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Reducing carbon dioxide emission by the adoption of contemporary earth construction in urban Bangladesh

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Abstract:
Stabilised earth is an alternative building material which is cheaper than conventional brick and concrete, and is also environmentally sustainable. Earth has been used as a construction material in every continent and in every age. The use of earth on site as a building material saves manufacturing cost, time, energy, environmental pollution and transportation cost. Most developing countries, in particular Bangladesh does not have any well structured and effective program to address the global agenda of environmental sustainability through the use of appropriate construction materials. In order to demonstrate stabilized earth as a sustainable appropriate construction material, the experiences and practices of using earthen architecture can be studied and harnessed from other countries to demonstrate the dynamism of this earth material suitable for construction in urban Bangladesh. This paper reviews and argues the environmental benefits (less carbon dioxide emission) of using stabilized earth as a building material and associated construction techniques for urban construction in Bangladesh. A critical literature review method was adopted in this paper to investigate how contemporary earth construction produces less carbon dioxide compared to the conventional brick and concrete construction.

Key words: Earth construction, sustainability, climate change, carbon dioxide emission.

Introduction:
Cities in the developing countries have, since the 1950's, experienced unprecedented growth in terms of spatial development and population increase; urban population increase has particularly been high due to rural-urban migration (Dwyer et al, 1981; Mafico, 1991). Bangladesh is not an exception from most of the developing countries. The annual urbanisation rate of Bangladesh is 6% (Akbar and Ahmed, 2008) and this urbanisation is an inherent part of the process of urban economic and infrastructure development in Bangladesh. In 1981 the total population in urban Bangladesh was 14.08 million, which increased to 22.45 million in 1991 (UNEP, 2001). With increased urbanization, the number of building also increased rapidly which contributed more to air pollution and carbon dioxide emissions. According to Allinson and Hall (2007), it is estimated that the construction and the operation of buildings is responsible for around half of all global Carbon Dioxide emissions, thereby contributing the largest single source attributable to climate change. According to Ahmed and Hossain, (2008), air pollution is one of the major manmade environmental problems that have recently gained importance among environmental issues in Bangladesh and exposure to air pollution is the main environmental threat to human health in towns and cities. Therefore, a solution has to be found to provide sustainable solution to this air pollution which is 'eco'-friendly and will preserve the environment for future generations; because climate change has been described as one of the most important environmental issues facing world today. According to Barbosa et al (2007, p30), the use of unburned earth in construction will contribute to reduce energy consume, Carbon Dioxide emission, amount of residues and desertification process. A critical literature review method was adopted in this paper to investigate how the use of stabilised earth in the construction can potentially reduce air pollution and carbon dioxide emission in Bangladesh. The paper begins with demystifying climate change and describing current scenarios of conventional fired brick making in Bangladesh. The paper also describes the different contemporary earth construction techniques which is viable in terms of natural disaster and critically analyses the environmental benefits of earth construction in general.

Conventional brick manufacturing in Bangladesh and carbon dioxide emission:
The total population of Bangladesh is 156 million (2006 census) and the area of the country is only 144000 sq. km (Ferdausi et al, 2008). Air pollution is one of the major environmental problems nowadays, especially for developing countries such as Bangladesh and brickfields have been identified as a vital pollutant source of the major cities of the

country (UNEP, 2001, Ahmed and Hossain, 2008; Ferdausi et al, 2008). According to Ahmed and Hossain, (2008), numerous brick-making kilns operating in the dry season are one of the major sources of air pollution in cities and a significant factor is that brick kilns are usually clustered near big cites in different parts of Bangladesh (Figure 1). Every year more than 20 lakh (2 million) metric tonnes of low quality coal and 20 lakh (2 million) metric tons of wood are burnt in the brick fields along with tires and rubber in Bangladesh (BPPW, 2005). Therefore, the parts of the city in the immediate vicinity of the brick-field clusters have air pollution problems. Figure 2 shows a common scene of conventional brick making in Bangladesh, which is one of the major air pollutant in Bangladesh.

Moreover even under well-controlled processes worldwide, 0.2 microgram toxic equivalents of dioxins and furans are emitted as by-product into the air during the production of each ton of brick, which is very harmful for lives (UNEP, 2005). According to Akbar and Ahmed (2008), brick making in Bangladesh is an informal sector activity with more than a million people depending on it for their livelihood and it is seasonal, highly energy intensive, and a major source of GHG emissions. Total production in Bangladesh is estimated at 15 billion bricks annually, and given the extensive use of coal and wood in the industry, the GHG emissions are estimated to be 8.75 million tonnes of CO_2 equivalent annually and demand for bricks is growing at about 5.6% annually, closely trailing the urbanization rate of approximately 6% (Akbar and Ahmed, 2008). Therefore, an alternative building material instead of fired brick is vital and the next section is going to analyse earth construction as an alternative solution in historical point of view.

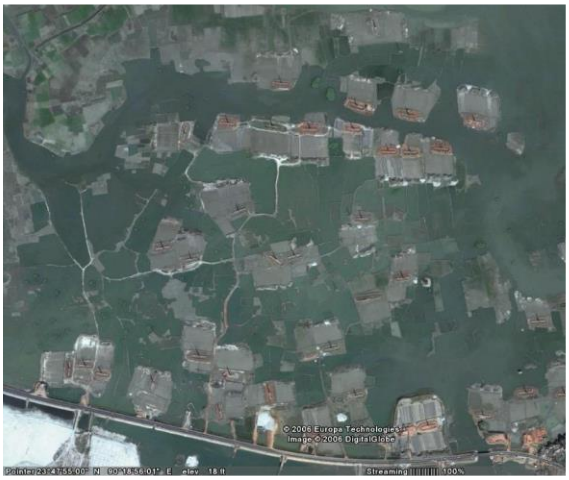

Figure 01:
Satellite image of the cluster of brick kilns near Dhaka City. Source: Ahmed and Hossain, 2008.

Figure 02:
A typical brickfield in Bangladesh and air pollution. Source: BANGLAPEDIA: brickfield.

Earth construction in history:

It is essential to look at historical evidences of success of earth construction. Earth has been the most basic building material since the dawn of man and rammed earth construction was first recorded by the Babylonians in 5000 B.C (Das, 2007). It is currently estimated that over one third (Dethier, 1981) to over one half (Smith & Austin, 1989) of the world's population lives in some type of earthen dwelling. The history of earth building lacks documentation, because it has not been highly regarded compared to stone and wood (Houben & Guillaud, 1989, p8). Archeological evidence shows, nearly 10000 years old of entire cities built of raw earth, such as: - Catal Hunyuk in Turkey; Harappa and Mohenjo-Daro in Pakistan; Akhlet-Aton in Egypt; Babylon in Iraq; (Easton, 1996, p3). "30% of the world's population, or nearly 1,500,000,000 people, live in a home in unbaked earth. Roughly 50% of the population of developing countries, the majority of rural populations, and at least 20% of urban and suburban populations live in earth homes" (Houben & Guillaud, 1989, p6). Figure 3 illustrates the world geographic locations of where earth structure is used and Figure 4 shows the spread of different kinds of earth structure being used by different regions of the world.

Figure 03:
Geographic locations of earth structure.
Source: Houben & Guillaud, 1989, p6.

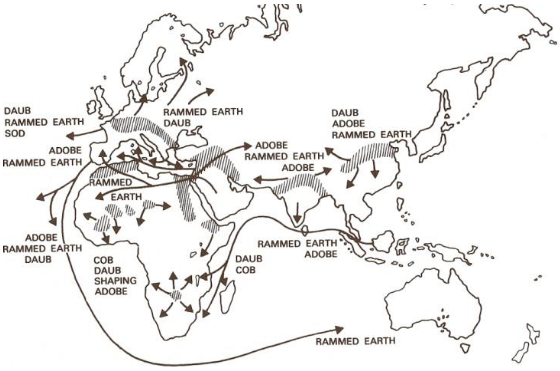

Figure 04:
Different forms of earth structure being used by different region of the world.
Source: Houben & Guillaud, 1989, p12.

In Europe, primitive dwellings were constructed of woven wood and clay evolving to un-burnt clay (Houben and Guillaud, 1989, p10). The un-burnt clay brick was jointly used with Tuff (hard volcanic rock composed of compacted volcanic ash), Gypsum, Schist, Marble and Wood. According to Easton (1996, p4), rammed earth construction was brought to the temperate regions of Europe by the Romans and Phoenicians. During the Roman Empire, houses were constructed using earth brick walls before stone replaced them for the rich, while the poor remained housed in buildings of earth until the time of Augustine who recommended the use of earth on a national scale (Houben and Guillaud, 1989, p11). Raw earth construction was not a forefront building method until the 18th century when an emerging use of cob, rammed earth and un-burnt brick could be observed and building with earth continued until the 1950s; there was a sudden increase in the use of the material after the Second World War, as the demand of housing increased due to war displacements (Houben and Guillaud, 1989, p11). According to Morton (2007, p377), traditional techniques of building with earth largely died out in the UK during the 19th century and despite this loss of traditional earth construction, there are estimated to still be 500,000 inhabited earth buildings in the UK (ICOMOS UK, 2000).

According to Denyer (1978), "earth architecture should not of course be considered a miraculous solution to neither all our housing problems, nor one which can be applied successfully anywhere, everywhere." Before any building is constructed with earth, it is essential to identify the soil to be used. The identification process involves various tests, which need the use of a laboratory. Apart from the laboratory identification process, local knowledge of the soil and traditional skills is necessary. Therefore, it is essential to analyze the contemporary stabilized earth construction methods. The following section is going to highlight on contemporary earth construction methods which can be applicable as a sustainable urban construction in Bangladesh.

Production methods of contemporary stabilized earth construction:

Nowadays, stabilisation of earth is a very common modern construction method. Stabilisation is done in three ways, namely: - Mechanical, Physical and Chemical stabilisation (Houben and Guillaud, 1989, p74). Mechanical stabilisation involves the application of force directly on the soil by compressing or ramming, thus changing the density, compressibility, permeability and porosity. Physical stabilisation is the modification of the texture by varying the percentages of the mixed particles. Chemical stabilisation makes use of chemicals or other materials to modify the soil properties. According to Houben and Guillaud (1989, p163), the possible ways in which earth can be used as a construction material are very numerous. Among the most widely known and practical construction methods are rammed earth in formwork, and compressed earth blocks, which are produced in presses. Below are the brief descriptions of rammed earth (RE) and compressed stabilized earth blocks (CSEB) production methods.

According to Walker et al (2005, p2), rammed earth is formed by compacting moist sub-soil inside temporary formwork. Stabilised Rammed Earth is an alternative form of wall construction that uses the rammed earth technique, but includes cement, primarily as an additive to change the material's physical characteristics (Walker et al, 2005, p1). Walls are typically 300-450mm thick, but this can vary widely according to design considerations and requirements. Correct proportions of sand, clay and water are mixed together and poured into the formwork in layers 100-150mm deep and compacted by ramming to the sufficient wall strength after which the framework is moved to another section of the wall, either horizontally or vertically, repeating the same process until the wall is finished. The soil is normally collected from the excavation and screened through a mesh to remove large stones and unwanted particles. The breaking down of small particles is necessary to ensure an even distribution of soil particles and in the case of clay soil; pulverisation affords the opportunity to mix with a sand proportion to attain an ideal mixture. Soil mixing produces a homogeneous mixture of soil at which point a stabiliser is added. According to Lal (1995, p121), the exact quantity of stabiliser to be added depends on the type of soil and a rough guide under normal situation is as follows: - Sandy soil: 5% cement stabilisation, Clayey soil: 5 to 6% hydrated lime and 2% cement, Normal red soil with up to 25% clay: 2.5% hydrated lime. Figure 5 shows manufacturing process of stabilised rammed earth production in construction.

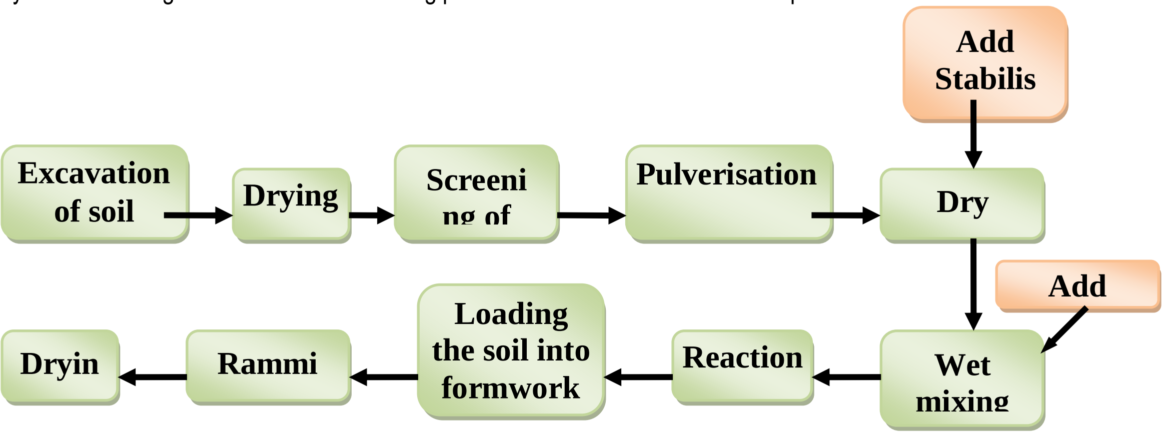

Figure 05: Production process of in situ stabilised rammed earth. Source: Zami and Lee, 2007.

According to Walker, et al (2005), in recent years, in line with the general move towards off-site fabrication of building elements, prefabricated rammed earth has developed. To date, prefabrication has been used by only a very small number of specialist overseas practitioners (Kapfinger, 2001), and the wider use of pre-formed rammed earth is largely unproven in UK. The use of prefabricated rammed earth is likely to increase in forthcoming years. According to Rauch (2007), increasingly prefabricated rammed earth walls are – are completely or in segments – transported to the building site and installed with a crane. Examples to date include large load bearing wall (300-500 mm) blocks (Figure 6) as well as 100-200 mm thick cladding panels. In recent years, rammed earth has been used for a variety of innovative items of furniture (Figure 7), sculpture and utilities, including fireplaces, stoves and church altars (Walker, et al. 2005, p21), and toilet fittings (Figure 8) as well (Minke, 2007).

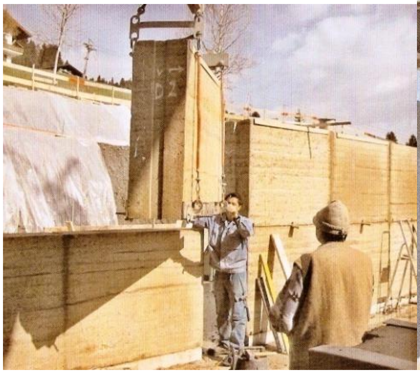

Figure 06:
Prefabricated rammed earth wall. Source: Rauch (2007).

Figure 07:
Prefabricated RE Office desk, Source: Walker, et al. 2005, p21.

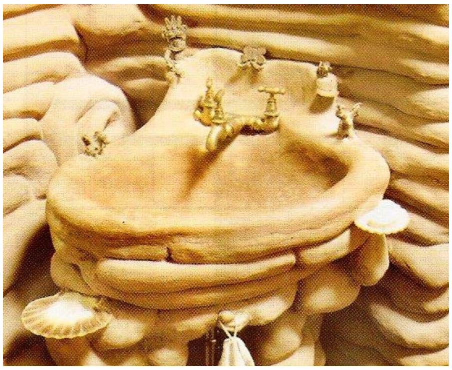

Figure 08:
Wash basin from stabilised loam. Source: Minke, 2007, p17

Prefabricated rammed earth technology is really advantageous for developed nation. In the case of developing nations, particularly Bangladesh, transportation of prefabricated rammed earth segments might be impossible due to sophisticated nature of transportation, packaging and handling required. Besides, skilled professional and labour in the prefabricated rammed earth factory is essential to control quality of the product; which is not affordable by some of the developing nation, particularly Bangladesh.

Compressed stabilised earth bricks or blocks are becoming popular in various part of the world especially with the introduction of sustainable construction concepts and soil is the main raw material used in CSEB manufacturing

(Jayasinghe, 2007, p252). Some of the process stages in the production and construction with compressed stabilised earth blocks are similar to RE. First, the subsoil is excavated after the removal of the topsoil. Soil for block making should be reasonably free from organic material (root, humus, grass etc.). The soil is then dried and pulverised. After pulverisation, the soil is screened so as to use particles no courser than 6 mm in diameter. Homogeneous colour is first obtained in mixing the dry components. Water is added gradually to the mixture to obtain a semi-dry blend reaching the optimum moisture content. Finally, blocks are made in a press machine; there are many types of presses, ranging from hydraulic, motorised, electrical and manual. The fresh blocks are stacked in piles up to one meter in height where they are cured in two stages. After moulding the blocks, they are maintained under humid conditions for 7 days and then exposed to air to cure for a further 21 days. Figure 9 shows the total manufacturing process of CSEB production.

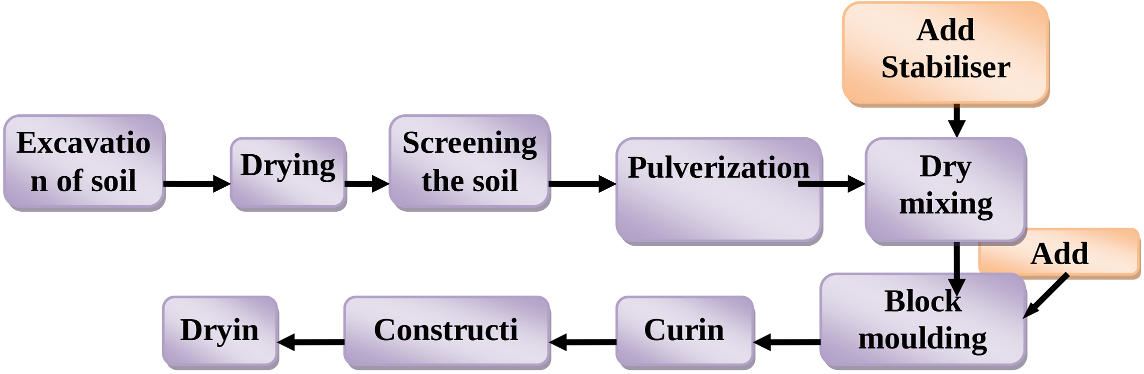

Figure 09: Production process of stabilised compressed earth block. Source: Zami and Lee, 2007.

Contemporary earthen architecture and natural disaster:

The above sections discussed the contemporary earth construction techniques in general applicable as an alternative solution to fired brick construction. But one may ask whether these alternative construction techniques are suitable in Bangladesh considering the natural disasters. According to Houben and Guillaud (1989, p 305), in 1976 alone seismic activity in the Philippines, Indonesia, Turkey, Italy and China caused the loss of more than 500,000 lives. Figure 10 shows the seismic areas of the world and part of Bangladesh is within seismic area. Figure 11 shows storm regions of the world and Bangladesh is situated within the storm area of the world. Flood is another form of natural disaster which causes many deaths and the destruction of human settlements every year. During the Honshu Tsunami on 15 June 1896, 26000 people were killed in Japan (Houben and Guillaud 1989, 324). Figure 12 shows the flood areas of the world in which it is clearly shown that Bangladesh is affected by flood as well. So, from the above discussion it can be posited that contemporary earth construction needs special consideration of natural disasters in Bangladesh.

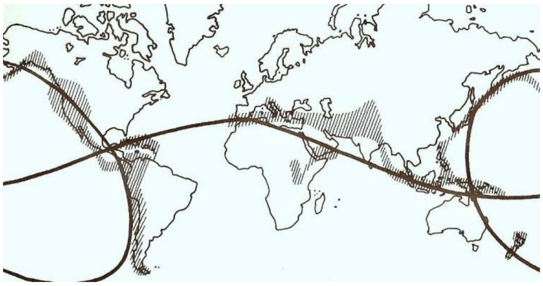

Figure 10:
Seismic regions of the world.
Source: Houben and Guillaud, 1989, 306.

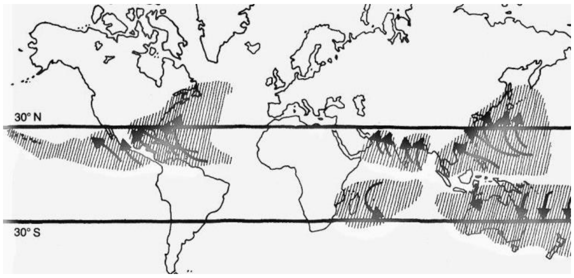

Figure 11:
Storm regions of the world.
Source: Houben and Guillaud, 1989, 320.

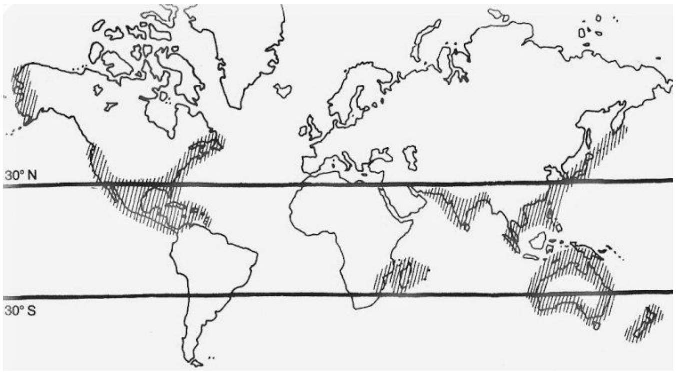

Figure 12: Flood regions of the world. Source: Houben and Guillaud, 1989, 324.

As discussed above, geographically Bangladesh is located in such a position that, flood and storm is a real threat to earth structure. A significant progress in research on disaster resistant earthen structure has been made recently which could be considered before the implementation of urban earth construction projects in Bangladesh. Bangladesh frequently faces natural disasters and contemporary earth construction addresses the natural disaster effecting the buildings, which is going to be explained this section. According to Blondet and Aguilar (2007), most vernacular earthen houses are built without professional intervention, and thus with poor construction quality. Besides most present day earthen houses are built without any structural reinforcement, with several stories, thin walls, large windows and door openings, irregular plan and elevation configurations and these buildings are extremely vulnerable and suffer significant damage or collapse during earthquakes (Blondet and Aguilar, 2007).

During last three decades, researchers at the Catholic University of Peru (PUCP) have attempted to find solutions for improving the seismic performance of earthen buildings (Vargas et al. 2005). The principal alternative solutions of seismic reinforcement for these vulnerable buildings are consisting of: - internal cane mesh reinforcement (Figure 13), external wire mesh reinforcement, and external polymer mesh reinforcement (Figure 14).

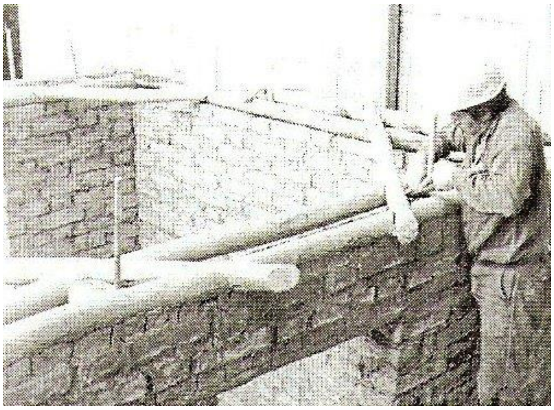

Figure 13:
Internal Cane mesh reinforcement in CSEB Construction. Source: Blondet and Aguilar, 2007.

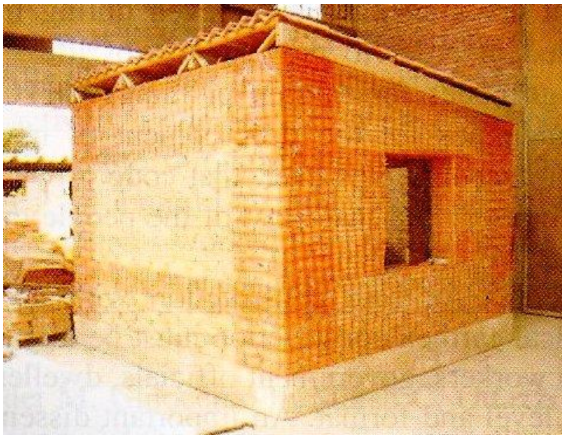

Figure 14:
Adobe model reinforced with plastic mesh. Source: Blondet and Aguilar, 2007

According to Maini (2007), extensive research was carried out to develop cost effective technology of reinforced masonry with hollow interlocking CSEBs. Vertical and horizontal reinforced concrete members reinforced the masonry so as to create a box type system which can resist disasters. As a result of the research two types of blocks have been developed: - the square hollow interlocking block suitable for two storied building and the rectangular hollow interlocking block suitable for single storied building. This technology has been used extensively in Gujarat for the rehabilitation after the 2001 earthquake with a six months technical assistance of Auroville Earth Institute and with this assistance the Catholic Relief Services built 2698 houses and community centres in 39 villages (Maini, 2007). According to Maini (2005), this technology has been approved by the Government of Gujarat (GSDMA) as a suitable construction method for the rehabilitation of the zones affected by the 2001 earthquake in Kutch district (Figure 15), the Government of Iran (Housing Research Centre) as a suitable construction method for the rehabilitation of the zones affected by the 2003 earthquake of Bam (Figure 16), the Government of Tamil Nadu, India (Relief and Rehabilitation) as a suitable construction method for the rehabilitation of the zones affected by the 2004 tsunami of Indonesia (Maini, 2007).

Figure 15:
Houses built by the CRS – Gujarat, India.
2698 houses built in a year time, in 39 villages.
Source: Maini, 2005.

Figure 16:
House built by the International Blue Crescent.
Bam – Iran. Source: Maini, 2005.

According to Kotak (2007), there was a huge demand for houses to rehabilitate the earthquake affected families in Gujarat state (India) after 2001 Kutch earthquake. HUNNAR SHAALA Foundation for Building Technology and Innovations, Bhuj, India is a registered not-for-profit corporation who built several stabilised rammed earth houses for the earthquake affected families. There were two types of houses built in this rehabilitation exercise: - Circular (Figure 17) and Rectangular (Figure 18) stabilised rammed houses.

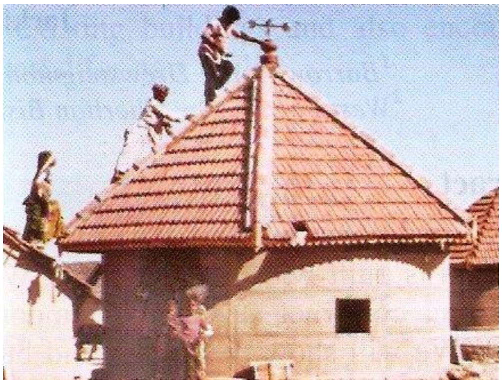

Figure 17:
Circular house under construction in
2001 Kutch earthquake rehabilitation exercise.
Source: Kotak, 2007, p71.

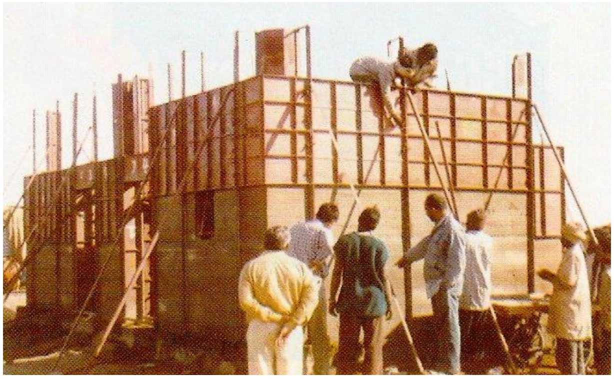

Figure 18:
Rectangular house under construction in
2001 Kutch earthquake rehabilitation exercise.
Source: Kotak, 2007, p70.

According to Lal (1995, p122), the major advantage of the stabilized soil block vis-a-vis the burnt brick is the significant saving in energy (about70%) and such blocks are cheaper by 20 to 40% compared to burnt bricks. The pure mud constructions (un-stabilized) suffer from two major drawbacks: - complete loss of strength on saturation and erosion due to rain impact; hence, the soils are stabilised and used for various engineering applications (Reddy, 2007, p194). In the case of urban earth structures of Bangladesh, flood and excessive rain could be the major threat. But cement stabilized earth construction can overcome the problem of structural failure due to flood or rain. According to Bui and Morel (2007, p113), in order to comply with the standards devoted to industrial materials, more stringent durability norms are expected from rammed earth. Several types of durability tests (i.e. spray and drip test, wet to dry strength approach, etc.) are proposed for earthen materials in general and rammed earth in particular (Heathcote, 1995). Since non-stabilized rammed earth could not pass these tests, it was systematically abandoned and replaced with stabilized rammed earth (Bui and Morel, 2007). These statements of various authors (Lal, 1995; Reddy, 2007; Bui and Morel, 2007) support that the disadvantages associated with un-stabilised earth can be overcome by suitable soil stabilization. Therefore, the drawbacks of earth construction can be addressed and solved by different solutions invented in contemporary stabilized earth construction research and innovation.

Reduction of shrinkage cracks, solution to water erosion, enhancement of binding force, increasing compressive strength, earth roofing technique, prefabricated earth construction, strength against abrasion and increasing thermal insulation of earth building material is explained by different researchers, such as Houben and Guillaud, 1989; Minke, 2006; Walker, 2005; Raunch, 2007; Reddy, 2007; Barbosa, 2007 and Maini, 2005 and 2007 in their published books and publications (reference list) in detail. These researchers published several journal papers and handbooks on stabilized earth construction which cover how to address the drawbacks of earth construction. Furthermore, Ahmed (2005) published a handbook titled, "Design and construction of housing for flood-prone rural areas of Bangladesh", explains in detail about the flood resistant stabilized earth construction.

Therefore, natural disaster resistant contemporary stabilized earth construction is effectively solving the problems of natural disaster destructive to shelters all over the world in particular in India – a neighbouring country of Bangladesh.

Success of stabilized earth construction in India:

Auroville is an international township under construction, located on the Coromandel Coast in South India. The Auroville Earth Institute in India is a research and training centre in earth architecture, and training courses have been conducted for the very onset and many technologies have been researched, developed and promoted under the supervision of the director Satprem Maini. This institute is the Asian representative and Resource centre for the UNESCO Chair "Earthen Architecture – Constructive Cultures and Sustainable Development". Since 1990, more than 4775 people from 50 different countries have been trained in Auroville and elsewhere in the world. According to Maini (2005, p5), cost is too often limited only to the monetary value and it is understandable and one can remember that in Auroville a cubic metre of CSEB (compressed stabilised earth block) is around 23.6 % cheaper than a cubic metre of country fired bricks. But the energy approach should be integrated: some studies have shown that, in the Indian context, building one square metre of masonry with CSEB consumes 5 times less energy than a square metre of wire cut bricks masonry and 15 times less than country fired bricks. CSEB are generally cheaper than fired bricks and this varies from place to place and specially according to the cement cost (Maini, 2005, p6). The cost break down of a 5 % stabilised block will depend on the local context and in India with manual equipment (AURAM press 3000), it is usually within these figures:

- Labour: - 20 - 25 %, Soil & sand: - 20 - 25%, Cement: - 40 - 60 %, Equipment: - 3 - 5 %.

Maini (2005, p6) further stated that, in Auroville, a finished cubic metre of CSEB wall is generally 48.4 % cheaper than wire cut bricks and 23.6 % cheaper than country fired bricks. The strength of a block is related to the press quality and the compression force, and to the quantity of stabiliser and this implies that to reduce the cost of a block one should try to reduce the quantity of cement but not the cost of the labour with unskilled people. One should also not cut down the cost of the press with cheap quality machines, which would not last long and would not give strong blocks.

According to Maini (2005), some studies have shown that, in the Indian context, building a square metre of masonry with CSEB (compressed stabilised earth block) consumes 5 times less energy than a square metre of wire cut bricks masonry and 15 times less than country fired bricks. Maini (2005) also stated that the compressed stabilised earth blocks (CSEB) are more eco-friendly than fired bricks and their manufacture consumes less energy and pollute less than fired bricks.

Energy consumption	**Pollution emission**
4.9 times less than wire cut bricks	2.4 times less than wire cut bricks
15.1 times less than country fired bricks	7.9 times less than country fired bricks

Table 1 shows a comparative analysis of energy consumption and carbon dioxide emission of four types of building material. According to the numerical data shown in Table 1, CSEB consume the lowest energy and lowest carbon dioxide emission if compared with Wire Cut Bricks, Country Fired Bricks, and the Concrete blocks.

Product and thickness	Number of units (Per square metre)	Energy consumption (MJ per square metre)	Carbon dioxide emission (Kg per square metre)
CSEB – 24 cm	40	110	16
Wire Cut Bricks – 22 cm	87	539	39
Country Fired Bricks – 22 cm	112	1657	126
Concrete blocks – 20 cm	20	235	26

Table 01: A comparative analysis of energy consumption and carbon dioxide emission of four types of building material. Source: Maini, 2005.

Beside the low energy consumption and carbon dioxide emission, contemporary earthen structures proved adequate structural performance and aesthetically beautiful compared to fired brick construction. According to Maini (2005), The Visitors' Centre (Figure 19) of 1200 square meter was the starting point of the development with earth architecture in Auroville and it was granted the "**Hassan Fathy Award for Architecture for the Poor"** in 1992. CSEB was used to construct this visitor complex. To date, Auroville can show a wide variety of earthen projects: - public buildings (Figure 20 and 21), schools (Figure 22), apartments (Figure 23) and individual houses (Figure 24).

Figure 19:
Arches of the Visitor's Centre at Auroville, CSEB Technology. 1992 Hassan Fathy Award for Architecture for the Poor. Source: Maini, 2005.

Figure 20:
Training Centre at the Auroville Earth Institute, Various vaults with stabilized earth waterproofing Source: Maini, 2005.

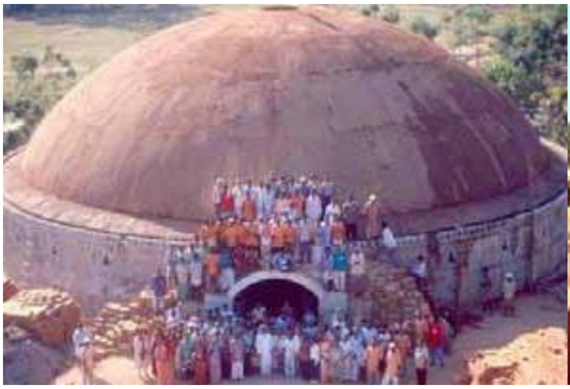

Figure 21:
Dome of the Dhyanalingam temple near Coimbatore, 22. 16m dia, 7.90m rise, 570 tons – Built in 9 weeks. Source: Maini, 2005.

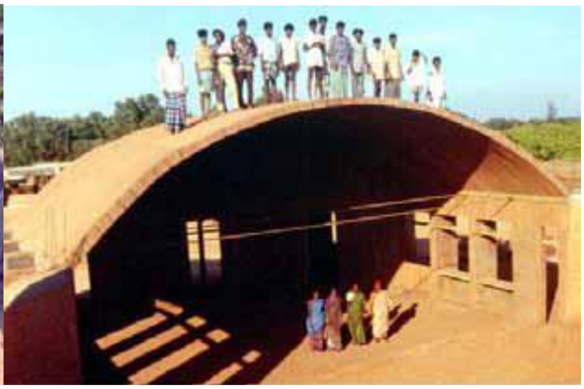

Figure 22:
Vault of Mirramukhi School at Auroville, CSEB. 10.35m span, 2.25m rise, 30 tons – Built in 3 weeks Source: Maini, 2005.

Figure 23:
Staff quarter of the Health Centre. CSEB
Source: Maini, 2005.

Figure 24:
House at the Auroville Earth Institute, 3.60m span, Technology. Built in 36 days. Source: Maini, 2005.

Conclusions:

It is notable from this paper that there has been increasing levels of Carbon Dioxide emission due to the unplanned brick manufacturing in Bangladesh contributing to the severe air pollution, which will in some way affect every individual person. Besides, it is evident that stabilized earth construction is environmentally sustainable compare to the conventional (fired brick, concrete, etc.) building materials and would be appropriate in the case of urban building construction in Bangladesh. Promotion and implementation of earth as an alternative urban construction material is worthwhile and significantly helpful in achieving environmental sustainability (less fossil fuel is used, therefore, less carbon emission). It is also notable from this paper that stabilization of earth doesn't only mean the cement stabilization. There are other stabilizers which is more environmentally sustainable than the cement stabilized earth. It is possible to use un-stabilized raw earth as rammed earth or compressed earth blocks; this paper described why the stabilized form is more suitable for the Bangladesh context in terms of overcoming the Natural disasters. The only challenge that prevents earth becoming the preferred choice of building material amongst the general population is the acceptability of this material. An awareness and understanding by people to environmental issues such as air pollution, deforestation, land degradation, climate change and energy conservation would help them change their attitudes and views towards earth building. As a matter of fact, earth building conserves energy during construction or during other lifecycle stages. Rammed (Stabilized) earth construction, due to their low thermal conductivity and higher thermal mass as opposed to conventional Brick-Block or RCC construction, is more thermally comfortable. Hence, it consumes less energy during operation. Operational energy use is important to tackle/mitigate the impacts of climate change. It is generally accepted that if lifetime energy consumption of a building is 100 units, approximately 15 units are consumed during construction and the rest 85 units are during operation. This is why, tackling operational energy use is essential for ensuring energy security of a nation as well as to reduce CO2 emissions from buildings. Besides, in earth construction individuals and community as a whole can easily participate in building their own homes in affordable ways addressing their moral obligation to climate change.

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