

Experimental Investigation on E-Waste Concrete Using Mineral Admixtures

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Abstract: Our reliance on electronics, a cornerstone of modern life, comes at a cost. The relentless pace of technological advancement generates mountains of discarded devices, creating the growing problem of electronic waste. This E-waste, if improperly disposed of, can contaminate landfills and release harmful materials into the environment. This study investigates a potential solution: using a portion of e-waste in place of fine aggregate. To improve overall performance, we also incorporate mineral admixtures. Our research aims to understand how both the amount of e-waste and the specific mineral admixtures used influence the final properties of the concrete. We systematically replaced the fine aggregate with e-waste at varying percentages (0%, 10%, 20%, and 30%) and meticulously analyzed the resulting effects. The study identifies 10% e-waste replacement as the optimal level for achieving desirable properties in M20 grade concrete, a commonly used strength classification. This approach offers a two-fold benefit. It tackles the e-waste crisis by providing a sustainable disposal option, and it potentially reduces the construction industry's reliance on virgin resources like natural sand, contributing to a more sustainable future.

Key words: E-waste, Fly ash, Fine Aggregate, Coarse Aggregate.

1. Introduction:

Our fast-changing technological environment is currently facing a growing concern: electronic waste, also known as E-waste. As E-waste management becomes a crucial health issue, it is essential to come up with innovative solutions for its reuse and recycling. This research focuses on exploring the possibility of using E-waste as a replacement for fine aggregate in concrete. By utilizing the well-known M20 concrete mix design, which is recognized for its optimal strength and workability, we seek to analyze the effects of this substitution on the mechanical properties, durability, and environmental impact of the resulting concrete. By examining the feasibility of incorporating E-waste as a sustainable construction material, our study aims to encourage environmentally friendly building

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practices. Through a systematic assessment of concrete performance with different concentrations of E-waste, this research strives to provide valuable insights for industrial applications and potential regulatory frameworks. Ultimately, the findings of this study **Saad Ullah et al. (2022)** This exploration examined the impact of replacing 20%. The study included specimens with various shapes (circular, rectangular, and square) to analyze how the shape interacts with the e-waste incorporation. Additionally, the research explored the effect of CFRP confinement on these specimens, offering valuable insights into potential strengthening methods or concrete containing e-waste. [1] R. Rajkumar et al. (2021) This study evaluated the performance of concrete reinforced with a composite material combining electronic waste (e-waste) and jute fibers. The research involved partially replacing coarse aggregate, specifically allocating 5% of the original volume to e-waste. [2] Arivalagan S (2020) The research evaluates the benefits of utilizing E-waste in place of coarse aggregate. The study analyzed the effects of incorporating E-waste at different levels. [3]

The objective of this study is to investigate the impact of incorporating different proportions of electronic waste (E-waste) on the mechanical properties and performance of M20 grade concrete, evaluated using non-destructive testing methods. The research involves the use of varying levels of E-waste (0%, 10%, 20%, and 30%) as a partial replacement for the fine aggregate component.

2. Materials and Methods:

Cement: Essential in construction, (OPC) constitutes a crucial building block with a composition primarily comprising clinker (approximately 95%) and gypsum (about 2-5%). The formation of clinker, derived from heating a blend of limestone and clay, serves as the fundamental element in OPC, with gypsum introduced during the grinding process to control the setting time of the cement. These integral constituents collectively contribute to the strength and adaptability of OPC. The properties of cement are presented in table 1

Table 1 Properties of Cement

S.No	Properties	Values
1	Grade	OPC 53
2	Fineness	5%
3	Standard Consistency	33.5%

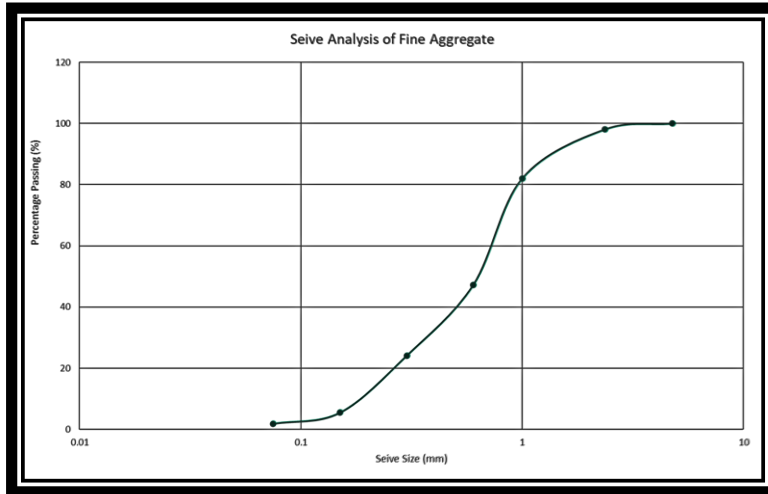
Fine aggregate: Fine particles, such as sand or crushed stone, play a crucial role in concrete composition due to their small size, measuring less than 5 millimetres. These particles effectively fill the spaces between larger particles like gravel, thereby improving the strength and manageability of the concrete mixture. Any particles that can pass through a 4.75mm sieve are considered for analysis. Detailed information about the properties of the fine aggregate can be found in table 2, and the results of the sieve analysis are illustrated in figure 1.

Table 2 Properties of Fine Aggregate

S.No	Properties	Values
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1	Percentage of Water Absorption	5.28%
2	Fineness	2.78
3	Zone	I

Figure 1: Sieve analysis of fine aggregate



Coarse Aggregate: The relative density of the 20mm coarse aggregate is 2.67, and it has a fineness of 7.54. In the test specimens, 60% of the coarse aggregate passes through a 20mm

Figure 2: Sieve analysis of coarse aggregate

sieve but is retained by a 10mm sieve, while the remaining 40% passes through a 10mm sieve but is stopped by a 4.75mm sieve. The characteristics of the coarse aggregate are listed in Table 3, and the sieve analysis of E-Waste is illustrated in figure 2.

Table 3 Properties of Coarse Aggregate

S.No	Properties	Values
1	Percentage of Water Absorption	0.80%
2	Fineness	7.54
3	Shape	Angular

E-waste: Electronic waste, or E-waste, is comprised of outdated electronic devices like old computers, phones, and other gadgets that are no longer operational. The properties of E-waste powder play a significant role in defining the qualities of these discarded electronic items. The characteristics of E-waste aggregate can be found in Table 4, whereas the sieve analysis of E-waste is depicted in figure 3.

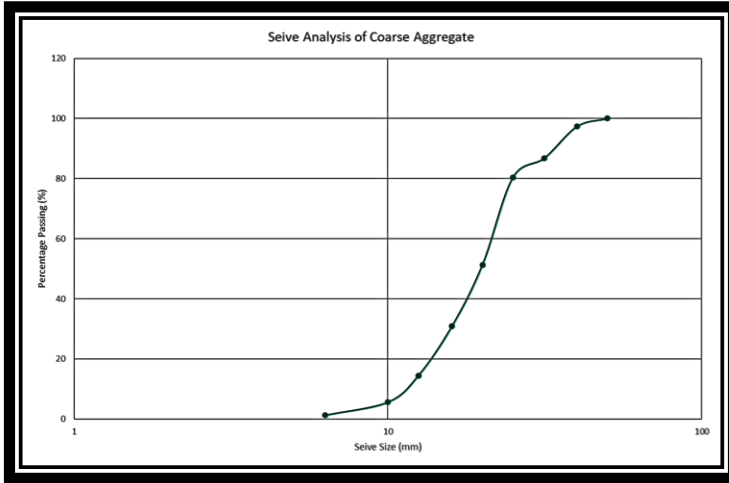


Figure 3: Sieve analysis of E-Waste

Table 4 Properties of E-waste Aggregate

S.No	Properties	Values
1	% of Water Absorption	0.2%
2	Colour	Light Green
3	Fineness	3.51
4	Zone	III

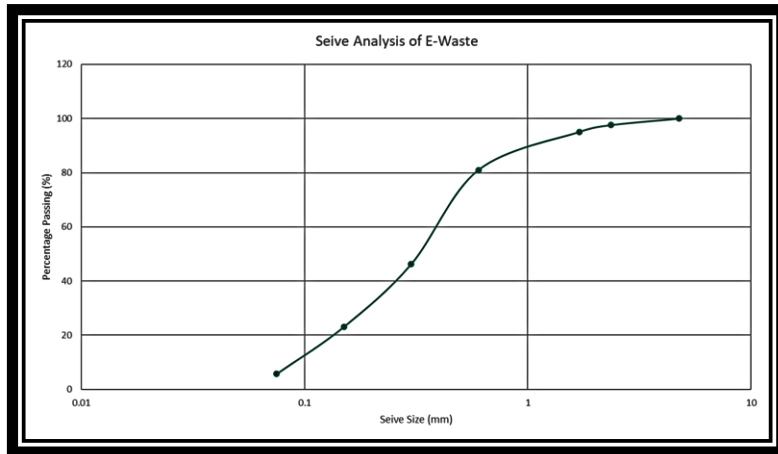


Figure 4 Compressive strength

Fly ash: The mixture is mainly made up of oxides, with a notable amount of silica.

- Silica (SiO₂): 40-60%
- Alumina (Al₂O₃): 15-30%
- Calcium Oxide (CaO): 4-12%
- Iron Oxide (Fe₂O₃): Around 5%.

These values can vary depending on the source coal and combustion conditions.

3. Mix Design and testing methods:

The concrete mix was modified by substituting 30% of the cement with flyash to enhance the flyash content. The quantity of flyash utilized was determined based on Table 9 of IS 10262:2019. Various tests were carried out on the specimens, such as Compressive strength

[IS: 516-1959], Split tensile strength [IS 5816(1999)], Ultrasonic pulse velocity [IS 13311-1992], Rebound hammer [IS:13311 (2)-1992], Water absorption, and Density. The proportion of ingredients for M20 grade concrete is detailed in table 5.

Table 5 Mix design of M20 grade concrete

S.NO	Materials	% of E-Waste			
		0	10	20	30
1	Cement (kg/m ³)	300	300	300	300
2	Fine aggregate (kg/m ³)	780.80	702.72	624.64	546.56
3	Coarse aggregate (kg/m ³)	1017.19	1017.19	1017.19	1017.19
4	E-Waste (kg/m ³)	0	78.08	156.16	234.24
5	Water (kg/m ³)	197	197	197	197
6	Flyash (kg/m ³) 30%	0	90	90	90

4. Results and Discussion

Compressive Strength: The durability of the concrete was found to have a intricate connection with the quantity of e-waste, as indicated by the findings of the compressive strength test. The inclusion of 10% e-waste in the mixture resulted in a higher compressive strength compared to the control blend without e-waste. However, the introduction of 20% and 30% e-waste caused a decline in the overall compressive strength. Figure 4 provides the detailed results of the compressive strength assessment.

Split Tensile Strength: The concrete specimens underwent a tensile strength test, incorporating different proportions of e-waste (0%, 10%, 20%, 30%), alongside control samples and fly ash mixes. It is crucial to emphasize that when the e-waste content reached 10%, both the e-waste and fly ash mixes exhibited strength levels similar to the control samples. However, as the e-waste levels increased to 20% and 30%, there was a gradual decline in strength compared to the control and fly ash mixes. These findings suggest that fly ash has the potential to alleviate the negative effects of high e-waste content, highlighting

the need for further research on their combined impact on tensile strength. The results of the split strength test are illustrated in figure 5

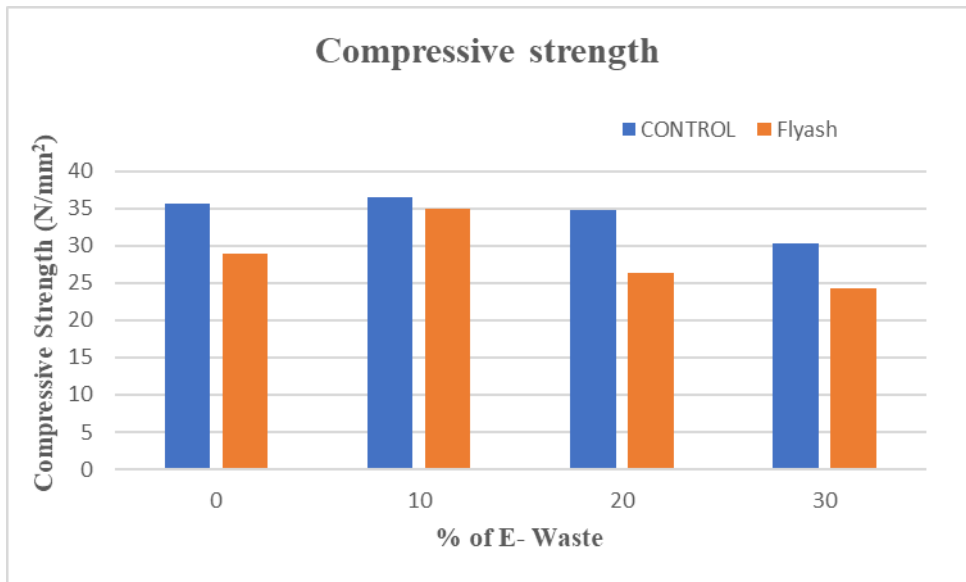


Figure 5 Split strength

.Ultrasonic pulse velocity test: In the absence of fly ash, the UPV experiences a decline at 10% E-Waste, with further reductions at 20% and 30% E-Waste. Conversely, in the presence of fly ash, generally lower UPV values are observed across the board. The UPV diminishes as the percentage of E-Waste increases, indicating a potential influence on the structural quality of the concrete. These results underscore the significance of comprehending the interactions between fly ash and E-Waste in the concrete mix. Figure 6 depicts the results obtained from the ultrasonic pulse velo

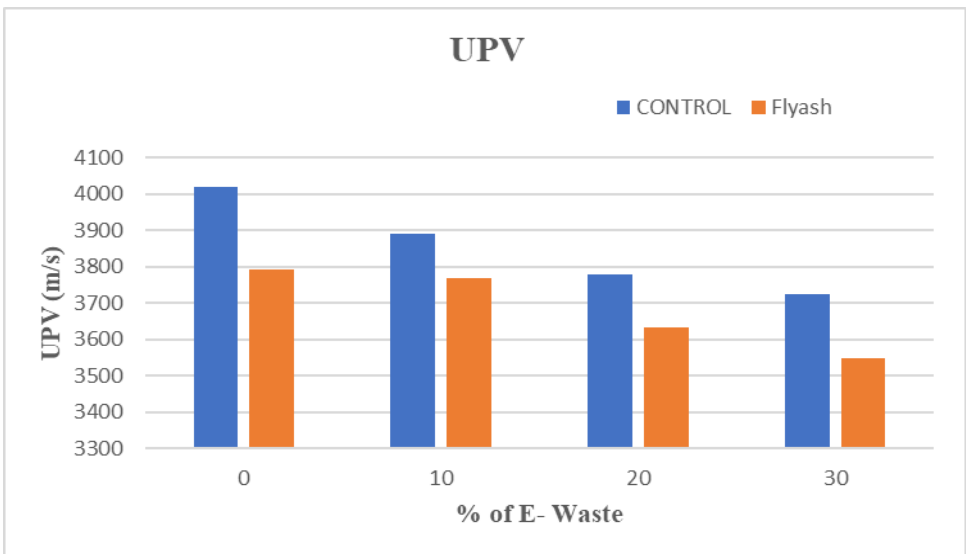


Figure 6 Ultrasonic pulse velocity city analysis.

Rebound hammer test: Rebound Hammer values, indicative of surface hardness, reveal consistent readings across control and Fly Ash mixes, both registering 30. However, with the inclusion of E-Waste, a marginal decrease is observed. At 20% and 30% E-Waste, the rebound values decrease to 29 and 28, respectively. This slight reduction in rebound values may suggest a potential impact on hardness due to the presence of E-Waste. Rebound hammer results are shown in figure 7

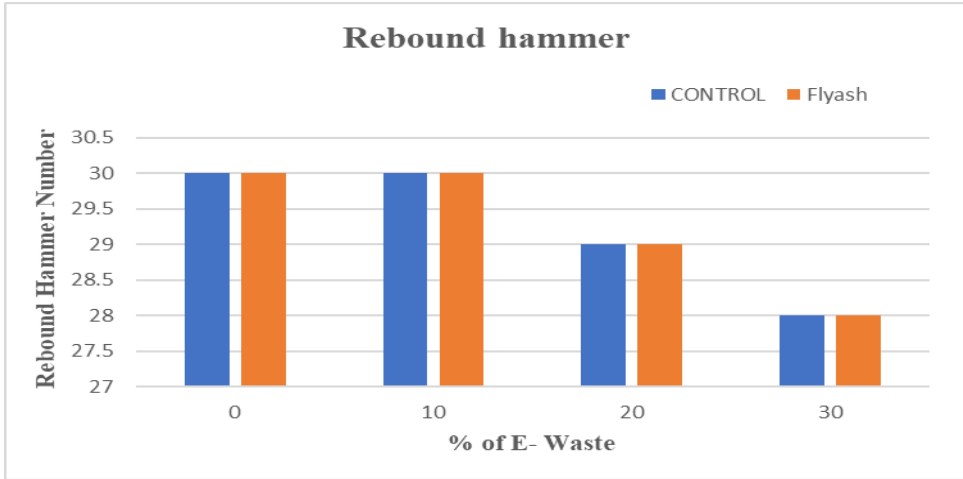


Figure 7 Rebound hammer

Water absorption test: This test revealed a direct correlation between the % of E-waste and water uptake in concrete compared to the control mix. In other words, concrete with higher E-waste content absorbed more water. Conversely, the water absorption of the Fly Ash mix did not exhibit a significant difference compared to control. Figure 8 displays the results of water absorption measurements.

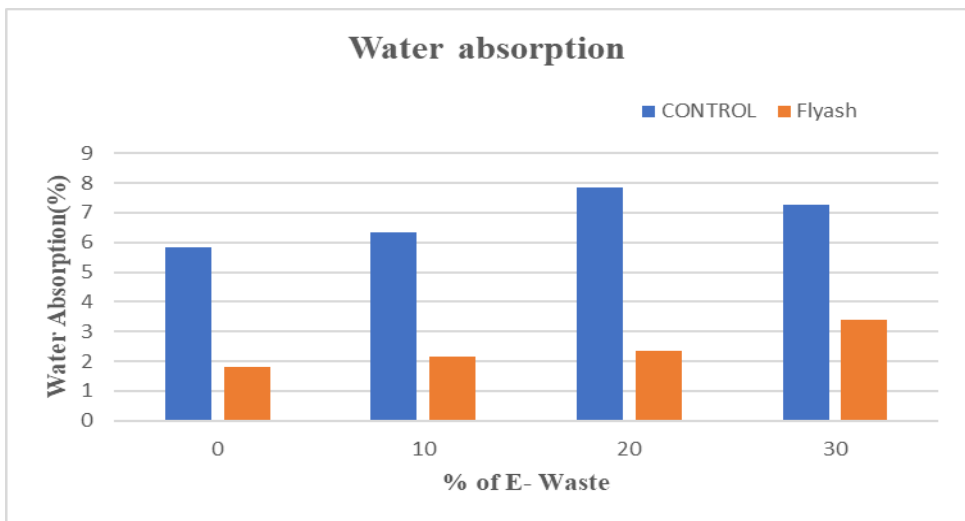


Figure 8 Water absorption

Density: As the percentages of E-waste increased, both the control mix and the fly ash mix experienced a decrease in density. This clearly demonstrates that the inclusion of E-waste leads to a reduction in the overall density of concrete. The density outcomes are visually presented in figure 9.

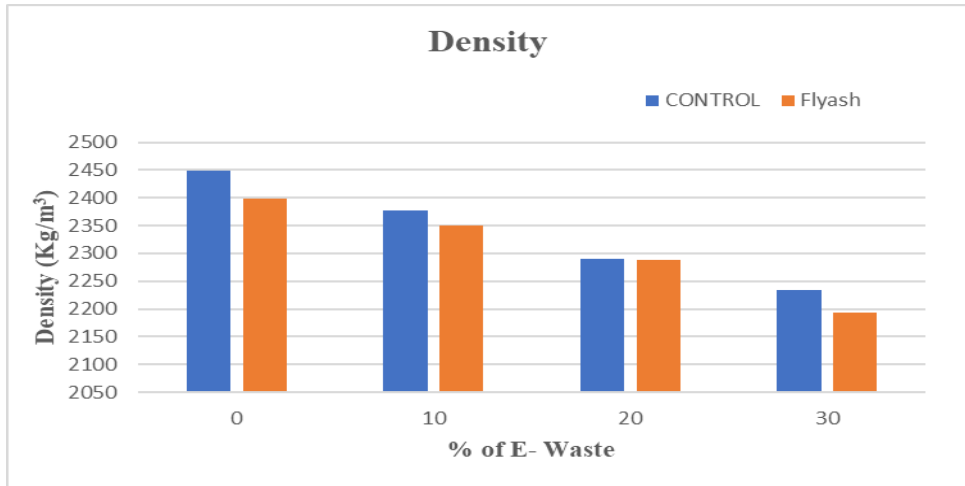


Figure 9 Density

5. Conclusions

- The optimal E-Waste percentage for achieving favorable properties in M20 grade concrete with flyash is 10%.
- The inclusion of fly ash appears to have a beneficial effect on the outcomes of the compression and split tensile strengths test, especially when the E-waste concentration is set at 10%.
- A rise in the E-Waste percentage is associated with a decline in ultrasonic pulse velocity values, indicating a potential impact on the structural integrity of the concrete.
- A noticeable reduction in density is observed with an increasing E-Waste percentage, implying a correlation between E-Waste content and concrete density and hence recommended for light weight concrete

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