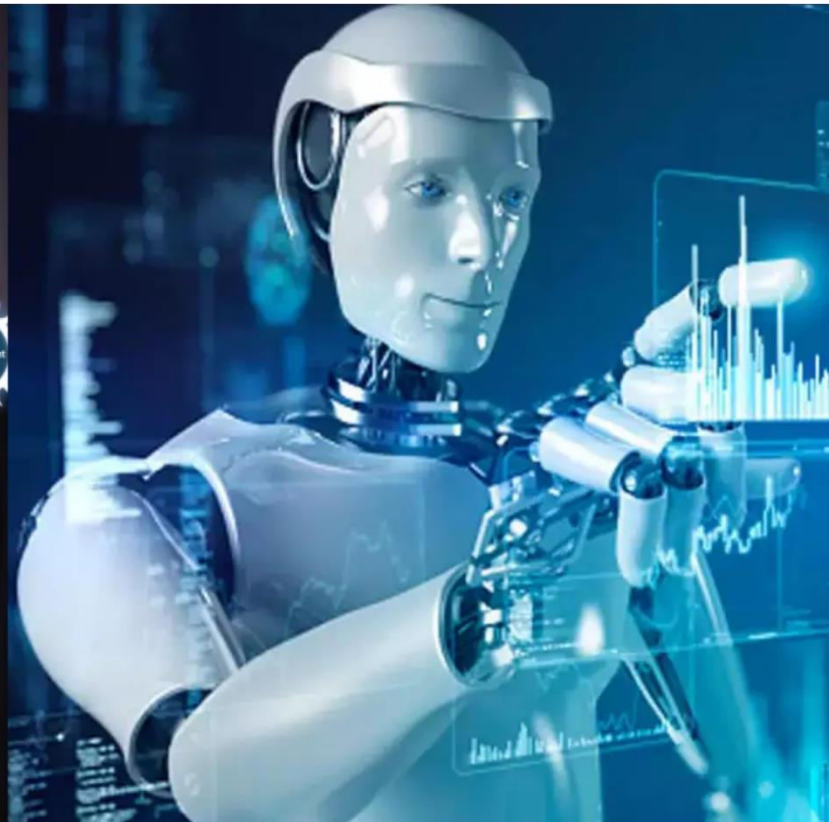




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# High Performance Concrete using Industrial E-Waste and Rubber

**Prof. Navale R.B., Mr. Kurkute Omkar Pandharinath, Mr. Yewale Suyog Dattatray, Mr. Wagh Samarth Naresh, Mr. Jadhav Rahul Dattatray, Mr. Rode Jaydip Bharat**

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

Department of Civil Engineering, Samarth College of Engineering and Management, Belhe, Junnar, Pune, India

**ABSTRACT:** Concrete is the most widely used construction material, but its production causes serious environmental problems due to high use of natural resources and cement. At the same time, electronic waste and rubber waste are increasing rapidly and create disposal issues. This research studies the use of industrial E-waste and waste rubber in High Performance Concrete (HPC). E-waste is used as a partial replacement of aggregates, and rubber is used to improve flexibility and durability. Different percentages of waste materials are added to concrete and tested for strength and workability. The results show that properly designed mixes with E-waste and rubber can produce strong, durable, and eco-friendly concrete. This method helps in reducing pollution and conserving natural resources.

**KEYWORDS:** High Performance Concrete, E-waste, Rubber Waste, Sustainable Construction, Green Concrete

## I. INTRODUCTION

Concrete plays a very important role in modern construction. It is used in buildings, bridges, roads, and many other structures. However, large-scale use of concrete consumes huge amounts of sand, stone, and cement, which leads to environmental damage.

Cement production releases a high amount of carbon dioxide, which increases global warming. Also, industries and households generate large amounts of electronic waste and rubber waste from old tyres. These wastes are difficult to decompose and pollute land and water.

High Performance Concrete (HPC) is specially designed to provide high strength, durability, and long service life. In this study, E-waste and rubber waste are used in HPC to reduce environmental impact and improve sustainability. By using waste materials in concrete, pollution can be reduced and useful construction materials can be produced at low cost.

## II. OBJECTIVES AND PROBLEM STATEMENT

**A. Objectives:** The main objectives of this study are:

1. To study the properties of E-waste and rubber suitable for concrete.
2. To prepare HPC using E-waste and rubber as partial replacements.
3. To evaluate workability, compressive strength, and durability.
4. To compare modified concrete with normal concrete.
5. To analyze environmental and economic benefits.

**B. Problem Statement:** The construction industry uses large quantities of natural materials, causing resource depletion. At the same time, E-waste and rubber waste are increasing rapidly and cause pollution. Traditional disposal methods are not sufficient. Therefore, a sustainable solution is needed to use these wastes safely in construction.

### III. LITERATURE REVIEW

Many researchers have studied the use of waste materials in concrete.

Moolchandani and Sharma (2025) found that crumb rubber improves durability and flexibility but reduces strength if not treated properly. Farahzadi et al. (2025) reported that supplementary cementitious materials reduce carbon emissions significantly.

Zheng et al. (2025) used industrial tailings as sand replacement and achieved good strength and durability. Ahmad et al. (2025) studied E-waste in concrete and observed improved resistance to chemical attack.

Pham et al. (2024) reported that rubberized concrete reduces CO<sub>2</sub> emissions and improves vibration resistance. Bahrami et al. (2024) showed that combining rubber and lime waste improves sustainability.

These studies prove that waste materials can be effectively used in high-performance concrete.

### IV. METHODOLOGY

#### A. Materials Used:

The following materials were used:

1. Ordinary Portland Cement
2. Natural Sand
3. Coarse Aggregate
4. E-waste (plastic and PCB residues)
5. Crumb Rubber
6. Water
7. Superplasticizer

#### B. Material Testing:

Basic tests were conducted:

1. Cement Tests
2. Fineness test
3. Setting time
4. Compressive strength
5. Sand Tests
6. Sieve analysis
7. Moisture content

#### Aggregate Test:

1. Sieve analysis
2. Crushing value
3. Impact value

#### C. Mix Design:

1. Refine proportion based on tests result
2. Preparing detailed mix design
3. Typical mix ratios and water-cement ratio

Water-cement ratio was selected as per IS 456 and IS 10262 standards.

Grade	Cement-sand-aggregate	Approximate water-cement ratio
M20	1:1.5:3	0.50
M25	1:1.2:2.8	0.45
M30	1:1.1:2.5	0.45

Table- W/C Ratio

**Step-by-step Procedure for M-35 Grade Concrete (IS 10626)**

**Step 1: Determine the Target Mean Strength (f'ck)**

For M-35 concrete, the characteristic compressive strength at 28 days, fck, is 35 MPa. To account for variability, the target mean strength is calculated as:

$$F_{ck} = f_{ck} + 1.65 \times \text{Standard deviation}$$

$$= 35 + 1.65 \times 5$$

Target Mean Strength = 43.25 N/MM<sup>2</sup>

Typically, for M-35, the target mean strength is taken as 43.25 MPa.

Concrete Grade	Strength
M10 & M-15	3.5 n/mm <sup>2</sup>
M20 & M25	4.0 n/mm <sup>2</sup>
M30 & M50	5.0 n/mm <sup>2</sup>

Typically, for M-35, the target mean strength is taken as 43.25 MPa.

**Step 2: Determination of Air Content-**

Table no-3 IS 10262, 20 mm size of aggregate entrapped air is 1.0%

As per table No-3

Table from IS code 10626 for Entrapped Air Content For Different Nominal SIZE

Sr. No.	Nominal size of aggregate in mm	Entrapped air as % of volume of concrete
1	10	1.5
2	20	1.0
3	40	0.8

Table- Entrapped Air Content For Different Nominal SIZE

**Step 3: Selection of Water-Cement Ratio (w/c)**

1. From graph (fig1) w/c IS 456:2000; the maximum w/c ratio for M-35 concrete is 0.50.
2. For desired strength, refer to IS 10262:2019, which suggests a w/c ratio of approximately 0.45 for M-35.
3. As per table 5 of IS 456-2000, curve-1 for 33 grade, curve-2 for 43 grade and curve-3 for 53 grade

4. Adopted  $W/C < \text{Maximum free } w/c$

**Step 4: Determine the Cement Content-**

Table no-2, IS 10262, 20 mm size of aggregate water content is 186 kg/m<sup>3</sup> as per is 10262 maximum size of aggregate is as follows –

Sr. No.	Nominal Maximum Aggregate (mm)	Maximum Water Content
1	10	208
2	20	186
3	30	165

**Table- Aggregate Water Content**

1. For increase in water content by 3% for every 25 mm slump above 50 mm slump.
2. Hence for 125 mm slump we have increase water content by 8.4%
3. Water content=186+(8.4/100) X186=202 kg
4. Assume 1% super plasticizer reduce water content by 20%

Water Content=202x0.80=163 liter =165 liter

For workability, water content can vary i between 165-180 liters/m<sup>3</sup>; typically, 165 liters for good workability.

**Step 5: Determine the Cement Content-**

Adopted W/C ratio is 0.45

Cement content=165/0.45=366.66 kg/m<sup>3</sup>

1. From IS 456:2000, TABLE NO-5 PAGE NO-20 FOR 0.45 W/C RATIO MINIMUM IS 340 for M-35 grade, the initial cement content is usually taken as 340 kg/m<sup>3</sup>.
2. Adjustments are made based on workability, durability, etc. 366.66 > 340 kg/m<sup>3</sup> .... hence ok

**Step 6: Proportion of Volume of Coarse Aggregates and Fine Aggregate-**

From table, 3 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate zone-I 0.50-0.60;

1. CA for pumpable concrete values reduced by 10%
2. Volume of coarse aggregate=0.60x0.9=0.54
3. Volume of fine aggregate=1-0.56=0.44

**Step 7: Mix Calculation-**

1. Volume of concrete-1 M<sup>3</sup>
2. Volume of air content-0.01 M<sup>3</sup>
3. Volume of cement - mass of cement/sp gravity x1/1000 =366.66V3.15\*1/1000=0.1164 m<sup>3</sup>
4. Volume of water =mass of water/sp.gravity waterx1/100 =165x1/1000=0.165 m<sup>3</sup>
5. Volume of plasticizers 1% dosage and sp.gravity 1.115  
Mass of plasticizers = 366.66x1/1000 =3.66kg  
Volume of admixture = (3.66/[1.115])x(1/1000)=0.00328
6. Vol. of total aggregate= 1-(a+b+c+d)  
=1-(0.01+0.1164+0.165+0.0035)  
=0.7051 m<sup>3</sup>
7. Mass of CA= (Vol of total aggregate) x (Vol of proportion of coarse aggregate) x (mass density)  
=0.7051x0.54x2.84x1000 =1081.34 kg
8. Mass of FA= (Vol of total aggregate) x (Vol. of proportion of fine aggregate) x(mass density)  
= 0.7051x0.46x2.59x1000  
=840.05 kg

**Step 8: Trial Mixes –**

Unit	Cement	FA in SSD	CA IN SSD	WATER	Admixture
Kg/m <sup>3</sup>	366.66	840.05	1081.34	165	3.66

**Table- Trial Mixes**

Dimensions: 150 mm x 150 mm x 150 mm  
 Convert to meters: 150 mm = 0.15 m Volume  
 = 0.15 m x 0.15 m x 0.15 m  
 = 0.003375 m<sup>3</sup>

**Step9: Determine material quantities based on the provided data-**

Given data (per 1 m<sup>3</sup> of concrete):

Cement: 366.66 kg

Coarse Aggregate: 1081.34 kg

Fine Aggregate: 840.05 kg

Water: 165 kg

Admixture: 3.66 (kg)

**Step 10: Calculate quantities for the Batch**

Multiply to the quantities of material to the required batch size 0.025

1. Cement: = 366.66 kg x 0.025 = 9.166 kg
2. Coarse Aggregate: = 1081.34 kg x 0.025 = 27.033 kg
3. Fine Aggregate: = 840.05 kg x 0.025 = 21.001 kg
4. Water: = 165 kg x 0.025 = 4.125kg
5. Admixture: = 3.66 x 0.025 = 91 gm

**D. Summary of materials as per batch size (150x150x150 mm):**

Material	Quantity
Cement	9.166 kg
Coarse Aggregate	27.033 kg
Fine Aggregate	21.001 kg
Water	4.125kg
Admixture	91 gm

**V. RESULTS**

**A. Result for 5% Replacement for M35 concrete-**

Material	Quantity (Kg)
Cement	9.166 Kg
Sand (90%)	19.951 Kg
E-waste replacement 10%	1.050 Kg
Aggregate (90%)	25.683 Kg
Rubber 10% replacement	1.351 Kg
Water	4.125 L

**Table- Mix for 5% Replacement**

5% replacement for M35 grade concrete



**Fig-Replacement Prepared specimen**

**1. Fresh Concrete Slump Cone Test**

Sr. No	Concrete Type	Initial slump	Slump After 1hr
1.	Normal concrete	Collapse	190mm
2.	Concrete with 10% replacement	Collapse	185mm

**Table- Slump Cone Test Result**



Fig- Fresh Concrete Slump Cone Test

## 2. Hardened Concrete Tests

Compressive strength: Compressive strength on specimen after 14 days  
 Strength of normal M35 concrete after 14 days = 32.48 MPa  
 Strength of 5% replacement concrete block after 14 days are 30.91 MPa  
 Compressive strength on specimen after 28 days  
 Strength of normal M35 concrete after 28 days = 41.62 MPa  
 Strength of 5% replacement concrete block after 28 days are 38.19 MPa

### B. Result for 10% Replacement for M35 concrete-

Material	Quantity (Kg)
Cement	9.166 Kg
Sand (95%)	18.901 Kg
E-waste replacement 5%	2.100 Kg
Aggregate (95%)	24.333 Kg
Rubber replacement 5%	2.703 Kg
Water	4.125 L

Table- Mix for 10% Replacement

**1. Fresh Concrete Slump Cone Test**

Sr. No	Concrete Type	Initial slump	Slump After 1hr
1.	Normal concrete	Collapse	180mm
2.	Concrete with 10% replacement	Collapse	170mm

**Table- Slump Cone Test Result**



**Fig- Fresh Concrete Slump Cone Test**

**2. Hardened Concrete Tests**

Compressive strength:

Compressive strength on specimen after 14 days

Strength of normal M35 concrete after 14 days = 31.92 MPa

Strength of 10% replacement concrete block after 14 days are 30.19 MPa

Compressive strength on specimen after 28 days

Strength of normal M35 concrete after 28 days = 40.60 MPa

Strength of 10% replacement concrete block after 28 days are 37.58 MPa

**C. Result for 15% Replacement for M35 concrete-**

Material	Quantity (Kg)
Cement	9.166 Kg
Sand (85%)	17.851 kg
E-waste 15% replacement	3.150 kg
Aggregate (85%)	22.983 kg
Rubber 15% replacement	4.05 kg
Water	4.125 L

**1. Fresh Concrete Slump Cone Test**

Sr. No	Concrete Type	Initial slump	Slump After 1hr
1.	Normal concrete	Collapse	190mm
2.	Concrete with 15% replacement	Collapse	170mm

**Table- Slump Cone Test Result**

**2. Hardened Concrete Tests**

Compressive strength

Compressive strength on specimen after 14 days

Strength of normal M35 concrete after 14 days = 32.65 MPa

Strength of 15% replacement concrete block after 14 days are 28.88 MPa

Compressive strength on specimen after 28 days

Strength of normal M35 concrete after 28 days = 41.29 MPa

Strength of 15% replacement concrete block after 28 days are 36.97 MPa



**Fig. Compression Testing**

**D. Result for 20% Replacement for M35 concrete-**

Material	Quantity (Kg)
Cement	9.166 Kg
Sand (80%)	16.801 kg
E-waste 20% replacement	4.200 kg
Aggregate (80%)	21.633 kg
Rubber 20% replacement	5.40 kg
Water	0.56 L

**Table- Mix for 20% Replacement**

**1. Fresh Concrete Slump Cone Test**

Sr. No	Concrete Type	Initial slump	Slump After 1hr
1.	Normal concrete	Collapse	180mm
2.	Concrete with 20% replacement	170	120mm

**Table- Slump Cone Test Result**



Fig Compression Testing

## 2. Hardened Concrete Tests

Compressive strength

Compressive strength on specimen after 14 days

Strength of normal M35 concrete after 14 days = 31.40 MPa

Strength of 20% replacement concrete block after 14 days are 26.46 MPa

Compressive strength on specimen after 28 days

Strength of normal M35 concrete after 28 days = 40.38 MPa

Strength of 20% replacement concrete block after 28 days are 35.24 MPa

## VI. ENVIRONMENTAL AND ECONOMIC BENEFITS:

Using E-waste and rubber in concrete provides many benefits:

1. Reduces landfill waste.
2. Saves natural aggregates.
3. Lowers carbon emissions.
4. Reduces material cost.
5. Promotes recycling and circular economy.

This approach supports sustainable construction.

## VII. CONCLUSION

This study shows that industrial E-waste and rubber can be successfully used in High Performance Concrete. Proper mix design and controlled replacement levels are necessary to maintain strength and durability. The optimum mix containing 5–20% waste materials gives good mechanical properties and environmental benefits. This method reduces pollution and conserves natural resources.

Future studies should focus on long-term durability and large-scale applications.

Sr. No.	Replacement %	Time	Slump		Day	Strength	
			Normal Concrete	Replacement concrete		Normal Concrete	Replacement concrete
1	5% Replacement	Initial	Collapse	Collapse	14 <sup>th</sup> Day	32.48MPa	30.91MPa
		After 1 hour	190 mm	185 mm	28 <sup>th</sup> Day	41.62MPa	38.19MPa
2	10% Replacement	Initial	Collapse	Collapse	14 <sup>th</sup> Day	31.92MPa	30.19MPa
		After 1 hour	180 mm	170 mm	28 <sup>th</sup> Day	40.60MPa	37.85MPa
3	15% Replacement	Initial	Collapse	Collapse	14 <sup>th</sup> Day	32.65MPa	28.88 MPa
		After 1 hour	190 mm	170 mm	28 <sup>th</sup> Day	41.29MPa	36.97MPa
4	20% Replacement	Initial	Collapse	170 mm	14 <sup>th</sup> Day	31.40MPa	26.46MPa
		After 1 hour	180 mm	120 mm	28 <sup>th</sup> Day	40.38MPa	35.24MPa

**Table- Final Results**

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