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Investigation on Partial Replacement of Coarse Aggregate using E-Waste in Concrete

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Abstract: Waste from Electric and Electronic Equipment's (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 landfilling and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. 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 partially replace all the material to achieve desire properties of concrete. In this paper an experimental work have been done to determine the compressive strength, tensile strength and flexural strength of concrete by using E-Waste as a partial replacement material for coarse aggregate. Different types of conventional cubes with partial replacement of E-waste on a percentage of 5%, 10%, 15%, 20%, 25% and 30% to coarse aggregate with water cement ratio as 0.5 was made. The main aim of this study recommends the recycling of E-waste as an aggregate in the production of new concrete.

Keywords: *E-Waste, Compressive Strength, Split Tensile Strength, Flexural Strength, Concrete*

1. Introduction

E-waste or Electronic waste describes discarded electrical or electronic devices. Used electronic which are destined for reuse, resale, salvage, recycling or disposal are also considered as E-waste. Old electronic equipment that becomes junk could turn out to be positively harmful for the environment if not taken care properly. Over the years there have been significant rise in the number of people that use electronic equipment like mobile phones, computers and smart phones. In the past few years, india has emerged as one of the primary contributors of E-waste in the world. The main reason for this is because of the technology boom which the nation is currently undergoing. The main source for E-waste in india is public and private sector institutions which contribute to around 70% of the total E-waste. Household waste is relatively small and accounts for just above 15%. We are only recycling 4% of it. Today, it has become a real challenge as to how to dispose electronic products without causing any damage to the environment. 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. Now a day's use of concrete is very large so availability of natural material is reduced and there is no material to fulfill the requirement of industries. Thus the use of E-waste materials in concrete not only helps in getting them utilized but also to reduce the cost of construction materials.

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 [1]. 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 [2]. 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 [3]. PCB waste and demolished waste can be utilized in concrete making and hence solve a potential disposal problem and it saves natural aggregate [4]. E-Waste can dispose in concrete as a coarse aggregate; it can withstand the earthquake effect upto a certain level due to its flexibility in nature [5]. The physical recycling techniques of Printed Circuit Board (PCB) effectively separate the metallic and non-metallic fractions of waste PCBs; offer the most promising gateways for the environmentally-benign recycling of this waste [6]. Due to the heterogeneous composition and hazardous material contents, proper recycling methodology is still a challenging task. More studies are needed in the area of metal separation and recovery from PCB leach liquor [7]. Reuse of bulky wastes is considered as the best environmental alternative for solving the problems of disposal. Recycled plastics can be used to

fabricate marine construction materials that are economically competitive and environmentally superior to conventional marine construction products [8].

The objective of the present research work is to get the characteristics of concrete which are replaced by E-Waste as a coarse aggregate. E –waste (Printed Circuit Boards) was crushed in various sizes and sieved through 4.75mm, 10mm, and 20mm. It was used to replace coarse aggregate (by weight) in concrete at various percentages as listed in Table 1 are taken for the investigation. Concrete Grade of M20 is adopted in the present investigation. The concrete cubes of size 150x150x150 mm, cylinders of 100x200 mm size and beams of 500x100x100 mm size were cast. The cast specimens are removed after 24 hours and these are immersed in a water tank for a curing period of 28 days and are tested for Compression, Split tensile and Flexural strength test. These results are compared with conventional concrete.

Table 1: *Mix proportions*

Mix Specification	Ctrl Mix	S1	S2	S3	S4	S5	S6
Proportion of E-Waste in %	0	5	10	15	20	25	30

2. Materials used

2.1. Cement

The cement used in all mixtures was Ordinary Portland cement of grade 43 conforming to IS 12269-1987. Tests are carried out in accordance with procedures described in IS 4031:1968.

2.2. Fine Aggregate

Locally available river sand passed through 4.75mm IS sieve is used as fine aggregate conforming to the requirements of IS 383 – 1970. The river sand is washed and screened to eliminate waste materials and over size particles.

2.3. Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate which was obtained from local quarry conforming to IS: 383.

2.4. Water

Potable water available in the laboratory was used for mixing and curing.

2.5. E-waste

The E-Wastes like printed circuit board are used. The PCB was crushed and considered as partial coarse aggregate substitute retaining the mix ratio as the same. The divided particle size of E-Waste as shown in Figure 1 is assumed to be between 1.18mm – 2.36mm.

Figure 1 *E-waste*

3. Experimental Results and Discussion

Different mixes including one control mix were used to examine the influence of adding E-Waste (Printed Circuit Boards) as coarse aggregate. Details of the mixes are given in Table-1. The water cement ratio for all the mixes was 0.5. In mixes S1, S2, S3, S4, S5, S6, the coarse aggregate was replaced with 5%, 10%, 15%, 20%, 25% and 30% (by weight) of E-Waste, respectively.

3.1. Compressive Strength

The Compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concretes are employed primarily to resist compressive stresses. The compressive strength is frequently used as a measure of these properties. Concrete cube specimens of 150mmx150mmx150 mm were cast using OPC and with various ratio of E-Waste (PCBs) 5%, 10%, 15%, 20%, 25% and 30% by weight of coarse aggregate. Quantity of cement, fine aggregate and coarse aggregate for one cube 1.5kg, 2.25kg and 4.5kg respectively. Tests was done on compressive testing machine (CTM) having loading capacity of 2000KN. Figure 1 shows the compressive strength results obtained for different systems after 28 days of curing.

Compressive strength results are shown in fig 1.

From the result it is observed that OPC with 15% E-Waste has higher compressive strength when compared to the other systems. In general S1, S2 mix specifications have higher compressive strength than the OPC. In printed circuit board the chemical composition is silica 63.55% and copper 36.44% due to this reason it increases the strength [4]. Beyond the 15% replacement of E-Waste there is a reduction in strength found than the control mix.

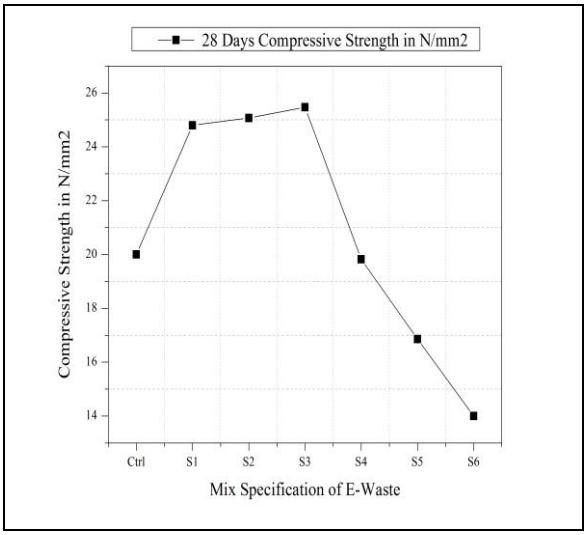

Figure 2 *Compressive strength in N/mm^2*

3.2. Split Tensile Strength Test

Cylindrical specimens (300mm x 150mm diameter) were cast for finding the split tensile strength of concrete at 28 days. It is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. Obtained Split tensile strength results are shown in figure 2.

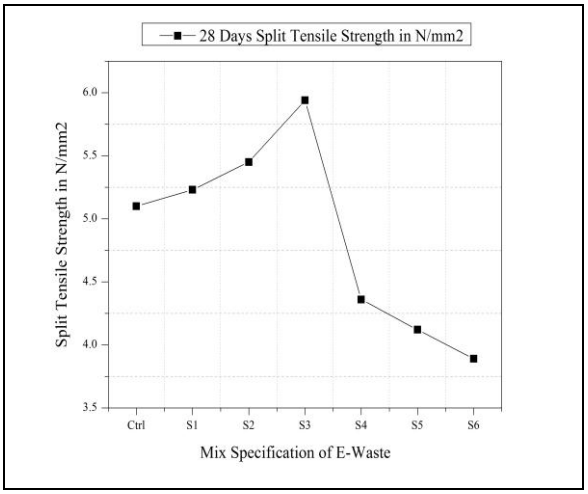

Figure 3 *Split tensile strength in N/mm^2*

From the results it is observed that OPC with 15% E-Waste has higher tensile strength when compared to the other systems. In general all the system has higher split tensile strength but beyond 15% replacement of E-Waste the strength gets reduced.

3.3. Flexural Strength Test

To find flexural strength beam mould of size 100mm x 100mm x 500mm was made. The flexural strength is expressed as modulus of rupture (MR) in psi (Mpa) and is determined by standard test methods ASTM C 78 (three point loading). Test results obtained for different systems after 28 days of curing are shown in figure 3.

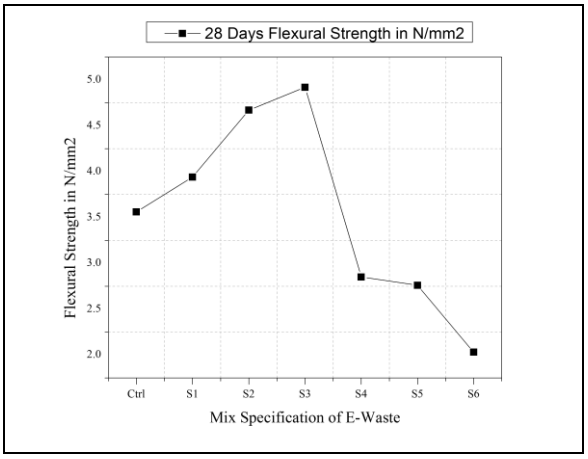

Figure 4 *Flexural strength in N/mm^2*

From the result it is observed that OPC with 15% system has higher flexural strength when compared to the other systems.

4. Conclusions

The following conclusions can be drawn from the above investigation:

- By comparing the results with conventional concrete at 28 days strength it is observed that the compressive strength of concrete is found to be 27% higher when coarse aggregate is replaced by 15% with E-Waste.
- More than 15% of replacement for coarse aggregate is not considerably useful for construction field because of strength decrease.
- Similarly Split tensile strength and Flexural strength tests shows good result on 15% replacement of E-waste.
- From this study we can conclude that use of E-Waste in to the concrete by replacing coarse aggregate is possible.
- Hence it solves a potential disposal problem and it saves natural aggregate.
- Thus the environmental effects from industrial waste can be significantly reduced.

References

[1] Gupta Reena, Sangita, Kaur Verinder, "Electronic Waste: A Case Study", *Research Journal of Chemical Sciences*, Volume 1, 49-56, December 2011.

[2] 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, 82-84, June 2014.

[3] 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), 38-38, April 2015.

[4] S.P. Kale, H.I. Pathan, "Recycling of Demolished Concrete and E-Waste", *International Journal of*

Science and Research (IJSR)", Volume 4, Issue 1, 789-792, January 2015.

[5] 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, 242-246, March 2015.

[6] 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,* 234-243.

[7] 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, 5-19, (2015).

[8] Rafat Siddique, Jamal Khatib, Inderpreet Kaur, "Use of recycled plastic in concrete: A review" *Waste Management 28,* 1835-1852, *(2008),*

[9] Iftekar Gull, M.Balasubramanian, K.S.Anandh, K.Vetrivel, "An Experimental Investigation on Use of Post Consumed E-Plastic Waste in Concrete", *International Journal of Engineering Research Online*, Volume 2, Issue 2, 260-268, April 2014.

[10] 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, 1100-1108, (2013).

[11] M.S Shetty, "*Concrete Technology",* S.Chand & Company, Seventh Revised Edition 2013.

[12] M.L Gambhir, "*Concrete Technolgy",* Tata McGraw-Hill, 2006.

[13] A. M. Neville, J.J Brooks, "*Concrete Technology"*, Pearson Education India, 2006.

[14] IS 10262, "*Concrete Mix Design",* 2009.

[15] IS 516, "*Methods of tests for strength of concrete"*, 1959.