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PREPARATION OF CONCRETE BRICKS BY USING E-WASTE AND REDMUD

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ABSTRACT

Electronic waste is an emerging issue posing serious pollution problems to the human beings and to the environment. The rate of E-waste generation is increasing day by day in the modern world 80 % to 85% of different electronic items wastes disposed of in landfills or incinerators which can include or discharge certain lethal gases into air, it may influence environment and human being health conditions. The disposal which is becoming a challenging problem. For solving this process, the removal of large amount of E-waste material, reuse of E-waste in concrete industry is recommended as the most feasible application. Due to increase in cost of normal coarse aggregate it has forced the civil engineers to find out the suitable alternatives to it. E-waste is used as one of the alternatives for coarse aggregate. Owing to less production of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was tried. The work will conduct on M10 grade concrete bricks. The replacement of coarse aggregate with E-waste in the range of different percentages (0%, 5%, 10%, 15% and 20%) and 25% replacement of cement with red mud. The specimens were Casted a size of 190mm x 90mm x 90mm and the Shape and size test, Compression test, water absorption test, Soundness test, drop test, Efflorescence test, Colour test, Structure test and Hardness test were conducted to analyze their suitability as a construction material.

Keywords: M10 grade of concrete, red mud, E-waste (Electronic waste), Shape and size test, Compression test, water absorption test, Soundness test, Drop test, Efflorescence test, Colour test, Structure test.

1. INTRODUCTION

1.1 General

Waste management is typically dealt depending on the type of waste, quantity of waste generated and the degree of associated problems with the environment. It is believed that recycling of industrial wastes is technically economical and also has several environmental benefits. Wastes from the industries can be used as the constituents of concrete by replacing or partially replacing the cement or aggregates which makes it cost effective and also conserves the natural resources. Concrete is the important material in construction other than steel and timber and its main constituents are cement, sand, fine and coarse aggregates, and water. But, one of the greatest environmental concerns in construction industry are the production of cement which emits large amount of co_2 to the atmosphere. It is estimated that production of one ton of clinker/cement releases equally one ton of co_2. Therefore, the past two decades of research is diverted primarily in making concrete without cement or at least partially in low or high volumes, replacing cement by suitable alternatives like fly ash, silica fume, ground granulated blast furnace slag, rice husk ash. China, India, united states of America is the order of countries having largest cement consumption.

E-waste describes as loosely thrown-out, not needed any more, no longer useful/no longer used, broken, electrical or electronic devices. Fast technology change, low initial cost has resulted in a fast growing of electronic waste around the globe. Several tons of E-waste need to be disposed per year. Traditional place where garbage and trash are dumped method is not a related to surrounding conditions or the health of the Earth friendly solution and the disposal process is also very complicated. How to reuse the non-disposable E-waste becomes an important research topic. The processing of electronic waste causes serious health and pollution Problems due to electronic equipment contains serious contaminants such as lead, Cadmium, Beryllium, Poisonous metal, Mercury, Nickel, Silver, Zinc. In India, E-waste is mostly generated in large cities like Delhi, Mumbai and Bangalore. In these cities a complex e-waste handling infrastructure has developed mainly based on a long tradition of waste recycling. Sixty-five cities in India generate more than 60% of the total e waste generated in India. Ten states generate 70% of the total E-waste generated in India. Because of increment in cost of typical coarse aggregate it has constrained the civil engineers to discover appropriate other options to replace it. E-waste can be utilized as one such option for coarse aggregate. Owing to shortage of coarse aggregate for the planning of solid, incomplete supplanting of E-waste with coarse aggregate was tried.

1.2 E-Waste

E-waste is the waste generated form the discarded electronic devices it is an emerging issue causing serious environmental problems as it is very difficult to efficiently dispose the e-waste without causing any harm to the environment. The conventional method for the disposal of e- waste is dumping the waste into land fill but this method has so many serious problems as it needs a lot of landmasses which is in scarcity in our country and it also contains so many different harmful materials like lead, cadmium, beryllium etc. these materials when mixes with soil they contaminate the soil and when mixes with ground water they contaminated it also makes it very harmful to consume by any anyone and if someone consume this water it with cause serious health issues and in some cases, it even causes cancer. In India we generate about 15 million metric tons of e-waste and this number is going to 30 million metric tons by the year 2018 and still 3% of the e-waste generated in is decomposed properly and the rest of it is decomposed by the small peddlers who will not concern the harmful effects of the e-waste.

E-waste refers to electronic products nearing the end of their “useful life” for example, computers, televisions, VCRs, stereos, copiers, and fax machines. Many of these products can be reused, refurbished, or recycles. In this project this e-waste was crushed and used in the place of 20mm coarse aggregate.

Fig. 1: E waste.

1.3 Red Mud

Red mud is an aluminium industrial waste product which is red in colour. Its characteristics depends on the nature of bauxite ore used in the extraction of aluminium which slightly differ from place to place, out of which 4.5 tons of bauxite 1.0 tons of aluminium is extracted and 2/3rd will be the waste product. This red mud (alumina waste) is used in concrete for partial replacement of cement without sacrificing the quality and the desired strength. As to the resource utilization of red mud, alumina companies have been carrying out many technical researches on production of construction material, especially cement production and glass production, production of filling material for plastic, production of road base. And they have made some progress, especially in the production of cement using red mud.

Fig. 2: Red mud.

2. LITERATURE REVIEW

According to a Delhi-based non-governmental organization (NGO) Toxics Link, $1.5 billion worth of E-waste is generated domestically in India annually and 8,000 tons a year is generated in Bangaluru, the IT hub of India [3]. Tirupati is a cultural and pilgrimage in located in Southern part of India located at the foothills of eastern ghats (13.65°N 79.42°E, 162 meters above sea level), 65 km from Chittoor in Andhra Pradesh province. Here also there is no organized sector for disposing e-waste. Although there are private unorganized peddlers who make money by collecting and transporting e-plastic waste to cities like Delhi, Chennai, Mumbai, it is only some part, rest of it stays in city unprocessed. As Tirupati is a tourist place many people come here daily, government has to take necessary steps to dispose solid waste. E-waste now constitutes a major portion of solid waste stream therefore its well managed treatment and disposal becomes a major concern. Recycling of e-waste includes disassembling and destroying the individual parts to retrieve several materials [4].It has been reported that 95% of a computer's useful materials and 45% of a cathode ray tubes materials can be retrieved through recycling [5].In case of developed countries possessing appropriate technology Recycling methods have minimum environmental impact [6], whereas in developing countries the final environmental benefit-impact balance for e-waste recycling is not always positive [4]. recycling, in any case, has smaller ecological. Foot print than e-waste dumping and burning [7] but the adverse environmental impact due to energy consumed for transportation of the waste to be recycled reduces its environmental benefit [8]. The Government of India has drafted E-waste (Management & Handling) Rules 2011and these rules have come into effect from 1st May 2012.This makes Sustainable management of e-waste mandatory for all polluters. Acute shortage of construction materials on one hand and increasing volume of e-waste on the other has led to researchers to take up experimentations related to reutilization of recoverable waste materials like plastics and glass from the e-waste stream in concrete mix design. Segregation of recoverable materials and reusing them is a good management option. Rathod et al [9] replaced 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% of cement with red mud taking control mix with 0%. It was observed that the compressive strength and tensile strength decreased with the increase in the proportion of red mud. The optimum percentage of red mud to be replaced with cement was recommended as 25%.

3. OBJECTIVE OF THE STUDY

3.1 Aim

The aim of study is to evaluate the performance and suitability of replacement of E-waste with coarse aggregate and cement with red mud in concrete bricks manufacturing.

3.2 Objective

The objectives of experimental study are:

- Study on strength characteristics of M10 grade concrete bricks with replacement of 25% cement by red mud and replacement of 5%, 10%, 15% and 20% coarse aggregate by E-Waste.
- To determine the Shape and size test, Compression test, water absorption test, fire ignition, Soundness test, Drop test, Efflorescence test, Colour test, Hardness and Structure test for E-waste - Red mud concrete bricks.

4. EXPERIMENTAL WORK

4.1 MATERIALS USED

- Cement
- Coarse Aggregates
- Fine aggregates

- Water
- E waste (Electronic waste)
- Red mud

4.2 Materials Testing

4.2.1 Aggregates Sieve analysis

Sieve analysis is a test used to assess the particle size distribution of a particular material. The size distribution is often of critical importance to the way the material performs in use. This test was done to determine the fineness modulus of cement, fine aggregate, and coarse aggregate. It was done as per IS: 4031-1989 for cement and IS: 2386- 1963 for aggregates.

Coarse aggregates

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

The coarse aggregate produced from quarry was sieved through all the sieves (i.e., 80mm, 40mm, 20mm, 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, coarse aggregate retained on each sieve is mixed in appropriate proportions which are shown below.

i. The fineness modulus for coarse aggregate(20mm) 7.07
ii. The fineness modulus for coarse aggregate(12.5mm) 7.75

Fine aggregate

The fine aggregate used was obtained from a nearby river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

The sand was sieved through a set of sieves (i.e., 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ and 150µ). Sand retained on each sieve was filled in different bags and stacked separately. To obtain zone – II sand correctly, sand retained on each sieve is mixed in appropriate proportion.

i. The fineness modulus for fine aggregate 2.8

Table. 1: Physical properties of fine aggregates & coarse aggregates.

Property	**CA**	**FA**
Water absorption	0.7%	1.05%
Specific gravity	2.72	2.64
Impact value	8%	-
Crushing value	14.21%	-

4.2.2 Cement

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS: 12269 – 1987.

Table. 2: Physical properties of cement.

Property	**Result**
Standard Consistency	31%
Initial Setting Time	41min

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Final Setting Time	315min
Specific gravity	3.13

4.2.3 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Water cement ratio used in the mix is 0.50.

4.2.4 E – Waste (Electronic waste)

E-waste refers to electronic products nearing the end of their "useful life" for example, computers, televisions, VCRs, stereos, copiers, and fax machines. Many of these products can be reused, refurbished, or recycles. In this project this e-waste was crushed and used in the place of 20mm coarse aggregate.

Table. 3: Physical properties of E – waste.

Properties	**Values**
Water absorption	0.04%
Specific gravity	1.21
Impact value	1.95%
Crushing value	2.35%

4.2.5 Red mud

A solid- waste generated at the Aluminium plants all over the world. In Western countries; about 35 million tons of red mud is produced yearly. Because of the complex physico-chemical properties of red mud it is very challenging task for the designers to find out the economical utilization and safe disposal of red mud. Disposal of this waste was the first major problem encountered by the alumina industry after the adoption of the Bayer process.

Fig. 3: Red mud.

Table. 4: Physical properties of red mud.

Property	**Value**
Specific gravity	2.64
Fineness value	3%

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4.3 Methodology

The present study requires preliminary investigations in a systematic manner.

- Selection of type of grade of mix, mix design by an appropriate method, trial mixes, final mix proportions.
- Estimating total quantity of concrete required for the whole project work.
- Estimating quantity of cement, red mud, fine aggregate, coarse aggregate, E-waste required for the project work.
- Preparing the concrete bricks with partial replacement of cement by red mud, coarse aggregates by E-waste and fine aggregates, water-cement ratio kept constants.
- Prepared bricks cure for 7days by sprinkling of water daily 2times.

4.4 Mix design

Adopted Grade was **M10** for preparation of concrete bricks. **For 1 Brick making** (25% Replacement of cement with red mud and 0% to 20% replacement of coarse aggregates with E-waste).

Table. 5: Material weights requirement for making 1 brick.

Red mud (%) – E waste (%)	Cement (kg)	Red Mud (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	E-waste (kg)	Water (kg)
0 – 0	0.823	0	2.744	6.174	0	0.452
25 – 0	0.618	0.205		6.174	0	
25 - 5				5.865	0.308	
25 – 10				5.556	0.617	
25 - 15				5.247	0.926	
25 – 20				4.012	1.234	

4.5 Sample Production

Control mix: The cement, fine and coarse aggregates were weighted according to mix proportion of M_{10}. All are mixed in a bay until mixed properly and water was added at a ratio of 0.55. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

Red mud based Concrete bricks: The cement, red mud (25% of cement weight replacement), fine and coarse aggregates were weighted according to mix proportion of M_{10}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.55. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

E waste & Red mud based concrete bricks: The cement, red mud (25% of cement weight replacement), fine aggregates, coarse aggregates and E-waste (0 to 20% of coarse aggregates weight replacement), were weighted according to mix proportion of M_{10}. All are mixed together in a until mixed properly and water was added at a ratio of 0.55. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

A standard 190x90x90 mm brick specimens were casted for all above various types of concrete mixes. The samples were then stripped after 24hours of casting and are then be sprinkling of water for curing 7days (daily 2 times). As casted, a total of (28) 150x150x150mm bricks specimens were produced.

Fig. 4: Mixing of all ingredients.

Fig. 5: Concrete bricks moulds.

Fig. 6: Sprinkling water curing of bricks.

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Fig. 7: Brick samples.

4.6 Concrete Bricks Testing

4.6.1 Compression Test

- Brick specimen to be tested is placed on a horizontal surface and the specimen is to be centered between the plates on Compression testing machine.
- Apply the load at a uniform rate till the failure occurs.
- Note down the maximum load at failure.

4.6.2 Water Resistance Test

In this the bricks first weighted in dry condition, and they are immersed in water for 24 hours. After that they are taken out from water and they are wipe out with cloth. Then the difference between the dry and wet bricks percentage are calculated. The less water absorbed by bricks the greater its quality. Good quality bricks don't absorb more than **20%** water of its own weight.

4.6.3 Efflorescence test

The presence of **alkalis** in bricks is harmful and they form a grey or white layer on the brick surface by absorbing moisture. To find out the presence of alkalis in bricks this test is performed. In this test, a brick is immersed in fresh water for **24** hours and then it's taken out of the water and allowed to dry in shade. If the whitish layer is not visible on the surface it proofs that absence of alkalis in brick. If the whitish layer visible about **10%** area of the brick surface, then the presence of alkalis is in the acceptable range. If that is about **50%** of surface area then it is moderate. If the alkali's presence is over **50%** of the brick surface area, then the brick is severely affected by **alkalis**.

4.6.4 Shape and Size Test

Shape and size of bricks are very important consideration. All bricks used for construction should be of same size. The shape of bricks should be purely rectangular with sharp edges. Standard brick size consists of length x breadth x height as 19cm x 9cm x 9cm.

4.6.5 Colour Test

A good brick should possess bright and uniform colour throughout its body.

4.6.7 Soundness test

Soundness test of bricks shows the nature of bricks against sudden impact. In this test, 2 bricks are chosen randomly and struck with one another.

Then sound produced should be clear bell ringing sound and brick should not break. Then it is said to be good brick.

4.6.8 Hardness test

A good brick should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick.

4.6.9 Drop test

When bricks are dropped from the height of 1 to 1.2m (4 feet), it should not crack or break. This ensures the durability and quality of bricks.

4.6.10 Structure of Bricks

To know the structure of brick, pick one brick randomly from the group and break it. Observe the inner portion of brick clearly. If there are any flaws, cracks or holes present on that broken face then that isn't a good quality brick.

5. RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

5.1 Brick Test Results

5.1.1 Compression Test

Table. 6: Compression test results.

Red mud (%)- E waste (%)	Compression(N/mm2)
0 – 0	5.6
25 – 0	7.1
25 - 5	7.0
25 – 10	6.8
25 - 15	6.5
25 – 20	5.7

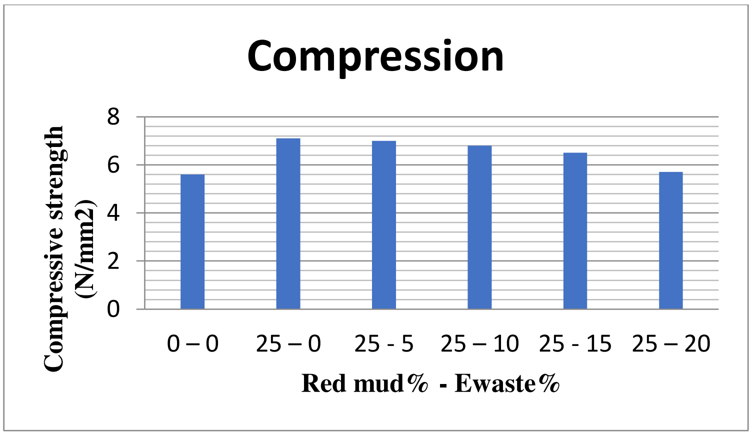

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Fig. 8: Compressive strength test results graph.

5.1.2 Water Resistance Test

Table. 7: Water resistance test results.

Red mud (%) - E waste (%)	Water Resistance (%)
0 – 0	8.2
25 – 0	8.2
25 - 5	7.8
25 – 10	7.5
25 - 15	7.2
25 – 20	6.5

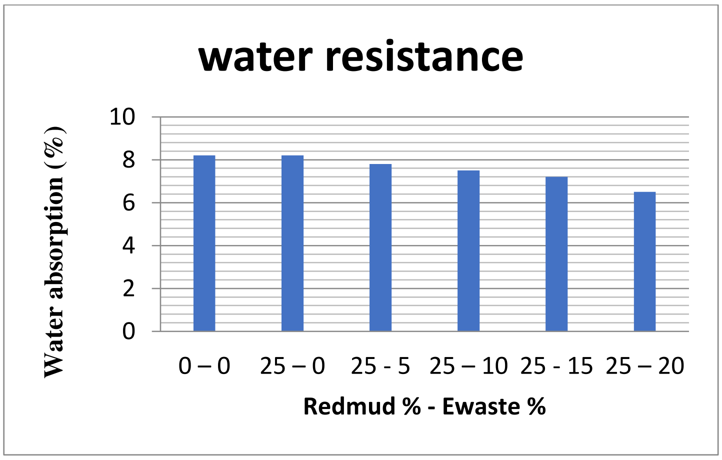

Fig. 9: Water absorption test results graph.

5.1.3 Efflorescence test

No efflorescence visible on all bricks.

5.1.4 Shape and Size Test

For all bricks are rectangular shape and size 15 cm x 15 cm x 15 cm.

5.1.5 Colour Test

All the bricks having the uniform colour for entire structure.

5.1.7 Soundness test

For all the bricks ringing sound produced and bricks are not breaked. Then the bricks are good quality bricks.

5.1.8 Hardness test

Little bit scratch visible on all bricks except concrete bricks.

5.1.9 Drop test

For all the bricks can't breaked while performed drop test, then the bricks are good quality bricks.

5.1.10 Structure of Bricks

There are no flaws, cracks or holes present on that broken face then that is a good quality bricks.

6. CONCLUSIONS

1. The aggregates are vital elements in concrete Bricks. The usage of enormous quantities of aggregates results in destruction of hills causing geological and environmental imbalance. The environmental impacts of extracting river sand and crushed stone aggregates become a source of increasing concern in most parts of the Country. Pollution hazards, noise, dust, blasting vibrations, loss of forests and spoiling of natural environment are the bad impacts caused due to extraction of aggregates. Landslides of weak and steep hill slopes are induced due to unplanned exploitation of rocks.
2. Considering the depletion of natural sources and the effect on environment, the disposal problems involved in disposing red mud, light weight characteristics of E-waste with good mechanical properties (Impact value 1.95% & crushing value 2.35%) and water absorption value is approximately zero as seen in the above investigation, a particular attention may be focused on the usage of red mud and E-waste aggregates in concrete.
3. Trying to replace aggregate by E-waste partially to make concrete structure more economic along with good strength criteria. This can be useful for construction of low-cost housing society. Solves problems of disposal of E-wastage.
4. Up to 20% of coarse aggregate replaced by E-waste and 25% of cement replaced by flash is good according to strength and cost wise.
5. Up to 20% of aggregate replaced by E-waste and 25% of cement replaced by red mud gives higher compressive strength compare to control mix.
6. The water resistance value is decreasing by increasing E-waste replacement by coarse aggregates. The structure test, soundness test, drop test, Colour test, Size and shape test the properties are similar to good quality bricks. And these bricks are very lesser cost compare to normal concrete and flyash bricks.

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