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PERFORMANCE EVALUATION OF SUSTAINABLE COMPRESSED STABILIZED EARTH BRICKS

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Abstract- Manufacturing of bricks with compression and stabilization is an ancient technique used from the decades. In this technique, mainly locally available soil is used as raw material along with certain stabilizer. Cement and lime are mostly used as stabilizers in the previous researches. Soil along with stabilizer is molded in the compression machine which applies a pre-defined amount of pressure to cast a brick sample. Cement is used as stabilizer in this study and due to adverse environmental effects of cement production process, the amount of cement used as stabilizer was kept minimum 5%. Comparison is done between controlled samples (CS) of 0% cement stabilizer and 5% cement stabilizer used for the preparation of compressed stabilized earth bricks (CSEBs). Water absorption test is a durability test done on CSEBs resulting 12.23% water absorption of CSEBs while CS units completely deteriorated during 24-hour submersion in water. Compression test was done on the brick samples in the universal testing machine and 28 days average compressive strength was found 416.4 psi for stabilized brick unit and 212.4 psi for controlled samples. This 96% increase in the compressive strength of stabilized units depicts the strengthening behavior of minimum (5%) cement content. Masonry prisms of 18"x18" was fabricated using the designed stabilized brick unit and mortar used was mud mortar with the compressive strength of 291.5 psi. The compressive strength and modulus of elasticity of masonry prism was found to be 171.27 psi and 41.4 ksi which indicates that the designed brick unit can be used as a construction material for single storey building.

Keywords- CSEB, stabilized, cement, masonry, brick unit, compression test

1 Introduction

Residential building are made of walls built with brick units and combined with the help of mortar [1]. Bricks commonly used are fired clay bricks which releases a large amount of energy and carbon dioxide CO_2 [2]. To be more specific, CO_2 emission from conventionally used fired clay bricks is 200 kg/t which is very alarming for the environment [3]. An alternative measure of these fired clay bricks is unfired clay bricks for construction [4]. Compressed stabilized earth bricks (CSEB) is also a type of unfired clay brick. CSEB are made by using soil as raw material, stabilizing the soil with certain stabilizer and compressing the mixture in a compressing machine [5]. These stabilized blocks are very efficient for low cost housing [6]. These CSEBs are cheap, affordable, easy to use, sustainable, fire resistant and environmentally friendly to be used as construction material in the industry [7]. Different materials are used for the stabilization in CSEBs and each material have its own effect on the properties of CSEB. Cement stabilization is very effective and it enhances all the properties such as strength, water resistant, erosion resistance, and reduces shrinkage of bricks [8]. Compression of brick sample while molding also has great effect on the properties of CSEB units. As dry density of brick is increases with compression so it can be stated that compressive strength also increases with compression [9].

In a study 8% cement, 46% quarry dust and 46% granite sludge were used in varying proportions and concluded that stabilized block have greater strength than ordinary adobe block [10]. Achievement of low cost housing is possible practically is stabilizing materials are used properly in proper proportions [11]. Cement increases the strength of units [12].

2 Research Methodology

2.1 General

In this study, soil was first tested for the basic properties. After that cement was tested for finess which was passing the criteria specified by ASTM C184-94. CSEB sample moulding was done in the compression machine by pouring the soil in the mould and then mechanical compression and vibration is applied to fabricate the brick unit. Compression test was done on brick sample according to ASTM C67 to find the compressive strength of units. After that water absorption test (ASTM D570) was done to find the durability behaviour of CSEB units. Two types of samples, controlled and stabilized, were prepared for the compression testing of brick unit to compare the stabilized sample with controlled sample. Masonry prism fabrication was done using the pre-designed clay mortar of compressive strength 291.5 psi. Lastly, compressive test on the masonry prism according to ASTM C1314 concluded the study.

2.2 Compressive test on brick unit

Brick unit of standard size having area A (in^2) is placed in the universal testing machine (UTM). Two rigid plates are placed above and below the brick unit for the uniform distribution of load as shown in the figure (1). Load is applied up to the rupture of brick. The value of this load is noted as P (lb).

Figure 1 Experimental setup for CSEB unit compressive strength

2.3 Compressive test on masonry prism

Masonry prisms were tested for compression in the universal testing machine (UTM). The load capacity of UTM is 50 tons. Size of masonry sample used for testing was 18"x18". Linear variable digital transformer (LVDT) were attached on both sides of masonry prisms as shown in figure (2) to detect the linear shortening of masonry sample under compressive loads. The LVDTs were connected with data logger to obtain stress strain data.

Figure 2 Experimental setup for masonry compressive strength

3 Results

3.1 Soil test results

The results of all the basic tests done on soil are given in Table (1).

Table 1 Soil test results

Test	Results	Test	Results	Test	Results	Test	Results
Moisture Content	7.30%	Liquid Limit	39%	Plasticity Limit	15%	Specific gravity	2.53

3.2 Water absorption test results

Water absorption test is done according to ASTM C67-94. Results of this test are given in table (2)

Table 2 Water absorption test results

Dry weight (kg)	Wet Weight (kg)	Water Absorption (kg)	% WA	Average % WA	COV (%)
3.541	4.012	0.471	13.301	12.232	9.72
3.601	3.994	0.393	10.914		
3.518	3.953	0.435	12.365		
3.598	3.998	0.4	11.117		
3.61	4.096	0.486	13.463		

3.3 Brick unit compressive test results

Compressive strength is an important parameter to be found for CSEB units. Five samples of each CSEB units with 5% cement and controlled sample (CS) with 0% cement were tested for compressive strength at the ages of 3 days, 14 days and 28 days. The results are given in table (3).

Table 3 Compressive test results for CSEB and CS

Sample Name	Compressive strength (P/A) in psi (CSEB samples 5 % cement)			Compressive strength (P/A) in psi (Controlled samples 0% cement)		
	3 day	7 day	28 day	3 day	7 day	28 day
Sample 1	150	271	416	78	132	201
Sample 2	157	265	408	63	121	214
Sample 3	147	289	412	72	125	209
Sample 4	141	280	425	81	118	217
Sample 5	159	276	421	85	135	221
Average	**150.8**	**276.2**	**416.4**	**75.8**	**126.2**	**212.4**

3.4 Masonry prism compressive test results

In this study three samples of single wall of size 18" x 18" were tested and stress strain response was detected with data logger connected to testing machine. Properties of masonry prisms and results are given in table (4) and stress strain behavior of masonry is shown in figure (3)

Table 4 Masonry prism compressive test results

Sample Name	Size of specimen (in)			Maximum Load (Ton)	Maximum Stress (psi)	Modulus of elasticity (ksi)
	Length	Width	Thickness			
Prism 1	18.3	18	9.1	14.4	193.8	40.76
Prism 2	18	18.5	8.8	12.1	163.4	44.1
Prism 3	18.5	18.2	9.3	12	156.6	39.2
Average Values				12.8	171.3	41.4

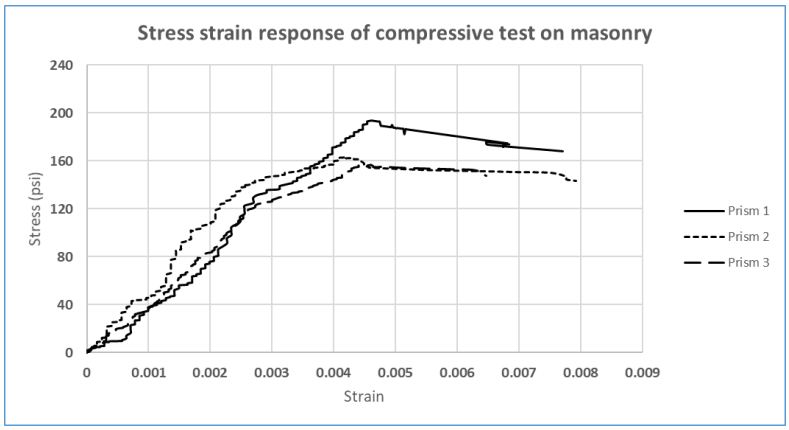

Figure 3 Stress strain curve for masonry compressive test

4 Conclusion

Following are the conclusions that can be drawn from the study conducted:

1 Water absorption of CSEB is 12.23% which is less than water absorption of 1st class brick. This depicts durable behavior of CSEB unit to be used in rainy season.
2 The compressive strength of CSEB units (5% cement) increased by 96% to that of CS with no cement content.
3 Average compressive strength of masonry is found to be 171.3 psi which is 41% of brick unit strength and average modulus of elasticity is 41.4 ksi. Compressive strength and modulus of elasticity of masonry prisms yield satisfactory results to be used in single storey low cost housing in the developing countries.

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