EXPERIMENTAL STUDY ON CONCRETE CONTAINING E-WASTE AND FLY ASH

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ABSTRACT: Utilization of waste materials and byproducts 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 cement and 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 25% 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 E plastic particles as partial replacement of coarse aggregate has been presented.The physical and chemical properties of forty nine different fly ash products from different sources within the United States are evaluated the evaluation was conducted based on the standard physical and chemical requirements of ASTM C 618, standard specification for coal fly ash and raw or calcined natural pozzolan for use in concrete physical properties including fineness, density, water requirement and strength activity index and major chemical properties including acidic elemental analysis and loss on ignition were characterized. "Standard test method for sampling and testing flyash or natural pozzlans for use in portland cement concrete". The effects of fineness and carbon content on 7 day strength activity index activity are described.

KEY WORDS: Compressive strength, e waste, Slump, Waste

1.INTRODUCTION

Concrete is one of the most widely used construction materials in the world because of its versatility, durability, and strength. However, the increasing demand for concrete has led to the excessive use of natural aggregates and cement, resulting in the depletion of natural resources and environmental degradation. At the same time, rapid industrialization and technological advancement have led to the generation of large quantities of electronic waste (E-waste) and industrial by-products such as fly ash, creating major challenges in waste disposal and environmental management.E-waste refers to discarded electrical and electronic devices such as computers, mobile phones, televisions, circuit boards, and cables. These wastes contain non-biodegradable materials, plastics, and metals that cause severe environmental pollution if not properly managed. Recycling and reusing E-waste in construction materials such as concrete can help reduce landfill problems and conserve natural resources. When processed and crushed, E-waste materials can be utilized as a partial replacement for coarse or fine aggregates, leading to sustainable and eco-friendly concrete production.Fly ash, on the other hand, is a by-product obtained from coal combustion in thermal power plants. It is a fine, pozzolanic material that reacts with calcium hydroxide in the presence of moisture to form additional calcium silicate hydrate (C–S–H), which contributes to the strength and durability of concrete. The inclusion of fly ash as a partial replacement for cement improves Combining E-waste and fly ash in concrete offers a dual benefit — effective waste utilization and improved performance characteristics. While E-waste contributes to the conservation of natural aggregates and reduction in dead load, fly ash enhances the microstructure and overall strength development of concrete. This combination supports the concept of sustainable construction, reducing carbon footprint and promoting resource efficiency.

2. SCOPE OF THE STUDY

The scope of an experimental study on concrete containing electronic waste (e-waste) and fly ash defines the boundaries, specific materials, testing parameters, and structural applications investigated in the research**.**

3. OBJECTIVES

The objective of an experimental study on concrete containing **E-waste** (electronic plastic/circuit board waste) and **fly ash** (a coal combustion byproduct) is to evaluate how partially replacing natural coarse aggregates and cement with these waste materials affects the concrete's mechanical and environmental properties.

4. MATERIALS AND METHODOLOGY

4.1 MATERIALS

4.1.1 Cement

Cement is the critical binder that helps hold everything together. It is a powder made from calcined limestone and clay. Cement has two setting stages: initial setting (30-45 minutes) and final setting (6-10 hours). These times ensure sufficient working time and proper hardening for construction.

4.1.2 Water

Water reacts with cement to initiate a chemical reaction called hydration. The hydration reaction leads to the hardening and setting of the concrete. The appropriate water-to-cement ratio is crucial for achieving the desired strength and durability of the final product.

4.1.3 Aggregate

Aggregates, such as gravel, sand, crushed stone, or recycled materials, provide the bulk and stability to concrete.

4.1.4 Fine aggregate

Fine aggregate is the filler for the voids in the coarse aggregate one of the main Ingredient in concrete. Fine aggregate can hold moisture in three forms: surface, absorbed, or free water. This property impacts the water-cement ratio and workability. Fine aggregates should have a rounded or angular shape and smooth texture for better workability and bonding in concrete

4.1.5 Coarse aggregate

Coarse aggregates are typically used in coarser concrete mixes, while fine aggregates are used in finer mixes. Coarse aggregate is less expensive than cement. By forming a large part of the concrete volume, it reduces the overall cost of the mix. In pavements and other high-wear applications, coarse aggregate provides resistance to abrasion and impact, extending the service life of the structure.

4.1.6 E–WASTE

E-waste used in this study mainly consisted of shredded plastic components from discarded electronic devices such as computer monitors, keyboards, mobilephones, and circuitboards. The collected E-waste was cleaned, crushed into angular pieces, and sieved to obtain particle sizes similar to that of coarse aggregates (10–20 mm). E-waste serves as a partial replacement for coarse aggregate by 0%, 10%, 20%, and 30%.

4.1.7 FLY ASH

- Flyash is a by-product obtained from coal combustion in thermal power plants.It was used as a partial replacement for cement by 10%, 15%, and 20%. Class F fly ash conforming to IS: 3812 (Part 1)–2013 was used.
- The inclusion of fly ash enhances the workability, reduces the heat of hydration, and contributes to long-term strength through pozzolanic reactions.

4.2 METHODOLOGY

4.2.1 Concrete Mix Design

In the present study, M20 grade with nominal mix as per IS 456 – 2000 was used. Concrete mix proportion by weight for $1m^3$ and water cement ratio of 0.5. Table 1. Gives the mix used for study.

Table 1: Mix proportion

S.NO	Cement	Water	Fine aggregate	Coarse aggregate
Normal concrete	1	0.5	1.6	3.2
E – waste and fly ash	1	0.5	2.9	1.3

4.2.2 Casting and Testing

Pumice was added in concrete in step of (10%, 20%, 30%). The percentage of partially replacement are arrived with trial study using Pumice. For each percent of E – waste and Fly ash partially replacement as coarse aggregate, cubes, cylinders, beam were casted. Final strength of cubes, cylinders and beams are tested for 7days, 14days and 28 days curing. The average compressive strength, split Tensile strength and Flexural strength are then determined for each mix proportion and discussed in the result and discussion.

5.RESULT AND DISCUSSION

5.1 Test results of compressive test

The cube specimens are tested for compressive strength at the end of 7days, 14days and 28days.

$fc = P / A \quad N / mm^2$

The results of the compressive strength tests on concrete cubes are shown in Table 2(a) and Figure 2 (a)

Table 2(a): Test result of Compressive Strength

S.NO	Percentages replacement of E – waste and fly ash	Average Compressive Strength N/mm^2		
		7 Days	14 Days	28 Days
1	10%	14.65	18.59	22.54
2	20%	12.96	16.27	19.95
3	30%	12.72	15.05	18.03

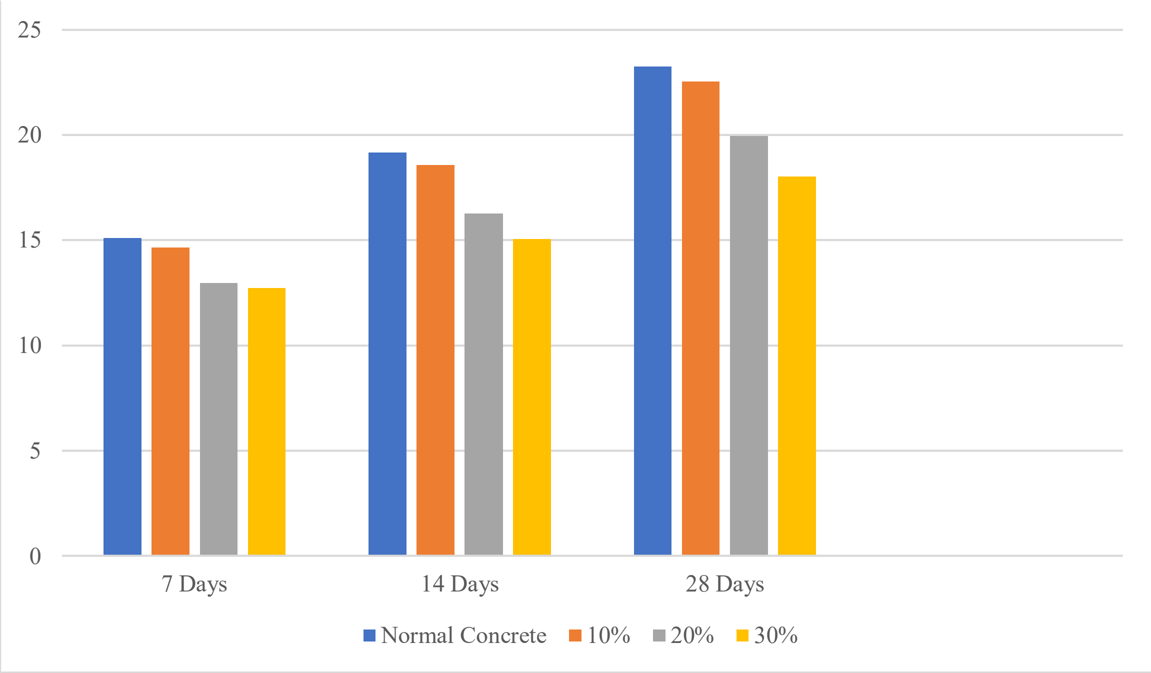

Figure: 2 comparison of compressive strength result

Figure: 2(a) Compressive Test

5.2 Test results of Split Tensile test

The cylinders specimens were tested for split tensile strength at the end of 7 days, 14 days and 28 days. The split tensile strength of the specimen was calculated by using the formula fc = 2p /πdl

The results of the split tensile strength tests on concrete cylinders are shown in Table 2 (b) and Figure 3

Table 2(b): Test results of Split Tensile Strength

S.NO	Percentage replacement of E – waste and fly ash	Average Split Tensile Strength N/mm^2		
		7 Days	14 Days	28 Days
1	10%	1.57	2.0	2.43
2	20%	1.46	1.86	2.26
3	30%	1.07	1.36	1.65

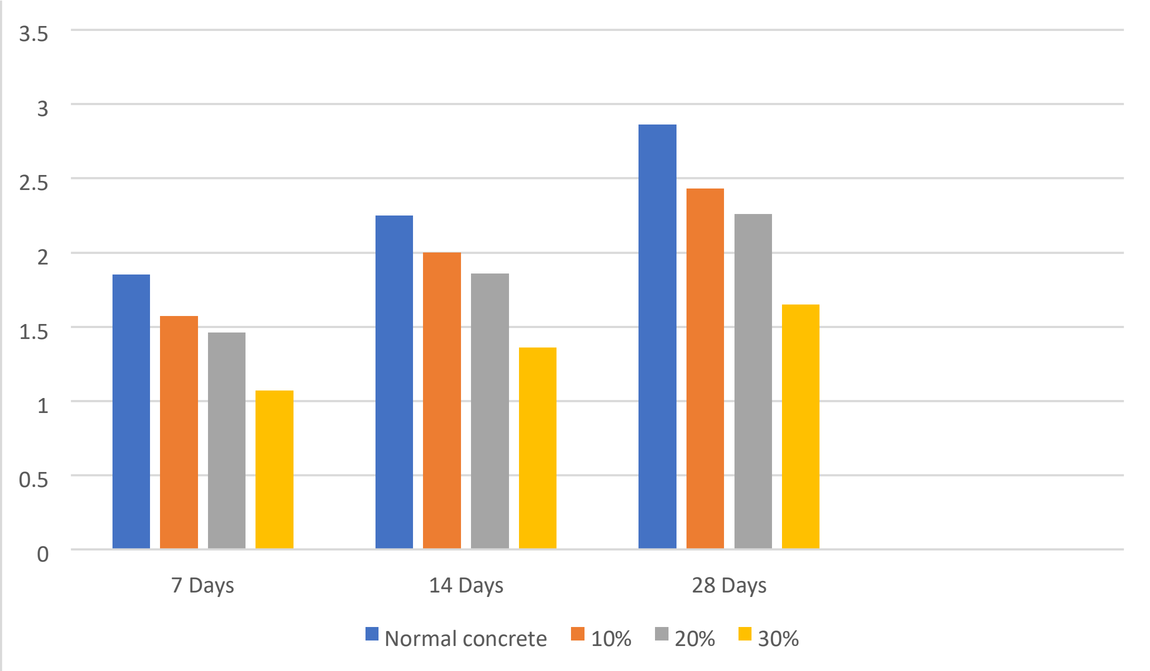

Figure 3: Comparison of split tensile result

Figure 3(a): Split Tensile Test

5.3 Test result of Flexural strength test

The beam specimens are tested for flexural strength at the end of 7 days, 14 days and 28 days.

The Flexural Strength of the specimen is calculated by

$Fb = Pl^2\ N/mm^2/bd$

The results of the Flexural strength tests on concrete beams are shown in Table 2(c) and Figure 4 Table 2(c) Test results of Flexural strength

S.NO	Percentage replacement of E – waste and fly ash	Average Flexural Strength N/mm^2		
		7 Days	14 Days	28 Days
1	10%	1.98	2.52	3.06
2	20%	1.93	2.45	2.97
3	30%	1.79	2.27	2.76

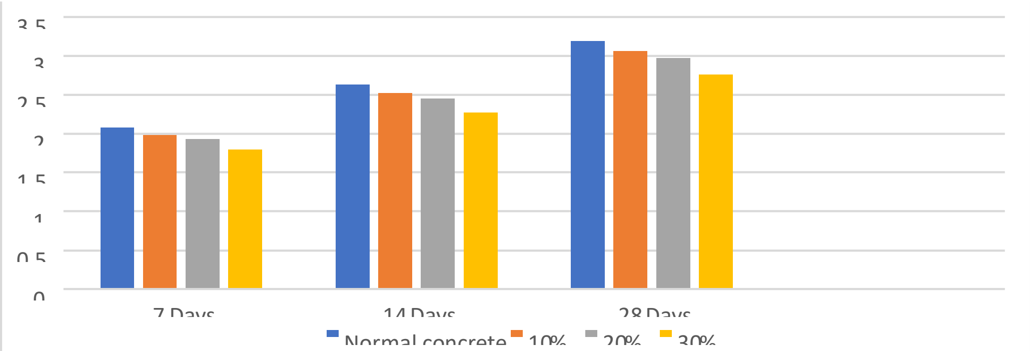

Figure 3: Comparison of flexural test

Figure 3(a): Flexural Test

6. CONCLUSION

- The experimental investigation was carried out to study the performance of concrete in which E-waste was used as a partial replacement for coarse aggregate and fly ash as a partial replacement for cement.

All materials were tested as per Indian Standards, concrete mixes were prepared, cured, and tested for mechanical strength, and the results were compared with those of conventional concrete.

- The study involved replacement of coarse aggregate by E-waste (0 %, 10 %, 20 %, 30 %) and cement by fly ash (0 %, 10 %, 15 %, 20 %) in M25 grade concrete.
- Tests were conducted on fresh and hardened concrete, including workability, compressive strength, split tensile strength, and flexural strength.

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