Experimental Study of the Strength Aspects of Compressed Stabilized Earth Blocks using Marble Dust, Sugarcane Bagasse Ash and Paddy Straw Fiber

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Abstract. The world is facing pollution crises and these cries are due to improper disposal of waste material. Some of the waste materials can easily be disposable in the construction industry by using them in the concrete or in any other construction material. This paper deals with this waste material to be utilized in the compressed earth blocks. To study the mechanical properties of compressed soil blocks prepared by a combination of various ratios of Marble powder, paddy Straw Fiber and Sugarcane bagasse ash, the compression test, and water absorption test was performed. The marble powder is introduced in the manner to replace soil by 25%, 35%, and 45%. Paddy Straw fibers are introduced by the replacement percentage of 6%, 8%, and 1% whereas the bagasse ash is been introduced in the manner of 8%, 10%, and 12%. This various test shows that the Marble powder Waste increase dry density which helps in increasing the compression Capacity of the brick. Whereas Paddy Straw fiber and bagasse ash decrease the dry density of brick which results in decreasing the optimum water content of the mix of the brick. Bagasse ash and paddy straw fiber increase the water absorption capacity of the brick.

Keywords: Earth Compressed bricks, Impact, Proctor test, Marble powder, bagasse ash, Paddy Straw Dust

1. INTRODUCTION

As we know that compressed earth bricks are also known as pressed earth or pressed soil blocks. These are made from damp soils which are compressed at high pressure as shown in figure 1 in order to mold them to the form of blocks[1]. An amount of 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. These blocks must be submerged in water for about 4-6 hours. Marble powder is used as an additive in the following research along with that of paddy fiber and bagasse ash. [2]Marble powder had positive effects on the physical, mechanical as well as chemical strength of the compressed earth blocks. Marble powder could be used in the manufacture of compressed earth bricks without causing any harm to the technical properties of the final product. Excess use can lead to more water absorption. Thus use of waste marble...
powder as an additive could play a significant role in brick production also contributing to ecology and economy. [4–7]

Bagasse ash being the next additive has its own type of quality which could contribute to the good strength of earth brick[1,8–10]. Bagasse ash is nothing but ash with high silica content and high portions of quartz. By using it in bricks as an additive it could give us eco-friendly bricks along with solving the problem of disposal. 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. 2-5% use of bagasse 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 bagasse ash could also lead to increased water absorption. Rice husk fiber or paddy fiber is another additive in the manufacturing of earth bricks. Rice husk is a widely produced agro-waste and can be used to improvise properties of earth brick. 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[11–14]. The size of the rice husk also plays a vital role in exfoliating the mechanical properties of earth brick. The larger grains of rice husk tend to reduce tensile strength as well as impact strength of earth bricks. The fiber weight fraction also plays a significant role in the strength of earth brick.

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
Alavéz-Ramírez et al.[1] explored the impact of bagasse debris on the strength of lime-balanced out soil blocks. Squares were ready with 10% lime and a mix of 10% lime with 10% sugarcane bagasse debris and restored for 7, 14, and 28 days of relieving. The settled squares were then exposed to pressure and flexure tests in both dry and immersed states. The tests uncovered that the expansion of bagasse debris to lime settled squares fundamentally worked on the exhibition of the balanced-out blocks. Mineralogical and microstructural examinations were likewise completed which uncovered an impressive improvement in the settled soil grid because of the arrangement of CSH and CAH stages.

James et al. [10] researched the utilization of bagasse debris paver blocks on low traffic street asphalts. The examination comprised of planning and testing four preliminary blends in with bagasse debris as per BIS and IRC norms. This was trailed by the plan of an adaptable asphalt for low volume traffic streets. The paver blocks were planned with half bagasse debris expansion in the blend. The compressive strength aftereffects of the paver hinders just as solid shapes uncovered that however, the strength of the paver blocks with bagasse debris was lower than the control examples, the strength esteems were exceptionally near the control. The plan of asphalt with bagasse debris paver blocks was less expensive than ordinary
adaptable asphalt by 24.15%. The creators additionally refer to higher plan life for bagasse debris paver block asphalt just as diminished support costs when contrasted with traditional adaptable asphalt. Studies by Danso et al. [15,16] 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 4, 45 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.

Bahar et al. [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. Bahar et al. [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 causes. Balaji et al. [18] have shown that the pore boundary of the structure materials (like the absolute pore volume) principally relies upon the molecule pressing thickness [19–22]. As the thickness of the square expands, the level of complete pore volume diminishes, and the warm conductivity increments correspondingly [23,24]

3. METHODOLOGY

The investigational study is done on the earth-compressed bricks to find the durability and strength of brick prepared by waste materials like Marble Powder, Sugarcane Bagasse ash, and Paddy fiber. This waste material is mixed in various ratios and different 27 mixes are prepared. These 27 mixes are driven to the mould and formed bricks are tested for the compression capacity, water absorption capacity, and durability test by taking all the consideration of IS 3495.

For compression, the bricks of 90mmX90mmX190mm are prepared and tested in the compression testing machine as shown in figure 2. Water absorption capacity is checked by the specimen immersed in water for 24hrs and then the percentage change in weight is noted. Impact test was done by taking bricks on 1mts heigh and making free fall. Patterns of breaking and breaking half determine the durability of brick.

![Figure 2 Mould for brick](image)

The bricks are prepared by taking ratios of marble powder as 25%, 35%, and 45% with the other ratios of bagasse ash and Paddy fibers. Each ratio of marble powder is tested with the following ratios of bagasse ash and Paddy Straw fiber as shown in table 1.
Table 1 Ratios and contents of bagasse ash and Paddy Straw fiber

| Ratio | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-------|---|---|---|---|---|---|---|---|---|
| Bagasse ash content | 8% | 8% | 8% | 10% | 10% | 10% | 12% | 12% | 12% |
| Paddy straw Fiber content | 0.6% | 0.8% | 1% | 0.6% | 0.8% | 1% | 0.6% | 0.8% | 1% |

For the study the following properties of constituent material are taken as shown in table 2.

Table 2 Properties of Constituent Material

| Soil | Moisture Content | Modified Proctor test (Compaction) - Y_d =1.69 at 18% |
|------|-----------------|---------------------------------------------------|
|      | Plasticity limit | - 31.7%                                           |
|      | Liquid limit    | - 62%                                             |
|      | Plasticity index| 30.3%                                              |
| Bagasse ash | Specific Gravity | 2.1                                                |
|      | Finess (90micron) | 97%                                                |
|      | Moisture content | 27.3%                                              |
| Paddy Straw fiber | Constituent length | 30mm                                              |
| Marble powder | Specific Gravity | 2.71                                               |
|      | Finess(90micron) | 100%                                               |

If a brick has a weight of 3 kgs and a brick made of 1% of Paddy Straw fiber, 25% Marble powder, and 10% bagasse ash had Soil -1920 Grams, Marble Powder- 750 Grams, Bagasse Ash – 300 Grams and Paddy Straw – 30 Grams. Water is taken in accordance with the workability of the mix because bagasse ash absorbs water. The mix is converted to the proper ball and inserted in the compressed brick machine. The bricks are kept for sun drying for 21 days.

4. RESULTS

4.1 Proctor test

Proctor test of any mix of the soil gives us the idea of the optimum water content of soil at which the soil is fully saturated and it has its highest dry density of soil. All the mixes prepared by bagasse ash, marble powder, and paddy fiber are tested for dry density. Marble powder is nonabsorbent of water which does not absorb water when introduced in the brick increases the dry density of the brick but at the same time, bagasse ash and paddy fiber both absorbs water and reduces the dry density of the brick. Using bagasse and paddy fiber reduces the weight of brick by providing the voids in the bricks.
Figure 3 Proctor test of mix at Marble powder 25%
it is seen in the experimental study that as the dry density of the mix decreases the optimum percentage of water content also disturbs as shown in figure 3, figure 4 and figure 5. When the bagasse ash is introduced into the mix the dry density starts reducing due to the absorption of water to a great extent as marble powder is non-absorbent of water so there is some increment due to it. On average the proctor value for virgin soil comes to be 1.69 but on adding the marble powder, ash and fiber it decreases averagely. As the increment in the content of marble powder is done the dry density of the mix starts increasing i.e. it increases from 1.48 to 1.62. If talked about only the marble powder then the dry density would have been crossed the value of 2 but on the same time we are using the ash and the fiber which absorbs water and reduces the dry density of the mix.

**Figure 4** Proctor test of mix at Marble powder 35%

**Figure 5** Proctor test of mix at Marble powder 45%
5. Compression Test

![Compression strength of brick at Marble Powder 25%](image1)

Figure 6  Compression strength of brick at MP 25%

![Compression strength of brick at Marble Powder 35%](image2)

Figure 7: Compression Strength of Brick at MP 35%

![Compression strength of brick at Marble Powder 45%](image3)

Figure 8  Compression strength of brick at MP 45%
The use of marble waste powder in the brick increases the strength of brick by filling up the voids, generally, earth compressed brick some amount of stabilizing material so that they can bind all the constituents particles nicely and tightly as shown in figure 6, figure 7 and figure 8. Marble powder being very finer than the soil easily attains the voids of the bricks and makes a good increment in the compression strength of the soil. Bagasse ash being a very light material reduces the weight of the brick and also contributes to the binding of the particles in the brick. Paddy fiber rescued the compression strength of the brick.

As the content of marble powder increases from 25% to 45% it is seen that there is the increment in the compressive strength of the brick. The fineness of the marble powder fills the voids of the brick and makes a good increment in the strength. Having pozzolanic action bagasse ash reduces the strength of the brick due to its low density and water absorption properties.

6. Water Absorption

Water absorption of the brick depends on the void ratio of the soil. More the void ratio more will be the water absorption, but marble powder replaces the soil and fills the voids in the brick and reduces the water absorption but bagasse being a Waterous plant its ash absorbs the water and increases the overall capacity of the water absorption.

The dry paddy fiber when comes in contact with the water it absorbs some water which makes an increment in the overall capacity of absorption of water and this leads to the decreasing the strength of the soil.
Figure 9 Water absorption at Marble Powder 25%

Figure 10 Water absorption at Marble Powder 35%

Figure 11 Water absorption at Marble Powder 45%
Bagasse ash absorbs up to 50% water of its weight which increases the weight of the brick also as the marble powder increases the water absorption decreases as shown in figure 9, figure 10 and figure 11. When only compared with marble powder as a substitute Specimen of 25% will have more water absorption than 45%.

7. CONCLUSIONS

The brick made up of marble powder, bagasse ash, and paddy fiber increases the durability of brick does not break into parts because fiber resists the breaking of the brick. Marble powder increases the dry density of the brick which results in an increase in the strength of the brick. Bagasse ash increases the water absorption of the brick because ash absorbs water. Which reduces the dry density and reduces the strength but helps in binding the material and reduces the weight of the bricks.

8. LIMITATIONS AND FUTURE SCOPE OF THE STUDY

In this study, the effect of the waste materials on water absorption, 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 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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