Paper ID: MS-32

Evaluation of Stabilized Soil Blocks with the inclusion of 'Plastic Fibre' as Sustainable Building Material: A Complete Review

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Abstract

Now-a-days, huge amount of waste plastics is one of the major and important environmental hazards in Solid Waste Management (SWM) sector. So an efficient and effluent use or management is necessary to recycle these jungles of waste plastics. Through a fundamental research, use of these waste plastics in the specific form of fibres in making block may prove more efficient and undoubtedly a great feedback to Solid Waste Management. The significant effects of Plastic Fibre (which is embedded from waste plastic) on stabilized mud blocks as well as performance effect as a sustainable building material is highlighted and reviewed in this research paper through a systematic investigation process. By adding Portland cement, Lime and their combination was used for preparing stabilized soil. Plastic carry bags (locally known as plastic bazar bags), plastic juice bottles and mineral water bottles in chopped form were the major source of Plastic Fibre. These fibres were added 0.1% & 0.2% by weight of soil as reinforcement. The blocks mix compositions are different in percentage of cement and percentage of lime with different percentage (0.1% by weight of soil & 0.2% by weight of soil) of plastic fibres. The failure patterns of the blocks were analyzed along with tested for density as well as compressive strength in MPa. From investigation it was found that, strength increases about 3% to 10% for different cement and lime percentage for blocks prepared with 0.1% of plastic fibres. From failure pattern observation it was also visible that, uses of fibres reinforcement improve ductility which was compared with raw blocks.

Keywords: *Sustainable building materials, Solid waste management, Plastic fibres, Stabilized blocks, Density, Compressive strength, Ductility.*

1. Introduction

Earth in the form of mud bricks has been used as the construction material for thousands of years. To improve physical characteristics of compressed soil masonry blocks, moist soil is mechanically compacted. But the key problems arise from the materials, in the presence of water or moisture is low tensile strength with brittle behavior and deterioration. Stabilization with renowned binders like cement or lime can improve the water resisting capacity as well as strength. From H. Binici *et al.* (2007) and A. Mesbah *et al.* (2004) it is clear that, to improve tensile strength, durability and ductility in tension and to reduce shrinkage cracking, natural fibres have been used from long days ago. Theoretical models were also developed on composite soil blocks reinforced with fibres subjected to shear.

The enormous amount of waste plastics is one of the major environmental concerns for recent decades as a part of solid waste management. In mud block making uses of waste plastics in the form of fibres which may term as 'Plastic Fibre-Mud Blocks' is one of the interesting and efficient methods of solid waste management. The efficiency and contribution of this type of solid waste management can be investigated through a fundamental research. Maximum studies on natural fibres are concentrated on cellulose based or vegetable fibres, which may obtain from renewable plant resources and it is evident from the review of the existing literature. But in case of animal fibre, and plastic fibre as well as polystyrene fabric this resource is not valid at all. That's why, to make plastic fibre mud blocks appealing to all and applicable widely, some research on the physic-mechanical properties and characteristics is indispensible. From the preliminary investigation of some systematic study, this paper highlights and represents the key observations on the effect of embedded fibre (the source is plastic waste) on the strength performance of stabilized mud blocks corresponding to different amount of plastic fibre.

2. Key Materials and Experimental Approach

The soil which is being collected for making blocks was carried through standard soil classification. The basic summaries is shown in Table 1

Table 1. Summary of Standard Soil Classification

Sand (%)	Silt (%)	Clay (%)	Specific Gravity	Optimum Moisture Content (%)	Dry Density (g/cc)
58.5	37.5	4.00	2.63	17.5	1.83

Soil was stabilized by combination of cement-lime. The quantity of cement and lime added was 8% & 10% and after several trials 2% & 4% by weight of soil respectively. Similar observations regarding the quantity of stabilizers (7.5% of cement and 2% lime) were made by Jagadeesh, 2007 at *'Building with Stabilised Mud'*. Basically it relies on the type and nature of soil. During making of block, plastic fibre of length 20 mm were added with mixture of 0.1% & 0.2% by weight of soil. The plastic fibre was in chopped form of carry bags having aspect ratio 125 and mineral water bottles having aspect ratio 84. Figure 1 show some chopped plastic fibres which wasn't the actual picture of the experiment but supplied with this paper to identify the types and format of the chopped plastic fibre. Seven types of sample were prepared where one is control block containing only raw soil. The remaining six types of samples were raw soil with 8% cement, raw soil with 8% cement and 2% lime, raw soil with 8% cement and 4% lime, raw soil with 10% cement, raw soil with 10% cement and 2% lime, raw soil with 10% cement and 4% lime respectively, having blocks size 305mm x 143mm x 100mm. These mixture combinations are shown in tabular form in Table 2.

By pressing the prepared soil at OMC, blocks were made and straw as well as gunny bag were used to cover the block stack during curing period. Sprinkling of water on these covers consists the curing. After 3, 7 and 28 days the prepared blocks were tested for compressive strength by using a digital compression testing machine with lowest count of 20 N which ranges up to 1000 kN. In the end, dry density fluctuations and effect on compressive strength were analyzed and finally from the deep observation of failure pattern of the sample blocks the benefits of fibre reinforcement in ductility and crack propagation properties were evaluated.

Fig. 1. Chopped Plastic Fibre

Table 2. Composition of the Blocks

Composition of the Mix	Dimension (mm) L x B x H	Sample Labeling
Raw Soil (Control Block)	305 x 143 x 100	C
Raw Soil with 8% Cement	305 x 143 x 100	C1
Raw Soil with 8% Cement and 2% Lime	305 x 143 x 100	C2
Raw Soil with 8% Cement and 4% Lime	305 x 143 x 100	C3
Raw Soil with 10% Cement	305 x 143 x 100	C4

Raw Soil with 10% Cement and 2% Lime	305 x 143 x 100	C5
Raw Soil with 10% Cement and 4% Lime	305 x 143 x 100	C6

3. Results and Discussions

3.1 Effects on Density and Specific Gravity

There is a significant effect on density and specific gravity for different mixing proportions. From experiment it is visible that, the density of the soil blocks with different mixing compositions varied from 1800 kg/m^3 to 1898 kg/m^3. Effects of different mix composition with (0.1% by weight of soil & 0.2% by weight of soil) or without plastic fibre, on density is shown in Table 3 in the form of test result. It is also proved from experiment that adding of plastic fibre doesn't create a radical change in density and in almost each cases density falls slightly after adding 0.1% fibre and density falls remarkably after adding 0.2% fibre. It is clearly shown in Figure 2. Most important thing to mention that, the specific gravity of the fibres fluctuates within 1.07 to 1.1.

Table 3. Density (Kg/m^3) for Different Composition

Sample No.	**0% Fibre**	**0.1% Fibre**	**0.2% Fibre**
	Kg/m^3	Kg/m^3	Kg/m^3
C	1889	1825	1800
C1	1892	1888	1841
C2	1883	1854	1829
C3	1855	1847	1831
C4	1898	1882	1834
C5	1885	1865	1823
C6	1866	1860	1822

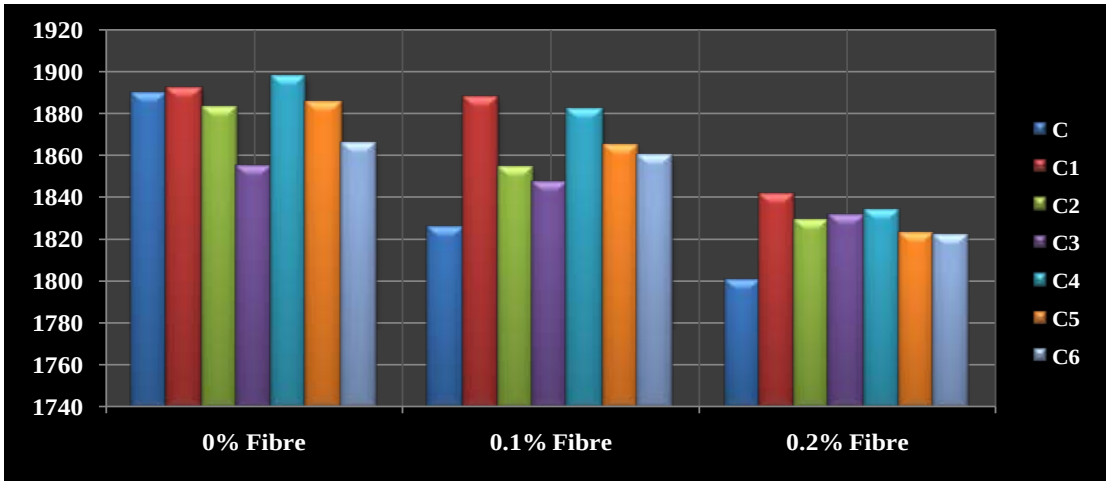

Fig. 2. Fluctuation of Density for Different Composition

3.2 Effects on Compressive Strength

At 28 days curing the compressive strength of the blocks fluctuated from 2.00 to 4.29 MPa depending on different composition of mix and percentage of plastic fibre. If control blocks (C) and blocks stabilized with 8% cement content (C1) compared, it is evident that strength increases approximately 8.5%. Moreover, 29.5% strength increases in case of comparing between control blocks (C) and blocks consists of 10% cement (C4). Again compared to block with 10% cement (C4) there was an increase of 5.6% and approximately 18% in strength when this soil block was stabilized by 2% (C5) and 4% of lime (C6) respectively. The stabilized treated mud blocks exhibits strength values ranges from 2.71 MPa to 4.14 MPa which contains 0% plastic fibre and these may compared with the well burnt brick's compressive strength of 3.5 MPa as per BIS 1077-1992 (Fifth Revision). It is notable that, for all mixing compositions the blocks with 0.2% of plastic fibre the compressive strength were reduced but it was positive for 0.1% plastic fibre. Almost in every case compressive strength was increases significantly for the blocks with 0.1% plastic fibre. Large quantity of fibres distributed non-uniformly

in the blocks and creating weaker plane, which may leads to reduction in strength. The strength in MPa are shown in Table 4 with sample number and Figure 3 shows the fluctuation of strength pattern with respect to different mixing composition for with (0.1% and 0.2%) and without plastic fibre.

Table 4. Strength (MPa) for Different Composition

Sample No.	0% Fibre	0.1% Fibre	0.2% Fibre
	MPa	MPa	MPa
C	2.71	2.90	2.00
C1	2.94	3.36	3.00
C2	3.49	3.95	3.14
C3	2.95	3.60	3.02
C4	3.51	3.99	3.26
C5	3.71	3.97	2.85
C6	4.14	4.29	3.78

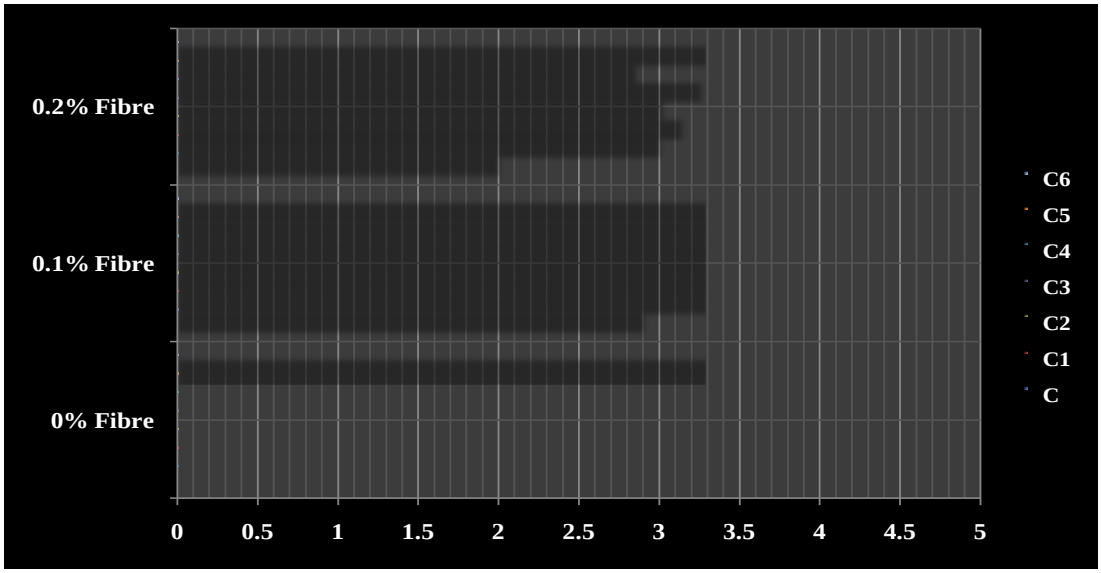

Fig. 3. Fluctuation of Strength for Different Composition

From this experiment and from S.M. Marandi et al. (2008) and C. Galan-Marin et al. (2010) it can be said that during fibre sliding, cement stabilized soil blocks provide some resistance and this leads to the increase in compressive strength at all.

3.3 Effects on Failure Mode and Crack Propagation

The control blocks which contains only raw soil, exhibits an abrupt failure without introducing any symptoms or warning and the mode is quick. On the contrary, the blocks with fibres were quite different in nature from control blocks and these specimens still deformed after the ultimate load was reached and finally crack was observed on the specimen. But these specimens showed fine irregular and distinguishable crack on its surface as like as raw soil control blocks. S.M. Marandi et al. (2008) observed same things in a study on strength and durability of randomly distributed palm fibres reinforced with silty-sand soils. From a complete analysis of failure modes and crack propagation the benefits of plastic fibre was evaluated that it can improve ductility as well as crack propagation after initial formation.

4. Conclusions

This research was conducted to evaluate the density, compressive strength and failure pattern for different stabilized condition with 0% plastic fibre, 0.1% plastic fibre and 0.2% plastic fibre respectively**.** By maintaining and following various standards this study was conveyed.

- The density of the soil blocks with different mixing compositions varied from 1800 kg/m^3 to 1898 kg/m^3. Adding of plastic fibre doesn't contribute magical change in density and in almost each cases density falls slightly after adding 0.1% fibre and density falls remarkably after adding 0.2% fibre.
- From comparison of control blocks (C) and blocks stabilized with 8% cement content (C1), it is evident that strength increases approximately 8.5% and 29.5% strength increases in case of comparing between control blocks and blocks consists of 10% cement (C4).
- There was an increase of 5.6% and approximately 18% in strength when this soil block was stabilized by 2% (C5) and 4% of lime (C6) respectively when compared to block with 10% cement (C4).
- Large quantity of fibres distributed non-uniformly in the blocks and creating weaker plane, which may leads to reduction in strength.
- The control blocks which contains only raw soil, exhibits an abrupt failure without introducing any symptoms or warning and the mode is quick
- The blocks with fibres deformed after the ultimate load was reached and finally crack was observed on the specimen.
- The chopped plastic fibres from mineral water pet bottle are not consistently sound with soil in improving the compressive strength.

5. Acknowledgement

The author wishes to thank Benny Mathews Abraham from School of Engineering, CUSAT, Kochi, India for his intellectual contribution and help throughout the work. The inspiration of Dr. G. M. Sadiqul Islam and Dr. Aysha Akter of Chittagong University of Engineering & Technology (CUET) are gratefully acknowledged.

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