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Sustainable Earth Block Using Phosphogypsum

Anju EC[1], Aswathy MR[2], Chaithra J Sing[3], Dhanya Daniel[4], Anniamma Chacko[5]

[1 2 3 4] Under Graduate Students,[5]Professor,[1 2 3 4 5] Mar Athanasius College Of Engineering, Kothamangalam, India

Abstract: **Sustainability is a wide growing concept in the present scenario. As the cost of the construction industries is rocketing up along with the deterioration of the environment, construction techniques which are eco-friendly and economic are started to be practiced. Cutting down the amount of cement could reduce both the cost as well as the pollution. It is tried to introduce this concept into blocks, specifically earth block using phosphogypsum. Phosphogypsum refers to the gypsum formed as a by-product of processing phosphate ore into fertilizer with sulphuric acid. In its natural state phosphogypsum is radioactive due to the presence of naturally occurring uranium and radium. By the long term exposure to atmosphere, the radioactivity of phosphogypsum can be gradually reduced. In this work, four different combinations of cement and phosphogypsum were used in stabilizing blocks. The percentage addition of stabiliser to earth block is limited to about 15-18%. It is observed that the combination of cement and phosphogypsum is more effective than using cement alone in making earth blocks.**

Keywords: **Sustainability, Phosphogypsum, Stabilisation.**

I. INTRODUCTION

Provision of housing is one of the most important basic needs for humans. In order to reduce the cost of construction various traditional construction materials have proved to be suitable and would have a great potential use in future. One such material is compressed stabilized earth block.To extend the use of compressed stabilized earth building blocks to all types of housing, production techniques need to be further improved so as to achieve better quality and reduce production costs. Good quality compressed stabilized earth block improve hygiene,reduce maintenance and repair costs and, in general, prolong the life span of the building.Ordinary earth blocks uses cement as the only stabilizer. Since the cement has become more expensive, the need for an alternative has become a growing demand. This work aims to reduce the cement content and replacing it with a waste product from the manufacture of phosphoric acid viz. phosphogypsum.

II. MATERIALS AND METHODS

A. SAMPLE COLLECTION:

Material used for making stabilised Earth Blocks such as laterite soil,cement ,phosphogypsum was collected.

B. MATERIAL TESTING:

Various tests were conducted on the different materials, so as to obtain the required proportion of the materials to be used for making stabilized earth block.

Soil sample was taken from the site at Ernakulam district and its geotechnical properties were tested.The geotechnical properties are tabulated in TABLE I.

TABLE I: Geotechnical properties of soil

Effective size(mm)	0.12
Uniformity coefficient	12.5
Coefficient of curvature	0.8
Gravel(%)	16
Sand(%)	83
Silt and clay(%)	1

Liquid limit(%)	41
Plastic limit(%)	25
Flow index	24
Optimum moisture content(%)	16.8
Maximum dry density(g/cc)	1.78

The cement used for earth blocks may be portland pozzolano cement, portland slag cement, pozzolona slag cement etc.It has been found that cement is not only used for binding for materials, it also helps in stabilizing the soil to a great extent. The range of cement content needed for good stabilization is between 3% and 18% by weight according to soil type. Cement used for making the block is portland pozzolano cement(PPC).

Phosphogypsum is the phosphate fertilizer industry solid waste, and phosphoric acid is the foundation of phosphate fertilizer industry,FACT,Ambalamukal. The particle diameter is generally 5 to 150 micrometers, the main ingredient is CaSO4.2H2O of 70 to 90%. Phosphogypsum has a general appearance of a gray, light yellow,light green, and other colors, the specific gravity is 2.22 - 2.37, the density is 0.733 - 0.880 g/cm3 The binding property of the material makes it useful for the stabilzation. The stabilizer used in the project is finer than 600 micron. Since it exhibits properties of gypsum, the setting time for the block is reduced.

Some of the tests that was conducted on cement as well as phosphogypsum are fineness test and consistency test. The above mentioned tests were conducted after mixing the cement and phosphogypsum together in various proportions, which is shown in the TABLE II. 15% of the total soil used, is replaced by cement. The cement is again replaced by phosphogypsum as 0%, 5%,10%,15%. Fineness of cement and phosphogypsum is tabulated in TABLE III.Consistency limits of cement and phosphogypsum in various proportions is tabulated in TABLE IV.

TABLE II: Mixing Proportions

Sl. No:	Cement (%)	Phosphogypsum (%)
1	15	0
2	10	5
3	5	10
4	0	15

TABLE III: Fineness of cement and phosphogypsum

Fineness of cement	6.5
Fineness of phosphogypsum	2.25

TABLE IV:Consistency limits for various proportions of cement and phosphogypsum

Cement (%)	**Phosphogypsum(%)**	**Consistency(%)**
15	**0**	**35**
10	**5**	**31.75**
5	**10**	**27.5**
0	**15**	**25.75**

C. BLOCK PREPRATION:

On the basis of geotechnical properties of soil,properties of cement and phosphogypsum, bricks were made in a better way. There are mainly three steps for obtaining the final product. The various steps adopted for preparation of blocks are:

1. Soil Prepration:

On digging the soil, it may be wet or it may be dry. The dry soil is easier to prepare and work with. If the soil obtained is wet, it should be dried out in sun till the moisturecontent is fully gone. This dry soil should be crushed using tools like punners or hammer-hoes. The soil is then passed through a sieve or screen. The sieve should have a mesh size of 12 mm. All stones bigger than this should be put aside, as they will cause cracking if they get into a block. If soil has too much clay, it might be mixed with sand to get the right proportions for stabilizing. Once the soil is crushed and sieved it will

need to be mixed with the stabilizer. Mixing should be done with the soil and the stabilizer both dry. It is probably accurate to measure quantities by mass. Mix the soil and stabilizer (i.e. cement and phosphogypsum) together very well. The best way to identify that enough mixing is done is when the mix is all the same colour. Mix with the amount of water that is needed slowly a little at a time. Sprinkle the water over the top of the mix with a watering can. Mix well, turning the mix over several times. Hand mixing with shovels is done as this is most efficient, satisfactory and cheap method

2. Block Pressing:

There are two types of presses. The first is called a "constant pressure press". The second type of machine is called a "constant volume" press. The mechanical press used in this project is constant volume press which makes 10 blocks each of size 30x20x10cm at a single press. It requires only a single man to operate the machine and by applying the press, the blocks of correct dimensions will be produced. The soil is loaded, pressed and finally extracted from the machine.

3. Block Curing:

The blocks were cured in the same place where it was casted. Block need to be cured in the shade in a clean and flat area The blocks can be stacked together after 24 hours, still in the shade. They should not be stacked tightly together or too high or the bottom layers will start to crack. Perhaps blocks should be stacked no more than 5 high until they are fully cured. Spaces should be left for air to pass between the stacked blocks.

The blocks are still not fully cured. They are still setting and growing stronger. Blocks stabilized with PPC should not be sold or used for at least 28 days after they are made. At this time the block should have about 75 % (3/4) of its final strength. The blocks should keep growing stronger for more than a year. Good curing is very important. Blocks that are not cured properly will tend to crack and be weak. It is a good idea to leave a few blocks to dry in the sun and not wet them. These sundried blocks will probably crack badly and perhaps not harden at all. If these blocks are tested with others from the same day that has been cured properly there should be a big difference in their strength.

Size of block = 30cm x 20cm x 10cm

Volume of the block = 0.006 m^3

Soil required for ten blocks = 0.0006 m^3

Cost of soil = 700 Rs./ m^3

Cost of soil for ten blocks = Rs.4

D. BLOCK TESTING:

Cured blocks were carried to the laboratory for testing whether it confirms to Indian Standards. The tests carried out are: Dry compressive strength and Water absorption. If these test are satisfied then the block will be of good quality.Water absorption and Dry compressive strength test results are tabulated in TABLE V and VI respectively.

TABLE V: Water absorption for various proportions of cement and phosphogypsum

Sl. No:	Cement (%)	Phosphogypsum (%)	PG + Cement (%)	Water absorption (%)
1	15	0	15	8.53
2	10	5	15	10.81
3	5	10	15	18.55
4	0	15	15	18.21

TABLE VI:Compressive strength for various proportions of cement and phosphogypsum

Sl. No:	Cement (%)	Phosphogypsum(%)	PG + Cement (%)	Compressive strength(N/mm^2)
1	15	0	15	1.07
2	10	5	15	2.5
3	5	10	15	1.34
4	0	15	15	0.67

Note: The total percentage of PG and Cement is limited to 15%

For burnt clay brick of size (30x 20 x 10cm^3)

Compressive strength = 3.79 N/mm^2

Water absorption = 21.92 %

Total cost of production for a volume equal to 6000cm3 is greater than Rs 28

III. CONCLUSION

The aim of the work was to introduce phosphogypsum along with cement in compressed stabilized earth blocks. Four different combinations of stabilisers were made and the properties of the blocks were tested as per Indian Standards. It was observed that, phosphogypsum alone cannot stabilize the block effectively. When phosphogypsum is added in a small ratio (5%) along with cement (10%), the compressive strength of block is more than that of the brick with cement alone. The cost of production of unit volume of earth brick is very less than ordinary clay burnt brick (Rs.17 for earth block but Rs 28 for clay burnt brick each of volume 30x20x10 cm). Water absorption of earth and phosphogypsum bricks (5%PG &10%C)are less than 15% as specified for higher class bricks as per IS 1725:1982. 5%PG and 10%C brick belongs to Class A(2-3N/mm^2), 15%C and 5%C, 10%PG belongs to Class B(1-2 N/mm^2).

Thus from the above results, it can be concluded that the earth block with 5% phosphogypsum and 10% cement has comparable compressive strength, low cost, durable and also is eco-friendly than the ordinary clay brick.

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