Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 5, Issue 01, January -2018

EFFECT OF E-WASTE IN THE STRENGTH OF CONCRETE

[1]Anju Nayas, [2]Ancy Mathew

[1]PG Student, Civil Engineering Department Saintgits College of Engineering Kottayam, India
[2]Assistant Professor, Civil Engineering Department Saintgits College of Engineering Kottayam, India

Abstract- *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. Today, the world is advancing too fast and our environment is changing progressively. Attention* ***is*** *being focused on the environment and safeguarding of natural resources and recycling of wastes materials. One of the new waste materials used in the concrete industry is E-waste. New electrical and electronic products have become an integral part of our daily lives providing us with more comfort, security, easy and faster acquisition. Due to technological growth, there is a high rate of obsolescence in the electronic equipments which leads to one of the fastest growing waste streams in the world. This waste stream consists of end of life electrical and electronic equipment products.*

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. In developed countries, previously it was about 1% of total solid waste generation and currently it grows to 2% by 210. In developing countries, it ranges 0.01% to 1% of the total municipal solid waste generation. Owing to the scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse was attempted. The work was conducted ***on M30*** *grade mix. In this work, the percentage of various replacement levels of coarse aggregate with E-waste in the range of 0%, 10%, 15%, and 20%. Finally the mechanical properties of the concrete mix specimens obtained from the addition of these materials are compared with that obtained by using control concrete mix.*

Index terms—*E-waste, Compressive strength, Flexural strength, Split tensile strength, Modulus of elasticity*

I. INTRODUCTION

E-waste encompasses ever growing range of obsolete electronic devices, such as computers, servers, main frames, monitors, TVs and display devices, cellular phones, calculators, audio and video devices, printers, scanners, copiers, refrigerators, air conditioners, washing machines, microwave ovens, electronic chips, processors, mother boards, printed circuit boards (PCBs), industrial electronics such as sensors, alarms etc.. Electronic and electrical equipments are made up of several components, many of which contains toxic substance, like lead, chromium, mercury, beryllium, cadmium, acids and plastics etc. Fig 1.1 shows electronic waste.

Figure 1.1: E-Waste

These toxic substances can have highly adverse impacts on human health and environment, if not handled properly. Often these hazards arise due to improper recycling and rudimentary processes used for disposal of E-waste. For example, improper breaking or burning of printed circuit boards (PCBs) and switches may lead to the release of mercury, cadmium and beryllium which are highly toxic to human health. Another dangerous process is the recycling of components containing hazardous compounds such as halogenated chlorides and bromides used as flame-retardants in plastic, which form persistent dioxins and furans on combustion at low temperatures. A study on burning printed wiring boards in India showed alarming concentrations of dioxins in the surroundings of open burning places reaching 30 times the Swiss guidance level. About 70% of the heavy metals especially mercury and cadmium, in landfills come from electronic waste. Consumer electronics is the root cause for the presence of about 40% of the lead in landfills. These toxins can cause brain damage, allergic reactions and cancer.

Research Significance

Globally about 20-50 million tonnes of e-wastes are disposed off each year, which accounts for 5% of all municipal solid waste. When this waste ends up in landfill, it creates leaching problem which in turn contributes to the pollution of ground water resources. According to Central Pollution Control Board (CPCB), the total e-waste production in India was about 400,000 tons in 2009 which has reached 800,000 tons in 2012, Out of which only 19,000 tons was recycled officially in 2009. A report of the United Nations predicted that by 2020, e-waste from old computers would jump by 500 per cent on 2007 levels in India. Additionally, e-waste from discarded mobile phones would be higher about 18 times in India than 2007 levels. Such predictions highlight the urgent need to address the problem of e-waste in developing countries like India, where the collection and management of e-waste and the recycling process is yet to be properly regulated. Printed circuit board (PCB) is a very usual part of almost every electronic product. The vast annual production of PCB waste creates environmental concerns because of the leaching of toxic chemicals into landfills when it is dumped and incineration produces dioxins and furans which persist in the environment for a longer period. Due to the task of dealing with the disposal of non-recyclable parts and the expense incurred in dealing the toxic waste, recycling is not willingly done. Hence it is necessary to arrive at a cost effective and environmental friendly solution for the disposal of PCB waste. The project aims at studying the feasibility of utilizing printed circuit boards (PCB) in concrete making. In particular, waste from the cutting of printed circuit boards are taken for the work.

Scope of Work

New waste management options are needed to divert End-Of-Life (EOL) electronics from landfills and incineration. Increasing the need for landfills is a burden to our environment. Also with the storage of landfill capacity and an increased concern about environmental quality, newer waste treatment methods are desired. While developing a successful diversion strategy, it must be based on its economic sustainability, technical feasibility and a realistic level of social support from the society. Reuse of EOL electronic product in construction industry is one of the environmentally friendly aspects. Hence the current study is aimed at utilize E-waste in concrete for understanding some of the mechanical properties of E-waste added concrete especially to compare the compressive strength, split tensile strength and flexural strength of M30 grade conventional concrete with PCB waste added concrete.

II. EXPERIMENTAL INVESTIGATION

Cement:

Portland Pozzalano Cement (PPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of three types, 33 grade, 43 grade, 53 grade. One of the important benefits is the faster rate of development of strength. The properties of cement are given in Table 1.1.

Table 1.1 Properties of cement

Properties of cement	
Grade of cement	53 Grade
Specific Gravity	3.26
Initial Setting Time	30 mints
Final Setting Time	10 hrs

Fine Aggregate:

The most important function of the fine aggregate is to provide workability and Uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension. Locally available clean and dry M sand passing through IS 4.75 mm sieve is used for casting the specimens. The specific gravity of fine aggregate is 2.62 conforming to zone II of IS 383: 1970.

Coarse aggregate:

Coarse aggregate 20 mm sieve passing and 12.5 mm sieve retained and having specific gravity 2.8 and water absorption of 0.5% is used for casting all specimens.

PCB waste:

E-waste was collected locally from a PCB cutting unit in the form of chips. The chips were broken down to the size 20 mm. Specific gravity and water absorption were tested for E-waste and the results are given in Table 1.2. Fig 1.2 shows broken PCB waste of 20 mm size

.

Table 1.2 properties of E-waste

Properties	
Specific gravity	1.9
Water absorption	0.1%
Colour	Ivory
Shape	Angular

Fig 1.2: PCB waste

Water:

Water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Hence locally available purified drinking water was used for the work.

Casting of Concrete Specimens

The moulds of standard dimensions were used. For compressive strength, mould of size 150x150x150 mm, for cylinder mould of diameter 150mm and height 300mm and for flexure rectangular mould of size 500x100x100 mm were used. All moulds were cleaned and oiled from inner surfaces. Then the moulds were filled and compacted as per standard procedures. Each mould was filled in three layers and thereafter compacted with the help of electrically operated table vibrator available in laboratory. The top surface of the mould was finished and leveled with help of standard trowels manually. It is done after suitable setting of concrete required for proper finishing. The moulds were opened manually with the help of spanner after 24 hours of casting. The specimens were then cured for 7, 14 and 28 days. The details of the concrete samples for each test are given in table 1.3.

Table 1.3: Details of concrete sample

Type of test	Size of sample	Total no: of samples	For 7 day testing	For 14 day testing	For 28 day testing
Compressive strength	Cube 150mmx150mmx150mm	36	12	12	12
Flexural strength	Beam 50cmx10cmx10cm	24	8	8	8
Split tensile strength	Cylinder Diameter- 150 mm, Height- 300mm	24	8	8	8
Modulus of elasticity	Cylinder Diameter –150 mm, Height – 300mm	2	0	0	2

Testing of Specimens

Cube compressive strength test

The compressive strength of concrete is one of the most important properties of concrete in most structural applications. For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast and cured for 7, 14 and 28 days . These cubes were taken out from the curing tank and tested on Compression Testing machine as per I.S. 516-1959. The failure load was noted. In each category three cubes were tested and their average value is reported. Fig 1.3 shows the compressive testing of cubes. The compressive strength was calculated as follows,

Compressive strength (MPa) = Failure load / cross sectional area

Fig 1.3: compressive strength testing of cubes

Flexural strength test

For flexural strength test, beam specimens of dimension 100x100x500 mm were cast and cured for 7,14 and 28 days. The specimens were taken out from the curing tank and tested under two point loading as per I.S. 516-1959, on Flexural testing machine. The load is normally increased & failure load is noted at cracking of beam specimen. In each category, two beams were tested and their average value is reported. Fig 1.4 shows the flexure testing of beams. The flexural strength was calculated as follows.

Flexural strength (MPa) = (P x L) / (b x d^2), Where, P = Failure load, L = Centre to Centre distance between the supports b = width of Specimen=100 mm, d = depth of specimen= 100 mm.

Fig 1.4: Flexure testing of beams

Split tensile strength test

For split tensile test, cylindrical specimens of diameter 150 mm and height 300 mm were cast and cured for 7,14 and 28 days. The specimens were taken out from the curing tank and tested as per I.S. 516-1959, on compressive testing. The load is normally increased & failure load was noted at cracking of cylindrical specimen. In each category, two specimens were tested and their average value was reported. Fig 1.5 shows the split tensile testing of cylindrical specimen. The split tensile strength is calculated as follows.

Split tensile strength (Mpa) = $2P/(\pi DL)$, where P is the failure load, L is the length of the specimen and D is the diameter of the specimen.

Fig 1.5 split tensile testing of specimen

Modulus of Elasticity

The modulus of elasticity of concrete is a very important parameter reflecting the ability of concrete to deform elastically. For this cylindrical specimen were cast and cured for 28 days. The specimens were then tested on compression testing machine. The compressometer readings were taken and stress strain graph were plotted. From the graph the value of modulus of elasticity were obtained.

III. RESULTS AND DISCUSSIONS

Compressive strength

The compressive strength of M30 grade E-waste incorporated concrete at 7 days, 14 days and 28 days are shown in table 1.4.There is significant improvement in the compressive strength of concrete as compared to the control mix. The compressive strength gradually increased to an optimum level of 15 % and then decreased. The maximum 7 day, 14 day and 28 day compressive strength at optimum replacement level were found to be 31.23 N/mm^2, 36.75 N/mm^2 and 45.31N/mm^2. The variation in compressive strength is shown in fig 1.6.

Table.1.4: Compressive strength test result for varying PCB waste replacement levels in concrete in N/mm^2

Sl no	Percentage replacement	7 day	14 day	28 day	Percentage increase
1	0%	20.58	29.96	32.75	-
2	10%	23.8	30.53	34.53	5.58%
3	15%	31.23	36.75	40.88	24.82%
4	20%	25.44	32.53	35.27	7.69%

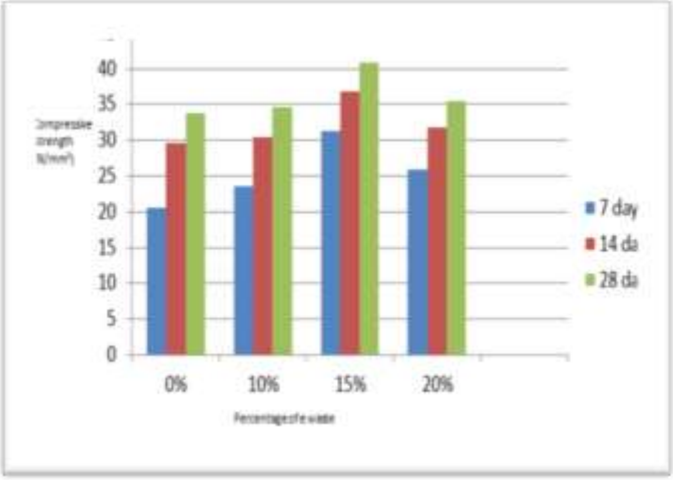

Fig 1.Fig 1.6: variation of compressive strength of concrete with PCB waste.

Flexural strength

The flexural strength of M 30 grade E-waste incorporated concrete at 7 days, 14 days and 28 days are shown in table 1.5.Flexural strength of the concrete specimen gradually increased up to an optimum replacement level of 15% and then decreased. The maximum 7 day, 14 day and 28 day flexural strength at the optimum replacement level were found to be 2.31 N/mm^2, 2.57 N/mm^2 and 3.74 N/mm^2. The variation in flexural strength is shown in fig 1.7.

Table.1.5 Flexural strength test result for varying PCB waste replacement levels in concrete in N/mm^2

Sl no	Percentage replacement	7 day	14 day	28 day	Percentage increase
1	0%	1.99	2.52	3.23	-
2	10%	2.12	2.65	3.34	3.40%
3	15%	2.31	2.77	3.46	7.12%
4	20%	2.11	2.53	3.11	3.71%

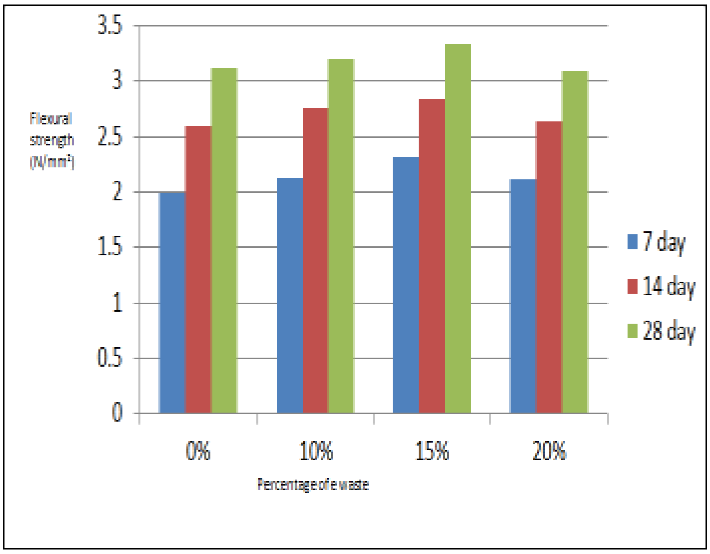

Fig 1.7 :Variation of Flexural strength with PCB waste

Split tensile strength

The split tensile strength of M30 E waste incorporated concrete at 7 days, 14 days and 28 days are shown in table 1.6.Split tensile strength of the concrete specimen gradually increased up to an optimum replacement level of 15 % and then decreased. The maximum 7 day, 14 day and 28 day split strength at the optimum replacement level were found to be 2.75 N/mm^2, 3.39 N/mm^2 and 3.63 N/mm^2. The variation of split tensile strength is shown in fig 1.8.

Table.1.6 Split strength test result for varying PCB waste replacement levels in concrete in N/mm^2

Sl no	Percentage replacement	7 day	14 day	28 day	Percentage increase
1	0%	2.37	3	3.21	-
2	10%	2.63	3.13	3.35	4.36%
3	15%	2.75	3.39	3.63	13.08%
4	20%	2.44	3.01	3.11	3.11%

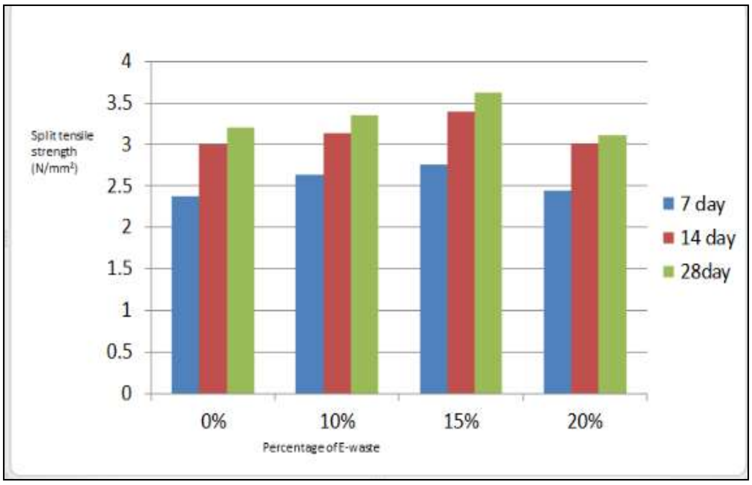

Fig 1.8 : variation of Split strength of concrete with PCB waste.

Modulus of elasticity

The modulus of elasticity of control mix was determined. It was found to be 24.66 Gpa and it conforms to IS specification. The modulus of elasticity of E-waste incorporated concrete at 15% replacement at 28 days was determined and the value obtained is 25.53 Gpa. The compressometer readings for optimum mix are shown in table 1.7. The stress strain graph is shown in fig 1.9.

Table 1.7: Compressometer reading

Load	Compressometer reading (div)	Deformation in mm	Stress in N/mm^2	Strain
20	1	$5x10^{-4}$	1.131	$3.5x10^{-5}$
40	3	$1.5x10^{-3}$	2.26	$1.37x10^{-4}$
60	4	$2x10^{-3}$	3.595	$1.38x10^{-4}$
80	6	$3x10^{-3}$	4.52	$2.2x10^{-4}$
100	7	$3.5x10^{-3}$	5.65	$2.7x10^{-4}$
120	9	$4.5x10^{-3}$	6.79	$2.79x10^{-4}$
126	10	$5x10^{-3}$	7.130	$3.1x10^{-3}$

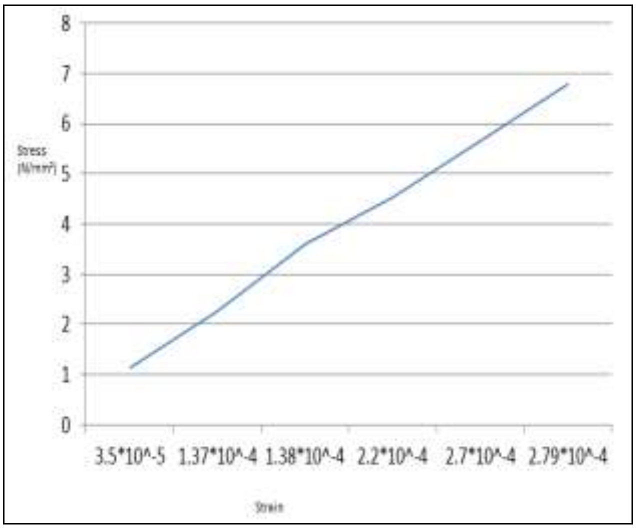

Fig 1.9: Stress Strain graph

IV. CONCLUSIONS

Based on experimental results the following conclusions are drawn:

1. Coarse aggregate replacement up to 15% with PCB waste leads to increase in compressive strength, split tensile strength and flexural strength for M30 grade. From 20 % there is a decrease in strength for 7, 14 and 28 days curing period.
2. The maximum replacement level of Coarse aggregates is 15% for M30 grade concrete.

3. The cube compressive strength of PCB waste incorporated M30 grade concrete of optimum replacement at 28 day is 40.88 N/mm^2 whereas the 28 day strength of control specimen is 32.75 N/mm^2. Therefore the percentage increase in cube compressive strength at optimum compared to that of control specimen at 28 day is 24.82%.
4. The flexural strength of PCB waste incorporated M30 grade concrete of optimum replacement at 28 day is 3.46 N/mm^2 whereas the 28 day strength of control specimen is 3.23 N/mm^2. Therefore the percentage increase in flexural strength of beam at optimum compared to control specimen at 28 day is 7.12%.
5. The split tensile strength of PCB waste incorporated M30 grade concrete of optimum replacement at 28 day is 3.63 N/mm^2 whereas the 28 day strength of control specimen is 3.21 N/mm^2. Therefore the percentage increase in split tensile strength of cylinder at optimum compared to control specimen at 28 day is 13.08%.
6. The modulus of elasticity of PCB waste incorporated concrete at optimum is 25.53 Gpa whereas modulus of elasticity of control specimen is 24.66 Gpa.

Hence it can be concluded that the coarse aggregate content can be reduced for the preparation of concrete by the use of PCB waste as coarse aggregate replacement and considerable percentage increase in various strength properties of concrete can be obtained.

ACKNOWLEDGMENT

I am thankful to my guide, Asst. Professor, Ancy Mathew in Civil Engineering Department for her constant encouragement and through guidance. I also thank my parents, friends and above all the god almighty for making this work complete.

REFERENCES

[1] 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 2015.*

[2] Salman Siddique, Sikander Shakil ,Scope of utilization of e waste in concrete. *International Journal of Advance Research In Science And Engineering.Volume 4 Special Issue 01* 2015.

[3] Suchitra 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 04* 2015.

[4] P Gomathi Nagajothi, Dr .T Felixkala.. Compressive strength of concrete incorporated with e-fibre waste. *International Journal of Emerging Technology And Advanced Engineering, Volume 4, Special Issue 04, June* 2014.

[5] 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 2 Special Issue 02* 2014.

[6] Lakshmi R, Nagan. Studies on concrete containing e plastic waste.*International journal of environmental sciences, Volume1, No 03* 2010.

