International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02(S) || PP.31-35

Review of Literature on Electronic Waste Materials Used in Concrete

Bala Subramanian. B[1], Dr. Gopala Krishna. Gvt[2] and Dr. Saraswathy.V[3]

1 Assistant Professor, Department of Civil Engineering, Mother Terasa College of Engineering and Technology, Pudukottai

2Professor, Department of Civil Engineering, PSNA College of Engineering and Technology, Dindigul

3Chief Scientist, Corrosion and Material Protection Division, CSIR-CECRI, Karaikudi

Abstract: Waste from Electric and Electronic Equipments (WEEEs) is currently considered to be one of the fastest growing waste streams in the world, with an estimated growth rate going from 3% up to 5% per year. Solid waste management is one of the major environment concerns in the world. With the scarcity of space for land filling and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. Research is being carried out on the utilization of E-Waste products in concrete. The use of E-Waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Total replacement of concrete is not possible due to no material plays the role of concrete in terms of strength, durability and workability. So we have to partial replace all the material to achieve desire properties of concrete. This paper includes survey of E-Waste material used in the concrete. From this survey we can understand the effect of EWaste materials on the properties of concrete. Waste from Electric and Electronic Equipments (WEEEs) is currently considered to be one of the fastest growing waste streams in the world, with an estimated growth rate going from 3% up to 5% per year. Solid waste management is one of the major environment concerns in the world. With the scarcity of space for land filling and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. Research is being carried out on the utilization of E-Waste products in concrete. The use of E-Waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Total replacement of concrete is not possible due to no material plays the role of concrete in terms of strength, durability and workability. So we have to partial replace all the material to achieve desire properties of concrete. This paper includes survey of E-Waste material used in the concrete. From this survey we can understand the effect of E-Waste materials on the properties of concrete.

Keywords: E-Waste, E-Plastic, Fly Ash, Printed Circuit Boards, Compressive strength, Tensile strength and Flexural strength

I. Introduction

E Wastes are one of the fast growing wastes in the world. It is a situation that prevails everywhere and it's hard to survive in this world without machines. Each year around 50 million ton of E-Waste are produced. Depending upon their nature of reaction, there are possibilities for dangers depending upon the situation. Discarded computers, mobile phones and other electrical and electronic wastes may results in unwanted results. So it's important to be aware of E-Waste in addition to the other physical wastes. Use of concrete is very large so availability of natural material is reduced and there is no material which plays the role of this ideal material (concrete) so to full fill the requirement of industries we have to replace E-Waste partially. This paper is based on the review of literature which gives the idea about the possibility usage of E waste material in concrete.

Gupta Reena et al. [1] have discussed national and international e-waste scenario along with hazards caused by ewaste and bit about its recycling. They have stated three categories of WEEE account for almost 90% of the total waste generation, which includes 42% large house hold appliances, 34% ICT equipment and 14% consumer electronics. About 4000 tons of E-waste is generated throughout the world for an hour. In India due to its growing economy and higher consumption, it is estimated that the annual generation of E Waste (Computers, Mobile Phone and Television only) is 4, 00,000 tons approximately and it expected to grow at a much higher rate of 10 – 15%. Mumbai generates 10, 000 tons of E Waste, Delhi 9000 tons, Bangalore 8000 tons and Chennai 5000– 6000 tons each year. Maharashtra state (including Mumbai city) alone produces 20270 tons of E-Waste annually. About 80% of the E-Waste generated in the US is exported to India. Only 3% of total E-Waste generated is recycled properly in India. The rest of it is handled by workers who have little or no knowledge of toxins in E-Waste, and are exposed to serious health hazards.

Iftekar Gull et al. [2] have investigated about the E Plastic waste (Insulation wires) is shredded into fibers of specific size and shape. Several design concrete mixes with different percentages (0%, 0.4%, 0.6%, 0.8%, 1%) of waste plastic fibers for three aspect ratios (3cm, 4cm, 5cm), are used as a admixture in concrete and casted into desire shape and size as per requirement of tests. The Workability, Compression and Tensile Strength tests were carried out for 7, 14 and 28 days. They have confirmed that no major changes are found in the Compressive strength of Concrete with the presence of EPlastic. However when 1% of E-Plastic for 5cm is added, the compressive strength gets reduced by 2.59% when compared to control mix. With addition of the E-Plastic – 4cm and EPlastic – 3cm the Compressive Strength gets increased up to a maximum of 5.9% and 10.6% respectively when compared to control mix. Also they have confirmed that increase in strength is found in the tensile strength of concrete with the presence of EPlastic. When 1% of the E-Plastic for 5cm is added, the tensile strength gets increased by 2.3% and for 1% of 4cm, the strength increase observed is 4.6% and for 1% of E-Plastic for 3cm is added, the tensile strength initially gets increased by 4.6% when compared to control mix at 28 days of curing and then gets decreased with increase in percentage. Thus they have concluded that strength was achieved in the EPlastic concrete compared to conventional concrete.

P. Krishna Prasanna et al. [3] have studied about E-Waste have been used as partially replacement to the coarse aggregate. They have made specimens by utilizing E-Waste particles as coarse aggregate in concrete with a percentage replacement from 0% to 20%. i.e. (5%, 10%, 15%, 20%) with addition of 10% Flyash. And conventional Specimens are also prepared for M30 grade concrete without using E-Waste aggregates and tested for Compressive Strength Test, Tensile Strength Test and Split Tensile Strength Test. They have resulted that the strength of concrete is reduced by 33.7% when coarse aggregate is replaced by 20% of E-Waste and it is reduced by 16.86% when coarse aggregate is replaced by 20% of E-Waste plus 10% Flyash. They have also observed that the Compressive Strength of concrete is found to be optimum when coarse aggregate is replaced by 15% with E-Waste. Beyond it the Compressive Strength gets decreased. They have concluded that the use of E-Waste aggregate results in the formation of concrete which has lesser weight than that of conventional concrete. They have recommends that reusing of E-Waste as coarse aggregate substitutes in concrete gives a good approach to reduce cost of materials and solve solid waste problems posed by E-Waste.

Lakshmi.R et al. [4] have studied about the utilization of EWaste particles as coarse aggregate in concrete with a percentage replacement ranging from 0% to 30%. i.e. (0%, 4%, 8%, 12%, 16%, 20%, 25%) on the strength criteria of M20 grade concrete. Compressive strength, Tensile strength and Flexural strength of Concrete with or without Electronic waste as aggregate had observed which exhibits a good strength gain. Ultrasonic tests on strength properties had also executed. They have concluded that upto 20% of replacement of E-Waste gave improvement in compression and Tensile strength and identified that E-Waste can be disposed by using them as construction materials.

Vivek S. Damal et al. [5] have investigated about the use of fine aggregate in concrete with a percentage replacement of EWaste Particles ranging from 0% to 21.5%. i.e. (7.5%, 15%, 21.5%) on the strength criteria of M30 concrete. Their main objective is to reduce the accumulation of used and discarded electronic and electrical equipments and transfer waste into socially and industrially beneficial raw materials using simple, low cost and environmental friendly technology. The E-Waste used for their investigation was collected from Computers, TV Cabins, Refrigerator, Mobile Phones and Washing Machine etc. They have also casted cubes and tested for Compressive Strength. The Compressive Strength of concrete is found to be optimum when fine aggregate is replaced by 7.5% with Electronic Waste. Beyond it the Compressive Strength of concrete goes on decreasing. The Compressive Strength of concrete get decreased gradually when fine aggregate are replaced beyond 15% with Electronic Waste.

S.P. Kale et al. [6] have studied about the comparison between fresh concrete materials, waste concrete materials and EWaste concrete materials for Compressive strength, tensile strength, flexural strength and bond strength. Various mixes were prepared for carrying out the research by varying the proportions of cement, sand and aggregates. All mixes were designed for characteristic strength of M25.The Compressive strength, tensile strength, flexural strength and bond strength was tested in laboratory after 7 and 28 days. The natural coarse aggregates were replaced with 5%, 10%, 15% and 20% (by weight) crushed concrete aggregate and the natural fine aggregate were replaced with 5%, 10%, 15% and 20% (by weight) crushed PCB (Printed circuit board). The compressive strength increases with the increase in the percentage of Printed circuit board up to replacement (10%) of sand in concrete. The split tensile strength was obtained with 10% replacement of crushed PCB is greater than conventional concrete and the strength was obtained with replacement of demolished waste and demolished with admixture is near about same in conventional concrete. The flexural strength increases with the increase in the percentage of PCB up to replacement (5%) of sand in concrete. The maximum 28 days bond strength was obtained with 5% replacement of fine aggregate is greater than conventional concrete. They have concluded that PCB waste and demolished waste can be utilized in concrete making and hence solve a potential disposal problem and it saves natural aggregate. Although recycled aggregate can be applied in the high strength structure, water content in the concrete mix has to be monitored carefully due to the water absorption capacity varying quantity of recycled aggregate.

Jakab Szalatkiewicz et al [7] have presented construction aspects of designed plasma technology for processing of waste of printed circuit boards for metals recovery, with design and exploitation data of plasma reactor: throughput, power, and products. Additionally, currently available technologies for processing of PCB waste are briefly presented. High temperature plasma technology processes the printed circuit boards without need of its preprocessing. For tests, complete circuit boards were boxed and feed to the reactor after reaching 1350 degree Celsius temperature in the reaction chamber. Single portion mass was 0.589 – 1.582 kg, while overall 18 kg of PCB was used. The mass balance of processed waste and solid products indicates that the mass of the waste was reduced by 61%. Mass of the recovered metal is 3.5 Kg and the rest of the slag is 7.1 Kg. The slag consists of metal oxides, and is formed during oxidation of metals in the rector. That is why slag mass is higher than the mass of metals in the input waste, and thus the mass balance is affected by oxidation of metals that increase the slag mass. Benefit of processing the waste near the urban areas is to develop and create new employment opportunities in the given area. By developing this new and innovative plasma technology for waste processing in small scale, they proved that such smelting processes can be designed and the infrastructure of the device can be developed.

Pravin A.Manatkar et al. [8] have analysed compressive strength of M20 and M25 grade of concrete by replacing coarse aggregate by adding non-metallic E-Waste in 0% to 20% (0%, 5%, 10%, 15%, 20%) They have observed that compressive strength decreases with increasing E-Waste percentage for both grades. Upto 5%, it is nearly same to normal concrete but after 15%, it reduces maximally. Upto 56% replacement of E-Waste is suitable to use up to (G+2) building construction, road construction. Up to 10% is not considerably useful for construction field because of strength decrease. E-Waste concrete block having flexibility it directly not fails during test. Firstly it compresses up to 1cm then break. It is very important at the time of earthquake it provides some time for clearance in structure. Thus they have concluded that the E-Waste can dispose in concrete as a coarse aggregate.

Pejman Hadi et al. [9] have reviewed the recent trends and developments in PCB waste recycling techniques, including both physical and chemical recycling. The 70% by weight non-metallic fraction has been traditionally discarded to landfill or used as very low cost fillers in the construction industry. The present review indicates that while substantial research needs to be done to pave the way forward for successful, environmentally friendly and economic waste PCB recycling, significant progress has been made both in the methods for separating PCB waste into its metallic and nonmetallic fractions but also in identifying more economically attractive uses for the 70% by weight nonmetallic component of E-Waste. They have concluded that the physical recycling techniques effectively separate the metallic and non-metallic fractions of waste PCBs, offer the most promising gateways for the environmentally-benign recycling of this waste.

B. Ghosh et al. [10] have reviewed more than 150 related articles mostly published in the last 15 years and covering the broad areas like characterization of waste printed circuit boards, health hazards associated with the processing and the different routes of recycling have been analyzed. Waste PCB account for 3% of nearly Mt/Year global E-Waste generations. A significant amount of Cu and Au in it attracts crude recyclers in some parts of Asia and Africa leading to substantial environmental and health problems. Due to the heterogeneous composition and hazardous material contents, proper recycling methodology is a still a challenging task. More studies are needed in the area of metal separation and recovery from PCB leach liquor.

Rafat Siddique et al. [11] Reuse of bulky wastes is considered the best environmental alternative for solving the problems of disposal. One such waste is plastic, which could be used in various applications.

However, efforts have also been made to explore its use in concrete. They have reviewed about waste and recycled plastics, waste management options. The availability types of recycled plastics can be used to fabricate marine construction materials that are economically competitive and environmentally superior to conventional marine construction products.

Suchithra et al. [12] have conducted an experimental investigation on partial replacement of E-waste in the range of 0%, 5%, 10%, 15% and 20% with coarse aggregate on M20 grade mix. They have also conducted test for the effects of sulphate and chloride attack. Thus the addition of E-Waste shows increase in compressive strength upto 15% replacement. But the split tensile strength is almost insignificant whereas gain in flexural tensile strength have occurred even upto 15% replacements. Durability study does not affect the strength of concrete and the optimal mix is more durable than the control mix. Thus the author concluded that it is possible to use E-waste in concrete as environment friendly manner.

Shoba Raj kumar et al. [13] an experimental study was performed to find the effect of partial replacement of coarse aggregate using E-waste in M25 grade concrete. Polystyrene retained on 10mm sieve was used as E-waste material and it was replaced in the range of 10%, 15% and 20%. The compressive strength, split tensile strength and flexural strength of concrete were found. It is identified that E-waste can be effectively used as construction material. Thus they have concluded that the optimum percentage of E-Waste can be used as replacement for coarse aggregate in concrete was found to be 10%.

Ashwini Manjunath B T et al. [14] have analysed the utilization of E-waste plastic particles as coarse aggregate in concrete with a percentage replacement ranging from 0%, 10%, 20% and 30% on the strength criteria of M20 concrete with w/c ratio of 0.5. By comparing the obtained results with conventional concrete at 28 days the compressive strength, split tensile strength and flexural strength of concrete is reduced by 52.98%. This proves that the strength of concrete gets reduced when coarse aggregate was replaced by E-waste plastic particles. Thus they have concluded that the introduction of plastic in concrete becomes fails in strength aspect. But plastic can be used to replace some of the aggregates in a concrete mixture to reduce the unit weight of the concrete. This is useful to produce light weight concrete such as concrete panels used in facades.

Vanitha et al. [15] this study was intended to know the reuse of waste plastics as a partial replacement of coarse aggregate in M20 grade concrete. Waste plastics were incrementally replaced in the range of 0%, 2%, 4%, 6%, 8% and 10%. Paver blocks and solid blocks were casted and compressive strength was tested for 7, 14 and 28 days strength. They observed that the compressive strength value of the concrete mix decreased with the addition of waste plastics more than 4%. Thus they have concluded that the waste plastics can be used in the cement concrete mix. It can be applied in the construction of rigid pavements. The optimum modifier content of waste plastics is found to be 4% for paver blocks and 2% for solid blocks. By doing this the cost of construction will reduce and also helps to avoid the general disposal technique of waste plastics namely land filling and incineration which have certain burden on ecology.

T. Subramani et al. [16] have studied on partial replacement of plastic waste as a coarse aggregate. The replacement was made of three different ratios i.e, 5%, 10% and 15%. The 7 days, 14 days and 28 days of Compressive strength test, Split tensile strength test and Flexural strength test was conducted. The Compressive strength and Split tensile strength of concrete containing plastic aggregate is retained more or less in comparison with controlled concrete specimens. However strength noticeably decreased when the plastic content was more than 20%. It has been concluded that 20% of plastic waste aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

II. Conclusion

This study was conducted to evaluate the effect of E-Plastic Waste materials used as substitutes for fine aggregates and coarse aggregate on the main mechanical properties of concrete mixes. It can be concluded that those E-waste materials can be used in concrete mixes up to the weight percent composition of 20%. This study is exploratory, requires further work and investigations to assess the possibility of increasing the fraction of E- waste beyond the range which was concluded in this study with any composite material. Thus, concrete with E-Waste is environmentally friendly and a better solution to the E-waste problem.

III. Acknowledgement

Words are inadequate to express my deep sense of gratitude to Prof. Gopala Krishna GVT, my guide, for his consistent guidance and inspiration throughout the project work, which I am sure, will go a long way in my life. I owe sincere thanks to Chief Scientist. Saraswathy.V, for their encouragement and guidance throughout the project work. I also owe sincere thanks to Assistant Prof. Vijay Prakash.M, Head of Civil Engineering Department and Prof. P. Rajkumar, Principal, Mother Terasa College of Engineering and Technology for their guidance throughout the project work. I express my sincere thanks to all those who have helped me directly or indirectly in completing this project.

References

[1]. Gupta Reena, Sangita, Kaur Verinder, "Electronic Waste: A Case Study", Research Journal of Chemical Sciences, Volume 1, December 2011.

[2]. Iftekar Gull, M.Balasubramanian, K.S.Anandh, K.Vetrivel, "An Experimental Investigation on Use of Post Consumed EPlastic Waste in Concrete", International Journal of Engineering Research Online, Volume 2, Issue 2, April 2014.

[3]. P.Krishna Prasanna, M.Kanta Rao, "Strength Variations in Concrete by Using E-Waste as Coarse Aggregate", International Journal of Education and Applied Research, Volume 4, Issue Spl 2, June 2014.

[4]. Lakshmi.R, Nagan.S, "Studies on Concrete Containing E Plastic Waste", International Journal of Environmental Sciences, Volume 1, No 3, 2010

[5]. Vivek S. Damal, Saurabh S. Londhe, Ajinkya B. Mane, "Utilization of Electronic Waste Plastic in Concrete", Journal of Engineering Research and Applications, Volume 5, Issue 4, (Part – 2) April 2015

[6]. S.P. Kale, H.I. Pathan, "Recycling of Demolished Concrete and E-Waste", International Journal of Science and Research (IJSR)",Volume 4, Issue 1, January 2015

[7]. Jakub Szalatkiewicz, Roman Azewczyk, Eugeniusz Budny, Tadeusz Missala, Wojciech Winiarski, "Construction Aspects of Plasma Bases Technology for Waste of Electrical and Electronic Equipment (WEEE) Management in Urban Areas" , Procedia Engineering 57 (2013) 1100 – 1108

[8]. Pravin A. Manatkar, Ganesh P.Deshmukh, "Use of non – metallic E-Waste as a Coarse Aggregate in a Concrete" International Journal of Research in Engineering and Technology, Volume 04, Issue 03, March 2015.

[9]. Pejman Hadi, Meng Xu, Carol S.K.Lin, Chi-Wai Hai,Gordon Mckay, "Waste Printed circuit board recycling techniques and product utilization" Journals of hazardous material 283

[10]. B.Ghosh, M.K. Ghosh, P.Parhi, P.S. Mukherjee, B.K.Mishra, "Waste Printed Circuit Boards recycling: an extensive assessment of current status" Journal of Cleaner Production 94 (2015)

[11]. [11]Rafat Siddique, Jamal Khatib, Inderpreet Kaur, "Use of recycled plastic in concrete: A review" Waste Management 28 (2008)

[12]. Suchithra. S, Manoj Kumar. Indu V.S. "Study on Replacement of Coarse Aggregate by E-waste in Concrete" International Journal of Technical Research and Applications, Volume 3, Issue 4, (July – August 2015), 266-270

[13]. Dr. D. Shoba Rajkumar, B.Nithya,"Experimental Investigation on the Strength Properties of M25 Grade Concrete with Partial Replacement of Coarse Aggregate by EWaste" International Journal of Engineering Research & Technology (IJERT), Volume 5, Issue 5, May- 2016, 305-309.

[14]. Ashwini Manjunath B.T, "Partial Replacement of EPlastic Waste as Coarse Aggregate in Concrete" Procedia Environmental Sciences 35 (2016), 731-739

[15]. S.Vanitha, V.Natrajan, M.Praba, "Utilisation of Waste Plastics as a Partial Replacement of Coarse Aggregate in Concrete Blocks" Indian Journal of Science and Technology, Volume 8 (12), June 2015

[16]. T.Subramani, V.K Pugal, "Experimental Study on Plastic Waste as a Coarse Aggregate for Structural Concrete" International Journal of Application or innovation in Engineering & Management (IJAIEM), Volume 4, Issue 5, May 2015, 144-152.