International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-7,October 2015
ISSN: 2395-3470
www.ijseas.com

Feasibility study on River dredged soil in Preparation of Compressed Stabilized Dredged Brick

Ms. Razia Begum, Md. Abdus Salam, Md. Shah Mostafa
Housing and Building Research Institute
Darus-Salam 120/3, Mirpur, Dhaka-1216, Bangladesh

Abstract

There is a need for development of alternative materials for the building industry with low carbon footprint and at the same time saving energy. Clay has been used as a building material from the beginning of humankind. The Compressed stabilized Earth Blocks often referred to simply as CSEB, is a type of manufactured construction material formed by the compression of the soil and stabilized with cement in a mould with the help of a manual or motorized press to form a regular block of appropriate shape and size. In the present work, Earth is replaced by Dredged soil and cement as stabilizer on some of the mechanical and physical properties of unfired CSDB was determined. A series of test bricks were fabricated using a Dredged soil stabilized with 3, 5, 6, 8, 10, and 12% cement, and compacted with a manual press (CINVA -RAM Machine). Results of Density, Compressive strength, Modulus of rupture, Water absorption are presented in this paper. Results show that the addition of cement and compaction with CINVA-RAM machine improves the mechanical and physical properties of CSDB. These preliminary results reinforce their suitability for application in low cost buildings.

Keywords: CSDB, Stabilization, Mechanical behaviors.

Introduction:

The utilization of earth in housing construction is one of the oldest and most common methods used by a larger percentage of the developing countries' population. It is the most readily available and cheap material found everywhere. It is easy to work with, requires less skills and as such, it encourages and facilitates unskilled individuals and groups of people to participate in their housing construction on self-help basis. It offers a very high resistance to fire and provides a comfortable built living environment due to its high thermal and heat insulation value. It also offers other important factors all of which attribute to the achievement of a good house planning/design and construction solution.

Over the past 40 to 50 years, there has been an increasing interest in the use of stabilized compressed earth blocks for residential construction [1-10]. They maximize the use of locally available materials; require relatively simple construction methods, whilst offering favorable thermal and acoustic insulation properties. Environmental benefits include reduced energy consumption in production and a lessening demand for non-renewable resources [1]. Earth building is not a characteristic only of the Third World. Earth walled houses can be found in France, Germany, New Zealand and in some regions of Australia about 20% of the houses are built with walls of unfired earth. In western countries, thousands of luxury earth homes have been built in the last few decades [7]. The shortage of low cost and affordable housing in Bangladesh has led to many investigations into new building masonry materials. Fired clay masonry bricks are conventionally used for mainstream masonry wall construction but suffer from rising price of energy plus other related environmental problems, such as high energy usage and carbon dioxide, fluorine, and sulfur emission. On the other hand, Bangladesh is drained by 300 major rivers and channels most of which originate outside the country (Er-Rashid, 1978)[11]. Using dredged soil, island char, attached char soil as building materials, increases in land elevation and water carrying capacity of the rivers will reduce flooding propensity in Bangladesh. Besides, use of fertile topsoil and the forest resources for the production of burnt clay bricks will be saved and carbon emission will be reduced.

Research has shown that controlling the water content and increasing the compression pressure can improve the properties of the adobe bricks. Using a rigid mould can enhance its appearance. These improvement can be achieved if the bricks are made under pressure in a brick making machine (Ogah Sylvester Obam and Amos.Y. Iorliam. 1980) [12]

So, Present work is aimed to develop Compressed Stabilized Dredged Bricks (CSDB) with dredged soil, island char, and attached char soil from various areas and stabilized by cement through compaction.

Experimental:

Materials:

The raw materials used for this study are dredged soil, sand and cement.

Sediment samples (Dredged soil) were directly collected from the Turag river,Dhaka during the dredging of Turag bed sludge, the sediment bed is about±16-25 ft. The selected sample drawing points of the Turag river includes near Beruliya. Design of soil sediment samples amount is expected 200cft for this site of sampling point.

Locally available fine sand are collected. Most commonly available sand of Bangladesh is Savar sand. Particle size distribution were determined prior to use in sample preparation. Basic physical properties were determined of Savar sand used for this research. Unit weight was measured as per ASTM C 29[13], specific gravity and absorption capacity were determined conforming ASTM C128[14] and sieve analysis was conducted conforming ASTM C136[15]. From the test result, specific gravity -2.14, absorption capacity-8.67%, average unit weight -1400kg/m^3 and fineness of modulus were found 1.02 respectively.

Portland composite cement (PCC) type CEM ll (BDS 197-1) were collected from the local market and characterized in the laboratory. PCC was tested at the laboratory of HBRI and specific gravity was found of 3.0. Cement was tested for compressive strength following ASTM C109 [16]. Average compressive strength of PCC for 3 days, 7 days and 28 days were 15, 20, 25 MPa respectively

Methodology:

Index Properties, Elemental analysis of dredged soil and Grain size analysis was carried out by use of standard test methods. The results of laboratory testing are shown in Table-1, Table-2 and Figure-1. Based on Table-1, Through experimenting with Trial and Error method, It was established that the most ideal mix design for the soil that was being used are shown in Table-3 and Table-4. Density of Compressed Stabilized Dredged Bricks (CSDB) were measured according to ASTM C 140[17]. The Compressive strength of Compressed Stabilized Dredged Bricks (CSDB) were measured according to ASTM C170 [18]. Water absorption measurements of these bricks were carried out according to ASTM C140-01[19].Modulus of rupture of Compressed Stabilized Dredged Bricks (CSDB) were measured according to ASTM C 99-87[20]. Submersion and Water jet test of Compressed Stabilized Dredged Bricks (CSDB) were measured according to Micek et al.2006 [21].

Sample Preparation:

The materials mentioned in Table-3 and Table-4 were added to the mixture with the proportion given in dry state. Dredged soil is mixed with water to create a damp mix. Water was added gradually and the ingredients were further mixed thoroughly using shovel until the mixture attained a uniform consistency.The soil, raw or stabilized, for Compressed Stabilized Dredged Brick(CSDB) is slightly moistened, poured into press (with or without stabilizer) and then compressed with a manual press (CINVA-RAM Machine). CSDB can be compressed in many different shapes and sizes. Subsequently, it can be used like common building bricks with a soil cement stabilized mortar.

The CSDB were molded using the CINVA-RAM machine delivers a capacity pressure of 2.8N/mm^2[22]. The machine comprises of a rammer and a liver arm which is used to push out the finish bricks of dimension 9.5"x 4.5"x 2.75" from one compartment box. One series of bricks was made with stabilizer and one series of bricks was made without stabilizer. Carefully move the bricks to the curing area after over night. Bricks were stored on a flat, non-absorbent surface in a shady environment to cure. A space of about an inch between bricks must be provided to cure them properly. Water was sprinkled over the bricks to optimize the curing process. After the fabricated bricks had cured (>28days) Density, Compressive strength, Modulus of rupture, Water absorption, Water jet and Submersion test were determined to identify the humidity level of bricks.

Table -1: Dredged soil index properties

Index properties	Unit	Ranges of values
Water content	%	60.15-70.74
Specific gravity	-	02.63
Organic content	%	0.75-4.0
Liquid limit(LL)	%	38.06
Plastic limit(PL)	%	18.98
Plastic Index(PI)	%	19.09
Shrinkage limit(SL)	%	25.22

Table-2: Elemental Analysis of Dredged soil

Elements	Results(%)
Na	0.473%
Mg	1.05%
Si	24.7%
Al	6.83%
Fe	6.54%
K	2.98%
Ca	1.56%
Ti	0.676%
S	0.177%
Mn	0.123%

Table-3: Mix composition of unfired Dredged soil specimens (wt %).

Mix ingredients (Low Dredged soil content)

Sl no.	Portland cement (%)	Sand (%)	Dredged soil (%)	Water/Solid ratio
01.	03%	48.50	48.50	0.142
02.	05%	47.50	47.50	0.135
03.	06%	47.00	47.00	0.125
04.	08%	46.00	46.00	0.125
05.	10%	45.00	45.00	0.115
06.	12%	44.00	44.00	0.115

Table-4: Mix composition of unfired Dredged soil specimens (wt %).

Mix ingredients (High Dredged soil content)

Sl no.	Portland cement (%)	Dredged soil (%)	Water/Solid ratio
01.	03%	97	0.138
02.	05%	95	0.136
03.	06%	94	0.135
04.	08%	92	0.130

05.	10%	90	0.130
06.	12%	88	0.128

Results and Discussion

The materials used for the construction of wall are normally required to possess adequate compressive strength and erosion resistance. Such properties of the dredged soil can be improved by stabilized with cement. The strength of stabilized dredged soil can further be improved by the process of compaction which leads to higher densities, thereby higher compressive strength and better resistance to erosion.

Characteristic Properties of dredged soil:

Index properties testing program of dredged soil were concerned with specific gravity, water content, density, and atterberg limit using standard test methods. The results of the different properties of dredged soil samples are presented in Table-1.The evaluation of the different properties revealed that the specific gravity of dredged soil samples is 2.63, water content is 60.15-70.74% and organic content is 0.75-4.0%.

Grain size analysis:

The grain size distribution of the tested dredged soil (Beruliya) was carried out according to ASTM D422-63 [23] and percentage of sand, silt, clay is 18%, 77%, 05% (Figure-1). Atterberg limit done according to ASTM D4318-05 [24] yielded a liquid limit of 38.06% and a plastic limit 18.98% and plastic index 19.09.

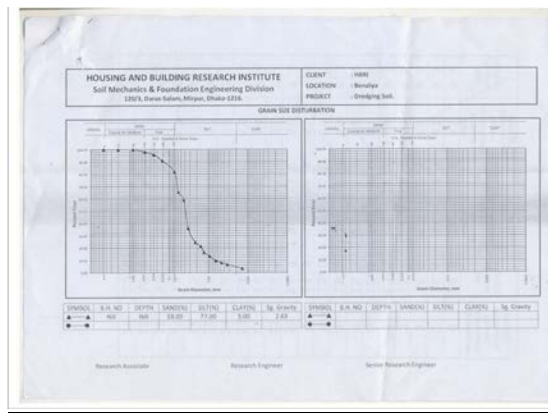

Figure-1: Grain size analysis of Dredged soil (Beruliya)

Density:

Figure-2 shows the Density Compressed Stabilized Dredged Bricks. The Density of the Compressed Stabilized Dredged Bricks (CSDB) is within the range of 1700-2000kg/m^3. Density of the Compressed Stabilized Dredged Brick (CSDB) is consistently related to its compressive strength and compactive force applied during production. The dry

International Journal of Scientific Engineering and Applied Science (IJSEAS) - Volume-1, Issue-7,October 2015
ISSN: 2395-3470
www.ijseas.com

density is largely a function of the constituent materials characteristics, moisture content during pressing and the degree of compactive load applied.The Density of the Compressed Stabilized Dredged Brick (CSDB) is determined according to standard procedure such as ASTM C 140 [17].

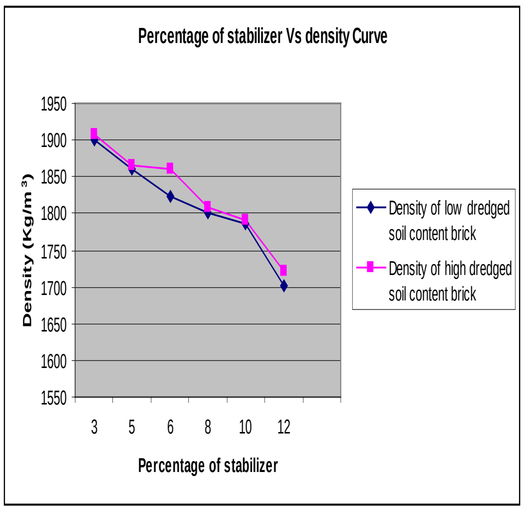

Figure-2: Percentage of stabilizer Vs density curve

Shrinkage:

Drying Shrinkage of the bricks was primarily governed by the plasticity index and cement content. The dimensions of the bricks (CSDB) were measured after three months. Usually very little water is required to produce Compressed Stabilized Dredged Brick. Besides, Sand was used to make the final product durable, in addition to reduce the effect of shrinkage of the clay that may occur. So, the bricks do not shrink or crack.

Water jet test:

The water jet test indicated the durability of the bricks when subjected to heavy rain conditions. The water jet test was chosen because the water pressure exerted on the bricks could be calculated and kept constant. Penetration depth of 0% was this investigations standard for a sufficiently durable brick. The approximate rate of water penetration was also visually noted. The percentage of water penetration for each type of brick is presented in (Table-5).The Water jet test of the Compressed Stabilized Dredged Brick (CSDB) is determined according to standard procedure such as Micek et al.2006 [21].

Table 5: Water Jet Test Results After 30 Second Water Exertion Type of Brick

Type of Brick	Average Penetration (%)
03%Cement Stabilized Adobe Brick	Negligible

05%Cement Stabilized Adobe Brick	Nil
06%Cement Stabilized Adobe Brick	Nil
08%Cement Stabilized Adobe Brick	Nil
10%Cement Stabilized Adobe Brick	Nil
12%Cement Stabilized Adobe Brick	Nil

Water absorption:

Figure-3 shows the water absorption of Compressed Stabilized Dredged Bricks. Water absorption test can be used as an indicator for the specimens resistance to immersion in water. The water absorption of the Compressed Stabilized Dredged Brick (CSDB) is determined according to standard procedure such as ASTM C 140 [17].The results explained that amount of the absorbed water decreased as the cement dosage increased.

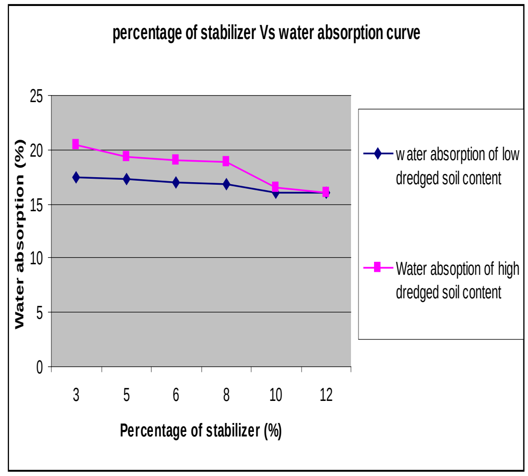

Figure-3: Percentage of stabilizer Vs water absorption curve

Submersion:

The submersion test indicates the durability of the bricks when exposed to flooding. The submersion test consisted of submersion brick in tank of water for 24 hours to observe condition after soaking. The bricks' deterioration was evaluated after one hour and after 24 hours, as prescribed by Micek et al. (2006)[21]. The standard for this submersion test was having no visible damage after 24 hours of flooding. The Submersion test of the Compressed Stabilized Dredged Brick (CSDB) is determined according to standard procedure such as Micek et al.2006 [21]. In this investigation all manual pressed cement stabilized adobe bricks have no visible damage (Table-6, Figure-4).

Table 6: Average rating for bricks after 1-hour and 24-hour Submersion Test Results

Brick Type	Percentage of stabilizer (cement)	After 1 hour submersion effect	After 24 hours submersion effect
Compressed Stabilized Dredged Brick (CSDB)	03%	No change	Negligible
	05%	No change	No change
	06%	No change	No change
	08%	No change	No change
	10%	No change	No change
	12%	No change	No change

Figure-4: Submersion test of Compressed Stabilized Dredged Bricks

Compressive strength:

The compressive strength of Compressed Stabilized Dredged Brick specimens were determined using Universal testing machine(Model No. TIB/M.C; Capacity -300 ton). The compressive strength test for the different levels of cement stabilization at the optimum w/c ratio at air dried curing method for dredged soil samples were undertaken.

The compressive strength of Compressed Stabilized Dredged Brick (CSDB) are presented in Figure-5. The results show that increased compactive effort and cement improve the compressive strength of Compressed Stabilized Dredged Bricks (CSDB) as compared with plain adobe brick. According to Uniform Building Code requirements [25] the minimum compressive strength acceptable is 300psi. According to The New Mexico Building Code (NMBC) minimum ultimate compressive strength is of 300 psi [26]. Morel, Pkla and Walker (2007) [27] stated that the typical compressed earth blocks (CEB) made with a manual press have compressive strengths in the range of 2-3 Mpa (290-435 psi). ASTM

C62 [28], BS EN 771 1-3[29,30] AND SANS 1215/SANS 227[31] are some of the national standards prescribing minimum compressive strength of solid clay and concrete masonry units, where the minimum are given by 8, 6. 5 and 3.5 Mpa respectively (Mention is however not made of the condition of bricks before testing i.e are to be tested when dry and when saturated.).

The strength obtained also compares favorably with the minimum British standard requirements of 2.8N/mm$^{2.}$ In this investigation all manual pressed cement stabilized adobe bricks have an acceptable compressive strength.

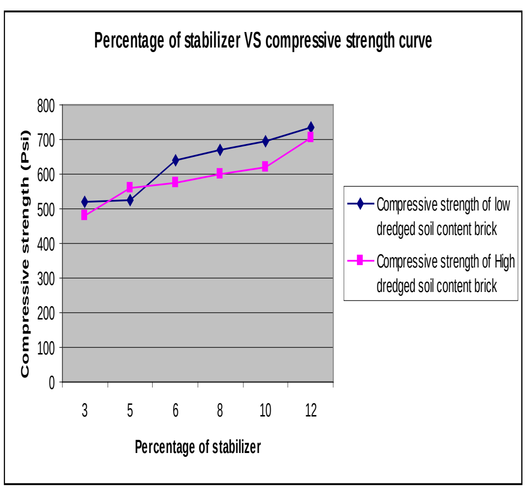

Figure-5: Percentage of stabilizer Vs Compressive strength curve

Modulus of rupture:

The intent of the Modulus of rupture test was to test and verify that each batch of bricks meet quality standards. Modulus of rupture of Compressed Stabilized Dredged Brick (CSDB) is determined according to standard procedure such as ASTM C 99-87[32](Figure-6).The New Mexico Compressed Earth Block Building Code, modulus of rupture standard is 50psi. In this investigation, 03%-12% cement mix Compressed Stabilized Dredged Brick (CSDB) meet the allowable modulus of rupture standard of 50 psi.

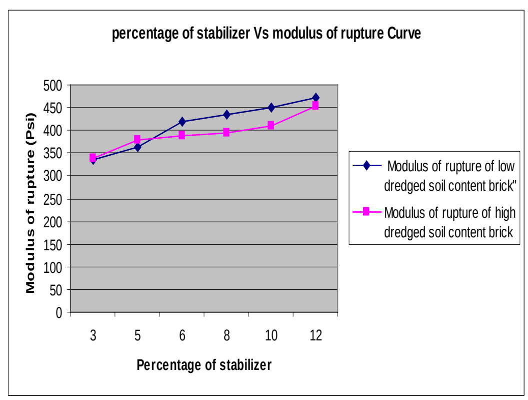

Figure-6: Percentage of stabilizer Vs Modulus of rupture curve

Conclusion:

This research project was based on evaluating dredged soils to determine their suitability for making Compressed

Stabilized Dredged Brick (CSDB) for use in affordable residential buildings. The Compressed Stabilized Dredged Brick (CSDB) made gave an average dry density of Low Dredged soil content is 1811.45 kg/m^3, an average compressive strength of 630.17 psi and a modulus of rupture of 411.75 psi and for High Dredged soil content average dry density is1825.51 kg/m^3, an average compressive strength of 590.32 psi and a modulus of rupture of 393.23 psi . These values are higher than the code requirements for this form of construction. Building Codes like the Uniform Building Code, and the New Mexico Compressed Earth Block Building Code, Earth Building Code, require average block compressive strengths of 300 pounds per square inch and an average modulus of rupture of 50 pounds per square inch for compressed earth block one story buildings. Normative documents published in Zimbabwe, Australia, France and the USA, reviewed by Delgado and Guerrero [32] indicate CSEB standards, compressive strength standards range between 1.3 and 2.1 Mpa for use in non load bearing walls. However, Deboucha and Hashims [33]study find that in practice typical compressive stresses in up to 1 storey construction range from 1-4 Mpa. Many building authorities around the world recommend values within this range (CDE, 1998).These Compressed Stabilized Dredged Bricks (CSDB) meet such code requirements and therefore can be used for the stipulated type of housing. The reduction of transportation time, cost and attendant pollution can also make CSDB more environmentally friendly than other materials.

Acknowledgement:

This study was supported by the Housing and Building Research Institute. The authors would like to acknowledge the experimental facilities provided by the Chemical Testing and Research Laboratory (CTRL) of HBRI. The authors are grateful to the support and assistance provided by Mohammad Abu Sadeque PEng (Joint Secretary), Director of HBRI and the other members of the research team, for their contributions. Geological Survey of Bangladesh were carried out the analysis Dredged soil by the method of X-ray florescence. The authors are grateful for their support.

References:

[1]. Peter Walker and Trevor Stace, "Properties of cement stabilize compressed earth block and mortars", Materials and Structures, Vol. 30, pp 545-551, November 1997

[2]. E.E.J Kamang "Strength properties of compressed earth bricks with earthworm cast as stabilizer", Journal of Environmental Sciences, 1(2),pp.65-70,1998

[3]. Lowenhaupt, "CAST EARTH". Website, www.castearth.com , December 2005.

[4]. "In-services deterioration of compressed earth blocks", Geotechnical and GeologicalEngineering 23: 461-468, 2005

[5]. Vroomen, R., "Gypsum stabilized earth" research on the properties of cast Gypsum- stabilized Earth and its Suitability for low cost housing construction in developing countries, Thesis for MSc Arquitecture, Building & Planning, Endhoven University of Technology, The Netherlands, June 2007.

[6]. Lawrence, M. et.al "Mortars for thin unfired clay masonry walls". Koblenz,Germany.pp.67-73, 2008

[7]. Joes Luis Reyes Araizal, Alejandr Manzano-Ramirez, "Unfired bricks made of clay-gypsum: Mechanical and thermal properties". Proceedings of the International Conference on Non-conventional Materials, Bath, UK,6-9 September 2009.

[8]. Isik, B., "Earth Construction", 14-May-2009 Website www.kerpic.org/alker technology.ht.

[9]. Carlos Marin Lopezl, "Effect of fly ash and hemihydrate gypsum on the properties of unfired compressed clay bricks", International Journal of the Physical Sciences Vol. 6(17),pp.5766-5773, 16 October, 2011

[10]. Esther Obonyo, "Optimizing the Physical, Mechanical and Hygrothermal Performance of Compressed Earth Bricks", Sustainability 3, 596-604, 2011 www.mdpi.com/journal/sustainability

[11].Er-Rashid, "Floods in Bangladesh: Possible Causes and solutions". 1978

[12].Ogah Sylvester Obam and Amos. y. Iorliam "Engineering Properties of clay rice husk ash composites".1980.

[13]. ASTM C 29 Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate.

[14]. ASTM C 128 Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregates

[15]. ASTM C 136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

[16]. ASTM C 109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

[17]. ASTM C 140, American Society for Testing and Material, ASTM C140-12/2012

[18]. ASTM C 170(ASTM 2006) "Standard Test Method for Compressive Strength of Dimension Stone" ASTM (2006): C 170-06.

[19]. ASTM C140-01, Standard test methods for sampling and testing concrete masonry units and related units, (2001).

[20]. ASTM C 99-87(ASTM 2006) "Standard Test Method for Modulus of Rupture of Dimension Stone" ASTM (2006): C 99-87.
[21]. (Micek 2006) Micek, Joel, et al. Adobe Brick Design. Senior Project. California Polytechnic State University, San Luis Obispo.2006.
[22].Y. G. Balami and Y. D. Izam, "Soil -Bitumen as a walling materials," Journal of Environmental Sciences, Vol.1(2).pp 29-34,1998.
[23]. ASTM D 422-63. 2002. Standard Test Method for Particle Size Analysis of Soils, Vol. 04.08
[24]. ASTM D 4318-05. 2006. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, Vol. 04.08, American Society for Testing and Materials, West Conshohocken, Pennsylvania, PA 19428, USA
[25].Handbook to the Uniform Building Code: an Illustrative Commentary. Whittier, Calif.: International Conference of Building Officials, c1988.
[26]. 2009 NEW MEXICO EARTHEN BUILDING MATERIALS CODE (Part -4)
[27].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.
[28]. ASTM C62 (2008), Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale), Vol 05.08, American Society for Testing and Materials, West Conshohocken, Pennsylvania, USA
[29]. BS EN 771-1 (2003), Specification for Masonry Units - Part 1: Clay Masonry Units, British Standards Institute
[30]. BS EN 771-3 (2003), Specification for Masonry Units – Part 3: Aggregate Concrete Masonry Units, British Standards Institute
[31]. South African National Standards (2008), SANS 1215 – Concrete Masonry Units, Standards South Africa, Pretoria.
[32]. Delgado M.C.J. and Guerrero I.J. (2007),The Selection of Soils for Unstabilised Earth Building: A Normative Review, Construction and Building Materials, Vol 21, pp 237 – 251.
[33]. Deboucha S. and Hashim R (2010), A Review on Bricks and Stabilised Compressed Earth Blocks, Scientific Research and Essays Vol. 6(3), pp. 499 – 506.

AUTHOR'S PROFILE

	**Ms. Razia Begum** Senior Research Officer, Housing and Building Research Institute, 120/3 Darus Salam, Mirpur, Dhaka-1216
	**Eng. Abdus Salam** Senior Research Engineer, Housing and Building Research Institute, 120/3 Darus Salam, Mirpur, Dhaka-
	**Md. Shah Mostafa** Research associate Housing and Building Research Institute, 120/3 Darus Salam, Mirpur, Dhaka-