Partial Replacement of Coarse Aggregate by E-Waste in Concrete

Kumar gaurav[1], Md. Shahnawaz Ali[1] ,Rahul Kumar[1] ,Prashant Kumar[1],

Chandan Kumar[2], Dr. Krishna Murari[3]

[1] UG Student, Dept of civil engineering, NSIT Bihta, Patna(India).
[2]Assistant Professor, Dept of civil engineering, NSIT Bihta, Patna(India).
[3]Professor, Dept of civil engineering, BIT Sindri, Dhanbad (India).
Corresponding Author: Chandan Kumar.

---***---

Abstract: -Concrete is the first choice for the construction many countries today. This has increased the fast vanishing of natural resources. On the other hand new electrical and electronic products have become an integral part of daily lives providing us with more comfort, security, easy, and faster acquisition. Due to technological growth, there is a high rate of obsolescence in the electronic equipment which leads to one of the fastest growing waste stream in the world ,which is known as e-waste.Now-a-days, the world facing a real challenge is disposal of solid waste in particular e-waste without inducing any environmental issues. There is some alternative way for the disposal of e-waste that is dumping the waste into land fill but this method has so many serious problems as it needs a lot of landmass which is in scarcity in our country and it also contains so many different harmful materials like lead, cadmium, beryllium etc. these materials when mixes with soil they contaminate the soil and when mixes with ground water they contaminated it also makes it very harmful to consume by any anyone and if someone consume this water it with cause serious health issues and in some cases it even cause cancer.So this is a very good concept of using e-waste as an ingredient in concrete by partial replacement of aggregate. We cannot replace it completely as aggregate provides some key properties to concrete like strength, durability and workability. Using e-waste as building material seems right when we look at the amount of aggregate required for making concrete and if we are able to reduce that amount it will be very beneficiary as it reduces the load from the natural resources. In our research work we have partially replaced the aggregate with e-waste. We have casted concrete cubes with 0% ,3%, 7%, 10% and 12% e-waste and compare the compressive strength of concrete with conventional concrete cubes of M-30 grade. In our results we have found out that compressive strength of cubes starts increasing when we add e-waste, but after a point it starts decreasing. At the inclusion of 7% e-waste the compressive strength of concrete is 45.74N/mm^2 and thereafter it starts decreasing. At the replacement of 10% aggregate with e-waste the compressive strength of concrete is 35.05N/mm^2.The test results showed that a significant improvement in compressive strength was achieved in the E-waste concrete compared to conventional concrete and can be used effectively in concrete. The reuse of E-waste results in waste reduction and resources conservation.

Keywords: - E-waste, Workability, Compressive strength, Durability, Split tensile strength, Flexural strength.

INTRODUCTION:-

In the present world, no construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability. On the other side e-waste is an emerging issue posing serious pollution problems to the human and the environment.E-waste is the problem with which every country is dealing right now. Because there is no method for the disposal of e-waste and with the growth in the consumption of electronic goods this problem is getting bigger and bigger. The most effective way of the disposal of e-waste is through landfill and this method require large land mass which is very difficult to find in these days. In India, the primary source of e-waste is public and private sector institutions which leads 70% of the total waste. The estimated annual generation if electronic waste is 4,00,000 tons that is (10-15%) approximately. The waste 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 respectively. But from these sources 4% only recycling of it. 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-waste 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 3 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–

friendly concrete and protecting environment from the effect of pollution. This project is to check the efficiency of concrete by using the e-waste in replacement of coarse aggregate in concrete and to reduce the cost of construction.

I. MATERIALS AND METHODS :-

1) **CEMENT :-**A building material made by grinding calcined limestone and clay to a fine power, which can be mixed with water and poured to set as a solid mass or used as ingredient in making mortar or concrete. In this project work we are going to use Ordinary Portland Cement (OPC) of 43 grade of brand Ambuja Cement. Cement is preferred according to (Indian Standard) IS 12269:1987

- **The physical properties of OPC as determined given in the table (1).**

S.No	Properties	Experimental Value
1.	Normal Consistency%	33%
2.	Initial setting time	41min
3.	Final setting time	225min
4	Soundness of Cement (Le chatelier expansion)	2.75mm
5.	Fineness of Cement (%age retained on 90 micron IS sieve)	3.77%
6.	Specific gravity of Cement	3.1
7.	Compressive strength at 7 days 28 days	 31.71 MPa 45.25 MPa

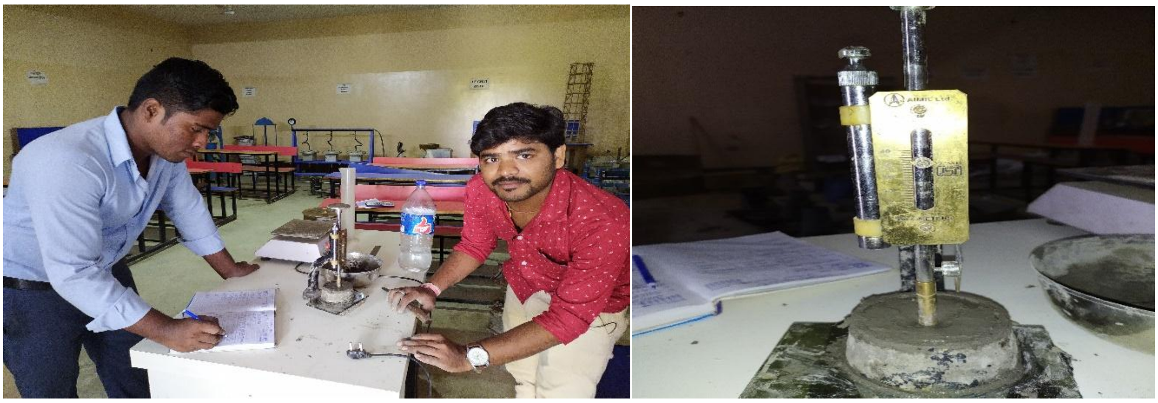

Fig1. Lab work of Consistency of cement

2) **AGGREGATE :-** Aggregate is prime constituent of concrete as it provides volume to the concrete. It a chemically inert material, it provides strength and durability to the concrete. For fine aggregate we will use locally available sand which pass through 4.75mm sieve. And for coarse aggregate we will use aggregate of size 10mm and 20mm conforming to IS: 383-1970,were locally availablein Bihta, Dist- Patna(Bihar) and physical properties were found through various laboratory tests conducted in Concrete and Road material lab, NSIT Bihta.

- **The physical properties of aggregate are given in table (2)**

S.No	Properties	Experimental Values of coarse aggregates	Experimental Values of fine aggregates
1.	Water Absorption	0.30%	0.45%
2.	Specific gravity	2.74	2.61
3.	Crushing Value	18.05%	-
4.	Impact Value	12.55%	-

5.	Fineness Modulus	6.15	2.70
6.	Bulking Of Sand	-	24%
7.	Unit weight	-	1.72gm/cc
8.	Color	Dark	Dark
9.	Shape	Angular	Angular

Fig2. Sieve Analysis of fine aggregates at lab

Fig3. Bulking of fine aggregates at lab

3) **E-WASTE:-** Printed Circuits Boards (PCB) as e-waste we are using in our project.And collected at the locally available electronic shops. All the metals attached on the PCB will be removed by hand. Copper strips present at the bottom of PCB were removed manually and broken in to 20mm size. Specific gravity and water absorption will be tested for E-waste.

- **Table-3 Properties of E-waste**

S.No	Properties	Experimental Values of E-waste
1.	Water Absorption	0.45%
2.	Specific gravity	1.25
3.	Crushing Value	2.40%
4.	Impact Value	1.85%
5.	Fineness Modulus	2.55

4) **WATER:-** 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. In general, water fit for drinking is suitable for mixing concrete. Impurities in the water may affect concrete setting time, strength, shrinkage or promote corrosion of reinforcement. Hence locally available purified drinking water will be used for the work.
5) **CONCRETE MIXES:-** The concrete mixes will be assigned with the use of type of fine aggregate and grade of the concrete. In this project we are using grade of concrete as M30. The percentage replacement of e-waste added by 0%, 4%, 8%, 12% and 16% with a w/c ratio of 0.5%. The mix proportion of 1:0.75:1.5 (where 1is for cement 0.75 for fine aggregate and 1.5 for coarse aggregate of size 10mm to 20mm).The mixes were designated with the grade of concrete and the type of fine aggregate used. IS method of concrete mix was used to achieve a mix with cube strength of 30 Mpa. Mix proportions were arrived and E-waste was added to the concrete mix with a w/c ratio 0.5. the percentage of E-waste added by weight was 0, 3 ,7, 10 and 12. Control mix concrete and modified concrete with varying percentage of E-waste and the percentage for various replacement levels are presented in Table 4.

- **Table 4. Details of Concrete Mix**

Mix Specification	Control Mix	Modified Mix 1	Modified Mix 2	Modified Mix 3	Modified Mix 4
Proportion of E-waste added	0%	3%	7%	10%	12%

Water curing is the most effective method of curing. It produces the highest level of compressive strength. If aconcrete is not well cured, it cannot gain the properties and durability to endure long life service. A proper curing greatly contributes to reduce the porosity and dry shrinkage of concrete and thus achieves higher strength and greater resistance to physical and chemical attacks in aggressive environments. With these results in mind, proper curing was done for specified days after the specimens are removed from the moulds.

6) **Preparation of Test Specimens:-** For the purpose of testing specimens, various concrete specimens were prepared for different mixes using rotating drum mixer. Preparation of concrete specimens aggregates, cement and E-waste was added. After thorough mixing, water was added and the mixing was continued until a uniform mix was obtained. The concrete was then placed in to the moulds which were properly oiled. After placing of concrete in moulds, proper compaction was given using the table vibrator. For compressive strength test, cubes of size 150mmx150mmx150mm were cast. For splitting tensile strength test, cylinders of size 150mm diameter and 300mm height were cast and for flexural strength test, beams of size 150mmx100mmx100mm with and without reinforcement were cast. Specimens thus prepared were demoulded after 24 hours of casting and were kept in a curing tank for curing. For durability test, cubes of 150mmx150mmx150mm were cast for acid and sulphate attack. The durability test was done after 28 days of water curing. The dimensions of specimens used for the present study are given below.

- **Table 5. Details of test specimens**

Test Details	Shape and Dimension of the specimens
Compressive strength	Cube: 150x 150x150 mm
Splitting Tensile strength	Cylinder: 150x 300 mm
Flexural strength	Beam:100x100x500 mm
Durability test	Cube: 150x 150x150 mm

II. RESULTS AND DISCUSSION:-

a) **Workability:-**Workability is the ease with which a concrete mix can be handled from the mixer to it's finally compacted shape.A concrete is said to be workable if it is easily transported, placed, compacted and finished without any segregation. It was seen that the workability increase with increase percentage of E-waste the results are shown in table 6.

- **Table-6. Workability of concrete with varying dose of e-waste**

S.No	Cube Designation	Slump in mm	%age of E-waste
1.	A1	29	0%
2.	A2	31	3%

3.	A3	36	7%
4.	A4	40	10%
5.	A5	48	12%

b) **Compressive Strength:-** The compressive strength of standard concrete as well as concrete with e-waste at 7days and 28days are given in table-6. It can be clearly seen that the strength of the concrete will increase up to 24.57% when 7% aggregate is replaced by e-waste after 28 days. But when we further increase the percentage of e-waste the strength of concrete starts decreasing.After completing the curing period of the test specimens were kept in dry place for few hours to attaining surface dry condition. Compressive strength machine (CTM) of 2000KN capacity. Compressive strength test was carried out on 150mm x 150mm x 150mm cube specimen for which three cubes were prepared for each mix. Strength of each cube was evaluated after 7 days and 28 days.

- **Table-6 Result of Compressive Strength**

S.NO	%age of E-waste added	CompressiveStrength (N/mm^2) at 7days	CompressiveStrength (N/mm^2) at 28days
1.	0%	24.58	37.54
2.	3%	29.22	42.58
3.	7%	31.24	45.74
4.	10%	24.68	35.05
5.	12%	20.75	31.84

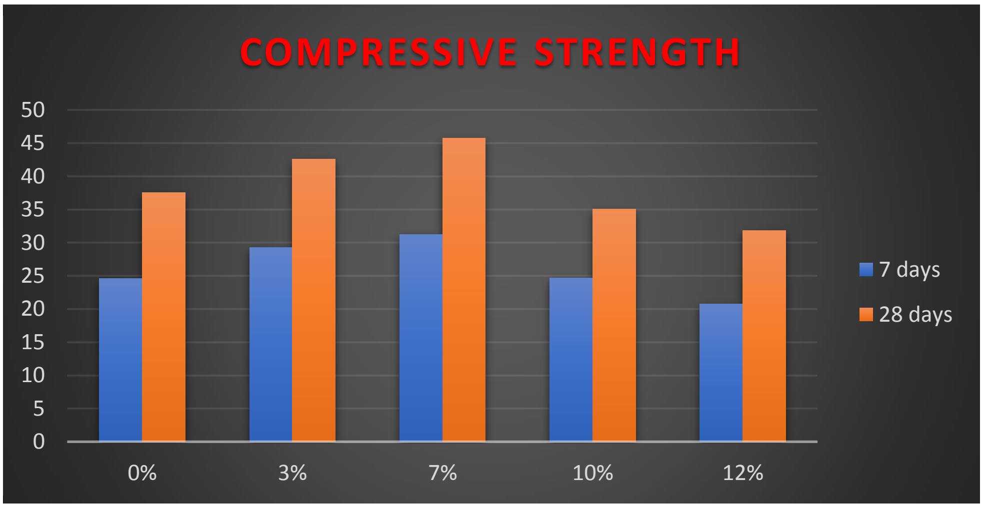

Fig. 4 Compressive strength of concrete with varying dose of e-waste (bar chart)

c) **Split Tensile test:-**Standard cylinder of 15cm Diameter and 30 cm length were supported with the observation made that the upper pate is parallel to the lower plate and the specimen was tested out in accordance with IS : 5816:1999. The diametrical compressive load along the height of the cylinder was applied and the ultimate load at failure or rupture was noted for calculations. . Results are shown in Table 7.

The split Tensile strength of the specimen was calculated as :

$F_{ct}=2P / \pi lD$

Where ,
P = Maximum load in Newton applied to the specimen
l = Length of the specimen, in mm
D = Cross sectional dimension of the specimen, in mm

- **Table-7 Result of Split tensile test**

S.NO	%age of E-waste added	Split Tensile strength in N/mm²at 7days	Split Tensile strength in N/mm²at 28days
1.	0%	2.22	3.68
2.	3%	2.74	3.72
3.	7%	3.25	3.98
4.	10%	2.74	3.55
5.	12%	2.56	2.74

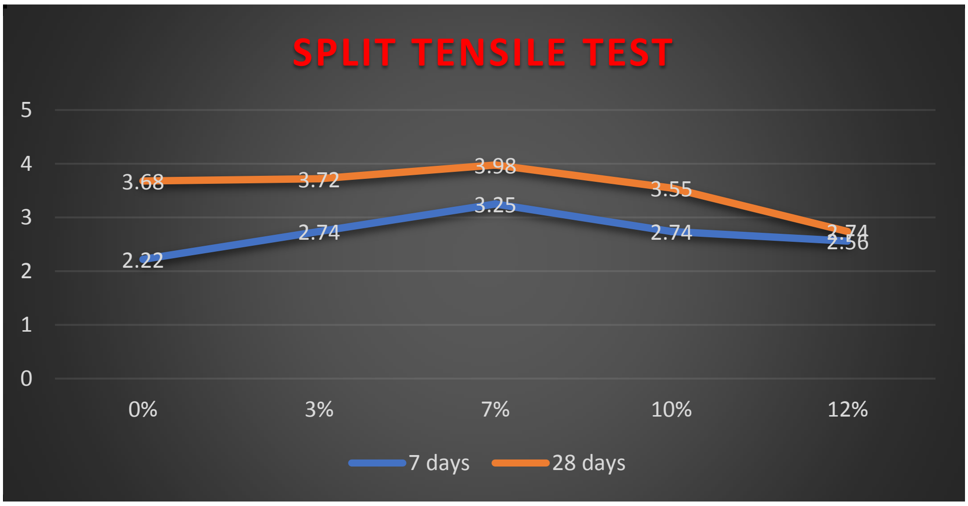

Fig. 5 Split tensile strength of concrete with varying dose of e-waste (line chart)

d) Flexural strength:- The flexural behaviour 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. Flexural strength can be described as the capacity of a beam to resist failure due to bending.

The Flexural strength of the specimen was calculated as :

Fb = (pl)/(bd2)
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 8 From the Table 8, the flexural strength is maximum when replacing 7% of coarse aggregate by E–waste in concrete

- **Table-8 Result of Flexural strength test**

S.NO	%age of E-waste added	Flexural strength in N/mm² at 7days	Flexural strength in N/mm² at 7days
1.	0%	3.12	3.90
2.	3%	4.98	5.25
3.	7%	5.65	6.34
4.	10%	5.38	6.17
5.	12%	4.02	5.09

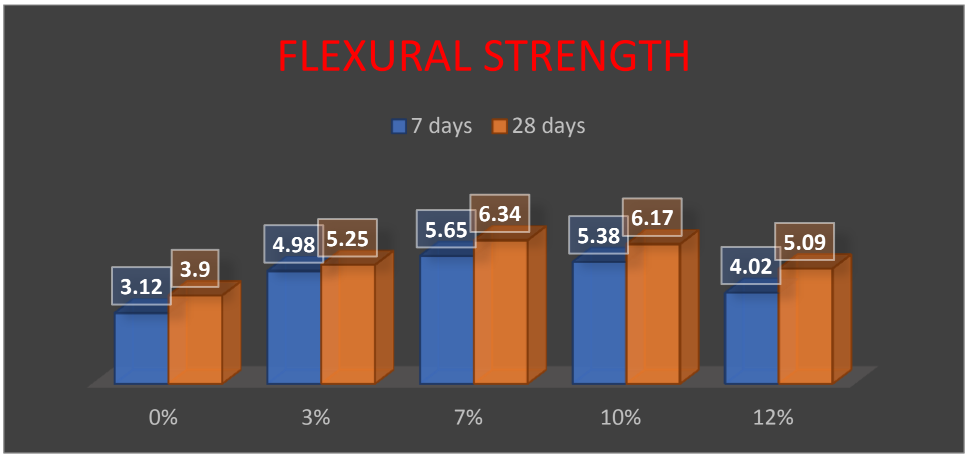

Fig. 6 Flexural strength of concrete with varying dose of e-waste (bar chart)

CONCLUSION:-

1) Saves the land which is used to dispose the e-waste.
2) Makes the concrete light weight and thus the weight of structure is reduced.
3) The strength of concrete is increased by 24.57% at the inclusion of 7% of e-waste.
4) Makes the concrete more flexible hence can easily bear the seismic loads.
5) It reduces the stress on the natural resources.
6) It increase the workability of concrete.
7) It reduces the risk due to the harmful materials of e-waste.

REFERENCES:-

1. Chandan Kumar , Priti Kumari , Krishna Murari"Utilization of e-waste in geopolymer concrete by partial replacement of coarse aggregate."IJCRT | Volume 8, Issue 5 May 2020 | ISSN: 2320-28820
2. E-waste in India paper presented by Research Unit (Larrdis) Rajya Sabha Secretariat New Delhi June, 2011.
3. IS: 456. 2000. Indian Standard "Plain and Reinforced Concrete" - Code of practice. Bureau of Indian Standards, New Delhi.
4. IS-10262 2009, Guidelines for concrete mix design proportioning, Bureau of Indian Standards, New Delhi.
5. IS: 516. 1959. Indian Standard "Methods of Tests for Strength of Concrete"- Code of practice. Bureau of Indian Standards, New Delhi.
6. http://rajyasabha.nic.in/rsnew/publication_electronic/E-Waste_in_india.pdf
7. National Conference on Hazardous e-Waste Management, 2013.
8. IS: 10262: 1982 Standard Code for "Recommended guidelines for concrete mix design".
9. Vivek S. Damal, Saurabh S. Londhe, Ajinkya B. Mane, India, April 2015, 'Utilization of Electronic Waste Plastic in Concrete', Int. Journal of Engineering Research and Applications, Vol. 5, Issue 4, (Part -2),

10. IS: 1489: 1991 Standard Code for Portland pozzolana cement.
11.] IS: 383. 1963. Indian Standard “Specification for Coarse and Fine Aggregates from Natural Sources for Concrete”-Code of practice. Bureau of Indian Standards, New Delhi.
12. D.W.Gawatre, VivekS.Damal ,SaurabhS.Londhe, AjinkyaB.Mane,HrishikeshGhawate, India, May 2015, ‘Environmental Issues of Plastic waste use in Concrete’,International Journal of Innovative Research in Advanced Engineering, Vol. 2, Issue5
13. Balasubramanian, B., Gopala, K.G.V.T. and Saraswathi, V. (2016). Investigation on partial replacement of coarse aggregate using E-waste in concrete. International journal of Earth Science and Engineering. 9(3) : 285-288.
14. P.Krishna Prasanna and M.Kanta Rao “Strength Variations in Concrete by Using E-Waste as Coarse Aggregate” International Journal of Education and applied research, Vol. 4, Issue Spl-2, Jan -June 2014, 82-84