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Research Article

EXPERIMENTAL STUDY ON E–WASTE CONCRETE AND COMPARING WITH CONVENTIONAL CONCRETE

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ABSTRACT

The solid waste management is regarded to be one of the fastest arising waste streams in the world, especially the waste from Electric and Electronic equipment's (WEEEs). The waste utilization is sustainable solution to the environmental problem and use of waste materials reduces the cost of concrete in the production of house building environment. This paper presented an experimental work have been done to determine the effects of recycled concrete aggregate (RCA) under the curing conditions of 2.1 pH in sulphuric acid (H_2SO_4) and 0.5 N in Hydrochloric Acid (Hcl) severally. The replacement percentages of RCA were 0%, 5%, 10% and 15% respectively. The partial replacement of RCA to achieve the mechanical properties (compressive and flexural strength) and chemical properties (corrosion resistance and alkali attack) of concrete by utilizing E–waste as compared with the ordinary conventional concrete. The present study aspire that the major work has been replacing of E–waste in the production of low cost concrete in civil engineering society.

INTRODUCTION

Now-a-days, the world facing a real challenge is disposal of solid waste in particular E- waste without inducing any environmental issues. Electronic waste accounts that obsolute, broken, surplus, and loosely discared electrical or electronic devices (Krishna and Kanta, 2014; Suchithra, *et al*., 2015). In India, the primary source of E–waste is public and private sector institutions which leads 70% of the total waste (Balasubramanian, *et al*., 2016). The estimated annual generation if electronic waste is 4,00,000 tons that is (10-15%) approximately. The wates are generated from the top cities such as Mumbai, New Delhi, Bangalore and Chennai were calculated to be 10,000 tons, 9,000 tons, 8,000 tons and 6,000 tons repectively. But from these soureces 4% only recycling of it (Vivek, *et al*., 2015). The need for disposal of E–waste several tons per year due to its increasing manner. The efforts have been made to use the components of E–weaste as a partial replacement of (10-12.5 mm) the coarse aggregate in the field of construction. Utilization of crushed E–waste materials as a conventional concrete and other materials in the building construction, helps in reducing the cost of concrete manufacturing. It is the most important method to reduce the quantity of E–waste as well as to achieve an eco–ffriendly concrete and protecting environment from the effect of pollution (Bavan and Yogendra, 2015). Many researchers examined the mechanical properties of RCA (Valeria, 2010; Rasiah, *et al*., 2012; Belen, *et al*., 2011; Xiao, *et al*., 2006; Amnon, 2003; Poon, *et al*., 2004; Arundeb, *et al*., 2011; Shi-cong, *et al*., 2011; Katrina and Thomas, 2013), only few of them studied the effects of curing conditions on the mechanical behaviour of RCA (Lakshmi and Nagan, 2011). The objective of the experimental work have been done to exhibit the mechanical and chemical properties such as compressive strength, flexural strength, corrosion resistance and alkali attack under different curing conditions. E waste reinforced concrete elements behave as a non corroded concrete structural elements. This study to check the efficiency of concrete by using the E waste in it and to improve the strength of concrete using Portland cement.

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LITERATURE REVIEW

Generation of E–waste is one of the most dissipated developing waste streams and estimated from the rate of expansion is doubled every year. One of the best solutionto this crisis lies in recycling wastes into paricable own growth. Krishna Prasanna et al. examined the strength variations by using E–waste as a coarse aggregate in concrete. This study shows that more than 20% of partial replacement of coarse aggregate is not suitable to replace the fine aggregate doe to the decreasing strength (Krishna and Kanta, 2014). (Balasubramanian, *et al*., 2016) investigated the production of new concrete with the partial replacement of coarse aggregate using E–waste. No materials possessing the properties of concrete in terms of strength, durability and workability, the total replacement is not possible. This experimental work determined the compressive strength, tensile strength and flexural strength of concrete but utilizing the electronic waste as a partial replacement for coarse aggregate with different percentages (Balasubramanian, *et al*., 2016).

(Kulkarni, *et al*, 2016). conducted the experimental investigation on modulus of elasticity of recycled aggregate concrete (RAC). Modulus of elasticity (E) is an important factor that indicates the stiffness characteristics which depends on the replacement percentage of RAC. The experimental study described that E value decreases due to the increase of the replacement percentage of RA in concrete. Also the compressive strength decreases with increase in the replacement percentage of RAC which can be accomplished by RAC for various grades if concrete.

(Aditya, *et al*., 2016) carried out the experimental work have been made to use non–biodegradable components of E–waste (plastic) as a partial replacement of coarse aggregate. The effoerts of work exhibits that good strength in the concrete with 10% replacement of M20 grade. Also it was replace with the river sand as compared with the control specimen will reduce the essential for conventional coarse aggregates.

(Nadhim, *et al*., 2016) investigated the comparative study on E–plastic waste and fly ash concrete with conventional concrete. This study shows that E–plastic waste as coarse aggregate which is compared with the fly ash as cement that improves the strength and durability. Also reduces the bleeding, segregation and lower the heat of hydration (Nadhim, *et al*., 2016). The literature study shows that 0–20% replacement of E–waste in concrete is giving improvement in compressive and flexural strength. However, strength is decreases when E–waste content is more than 20%.

MATERIALS AND METHODS

A. **Materials used**

Fifty three grade type I ordinary Portland cement is used for general concrete structure, preffered according to (Indian Standard) IS 12269:1987. The experimental work have been done using ordinary cement for the comparative study of E–waste concrete and conventional concrete. River sand was used as coarse aggregate as per IS 383–1970 for E–waste and conventional concrete. E–waste is the material for replacement of coarse aggregate. Aggregates are the important component gives body to the concrete, reduce shrinkage and greater durability. The coarse aggregate materilas less than 4.75 mm are used for conventional concrete. Water is an important component of concrete participates in the chemical reaction with cement. The pH value of water used in concrete shall not be less than 6. The portable water can be used for mixing and curing IS 456:2000 (Table 1).

Table 1. Properties of E-waste

Properties	Values
Specific gravity	1.20
Water absorption (%)	0.20
Crushing value (%)	2.35
Fineness	2.50

B. **Mix proportions**

To design M25 grade concrete

Characteristic strength = 25 N/mm^2

Degree of quality control = good

Maximum size of aggregate = 20 mm

Specific gravity of coarse aggregate = 2.71

Specific gravity of fine aggregate = 2.38

Specific gravity of cement = 3.46

Type of exposure = Moderate

Type of usage PCC structure

Grading of sand zone is II as per sieve analysis results

Weight of water = 180 kg/m^3

Weight of cement = 450 kg/m^3

Weight of fine aggregate = 704.89 kg/m^3

Weight of coarse aggregate = 1150.1 kg/m^3

EXPERIMENTAL INVESTIGATIONS

A. **Determination of fineness of cement**

Weight of the sample of cement W_1 = 100 g

Weight of the residue W_2 = 8 g

Fineness index of the sample = $(W_2/W_1) \times 100$ = 8%

B. **Determination of normal consistency of cement**

Percentage of water by weight of dry cement required to prepare cement paste of standard consistency, P = (W/C) × 100

Percentage of water to prepare standard consistency = 31% (Table 2).

Table 2. Normal consistency test on cement

S. No.	Weight of cement (gm)	Quantity of water added (%)	Weight of water added (gm)	Reading on Vicat apparatus (mm)
1	400	25	100	31
2	400	27	108	22
3	400	29	116	13
4	400	31	124	6

C. **Concrete mix**

The concrete mixes were assigned with the use of type of fine aggregate and grade of the concrete. The percentage replacement of E-waste added by 0%, 5%, 10% and 15% with a w/c ration of 0.5%. The various replacement of E-waste levels are presented in the Table 3.

Table 3. Details of concrete mix

Mixing specifications	Control mix 1	Control mix 2	Control mix 3	Control mix 4
E-waste proportion	0%	5%	10%	15%

D. **Preperations of test specimens**

The concrete of various specimens were prepared for different mixes with added cement and E-waste. After that water was added and the mixing was continued until the consistent mix was obtained and the concrete was placed in the moulds. For compressive strength and durability test, cubes of size 150 × 150 × 150 mm were cast. For flexural strength test, corrosion resistance and alkali attack test, beams of size 230 × 300 × 1000 mm were cast and curing for 28 days. The size, shape and dimensions of the specimens are listed in the Table 4.

Table 4. Details of test specimens

Test details	Size, Shape and dimensions of the specimens
Compressive strength	Cube: 150 × 150 × 150 mm
Flexural strength	Beam: 230 × 300 × 1000 mm
Durability strength	Cube: 150 × 150 × 150 mm
Corrosion resistance	Beam: 230 × 300 × 1000 mm
Alkali attack	Beam: 230 × 300 × 1000 mm

RESULT AND DISCUSION

A. **Compressive strength**

Compressive strengths were measured using a compression testing machine with a maximum capacity of 2000 KN. For all tests, each value was taken as the average of three samples. Test results for conventional concrete for both 7 and 28 days curing were tabulated in Table 5. The compressive strength is defined as resistance of concrete to axial loading. The dial gauge readings were recorded and the compressive strength was calculated (Lakshmiand and Nagan, 2010).

Table 5. Compressive strength results for conventional concrete cubes

Days of testing	Mix specifications	Fresh concrete weight (kg)	Dry concrete weight (kg)	Load (KN)	Compression N/mm^2
7 days	5%	8.450	8.430	374	16.6
7 days	10%	8.445	8.425	378	16.8
7 days	15%	8.440	8.420	454	20

Compressive strength =Maximum load/Cross sectional area (Fig. 1 and 2).

Fig. 1 Cube specimen for testing.

Fig. 2 Compressive strength testing.

B. **Compressive strength testing**

From the table, the maximum compressive strength is obtained by when replacing 15% of coarse aggregate by E-waste in concrete. The compressive strength for 7 and 28 days are presented in the Table 5 and Table 6.

C. **Flexural strength**

The flexural behavior of the beams shows that structural properties similar to the load–deflection curve pattern. Before cracking, The linear slope of the load–deflection curve was steep occurred in all testing beams due to the stiffness reduction, The flexural cracks were observed from the change in slope of the load–deflection (Fig. 3). Flexural strength can be described as the capacity of a beam to resist failure due to bending [19].

Table 6. Compressive strength results for conventional concrete cubes

Days of testing	Mix specifi-cations	Fresh concrete weight (kg)	Dry concrete-weight (kg)	Load (KN)	Compres-sion N/mm^2
28 days	5%	8.450	8.430	714	31.733
28 days	10%	8.445	8.425	737	32.75
28 days	15%	8.440	8.420	914	40.622

Fig. 3 Beam for flexural strength testing.

$F_b = (pl)/(bd^2)$

Where,

p = Maximum load applied (N),

I = Supported length of the specimen (mm)

b = Measured width of the specimen (mm)

d= Measured depth of the specimen at the point of failure (mm)

The experimental result for flexural strength is given in the Table 7. From the Table 7, the flexural strength is maximum when replacing 15% of coarse aggregate by E-waste in concrete (Fig. 4 and 5).

Table 7. Flexural strength result for conventional concrete

Specimen	Load (KN)	Deflection (mm)
1	156	5.11

From the Table 8, the ultimate crack deflection for 5%, 10% and 15% of H_2SO_4 were found to be 4.26,6.23 and 3.88 with loads 272, 192 and 180 respectively. Also the ultimate crack deflection for 5%, 10% and 15% of Hcl were found to be 5.08,6.19 and 3.81with loads 228, 196 and 180 respectively.

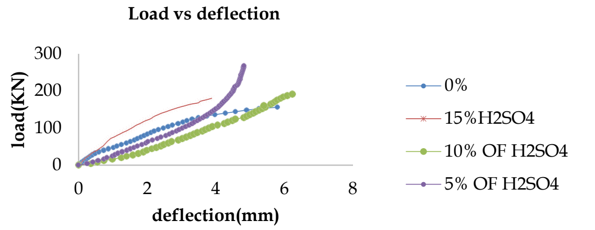


Fig. 4 Partial replacement aggregate of e-waste beam H_2SO_4 curing.

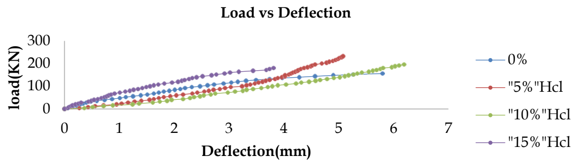


Fig. 5 Partial replacement aggregate of e-waste beam HCl curing.

Table 8. Flexural strength of load deflection value

Acids	Mix proportions of E – waste	Load (KN)	Deflection N/mm^2
H_2SO_4	5%	272	4.26
	10%	192	6.23
	15%	180	3.88
HCl	5%	228	5.08
	10%	196	6.19
	15%	180	3.81

D. **Corrosion resistance**

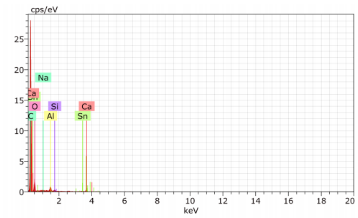
Corrosion resistance refers to the resistance a material offers against a reaction with adverse elements that can corrode the material. From the (Fig. 6) it shows that the E–waste materials in the concrete does not influenced by sulphate under the curing condition of 2.1 N of H_2SO_4 for 28 days.

Fig. 6 Corrosion resistance under the curing condition of 2.1 N of H_2SO_4.

E. **Alkali attack**

Alkali–aggregate reaction which occurs over time in concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates. This reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete. It can cause serious expansion and cracking in concrete, resulting in major structural problems and sometimes necessitating demolition. From the (Fig. 7 and 8), the beam cause without any damage and cracks under the curing conditions of 0.5 pH of HCL for 28 days.

Fig. 7 Alkali – aggregate reaction under the curing conditions of 0.5 pH of HCl for 28 days.



Spectrum: training

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
C	6	K-series	79.80	79.80	84.80	11.19
O	8	K-series	18.16	18.16	14.48	3.61
Sn	50	L-series	0.67	0.67	0.07	0.14
Al	13	K-series	0.61	0.61	0.29	0.07
Na	11	K-series	0.40	0.40	0.22	0.07
Ca	20	K-series	0.23	0.23	0.07	0.16
Si	14	K-series	0.14	0.14	0.06	0.04
		Total:	100.00	100.00	100.00	

Fig. 8 E-waste sample testing results for chemical properties.

CONCLUSIONS

According to the experimental results, we can concluded that:

1. Utilization of patial replacement of E–waste as a coarse aggregate is the best alternative for the conventional concrete.

2. The disposal of E–waste can be used as a coarse aggregate provides the reduction in burden on landfill disposing and environmental pollution.

3. The E–waste concrete density is less as compared with the conventional concrete which reduces the cost of the concrete and produces the light weight concrete structure.

4. The results shows that the good strength, greater durability and addition of E–waste exhibits increase in compressive strength upto 15% replacement.

5. The use of EWC is potential to improve the mechanical and chemical properties which rends eco–friendly concrete.

6. The corrosion resistance reaction shows that the EWC does not tempted by sulpur under 2.1 N curing conditions of H_2SO_4.

7. Alkali aggregate reaction exhibits the beam cause without damage and crack under 0.5 pH curing conditions of Hcl.

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