Economic Consideration of Stabilized Soil Blocks

Eswara Reddy Orekanti

Associate Professor and Head, Department of Civil Engineering, Sree Vidyanikethan Engineering College, Sree Sainath Nagar, A. Rangampet - 517 102, Tirupati, A.P., INDIA.

Abstract

The aim of the present investigation is to focus on the experimental work of stabilized soil block obtained by stabilizing the soil available locally at Vadavalli-Coimbatore with stabilizer like cement, lime, fly-ash, quarry dust, rice husk, saw dust and gypsum in various combinations there by reducing the cost of block with increased strength. The economy in making of stabilized soil blocks is to be obtained only after detail investigations on stabilized soil blocks made with different percentage of stabilizers of different combination. The soil tests are being done to find its quality. The compressive strength of the block has been found after 7 days of curing. Cost analysis has been made for the stabilized soil blocks with optimum strength. It has been observed that blocks having combination of 5% of cement combined with 1% of rice husk and 25% of sand gives optimum strength result. There is 41% cost saving in stabilized soil block compared with burnt bricks. Cost analysis is also made for soil block masonry assuming 5% cement and 1% rise-husk as stabilizer and it is compared with ordinary brick masonry. The saving in cost per cubic meter of wall works out to be nearly 25%.

1. Introduction

The housing development has various complex dimensions, the important one is the use of appropriate building technologies to reduce the time and cost of construction. To ensure economy, strength and better quality, implementation of innovative low cost materials with improved techniques in construction is essential. The use of the traditional construction practices and local materials with appropriate technology inputs appear to be holding the key for majority of the countries. Earth is being used as a building material from time immortal. Its high thermal insulation and heat storage capacity makes an ideal material for the hot arid zone of our country. The strength and resistance to weathering, of almost all soils increases when treated with stabilizers. For every soil there exists an optimum stabilizer requirement for obtaining maximum strength. The amount of stabilizer depends upon the type of stabilizer used and the properties of soil. It is well known fact that the cost of construction depends on the cost of material and transportation. Hence it is obvious that if soil is available at the site or near by the construction of building, is made use of it, will result in the reduction of cost to a great extent. Keeping all these factors in mind, the present study has conducted to explore the possibilities of reducing the cost and increase the strength of soil blocks using soil available at Vadavalli, Coimbatore.

The research reported in this paper is concerned with the selection of appropriate type of stabilizer and its optimum percentage to achieve a high degree of compressive strength of soil blocks stabilized with different stabilizers such as cement, lime, cement and fly ash, cement and quarry dust, cement and rise husk, cement and saw dust, fly- ash, lime and gypsum combined together. The cost of production of stabilized soil blocks are compared with ordinary bricks and compared the economy of stabilized soil block masonry with ordinary brick masonry. The results of this study can provoke thoughts for applying stabilization techniques to explore the possibilities of new building materials.

2. Review of Literature

Rosenak, S (1957) based on his experiments and experience, he gave the following conclusions: Soil having liquid limit below 25%, clay content up to 20%, a minimum sand content of 35% and plastic index between 8.5% and 10.5% is found to be suitable for stabilization with 5% cement. For clayey soil (with plasticity index >12%), the compressive strength increases with the increases with decreases with in moulding moisture content. Indian institute of science, Bangalore made following conclusions based on their tests and experience with stabilized soil blocks:1) Soil containing too manipulating sand or clay content to poor handling strength is reduced. Such soils may be utilized by adding suitable quantity of coarse sand and clayey soil, 2) Soil containing considerable amount of clay are often not suitable for cement stabilization. Such soils can be stabilized by adding sand and lime suitably, 3) Block having Wet strength >2 N/mm used for two storied building with span 3.6m and less. Wet strength 1.2 to 2 N/mm^2 used for single storied buildings, 4) Wet strength 0.7 to 1.2 N/mm2 used for single storied and light roofed building, and 5) Cement stabilization is often well suited for soils containing about 60-70% sand and 10-20% clay for soil cement block. Moreover, several research publications reveal the importance of studies on stabilized soil blocks.

3. Experimentation

Stabilized soil blocks are energy efficient, interesting and aesthetic alternative to burnt bricks. They are simply made by pressing a mixture of soil and stabilizer like cement, lime, fly ash etc., in a machine at suitable moisture content. The effectiveness of stabilized soil blocks can be gauged from the points like low cost, high energy, comparable strength, more functional efficiency, better appearance / aesthetic feature, use of local resource and materials and no plastering is required. The soil available locally at Vadavalli-Coimbatore was considered for stabilization. Field tests for determination of water content, dry strength, consistency and cohesion were carried out. Laboratory tests like specific gravity test, liquid limit test and plastic limit test were conducted to estimate the plasticity index of the soil sample. Different stabilizing materials namely cement, lime, fly-ash, gypsum, quarry dust, saw dust and rice husk were used in the present study. Quarry dust was collected from a place called Thadagam 35 km from the study area. The stabilized soil blocks have been caste using ITGE VOTH block making machine at Kattida Maiyam, Vadavalli, Coimbatore (Fig.1). The economy and strength of the stabilized soil blocks majorly depends on the type of stabilizer chosen.

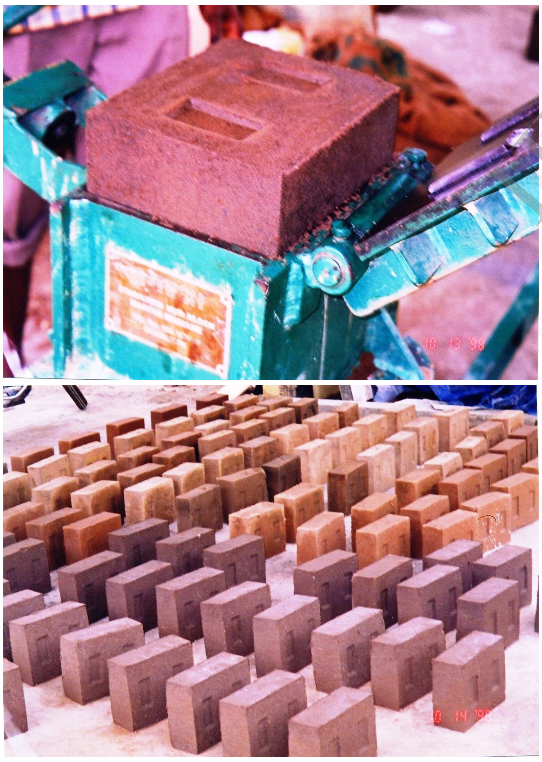

Fig.1 Block Making

4. Results and Discussions

From the dry strength test it was confirmed that soil sample considered for the study has moderate dry strength which indicates the soil contains silt or sandy clay (As per HUDCO zonal training centre, Chennai). Consistency test showed the soil considered for the block making was of medium thread and of moderate clay content and cohesion test shows the soil used for block making forms a short ribbon and it contains moderate clay content. The soil possesses the specific gravity of 2.58, the liquid limit of for the soil sample was 24.45% and the plastic limit of 12.365%.so, the plasticity index of the soil sample was worked as12.09%. According to Rosenak.S (1957) when the liquid limit below 25% then the soil contains maximum of 20% clay and minimum 40% of sand. Further, the test results obtained on stabilized soil blocks with different stabilizers have been discussed.

4.1 Unstabilized Soil Block

The average compressive strength of the unstabilized soil block manufactured with an additional 25 % of sand of size 115 mm x 190 mm x 100 mm has been determined as 0.23 N/mm^2 at 7 days strength.

4.2 Stabilizer - Lime

The compressive test results on lime stabilized soil blocks are depicted in Fig. 2. The curve shows that the compressive strength of the blocks increases gradually as the lime content increases gradually. And also the optimum strength is obtained when 20% of lime is used as stabilizer. The percentage increase in strength is 695.65% (1.83 N/mm^2) with respect to unstabilized block.

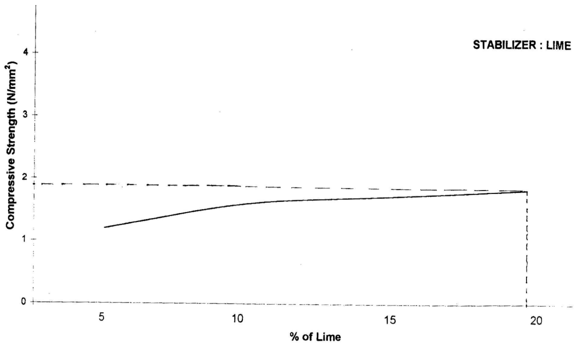

Fig.2 Strength curve for soil blocks stabilized with lime

4.3 Stabilizer - Cement

The compressive test results on cement stabilized soil blocks are presented in Fig. 3. The curve shows that the compressive strength increases gradually as the cement content increases gradually. It starts from 1N/mm^2 to 3N/mm^2. Moreover, the optimum strength is obtained when 5% of cement is used as stabilizer. The percentage increase in strength is 1165.21 % (2.93 N/mm^2) with respect to unstabilized block.

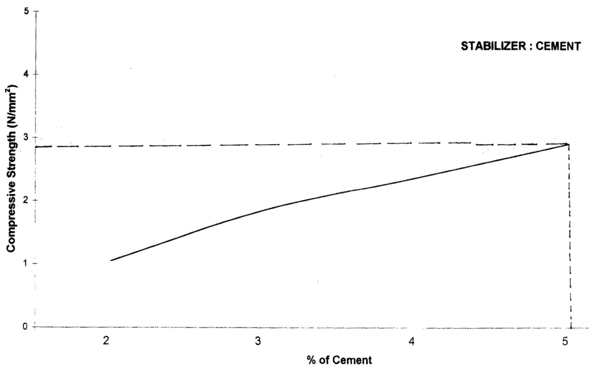

Fig. 3 Strength curve for soil blocks stabilized with cement

4.4 Stabilizer - Cement and Fly Ash

The strength test results on soil blocks stabilized with cement and fly ash are as shown in Fig.4. Curve 1 and 3 shows 5% and 25% of fly ash respectively and the strength increases mildly up to 3% of cement and then increases gradually. Curve 2 shows that due to increase of cement with 15% of fly ash combination shows a decrease in strength.

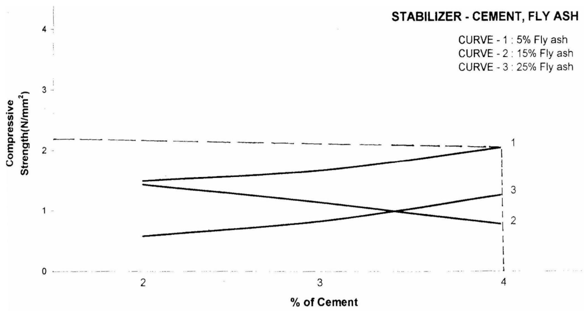

Fig.4 Strength curve for soil blocks stabilized with cement and fly ash

From Fig.4, the optimum strength is attained at 4 % of cement combined with 5 % of fly ash. The percentage increase in strength is observed as 797.90% (2.013 N/mm^2) with respect to the unstabilized block.

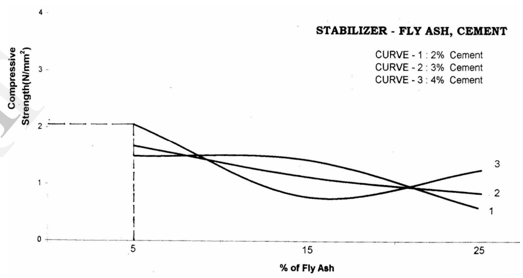

Fig.5 Strength curve for soil blocks stabilized with fly ash and cement

From Fig.5, Curve 1 shows 2% of cement, the decrease in compressive strength is mild up to 15% of fly ash and then decreases steeply from 15 to 25% of fly ash. Curve 2 shows 3% of cement, the compressive strength decrease gradually from 5% to 25% of fly ash. Curve 3 shows 4% of cement, the compressive strength decreases steeply from 5% of fly ash and then from 15% to 25% of fly ash, the strength increases gradually.

4.5 Stabilizer - Cement and Quarry Dust

Fig.6 depicts the compressive test results on soil blocks stabilized with cement and quarry dust. The curve 1 and 2 shows the 5% and 15% of quarry dust. The compressive strength gradually increases from 2% to 4% of cement. The curve 3 shows the 25% of quarry dust. The compressive strength increases gradually from 3% to 4% of cement.

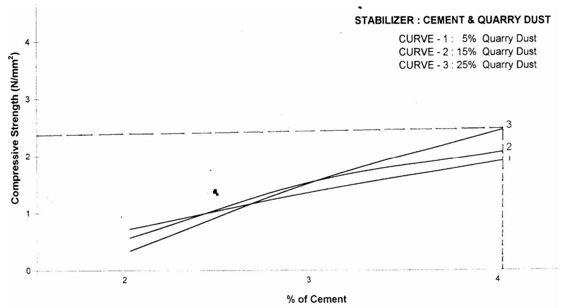

Fig.6 Strength curve for soil blocks stabilized with cement and quarry dust

From Fig.7, the curve 1 shows that for 2% of cement, the compressive strength of block decreases gradually from 5% to 25% of quarry dust. The curve 2 shows that for 3% of cement, the compressive strength of the block increases slightly from 5% to 15% of quarry dust and then the strength remains the same from 15 to 25% of quarry dust. The curve 3 shows that

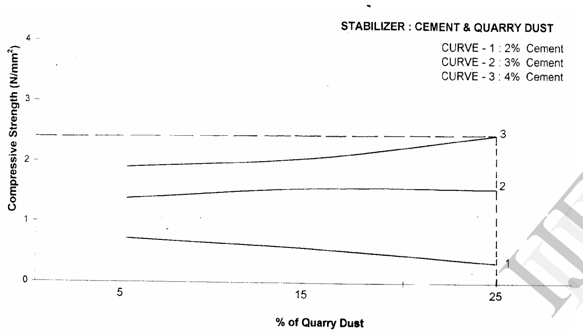

Fig.7 Strength curve for soil blocks stabilized with quarry dust and cement

for 4% of cement, the compressive strength of the block increases slightly from 5 to 15% of quarry dust and then increases gradually up 25% of quarry dust.

From Fig.6 and Fig.7, the optimum strength is attained at 4% of cement combined with 25% of quarry dust. The percentage increase in strength is observed as 969.56% (2.456 N/mm^2) with respect to the unstabilized block.

4.6 Stabilizer - Cement and Saw Dust

The compressive test results on soil blocks stabilized with cement and saw dust are as shown in Fig.8. Curve 1 and 3 shows the 1% and 3% of saw dust. The compressive strength decreases gradually from 3% to 4% of cement. Curve 2 shows the 2% of saw dust. The compressive strength decreases gradually from 3% to 4% of cement and then decreases slightly from 4% to 5% of cement.

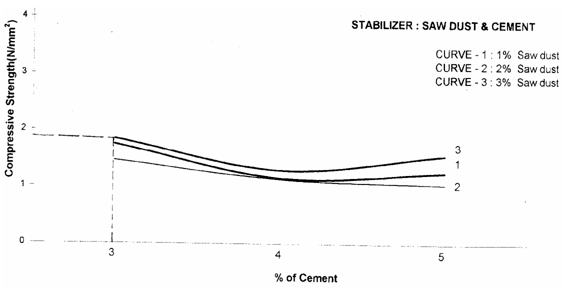

Fig.8 Strength curve for soil blocks stabilized with cement and saw dust

In Fig. 9, the curve 1 and 3 shows the 3% and 5% of cement. The compressive strength decreases gradually up to 2% of saw dust and then increases very slightly from 2 to 3% of saw dust.

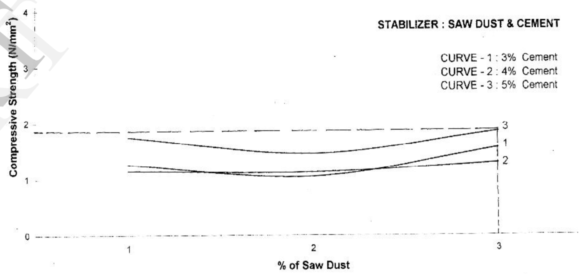

Fig.9 Strength curve for soil blocks stabilized with saw dust and cement

From Fig.8 and Fig.9, the optimum strength is attained at 3% of cement combined with 3% of saw dust. The percentage increase in strength is observed as 704.34% (1.85 N/mm^2) with respect to the unstabilized block.

4.7 Stabilizer - Cement and Rice Husk

The strength test results on soil blocks stabilized with cement and rice husk are depicted in Fig.10. Curve 1 show for 1% of rice husk, the compressive strength increases steeply from 3% of cement of 5% of cement. Curve 2 & 3 shows 2% & 3% of rice husk respectively. The compressive strength increases gradually from 3% to 5% of cement.

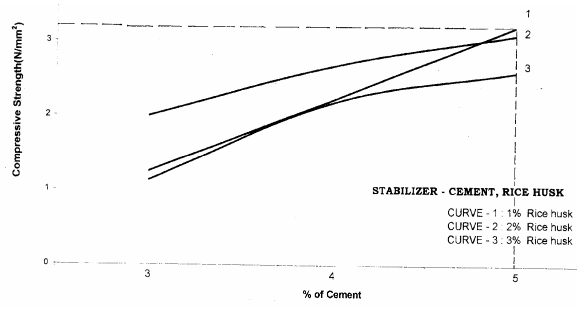

Fig.10 Strength Curve for Soil Blocks Stabilized with Cement and Rice Husk

In Fig.11, curves 1, 2, 3 represent the 3%, 4% and 5% of cement respectively. The compressive strength decreases gradually from 1% to 2 % of rice husk and then increases gradually from 2 % to 3% of rice husk for different percentages of cement.

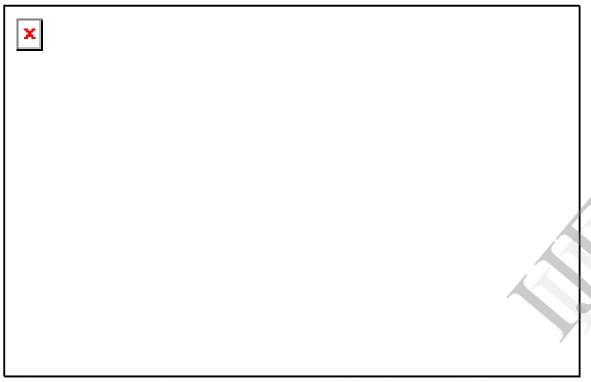

Fig.11 Strength curve for soil blocks stabilized with rice husk and cement

From Fig.10 and Fig.11, the optimum strength is attained at 5% of cement combined with 1% of rice husk. The percentage increase in strength is observed as 1300% (3.22 N/mm^2) with respect to the unstabilized block.

4.8 Stabilizer - Fly Ash, Lime and Gypsum

The curves in Fig.12 shows the compressive test results on blocks of with FAL G and Soil ratio. The curves 1, 2, 3 shows the 1:2, 1:2.5, 1:3 of FAL G: Soil ratio blocks respectively. The compressive Strength increases steeply from FAL G1 to FAL G2 and then strength decreases gradually from FAL G2 to FAL G3.

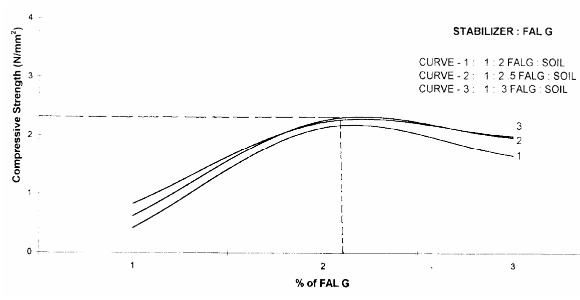

Fig.12 Strength curve for soil blocks stabilized with fly ash, lime and gypsum

From Fig.13, the curve 1 and 2 show the FAL G1 & FAL G2. The compressive strength increases gradually with FAL G: soil ratio. The curve 3 shows the FAL G3. The compressive strength increases gradually from FAL G: soil ratio of 1:2 to 1:2.5 and then the strength remains constant up to FAL G: Soil ratio of 1:3.

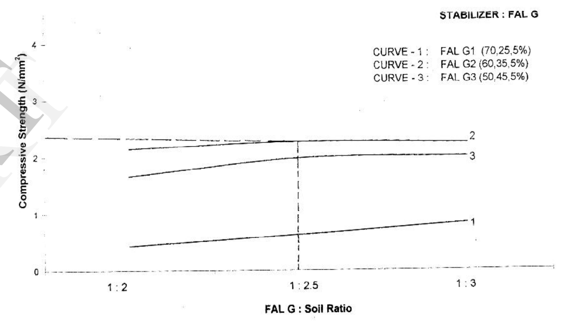

Fig.13 Strength curve for soil blocks stabilized with fly ash, lime and gypsum

From Fig.12 and Fig.13, the optimum strength is attained when 60% of fly ash, 35% of lime and 5% of gypsum all combined together. For FAL G: Soil ratio of 1:2.5, percentage increase in strength is 884.95% (2.265 N/mm2) with respect to unstabilized soil block.

5. Cost Analysis

Stabilized soil block which gave optimum strength obtained from test results and its cost is compared with burnt bricks. Stabilized soil block masonry without facing work and its cost per unit quantity is compared with ordinary brick masonry without plastering. Economy of stabilized soil blocks over burnt bricks is dealt in this section.

5. 1 Preliminary Data

Type of block making machine: **ITGE VOTH**
Size of Block (mm) : 230 x 190 x 100
Weight of block : 8.5 kg approx.
Cement : Portland cement
Lime : Slaked lime (powder form)

Quantity	Description	Rate (Rs.)	Unit	Amount (Rs.)
415 Nos.	Bricks (230 mm x 110 mm x 75	1.50	Each	622.50
0.22 m^3	Cement Mortar 1:6	1060	$1m^3$	233.20
1 m^3	Labour charge	200	$1m^3$	200.00
	Sundries			0.30
			Total	**1056.00**

Soil location : Kattida Maiyam, Vadavalli, Tamil Nadu.
Sand : River Sand
Brick : Country Brick
Brick size (mm) : 230 x 110 x 75

5. 2 Cost Data

Capital cost of the machine / block : 17 paisa
1 kg of the cement cost : Rs 2.60
Cost of water and soil : Rs 0.30/ block
Brick cost : Rs 1.50 each
Sand cost : Rs 310/ m^3
Lime cost : Rs 0.80 per kg
Rice husk : Rs 2.00 per kg

5.3 Cost of Stabilized Soil Block

Cost details for one block **Cost (paisa)**
I. Capital cost of machine : 17
II. Cost of sand, soil & water : 64
III. Labour cost : 53
Cost of Block without Stabilizer : 134

Cost of block for optimum strength (Block with 5% Cement and 1% Rice Husk as Stabilizer) as obtained from test results.

Cost details for one block **Cost (paisa)**
Cost of cement : 110
Cost of rice husk : 10
Cost of block without stabilizer : 134
Total cost of block : 254

It is assumed that one machine will produce 1 lakh blocks in its life time with minor repairs and cost of machine Rs. 17000/-. It is observed by experience, 7 persons will produce 800 blocks per 8 hour working day. (Rs.60 per person per day). Further, the cost analysis is based on 2006 schedule of rates.

Table 1 Data for $1m^3$ of soil cement block masonry using CM 1:6

Quantity	Description	Rate (Rs.)	Unit	Amount (Rs.)
195 Nos.	Stabilized Soil	2.54	Each	495.30
0.415 m^3	Cement Mortar 1:6	1060	$1m^3$	153.70
1 m^3	Labour	150	$1m^3$	150.00
			Total	**799.00**

Table 2 Data for cost of burnt brick masonry for $1m^3$ CM 1:6

Table 3 Sub-data for cement mortar 1:6-1 m^3

Quantity	Description	Rate (Rs.)	Unit	Amount (Rs.)
240 kg	Cement	3.04	Kg	729.60
1 m3	Sand	310	$1m^3$	310.00
1 m3	Mixing	20	$1m^3$	20.00
	Sundries			0.40
			Total	**1060.00**

Table 4 Comparison of burnt bricks and stabilized soil blocks

S. No.	Parameter	Burnt bricks	Stabilized Soil Blocks
1	Dimensions (mm)	230 x 110 x 75	230 x 190 x 100
2	Volume (mm^3)	(1.89×10^6)	(4.37×10^6)
3	Volume ratio	1	2.303
4	Weight	2.2 kg	8.5 kg
5	Stabilizer	Fire	Cement
6	Cost/ unit on site	1.50	2.54
7	Units/m^3 Raw material	527	228
8	Water absorption	10 to 15%	4 to 13%
9	Cost of wall / m^3	1056.00	799.00

6. Conclusions

The optimum strength of 3.22 N/mm^2 is attained for the stabilized soil block with using 5% cement combined with 1% rice husk as stabilizer and the percentage savings in cost compared with burnt bricks is found to be 41%. The savings can be achieved in wall construction by using stabilized soil blocks without plastering instead of using ordinary bricks. Soil block masonry gives good appearance and it does not require plastering. The weight of the stabilized soil block per m3 is comparatively less than that of burnt brick. Hence stabilized soil blocks are more effective than that of burnt bricks in the case of earthquake resisting construction.

7. Scope for Future Study

Attempts can be made to study the suitability of soil blocks for multistoried load bearing structures, the micro analysis of the effect of stabilizers, with soil in block, the thermal resistance of the soil block, the permeability characteristics of soil block, the acoustic effect on stabilized soil block, face protection for stabilized soil block, cost analysis for all types of stabilized soil blocks having optimum strength value in comparison with bricks, and also for masonry.

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