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Sorption characteristics of stabilised soil blocks embedded with waste plastic fibres

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HIGHLIGHTS

- Disintegration of raw specimens during Water absorption test clearly suggest the essentiality of Cement stabilisation.
- Static compaction with Cement stabilisation reduces Water absorption.
- 10–15% Cement stabilisation reduce the Water absorption to fall within the BIS specifications.
- The Sorptivity values varied from 0.984 to 0.304 mm/$\sqrt{}$min, for different combinations of stabilisers and fibres.
- The combination of mechanical and chemical stabilisation has resulted in a reduction in Sorptivity.

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ABSTRACT

This paper highlights the results of an experimental investigation, on the Sorption Characteristics of plastic fibre reinforced soil, done to study the possibility of utilisation of waste plastics in soil masonry blocks. Cylindrical specimen of raw soil and modified soil were prepared by compacting at different moulding pressures and were tested for sorption characteristics. Raw soil is modified by adding varying percentage of stabiliser (Cement: 5%, 10% and 15%), fibre types (made out of mineral water bottles and carry bags), fibre lengths (1 cm and 2 cm) and fibre percentages (0.1% and 0.2%). The sorption characteristics of mud blocks have been studied by measuring Water absorption and Sorptivity. Water absorption of samples with 10 - 15% Cement stabilisation was less than the value specified by IS 1725-1982. The combination of mechanical and chemical stabilization without fiber addition has resulted in a reduction in sorptivity. But fiber addition increased the sorptivity.

1. Introduction

Water resistance characteristics can be studied by measuring Water absorption after complete immersion in water [1–7] or by measuring the height of water penetration by capillary [8]. Water absorption is a function of clay and Cement content and usually related with the strength and durability of earth bricks and therefore it is important to determine the rate of Water absorption of earth bricks [5]. It is also a function of compaction pressure and methods [2,8]. Raw specimen disintegrated during Water absorption test, clearly suggesting the necessity of Cement stabilisation, if the blocks were meant for exterior use without protection. Fibres have been used in earthen construction with and without stabilisation to reduce shrinkage cracking, to improve tensile strength, durability and improved ductility in tension [6,9,10]. In the case of fibre reinforced mud blocks, the moisture movement behaviour becomes more complex as it contains randomly oriented plastic fibres. This paper deals with the investigation of the sorption related properties of soil specimens as influenced by the Moulding pressure, Cement content, type, length and quantity of fibres. Results of Water absorption by complete immersion and Sorptivity by capillarity for various specimens with different levels of parameters were analysed.

2. Materials and methods

2.1. Materials

Standard classification tests were carried out, on the soil collected for block making and a summary of the test results are given in Table 1 and the grain size distribution curve is given in Fig. 1.

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Table 1
Physical properties of the soil used.

Sl. no.	Property	Value
1	Specific gravity	2.68
2	Grain size distribution	
	(a) Clay (<0.002 mm)	6%
	(b) Silt (0.002–0.075 mm)	42%
	(c) Sand (0.075–4.75 mm)	52%
3	Standard proctor test results	
	(a) Optimum moisture content	14%
	(b) Maximum dry density	1.84 g/cc

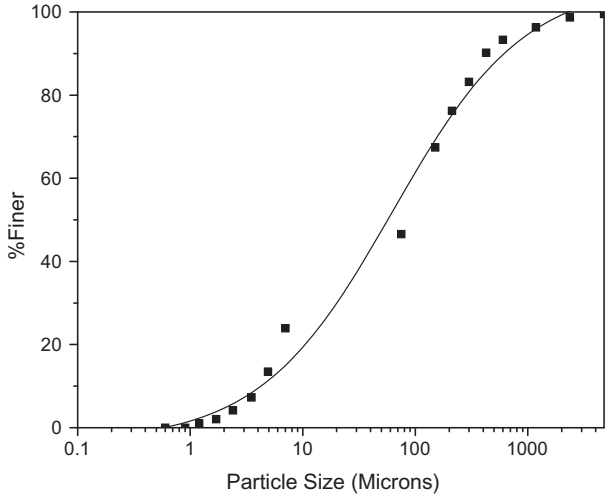

Fig. 1. Grain size distribution curve for the soil.

Table 2
Properties of Cement used.

Sl. no.	Properties tested	Values	BIS specifications (BIS 8112-1989)
1	Normal consistency	32%	–
2	Initial setting time	42 min	Not less than 30 min
	Final setting time	123 min	Not more than 600 min
3	Compressive strength, 3 days	25 MPa	Not less than 23 MPa
	Compressive strength, 7 days	36 MPa	Not less than 33 MPa
	Compressive strength, 28 days	49 MPa	Not less than 43 MPa

The approach was to compare the properties and performance of two categories of samples, namely base samples and modified samples. Modified samples are different from base samples in their composition like the presence and type of fibres, the type of additives, the Moulding pressure and the curing of samples. Ordinary Portland Cement (OPC, 43 grade) at different dosages has been used as the chemical stabiliser. In some of the earlier studies [1,3,8], Cement content as stabiliser in soil blocks was varied from 5% to 20%. Also, sandy soils are best suited for Cement stabilised mud blocks [3]. But, an over dosage of the stabiliser may hinder the viability of the work as it will tell upon the cost. These facts guided us to stick on to the Cement addition of a minimum of 5% to a maximum of 15% for the type of the locally available soil which has the relevant Engineering properties highlighted in the paper. The properties of the Cement used are given in Table 2 and compared with the specifications given in BIS 8112-1989 [11]. Two types of fibres were used, the one made out of PET bottles and the other from carry bags (pick up bags) as shown in Fig. 2, henceforth referred to as 'Bottle fibres' and 'Kit fibres' respectively. Fibres are made out of these plastic wastes by chopping them into small length with almost the same minimal width of 2–3 mm. A pilot study on soils blocks with different length and quantity of fibres of both types have shown that when fibre length is more than 2 cm and the quantity is more than 0.2%, engineering performance of the soil blocks using fibres gets adversely affected. Based on this, the lengths of the fibres used for the investigation were of 1 cm and 2 cm and fibre content was taken as 0.1% and 0.2% by weight of the dry soil used. Moulding (compaction) pressure was controlled by a digital Compression testing machine, having a capacity of 1000 kN and least count 100 N. Experiments were carried out for a Moulding pressure of 1.25–7.5 MPa at 1.25 MPa intervals.

2.2. Mixing, Moulding and curing

Various mixing procedures that are given in literature are reviewed [1,8,12–14]. Prior to the mixing, the natural soil constituents for block production were prepared by initially air drying, lumps of dried soil were broken down manually and sieving was done to remove particles exceeding 4.75 mm. To achieve uniformity, materials were carefully weight batched into the tray prior to compaction. In the case of stabilised soil, a homogeneous mixture was obtained by blending the required amount of Cement with the dry soil in a tray before adding water and further mixing. Then required water was added to the uniform mixture of soil, soil–Cement, or soil–Cement–fibre as the case may be, to attain the optimum water content (OMC = 14 percentage by weight of soil/soil–Cement mixture). Same water content was used for all the block compositions (with and without Cement and fibre). During the mixing process, the fibres were added by hand in stages, to achieve a homogeneous soil–Cement–fibre matrix. Mixing was continued to get a uniform distribution of fibres throughout the above matrix, without aggregation of the fibres, which will result in the congestion and conglomeration of the matrix.

Cylindrical samples were prepared by filling the soil at stages, in a mould of internal diameter of 101.5 mm and a height of 117 mm with the collar of height 50 mm on its top (Fig. 3). Soil requirement for each sample at a given Moulding pressure was arrived by trial and error. To achieve uniformity, materials were carefully weight batched into the mould prior to compaction. Required soil was filled in layers to the mould with the collar, applying conventional tamping. Then the soil in the mould was compressed to the required Moulding pressure by using a Compression testing machine. Then the collar was removed and the excess soil was trimmed to make it level with the top of the mould. After compaction, the specimens were extruded from the mould and stacked for curing. Cement stabilised specimens were moist cured under Jute bags for 28 days before the preparation for testing (Fig. 4). The unstabilised specimens were air dried in the laboratory, until testing.

Summary of the input variables used in the experimental investigation is shown in Table 3.

2.3. Testing for Sorption Characteristics

2.3.1. Water absorption

Water absorption test is based on BIS 1725, 1982 (Reaffirmed in 2002) [15] and tested in accordance with BIS 3495, 1992: the code for the test on burned clay bricks [16]. The specimens were wetted in cold water for 24 h and its weight was

(a) Carry bags ('Kit fibre') **(b) PET bottles ('Bottle fibre')**

Fig. 2. Type of fibres.