Characteristics of unfired soil blocks stabilized with industrial waste and agricultural waste

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Abstract. The problem of pollution is on daily rise and environment protection is becoming challengeable task due to production of fired bricks and improper disposal of waste materials. This experimental investigation is conducted on unfired compacted soil block stabilized with waste materials. The waste materials utilized in this investigation were paddy straw fiber, sugarcane bagasse ash and marble dust because of their improper disposal and burning of paddy straw is one of them. Marble dust was put on at distinct percentages in the span of 25% to 35%, bagasse ash and paddy straw fibers (75mm length) were also added in varied %age. Experiments were conducted on the blocks to determine the compaction properties and compressive strength of the blocks. The outcome of this experimentation determined that the light weight unfired admixed soil block is achievable with optimum amount of waste materials. Also, inclusion of marble dust in soil block admixed with bagasse ash and paddy straw fiber increases the compressive strength.

Keywords: soil block; marble dust; compressive strength; paddy straw; dry density; bagasse ash

1. Introduction

Earth is abundant with soil and has been used as a building material for providing shelters to millions. 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. While manufacturing compressed earth bricks the advantage of cost reduction and benefit enhancement approach is kept in mind. Block making machines can be hand-operated or mechanically operated. Paddy straw fiber being used as an additive[1] is also exfoliating material in its own way[2–4]. Significant impacts on tensile as well as impact strength are observed during the use of fine and coarse or large grains[5,6] of rice husk in earth brick. Marble powder is used as an additive and the use of waste marble powder as an additive could play a significant role in brick production also contributing to ecology and economy [7]. Bagasse ash is nothing but ash rich in silica and quartz. 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 effective utilization of these wastes through economic and environmental impact is a demanding task for the researchers[8,9]. This experimental investigation is conducted on unfired compacted soil block stabilized with agricultural and industrial waste [10,11]. The practical applications of this study is that there is a huge demand for
lightweight, durable, cheaper, and effective materials which can reduce the cost as well as must-have good strength. Thus, the unfired admixed soil blocks have the potential to find its various uses in the civil engineering field in the form of building blocks for the construction of walls, interlocking tiles for pavement and other structures [12–15].

2. Materials And Methodology

2.1 Materials

Table 1 and 2 list the engineering properties and chemical composition of soil and marble dust powder respectively. Whereas, the chemical properties of bagasse ash used in the study are given in table 3.

Table 1. Soil Properties

| Soil Properties                              | Value |
|----------------------------------------------|-------|
| CBR                                          | 4.43  |
| Maximum Dry Density (gm/cm$^3$)              | 1.67  |
| UCS (KN/m$^2$)                               | 91.6  |
| Optimum Moisture Content (%)                 | 19    |
| Plasticity Index (%)                         | 19.1  |
| Liquid Limit (%)                             | 42.3  |
| Specific Gravity                             | 2.66  |
| Plastic Limit (%)                            | 23.2  |
| Unified soil classification system           | CI    |

Table 2. Composition of marble dust

| Constituents | Percentage |
|--------------|------------|
| SiO$_2$      | 0.78       |
| Al$_2$O$_3$  | 0.22       |
| Fe$_2$O$_3$  | 0.07       |
| CaO          | 54.82      |
| MgO          | 0.26       |
| SO$_3$       | 0.25       |
| Cl$^-$       | 0.06       |
| SrO          | 0.05       |
| L.O. I       | 43.22      |
| Constituents       | Percentage |
|-------------------|------------|
| Silica (SiO$_2$)  | 74.14      |
| Potassium Oxide ($K_2O$) | 5.67      |
| Alumina ($Al_2O_3$) | 2.32      |
| Iron oxide ($Fe_2O_3$) | 1.73      |
| Other Oxides      | 16.14      |

**Table 3. Chemical Composition of Sugarcane Bagasse Ash (SCBA)**

2.2 Methodology

Marble dust was put on at distinct percentages in the span of 25% to 35%, straw fibers (75mm length) were reinforced at 0.8% to 1.2% and bagasse ash was added in the range of 7.5% to 12.5%. The soil preparation as per (BIS) IS [16] [17] was performed. Soil blocks prepared with the help of a motorized hydraulic press under certain amount of pressure as shown in figure 1.
Figure 1. Soil Block manufacturing machine

The methodology adopted for compressive strength of soil blocks was as per IS 3495 (Part 1): 1992 [18] and omc, mdd was determined as per IS 2720 Part 7 [19].

3. Result

3.1 Effect on MDD and OMC of unfire19d admixed soil block

Under this experimental study, maximum dry density tends to increase with the increment in %content of marble dust. The downtrend of MDD of the soil and varying fiber (0.8%, 1% and 1.2%) mix with distinct % of bagasse ash and marble dust is shown in figure 2, figure 4 and figure 6.
Figure 2. MDD of block with 0.8% fiber

Figure 3, figure 5 and figure 7 shows the uptrend of OMC of the fiber (0.8%, 1% and 1.2%) mix with distinct % of marble dust and bagasse ash.

Figure 3. OMC of block with 0.8% fiber

Figure 4. MDD of block with 1% fiber
Figure 5. OMC of block with 1% fiber

Figure 6. MDD of block with 1.2% fibers
Figure 7. OMC of block with 1.2% fibers

3.2 Effect on Compressive strength of unfired admixed soil block

Under this experimental study, the compressive strength of the unfired admixed soil block increases with addition of fibers, bagasse ash and marble dust. Various authors [2–4,7] have recommended that compressive strength of unfired compacted soil block should be greater than 2.5 MPa. The results of the compressive strength conducted on soil block stabilized with 0.8% fiber and varied %age of bagasse ash and marble dust is shown in figure 8.

Figure 8. Compressive strength of block with 0.8% fiber
The compressive strength of the soil block shows the uptrend as shown in figure 8. Similar trend was also observed with 1% paddy straw fiber and 1.2% fiber as shown in figure 9 and figure 10 respectively attaining peak values with marble dust: bagasse ash as 30%:12.5%.

![Figure 9. Compressive strength of block with 1% fiber](image)

![Figure 10. Compressive strength of block with 1.2% fibers](image)

4. **Conclusion**

   In this study, experimentation on the mdd, omc and compressive strength of the unfired soil block has been conducted.

   1. The MDD of the unfired soil block achieved its peak value when 0.8% fiber (75mm) was stabilized with bagasse ash: marble dust as 7.5%:35% and minimum value when stabilized with bagasse ash: marble dust as 12.5%:30%. Similar trend was observed when unfired admixed soil block was reinforced with 1% fiber and 1.2% fiber.
2. With marble dust: bagasse ash as 30%:12.5% in soil block, the compressive strength of the unfired soil block achieved its peak value when admixed with 0.8% fiber (75mm). Similar trend was observed when unfired admixed soil block was reinforced with 1% fiber and 1.2% fiber.

3. It has been found that bagasse ash: marble dust as 12.5%:30% with inclusion of 0.8% fiber (75mm) in soil block has the maximum compressive strength of 9.84 MPa. The light weight unfired admixed soil block with compressive strength of 8.21 MPa is achievable when marble dust: bagasse ash as 25%:12.5% is reinforced with 1.2% fiber reinforced unfired soil block.

5. Limitations and Future scope of the study

In this study, the effect of the waste materials on mdd, omc and compressive strength of unfired soil block 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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