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SOIL CEMENT BLOCK: A REPLACEMENT FOR BRICK

Vasim S. Khan[1], Pruthvi S. Yadav[2], Priyanka V. Naranje[3]

[1]U.G.Student, Department of Civil Engineering, J.D.I.E.T., Yavatmal, Maharashtra, India, ***vasim032@gmail.com***

*[2]U.G.Student, Department of civil engineering, J.D.I.E.T., Yavatmal, Maharastra, India,****pruthviyadav3@gmail.com***

*[3]U.G.Student, Department of civil engineering, J.D.I.E.T., Yavatmal,Maharashtra,India,****priyankanaranje554@gmail.com***

Abstract

Red Earth is most commonly used as material in the building and road construction. Many a times, the red earth found in various quarries is found not suitable for construction. Cement of 4% and 8% of dry mass of red earth was added to improve its suitability as building block and structural pavement material. To know the influence of waste plastic fibre on cement stabilized red earth, 1% fiber was also added to the mixture. It is shown that the compressive strength of cement stabilized red earth block was improved with seven days of curing. The addition of cement to red earth enhanced soakedCBR value. The soaked CBR value of fibre reinforced cement stabilized red earth was about1.3 to 1.5 times that of unreinforced cement stabilized red earth.

Keywords:*red earth, cement, stabilized earth*

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INTRODUCTION

1.1 General

Red Earth also called Murrum / Moorum is formed in the tropics through the weathering process that favors the formation of iron, aluminum, manganese and titanium oxides. Iron and aluminum oxides are prominent in red earth, and with the seasonal fluctuation of the water table, these oxides result in the reddish-brown colour. Red Earth was found in the southern parts of India where this soft, moist soil was cut into blocks of brick size and then dried in the sun. The blocks became irreversibly hard by drying and were used as building bricks. Red Earths are widely distributed throughout the world in the regions with high rainfall, but especially in the intertropical regions of Africa, Australia, India, South-East Asia and South America, where they generally occur just below the surface of grasslands or forest clearings. Red earth is a low grade marginal material for road construction and has generally low bearing capacity and high water absorption value in comparison to conventional aggregates. Cement and lime treatment has become an accepted method for increasing the strength and durability of soils. Cement could be effectively used to stabilise red earth. Several researchers have reported that cement stabilized red earths can be used in road and building construction. Engineering properties such as compressive strength and CBR were markedly improved. It could be concluded that formation of reaction product such as Calcium Silicate Hydrate contributed to strength development of the cement stabilized earth. Moorum admixed with 3% ordinary portland cement (OPC) is preferable.

1.2 Needs & Advantages

- It is more economical in terms of energy required to increase the bearing capacity of soil.
- Soil cement stabilised blocks are much more water proofed; this prevents water from entering.
- It helps in reducing the volume change due to change in temperature or moisture content.
- Stabilization improves the workability and the durability of the soil cement blocks
- Massive housing programmes based on energy intensive materials such as bricks will lead to intolerable pressures on the energy resources such as wood and coal. Considerable amount of energy can be saved by using pressed soil cement block in place of burnt brick

2.1 MATERIALS USED

2.1.1 Soil (Red Earth)

The soil used in this investigation was collected from a borrow pit at a depth of 0.5 m to 1.0 m from Gollenapalli Quarry which was about 30 km to Vijayawada, Andhra Pradesh, India. The area was largely covered by red soils. The collected soil was a reddish brown soil with inclusions of white mottles and it was completely disintegrated into sandy granules from rocks existing at the site. People call it as Murrum or gravelly soil. They constitute mixture of weathered rock pieces in varying sizes, sand, silt and clays. The property of the soil was evaluated according to the ASTM standards and results were presented in Table 1. liquid limit, plastic limit, and plasticity index of the soil were evaluated as per ASTM D4318-10. The Soil was classified as SM as per Unified Soil Classification System.

Table 1 properties of soil

Properties of soil	Values
Gravel (%)	27.00
Coarse sand (%)	19.50
Medium sand (%)	33.82
Fine sand (%)	5.942
Fines (silt +clay) (%)	13.70
Liquid limit (%)	34.30
Plastic limit (%)	NP
Us classification of soil	SM
Maximum dry density (g/cc)	2.015
Optimum moisture content (%)	10.39
Soaked CBR value (%)	7.00

2.1.2 Cement

Cement used in the current study was commercially available ordinary Portland cement of 53 grade.

2.1.3 WASTE PLASTIC STRIPS

The waste plastic strips used in the present study were chopped from discarded packaging plastic threads. The length of the strips was about 6-12 mm and the diameter was of 3 mm. Plastic strips used in the present study are shown in Figure 1

Fig. 1 plastic strips used in the present study

2.2 Soil Preparation

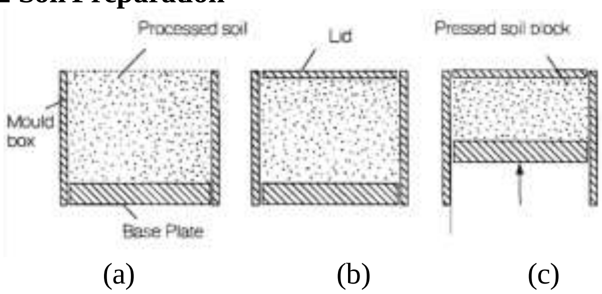

Figure2. The process of compaction for pressed soil block production: (a) mould filled with processed soil (b) compaction at top due to lid closure (c) compaction at bottom due to piston stroke

Soil is sieved through 5mm sieve in order to remove bigger day lumps, gravel etc. Sieved soil is spread into a thin layer on level ground and then the cement is spread on top and mixed thoroughly using a spade. Now water is sprinkled on the dry soil cement mixture and mixed manually, such that the water gets dispersed uniformly. The wetted soil-cement mixture is pressed into a block using the machine. Soil preparation has to be carried out in batches such that the wetted soil-cement mixture should be converted into blocks within 40 minutes. This is mainly to avoid setting of the cement before pressing into a block

3. TESTS CONDUCTED

The modified proctor compaction tests were conducted on soil (red earth) with and without adding cement of 4% and 8% of dry mass of soil. Compaction tests were also conducted on 1.0% of waste plastic fiber reinforced soil-cement mixes. Cement treated soil blocks, cured for seven days, were tested to evaluate compressive strength. One sample was made for conducting each test. Soaked CBR tests were conducted on soil and soil added with 4 and 8% cement. Soaked CBR tests were also conducted on 1.0% of waste plastic fiber reinforced soil-cement mixes.

3.1 Compaction Test

Compaction tests were conducted on red earth and red earth mixed with 4% and 8% cement respectively. Compaction tests were conducted according to the procedure laid in ASTM.

According to ASTM,

This test method covers laboratory compaction method used to determine the relationship between molding water content and dry unit weight of soils (compaction curve) compacted in a 4 or 6 in. (101.6 or 152.4 mm) diameter mold with a 10.00 lbf. (44.48 N) rammer dropped from a height of 18.00 in. (457.2 mm) producing compactive effort of 56000 Ft-lbf/ft^3 (2700 kN-m/m^3).

3.2 Compressive Strength Test

The soil samples were sieved through the 20 mm sieve and mixed with cement 4% and 8%, respectively, using omc previously determined. The mixture was placed into the block mould of size 150 mm × 150 mm × 150 mm and compacted with 62 blows, with 3 layers each, to ensure the desired MDD. One sample was made for conducting each test. The stabilized red earth blocks were placed in moist gunny bags for curing (fig. 3). The curing time considered was of seven days. After seven days of curing, the blocks were tested in the universal testing machine (fig. 4), to evaluate compressive strength.

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Fig. 3. Curing of cement stabilized soil blocks

Fig. 4. Compressive strength test on cement Stabilized Soil Blocks

3.3 Soaked CBR Test

California bearing ratio is term described as force per unit area required to penetrate into a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min Soaked CBR tests were conducted on red earth and red earth added with 4% and 8% cement. CBR tests were conducted according to the procedure laid in ASTM. Cement-modified soil mixes should be designed on the basis of their soaked CBR values. For design purposes, the CBR field should be regarded only as 45% to 60% of that obtained in the laboratory, depending upon the efficiency of mixing, placing, curing and other related factors.

Fig 5Testing of CBR specimen

4. RESULTS

4.1. Compaction Test

Compaction curves are shown in Figure 5. Compaction characteristics, namely Maximum Dry Density (MDD) and the Optimum Moisture Content (OMC) were observed from compaction curves and were presented in table 2. The addition of cement to red earth led to increase in the MDD and OMC. The increase of the MDD may be attributed to more densely packing. Another explanation could be that since cement with a specific gravity of 3.15 was added to the red earth of specific gravity of 2.58, a resulting mixture with a higher specific gravity emerged, which in turn gave rise to an increase of the MDD of the entire mixture. The increase of the OMC with the increase of the quantity of cement could possibly be due to the increase of the surface needing to be coated as the quantity of cement increases, which makes the mix require more water for the hydration of cement. Compaction tests were also conducted on cement stabilized soils reinforced with 1% fibre. The addition of 1% fibre reduced MDD and increases OMC of soil-cement mixes.

Table 2 Compaction characteristics

Mix	MDD(g/cc)	OMC(%)
Soil + 0% cement	2.015	10.39
Soil + 4% cement	2.035	11.07
Soil + 8%cement	2.102	11.10
Soil + 4% cement + 1% fibre	2.024	11.71
Soil + 8% cement + 1% fibre	2.022	13.52

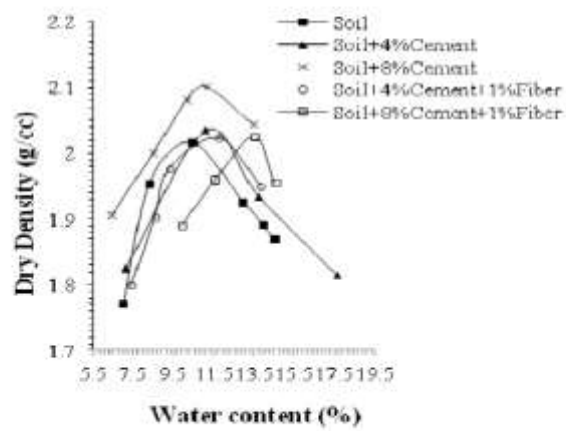

Fig 6. Compaction curves for Soil, Soil-Cement Mixes and fibre reinforced Soil-Cement mixes

4.2 Compressive Strength Test

Compressive strength values of cement treated red earth cured for seven days are presented in table 3 and plotted in figure 6. Curing enhances the strength of cement stabilized soil due to pozzolanic reaction, resulting in formation of C-S-H gel. 8% cement stabilized red earth, cured for seven days, can be used as structural building block for construction of two story building as it possess more compressive strength. Block made of soil added with 8% cement cured for seven days has shown water absorption of 2.66% and it was less than allowable water absorption of 20% prescribed by Indian Standard IS:1077. Water absorption tests were conducted in accordance with the procedure specified by a regression model was developed to assess the seven-day compressive strength (f) of cement stabilized red earth, in terms of %Cement (C)

$$F = -0.0572C^2 + 1.0113C + 0.07$$

Coefficient of determination, $R^2 = 1$

Table 3 Compressive Strength values

Mix	Seven day compressive strength (MPa)
Soil	0.072
Soil + 4% cement	3.2
Soil + 8% cement	4.5

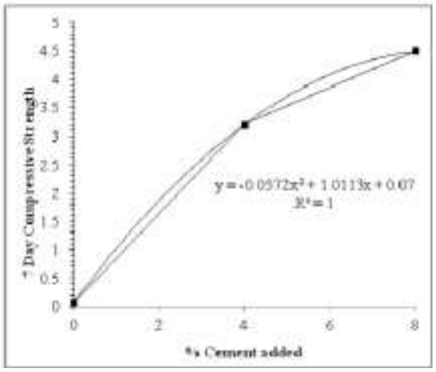

Fig. 7. Compressive strength of Red Earth with Addition of Cement

4.3 Soaked CBR Test

The values obtained from soaked CBR test are tabulated in table 4 The addition of 1% waste plastic fibre strips to soil + 4% cement mix resulted in a soaked CBR value of 127%. The addition of 1% waste plastic fibre strips to soil + 8% cement mix gave a soaked CBR value of 344%. It was observed that the high degree of enhancement in the soaked CBR value was achieved with addition of waste plastic fibre. The soaked CBR value of fibre reinforced cement stabilized soils was about 1.3 to 1.5 times that of unreinforced cement stabilized soils.

Table 4 Soaked CBR values

Mix	Soaked CBR value (%)
Soil	8.6
Soil + 4% cement	64.4
Soil + 8% cement	270.2

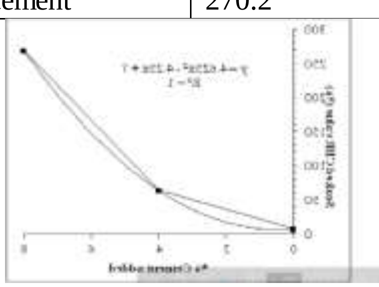

Fig. 8 Soaked CBR values of Red Earth with addition of Cement

From this, it can be concluded that the 1% fibre reinforced cement stabilized red earth can be used as structural pavement layers such as sub-base and base. Cement stabilized red earth is a more economical material as compared to graded aggregates for construction of sub-base and base of low volume rural roads. The variation of soaked CBR value, with addition of cement, is shown in figure 7. A regression model was developed to estimate the soaked CBR value (CBRS) of cement stabilized red earth in terms of % cement (C)

$$CBRS = 4.625C^2 - 4.25C + 7$$

Coefficient of determination, $R^2 = 1$

In order to study the effect of waste plastic fibre on soil-cement mixes, 1% of waste plastic fibre was added to red earth-cement mixes. The addition of 1% waste plastic fibre strips to soil + 4% cement mix resulted in a soaked CBR value of 127%. The addition of 1% waste plastic fibre strips to soil + 8% cement mix gave a soaked CBR value of 344%. It was observed that the high degree of enhancement in the soaked CBR value was achieved with addition of waste plastic fibre. The soaked CBR value of fibre reinforced cement stabilized soils was about 1.3 to 1.5 times that of unreinforced cement stabilized soils. From this, it can be concluded that the 1% fibre reinforced cement stabilized red earth can be used as structural pavement layers such as sub-base and base.

5. CONCLUSIONS

The following conclusions were drawn based on the present study:

1. Blocks made of red earth mixed with 8% cement cured for seven days can be used as building blocks for two story structures. The block made of red earth added with 8% cement has shown water absorption of 2.66%
2. The soaked CBR strength of red earth increased from 7% to 64% with the addition of 4% cement and to 269% with the addition of 8% cement. Thus, the stabilized red earth can be promoted not only from subgrade to subbase, but also to base course in pavements.
3. The soaked CBR value of 1% fibre reinforced cement stabilized soils was about 1.3 to 1.5 times that of unreinforced cement stabilized soils. The addition of waste plastic fibre phenomenally increases CBR value

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