# Adobe Bricks Stabilized With Cement and Natural Rubber Latex

**Razia Begum, Ahsan Habib, Hosne Ara Begum**

***Abstract- This study seeks to assist people in rural areas of Bangladesh by proposing sustainable methods which implement affordable and durable adobe bricks for construction. Adobe one of the oldest building materials in the world, is strong when dry but lacks structural integrity when exposed to moisture. Chemical additives such as cement and natural rubber latex are added into the adobe mixture to protect the brick against moisture decomposition. Once the chemicals are added and the mixture is formed into a brick , a stabilized adobe brick is formed. The tested brick mixes, measured by volume were 1:1:1 (Soil: Fine Sand: Cement) with natural rubber latex 0, 01, 02, 03, 04, 05% (by wt of water). After testing these bricks by water jet, submersion, Water absorption, modulus of rupture and compression, 1:1:1 soil, fine sand, cement with natural rubber latex 05% proved to be viable options for economical and durable bricks. This study explores that cement and natural rubber latex in adobe brick effects optimum compressive strength and low water absorption. The results provide a guideline for producing adobe brick containing cement and natural rubber latex with improved compressive strength and low water absorption. Adobe brick with performance improved in this ways will be beneficial for developing low cost architecture for local people and for building hotels and recreation facilities for the tourism industry.***

## I. INTRODUCTION

In Bangladesh, resources of conventional building materials are brick, timber, cement etc. These are very scarce and can not cope with the increasing demand. The cost of better alternative building materials is high. The income of our common people is comparatively low and the living condition of majority of our families is far below the average living standard. Therefore, our research and development in the field of housing and building has so far been aimed at helping construction of houses which are durable, economical and conform to better health standards and simultaneously emphasis has been laid to improve traditional building materials.

Adobe has not lost its indispensability as a building material since the primitive ages of civilization. Use of these sun dried blocks/bricks dates back to 8000 B.C.(Houben and Guillard 1994)[1].The greatest merits of adobe are its low cost, easy availability and possibility of production by unqualified workmen. Adobe buildings also offer significant advantages in hot, dry climates. They remain cooler during the day and warmer during the night, as adobe stores and release heat very slowly. Besides, earth construction offers a way for people to feel and actually become more meaningfully connected to nature because it is a form of natural architecture built with environmentally friendly materials (Taylor. 2009)[2.]

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Binici et al (2007)[3] studied the thermal isolation of fiber reinforced mud bricks as wall materials. Their results showed that the fiber reinforced mud brick house results in a temperature of 56.3% cooler than the concrete brick house in the summer and 41.5% warmer in the winter. For centuries, mankind has tried to find remedies for its two major deficiencies, its non-resistance to water and comparatively low mechanical strength. The question is how to minimize the two deficiencies of adobe without impairing these merits. Although there are reports of innumerable works on the subject of stabilization of soil with cement, lime[4].Usually cement and/or lime and compacting it increases the materials compressive strength and durability, reduces shrink and swell, and provides water proofing qualities (Winterkorn 1975[5], Akpokodje 1985[6], UN 1992[7], Heathcote 1995[8], Symons 1999[9], Walker 2004[10]). The effects of lime and cement on soil stabilization are well documented (Croft 1968[11], Bryan 1988b[12], Walker 1995[13], Bell 1996[14], Ngowi 1997[15], Reddy and Gupta 2005[16]). So, the efforts for improvement comprise addition of suitable admixtures. Present work is mainly a similar effort aimed stabilizing adobe with cement and natural rubber latex.

## II. MATERIALS AND METHODS

### *2.1 Raw materials*

Locally available soil, fine sand, cement and natural rubber latex are required for manufacture of adobe bricks. Soil used in this study collected from Saver, Dhaka. Test for the basic properties of soil included the percentage of clay, sand and silt particles. Other test included the Atterberg's limit of soil mass according to ASTM D4318 (ASTM 2006)[17] to determine the liquid limit, plastic limit, plastic index and activity. Physical analysis of raw soil sample was done at Housing and Building Research Institute (HBRI) laboratories. The results are presented in Table-1.The cement used in this study was a commercial ASTM type-1 ordinary Portland cement.

### *2.2 Experimental:*

#### *2.2.1 Preparation of the specimens:*

For the preparation of adobe brick specimens cement, fine sand and soils ratio of 1:1:1 in weight basis and water : cement ratio of .55 was used. The particle size of fine sand used in this study was in the range of 0.02-2mm. The amount of natural rubber latex added were 0, 01, 02, 03, 04, 05% based on the weight of water and specimens designated as A,B,C,D,E,F.

The adobe making process involves mixing of cement, soil, fine sand (<2mm) by hand. After dry mixing of all the ingredients, then mixing with water and natural rubber latex of 0, 01, 02, 03, 04, 05%(by wt of water) to get a required consistency. A uniform mix for each batch was achieved by mixing thoroughly. The prepared mixture was then placed into the mold


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(9.5"x4.5"x2.75") and compressed using a manual ram. After 24 hours the mold is demolded and cured in the shade for at least 28 days, where they were sprayed with water every three days. This allows optimal consolidation through out the adobe bricks. Control adobe brick(clay adobe)specimens were also prepared to be used as reference point to compare the stabilized adobe bricks. Clay adobe and stabilized adobe mix proportions (% measured by volume) are presented in Figure-1 and Fig.-2.

After preparation, Durability and strength tests performed on stabilized adobe bricks. For durability, water jet, submersion and water absorption tests were carried out according to Micek et al (2006 )[18] and (ASTM C20) [19] .

For strength, Modulus of rupture (ASTM C99-87)[20] and compression test (ASTM C170)[21] were carried out. Test results are presented in Table-3, Figure-1-2.

**Table-1Physical properties of soil**

| | |
|---|---|
| Clay | 58% |
| Silt | 22% |
| Sand | 20% |
| Liquid limit | 142.80 |
| Plastic limit | 56.00 |
| Plastic index | 88.60 |
| Activity | 0.45 |

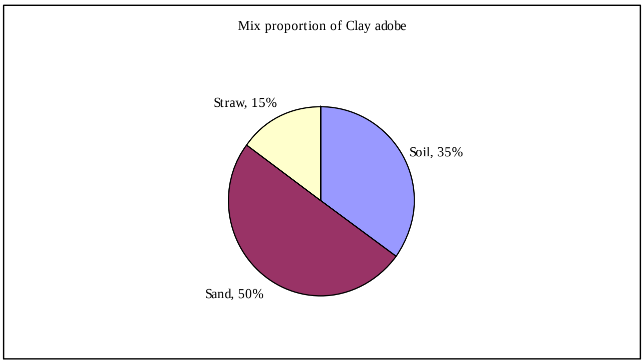


Figure-1: Clay adobe mix proportions.

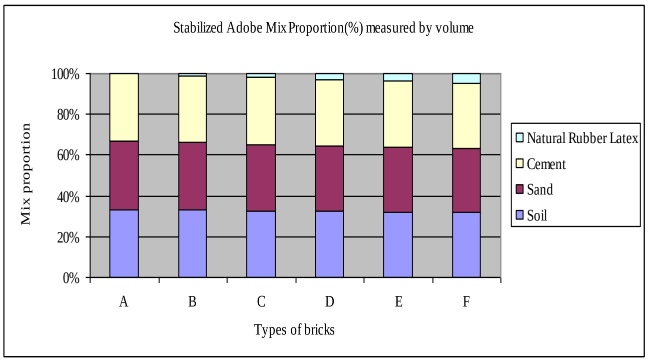


**Figure-2: Stabilized adobe mix proportions**

**Table-2Durability test results performed on stabilized adobe bricks.**

| Brick Type | Water jet test results after 30 seconds exertion. Average penetration (%) | Submersion test results after 24 hours submersion. |
|---|---|---|
| Clay adobe | 22.7 | Severe |
| A | 0 | Negligible |
| B | 0 | Nil |
| C | 0 | Nil |
| D | 0 | Nil |
| E | 0 | Nil |
| F | 0 | Nil |

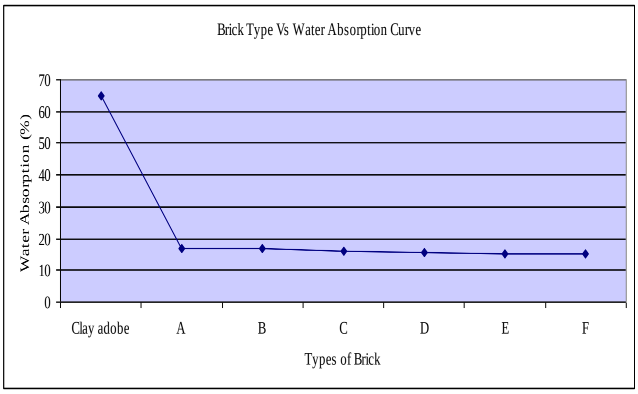


**Fig- 1: Brick Type Vs Average water absorption (%) curve.**

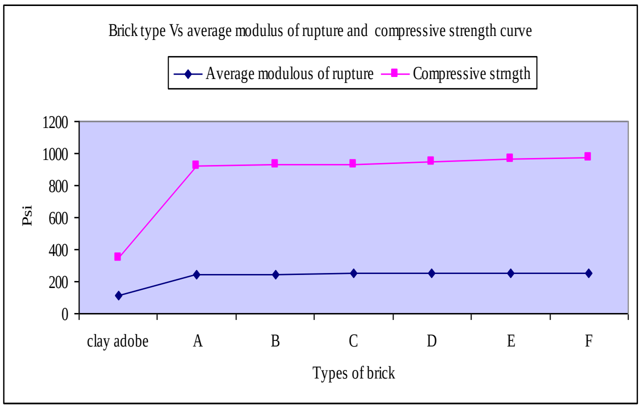


**Fig- 2: Brick Type Vs Average Modulus of rupture and compressive strength Curve.**

## III. RESULTS AND DISCUSSIONS

Properties of soil used in this study are shown in Table-1. The soil properties included liquid limit, plastic limit, plastic index and activity. The activity less than o.75 indicated that soil has relatively small volume changed, which is suitable for adobe bricks production. Stabilized adobe mix proportions (% measured by volume) are presented in Table-2. In this study, adobe stabilized with cement and natural rubber latex. Latex additives do add several positive characteristics to sand cement mortar mixtures increased tensile strength, bond strength, water resistance, impact resistance, density etc. [22]. The adobe brick in this study were compressed using a manual ram, which is a technique different from the traditional method of making adobe. Because, compressing the aggregate with cement allows for proper adhesion and unification for each bricks. Adobe is traditionally placed in a molds and cured in direct sunlight but in this study, adobe bricks cured in a shade since hydrolysis is a slow process and cement stabilized bricks should cure in cool environments.

Table-2 represents the durability test results performed on stabilized adobe bricks. The water jet test indicated the durability of the bricks when subjected to heavy rain conditions. Penetration depth of 0% was this investigations standard for a sufficiently durable bricks. The approximate rate of water penetration was also visually noted. As soon as the water breached the surface of the brick, the penetration rate increased. For this reason, the 0% water penetration standard was chosen for brick durability. If some level of penetration were acceptable, the entire brick would likely deteriorate after the first rainy season.Table-2 also represents average rating for bricks after 24 hours submersion. The submersion test indicates the durability of the bricks when exposed to flooding. The standard for this submersion test was having no visible damage after 24 hours of submersion. Clay adobe bricks are vulnerable to moisture. But cement and natural rubber latex stabilized adobe bricks performed extremely well in water submersion. Bricks undergoing a water jet test followed by a submersion test attempted to simulate real life conditions of heavy rain pounding on the bricks followed by flooding.

Water absorption is an important parameter for adobe bricks. From Figure -1, It is observed that the water absorption of the brick bodies decreases with increase in natural rubber latex content for all brick bodies compositions, since a greater densification of the sample occurred. The combination of cement and natural rubber latex sample F presents a low water absorption than clay adobe and sample A without natural rubber latex content.

Modulus of rupture is important for adobe bricks. The intent of the modulus of rupture test was to test and verify that each batch of bricks meet quality standard. According to the Masonry Standard Joint Committee (MSJC), the allowable flexural tensile stress or modulus of rupture, for clay and concrete masonry is 30 psi (MSJC Table 2.2.3.2). Using 30 psi as the quality standard, the allowable rupture load could be determined. From 0, 01, 02, 03, 04, 05% (by weight of water) mix of natural rubber latex meet the allowable MSJC modulus of rupture but the clay adobe bricks do not. Figure-2 shows the variation of modulus of rupture as a function of natural rubber latex. Modulus of rupture depends on the materials composition and dimension. The combination of cement and natural rubber latex sample F presents a high modulus of rupture than clay adobe and sample A without natural rubber latex content. The compression test exhibits the capacity of the bricks when subject to an axial load. The experimental results are shown in Figure-2, In clay adobe, the compressive strength is 351 psi at 28 days, while the corresponding strength of sample F is as high as 970 psi. Morel, Pkla and Walker (2007) (23) stated that typical compressed earth blocks (CEB) made with a manual press have compressive strengths in the range of 2-3Mpa (290-435psi). In this investigation, all stabilized bricks fall above the typical compressive strength category. Besides, in this study the sand particles are between 0.02-2mm, the clay will have a low level of porosity, a quality that increases compressive strength (Terzaghi Brazelton, &Gholamreza,1996). The modulus of rupture and compressive strength of stabilized adobe bricks with this additive, the strength improved by up to 5% and reduced water absorption up to 10%. These additives could help increase the strength and reduce the water absorption through the densification of the natural rubber latex brick body.

## IV. CONCLUSIONS

The astronomical rise in building materials has leads to the search for ones that are cheap and locally available, especially in poor countries of the world. Adobe brick has been in used in rural areas in Bangladesh. In order to improve the quality of the adobe, the addition of cement and natural rubber latex to soil has been examined. Compressive strength, Modulus of rupture, water absorption and cracking of adobe were improved. Incorporation of natural rubber latex in adobe mixture has significant effects on the properties of adobe namely water absorption, modulus of rupture and compressive strength. Strength and water absorption is an important factor that influences brick durability. A brick with low water absorption and high strength can be expected to have greater durability and resistance to the natural environment.

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## REFERENCES

1. Houben, H. and Guillaud, H., 1994. Earth construction: a comprehensive guide. London: IT Publications.
2. Taylor, C.R. (2009) Building for free with alternative natural materials. Retrieved on 23 January 2009, from www. countrysidemag.com
3. Binici,H., Aksogan, O.,Nuri,B.M., Akca,E., & kapur,S.(2007). Thermal isolation and mechanical properties of fibre reinforced mud bricks as wall materials. Construction and Building Materials, 21,901-906.
4. Eyre, T.T. (1935), The Physical Properties of Adobe used as a Building Material. The University of New Mexico Bulletin, No. 263, Albuquerque.
5. Winterkorn, H.F., 1975. Soil stabilization, Foundation engineering handbook, H.F. Winterkorn and H.-Y. Fang, eds., Van Nostrand Reinhold Company, New York.
6. Akpokodje, E.G.1985. The stabilization of some arid zone soils with cement and lime. Quarterly journal of engineering geology, 18,173-180.
7. UN.,1992. Earth construction technology United Nations Centre for Human Settlements, Nairobi.
8. Heathcote, K.A. 1995. Durability of earthwall buildings, Construction building materials, 185-189.
9. Symons, W. G., 1999. Properties of Australian soils stabilized with cementitious binders, Structural Materials and Assemblies Group Univ. of South Australia, The Levels, South Australia.
10. Walker, P.J., 2004. Strength and erosion characteristics of earth blocks and earth block masonry, Journal of Materials in Civil Engineering, 16(5), 497-506.
11. Croft, J.B., 1968. The problem in prediction the suitability of soils for cementatious stabilization Engineering Geology (Amsterdam), 2(6) 397-424.
12. Bryan, A.J., 1988b. Soil/cement as a walling material-I. Stress/strain Properties. Build environment, 23(4), 321-330.
13. Walker, P.J., 1995. Strength, durability and shrinkage characteristics of cement stabilized soil blocks. Journal of Materials in Civil Engineering, 17, 301-310.
14. Bell, F.G. 1996. Lime stabilization of clay minerals and soils, Eng. Geol. (Amsterdam), 42 (4),223-237.
15. Ngowi, A.B.,1997. Improving the traditional earth construction: A case study of Botswana. Construction building materials, 11(1), 1-7.
16. Reddy, B.V.V., and Gupta, A. 2005. Characteristics of soil-cement block using highly sandy soils. Materials and structures, 38(6), 651-658.
17. ASTM D4318 (ASTM 2006). Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
18. (Micek 2006) Micek, joel, et al.. Adobe Brick Design. Senior Project. California Polytechnic State University, San Luis Obispo. 2006.
19. (ASTM C20) Standard Test Methods for water absorption.
20. (ASTM 2006) " Standard Test Method for Modulus of Rupture of Dimension Stone" ASTM. (2006): C99-87
21. (ASTM 2006) " Standard Test Method for Compressive Strength of Dimension Stone." ASTM. (2006): C170-06.
22. Installing ceramic tile veneers with latex modified mortar and grouts, Ceramic tile institute of America, INC. 12061 Jefferson Blvd., Culver City, CA 90230-6219
23. (Morel, Pkla, and Walker 2005) Morel, Jean-Claude, Abalo Pkla, and Peter Walker. "Compressive strength testing of compressed earth blocks." Construction and Building Materials. 21(2007) 303-309.
24. Terzaghi, K., Brazelton, P.r., & Gholamreza, M.(1996). Physical properties of soils. Soil Mechanics in Engineering Practice.New York: Wiley-IEEE.