Examination of Strength and Durability Properties of E-Concrete using PCB as Coarse Aggregate

SKM.Pothinathan, M.Muthukannan, S.Christopher Ganaraj

Abstract*: *This examination intends to use the electrical Waste Printed Circuit Board (WPCBs) as partial substitution of coarse aggregate in concrete. WPCBs are supplanted by 0%, 5%, 10%, 15% and 20%. Compressive quality, Durability and self-compacting properties were considered by pressure test at 7days, 14days and 28days, sulfate test at 56days, chloride test at 56 days. To improve the rheological exhibition B233 added by 1.5% to the weight of bond and 12% to the weight of silica fume were supplanted the bond to improve the mechanical properties of e concrete. A blend configuration arranged for M30 evaluation concrete by Indian standard strategy at water proportion of 0.375. The outcome demonstrates that the addition of silica fume improves the mechanical property of e-concrete however decreased flow character. 5% of reusing the PCBs as coarse total can accomplish the equal quality and execution contrasted with customary cement.

Keywords* : *E-waste, PCB, B233, Silica fume

I. INTRODUCTION

The market of electronic items is quickly developing stream, the world over especially cell phones, PCs, workstations, printer and other modern machines. When the machines are dead it turned out to be squandered. These waste items contain composite of materials like valuable metals, for example, gold, platinum, silver and copper and poisonous items, for example, mercury, chromium and lead and so forth., Likewise it contains different plastic materials in it (1). These monstrous developments of electrical and electronic material drawn much consideration and transfer of these lethal waste ought to be done in an eco-friendly way. In India, a lot of utilized electrical and electronic things are sent to land disposal and burning. Land transfer of e-materials may pollute soil and ground water. Consuming the waste will dirty the earth and gives genuine medical issues to the livings. These sorts of transfer are because of the absence of codification. (2) To build up the eco-friendly transfer of electronic squander India began e-waste the board leads in 2012 and refreshes in 2016 were distributed by the Government of India in the Ministry of Environment, Forest and Climate Change yet the uprising of IT businesses are begun mid-1990 (3). The standards clearly characterize the obligations of maker, authorities, refurbishers, dismantlers, and recyclers. However, there is much work ought to finish to recover and reuse the waste item (4).

Recycling and reuse are the best alternatives for e-waste management. But the recycling is done by manual process its resulting contamination of the environment. India, China, South Africa, and Pakistan are the big e-waste recycling countries. Instruments like Life Cycle Assessment (LCA), Multi-Criteria Analysis (MCA), Extended Producer Responsibilities (EPR) and Material Flow Analysis (MFA) are utilized for waste administration by national and global dimensions. These administration instruments start an eco-friendly plan of gadget, accumulation of e-waste, the partition of reuse materials from the waste, recuperation of materials and to make awareness about the e-waste to lessen the waste administration issues (5). In reusing two principle methodology are chased around the world. It is preprocessing which incorporates disassembling, shredding, disconnection of materials. End handling incorporates liquefying of valuable metals, dissolving the metals using chemicals and microbes to leach the metals (6).

It has been seen that the utilization of electronic waste in construction industries are constrained numbers. This investigation depends on the use of PCB of different electronic gadgets are included with the concrete mix Electronic waste in concrete reduce the load carrying capacity of the concrete (7). In the meantime, functionality of the e-concrete expanded (8). As a result of the above issue, silica fume is utilized to enhance the e-concrete property.

II. MATERIALS AND METHODS

A. Materials

In this investigation, OPC, PCB, Silica fume and plasticizers are utilized to create the e-concrete. Customary Portland concrete fulfilling IS 12269 standards was utilized and Zone I stream sand were utilized all through the examination for mortar blend according to IS 383. Electronic waste depicted as discarded parts from electronic gadgets especially the Printed Circuit Board (PCB) utilized in this investigation was gathered from Madurai reusing unit. To utilize this PCB as coarse aggregate, at first, the wires are evacuated and afterward, the sheets are broken into little pieces by hammering shown in Fig 1.

The PCBs are taken by which is passed sieve measure 20mm and held in 10mm

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sieve. Silica fume is utilized to improve the load carrying property. The specific gravity of every concrete ingredient is shown in table 1.

Table- I: Specific gravity and fineness of used materials

Materials	Specific Gravity	Fineness (%)
Cement	3.23	3
Fine aggregate	2.57	3.353
Coarse aggregate	2.79	2.44
PCB	1.01	-
Silica fume	2.3	-

Fig. 1. Printed Circuit Board

B. Mix proportions

Absolutely 7 distinct mixes are tried in this examination with water binder proportion of 0.37 and the total binder substance of 550kg/m3. Concrete mixtures are set up with substitution of PCB with 5%, 10%, 15% and 20%. Additionally, specimens are included with 12% of silica fume to upgrade the mechanical property. Because of silica fume, the rheological property went down. To expand it, B233 was included 1.5% of the binder as additive. The blend extents of every single concrete ingredient are shown in table 2

Table- II: Mix Proportions

Mix Code	Water (kg/m³)	Cement (kg/m³)	FA (kg/m³)	CA (kg/m³)	PCB (kg/m³)	Silica fume (kg/m³)	B233 (kg/m³)
CS	206	550	595	1006	-	-	-
CSCC	206	529	595	1006	-	66	-
CSSF	206	529	595	1006	-	66	8.25
CSF5	206	529	595	956	50.3	66	8.25
CSF10	206	529	595	906	100	66	8.25
CSF15	206	529	595	855	151	66	8.25
CSF20	206	529	595	805	201	66	8.25

C. Mixing procedure

To achieve the homogeneity, laboratory pan mixer was utilized to blend the concrete. Weight batching was accomplished for all concrete ingredients. Initially, fine aggregate, coarse aggregate, and PCBs were blended in dry state for 1min. Then cement and silica fume was introduced and blended well. Once the homogeneity condition was achieved, partial amount of water was added to the blend about 5min. Finally, the rest of the water with B233 included into the concrete mix and blended for another 5min.

III. EXPERIMENTAL WORK

Mix was prepared in a correct proportion and 150x150x150mm cubes are cast. The casted specimens are removed from the mould after 24hrs and cured for compression and durability testing. These samples are tried at 7days, 28days for strength quality test and 56days for durability test. All specimens are compacted in standard technique as three layers with 25 blows. The examples are demolded after 24hrs and cured in water until the date of testing.

Density test was done after 28days of curing. During the test day, the examples are taken out from the curing tank and the samples are oven dried for 24hrs and the heaviness of the example was estimated. Compressive strength test was done in standard Compression testing machine. The load on the specimen was expanded in a slow way up to the failure of the specimen. After 28days curing the cubical example was immerged in sodium sulfate and sodium chloride blended water 5% by weight for 28days to test the strength property of chloride and sulfate resistance. These tests are increasingly significant when managing the sturdiness of cement. Chloride causes corrosion of reinforcement and sulfate will cause the volume change in cement.

IV. RESULT AND DISCUSSION

A. Compression Strength

Absolutely The compressive test is a significant parameter to know the mechanical properties of hardened concrete. This quality investigation was estimated in 7days, 14days, and 28days. For each test three samples, 150 x 150 x 150mm cubes are cast and immerged in water for legitimate curing. The quality of modified concrete is analyzed by the standard control mix. The outcomes are given in table 3.

The compressive strength of control specimen is 26.98MPa in 7days and it is expanded to 36.5MPA and 38.5MPa at 14 and 28days. At first, the table demonstrates that the CSSE gave about 35.1MPa, 40.5MPa, and 43.4MPa and this is the best outcome comparing with every one of the samples. This improvement is accomplished by the pozzolanic impact of silica fume. CSE5 gives critical improvement 27.17MPa, 36.03MPa, and 39MPa in 7, 14 and 28days. By looking at the control sample CSE5 gives the same mechanical property in all the tests.

The outcomes demonstrate the level of e-squander substitution had lower strength value. Increment in PCB results to diminish in quality. At the same time the addition of silica fume expanding the quality. The stature value is acquired by the silica fume supplanted samples with zero rate PSB. Likewise, 5% substitution of PCB as coarse aggregate giving extensive quality when contrasted with the control specimens at 7days, 28days. This is because of the presence of silica fume. The outcome obviously demonstrates that the ordinary concrete itself insufficient for the craving property, that a pozzolanic material like silica fume expected to improve the mechanical property of e-concrete. Fig 2 demonstrates that increasing the PCB substance result in the decline in quality. It is because of the flakiness of the PCB.

Table- III: Test result

Concrete ID	Compressive strength (MPa)			Density test		Sulphate Attack test		Chloride Attack Test	
	7 days	14 days	28 days	Weight	The density of concrete (kg/m^3)	Before exposure (MPa)	After Exposure (MPa)	Before exposure (MPa)	After Exposure (MPa)
CS	26.98	36.5	38.5	8.807	2609.48	36.5	33.33	36.5	18.78
CSCC	19.5	25.3	28.5	8.859	2624.89	25.3	23.11	25.3	19.4
CSSF	35.1	40.5	43.4	9.174	2718.22	40.5	38.44	40.5	35.6
CSF5	27.17	36.03	39	8.452	2504.3	36.03	33.33	36.03	20.9
CSF10	23.5	26.5	38.8	7.82	2317.04	26.5	13.38	26.5	20.67
CSF15	19.5	23.2	26.5	7.475	2214.81	23.2	22	23.2	14.22
CSF20	17.8	20.5	22.8	6.982	2068.74	20.5	14.67	20.5	12.7

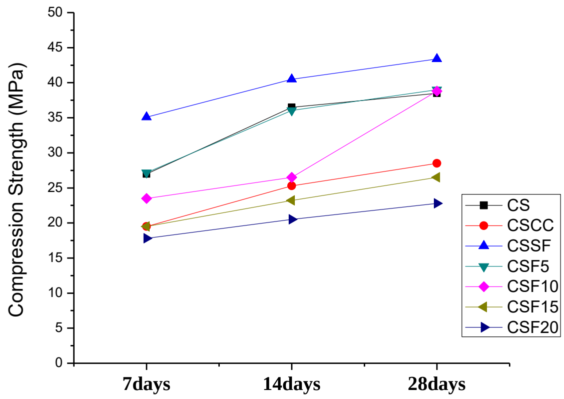

Fig. 2. Compression Strength

B. Density Test

Fig 3 indicates the density of different examples. Three samples unit weight was estimated, and the average value is noted. Looking at the control specimen, PCB introduced samples are got low density up to 20% reduction. The increase of PSB results in the decline of unit weight. This is because of the low specific gravity of circuit boards. The outcomes demonstrate that the silica fume blend specimens are denser than other samples. This test plainly demonstrates that the lightweight cement can accomplish by supplanting the coarse aggregate with a circuit board. By avoiding silica fume in e-concrete may result in a further reduction in density. The reduction in density is also responsible for the reduction in strength. In this way, the utilization e-concrete may fitting where the strength is definitely not an issue.

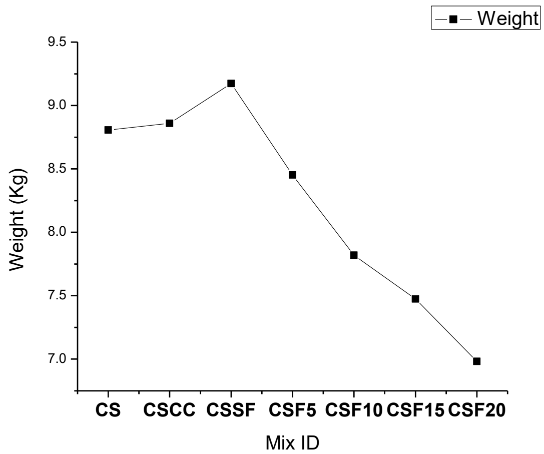

Fig. 3. Weight of specimen

C. Sulphate Attack Test

Numerous ecological conditions will influence the strength of concrete, Sulphate is one of the most harmful for corrosion of concrete. Sulphate lead to expansion of concrete by reacting with unhydrated cement paste. Exposure in sulphate leads to reduction in strength property. Compression test was directed in a standard way to quantify the strength quality. The properties are given in fig 4. The consequence of this test is done in the normal of three samples. The information demonstrates that the most extreme decrease of 60% quality because of the sulfate attack on concrete. Silica fume blended samples are preformed well in the durability test. At an equivalent time, 5% substitution of PCB gives the same outcome as the control specimen.

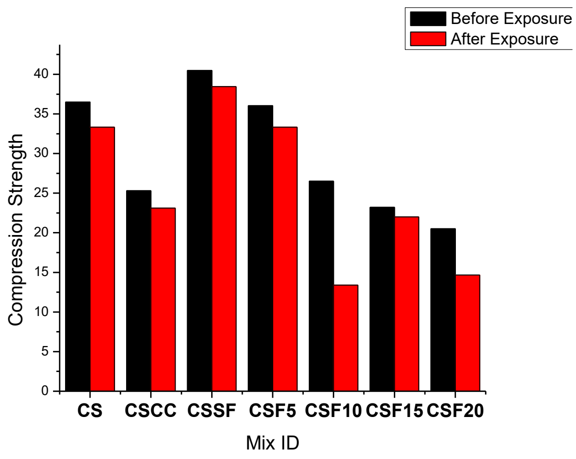

Fig. 4. Sulphate attack test

D. Chloride Attack Test

Fig 5 rundowns the outcome acquired for the sample under 5% chloride exposure. Unmistakably the PCB builds, the chloride obstruction gets diminished. Additions of silica fume give the essential protection from chloride infiltration and accomplish practically 20% ascent in quality than the control specimen. It is seen that there is a significate impact of chloride on the concrete when PSB added. The control specimen also gets up to 50% strength loss. Contrasting with the control sample 5% and 10% substitution of PSB gives more quality in the presence of silica fume. 15% and 20% substitution of PCB, the penetrability of concrete is expanding. In this way, the entered chloride effectively influences the hydration procedure of cementitious materials and it prompts the strength reduction.

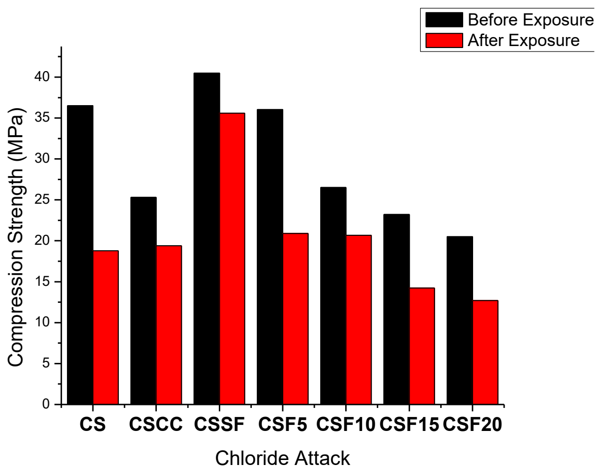

Fig. 5. Chloride attack test

V. CONCLUSION

- The impact of e-waste contamination is mainly of circuit boards, that contains harmful materials. It tends to be decreased by utilizing it in concrete as coarse aggregate. This investigation has demonstrated that to reutilize the e-waste as coarse aggregate in concrete.
- The presence of PCB contributing to the reduction of strength and durability character. So the addition of pozzolanic material like silica fume required to improve the strength and durability property.
- It is presumed that 5% substitution of PCB giving extensive strength and durability property when compared with the control specimen with the presence of silica fume.
- 5% substitution is relatively small, however, the contamination brought by PCB in environment condition and storing, dismantling, recycling cost can get rid of.
- This test unmistakably demonstrates that the lightweight concrete can accomplish by supplanting the coarse aggregate with a circuit board.
- From the test result, the substitution of 15% and 20% of e-waste has highly affected than other concrete mixes.

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