ISSN (ONLINE): 2454-9762
ISSN (PRINT): 2454-9762
Available online at www.ijarmate.com

International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE)
Vol. 7, Issue 4, April 2021

Experimental Investigation On E-Concrete and It's Application On Pavement Block

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Abstract— **Electronic waste or waste electronic and electrical equipment is an emerging issue posing serious pollution problem to the human and the environment due to the new technologies introduced daily. New effective waste management options need to be considered especially on recycling concepts. This project is the results of an investigation to study the performance of concrete prepared with E-waste as part of coarse aggregate. An effort has been made to detail a systematic study of compressive strength, split tensile strength and flexural strength of concrete. By a specific proportion in concrete it can be used effectively and thus results in waste reduction and resources conservation. Nowadays availability of river sand is quite expensive and causes environmental degradation. This project has also used Eco-sand, an inert industrial solid waste, which is locally available and a low cost sand. Hence, use of Eco-sand will be a partial solution to the above problems.**

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I. Introduction

Utilization of waste materials and by-products is a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Electronic waste, abbreviated as E-waste, consists of discarded old computers, TVs, refrigerators, radios– basically any electrical or electronic appliance that has reached its end of life. Efforts have been made in the concrete industry to use non-biodegradable components of E waste as a partial replacement of the coarse or fine aggregates. An experimental study is made on the utilization of E-waste particles as coarse aggregates in concrete with a percentage replacement ranging from 0 % to 30% on the strength criteria of M20 Concrete. Compressive strength, Tensile strength and Flexural strength of Concrete with and without E-waste as aggregates was observed which exhibits a good strength gain. Ultrasonic tests on strength Properties were executed and the feasibility of utilizing the

E plastic particles as partial replacement of coarse aggregate has been presented.

II. TEST ON MATERIALS

A. *Tests on Cement*

a. Fineness test:

Fineness of cement is the property of cement that indicates particle size of cement and specific area. Strength development of concrete is the result of the reactions of water with cement particles. The reaction always starts with the cement available at the surface of particles. Thus larger the area available for reaction, greater rate of hydration. Rapid development of strength requires greater degree of fineness.

Observation:

TABLE I: FINENESS TEST

Observations	I	II	III
a) Weight of cement (W)g	100	100	100
b) IS sieve size (micron)	90	90	90
c) Sieving time (min)	15	15	15
d) weight retained on sieve (W1)g	5	7	5
e) %Weight retained on sieve (W1x100)/W	5%	7%	5%
f) Mean%	5.6%		

Result:

Fineness of cement = 5.6%

b. Test for consistency:

Cement paste of normal consistency is defined by the percentage of water by weight of cement which produces a consistency which permits a plunger of 10mm diameter to penetrate up to a depth of 5mm to 7mm above the bottom of Vicat's mould.

TABLE II: CONSISTENCY TEST

SI No.	Quantity of water added (ml)	%by weight	Time of gauging (min)	Penetration from bottom of mould (min)
1	112	28%	3	34
2	120	30%	3	25
3	128	32%	3	18
4	136	34%	3	10
5	144	36%	3	6

Calculation:

Percentage of water required for preparing cement paste of standard consistency (P)

$$P=W/C \times 100$$
$$=144/400 \times 100$$
$$=36\%$$

Result:

Normal consistency of the given sample=36%

c. Initial setting time:

It is defined as the time elapsed between the moment water is added to the cement , to the time at which the needle of 1mm square fails to pierce the test block to a depth of about 5mm, from bottom of mould.

Observation:

Water standard consistency =34%

Water to be added=115.6ml

Time at which water is first added (T1) =11hrs 10min

TABLE III: INITIAL SETTING TIME

Sl.No.	Penetration reading	Time at which penetration readings taken
1	0	11hrs 15min
2	0	11hrs 20min
3	0	11hrs 25min
4	0	11hrs 30min

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5	1	11hrs 35min
6	3	11hrs 40min
7	3	11hrs 45min
8	4	11hrs 50min
9	5	11hrs 55min

Time at which needle fails to pierce 5mm to 6mm from bottom of mould(T2) = 11hrs55min

Initial setting time = (T2-T1)

= 45minutes

Result:

Initial setting time = 45 minutes.

B. Tests on Coarse Aggregate

a. Sieve analysis:

From the sieve analysis the particle size distribution or graduation in a sample of aggregate can be obtained. Fineness modulus is a term indicating the coarseness or fineness of the material.

Observations:

Total weight of sample = 2kg

TABLE IV: SIEVE ANALYSIS

IS sieve size	Weight retained (g)	%weight retained	Cumulative % retained	Cumulative reading
80mm	0	0	0	100
40mm	0	0	0	100
20mm	265	13.25	13.25	86.75
10mm	720	36	49.25	50.75
4.75mm	820	41	90.25	9.75
2.36mm	125	6.25	96.5	3.5
1.18mm	10	0.5	97	3
300micron	10	0.5	98.75	2.25
150micron	20	1	98.75	1.25
pan	25	1.25	100	0

Fineness modulus= sum of cumulative %retained/100

=740/100

=7.4%

Result:

Effective size D10=4.8mm

Uniformity coefficient =1.92mm

Fineness modulus=7.4%

b. Specific gravity

It is the ratio of dry weight of aggregate to the weight of equal volume of water. The higher the specific gravity, the stronger is the aggregate.

Observation:

TABLE V: SPECIFIC GRAVITY –COARSE AGGREGATE

Weight of pycnometer(W1)g	395.3g
Weight of pycnometer + aggregate(W2)	932g
Weight of pycnometer + aggregate + water(W3)	1440.8g
Weight of pycnometer + water(W4)	1100g
Specific gravity	2.72 kg/m³

Calculation:

Specific gravity (G) =M2-M1/ (M2-M1)–(M3-M4) =2.72

Result: Specific gravity of coarse aggregate=2.72 kg/m³

c. Water absorption:

It is the percentage by weight of water absorbed by the material

Observation:

TABLE VI: WATER ABSORPTION

SI no	Determination no	I
1	Weight of saturated surface dried sample (W1)	500
2	Weight of oven dried sample (W2)	497.5
3	Water absorption	0.5

Water absorption = W2-W1/W1 x100 =0.5%

Result: Water absorption of coarse aggregate=0.5%

C. Tests on Fine Aggregate

a. Specific gravity

It is the ratio of dry weight of aggregate to the weight of equal volume of water. The higher the specific gravity, the stronger is the aggregate

Observation:

TABLE VII: SPECIFIC GRAVITY –FINE AGGREGATE

Weight of pycnometer (W1)g	395.3g
Weight of pycnometer + aggregate (W2)	545g
Weight of pycnometer + aggregate + water (W3)	1195.1g
Weight of pycnometer + water (W4)	1100g
Specific gravity	2.74 kg/m³

Calculation:

Specific gravity (G) =M2-M1/(M2-M1)–(M3-M4)

Result: Specific gravity of fine aggregate = 2.74 kg/m³

III. MIX DESIGN

TABLE VIII: MIX DESIGN -NOMINAL MIX

Cement (kg/m³)	Water (litre)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	Chemical admixture	Water cement ratio	Fibre
350	140	776	1267	nil	0.4	nil

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TABLE IX: MIX DESIGN -E-CONCRETE MIX

Cement (kg/m³)	Water (litre)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	Chemical admixture	Water cement ratio	Fibre
350	140	776	1267	7	0.4	2% of cement

Mix Ratio: 1:2.2:3.62

IV. EXPERIMENTAL INVESTIGATION

A. Compression test on concrete cubes

Compression tests are done on both cubes and cylinder specimen. For concrete of given mix proportion the strength is influenced by ratio of cement to water (w/c), ratio of cement to aggregate, size, grading and shape of aggregates. Standard specimens are tested at prescribed ages, generally at 28 days and additional tests are often made at 3 and 7 days

Observation:

TABLE X: NOMINAL MIX –CUBE

SI No.	Age of specimen	Size of specimen (mm)	Area (mm²)	Mix proportion	Mean load at failure (KN)	Compressive strength (N/mm²)
1	7	150x150	22500	1:2:3	333	14.8
2	14	150x150	22500	1:2:3	394	17.52
3	28	150x150	22500	1:2:3	510	22.9

Result:

Compressive strength at the end of 7 days = 14.8 N/mm²

Compressive strength at the end of 14 days = 17.52 N/mm²

Compressive strength at the end of 28 days = 22.9 N/mm²

B. Split tensile test on concrete cylinder

To determine the compressive strength of concrete cylinders.

Observation:

TABLE XI: NOMINAL MIX –CYLINDER

SI No.	Age of specimen	Diameter of cylinder (mm)	Length of cylinder (mm)	Area (mm²)	Mix proportion	Mean load at failure	Split tensile strength (N/mm²)
1	7	150	300	17671.46	1:2:3	280	14.02
2	14	150	300	17671.46	1:2:3	330	16.75
3	28	150	300	17671.46	1:2:3	375	18.33

Result:

Compressive strength of concrete mix at the end of 7 days = 16.02 N/mm²

Compressive strength of concrete mix at the end of 14 days = 18.75 N/mm²

Compressive strength of concrete mix at the end of 28 days = 21.33 N/mm²

C. Flexure test on concrete beam

To determine the modulus of rupture of given concrete by conducting beam test.

Observation:

The Flexural Strength or modulus of rupture (fb) is given by fb = pl/bd² (when a > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen) or fb = 3pa/bd² (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

p = max. Load (kg)

TABLE XII: NOMINAL MIX –BEAM

Sl No	Age of specimen	Depth of specimen (mm)	Length of specimen (mm)	Mix proportion	Mean load at failure (KN)	a (mm)	Modulus of rupture (N/mm²)
1	7	100	400	1:2:3	4.25	14	1.7
2	14	100	400	1:2:3	7.15	15	2.86
3	28	100	400	1:2:3	10.3	15.8	4.12

Result:

Modulus of rupture of given concrete at end of 7 days = 1.7 N/mm²

Modulus of rupture of given concrete at end of 14 days = 2.86 N/mm²

Modulus of rupture of given concrete at end of 28 days = 4.12 N/mm²

V. REPLACEMENT USING E-WASTE

A. 0% Replacement using E-waste

TABLE XIII: STRENGTH VALUES (N/mm²) FOR 0% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	4.48	16.3	2.65
2.	14	4.66	21.12	2.63
3.	28	5.59	26.01	2.98

B. 20% Replacement using E-waste

TABLE XIV: STRENGTH VALUES (N/mm²) FOR 20% REPLACEMENT USING E-WASTE

Sl	Age Of	Flexural	Compressive	Split Tensile

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No	Specimen	Strength	Strength	Strength
1.	7	4.04	17.3	2.65
2.	14	4.56	21.15	5.63
3.	28	5.09	25	2.98

C. 30% Replacement using E-waste

TABLE XV: STRENGTH VALUES (N/mm²) FOR 30% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	5.19	21.7	2.20
2.	14	5.76	25.52	2.11
3.	28	6.34	29.35	2.01

D. 40% Replacement using E-waste

TABLE XVI: STRENGTH VALUES (N/mm²) FOR 40% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	8.16	31.33	9.35
2.	14	9.26	35.45	10.12
3.	28	9.78	41.33	14.95

E. 50% Replacement using E-waste

TABLE XVII: STRENGTH VALUES (N/mm²) FOR 50% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	7.06	21.38	6.35
2.	14	7.26	25.35	9.62
3.	28	8.18	31.33	13.95

F. 60% Replacement using E-waste

TABLE XVIII: STRENGTH VALUES (N/mm²) FOR 60% REPLACEMENT USING E-WASTE

Sl No.	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	5.49	20.52	3.29
2.	14	7.16	26.21	6.98
3.	28	8.14	30.50	9.67

G. 80% Replacement using E-waste

TABLE XIX: STRENGTH VALUES (N/mm²) FOR 80% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	5.49	24.52	2.29
2.	14	5.96	26.92	2.98
3.	28	6.84	30.85	3.67

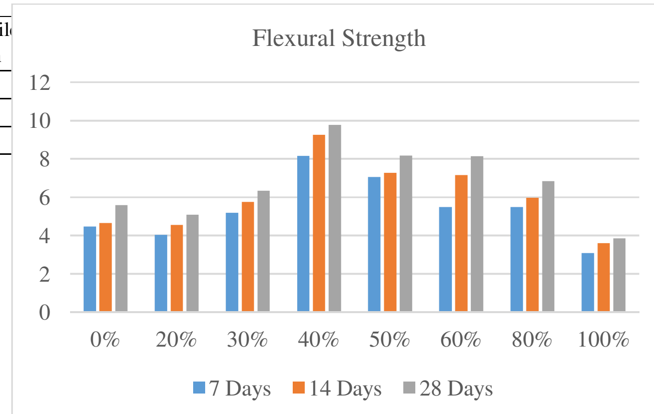
H. 100% Replacement using E-waste

TABLE XX: STRENGTH VALUES (N/mm²) FOR 100% REPLACEMENT USING E-WASTE

Sl No	Age Of Specimen	Flexural Strength	Compressive Strength	Split Tensile Strength
1.	7	3.09	14.52	2.29
2.	14	3.16	16.92	2.98
3.	28	3.84	18.85	3.67

VI. RESULTS

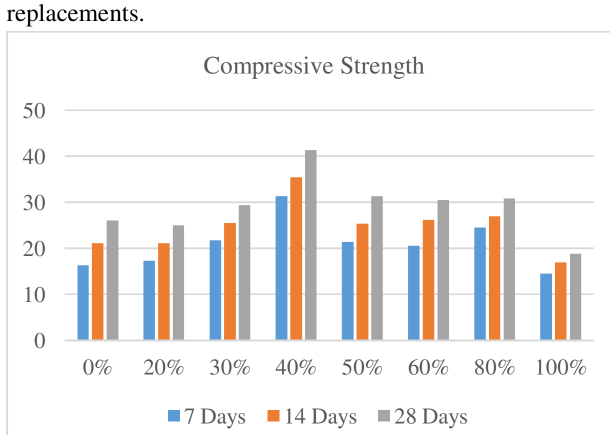
A. Plot between Strength values and various percentage replacement of coarse aggregate using E-waste



Replacement using E-waste-Flexural Strength (N/mm²) test results

Graph is plot between the percentage replacement of coarse aggregate by E-waste and the flexural strength values of specimens for 7, 14, 28 days.

From graph its clear cut that 40% replacement using E-waste attains peak value compared to other percentage replacements.



Replacement using E-waste-Compressive Strength (N/mm²) test results

Graph is plot between the percentage replacement of coarse aggregate by E-waste and the Compressive strength values of specimens for 7, 14, 28 days.

From graph its clear cut that 40% replacement using E-waste attains peak value compared to other percentage replacements.

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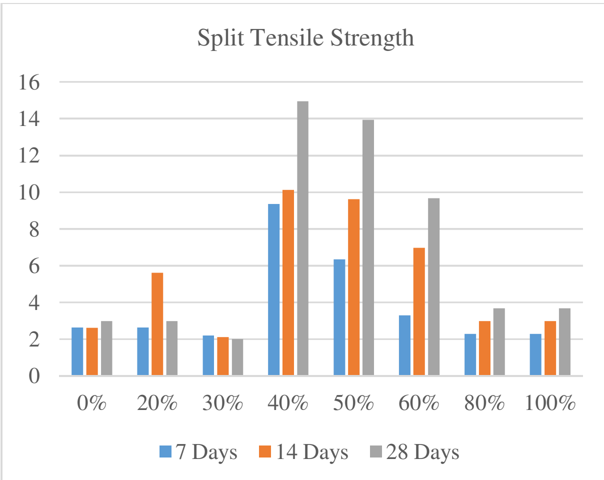
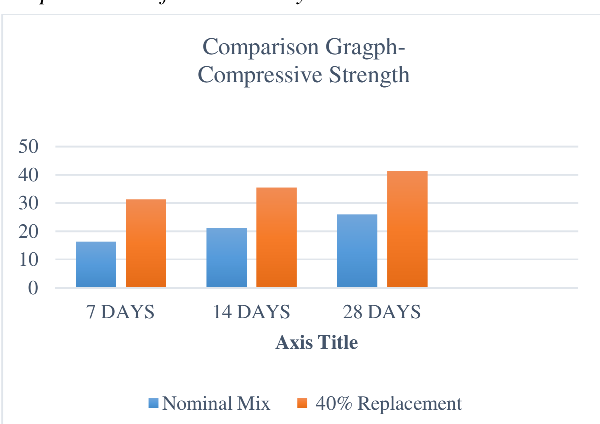


Replacement using E-waste-Split Tensile Strength (N/mm²) test results

Graph is plot between the percentage replacement of coarse aggregate by E-waste and the Split tensile strength values of specimens for 7, 14, 28 days.

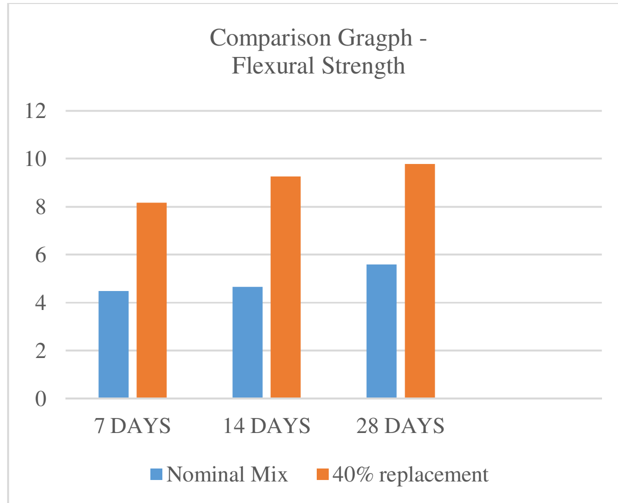
From graph its clear cut that 40% replacement using E-waste attains peak value compared to other percentage replacements.

B. Plot between Nominal mix of concrete and 40% replacement of coarse aggregate using E-waste and fully replacement of river sand by Eco-sand.



Graph is plot between the 40 percentage replacement of coarse aggregate by E-waste and the Compressive strength values for nominal mix of concrete specimens for 7, 14, 28 days

From graph its clear cut that 28 Days cured and dried 40% replacement of coarse aggregate by E-waste have the higher Compressive strength values



Graph is plot between the 40 percentage replacement of coarse aggregate by E-waste and the Flexural strength values for nominal mix of concrete specimens for 7, 14, 28 days.

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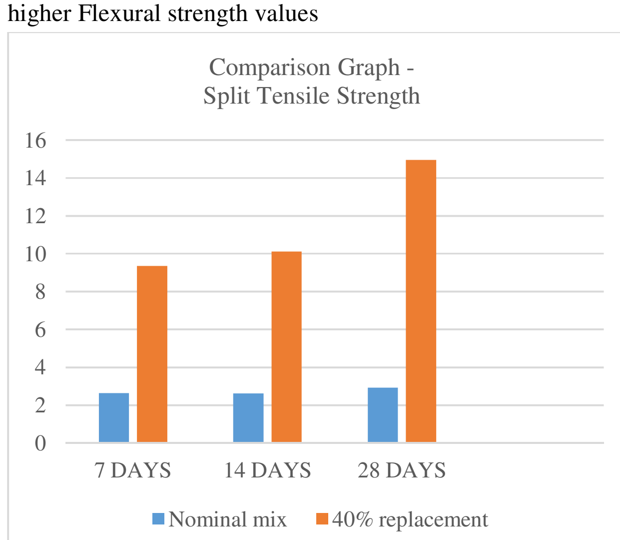

Graph is plot between the 40 percentage replacement of coarse aggregate by E-waste and the Split tensile strength values for nominal mix of concrete specimens for 7, 14, 28 days.

From graph its clear cut that 28 Days cured and dried 40% replacement of coarse aggregate by E-waste have the higher Split tensile strength values

VII. CONCLUSION

From the project following conclusions were obtained.

Compressive strength, Splitting tensile strength and flexural strength of concrete specimens using partial replacement of coarse aggregate by E-waste and fully replacement of river sand by Eco sand were higher than control concrete specimens at all the ages.

Compared to all other E-waste replacement percentage results, it's clear that **40% replacement** gives high value in test observations and for confirmation a replacement test of 30% and 50% were carried out.

Hence from graph, it's clear that **40% replacement** of E-waste shows high distinct strength value.

Compressive strength of concrete containing 40% of E-waste and fully replacement river sand by Eco-sand is acceptable when compared to the nominal concrete mix for 7, 14, 28 days.

Similarly the same results were obtained for Flexural Strength and Split tensile strength values and therefore 40% replacement of coarse aggregate using E-waste was found to be acceptable.

Hence from experimental study, the project concludes that E-waste and Eco sand replacements in comparison with conventional concrete, powers an assurance of potential market for concrete product in which the inclusion partial E-waste and Eco sand would be feasible which will utilize discarded electronics(E-waste) and cheap industrial waste sand(Eco-sand) that manages waste disposal and reduces environmental hazard.

Utilisation of dismantled electronics will be a partial solution and thereby project concludes to use **E-waste** to augment concrete property.

Also use of **Eco sand** instead of **river sand** will be a better advantage.

Project reveals the use of **Engineered Cementitious Composites (ECC)**, which exhibit many of the characteristics desirable for high performance pavement applications, including excellent durability, high ductility, and resistance to cracking.

As compared to plain concrete, ECC material with partial replacement of coarse aggregate using E-waste and fully replacement of river sand by Eco sand found its application to be desirable for pavement block.

Fiber reinforced concrete has advantage over normal concrete particularly in case of cement concrete pavements.

By experimental tests it's found to be acceptable in its use as a **pavement block.**

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