Behavior of Concrete in Compression by Partial Replacement of E-Waste

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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). The replacement percentages of RCA were 2.5%, 5% and 10% respectively. The partial replacement of RCA to achieve the mechanical properties (compressive and flexural strength) 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.**

Index Terms- **Cement, Compression, Concrete, and E-Waste.**

I 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 a public and private sector institution 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 material 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 behavior of RCA (Lakshmi and Nagan, 2011). The objective of the experimental work has been done to exhibit the mechanical properties such as compressive strength, flexural strength, under different curing conditions. E waste reinforced concrete elements behave as 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.

II REQUIREMENTS & PROPERTIES OF MATERIALS

2.1 Binding Materials

Cement or limes are used as the binding material. They behind the individual units of fine aggregate and coarse aggregate by virtue of its properties of setting or hardening in combination with water. The binding material helps to fill voids and imparts density to concrete.

2.2 Fine Aggregate

Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter.

E-Waste

Electronic waste (such as PCB boards) contains silica, Aluminum, Plastic fiber, copper. The e-waste is crushed into the standard size of fine aggregate (sand), it should pass through a sieve having 3/16 squares.

2.3. Coarse Aggregate

It is the main filler and forms the bulk of concrete, broken stones, broken bricks and gravels are generally used as coarse aggregates. Granite, basalt are also excellent coarse aggregate.

Crushing strength sand water tightness of concrete and its resistance to wear and tear depend upon the aggregates. The aggregate should be clean dense, hard, strong durable and sound.

2.4. Water

Water facilitates the spreading of cement over the aggregate and regulates the consistency. Water used should be clean. Sea water should not be used as it retards setting.

2.5. Properties of Materials

2.5.1. Cement

- Initial testing time should be less than 30 minutes.
- Final setting time should not more than 10Hrs.
- Compression strength after 7 days should not less than 22N/mm^2.
- Tensile strength after 7 days should be 2.5 N/mm^2.
- By I.S 90 micron sieve, residue by weight should not exceed 10%.
- Ratio of percentage alumina to that iron oxide should not be less than 0.65%.
- Weight of magnesia should not exceed 5%.
- Weight of insoluble residue should not be greater than 1.50%.

2.5.2 Fine Aggregate

- It should be clean and coarse.
- It should be free from any organic or vegetable matter; usually 3-4% clay is permitted.
- It should be chemically inert
- It should contain sharp, angular, coarse and durable grains.
- It should not contain salts which attracts moisture from the atmosphere.
- It should be well grade; it should contain particles of various sizes in suitable proportions.
- It should be strong and durable.
- It should be clean and free from coating of clay and silt.

2.5.3 Coarse Aggregate

- It should be contain sharp, angular, coarse and durable grains.
- It should be clean and free from coatings of clay and slit.
- It should be strong and durable.
- It should be free from any organic or vegetables matter; usually 3-4% clay is permitted.
- It should be clean and coarse.

III. OBSERVATION & CALCULATION

3.1 Cement

Fitness Test on Cement

Type of cement	Sample	W_1 (g)	W_2 (g)	$\frac{W_2}{W_1} \times 100$
Coromandel Cement	1	100	8	8%
	2	100	7.5	7.5%
	3	100	8	8%

Table 1: Fitness Test on Cement

The average fitness modulus of cement sample is 7.84%

Consistency

Trial	Wt. of cement taken (g)	Quantity of water		Penetration Index Reading (mm)
		%	g	
1	500	30	135	15
2	500	33	148.6	7
3	500	35	158	6

Table 2: As per IS: 4301 9Part-4) Consistency of Standard Cement

Obtaining cement paste of normal consistency of cement is 35% and index reading 5 to 7mm.

Initial setting Time

Trial	Index Reading (mm)	Initial Time(mins)
1	0	5
2	0	10
3	0	15
4	0	20
5	0.5	25
6	1	27
7	1	29
8	2	31
9	2	33
10	3	35
11	4	37
12	5	39

Table 3: As per IS: 4031 (part-5) for Initial Setting time of Cement

Initial setting time of the cement sample is 39 minutes.

Final Setting Time

Final setting time of the cement sample is 390minutes.

3.2 Fine Aggregate

Specific Gravity

Specific Gravity $= \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$

$= \frac{196}{726 - 640}$

Specific gravity= 2.27

Sieve no mm	Wt. of Fine Aggregate retained in each Sieve in (g)	Cumulative Wt. of the F.A retained in (g)	Cumulative % of F.A retained
4.75	31.5	31.5	6.3
2.36	70.6	102.1	20.4
1.18	99.10	201.2	40.2
600Microns	116.1	317.3	63.4
300microns	66.2	383.5	76.7
150Microns	116.5	500	100

Table 4: Fitness modulus Fine Aggregate

Fitness Modulus of Fine Aggregate

$= \frac{\text{Sum of Cumulative Percentage of F.A retained}}{100}$

$= \frac{6.3+20.4+40.2+63.4+76.7+100}{100}$

Fitness Modulus of Fine Aggregate = 3.02%

Bulking of Fine Aggregate

Bulking maximum 25mm at 16% of water

Bulking 0mm at 20% of water

3.3 Coarse Aggregate

Fineness Modulus of Coarse Aggregate

Sieve no mm	Wt. of Fine Aggregate retained in each Sieve in (g)	Cumulative Wt. of the F.A retained in (g)	Cumulative % of F.A retained
75	0	0	0
63	0	0	0
37.5	0	0	0
20	4140	4140	82.8
9.5	852	4992	99.84
4.75	8	5000	99.94
2.36	0	5000	100
1.16	0	5000	100
600µ	0	5000	100
300µ	0	5000	100
150µ	0	5000	100

Table 5: Cumulative %of C.A Retained

Fitness Modulus of Fine Aggregate

$= \frac{\text{Sum of Cumulative Percentage of F.A retained}}{100}$

$= \frac{82.8 + 99.84 + 99.94 + 100 + 100 + 100 + 100 + 100}{100}$

Fitness Modulus of Coarse Aggregate = 7.82

Specific Gravity of Coarse Aggregate

Specific gravity= 2.78

3.4 e- Waste

Sieve no mm	Wt. of Fine Aggregate retained in each Sieve in (g)	Cumulative Wt. of the e-Waste retained in (g)	Cumulative % of e-Waste retained
4.75	75	75	15
2.36	135	210	42
1.18	110	320	64
600Microns	160	480	96
300microns	12	492	98.4
150Microns	8	500	100

Table 6: Cumulative% of E-waste Retained

$= \frac{15 + 42 + 64 + 96 + 98.4 + 100}{100}$

Fineness modulus of marble waste is 4.15

Bucking of e-Waste is 3.09%

Specific Gravity is 2.04

3.4 Test Results

Description	Fine Aggregate	Coarse Aggregate	E- Waste
Specific Gravity	2.27	7.82	2.04

Fineness Modulus	3.02	2.78	3.02
Bulking	16%	16.25%	16%

Table 7: Comparison of fine, coarse and e-Waste

IV. CASTING OF CUBES

Materials Required for One Cube

Description	Normal Concrete	Replacement by e-Waste		
		2.5%	5%	10%
Cement (Kg)	1.45	1.45	1.45	1.45
Sand (Kg)	2.33	2.28	2.21	2.23
Jelly (Kg)	5.340	5.34	5.34	5.34
e-Waste	-	0.059	0.12	0.233
W/C Ratio	0.727	0.727	0.727	0.727

Table 8: Materials Composition of Concrete

The curing time of concrete is 7 and 28 days

Test for Compressive Strength

- Testing is done after 7 days 28 days, the days taken into account is from the time of water added to the ingredients.
- Test a minimum of 3 specimens at a time.
- Test the specimen immediately after talking it from the water and while they are in wet condition, wipe of the surface water. If the specimen received and dry, then keep them in water for 24hours before testing.
- Note down the dimension nearest to 02.mm and also note down height 1.

Conducting Experiment

- Place the specimen in such manner that load shall be applied to opposite side of cubes.
- Align carefully, at the Centre of the thrust of the spherically seated plate.
- Apply the loads slowly and at the rate of 140Kg/cm^2 per min till the cube breaks.
- Note down the maximum load and appearance of the concrete failure.

Compressive Test Results of the Specimens

Description	Compressive strength N/mm^2	
	7 Days	28 Days
Normal Concrete	15.5	21
2.5% of waste	16.2	21.5
5% of Waste	16.6	22.8
10% of Waste	17.3	23.4

Table 9: Compressive Strength

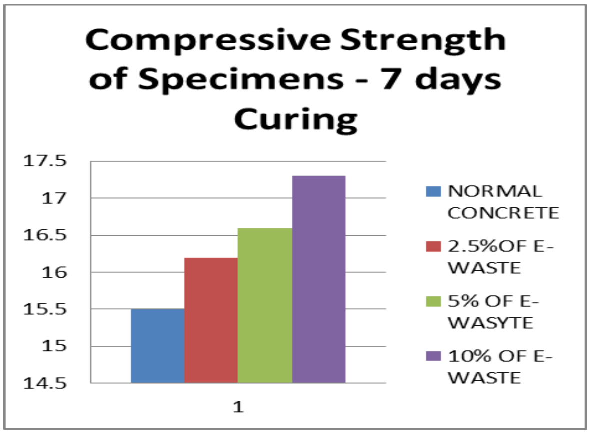

Figure 1: Compressive Strength of Specimens -& 7Days Curing Time

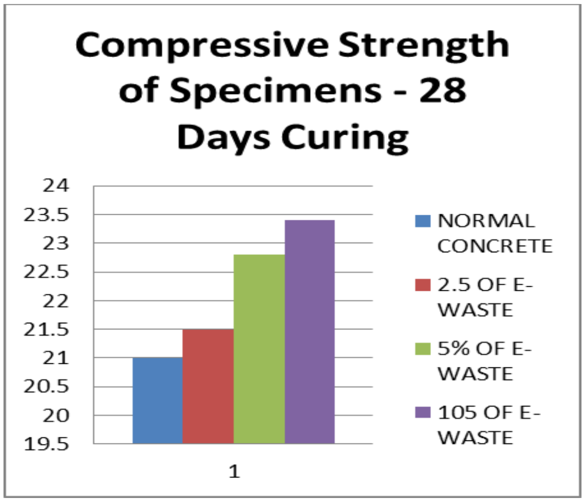

Figure 1: Compressive Strength of Specimens -& 28Days Curing Time

V. CONCLUSION

India has emerged as the second largest mobile market with fifth largest producer of e waste in the world discharging about 18.5 lakh metric ton of electronic waste each year with telecom equipment contributing 12% of e waste and India is also a country with sand scarcity, quiet expensive cost. Hence we had selected e waste as a partial replacing agent instead of sand moreover e waste contains materials like silica, aluminum, plastic and fiber etc., thereby increasing the strength.

Conclusion based on the experiment study as a follows;

- E- Waste shall be used as a partial replacement of sand in concreter.

- In 7 days curing, the compressive strength of (2.5- 1050 gave more strength (by 0.7%, 1.1% and 1.8% respectively increase) than the compressive strength of 7 days cured conventional concrete and even in 28 days curing, the compressive strength of (2.5 – 10% replacement) gave more strength (by 0055, 1.8% and 2.4% respectively increase) than the compressive strength of 28 days cured conventional concrete.
- We hereby suggest using those combinations of replacement (2.5%, 5% and 10%) in concrete works to increase the strength and to lower the cost towards purchasing sand.

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