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Effect of Curing Regimen on Mechanical Properties of Electronic Waste

P. K. Hinge[1], Revat Sawant[2], Sayam Padwe[3], Rajan Lothe[4], Riya Pathrabe[5] and Megha Akotkar[6]
[1]Assistant Professor, Department of Civil Engineering, Yeshwantrao Chavan college of Engineering, Nagpur, Maharashtra, India
[2-6]Under Graduate Student, Department of Civil Engineering, Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India

***Abstract*— A great need is the long-term fixes as the building sector uses massive resources of nature. In the meantime, with the growth of technologies, electronic garbage, also called e-waste, is gradually increasing in size, and its disposal has severe environmental effects. The utilisation of electronic waste in producing concrete as a temporary substitute for natural sand is one of the possible solutions. This paper has examined the influence of the curing period regarding the mechanical characteristics of "M40 grade concrete. When e-waste is used in place of coarse aggregate partially. Ponding which was a popular construction technique was employed as the treatment. Specimens of concrete were cast and tested in flexural, split tensile and compressive strength after 7, 14 and 28 days of curing. The result of the experiment have shown that it is possible to use e-waste in concrete, and the mechanical properties of the material are not worse than the ones of the regular one, thus showing that one can use the material as a sustainability source. The report points out that even though alternative resources have been used like e-waste, the curing should be done to achieve the desired strength and durability that concrete offers. Overall, this work of literature shows the advantages of minimizing wastes to the environment and utilizing building materials that are environmentally friendly. It also creates the insertion to further studies of other curing processes and non-destructive tests like chemical resistance like other scientists like non-destructive tests, which will aid in ascertainment of applicability of e-waste concrete in the actual situation.**

***Index Terms*— E-waste concrete, curing regimen, M40 grade, mechanical properties, ponding, sustainability.**

I. INTRODUCTION

The increase in electronic trash (e waste) has been very steep due to industrial and technical advances and due to the toxicity of the material it is hard to dispose of safely. E trash can also be used as a replacement of conventional aggregates in concrete, which is a sustainable method of reducing landfills and saving natural resources [1]. As found in research, the e waste concrete that has been well developed can potentially retain or even improve important properties such as; as durability, workability and compressive strength and therefore a balance between structural performance and environmental goals can be achieved [2].Curing influences greatly the hydration and long-term performance of such mixtures. This paper thus compares two curing regimes; ponding and gunny bag curing to evaluate how various moisture regimes impact on the strength and durability of waste concrete and which of the two regimes is most applicable in practical applications [3][4].

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Thus, the usage of such materials may satisfy construction demands while also ensuring environmental sustainability. E waste items, such as plastics and crushed electronic devices, have a low density and enough hardness, making them suitable for replacing some of the natural coarse aggregate in concrete. Their use conserves natural resources, provides a less destructive disposal method, and has the potential to extend service life through properties such as chemical assault resistance [4].

Furthermore, most studies demonstrate that light-weight structural components may be made from e-waste concrete, potentially saving on total building costs [5].

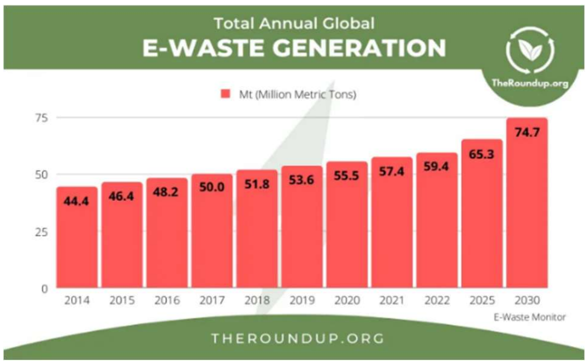

Figure 1. Generation of E-Wase every year

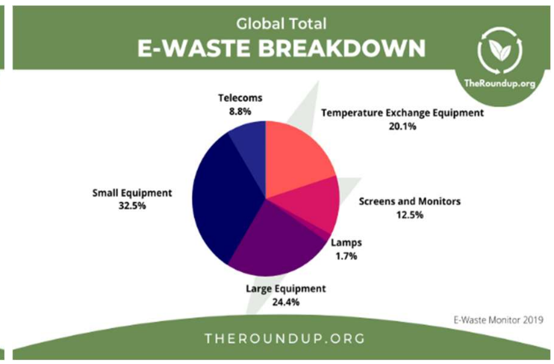

Figure 2. Composition of materials in E-Waste

Figure 1 shows the rapid increase in e-waste generation globally. As shown in figure 2, the composition of e-waste mainly consist of large and small equipments, but the impacts of various curing activities, notably on long-term performance indicators such as acid resistance and non-destructive examination outcomes, have been heavily emphasized [6][7].

This is an open field of knowledge, which restricts our understanding of the long term behavior of e-waste concrete and emphasizes the necessity for study into different curing regimes and their impact on service durability [7].

II. Materials and Methods

A. Materials

The cement used was OPC 53 grade because of its consistency in boosting the strength of high-grade mixtures [7]. A fine aggregate material was river sand that met IS:383 standards and was surface dry. Crushed industrial trash was utilized to replace some of the natural coarse aggregate. Crushed electronic debris (mainly plastic and ceramic bits from discarded gadgets) was utilized to replace a portion of the natural coarse aggregate, as reported in earlier research [8][9].

The e trash was rinsed and crushed into roughly 10 mm pieces, which were chosen based on study findings that it could still be powerful while still having an impact on the environment [10][15]. The mixing and curing were done using clean drinkable water.

B. Mix Design and Curing

M40 mixes of concrete were proportioned in line with IS:10262-2019, and some of the blends were created by partially replacing coarse aggregate with amounts of trash. Two curing procedures were used: normal ponding in water and bullet bag drying, in which examples were sealed in continually moistened gunny bags. These strategies were examined to see how they affected the hydration and stability of e-waste concrete when exposed to various circumstances [17][20].

C. Testing Methods

Following the required curing durations, all specimens underwent mechanical testing. A compression testing equipment was used to determine the compressive strength of cubes after 7, 14 and 28 days. Cylindrical specimens were utilized to measure split tensile strength and flexural strength, with beam specimens subjected to two point pressure to determine bending performance.

Compressive strength Test: Compression test were performed on cubes after 7, 14 and 28 days utilizing compression testing equipment.

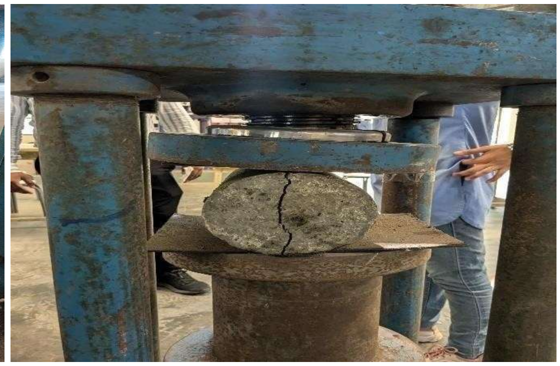

Figure 3. Testing of Cubes

Figure 4. Testing of Cylinder

Figure 5. Testing of Beams

Figure 6. Rebound Hammer

Figure 7. Ultrasonic Pulse Velocity

Figure 8. Acid Attack

D. Equipment used

- Testing machine for compressive & split tensile strength as shown in figure 3 and figure 4.
- Beam testing machine with a flexible design as shown in figure 5.
- Set up water tanks, including ponds and gunny bags.

E. Procedure

Materials (including cement, sand, coarse gravel, and e waste) were mixed according to IS norms, placed in greased cube, cylinder, and beam molds, and compacted.

After 24 hours, specimens were demolished and cured under ponding. Compression strengths were measured at 7, 14 and 28 days, as well as splitting tensile and flexural tests at 28 days.

Test results were compared to determine the effect of the curing regimen in the mechanical along with durability of the mixes.

III. Results and Discussion

A. Compressive Strength

TABLE I. COMPRESSIVE STRENGTH AFTER 7, 14 AND 28 DAYS

Proportion (%)	Curing Method Used	Average Load (N)			Average Compressive Strength (N/mm2)		
		7 Days	14 Days	28 Days	7 Days	14 Days	28 Days
0	Ponding	610×10^3	790×10^3	950×10^3	27.11	35.11	42.22
	Gunny Bag	590×10^3	760×10^3	930×10^3	26.22	33.78	41.33
16	Ponding	580×10^3	730×10^3	930×10^3	25.78	32.44	41.33
	Gunny Bag	560×10^3	710×10^3	920×10^3	24.89	31.56	40.99
17	Ponding	560×10^3	710 X 103	910×10^3	24.89	31.55	40.44
	Gunny Bag	540×10^3	680×10^3	900×10^3	24.00	30.22	40.00
18	Ponding	530 X 103	690×10^3	890×10^3	23.56	30.67	39.56
	Gunny Bag	510 X 103	660×10^3	860×10^3	22.67	29.33	38.22
19	Ponding	510×10^3	670×10^3	870×10^3	22.67	29.78	38.67
	Gunny Bag	490×10^3	640×10^3	830×10^3	21.78	28.44	36.89

G. Split Tensile Strength

TABLE II. SPLIT TENSILE STRENGTH AFTER 28 DAYS

Proportion (%)	Curing Method Used	Average Load (N)	Size (mm^2)	Average Tensile Strength(N/mm^2)
0	Ponding	315 X 103	45000	4.45
	Gunny Bag	310 X 103	45000	4.38
16	Ponding	300 X 103	45000	4.24
	Gunny Bag	290 X 103	45000	4.10
17	Ponding	290 X 103	45000	4.10
	Gunny Bag	285 X 103	45000	4.03
18	Ponding	285 X 103	45000	4.03
	Gunny Bag	280 X 103	45000	3.96
19	Ponding	270 X 103	45000	3.82
	Gunny Bag	265 X 103	45000	3.74

H. Flexural strength

TABLE III. FLEXURAL STRENGTH AFTER 28 DAYS

Proportion (%)	Curing Method Used	Average Load (N)	Size (mm^2)	Average Flexural Strength (N/mm^2)
0	Ponding	9 X 103	5000000	4.5
	Gunny Bag	9 X 103	5000000	4.5
16	Ponding	8.5 X 103	5000000	4.25
	Gunny Bag	8.5 X 103	5000000	4.25
17	Ponding	8 X 103	5000000	4
	Gunny Bag	8 X 103	5000000	4
18	Ponding	7.5 X 103	5000000	3.75
	Gunny Bag	7 X 103	5000000	3.5
19	Ponding	7 X 103	5000000	3.5
	Gunny Bag	6.5 X 103	5000000	3.0

I. Rebound Hammer

TABLE IV. REBOUND HAMMER RESULTS

NDT – Rebound Hammer Test										
Control Mix (0%)	Direction of Hammer (Plunger)	R 1	R 2	R 3	R 4	R 5	Ravg	Comp. Strength (MPa)	Avg. NDT Comp. Strength (MPa)	Avg. Destructive Comp. Strength (MPa)
C1	Vertically Down	40	39	35	36	35	37	40.00	40.67	41.33
C2	Vertically Down	39	37	40	35	36	37.5	41.00		
C3	Vertically Down	36	39	35	40	36	37.2	40.00		

(17%)	Direction of Hammer (Plunger)	R 1	R 2	R 3	R 4	R 5	Ravg	Comp. Strength (MPa)	Avg. NDT Comp. Strength (MPa)	Avg. Destructive Comp. Strength (MPa)
C1	Vertically Down	37	34	35	38	35	35.8	38.00		
C2	Vertically Down	38	34	32	38	36	35.6	38.47	38.33	40.00
C3	Vertically Down	36	39	31	37	36	35.8	38.50		

J. Ultrasonic Pulse Velocity Test

TABLE V. ULTRASONIC PULSE VELOCITY RESULTS

NDT – Ultrasonic Pulse Velocity Test (Direct Transmission) (L = 150 mm)			
Control Mix (0%)	Time	V = L/T (km/s)	Nature of Specimen
C1	33	4.54	Excellent
C2	34	4.50	Excellent
C3	34	4.50	Excellent
(17%)	Time	V = L/T (km/s)	Nature of Specimen
C1	38	3.94	Good
C2	39	3.84	Good
C3	40	3.75	Doubtful

K. Acid Attack Test

TABLE VI. ACID ATTACK RESULTS

S.N.	(17%)	CS of Cube 1	CS of Cube 2	CS of Cube 3	Mean CS	Decrease in CS
1.	Normal Curing	40.7	40.5	40.1	40.44	20.99
2.	Acidic medium Curing	33	32.3	30.55	31.95	

L. Water Absorption Test

TABLE VII. ACID ATTACK RESULTS

Sample	Sample Weight(g)		Water Absorption (%)
	Dry	Saturated	
1	7536	7828	3.78%
2	7693	7983	3.76%
3	7531	7831	3.98%

IV. CONCLUSION

The experiment indicates that when the 10 mm coarse aggregate is substituted with e-waste in concrete up to 16 and 17 percent, small losses are incurred in the hydraulic strengths (compressive, split tensile and flexural strength) of the concrete as mention in table 1, 2 and 3. The values were all within the structural usage requirements, and the ponding curing made a little more strength than gunny bag processing, although the difference was not that big. The strength quickly reduced in all forms of tests under the proportion of e-waste nearing 17.

The decrease was not very dramatic, which means that electronic garbage is a viable long-term alternative at moderate levels of substitution. As the Table 2 and 3 shows flexural and tensile strengths were again measured in the same way as they were comparable to ordinary concrete in case of e-waste content control. As shown in Table 6 and 7.

The tests on water absorption and acid attack indicated that the durability characteristics of 17 percent e-waste replacement were equal to the common concrete. This information makes it possible to confirm that the small increment of e-waste to the chemical attack or its permeability has no significant influence on the resistance of concrete, and thus it can be used in the practice of building construction.

The non-destructive methods of evaluation, like rebound hammer and UPV tests as shown in figure in 6 and 7 and table 4 and 5, were used to verify the overall integrity, surface hardness, and homogeneity of concrete containing e-waste.

To sum up, it should be noted that e-waste as a sum of up to 17 percent is likely to be effective and environmentally friendly, as well as a mechanism of achieving solid waste management and environment-related responsibility without losing significant concrete performance.

Future Scope

The given research only covered the ponding process in the treatment of M40 grade concrete that involves the utilization of electronic waste to partially substitued the coarse aggregate. In the subsequent research, the procedure of curing would be modified to gunny bags which would provide an opportunity to evaluate the functioning of different curing methods. The latter will assist in establishing whether the smaller and cheaper options can bring as good results as conventional ponding. The following research will use the same grade of concrete which is M40; the coarse aggregate will be a mixture of e-waste in different ratios of 16, 17, 18 and 19. Such a difference will enable further research on the optimal quantity of replacement, which will result in the balance between strength, durability, and sustainability. The mechanical experiments will be done to compare the effectiveness of concrete made from e-waste with the standard mixes including flexural, split and compressive strength.

Together with the destructive testing, it will be undertaking non-destructive tests (NDT)". These tests will give valuable data concerning homogeneity and in-situ strength in the concrete. An acid assault experiment will also be done to check the endurance of the e-waste concrete to adverse environmental conditions. This will give additional knowledge on its capacity to withstand and how it can be applied in practical life. Hopefully, this comprehensive study can be used to advance green building construction practices whereby dependence on natural building materials is minimized.

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