Experimental Investigation on Mechanical Properties of Compressed Soil Blocks Manufactured Using Waste Materials

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Abstract. This experimental investigation is done on the earth compressed block prepared by the Waste material. These waste materials are Rice Straw Fiber, marble powder, and Sugarcane Bagasse ash. This waste pollutes the environment and creates the problem of disposal. Redbrick needs heat treatment which results in air pollution, cement bricks need water for curing which needs water usage in huge quantity. Marble powder stabilized bricks need sun drying. An increase in marble content in the bricks results in the increment of compressive strength due to the presence of calcium content in the marble powder. It also increases the dry density of the brick because marble powder does not absorb water and can easily fill the voids created by the soil. Sugarcane Bagasse ash and Rice Straw fiber. Rice Straw Fiber reduces the compression of bricks reason is fiber cuts off on the pressure and it also creates voids when blended with the soil mix making usage of bagasse in the brick can help in increasing the strength of the concrete due to its pozzalonic action with cement but bagasse ash reduces the dry density of bricks and does not affect the strength of bricks because it creates voids and it is chemically neutral in bricks.

Keywords: Earth Compressed bricks, Proctor test, Marble powder, bagasse ash, Rice Straw

1. Introduction

As we know that compressed earth bricks are also known as earth pressed soil blocks. These are made from damp soils which are compacted at high pressure in order to mould them to the form of blocks [1]. Almost 21MPa pressure is applied thus reducing the original soil volume to about half. These blocks are manufactured according to standards in ASTM D1633-00. While manufacturing compressed earth bricks the advantage of cost reduction and benefit enhancement approach is kept in mind. These bricks have a low rate of thermal conductivity [2]. Marble powder is used as an additive in the following research [3]. Marble powder could be used in the manufacture of compressed earth bricks without causing any harm to the technical properties of the end
product[4–7]. Excess use can lead to more water absorption. Thus, the use of waste marble powder as an additive could play a significant role in brick production also contributing to ecology and economy. Bagasse ash is nothing but ash rich in silica and quartz[1,8–10]. The need for use of bagasse ash in earth brick sounds more effective when it acts as an eco-friendly material by reducing greenhouse emissions and reducing waste disposal issues of agro wastes. The bricks formed by the use of bagasse ash can reduce the seismic weight of buildings also reducing its cost making it cheaper and effective. 5-15% use of baggase ash in bricks can provide it good strength or else high percentages could lead it to high voids, high porosity, and less compressive strength. Higher contents of baggase ash could also lead to increased water absorption. Rice husk fiber being used as an additive is also exfoliating material in its own way. The finer the size of the husk the more strength and stability. Significant impacts on tensile as well as impact strength are observed during the use of fine and coarse or large grains of rice husk in earth brick[11–14]. A maximum of 1.5% of rice husk could be added to earth bricks without causing any harm to its natural properties or technical properties.

The practical application of the present study is that in the present scenario, the field of composite materials has become an eye-catcher point of era. There is a huge demand for lightweight, durable, cheaper, and effective materials which can reduce the cost as well as must-have good strength. It should be economically safe and eco-friendly. Thus, the use of such products which could reduce environmental hazards can prove a boon in the construction field.

2. Literature review

[1] Blends of bagasse debris and rice husk debris being developed of balanced out blocks with no other traditional folio. The examination included blends of bagasse debris and rice husk debris in equivalent extents changing from 10%till 30% . The blocks were tried for their compressive strength and water assimilation and checked for thickness of the cast block for different mixes. The test program uncovered that 10% bagasse debris with 1% rice husk debris delivered the most noteworthy strength, everything being equal. The water ingestion of the squares additionally expanded with expansion in squander content. The creators suggested the mix of bagasse debris and rice husk debris up to 20% in production of the block with extra benefit of the blocks being their light weight nature.

Studies by [15,16]Danso et al. additionally showed that the compressive strength of the coconut fiber supported soil blocks performed better compared to the bagasse and oil palm strands built up soil blocks. The draw out for all the fiber lengths can be clarified by filaments poor interfacial bond with the dirt grid and short lengths of the strands embedded in the dirt framework. The outcomes imply that with regular strands in soil, the instrument can either be pull-out or crack of the filaments, though considers on steel filaments in concrete composite the component is quite often pull-out on the grounds that steel strands are planned that way. In case they were long enough they would crack.

[17] detailed that shrinkage increments quickly during the initial 4 days for concrete balanced out earth blocks and the expansion of sand decreases the shrinkage as sand particles go against the shrinkage development. He additionally saw that the option of concrete substance can lessen the shrinkage until 44% for 10% concrete substance added. As seen by Oti mix blocks made of mud, concrete, lime and Ground Granulated Blast Furnace (GGBS) oppressed up to 100 cycles 24 hours rehashed of freezing and defrosting showed fulfillment result where just having greatest 1.9% weight reduction toward the finish of the 100th cycles. The assessment after the test showed no harmed happen of any kind.

[2,18] examined varieties in warm conductivity for various porosities and concrete substance in soil–concrete squares. The warm conductivity got for blocks with a concrete substance shifting from 4 to 10% and porosity range from 36 to 43% was 0.5009–0.7675 W/(m K). Akinmusuru (1994) explored the
impact of concrete substance on the warm conductivity of soil–concrete blocks at different temperatures (25, 250, 500, 750 and 1000°C). The outcome uncovered that the expansion of concrete diminished the warm conductivity of lateritic soil–concrete blocks. It was shown that the impact of warmth on plain squares is to expand their qualities while diminishing their warm conductivities, along these lines taking into account more warm solace in homes worked with the blocks.

[17] have researched the electrical conductivity of compacted concrete settled soil to survey the warm conductivity of the material. The outcome shows that warm conductivity imperceptibly diminishes with expanding concrete and sand content. This has been credited to bring down events of free water, because of hydration in examples with higher concrete substance cause. Balaji et al. have shown that the pore boundary of the structure materials (like the absolute pore volume) principally relies upon the molecule pressing thickness. As the thickness of the square expands, the level of complete pore volume diminishes and the warm conductivity increments correspondingly.

[19] have tried the dirt concrete squares having a piece proportion of 1:1:6 (cement:sand:soil) by volume to get a warm conductivity worth of 1•4823 W/(m K) for a mass thickness of 1913•17 ± 27•65 kg/m3 (tried by the Japanese standard JIS R 2618 (JIS, 1995)). The warm conductivity of soil–concrete squares with a creation of 1:7:7 (cement:sand:soil) by weight. The warm conductivity test completed according to ASTM C1113-99 (ASTM, 1999) uncovered a warm conductivity worth of 1•231 W/(m K) for a square thickness of 1800 kg/m3 . Adam and Jones (1995) examined the impact of stabilizers on thickness. An outstanding relationship for warm conductivity against dry thickness was acquired for the settled soil blocks. Their examination prescribed for additional exploration to relate warm conductivity with soil type, and to decide the impact of thickness on warm conductivity.

3. Methodology

For the experimental study of the bricks prepared by Marble powder, Bagasse ash, and Rice straw fiber the following material with their properties is used. Properties of marble powder and bagasse ash are listed in table 1 and soil properties are as shown in table 2. Rice Straw Fiber Constituent length 30mm

| Table 1 Properties of Marble Powder and Bagasse ash |
|-----------------------------------|
| Properties                      | Marble powder | Bagasse ash |
|---------------------------------|---------------|-------------|
| Specific Gravity                | 2.71          | 2.1         |
| Fineness (90micron)             | 100%          | 97%         |
| Moisture content                | 27.3%         | 2%          |

Table 2 Different Properties of soil

| Gravel Content | 0.01% |
|----------------|-------|
| Sand Content   | 19%   |
| Silt Content   | 10%   |
| Clay Content   | 70.99%|
| Plasticity test| 31.7% |
| Liquid Limit   | 30%   |
| Plastic Limit  | 61.7% |
| Specific Gravity| 2.48  |
| Soil type      | Clay with high Plasticity |
| Modified Proctor test (Compaction) | $Y_d$ | 1.83 |

Figure 1 Brick Moulding Machine
3.1 Mix design
The series of steps involved in going into the investigation involved preparation and characterization of materials, selection of block size and mould fabrication and additive content, casting and curing of bricks, and experimental investigation. The preparation of soil will be carried out in accordance with IS 2720:1983. Bricks are prepared as the replacement of soil for each constituent material. A brick has weight of 3 kgs and a brick made of 1% of Rice Straw, 25% Marble powder and 10% bagasse ash had following weight of material.

| Material  | Weight  |
|-----------|---------|
| Bagasse ash | 300 grams |
| Marble powder | 750 grams |
| Soil       | 1920 grams |
| Rice Straw | 30 grams |

The mix is converted to the proper ball and inserted in the compressed brick machine as shown in figure 1. The whole study is divided into three [20] parts depending on the replacement ratio of soil with marble powder i.e. 25%, 35%, and 45%. Further, the soil is being replaced by bagasse ash and Rice Straw fiber in different proportions as shown in table 3.

Bagasse ash replacement was done by 8%, 10%, and 12% by the weight of soil, and Rice straw fiber was replaced by 0.75%, 1%, and 1.25% [21–25]. The soil brick dimension was taken as 90mmX90mmX190mm for compression test purpose as shown in figure 2. The ratios designation and different contents are listed in table 4.

| Ratio Designation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|------------------|---|---|---|---|---|---|---|---|---|
| Bagasse ash content | 8 | 8 | 8 | 10 | 10 | 10 | 12 | 12 | 12 |
| Rice straw Fiber content | 0.75 | 1 | 1.25 | 0.75 | 1 | 1.25 | 0.75 | 1 | 1.25 |

Table 3 Mix Design of Modified brick Soil Mix

Table 4 Different Ratios of bagasse ash and Rice Straw Fiber

For each ratio of marble fiber this different ratios of Bagasse ash and Rice Straw fiber are studied experimentally. The test for the experimental study are:
- Proctor test of all mixes (for finding OMC and Dry density of All mixes).
- Compression test.
4. Results

4.1. Proctor test of Modified Mix for Brick

Various ratios of bagasse ash and Rice Straw fiber are introduced in the soil for the determination of various mechanical characteristics of the brick. As marble powder is free from any water absorption capacity when it is introduced in the soil the dry density should be increase but at the same time bagasse ash rice Straw fiber is also introduced in the brick therefore it reduces from 1.83 to 1.48 for marble powder to be25% rice Straw fiber to be 0.75% and bagasse ash to be 8% in the brick as shown in figure 3.
Fineness and Non Water absorbant behavior of the marble powder contribute nothing in the results of proctor test rather it increase the dry density of the soil but with 35% marble Powder we are using bagasse ash and rice straw so they make a decrease in the value of the proctor value which results the decrease in proctor value of 1.83 (virgin soil) to 1.52 (modified soil) as shown in figure 4.

When the marble powder is used around half of the weight of the soil i.e. 45% of the soil then the proctor value of the soil increase upto the highest value because the soil absorbs water and marble powder didn’t absorb any part of water but use of bagasse ash and rice straw in the modified soil mix decreases the proctor value i.e. dry density of the soil as shown in figure 6.

4.2. Compressive Strength Test

As the content of bagasse increased in the brick the strength starts decreasing because bagasse is very compacting ash it creates voids in the soil and reduces the strength of the brick for marble 25% as the highest strength of compression is taken on the ratio of bagasse ash 10% and Rice Straw Fiber 0.75% as shown in figure 5 but Rice Straw Fiber also absorbs water which increases the water demand of the mixes and dry density of mixes starts decreasing.
Marble powder imparts the increment of mechanical strength of the bricks in which the strength due to fineness of marble powder. Marble powder increases the pretty dry density of the mix but on the same hand fiber and ash decrease it due to the absorption of water. Powder increases the strength of brick but fiber and ash together decrease the compression capacity of the bricks as shown in figure 6.

![Figure 6 Compressive strength test results of mixes having Marble Powder 35%](image)

45% marble powder specifically for all intents and purposes has sort of the highest kind of basically compressive strength among the three ratios of the powder as shown in figure 7 where marble powder increase the strength and also increase the very kind of dry density of brick in a very major way. Using actually particularly high marble powder can increase the cost of the brick in a major way. Rice Straw Fiber reduces the erosion and sort of reality for all intents and purposes dry density to the kind of definitely good limit bagasse kind of due to its pozzolanic action mostly kind of contribute to strength of brick but reduces the compression of the brick.

![Figure 7 Compressive strength test results of mixes having Marble Powder 45%](image)
5. Conclusions

1. Using marble powder in the soil can be used as stabilizing material as well as it can increase the dry density of the soil with lower optimum water content. Marble powder increases the cost of the brick.
2. Bagasse ash content creates the voids in the brick which reduces the strength of brick but also decreases the dry density of the mix.
3. Using marble powder increase the compression capacity of brick but Rice Straw Fiber and bagasse ash forms voids which decrease the Compressive strength of the brick.

6. Limitations and future scope for study

In this study, the effect of the waste materials on mdd (maximum dry density), omc (optimum moisture content) and compressive strength of compacted soil brick is only investigated. In future, the experimentation on the other properties like water absorption, efflorescence, erosion, durability can also be conducted. Further, there is a scope of conducting studies using different fiber length and varied content of the waste materials.

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