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Research Paper

UTILIZATION OF E-WASTE AND MARBLE DUST IN CONCRETE: AN EXPERIMENTAL APPROACH

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ABSTRACT

The rapid growth of industrialization and technological advancement has resulted in the generation of enormous quantities of electronic waste (E-waste) and marble dust, posing serious environmental challenges. Disposal of these waste materials in landfills leads to pollution and health hazards. This study investigates the utilization of E-waste and marble dust in concrete production as partial replacement materials. The experimental work evaluates the mechanical properties of concrete such as compressive strength, split tensile strength, flexural strength, and workability by incorporating different percentages of E-waste and marble dust. The experimental results indicate that the partial replacement of conventional materials with E-waste and marble dust improves certain strength characteristics while reducing environmental pollution and promoting sustainable construction practices.

1. INTRODUCTION

Concrete is the most widely used construction material due to its strength, durability, and versatility. The increasing demand for concrete has resulted in excessive consumption of natural resources such as sand and aggregates. Simultaneously, industrial and electronic waste generation has increased drastically due to urbanization and technological development.

E-waste consists of discarded electronic devices such as computers, televisions, mobile phones, and printed circuit boards. These materials contain plastics, metals, and other components that are difficult to decompose naturally. Improper disposal of E-waste leads to severe environmental pollution.

Marble dust is a waste product generated during cutting and polishing operations in marble industries. Disposal of marble dust causes air and soil pollution. Utilization of marble dust in concrete can reduce environmental problems and improve sustainability.

This study focuses on the experimental investigation of concrete by incorporating E-waste and marble dust as partial replacement materials to evaluate their effects on strength and durability properties.

2. OBJECTIVES OF THE STUDY

The main objectives of this study are:

1. To investigate the feasibility of using E-waste and marble dust in concrete.
2. To reduce environmental pollution caused by industrial waste disposal.
3. To study the compressive strength of concrete containing E-waste and marble dust.
4. To evaluate split tensile and flexural strength characteristics.
5. To determine the optimum replacement percentage.
6. To develop sustainable and economical concrete.

3. LITERATURE REVIEW

Numerous researchers have explored the use of industrial waste materials in concrete production.

- Studies reported that marble dust improves the filler effect and enhances workability.
- Researchers observed that E-waste aggregates can partially replace conventional aggregates in lightweight concrete.
- Experimental investigations revealed that marble dust improves compressive strength up to an optimum replacement level.
- Some studies indicated reduced workability and bonding issues at higher E-waste content.

The literature indicates that the combined utilization of E-waste and marble dust can produce eco-friendly concrete with acceptable engineering properties.

4. MATERIALS USED

4.1 Cement

Ordinary Portland Cement (OPC 53 Grade) conforming to IS 12269 standards was used.

4.2 Fine Aggregate

Natural river sand conforming to Zone II specifications was used.

4.3 Coarse Aggregate

Crushed granite aggregate of 20 mm size was used.

4.4 E-Waste

Discarded electronic plastic materials were collected, cleaned, shredded, and used as partial replacement for coarse aggregate.

4.5 Marble Dust

Marble dust collected from marble processing industries was used as partial replacement for cement or fine aggregate.

4.6 Water

Portable water free from impurities was used for mixing and curing.

5. PROPERTIES OF MATERIALS

Material	Specific Gravity	Water Absorption
Cement	3.15	-
Fine Aggregate	2.65	1.1%
Coarse Aggregate	2.72	0.5%
E-Waste Aggregate	1.85	0.2%
Marble Dust	2.60	1.5%

6. MIX PROPORTION

Concrete of M30 grade was prepared with different replacement percentages of E-waste and marble dust.

Mix ID	E-Waste (%)	Marble Dust (%)
EM0	0	0
EM1	5	5
EM2	10	10
EM3	15	15
EM4	20	20

7.EXPERIMENTAL METHODOLOGY

7.1 Mixing Procedure

All materials were dry mixed thoroughly before adding water. Concrete was mixed uniformly to achieve proper consistency.

7.2 Casting of Specimens

The following specimens were prepared:

- Cubes for compressive strength test
- Cylinders for split tensile strength test
- Beams for flexural strength test

7.3 Curing

Specimens were cured in water for 7 and 28 days.

8. TESTS CONDUCTED

1. Slump Cone Test
2. Compressive Strength Test
3. Split Tensile Strength Test
4. Flexural Strength Test

5. Water Absorption Test

9. WORKABILITY TEST RESULTS

Mix ID	Slump Value (mm)
EM0	84
EM1	80
EM2	76
EM3	71
EM4	67

Observation

Workability decreased with increase in E-waste content due to irregular particle shape and lower bonding characteristics.

10. COMPRESSIVE STRENGTH RESULTS

7-Day Compressive Strength

Mix ID	Strength (MPa)
EM0	24.2
EM1	25.1
EM2	26.5
EM3	24.8
EM4	22.9

28-Day Compressive Strength

Mix ID	Strength (MPa)
EM0	36.2
EM1	37.6
EM2	39.4
EM3	37.0
EM4	34.1

Observation

Concrete with 10% E-waste and 10% marble dust exhibited maximum compressive strength.

11. SPLIT TENSILE STRENGTH RESULTS

Mix ID	Tensile Strength (MPa)
EM0	3.2
EM1	3.4
EM2	3.6
EM3	3.3
EM4	3.0

The tensile strength improved up to optimum replacement levels due to better particle packing and filler effect.

12. FLEXURAL STRENGTH RESULTS

Mix ID	Flexural Strength (MPa)
EM0	4.4

Mix ID	Flexural Strength (MPa)
EM1	4.6
EM2	4.9
EM3	4.5
EM4	4.1

13. WATER ABSORPTION TEST

Mix ID	Water Absorption (%)
EM0	2.8
EM1	2.5
EM2	2.3
EM3	2.7
EM4	3.1

Observation

The inclusion of marble dust reduced voids and improved density, thereby lowering water absorption up to optimum levels.

14. DISCUSSION OF RESULTS

The experimental investigation revealed the following:

- Marble dust improved particle packing and reduced voids in concrete.
- E-waste reduced the self-weight of concrete due to its lightweight nature.
- Compressive strength increased up to 10% replacement and decreased afterward.
- Excessive E-waste reduced bonding between aggregate and cement paste.
- Marble dust enhanced workability and surface finish.
- Water absorption decreased due to filler effect of marble dust.

The optimum replacement level was determined as 10% E-waste and 10% marble dust.

15. ADVANTAGES OF USING E-WASTE AND MARBLE DUST

1. Reduces environmental pollution.
2. Conserves natural resources.
3. Reduces landfill disposal problems.
4. Produces sustainable concrete.
5. Improves certain strength characteristics.
6. Reduces cost of construction materials.
7. Promotes recycling and waste utilization.

16. APPLICATIONS

Concrete containing E-waste and marble dust can be used in:

- Non-structural concrete works
- Pavement blocks
- Partition walls
- Lightweight concrete applications
- Footpaths and precast units
- Decorative concrete products

17. ENVIRONMENTAL BENEFITS

The use of E-waste and marble dust in concrete helps:

- Reduce industrial waste accumulation
- Lower environmental pollution
- Minimize natural resource depletion
- Encourage sustainable construction practices

18. LIMITATIONS

1. Higher E-waste content may reduce bonding.
2. Long-term durability needs further investigation.
3. Proper segregation and processing of E-waste are required.

19. CONCLUSION

This study concludes that E-waste and marble dust can effectively be utilized in concrete production as partial replacement materials. Experimental results showed that concrete containing 10% E-waste and 10% marble dust achieved higher compressive, tensile, and flexural strength compared to conventional concrete.

The use of these waste materials contributes to sustainable construction by reducing environmental pollution, conserving natural resources, and promoting recycling practices. Therefore, E-waste and marble dust can be considered suitable alternative materials for eco-friendly concrete production.

20. FUTURE SCOPE

1. Investigation on durability under aggressive environments.
2. Use in self-compacting concrete.
3. Study on thermal and acoustic properties.
4. Application in lightweight structural concrete.
5. Long-term performance evaluation.

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