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Performance Evaluation of Polymer E-Waste Concrete under Mechanical and Chemical Exposure Conditions

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***Abstract*— The rapid growth of populations and usage of electronic products are rapidly increasing in the present digital world. Especially developed countries and developing countries are producing huge quantity of electronic products and wastes. In the same time, the construction field is growing in veridical scaling and yet to reach its top of the core in the coming decades. So, the demand of raw materials likes cements, fine aggregate and coarse aggregate could go up. Lack of raw materials affects the growth of the construction industry and it forces us to think on alternative construction materials for constructions. In this research study, the use of polymer E waste is experimentally investigated as building materials to replace the conventional course aggregate. The use of electronic wastes in the concrete can resolve the problem of electronic waste and also satisfy the demand of raw materials for concrete. In this present study, crushed polymer electronic wastes were partially replaced in concrete as a coarse aggregate. The size of course aggregate produced from non-melted electronic wastes was varying from 10 mm to 12.5 mm. The E waste was added in concrete in percentage by volume with various percentages like 5%, 10%, 15%, 18% and 20% based on the existing research outcomes in the published journal papers. The concrete cube specimens which are casted using E waste were tested and analyzed under various curing conditions with different chemicals to check the durability. Major parameters like durability, efficiency and performance of E waste concrete in the curing in various chemical solutions were determined.**

Reinforced concrete beams were casted using M40 and M50 grade of E waste concrete and the beams were examined under gradual loading conditions at various percentages of electronic wastes. Mainly this research study brings out the behavior and performance of concrete using E wastes with various percentages in high strength concrete under the various loading conditions. Besides, the deflection, durability and stiffness of the electronic waste concretes and high performance concretes were examined. The optimum percentage of polymer E waste has been finalized using interpolation technique for the satisfactory performance as a viable option.

***Keywords*-- Polymer Electronic waste, Stiffness of RC beam, High- Performance E – Waste concrete.**

I. INTRODUCTION

General

Technology has been facing advancement since the mankind evolved. From the rock, stones converted to spear, knifes, human has created revolution in inventing so many gadgets, which plays a major role in our everyday life. Without those gadgets life seem to be miserable. Such technological advancement is much higher in the 20th and 21st century. These developments in modern times have been undoubtedly improved the quality of our life. At the same time the management of huge amount of waste generated due to mechanization of the entire world poses a great challenge nowadays. It is listed in Table 1.1 as the amount of waste generated from various sectors.

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TABLE 1.1 WASTE GENERATIONS

S.NO	Types of sectors	Waste generated (MT/day)	% waste composition
1	Domestic household	1870	37.18
2	Commercial establishments	350	6.95
3	Hotels & Restaurants	666	13.24
4	Institutions	125	2.48
5	Parks and Gardens	69	1.38
6	Street sweeping	325	6.47
7	Waste from drains	175	3.47
8	Markets	479	9.52
9	Temples	35	0.70
10	Chicken, mutton, fish stalls	164	3.26
11	Cinema halls	15	0.30
12	Function halls	88	1.74
13	Hospitals	35	0.69
14	Construction and demolition	635	12.62

(Source:http://www.slideshare.net/kamsaniravivarma/msw-in-india)

The waste are generated and dissipated by stockholders which consists of surplus drugs (Sainy Monica, 2016), throw away sharps, microbiological and biotechnological waste, body parts of human beings and animals become the anatomical waste. Liquid, solid, organic, hazardous and also recyclable wastes are generated in general (Abdul Khaliq *et al.,* 2014). This work focuses on the hazardous electronic wastes which when disposed into the environment could pose significant threat to the human health and to the environment.

The implementation of environmental sustainability is to minimize environmental pollution and it will protect people's health. Many of the world's industrialized countries in the early stages of development have caused severe environmental pollution, which has happened in developing countries as well as with the rapid evolution of their economies, all the countries are facing the shortages of natural resources and energy, environmental degradation, lack of infrastructure construction, unemployment and risks to human health. One of the serious consequences of economical and social development is the continuous increase in the volume of waste especially the electronic waste (E-waste In India, 2011). The hazardous waste material in the long run are injurious to nature as they are flammable, corrosive, reactive, toxic, volatile, poisonous and infectious. India is still stressed to dispose of the solid waste of municipalities as landfills and in open dumps.

The E-waste is the term used to cover items of all types of wastes of electrical and electronics equipments (WEEE) (Yeh *et al.,* 2012) as its parts have been disposed by the producers as waste without the consciousness of reuse. The WEEE is quickest developing waste stream around the world.

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The comprehensive volume of E-waste produced about 41.5 million tons in 2011 and during the year of 2016 it has reached to 93.5 million tons.

The electronic business is one of the major activities, and E-waste has turned into the quickest evolving waste stream. This waste stream covers an expansive and growing scope of obsolete electrical and electronics equipment from household appliances, for example, old TVs, coolers, aeration and cooling systems and too little entertainment, for example, video tape recorders (VCRs), MP3 players and personal digital assistants (PDAs).

In spite of the fact that E-waste is risky, if reused an appropriately a few or the greater part of its segments might utilize as a substitution for crude materials and components required in the developing hardware industry and other manufacturing industries (Vivekanandan *et al.,* 2013). Since the most E-waste creating nations are poor asset nations, E-waste reusing and transfer can assume a role in the far-reaching use of assets (Urena *et al.,* 2005). The regulated reusing and transfer procedure of E-waste can just recuperate the most valuable and separated materials like gold plating, aluminum, copper wiring (Yang *et al.,* 2011). Necessary additional materials, for instance, platinum, cadmium, and barium disposed of which are wasteful, as well as to a significant degree contaminates the earth. Further, industrialized nations trade the E-waste to the developing countries, in the name of donation, reuse or recycling. Such exports are increasing the E-waste issues in developing nations. Also, from taking care of their own rapidly developing E-waste, the countries are failed to take care of the E-waste being dropped within their national limits by industrialized countries. The E-waste administrations are exploded into a primary issue in the developing countries. Unlike the sophisticated accumulation, transportation, arrangement, destroying and reusing (Maria Paola Luda, 2011), the E-waste administration structure are creating problems, for example, Japan is still in the early phases of advancement (Clean Japan Centre, 2002). To address the issue of E-waste and to conform the directions of the industrialized nations, some nations have detailed and drafted a few laws and control to oversee E-waste while their authorization stays rough.

II. Material Used For Testing

Mix Design

(Referred Code Book Is 10262:2009, Is 456, Is 186)

Stiputations For Proportioning:

1. Grade designation = M 25
2. Type of cement = OPC 43 grade
3. Maximum nominal size of aggregate =12.5 mm
4. Workability = 100 mm
5. Method of concrete placing = pumping
6. Degree of supervision = good
7. Type of aggregate = crushed angular *aggregate*

Test Data For Materials

a) Cement used = OPC 43 grade conforming to IS:8112
b) Specific gravity of cement = 3.14
c) Specific gravity
i. Coarse aggregate =2.80
ii. Fine aggregate = 2.76

1.Target Strength For Mix Proportioning

f1ck = fck+1.65 S where S = 4.0 N/mm2
f1ck- target average compressive strength at 28 days.
fck – characteristic compressive strength at 28 days.
S – Standard deviation.
f1ck= 25+1.65x4 = 31.6 N/ mm2
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2. Selection Of Water Cement Ratio

Water cement ratio = 0.45

Selection Of Water Content

Maximum water content for 12.5mm aggregate = 202.5 liters

Calculation Of Cement Content

It is assumed that the efficiency of super plasticizer used as 25% . Therefore actual alter to used=202.5/0.45

Calculation Of Fine And Coarse Aggregate

According to IS383 -1970 table 4 fine aggregate comes under the zone III
Volume of course aggregate =0.50(From table 3 IS 10262:2009) for 20mm aggregate
Volume of fine aggregate =1-0.50=0.50

Calculation Of Mix Propotion

a) Volume of concrete =1m3
b) Volume of cement = 450/ 3.14 x 1/ 1000= 0.1433 m3
c) Volume of water = mass of water /Specific gravity of water x1/1000
= 202.5x1/ 1000
= 0.2025m3
d) Volume of all in aggregate = (a- (b+c))
= (0.98(0.1433+0.2025)
= 0.6542m3

e) Mass of coarse aggregate = volume off all in aggregate x volumeof coarse aggregate x
Specific gravity of coarse aggregate x 1000
= 0.6542X 0.50X2.80X1000
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= 887.88kg
f) Mass of fine aggregate = volume of all in aggregate x volume offine of fine aggregate x
specific gravity of fine aggregate x 1000
= 0.6542x 0.50x 2.76x1000
= 875.196 kg

Mix Proportions

Cement = 450kg/m3
Water = 202.5 liters
Fine aggregate = 875.196 kg/m3
Coarse aggregate = 887.88 kg/m3
Water cement ratio = 0.45

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III. METHODOLOGY

3.1 Flow Chart of Methodology

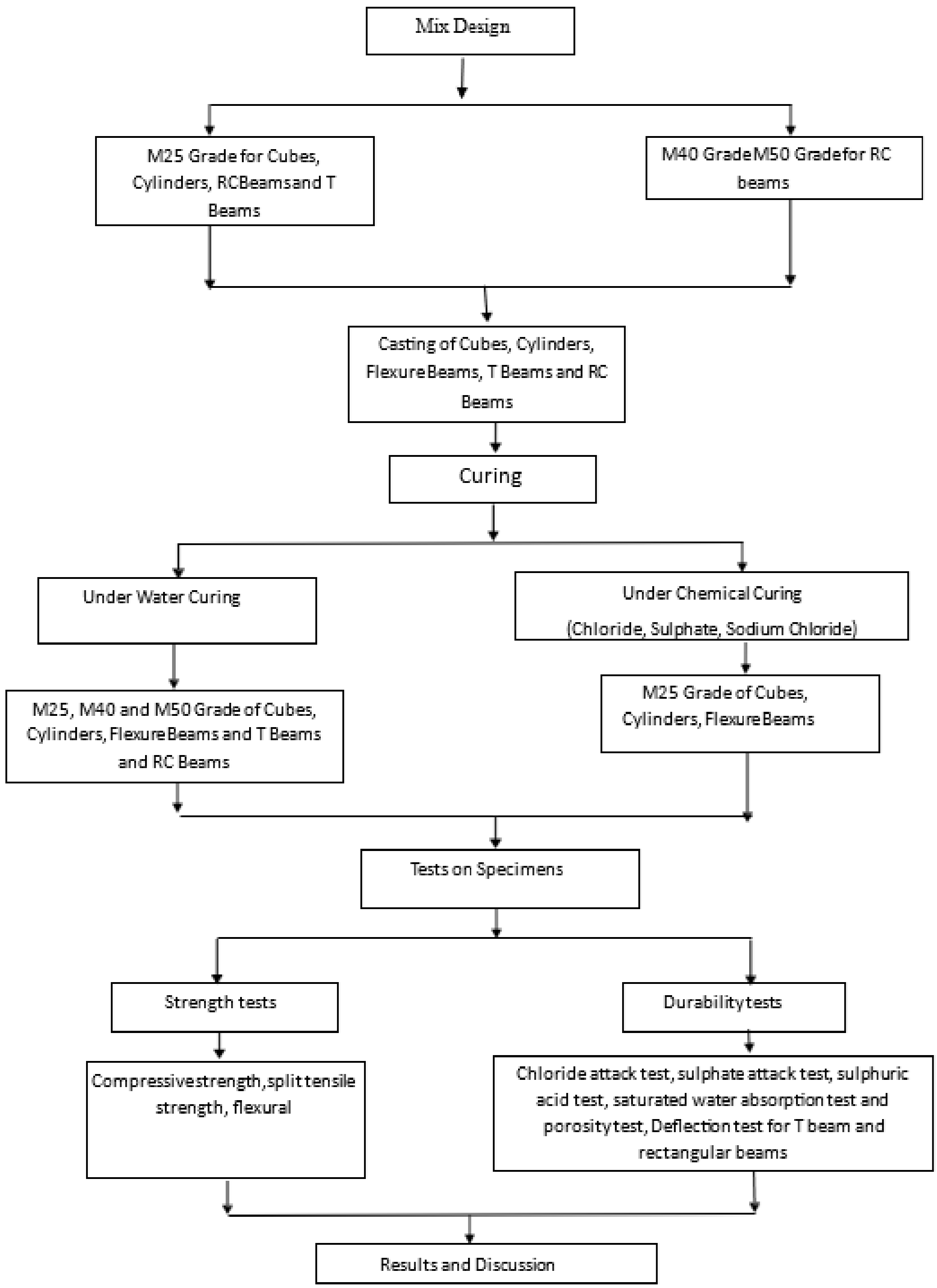

Figure 3.1 Flow chart for methodology

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3.1.1 Cement

The 43 grade ordinary portland cement was used in this investigation. The different physical properties of the cement were tested as per IS 4031:1988 code. The test results are tabulated in Table 3.1.

TABLE 3.1 PHYSICAL PROPERTIES OF CEMENT

Physical properties	Observations
Specific gravity	3.14
Standard Consistency	33%
Initial setting time	30 min
Final setting time	8 hrs 35 min
Compressive strength	43.86 N/mm^2

3.1.2 WATER

Clean potable water is used for casting and curing operation of the specimens.

The water used for entire testing was having pH value 7.5 – 8.0.

3.1.3 FLY ASH

The fly ash of class F samples was obtained from Mettur Thermal power plant (MTTP) through ACC, Ltd. Coimbatore, Tamil Nadu. Fly ash with specific gravity of 2.37 was used to cast the specimens. The chemical composition of fly ash is tested as per IS procedure and presented in Table 3.2.

TABLE 3.2 CHEMICAL COMPOSITION OF FLY ASH (MASS %)

$SiO_2+Al_2O_3+Fe_2O_3$	SiO_2	CaO	SO_3	Na_2O	MgO	Loss on ignition
90.5	58	3.6	1.8	2.0	1.91	2.0

3.1.4 FINE AGGREGATE

The well graded river sand was used as fine aggregate which conforming to grading zone II as per IS 383-1970 with a specific gravity of 2.76.

3.1.5 COARSE AGGREGATE

Locally available crushed and angular coarse aggregate with a specific gravity of 2.80 was used. The physical properties of coarse aggregate were tested as per IS 383-1970, and the results were tabulated in Table 3.3.

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TABLE 3.3: PHYSICAL PROPERTIES OF COARSE AGGREGATE

Properties	**Coarse aggregate**
Specific gravity	2.8
Absorption (%)	0.5
Colour	Dark
Crushing value	27.4%
Shape	Angular
Impact value	24.62%

3.1.1 E WASTE

E wastes were collected from the sources in the form of scrap material which resulted from the electrical or electronic devices. In this study, crushed E wastes were used as coarse aggregate for the partial replacement in concrete. The E wastes are collected from Sri Muneeshwaran scraps industry at Hosur in Tamilnadu state.

The outer frame of devices, polymer E wastes, were collected and crushed by crushing machine to the size range of 10 to 12.5 mm. Crushed E wastes were washed by potable water and dried over the sunlight to avoid the influence of fine powder generated during crushing. The determined physical and chemical properties of E wastes were listed in Table 3.4 and shown in Figure 3.2.


Figure 3.2: Crushed Electronic Waste

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TABLE 3.4: PHYSICAL PROPERTIES OF E WASTE

Properties	**E waste**
Specific gravity	1.07
Shape	Crushed and Angular
Size	10 – 12.5mm
Absorption (%)	<0.2
Colour	Dark
Crushing value	<2%
Impact value	<2%

3.1.2 MIX PROPORTIONS

Mix proportion for M25 grade of concrete was calculated using design process as per IS10262:1982. The estimated mix proportion was 1:1.56:2.56 with water, cement ratio of 0.45. The E waste material was used as coarse aggregate in concrete and different quantity of E waste were decided to cast the cubes.

The following quantities were finalized to replace the course aggregate by E waste by volume in addition to the controlled concrete with w/c ratio of 0.45. The percentages of E wastes in concrete were 0%, 5%, 10%, 15%, 18% and 20%. The series of mixtures were detailed in Tables 3.5.

TABLE 3.5 MIX SPECIFICATIONS – M25 GRADE

Type of concrete	Controlled concrete	M1	M2	M3	M4	M5
% of E waste added	0%	5%	10%	15%	18%	20%

3.1.3 CASTING AND CURING

The concrete specimens with electronic waste ranging from 0% to 20% were prepared. The prepared mix was tested for slump value. Regular tap water was used for casting and curing of all the specimens. A sufficient number of cubes, cylinders, prisms, beams, T beams and RC beams were casted and cured at a room temperature of almost 27°C ± 2°C. The casted concrete specimens were demolded and immersed in clean, fresh water and chemicals until the standard curing period.

3.2 EXPERIMENTAL TEST PROGRAMME

This project deals with the behaviour of polymer E waste concrete in partial replacement of coarse aggregate.

Also, It was determined the deflection and stiffness of M25 grade and high strength concrete such as M40 and M50 with electronic waste. Two hundred and sixteen cubes, three hundred and thirty three cylinders, forty eight beams were casted, cured and tested for compression, split tensile and deflection respectively. In this research study, modification of concrete strength for different percentage of replacement of coarse aggregate by E waste was studied.

3.2.1 COMPRESSIVE STRENGTH TEST

For casting of cubes to determine the compressive strength for both controlled and E waste added concrete, mould with 150 X 150 X 150 mm were used. For all the tests, 216 numbers of concrete cubes were casted and tested for compressive strength. Figure 3.3 shows the typical moulds for casting concrete cubes.

Figure 3.3 Cube Moulds for casting concrete

IV. Results & Conclusions

In this research work, E waste management were discussed based on the various tests to findout the different physical and chemical properties of fresh and hardened concrete. Based on the obtained results the following conclusions were derived.

- A gradual improvement of strength in E waste concrete upto 10% replacement of coarse aggregate in concrete by polymer E waste and followed by decreasing gradually.
- Density of concrete is decreasing gradually against increase in quantity of E waste in concrete, because the lesser specific gravity of E waste.
- The addition of E wastes in concrete more than 10% will increase the porosity of concrete and making the density of concrete low.
- Maximum split tensile strength of concrete cylinder was obtained at 15% at 28 days curing.
- The compressive strength at 10% replacement by E waste gets maximum value.
- The split tensile strength was resulted maximum at 15% addition of E waste.
- The linear regression analysis was carried out to find out the optimum value between 10% and 15%. From the analysis, it is found that 16.7% is the optimum percentage of replacement of course aggregate by polymer E waste.
- Modulus of elasticity as per test for controlled concrete was obtained that 8.2×10^3 N/mm^2.
- The modulus of elasticity of 5% of E waste concrete was reduced to 8.06×10^3 N/mm^2. The modulus of elasticity further reduced to 7.8×10^3 N/mm^2 for 10% of E waste concrete, for 15% addition it is obtained as 7.6×10^3 N/mm^2 and the same for 18% of E waste concrete was 6.6×10^3 N/mm^2. It clearly display the trend of variation of modulus of elasticity is decreasing order with increasing of E waste due to flexibility.
- Flexural strength of E waste concrete beam was 6.23 N/mm^2 which is maximum at 10% of E waste under H_2SO_4 curing conditions.
- The maximum flexural strength of the beam was 6.19 N/mm^2 at 10% replacement of E waste in concrete under chloride curing.
- Addition of E waste in the beam more than 10%, the strength was reduced gradually due to the high volume of E waste and also the bonding of waste and concrete is low compared to control.
- Chloride attack tests show that 2.5% loss of weight and 3.6% loss of compressive strength in E waste concrete compared to controlled concrete.
- The maximum loss of weight of E waste concrete under 60 days curing was observed at 15% replacement of course aggregate due to Sulphate.

- The maximum loss of weight of E waste concrete under 60 days curing was observed at 15% replacement of course aggregate due to the effect of sulphuric acid.
- The gain of strength was observed in T beam due to the addition of E wastes in the concrete.
- Under gradual loading conditions, the ultimate load was 68.60 kN and minimum deflection of E waste concrete beam was 0.03 mm at addition of 15% of E waste.
- Presence of E waste further increases the strength of concrete, bending moment capacity of the beam and reduces the failure load of beams.
- T beams performed well under the gradual loading conditions.
- Maximum stiffness value was obtained at 15% of E waste for M40 and M50 grade beams, the value is 66217.5 kN and also it leads to 7.35 mm deflection for M40 grade concrete beam.
- The addition of flyash resulted good improvement in properties. With 12% E wastes and 10% flyash produces the lowest value of 2.45% of weight reduction.
- The behavior of polymer E waste in concrete with respect to permeability, the saturated water absorption increases with increase of flyash and saturated water absorption decreases with increase in flyash content in concrete with or without E waste.
- Porosity in the concrete is increases with increase of flyash and sorptivity is marginally increasing with increase in flyash and E waste.

REFERENCES:

[1] Abdul Khaliq, Muhammad Akbar Rhamdhani, Geoffrey Brooks & Syed Masood. 2014. Metal Extraction Processes for Electronic Waste and Existing Industrial Routes, A Review Australian Perspective, Faculty of Science, Engineering and Technology, Swinburne University of Technology, Hawthorn, VIC 3122, Australia. 3(1): 152-179.

[2] Aditya, G., Dinesh, S., Shubam, S. and Praveen, P. 2016. Utilization of E–plastic waste in concrete. International Journal of Engineering Research & Technology. 5: 2278-0181.

[3] Adjei, S.M., Municipal solid waste minimisation through household waste segregation in Bantama, Kumasi. A thesis submitted to the Department of Environmental Science, Kwame Nkrumah University of Science and Technology, Kumasi, in partial fulfilment of the requirement for the award of Master degree in Environmental Science. 2013.

[4] AhamedShayan, AiminXu. 2004. Value-added utilisation of waste glass in concrete, Cement and Concrete Research. 34: 81-89.

[5] Aiswarya.S, AnandNarendran, Prince Arulraj.G. 2013. Experimental Investigation on Concrete Containing Nano-Metakaolin, An International Journal (ESTIJ), ISSN: 2250-3498. 3(1).

[6] Alagusankareswari,K, S. Sandeep Kumar, K. B. Vignesh and K. Abdul Hameed Niyas. 2016. An Experimental Study on E-Waste Concrete", Indian Journal of Science and Technology. 9(2).

[7] Alhozaimy, A. M. and Shannag, M. J. 2009. Performance of concretes reinforced with recycled plastic fibres. Magazine of Concrete Research. 61: 293-298.

[8] Aliaari, M. 2005. Development of Seismic Infill Wall Isolator Subframe (SIWIS) System. Ph.D. Thesis, Penn State University, University Park, PA, USA.388.

[9] Al-Manaseer AA, Dalal TR. 1997. Concrete containing plastic aggregates', Concrete International. 19(8):47–52.

[10] Amer, Ibrahem,Shakir.M, Al-Mishhadani.A, ZeinabH.Naji. 2013. The Effect Of Nano Metakaolin Material On Some Properties Of Concrete, Diyala Journal of Engineering Sciences. 6 (1): 50-61.

[11] American Society for Testing and Materials. 2008. Standard test method for determination of the composition of unprocessed municipal solid waste, In ASTM D 5231-92.

[12] AmiyaAkram, C. Sasidhar, K. Mehraj Pasha. 2015. E-Waste Management by Utilization of E-Plastics in Concrete Mixture as Coarse Aggregate Replacement. 4(7).

[13] Amnon Katz. 2003. Properties of concrete made with recycled aggregate from partially hydrated old concrete, Cement and Concrete Research. 33:703-711.

[14] Arensman, R. 2000. Electronic Business, the Management Magazine for the Electronics Industry. 26 (12): 108.

[15] Ari V. 2016. A review of technology of metal recovery from electronic waste, Ch. 6. In: Florin-Constantin Mihai (ed) E-Waste in Transition - From Pollution to Resource.

[16] Arlindo Goncalves, Ana Esteves and Manuel Vieira. 2004. Influence of recycled concrete aggregates on concrete durability, Proceedings of the International RILEM Conference, Barcelona. 279: 1-9.

[17] Arora, A and U. Dave. 2013. Utilization of E- Waste and plastic bottle waste in concrete", International Journal of Students Research in Technology and Management. 1(4): 398-406.

[18] Ashwini Manjunath B.T. 2016. Partial Replacement of E-Plastic Waste as Coarse Aggregate in Concrete, Procedia Environmental Sciences. 35, 731-739.

[19] Avila AF, Duarte MV, (2003) 'A mechanical analysis on recycled PET/HDPE composites', PolymDegradStabil, vol.80, no. 2, pp. 373–82.

[20] Baboo R, Tabin-Rushad S, Bhavesh KR, Duggal SK. 2012. Study of waste plastic mix concrete with plasticizer, International Scholarly Research Network, ISRN CivEng. 1–5.

[21] Balakrishna,k, CSukesh, P.S.Teja, M.T.Meher. 2011. Partial replacement of fine Aggregates with waste plastic in concrete, International Journal of Civil Engineering Research. 3(2):105-113.

[22] Balasubramanian, B., Gobala, 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.

[23] Balde, C. P. 2017. The global E-waste monitor, Quantities, flows and resources. United Nations University, International Telecommunication Union, and International Solid Waste Association.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435 (Online) Volume 15, Issue 07, July 2026)

[24] Batayneh M, Marie I, Asi I. 2007. Use of selected waste materials in concrete mixes', Waste Management. 27(12): 1870–1876.

[25] Benjamin TernengeAbur, Emmanuel EnomenaOguche. 2014. Characterization of Municipal Solid Waste in the Federal Capital Abuja, Nigeria, Global journals. 14(2).

[26] Bhogayata, K. D. Shah, B. A. Vyas, Dr. N. K. Arora. 2012. Performance of concrete by using Non Recyclable plastic wastes as concrete constituent, International Journal of Engineering Research and Technology (IJERT).1(4).

[27] Binegde, G. H., Nair, A. S and Zuberi, M. I. 2015. Electronic Waste Generation and Its Management in Bole and Akaki Kaliti Sub cities of Addis Ababa Ethiopia. International Journal of Environmental Sciences. 4(2): 46-51.

[28] Brahim S, Mohammed S, Djamila A and Madani M. 2013. The use of plastic waste as fine aggregate in the self-compacting mortars: Effect on physical and mechanical properties, Construction and Building Materials. 43. 436–442.

[29] Cagatay, I. H. 2005. Failure of an Industrial building during a recent earthquake in Turkey.Engineering Failure Analysis. 12(4): 497-507.