushed in to desired shape it pass over 20mm and retained on 4.75mm. The board have to be completely crushed and make it in to desired shape and size. As it suitable for the replacement of coarse aggregate.

Fig. 3.1. Before Crushing

Fig.3.2. after Crushing

3.3. Sieving of Coarse Aggregate

Sieving was done manually for by using the sieve size 20mm, 12.5mm, 10mm, and 4.75mm size. Maximum 20mm size of coarse aggregate is taken and minimum size of aggregates are used other fillers are used to fill the voids of the pores generated. The sizes of the coarse aggregate is taken as such a way that it will be a well graded.

3.4. Dry mixing

a) Dry mixing of cement and sand

b) Dry mixing coarse aggregate with cement sand mixture.

c) Mixing of E-Waste with cement sand C.A. mixture.

a) Dry mixing of cement and sand: - Spread out the measured quantity of sand uniformly on the mixing platform. Dump the cement on the sand and distribute it uniformly. Mix the sand and cement with the shovels, turning the mixture over and over again until it is uniform in color.

b) Dry mixing coarse aggregate with cement sand mixture: -Spread out the sand-cement mixture once again uniformly on the mixing platform. On top of this, spread the measured quantity of C.A (coarse aggregate). Don't dump at one place; otherwise the bigger particles will tend to roll out. Mix again at least three times by shoveling from the center to side, and then back to the center and again to the side.

c) Mixing of E-Waste with cement sand C.A. mixture

After that we mix the E-Waste material with the with the cement sand coarse aggregate mixture gradually with the help of travel and other equipment's.

Fig. 3.4. Dry Mixed Mixture

3.5. Wet Mixing

Wet mixing is nothing but the adding water with the dry mixture Make the mixture of dry mixing. Quarters of the total quantity of water required. While the material is turned in towards the center with shovels, add the remainder of the water slowly, turning the mixture over and again until the color and consistency are uniform throughout the pile. This will indicate that all ingredients are thoroughly combined. The water should be poured slowly into the mix. This is best done by means of a gardener's water can fitted with a rose-head. Throwing from a bucket all at a time will result in its running away and taking cement with it.

3.6. Moulding of Cubes

For compressive strength test, cubes of size 150mmx150mmx150mm were cast. The cube mould should be clean and lightly oiled. It should be filled in 50 mm layers and compacted, with a steel tamping bar, with a minimum of 25 or 35 tamps per layer for a 100 or 150 mm mould respectively. After tamping each layer, the mould should be lifted slightly and dropped or the sides tapped, to close the top surface of each layer. The final layer should slightly overfill the mould. Finally, the top layer should be trowelled off, level with the top of the mould. All sampling and test equipment should be cleaned immediately after use.

The fresh cube should be kept away from extremes of heat and cold. Ideally they should be covered to prevent surface evaporation and stored as close to 20C as possible until the moulds are stripped.

Fig.3.5. Moulding Preparation

3.7. Compaction with Tamping Rod

150 mm moulds should be filled in three approximately equal layers (50 mm deep). A taming rod is provided for

compacting the concrete. It is a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for ramming. During thecompaction of each layer with the compacting bar, thestrokes should be distributed in a uniform manner over the surface of the concrete and each layer should be compacted to its full depth. During the compaction of the first layer, the compacting bar should not forcibly strike the bottom of the mould. For subsequent layers, the compacting bar should pass into the layer immediately below. The minimum number of strokes per layer required to produce full compaction will depend upon the workability of the concrete, but at least 35 strokes will be necessary except in the case of very high workability concrete. After the top layer has been compacted, a trowel should be used to finish off the surface level with the top of the mould, and the outside of the mould should be wiped clean.

3.8. Identification of Cubes

Immediately after making the cubes they should be marked clearly. This can be done by writing the details of the cube in ink on a small piece of paper and placing on top of the concrete until it is demoulded

3.9. Demoulding of Cubes

Test cubes should be demoulded between 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable demoulding without damaging the cube, then the demoulding should be delayed for a further 24 hours. When removing the concrete cube from the mould, take the mould apart completely. Take care not to damage the cube because, if any cracking is caused, the compressive strength may be reduced.

3.10. Curing of Casted Cubes

Cubes must be cured before they are tested. Unless required for test at 24 hours, the cube should be placed immediately after demoulding in the curing tank or moist room. The curing temperature of the water in the curing tank should be maintained at 27-30°C. If curing is in a moist room, the relative humidity should be maintained at no less than 95%. Curing should be continued as long as possible up to the time of testing.

3.11. Compressive Strength Testing

The compressive strength of any material is defined as the resistance to failure under the action of compressive forces. Especiallyfor concrete, compressive strength is an important parameter to determine the performance of the material during service conditions. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete Minimum or specified Compressive Strength of concrete cubes of various grade of concrete at 28 days of curing are as follows.

Fig.3.11.Compressive Strength Testing Machine

3.11.1. Compressive Strength of Concrete at Various Ages:

The strength of concrete increases with age. Table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

Table 3.11.1. Minimum Compressive Strength of Concrete cubes of various grade of concrete after 28 days of Curing

Grade of Concrete	Specified Min. Compressive Strength of Concrete cubes of various grade of concrete after 28days of Curing.
M10	10N/mm^2
M15	15N/mm^2
M20	20N/mm^2
M25	25N/mm^2
M30	30N/mm^2
M35	35N/mm^2
M40	40N/mm^2
M45	45N/mm^2
M50	50N/mm^2
M55	55N/mm^2
M60	60N/mm^2
M65	65N/mm^2
M70	70N/mm^2
M75	75N/mm^2
M80	80 N/mm^2

Table.3.11.2.Percentage of compressive strength according to days.

Age	1 day	3 days	7 days	14 days	28 days
Strength%	16%	40%	65%	90%	99%

Table.3.11.3. Compressive Strength of Different Grades of Concrete at 7 and 28 days.

Grade of Concrete	M15	M20	M25	M30	M35	M40	M45
Minimum compressive strength N/mm^2 at 7 days	10	13.5	17	20	23.5	27	30
Specified characteristic compressive strength (N/mm^2) at 28 days	15	20	25	30	35	40	45

The work was conducted on M20 grade mix. The addition of coarse aggregate with E-waste in the range of 5%, 10%, 15%, 20%, and 25%. Finally, the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials is compared with control concrete mix.

The test results showed that a significant improvement in compressive strength was achieved in the E-waste concrete compared to conventional concrete and can be used effectively in concrete. The reuse of E-waste results in waste reduction and resources conservation.

The results of compressive strength are presented in Table 3.11.4. the test was carried out to obtain compressive strength of concrete at the age of 7, 14 and 28 days. The cubes are tested using compression testing machine of capacity 2000KN. From the table 4.4 the compressive strength is maximum when replacing 10% of coarse aggregate by E- waste in concrete.

Table.3.11.4. Compressive strength of cubes

S.N.	Amount of E-waste Replaced	7 days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
1.	Nominal Concrete	13.21	18.60	19.46
2.	5%	13.95	18.88	20.53
3.	10%	15.43	23.65	25.34
4.	15%	14.51	21.03	23.12
5.	20%	13.72	18.95	19.88
6.	25%	13.03	18.24	19.16

Although it yet it is not implemented but further we can use it in various construction purposes which will be prove very effective to the management of E-Waste.

Benefits of E-waste management- Due to E-waste Management method (recycling of e-waste) recovers valuable materials, from discarded electrical and electronics waste.

1. It reduces soil and water pollution as well as reduces greenhouse gas emission.

2. Recycling of e- waste conserves natural resources and save energy.

3. Reusing of E-waste reduces waste materials.

4. It disposes hazardous elements e.g. cadmium, mercury etc.

IV. RESULT AND CONCLUSION

4.1. Experimental Result: -

This study shows an alternative approach of application of the E-waste used in concrete. The modern world shows the great development in technologies and designs which leads to huge outcome of waste. The growing concern of resource depletion and global pollution has challenged engineers to seek and develop new material by recycling of wastes. One of the challenging hazardous waste material is Electronic waste (E-waste) in this report it shows the result of compressive strength. 10% replaced E-Waste concrete has more compressive strength than the ordinary concrete. And compressive strength of E-Waste replaced concrete has more compressive strength than the ordinary concrete up to a certain limit. After that it is decreased.

Table. 4.1. Compressive strength of cubes

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Although it yet it is not implemented but further we can use it in various construction purposes which will be prove very effective to the management of E-Waste.

V. CONCLUSION

E-waste management is a great challenge for governments of many countries. Although developed countries are currently producing large amounts of electronic waste. It contains hazardous constituents that may negatively impact the environment and affect human health if not properly managed. A plan needs to be established to address this issue and in order to avoid these environmental and health consequences. . Increasing information campaigns, capacity building, and awareness is critical to promote environmentally friendly e-waste management programs. Reducing, recycling and reusing are the proper methods of E-waste management rather than land filling and incineration because the land filling and incineration method increases public health and environmental impacts.

From experimental analysis it is to be observed that E-waste may be used up to some extent in concrete as coarse aggregate.

Following points give ideas about it-

1. It is identified that E-waste can dispose in concrete as a coarse aggregate.

2. Volume of E-waste on earth reduces when it use in concrete.

3. Up to 10% replacement of E-waste is used in construction according to experimental results.

4. More than 10% is not considerably useful for construction field because of strength decreases.

Based on the project, following are the salient conclusions:

• The e-waste increase day by day is much higher than the recycle, recovery and disposal. The most number of wastes recycle and recovery by informal sector is much higher than the formal sector. The informal sector has more manpower with unskilled employee and not governed by any health and environmental regulation.

• More pollution, while recycle, recovery and disposal of e-waste in informal sector.

• Finally, to creating awareness informal sector and public for disposal of waste.

• The discarded material collects, separate and transport by the informal sector and recycling, recovery and disposal by the formal sector is the way of reduction of pollution.

Solid Waste Management of E-waste can be done, when it is used in concrete.

FUTURE SCOPES

Further, development of workable models is needed which are suitable for the Indian conditions and which are backed by the government policies. Since waste administration has clear societal benefits, government legislations should provide facilitation, mediation and incentives for proper working of these models. In the Indian setting, due to the presence of highly unorganized sector, the role of the administration is greatly increased and should involve concerted efforts to educate the masses for increasing the acceptability of the new practices.

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