FEASIBILITY STUDY ON UTILISATION OF LATERITE SOIL FOR STABILIZED EARTH BLOCKS

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ABSTRACT

This paper deals with the experimental investigations carried out to study the feasibility of using laterite soil to produce stabilized earth blocks. A mix ratio of 1:6 was used to prepare the earth blocks. Totally 72 blocks were cast with cement and fly ash as stabilizers and the conventional fine aggregate is replaced by percentage laterite soil by 0%,20%,40%,60%,80% &100%. Curing was done by sprinkling water on the specimens. 36 blocks were tested for compressive strength and 36 blocks were used for water absorption test. Test results indicated that the compressive strength of blocks with 100% laterite soil and cement is 4.17 N/mm^2 which satisfies the Class 30 grade as specified in IS 1725: 1982. Water absorption test results also reveals that blocks made with laterite soil shows less water absorption. Hence laterite content is found to be suitable to produce earth blocks and hence can be recommended for building construction.

Keywords: Laterite soil, Earth blocks, Cement, Fly ash, Compressive strength, Water absorption

INTRODUCTION

Compressed earth blocks are cost effective and energy efficient alternative materials to the normal burnt clay bricks used for construction of buildings. Compressed earth blocks are also known as stabilized mud blocks (SMB) or Stabilized Compressed Earth Block (SCEB).The compressed earth block is modern descendent of moulded earth block. The idea of compacting earth is to improve the quality & performance of moulded earth blocks. Laterite has been used in construction of shelter from time immemorial and approximately 30% of world's present population still lives in laterite structures. It has been used extensively for wall construction around the world, particularly in developing countries. Laterite is a cheap, environmental friendly and abundantly available building material in the tropical region. Laterite has other advantages which make it potentially a very good and appropriate material for construction, especially for the construction of rural structure in the less developed countries.

Laterite is highly weathered soil which contains large, though extremely variable, proportions of iron and aluminium oxides, as well as quartz and other minerals. They are found in abundance in the tropics and sub tropics, where they generally occur just below the surface of grass lands or forest clearing in regions with high rainfall. The soil colour can vary from red, brown, and violet to black depending on the concentration of iron oxides. Laterite soil that has a reddish tinge as a result of the presence of iron compounds in the soil composition. Lateritic soils cover an area about 22 Lakh sq. km (3.7% of the country's area). Laterite soil also occurs at lower levels and in valleys. The Important areas where laterite soil is available in India include Kerala, Bangalore, Hasan, Kolar and Mysore districts of Karnataka; Ratnagiri, Satara, Sindhudurg and Kolhapur districts of Maharashtra; Medak, Nellore and East Godavari districts of Andhra Pradesh; Balasore, Cuttack, Ganjam, Mayurbhanj and Sundargarh districts of Orissa; Barddhaman,

Birbhum, Bankura and Medinipur districts of West Bengal; Sibsagar, Lakhimpur, North Cachar Hills and Nowgong districts of Assam; Garo Hills of Meghalaya; and Santhal Pargana district of Jharkhand.

Since the laterite soil is available in large quantities in most regions, this type of soil is easily accessible to low income groups as it a suitable construction material for most parts of the building. The use of this unlimited resource in its natural state involves no pollution and has negligible energy consumption thus further benefiting the environment by saving biomass fuel. Hence in this investigation an attempt has been made to produce stabilised earth blocks using laterite soil using cement and fly ash.

EXPERIMENTAL PROGRAM

Materials Used

Cement: Ordinary Portland Cement (OPC) - 43 grade conforming to IS: 8112 – 1989, having a specific gravity of 3.15 was made use of, in the casting of the specimens.

Fly ash : Class F dry fly ash conforming to IS 3812-2003 obtained from Mettur thermal power station of Tamilnadu from southern part of India was made use of in the casting of the specimens. The chemical composition of fly ash is given in Table 1.

Fine Aggregate : Locally available river sand having a bulk density of 1693 kg/m^3,fineness modulus of 2.75, specific gravity of 2.81 and conforming to grading zone-III as per IS: 383 - 1970 was used.

Laterite Soil : The laterite soil used in this work was collected from a village in Hyderabad and the chemical composition of the laterite soil is given in Table 2.The laterite soil has the following physical properties: Specific gravity – 2.64, Plastic limit – 23%, Liquid limit - 30%, Plasticity Index - 7%, Optimum moisture content – 14% and Maximum dry density -2.1 g/cm^3.

Preparation of blocks

A mix ratio of 1:6 (Cement : Sand) was adopted for preparing stabilized earth blocks. The Indian Standard specification IS 1725 – 1982 specifies the following three sizes for soil cement blocks: 29 x 19 x 9 cm, 19 x 9 x 9 cm and 19 x 9 x 4 cm. The size of the block selected for this investigation is 19 x 9 x 9 cm and wooden moulds were used for the casting of blocks. Two mixes were prepared namely Mix 1 and Mix 2. Mix 1 refers to the blocks prepared using 100% cement and Mix 2 refers to the blocks made using 70% cement and 30% fly ash. In both the mixes, sand is replaced by laterite soil in percentages of 0, 20, 40, 60, 80 and 100. For each mixes 36 blocks were cast out of which 18 blocks were tested for their compressive strength and 18 blocks were subjected to water absorption test. Laterite soil was dried and sieved in order to remove large lumps before it is mixed with cement. All the ingredients were thoroughly mixed and after dry mixing of all the ingredients, water is added a little at a time until the damp soil-cement reaches the right consistency. After complete mixing, soil- cement mixture was filled into the wooden moulds in three layers and the compaction was done for each layer manually. The blocks thus prepared are shown in Figure.1. After 24 hours of moulding of blocks, curing was done daily by sprinkling water thoroughly over them.

Testing of blocks

All the cast blocks were tested for the parameters like compressive strength and water absorption as per the requirements of IS 1725 – 1982 for soil – cement blocks. The compressive strength and water absorption tests were carried out as per the specifications given in IS 3495 -1992, Part 1 and Part 2 respectively. Each of the block is weighed before subjected to compression test and the density of the blocks were calculated.

RESULTS AND DISCUSSION

Density

Variation of density of blocks for Mix 1 and mix 2 for various percentages of laterite soil is shown in Figure.2. The values shown are the average densities of three blocks. For Mix 1, density ranges from 1978 kg/m^3 to 2261 kg/m^3. Similarly for Mix 2, density ranges from 2053 kg/m^3 to 2180 kg/m^3.In both mixes, blocks made with 40% laterite soil shows the maximum density. For both mixes, as the percentage of laterite soil is increased from 0 to 40 %, density values also increases. But beyond 40%, density of blocks starts decreasing. In general blocks made with 100% cement have highest density when compared with the blocks made with 70% cement and 30% fly ash. Exception occurs only when 100% laterite soil is used.

Compressive Strength

For each of the mixes and for each replacement level of laterite soil, three blocks were subjected to compression test and the average compressive strength of the blocks is shown in Figure.3. In Mix1, blocks with 40% laterite soil gives the highest compressive strength of 10.81 N/mm^2 and blocks with 100% laterite soil gives the least compressive strength of 4.18 N/mm^2. In Mix 2, blocks prepared using 20% laterite soil gives the highest compressive strength of 10.69 N/mm^2 and blocks with 100% laterite soil give the least compressive strength of 6.01 N/mm^2. In general blocks made with 100% cement have highest compressive strength when compared with the blocks made with 70% cement and 30% fly ash. Exception occurs only when 100% laterite soil is used. When 100% laterite soil is used Mix 2 gives higher compressive strength as compared with Mix 1. As per the recommendations of Indian Standard specification IS 1725 – 1982, soil cement blocks shall have a minimum average compressive strength of 1.96 N/mm^2 (20 kgf/cm^2) for Class 20 and 2.96 N/mm^2 (30 kgf/cm^2) for Class 30. From the test results it can be seen that in both the Mixes, blocks prepared with 100% laterite soil gives a compressive strength greater than 2.96 N/mm^2 and hence it can be concluded that Class 30 blocks can be prepared with 100 % laterite soil.

Water absorption

For each of the mixes and for each replacement level of laterite soil, three blocks were subjected to water absorption test and the average percentage of water absorption of the blocks is shown in Figure.4. In Mix1, blocks with 20% laterite soil shows the least water absorption of 3.1% and blocks with 100% laterite soil shows the maximum water absorption of 10.81%. In Mix 2, the range of water absorption is almost same for all the blocks with maximum water absorption of 10.2% for blocks with 100% laterite soil. In general blocks made with 100% cement have low water absorption when compared with the blocks made with 70% cement and 30% fly ash. Exception occurs only when 80% and 100% laterite soil is used. As per the

recommendations of Indian Standard specification IS 1725 – 1982, soil cement blocks after immersion in cold water for 24 hours shall not have an average water absorption of more than of 15 percent by weight. From the test results, it can be seen that for all the tested blocks the water absorption values are less than 15% and hence these blocks can be recommended for use.

Cost Analysis

Cost of Materials

1. Cement : Rs.6 per kg
2. Fly Ash : Rs.2 per kg
3. Laterite Soil : Free of Cost (Locally available Material)
4. Sand : Rs.28 per cubic feet

Cost Analysis for Mix 1

Cement used for 2500 blocks = 1155 kg

Cost of cement = Rs.6 per kg

Total cost of cement for 2500 blocks = 6 x 1155

= Rs.6930

Cost of soil = Nil

Sand used for 2500 blocks = 6930 kg

Cost of sand = Rs.0.62 paise per kg

Total cost of sand for 2500 blocks = 6930 x 0.62

= Rs.4300

For 0% laterite soil

Cost of 2500 blocks = 6930 + 4300

= Rs.11230

For 100% laterite soil

Cost of 2500 blocks = Rs.6930

Total Savings for 2500 Blocks = Rs.4300

Cost Analysis for Mix 2

Cement Cost = Rs.4850

Fly ash cost = RS.693

For 0% laterite soil = 4850+693+4300

= Rs.9843

For 100% laterite soil = 4850+693

= Rs.5543

Total Savings for 2500 Blocks = Rs.4300

CONCLUSION

Based on this experimental investigation, the following conclusions are drawn:

- Soil blocks made with cement and 100% laterite soil gives a compressive strength of 4.17 N/mm^2 which is greater than 2.96 N/mm^2. When 100% cement is used, Soil blocks made with 40% laterite soil gives the maximum compressive strength of 10.81 N/mm^2.
- Soil blocks made with cement, Fly ash and 100 % laterite soil gives a compressive strength for 6.10 N/mm^2 which also satisfies class 30 grade as per IS 1725-1982.When 30% fly ash is used with 70% cement, Soil blocks made with 20% laterite soil gives the maximum compressive strength of 10.69 N/mm^2.
- As per IS 1725-1982, average water absorption of blocks, after immersion in cold water for 24 hours, shall not be more than 15 per cent by weight. For the soil cement blocks produced with cement and different percentages of laterite soil, the water absorption is less than 15%.Also for the soil cement blocks produced with 70% cement ,30% fly ash and different percentages of laterite soil, the water absorption is less than 15%.
- Hence the soil cement blocks prepared using laterite soil can be recommended for construction of partition walls, load bearing walls, arches, and domes etc.

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Table 1. Chemical Composition of Mettur Fly ash

Parameters	**Content in %**	**Requirements as per IS 3812 - 2003**
SiO_2	64.11	SiO_2+ Al_2O_3+ Fe_2O_3=87%
Al_2O_3	18.58	
Fe_2O_3	4.32	Min 70.0
MgO	0.24	< 5%
CaO	1.21	-
K_2O	1.02	Na_2O + K_2O < 1.5%
Na_2O	0.21	
LOI	0.64	< 12%

Table 2. Chemical Composition of Laterite Soil

Parameter	**Content in %**
SiO_2	63.95%
Fe_2O_3	4.89%
Al_2O_3	11.25%
Na_2O	Traces
K_2O	Traces
CaO	Nil
MgO	Nil
LOI	14.58%

Figure.1 Cast Blocks

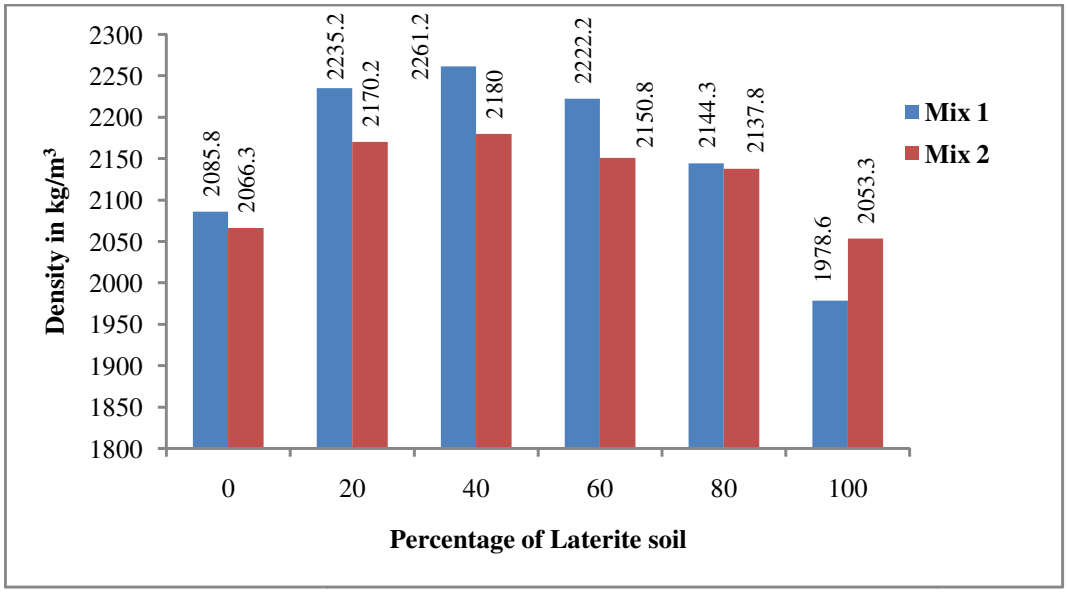

Figure.2 Density

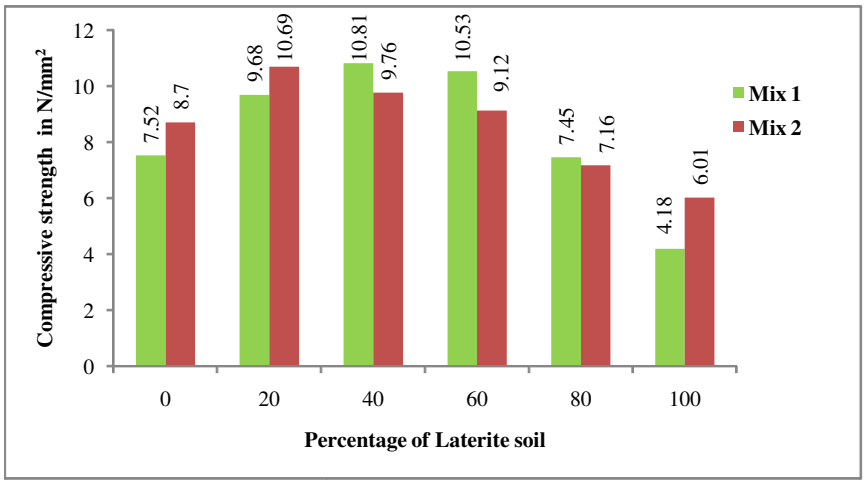

Figure.3 Compressive Strength

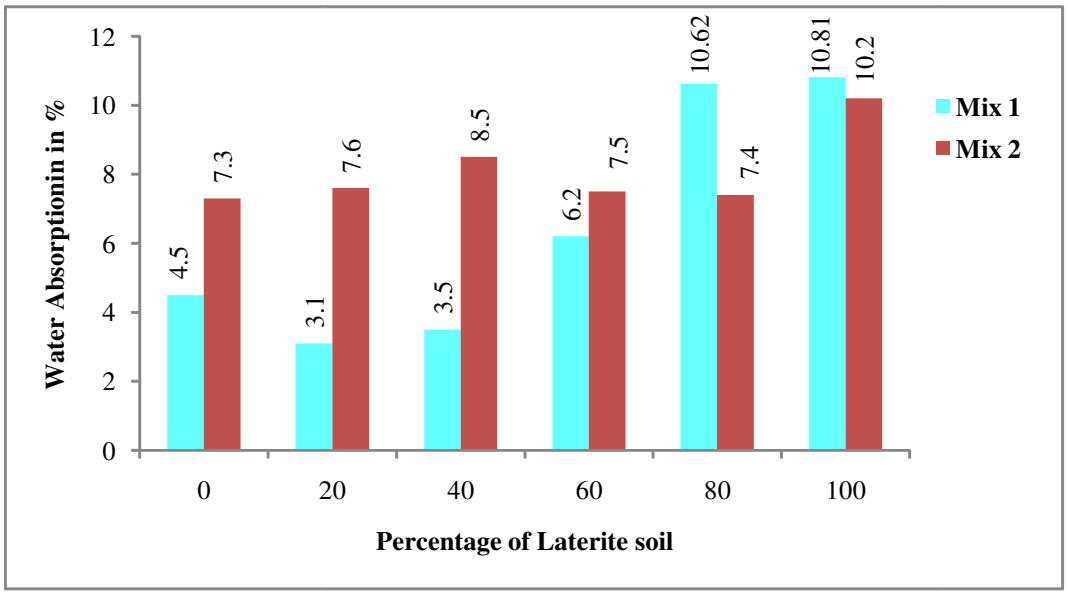

Figure.4 Water absorption