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Durability Properties of Stabilized Adobe

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Abstract. Stabilized Adobe is the traditional technique of making brick such adobe bricks suffers from water attack and cracks, thus they need prevention to keep them in a good condition. To overcome from this draw back stabilizers should be used. In our present study lime and cement as a stabilizer are used. Stabilizers used for both 15% clay content and 10% clay content stabilized adobes.in this study we adopted pugging technique for preparation of blocks. This paper studies the relationship between soil properties, stabilizers, strength properties and durability of stabilized Adobe. In all aspects cement with !0% clay content stabilized adobe shows good performance compared to lime alone and combination of lime and cement.

Keywords: Stabilized mud blocks; Pugging; Stabilizers.

1. INTRODUCTION

Masonry buildings were constructed from locally available material at hand. The provision of good quality housing is recognized as an important responsibility for welfare of people in any country. For this, building materials based on natural resources are often used. Mud (soil) is the most widely distributed resource for building construction; it is useful to explore ways of stabilizing mud without employing an energy intensive technique like brick burning.

Stabilized Adobes have drawback of water attack and cracks because of excessive clay content in the soil. Clay plays key role in the stabilized adobe due to of more percentage of clay content in soil leads to vulnerable deterioration and deserving of care and maintenance, which affects durability of blocks. Degree of stabilization and Strength mainly depend on the stabilization process and stabilizers which over comes the draw backs of stabilized adobe by using different stabilizers.
In the present study, an attempt is made to study the durability of the stabilized adobe by conducting tests like relationship between wet compressive Strength and Flexural Strength, Expansion on Saturation, Alternate Wetting and Drying, Efflorescence.

2 Materials

A good soil sample for mud block construction should have 10-15% gravel, 60-72% sand and 15-30% silt & 5-15% clay. In this study the materials used to make mud blocks are soil (image 1a), M-Sand (image 1b) and stabilizers, cement (image 1c) and lime (image 1d). According to BIS codes, basic tests for soil, cement, M-Sand and lime have been done. For

the present study Soil is procured from JP Nagar, Bangalore. The soil contains sand -43%, clay- 19.58%, and silt- 37.42%. To reduce the

clay content of 19.58% to 10% and 15% it is modified by adding M-Sand. Iron Mould of dimension 240mm*190mm*100mm size is used to prepare the adobe blocks, is as shown

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in image2 and Table1 represents Mix proportion of stabilized Adobe.

Image 1 a): soil 1b) :M-Sand

1c): Cement 1d): Lime

Image 2: Soil Block Mould

Table1: Mix proportion of stabilized Adobe

Sl no	Notations	Composition of clay and stabilizer
1	C15A	C_{15}-15%clay+ A-8% cement
2	C15B	C_{15}-15%clay+ B-8%lime
3	C15C	C_{15}-15%clay+ C-6%cement+3%lime
4	C10A	C_{10}-10%clay+ A-8%cement
5	C10B	C_{10}-10%clay+ B-8%lime
6	C10C	C_{10}-10%clay+ C-6% cement+3% lime

3. Process of making Stabilized Adobe

To prepare Stabilized adobe the following procedure is to be followed and image 3 represents the process of making stabilized adobe .The procured dry soil is screened through 4mm sieve mesh to remove lumps and deleterious materials. To the screened dry soil M-Sand is added to obtain required proportion of clay content in the soil i.e 15% clay content and 10% clay content . Cement, lime and

combination of cement and lime are used as a stabilizer to improve the further strength of Stabilized Adobe. By referring the literature [4] (In the case of kaolinite clays, the increase in strength begins with the addition of the first increment of lime. In the case of illite montomorillonite and some mixed layered structures, lime in excess of 4-6 per cent must be added before any strength developed) the mix proportion of 8% for lime is adopted. The quantity of cement as a stabilizer to be added to the soil as per the literature review [9] is half the percentage of clay content present in the soil.All ingredients are dry mixed thoroughly as per mix proportion given in table 1.To these mixes 20% of water is added which is kept constant for all types of Stabilized Adobe block. The wet mix is then pugged for 15-20 minutes. This pugged plastic mix is dashed to the Iron mould of size 230X190X100mm as shown in image 2 [10] from a height of 0.5m. After smooth finishing of surface, it is demoulded on a flat surface, which is as shown in image 3(e).

(a) (b) (c)

(d) (e) (f)

Image 3: (a) dry mixing of soil and M-Sand

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(b) Mixing of modified soil with Stabilizer (c) Dashing into the mould (d) Pugging of stabilized soil (e) casted moulds (f) Gunny bag curing

4. Experimental Programme

4.1 Wet compressive Strength

The compressive strength of Stabilized Adobe increases with density and the relationship is linear. Compressive strength also depends on the mixing methods and is adversely affected by any delay between mixing and compaction. The density of Stabilized Adobe depends upon the moisture content and type of compactive effort. The wet compressive strength of adobe blocks prepared with different stabilizers and clay content were evaluated at 28 days of curing period as per the standard procedure as prescribed by Bureau of Indian Standards IS 3495:1992(part 1)[1]. Among the stabilizers, the nature and properties of the reaction products responsible for slow development of strength in soil-lime systems compared to soil-cement systems [5].

4.2 water absorption

Natural soil exhibits no strength resistance against environmental factors and failed rapidly during soaking. Stabilization of the clayey soil with cement and lime is effective to enhance the strength against environmental factor[8].Water absorption test on bricks are conducted to determine durability property of brick. Water-absorption test is a test to determine the moisture content of soil as a percentage of its dry weight (British Standard 1377, 1967).

4.3 Flexure Strength

ASTM _1994_code outlines procedure for determining flexural strength of brick. A similar procedure was adopted to determine flexure strength of Stabilized Adobe. To determine the Flexure Strength of Adobe, the brick as a beam simply supported over two supports and concentrated load applied at the centre and the failure load is noted.

4.4 Alternate Wetting and Drying Test

Long term strength of stabilized adobe has been studied by subjecting Alternate Wetting and drying test. The blocks were subjected to twelve alternate wetting and drying cycles after curing them for 28 days. These blocks were soaked in water for two days and oven dried for three days for one cycle similarly for eleven other cycles were carried out. Visual observation, loss of material and compressive strength were noted and reported.

4.5 Expansion on Saturation

There is a volumetric change in soil when it is exposed to water due to considerable clay amount in the soil. This test is conducted to know the volumetric changes that occur at the time of saturation of adobe. In this test three dimensions of adobe length, width and height at three different points were measured using vernier callipers before and after immersing of blocks in water for 48hrs. Finally the ratio of initial dimension to final dimension is expressed in percentage.

4.6 Efflorescence test

Efflorescence is a whitish crystalline deposit of salts on the bricks. Usually magnesium sulphate, calcium sulphate and carbonate of sodium and potassium are found in efflorescence. In this, migration of salt occurs to the top surface of the porous material by capillary action. The test was conducted according to IS Code IS 3495 (part 3) and observation was done. Image 4 and image 5 represents before and after efflorescence test of stabilized adobe block.

Image 4: Before efflorescence test of stabilized adobe block

Image 5: After efflorescence test of stabilized adobe block

5. Results and Discussion

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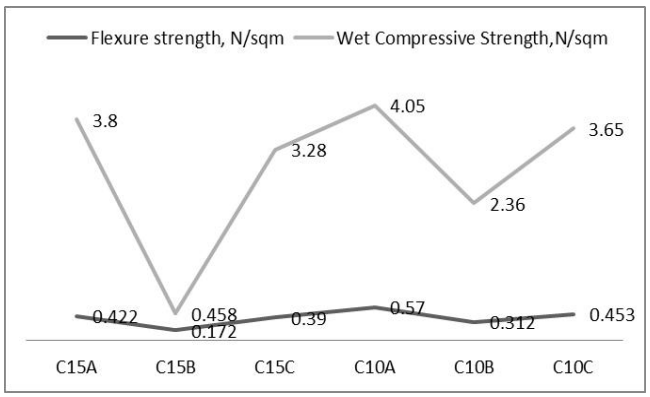
5.1 co-relation between wet compressive strength and flexural strength

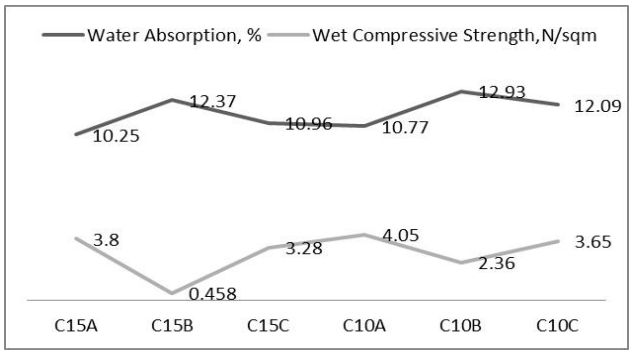
From the graph 1 it has been observed that the wet compressive strength curve and flexure strength curve resembles in configuration. As the wet compressive strength increased flexure also increased where wet compressive strength decreased there flexure strength decreased. in both wet compressive strength and Flexure strength 10% clay content with cement stabilized adobe shown highest strength value and 15% clay content with lime stabilized adobe showed least strength value. In both flexure strength and wet compressive strength compared to 15% clay content 10% clay content stabilized adobe shows good result. Among stabilizer, cement stabilized adobe [(flexure strength- 0.422N/sq.m (15% clay), 0.57 N/sqm (10% clay) and wet compressive strength-3.8N/sq.m(15% clay), 4.05N/sq.m)]shows good performance in both 15% clay content and 10% clay content stabilized adobe and lime alone shows least strength [flexure strength- 0.172N/sqm (15% clay), 0.312 N/sqm (10% clay) and wet compressive strength-0.458N/sqm (15% clay), 2.36 N/sqm (10% clay)]next to combination of cement and lime as a stabilizer [flexure strength- 0.39N/sqm (15% clay), 0.453 N/sqm (10% clay) and wet compressive strength-3.28N/sqm (15% clay), 3.65 N/sqm (10% clay)].



Graph 1: co-relation between wet compressive strength and flexural strength

5.2 Co-relation between wet compressive strength and water absorption

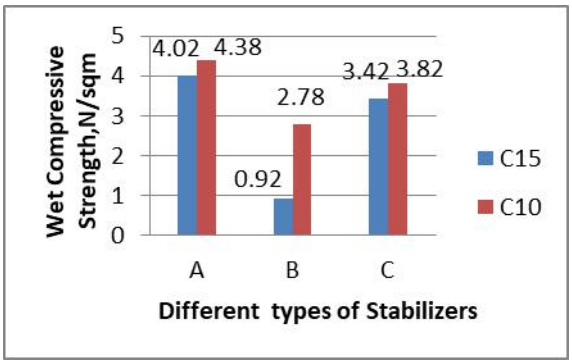
Graph 2 presents the co- relation between wet compressive strength and water absorption. It has been observed that as the water absorption increases wet compressive strength decreases and vice versa. It may be due to porosity nature of the stabilized adobe, which makes increase in water absorption as porosity increases which intern decreases the wet compressive strength also. In water absorption test compared to 10% clay content stabilized adobe 15% clay content stabilized adobe shows lesser water absorption it may due to well distributed particle size of soil ,sand and stabilizers. Among stabilizer, cement stabilized adobe [(water absorption- 10.25% (15% clay), 10.77% (10% clay) and wet compressive strength-3.8N/sqm(15% clay), 4.05N/sqm)]shows good performance in both 15% clay content and 10% clay content stabilized adobe than lime alone [water absorption- 12.37% (15% clay),12.93 N/sqm (10% clay) and wet compressive strength-0.458N/sqm (15% clay), 2.36 N/sqm (10% clay)] and combination of cement and lime as a stabilizer [water absorption- 10.96% (15% clay), 12.09% (10% clay) and wet compressive strength-3.28N/sqm (15% clay), 3.65 N/sqm (10% clay)].



Graph 2: Co-relation between wet compressive strength and water absorption

5.3 Alternate Wetting and Drying Test

In this test a set of stabilized adobe blocks are subjected to twelve cycles of alternate wetting and drying to know the durability of stabilized adobe. As per code IS 1725: 1982 [1], the loss of weight and wet compressive strength of the stabilized adobe blocks were calculated for all combinations at the end of 12 cycles. Graph 3 presents % loss of weight of stabilized adobe where we can observe 15% clay content lime stabilized adobe shows more loss in weight compared to other stabilized adobes



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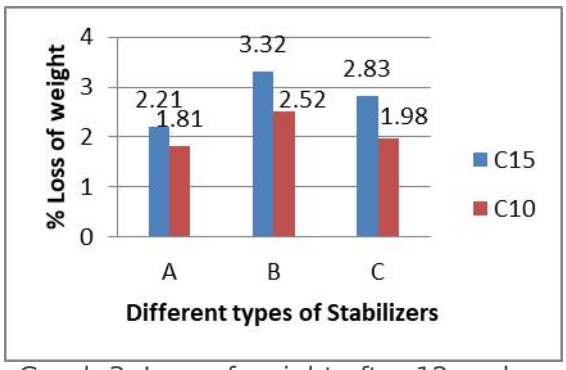
containing different stabilizers and percentage of clay content. In graph 4, in both 15% clay content and 10% clay content stabilized adobe cement stabilized adobe shows highest wet compressive strength and lime alone shows least wet compressive strength next to combination of cement and lime stabilized adobe. From image it can be observed that lime stabilized adobe shows more damage and cement shows less damage on the surface of the block. This loss may be due to handling and placing of stabilized adobe blocks during testing process.

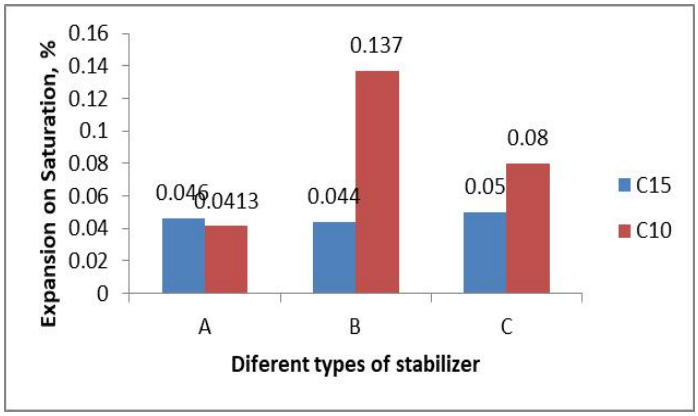


Graph 3: Loss of weight after 12 cycles of Alternate wetting and drying

Graph 4: wet compressive strength after 12 cycles
of Alternate wetting and drying

5.4 Expansion on Saturation

It can be observed from the graph 6 that expansion of stabilized adobe blocks on saturation is minimal and are within 0.3% as suggested by K S Jagadish[9].it shows negligible influence on the dimensions of stabilized adobe block. All types of stabilized blocks shows good volume stability against saturation of
Blocks.



Graph 6: Expansion on saturation of soil adobe with different types stabilizers

5.5 Efflorescence test

As per IS 3495(part 3):1992 presence of efflorescence shall be classified as nil slight, moderate, heavy or serious. From the image it has been observed there is no whitish crystalline deposition on the stabilized adobe blocks. Therefore we can conclude that it is susceptible to efflorescence.

6. Conclusions

Following are the some conclusions drawn from experimental study and test results

1) In wet compressive Strength cement alone as stabilizer shows higher wet compressive strength and lime alone as a least wet compressive strength and combination of cement and lime as a stabilizer lies in between them in both 15% and 10% clay content Stabilized adobe.
2) Flexure strength follows the same trend as wet compressive strength given the performance. In the flexure also Strength of cement alone as stabilizer shows higher wet compressive strength and lime alone as a least wet compressive strength and combination of cement and lime as a stabilizer lies in between them in both 15% and 10% clay content Stabilized adobe.
3) The wet compressive strength increased as the flexure strength increased and vice versa.
4) In the water absorption test lime as a stabilizer shows highest water absorption and cement as stabilizer shows least water absorption and combination of cement and lime as a stabilizer lies in between them in stabilized adobe.
5) As the water absorption increases wet compressive strength decreases and vice versa.
6) In alternate wetting and drying test, after completion of 12 cycles, loss of weight is less in cement alone and combination of cement and lime compared to lime alone.
7) In expansion on saturation test, all stabilized adobes are within 0.3% as sugested by Jagadish K S.
8) All types of stabilized adobes are free from whitish crystalline deposition on the surfaces.

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