Electronic waste in construction material

Vivek Mandot
V. K. B. Government Girls College, Dungarpur (Raj), India
mandot@gmail.com

Abstract- *Discarded, obsolete and unusable electronic and electrical equipments are known as electronic waste. With rapid urbanization, improvement in lifestyle, reduction of cost of electrical and electronic gadgets and availability of updated equipments has rendered a large number of such equipments useless. In last decade the use of mobiles have increased manifold and their average life is less than two years because of introduction of newer and updated mobiles. Mostly they are not in use and discarded or have become obsolete because of change in technology or have been replaced by updated version though they are working. All these factors are increasing the ewaste with alarming level. The bigger problem is that indiscriminate disposal or abandon in landfill of ewaste is dangerous because it contain heavy and toxic metals as well as non degradable plastic as its main contents. Researchers are working on various possible solutions to tackle this menace and help in better environment. Almost all strategies encourage reuse of all metals and recycling of plastics and glass and other reusable parts. After that a large quantity of non degradable plastics and other materials are left that also need proper disposal. Researchers are trying to use this material in construction materials and bricks and efforts are on to best utilize ewaste. Clay bricks, cement or concrete brick along with fly ash are commonly used in modern houses. If proper combination of fibres from electronic waste material is used in these bricks then it may help in reducing the waste. A review of different strategies to use this ewaste in construction work is presented in this paper.*

Keywords- *E-waste, recycle, construction, bricks, concrete*

Introduction

Industrial revolution in electrical and electronics industry has introduced technologies that were never thought of earlier. From bulky television sets of 1960s to latest slim lightweight smart televisions a long process has taken place. Introduction of Computers in 1990 for masses had similar process where we have seen changing shape of computers and monitors. Again from bulky monitors to slim all-in-one a lot has changed. Mobile revolution was even faster. In addition change in technology has introduced many new gadgets and rendered old ones unusable. Computers, laptops and mobile are most of the time replaced because of introduction of newer models with better processing power.

Generally the old equipments are discarded or sent to recyclers or thrown to landfills. This electronic waste need proper disposal and reuse under professional supervision as not doing so or dumping it to landfills may pose serious threat to human and animal health as well as it may affect the underground water quality. It is estimated that around 42 million tons of electronic waste was generated in 2014 [1]. Proper regulations as well as facilities lack in developing countries and thus they are more prone to harmful impact of this electronic waste. Informal processing put at risk the people working in them as well as the environment. Most of the electronic waste is being produced by developed countries. Many times the ewaste of developed countries is also being exported to these developing countries [2].

Toxic components of ewaste may leach into the soil or underground water and may produce long term harmful effects. Ewaste is also a source of many metals. Almost 60 different types of metals are used in ewaste and recovering of them is economically as well as environmentally beneficial. Among many metals it also contains gold, silver and other precious metals as well as hazardous substances like mercury, cadmium and lead [3]. Almost all countries are now working to tackle this menace and Indian Government has formulated mechanism for electronic waste management and is fixing the responsibility of producers [4-5].

Different methods have been developed by researchers to recycle and reuse different components of electronic waste. In most of the electronic gadgets the printed circuit board is difficult to process as it has plastic and many metal contacts with copper, silver, gold etc. Other plastics are directly sent to recycling but this printed circuit board need treatment and removal of metals from its surface. Printed circuit boards are processed in complex manner, they are cut and undergo pyrolysis, hydrometallurgical methods, air separation, using organic solvents, magnetic separation, biomerallurgical methods etc [6].

The long term hazards of ewaste are alarming. In one such study around Delhi it was observed that heavy metal has contaminated the soil and underground water in and around the unauthorized ewaste processing site [7].

This happens because of improper dumping and handling of ewaste and in that case the chances of leaching of heavy and toxic metal content into soil and underground water increases greatly. The researchers observed that copper, lead, cadmium and other pollutant materials were much higher than the prescribed level by Central Pollution Control Board. India is proactive in managing the electronic waste and has enacted Extended

Producers Responsibility 2016 in which producer will be liable to reuse or properly recycle the electronic waste. The Centre Pollution Control Board has been given the Extended Producer Responsibility (EPR) authorisation under the new e-waste rules by the Environment Ministry of Government of India [8].

Recycling of electronic waste

The recycling process of electronic waste invariably starts with collection of electronic waste. This waste is then sorted and many parts of it like capacitors, resistors, CRT, chips, wiring etc components are manually disassembled. Different parts are recycled with appropriate techniques. Printed circuit boards are separately recycled after several processes like magnetic separation, metallic separation, pyrometallurgy, hydrometallurgy and many other methods are used to separate different precious metals, other materials and waste plastic of PCB. A part of non metallic materials of PCBs are reused and rest of the plastic becomes waste that needs to be disposed off carefully. Cathode Ray Tubes are separately recycled as they contain glass with good amount of Lead, almost 1.2kg per cathode ray tube of television [9].

Electronic waste contains different materials that are removed with various techniques. Different materials have varying densities and to take advantage of it the density separation method separates such materials [10]. PCBs are decomposed by chemical recycling process and involve pyrolysis and gasification. As metal content of these printed circuit boards is high, therefore metal is first extracted and pyrometallurgy, hydrometallurgy and bio-metallurgy methods are popular to recover metal from the printed circuit boards. The non metallic parts of the PCBs are complex mixer. It contains plastics, fibreglass, thermosetting resins, additives and other materials [11].

This part is almost seventy percent of the printed circuit board by weight and thus it is important to manage this waste. Various researchers tried to use it into thermoplastics, as filler epoxy resin products, in making of models and composite boards [12-14]. Researchers are also trying to use this waste into construction materials. Different ways of using this material into construction work are discussed in this paper.

Using ewaste in construction material

Various researchers are working towards using PCB waste in construction work. In one such study it was observe that the strength of the concrete mix increased when crushed PCB waste particles were mixed with cement and sand. It was observed that compressive strength increases with the increase in the percentage of pulverized PCB in concrete in place of sand upto ten percent. The tensile strength and flexural strength also increased in the said study [15].

Singh and patel observed in their study of use of ewaste in high strength concrete cement that the ewaste can be disposed off as coarse grain in concrete aggregate while it is not suitable to replace the fine aggregate. The resultant aggregate of concrete with ewaste is lighter than traditional concrete aggretgate. They observed that the compressive strength of the concrete with ewaste plastic does not change for ewaste percentage below 20 percentage. Above 20 percentage of ewaste compressive strength decreases [16].

In one study Mou et al found that for building materials mechanical strength under bending and compression strength are very important. Their research observed that the concrete material with lighter non metallic PCB waste is more reliable microstructure. Different ratios of such ewaste in the mixer should be carefully prepared to find the ideal ratio of this non metallic ewaste that gives improved mechanical strength to the mixer. They made bricks using this non metallic PCB waste powder. They also mixed this non metallic PCB ewaste in concrete to reduce the dead weight and to improve the compression strength and tensile strength [17].

Kurup and Senthil experimented with ewaste fibres as electrical wire cuttings and observed that compressive strength of fibre reinforced concrete is higher. Compressive strength increases till these fibres are added in 0.6 to 0.8 percent in the concrete. At 1% the strength starts decreaseing [18]. In yet another study Senthil and Bhaskar observed that high impact polystyrene or ewaste plastic upto 30 percent in concrete aggregate replacement may be considered and can be used for structural concrete [19].

In another study it was observed by Ahirwar et al that workability of concrete increases till ewaste content in concrete is replaced in the ratio of 10 to 20 %. It was also observed that when fly ash was introduced in ewaste mixed concrete then the workability increases further. Though they observed that compressive strength decreases with increase in percentage of ewaste in concrete. It was also observed that fly ash and ewaste replaced as coarse grain increases the compressive strength [20].

Alagusankareswari et al observed that dead weight of concrete with ewaste is lower and can be consumed as light weight concrete. They also observed reduction in yield of concrete when ewaste is used as replacement for sand. The split tensile strength and compressive strength is slightly lesser with ewaste aggregate than the control concrete aggregate [21].

In the study of replacement of coarse aggregate by e-waste in concrete by Suchithra et al, it was observed that addition of ewaste shows increase in compressive strength till ewaste replacement by 15%. They also

observed that increase in split tensile strength was negligible while flexural tensile strength was increased. It was also found that the mix aggregate was more stable against sulphate and chloride attack [22].

Similar study by Shamili et al found that ewaste can be used as light weight aggregate in concrete. Increase in the percentage of ewaste reduces the weight of the aggregate but the workability decreases with increase in ewaste. They also observed that mechanical properties are slightly lesser in concrete with ewaste with respect to control mix [23].

Many other researchers experimented with ewaste in concrete and in one more study it was found that the strength of concrete gets reduced when fine aggregate are replaced by ewaste and adhesive strength of the material also reduced. So ewaste plastic can be used for some of the coarse aggregate of concrete [24].

Researchers are also trying to use this non metallic ewaste into making special products like surfboards, mannequins etc or to use them as fillers as non metallic plates [25].

Conclusions

Electronic waste is being reused or recycled to some extent at present but after extracting easier and important parts of ewaste the rest of it is not properly disposed off because of its low economic value. Though government world over have made rule are making them so as to ensure safe environment, it is the industry and researchers to provide proper way for it. Several approaches are being tried by scientists to use this non metallic part of ewaste as an aggregate in concrete. Different research findings shows different results and thus at present it is difficult to predict the exact beneficial use. It is almost certain that this non metallic ewaste can be used as coarse aggregate in small ratio so that different strength parameters gain. It is important to test this new concrete with ewaste to fire testing as ewaste of non metallic plastics also contain chemicals and on fire it may emit harmful gases. Further research is required to conclude anything substantive.

References

[1]. Balde, K.; Wang, F.; Huisman, J.; Kuehr, R. The Global E-Waste Monitor; United Nations University: Bonn, Germany, 2015.

[2] R.Widmer, H. Oswald-Krapf, D. Sinha-Khetriwal, M. Schnellmann, and H. B¨oni, "Global perspectives on e-waste," Environmental Impact Assessment Review, vol. 25, no. 5, pp. 436–458, 2005.

[3] Namias, J. The Future of Electronic Waste Recycling in the United States: Obstacles and Domestic Solutions; Columbia University: New York, NY, USA, 2013.

[4] E-Waste in India, https://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf , 2011.

[5] Central Pollution Control Board (CPCB), New Delhi, India, 23 March 2016, http://cpcb.nic.in/e-waste-rules/

[6] Mandot, V., An overview of electronic waste, JETIR, 5(5), 334-337, 2018.

[7] Panwar, R. M., Ahmed, S. Assessment of contamination of soil and groundwater due to e-waste handling, Current Science, 114, 1, 166, 2018.

[8] The Hindu, Business Line, https://www.thehindubusinessline.com/news/national/cpcb-given-extended-producer-responsibility-authorisation-in-new-ewaste-rule-environment-min/article9811981.ece, August, 2017.

[9] F. Mear, P. Yot, M. Cambon et al. The characterization of waste cathode ray tube glass. Waste Management, 26: 1468-1476, 2006.

[10]. Wills, B. A., "Mineral Processing Technology," 4th ed., Pergamon Press, Oxford, England, pp. 377–381, 1988.

[11]. Marques A. C., Marrero J. M. C., Malfatti C. D. F., A review of the recycling of non-metallic fractions of printed circuit boards, springerplus, 2, 521, 2013

[12]. Franz R. Optimizing portable product recycling through reverse supply chain technology, in: Proceeding of the 2002 IEEE International Symposium on Electronics and the Environment. USA: Libertyville, 274–279, 2002.

[13]. Mou P, Xiang D, Pan X, Wa L, Gao J, Duan G. Proceedings of the 2005 IEEE International Symposium on Electronics and the Environment. China: Beijing. New solutions for reusing nonmetals reclaimed from waste printed circuit boards; pp. 205–209, 2005.

[14]. Guo J, Guo J, Xu Z , Recycling of non-metallic fractions from waste printed circuit boards: a review. J Hazard Mater, Sep 15; 168(2-3):567-90, 2009.

[15]. Kale, S. P. and Pathan, H. I. Recycling of Demolished Concrete and Ewaste. International journal of science and research, 4(1):789-792, 2015.

[16]. Singh, S. S. and Patel, A. Utilization of E-waste in high strength cement concrete. International journal for scientific research and development, 3(9):691-694, 2015.

[17]. Mou, P, Xiang D, Duan G. Products Made from Nonmetallic Materials Reclaimed from Waste Printed Circuit Boards. Tsinghua Science & Technology. 2007;12:276–283. doi: 10.1016/S1007-0214(07)70041-X.

[18]. Kurup, A. R. and Senthil, K. K. Behaviour of concrete with e-waste fibres under compression. International conference on ACESC 2016. 197-199, 2016.

[19]. Senthil, K. K. and Bhaskar, K. Response surface for fresh and hardened properties of concrete with E-waste. Journal of waste management, 14, 2014. http://dx.doi.org/10.1155/2014/517219
[20]. Ahirwar, S., Malviya, P., Patidar, V. and Singh, V. K. An experimental study on Concrete by using Ewaste as partial replacement for coarse aggregate. International journal of Science technology and Engineering, 3(04):7-13, 2016.
[21]. Alagusankareswari, K., Kumar, S. S., Vignesh, K. B. and Niyas, K. A. H. An experimental study on Ewaste concrete. Indian journal of science and technology, 9(2), 2016. DOI: 10.17485/ijst/2016/v9i2/86345.
[22]. Suchithra, S., Kumar, M. and Indu, V. S. Study on replacement of coarse aggregate by ewaste in concrete. International journal of technical research and applications, 3(4):266-270, 2015.
[23]. Shamili, S. R., Natarajan, C. and Karthikeyan, J. An overview of electronic waste as aggregate in concrete. International journal of structural and construction engineering, 11(10):1444-1448, 2017.
[24]. Manjunath, A. B. T. Partial replacement of e-plastic waste as coarse aggregate in concrete. International conference on solid waste management 2015, 35: 731-739, 2016.
[25]. Li, J., H. Lu, J. Guo, Z. Xu, and Y. Zhou, "Recycle technology for recovering resources and products from waste printed circuit boards," Environ Sci. Technol., 41(6), 1995-2000, 2007.