An experimental Investigation on Mechanical properties of concrete by partial replacement of fine aggregate (Sand) with Electronic waste

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ABSTRACT

E-waste or Electronic waste describes discarded electrical or electronic devices coming from used electronics which are destined for reuse, resale, salvage, recycling or disposal. Informal processing of electronic waste in developing countries may cause serious health and pollution problems, as these countries have limited regulatory oversight of e-waste processing. The main aim of the study is to investigate the changes in mechanical properties of concrete with addition of e wastes in different portions from 0 to 30% to the concrete by partial replacement of fine aggregate. Based on the experimental study it is found that the use of e-waste aggregates results in the formation of light weight concrete hence subsequently reducing the dead weight of the structure. In present study the e-waste based concrete cubes and cylinders were cast manually and the strength of the test concrete in terms of compression and split tension were experimentally evaluated. It is found that the strength of e waste replaced concrete in terms of compression and split tension can be comparable with the conventional concrete.

Keyword: - *Concrete, dead weight, E-waste, Specimen Preparation, Testing*

1. Introduction

Research concerning the use of by-products to augment the properties of concrete has been going on for many years. Reuse of electronic waste in concrete industry is considered as the most feasible application. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains serious contaminants such as lead, cadmium, Beryllium etc. This Investigation deals with the non-hazardous and inert components of E-waste generated out of Obsolete Computers, TV Cabins, Refrigerator, Mobile phones and washing Machine etc. The major objective of this task is to reduce as for as possible the accumulation of used and discarded electronic and electrical equipment's and transfer waste into socially and industrially beneficial raw material using simple, low cost and environmental friendly technology. The main aim of the study is to investigate the changes in mechanical properties of concrete with addition of e waste with different proportions (from 0% to 30%) as a partial replacement of fine aggregate. Hence the utility of non-biodegradable components of E waste in production pursuits is the noteworthy solicitude of the task established now a days.

1.2. Advantages of electrical waste

- Keeps the environment clean and fresh
- Saves the earth and conserves energy
- Reduces environmental pollution
- Waste management will help you earn money
- Creates employment
- E-waste has good compressive and flexural strength.
- E-waste offers good performance to chemical acid attacks.
- Better workability
- Provides economical and safe disposal of e-waste.
- Easy manufacturing technique.
- Considerable change in self-weight of concrete.

1.3. Objectivities of the present Study

- To detect an alternative material for river sand in the production of cement concrete.
- The valuable cost and shortage of river sand has persuaded to a crisis where in a novel material has to be established out in order to boon the structure corporation.
- To procure and process the e waste.
- Convert e-waste materials into e waste fine aggregates by grinding the e waste chips to the required grain size distribution of fine aggregates.
- To produce the E-waste concrete of M25 Grade.
- To study the effect on workability and density of the different mixes (different proportions of E-waste fine aggregate) at constant W/C ratio.
- To study the strength properties of e-waste concrete by casting specimens (cubes, cylinders and beams) and curing it for 7 days, 14, and 28 days.
- To study the durability properties of e-waste concrete.
- Cost analysis of the e-waste concrete.

1.4. Outcome of the present study:

- The replacements with E-waste will positively benevolence the structure corporation awaited to the scantiness of river sand.
- Exploitation of scrap materials and corollaries is a resolution to green and biological complications.

1.5. Methodology of the study:

- Literature survey was carried out to review previous studies related to this thesis
- All the required materials were collected and delivered to the laboratory prior to initiate the test. These are; Cement, fine aggregate, coarse aggregate.
- Tests were conducted on the raw materials to determine their properties and suitability for the experiment
- The series of the cubes were casted in the laboratory and necessary curing shall be done to achieve the 28 days compressive strength.
- Static load test were carried out on the prepared concrete continuous beam samples.
- The data collection was mainly based on the tests conducted on the prepared specimens in the laboratory.
- The test results of the samples were compared with the respective control concrete properties and the results were presented using tables, picture and graphs. Conclusions and recommendations were finally forwarded based on the findings and observations.

2. LITERATURE REVIEW

Lakshmi. R and Nagan. S [1] Studies on Concrete containing E plastic waste. This study intended to find the effective ways to reutilize the hard plastic waste particles as concrete aggregate. The compressive strength and split tensile strength of concrete containing e-plastic aggregate is retained more or less in comparison with controlled concrete specimens. However strength noticeably decreased when the e plastic content was more than 20%.

Bahoria B.V., Parbat D.K. and Naganaik P.B. [2] have studied on Replacement of Natural sand in concrete by waste product. A State of The partial replacement of river sand with 20% CGF is recommended for use in concrete production for use in rigid pavement. Where crushed granite is in abundance and river sand is scarce, the complete replacement river sand with CGF is recommended for use in low to moderately trafficked roads.

Awanish Kumar Shukla [3] has presented experimental investigation on Application of CNC Waste with Recycled Aggregate in Concrete Mix. It is found that up to 50% replacement of natural coarse aggregate by recycled coarse aggregate (in addition to 2% CNC lathe waste) increases the compressive strength. There was 11% increment in compressive strength.

Kurian Joseph[4] have studied on Electronic Waste Management in India –issues and strategies. Solid waste management, which is already a mammoth task in India, is becoming more complicated by the invasion of e-waste, particularly computer waste. There exists an urgent need for a detailed assessment of the current and future scenario including quantification, characteristics, existing disposal, practices, environmental impacts etc.

3. Experimental Investigations:

The properties of the materials used in the experimental work are presented in this chapter. The material specifications for cement, fine aggregate, coarse aggregate and admixtures are discussed. The various tests like sieve analysis, specific gravity, Sieve analysis etc. was done for sand, e-waste and coarse aggregate to test their suitability to use in concrete.

3.2. Tests on cement

Table -1: Properties of Cement (PPC)

Sl. No	Properties	Values obtained	Standard values
1.	Specific gravity	3.0	3.15
2.	Normal consistency	31%	30%
3.	Initial and Final setting time	30 min and 580 min	Not less than 30 min Not greater than 10 hrs

Table -2: Fineness Modulus of cement (PPC)

S.No	Description	Trial 1	Trial 2	Trial 3	Fineness of Cement (%)
1.	Initial weight of sample (g)	100	100	100	5.66

3.3. Tests on fine aggregate

Table -3: Properties of fine aggregate

Properties	Values obtained
Specific gravity	2.60
Water absorption	1.01
Fineness Modulus	2.46

3.4. Tests on Coarse aggregate

Table -4: Properties of coarse aggregate

Properties	Values obtained
Specific gravity	2.74
Sieve Analysis	6.17

3.5. Tests on Electrical waste

Table -5: Sieve analysis of electrical waste

Sieve No. (mm)	Weight Retained (g)	Cumulative Weight Retained(g)	Cumulative% Retained	% Passing
4.75	0	0	0	100
2.36	0	0	0	100
1.18	135	135	27	73
0.6	70	205	41	59
0.3	260	465	93	7
0.15	30	495	99	1
<0.15	5	500	100	0

Fineness modulus of electrical waste = 2.60

3.6. Tests on Concrete

The following tests were conducted on concrete and concrete specimens at different ages

- Slump test
- Compressive strength test
- Split tensile strength test
- Flexural strength test
- Durability test

Table 6 Compressive Strength of concrete

Mix type	Compressive strength, N/mm2-M25 Grade				
	7 days	14 days	28 days	56 days	90 days
Control mix Grade)	19.56	25.43	33.22	35.22	36.11
MIX 10	19.13	21.22	31.83	32.76	33.11
MIX 20	18.30	19.76	26.42	28.25	29.56
MIX 30	17.78	18.12	24.23	26.74	27.43

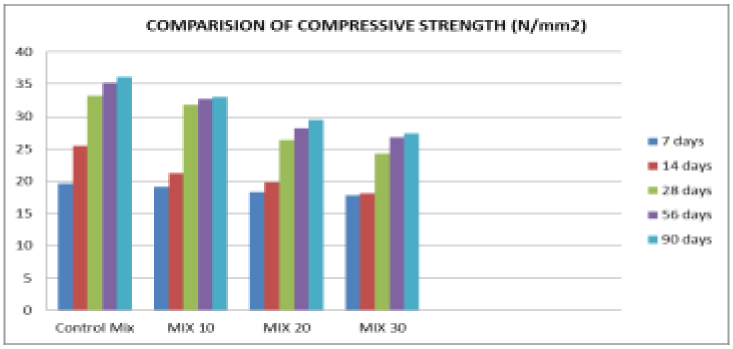

Chart -1: Comparison of Compressive strength

Fig-1: Compressive Strength of concrete

Table 7: Split Tensile Strength of concrete

Mix type	Split tensile strength, N/mm2-M25 Grade				
	7 days	14 days	28 days	56 days	90 days
Control mix	2.310	2.68	3.4	3.58	3.66
MIX 10	2.06	2.32	3	3.15	3.23
MIX 20	1.98	2.17	2.8	3.08	3.14
MIX 30	1.80	2.02	2.4	2.6	2.86

Fig-2: Flexural Strength of concrete

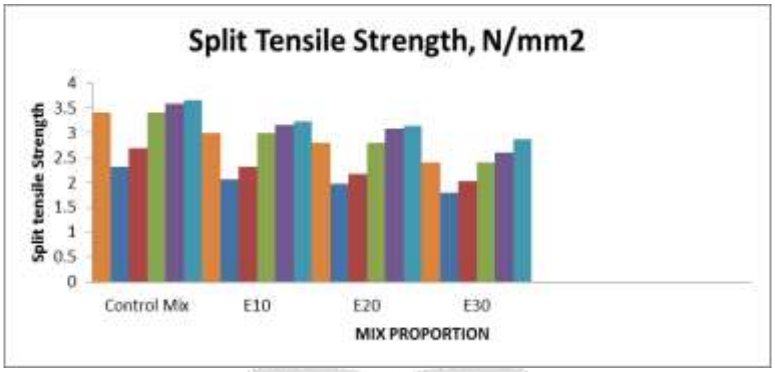

Chart -2: Comparison of Split tensile strength

Table 8: Flexural Strength of concrete

Mix type	Flexural strength, N/mm2-M25 Grade				
	7 days	14 days	28 days	56 days	90 days
Control mix	7.1	7.67	8.67	8.83	8.98
MIX 10	6.32	6.75	7.8	8.39	8.56
MIX 20	5.72	6.40	7.12	7.74	8.10
MIX 30	5.33	5.76	6.72	7.13	7.59

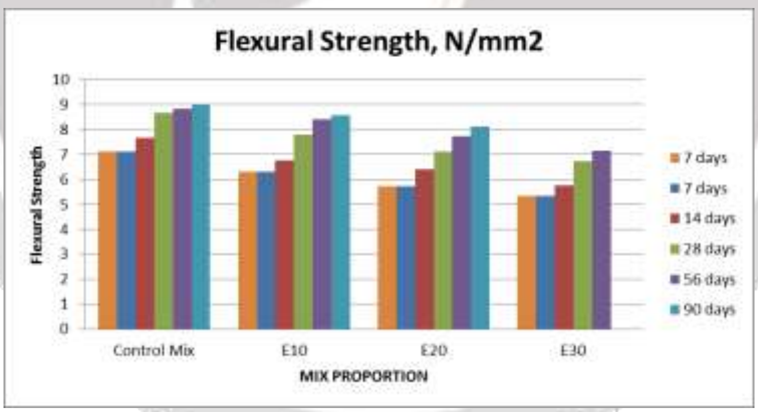

Chart -3: Comparison of flexural strength

3.7. Durability Test (Chemical attack test)

The specimens were subjected to chemical attack test in order to ensure its durability, if concrete is exposed to adverse effects of chemicals in its lifetime. Once the concrete specimens had attained their target strength that is after 28 days curing period, the specimens were taken out of curing tank and were left to dry for 24 hours..Once the specimens were dry, initial weight of the specimens (different mix proportions) were taken. Then the specimens were immersed into acid solution to carry out and curing is being done for 28 and 56 days. Sulphate attack test was done by immersing specimens into 6% Sodium Sulphate solution (Na2S04+94% water). Chloride attack test was done by immersing the specimens into 6% hydrochloric acid solution (6% Hcl+94% water). The acid concentration was maintained throughout the acid curing period to ensure uniformity. After 28 and 56 days period, the concrete specimens were taken out of the acid solution and kept for drying (24 hrs period). Final weights of the specimens were taken and calculated the percentage weight loss from initial and final weights and also determine the percentage strength loss.

Table 9: Weight Loss in Percentage Due to Sulphate Attack

Mix type	28 days	56 days
Control mix	1.2	1.75
MIX10	0.68	0.89
MIX 20	0.42	0.77
MIX 30	0.4	0.7

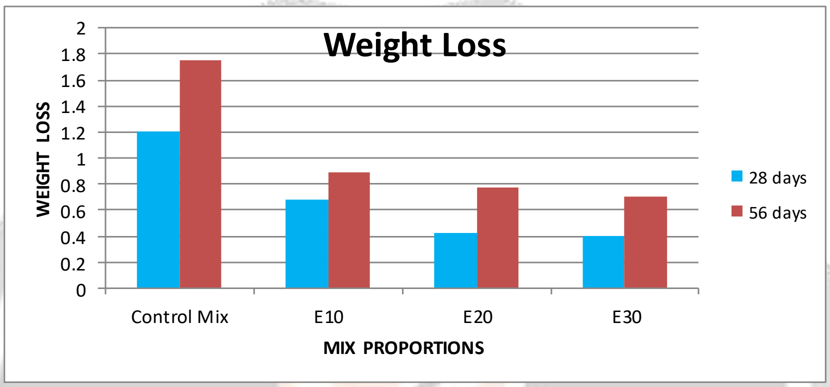

Chart -4: Weight Loss in Percentage Due to Sulphate Attack

Table 10: Strength Loss in Percentage Due to Sulphate Attack

Mix type	28 days	56 days
Control mix	5	8.3
E10	3.4	6
E20	2	4.5
E30	1.8	3.9

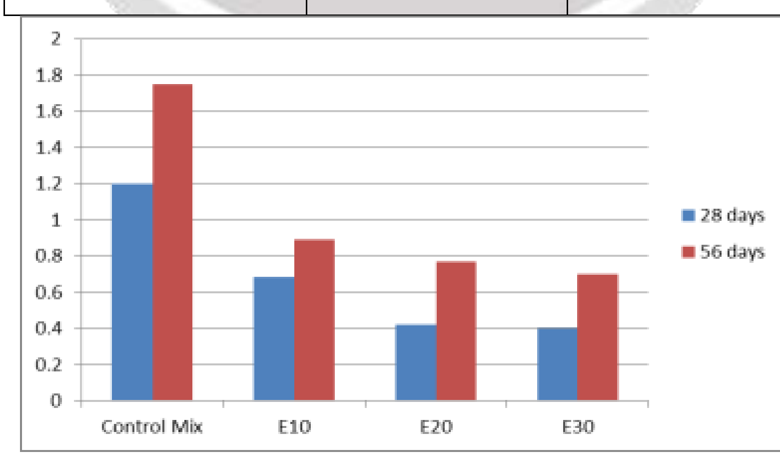

Chart -5: Strength Loss in Percentage Due to Sulphate Attack

Table 11: Weight Loss in Percentage Due to Chloride Attack

Mix type	30 days	60 days
Control mix	1.4	2.1
MIX 10	0.8	1.65
MIX 20	0.75	1.2
MIX 30	0.57	0.9

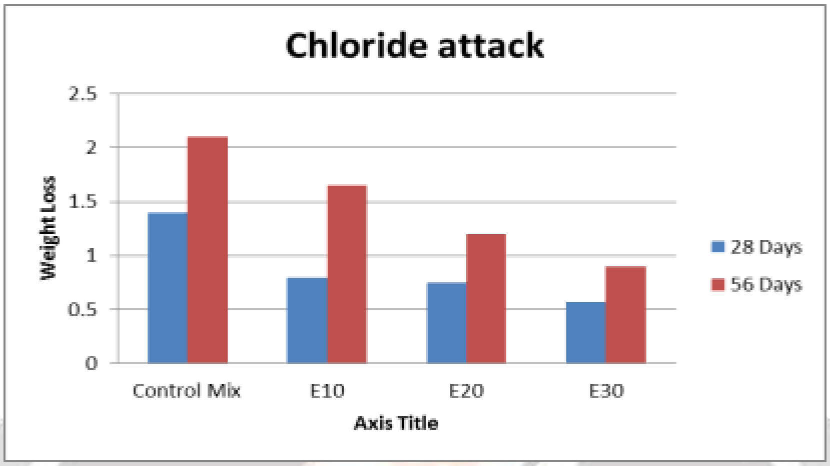

Chart -6: Weight Loss in Percentage Due to Chloride Attack

Table 12: Strength Loss in Percentage Due to Chloride Attack

Mix type	30 days	60 days
Control mix	7.5	10
MIX 10	6.2	8.1
MIX 20	5.8	7.4
MIX 30	4.7	6.3

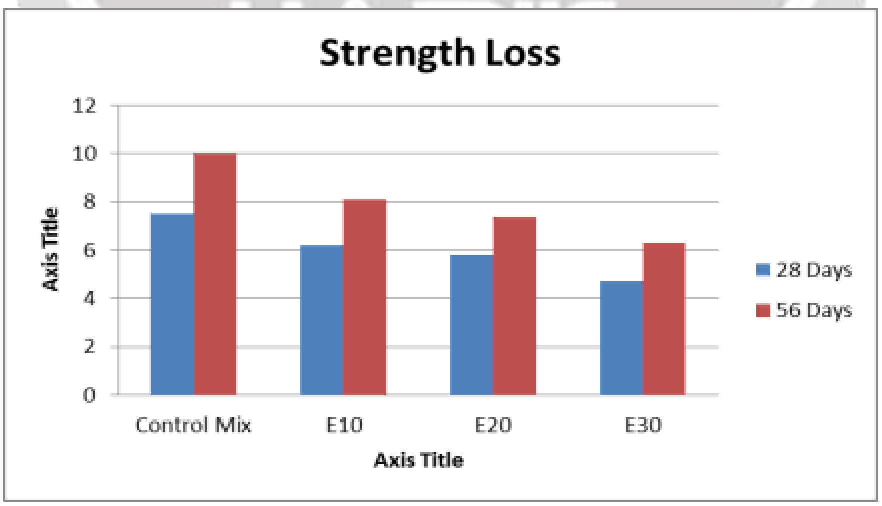

Chart -7: Strength Loss in Percentage Due to Chloride Attack

3.8. Cost analysis:

Cost of the Materials is an important as the beneficiary properties of different materials in a construction project. As it is well-known fact that material cost constitute a major portion of the total cost of the projects. Hence to sustain economic feasibility, it's important to develop and study cost analysis for the different materials that are used in the project.

Table 13: Rates of the different materials:

S. No	Material	Unit	Rate per unit in Rs.
1	Cement (PPC)	MT	7500
2	20mm Metal	Cum	1250
3	River Sand	Cum	1760
4	e-waste	Kgs.	1.5
5	Admixture	Liters	65
6	Water	K Lit	100

Table 14: Cost Analysis for Control Mix:

S. No	Description	Unit	Rate per Unit	Coefficient	Amount
1	Cement	MT	7500	0.41	3,075
2	Fine Aggregate	Cum	1760	0.285	501
3	Coarse aggregate (20mm metal)	Cum	1250	0.569	712
4	Admixture	Liters	65	1.025	67
5	Water	K Lit	100	0.164	16
	Total Cost in Rs per Cum				4,371

Table 15: Cost Analysis for Mix 10:

S. No	Description	Unit	Rate per Unit	Coefficient	Amount in Rs.
1	Cement	MT	7500	0.38	2,850
2	Fine Aggregate	Cum	1760	0.252	444
3	Coarse aggregate (20mm metal)	Cum	1250	0.504	630
4	Admixture	Litres	65	1.025	67
5	Water	K Lit	100	0.152	15
6	e-waste	Kgs	1.5	52	78
	Total Cost in Rs. per Cum				4,083

Table 16: Cost Analysis for Mix 20:

S. No	Description	Unit	Rate per Unit	Coefficient	Amount in Rs.
1	Cement	MT	7500	0.38	2,850
2	Fine Aggregate	Cum	1760	0.224	394
3	Coarse aggregate (20mm metal)	Cum	1250	0.448	560
4	Admixture	Liters	65	1.025	67
5	Water	K Lit	100	0.152	15
6	e-waste	Kgs	1.5	105	158
	Total Cost in Rs per Cum				4,044

Table 4.24: Cost Analysis for Mix 30:

S. No	Description	Unit	Rate per Unit	Coefficient	Amount
1	Cement	MT	7500	0.38	2,850
2	Fine Aggregate	Cum	1760	0.185	326
3	Coarse aggregate (20mm metal)	Cum	1250	0.37	463
4	Admixture	Liters	65	1.025	67
5	Water	K Lit	100	0.152	15
6	e-waste	Kgs	1.5	213	320
	Total Cost in Rs per Cum				4,039

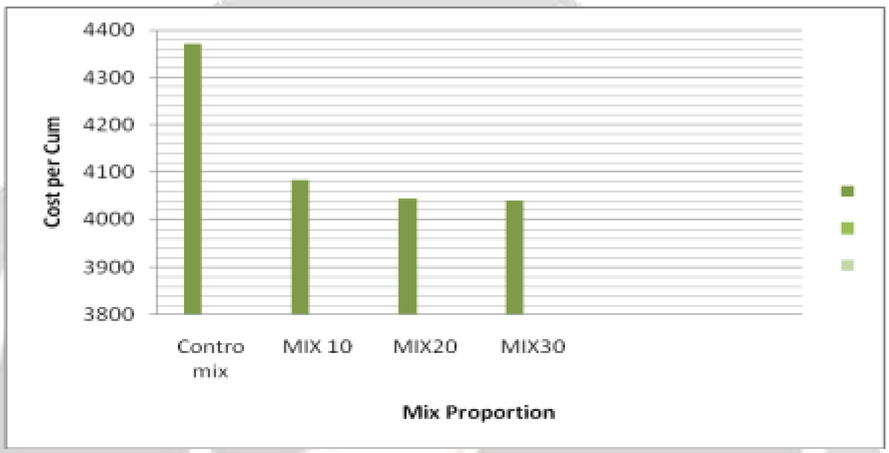

Chart -8: Cost comparison with deferent e waste proportions

4. CONCLUSIONS

- The inference from the analysis conducted on E-waste concrete is outlined as follows:
- The workability of the E-waste concrete mix increases with increase in percentage in e-waste in concrete.
- The viability of the concrete dwindles as the proportion of alternate of fine aggregates with Electronic waste accumulates. Presumption is executed with the slump estimate manifest which one is observe as a notch of workability. This may benefit in monitoring bleeding and segregation in concrete.
- Self-weight of concrete reduces when there is rise in E-waste percentage. Hence it can be consumed as a light weight concrete.
- The yield of concrete reduces when E-waste is used as a replacement material for sand.
- It is coherent that E-waste can be biased by using them as constructional material.

- The compressive strength and split tensile strength of concrete pertaining to E-waste aggregate is slightly lesser in comparison with control mix concrete sample.
- From the durability test (Chemical attack) is evident that the e-waste concrete offers more resistance to the chemicals.
- Due to the high durable property of EC, it may be used in marine conditions.
- Utilization of e-waste in concrete may be the efficient and economical and the best way of disposing the e-waste which is now the fastest growing solid waste in the world.

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