STABILISED SOIL BLOCKS EMBEDDED WITH WASTE PLASTIC FIBRES
ALKA RANI
Research Scholar of OPJS University
Churu (Rajasthan)-India -331303

ABSTRACT

This paper is a review of the state of uses of clay bricks and stabilized compressed earth blocks. We offer an overview of the world general building using clay bricks or stabilized compressed earth blocks compiled from various research organizations, modern projects which have been carried out and reports from existing manufacturing of clay bricks or stabilized compressed earth blocks. Although, stabilized compressed earth blocks as construction materials are highly unknown to most people, its advantages are seen in terms of rescuing the heritage and also as rediscovered environmentally friendly building materials. The sorption characteristics of mud blocks have been studied by measuring Water absorption and Sorptivity. Water absorption of samples with 10 - 15% Cement stabilisation was less than the value specified by IS 1725-1982. The combination of mechanical and chemical stabilization without fiber addition has resulted in a reduction in sorptivity. But fiber addition increased the sorptivity.

INTRODUCTION

The history of civilization is synonymous to the history of masonry. Man’s first civilization, which started about 6000 years ago, was evident from the remains of the Mesopotamians masonry heritage. During those days, masonry buildings were constructed from any available material at hand. The Mesopotamians used bricks, made from alluvial deposits of the nearby River Euphrates and Tigris to build their cities beside two rivers. Where civilization existed in the vicinity of mountains or rocky outcrops, stone was used. The Egyptian pyramids that existed along the rocky borders of the Nile valley were examples of such stone masonry. In the Eastern civilization, remains of historical masonry are the reputed Great Wall of China, which is considered as one of the seven construction wonders in the world. The prevision 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. Some examples are the use of clay for making bricks, and river sand for
making cement sand blocks. The commercial exploitation of these resources often leads to various environmental problems. If clay mines are not properly filled up, they can collect water and allow mosquitoes to breed. Extensive sand mining can lower the river-beds and allow salt-water intrusion inland. Therefore, the development of many alternative walling materials as possible will be of immense benefit to minimize the impact on the environment.

Earth can be used for construction of walls in many ways. However, there are few undesirable properties such as loss of strength when saturated with water, erosion due to wind or driving rain and poor dimensional stability. These draw backs can be eliminated significantly by stabilizing the soil with a chemical agent such as cement. Cement stabilized soil is generally used as individual blocks compacted either with manual hydraulically operated machines. Significant research data are available for these applications either as block strength or wall strength (Perera and Jayasingh, 2003; Reddy and Jagadish, 1989). Some of the reasons for this are the energy saving in manufacturing compared to clay bricks, the cement used was compared to concrete blocks, the transport savings, if soil comes from the construction site or vicinity and the natural appearance and colours that help buildings integrate into the landscape (Carmen and Ignacio, 2005). In Malaysia, there is more research needed in the area of stabilized earth for constructing materials and the problems faced in using it today.

LITERATURE REVIEW

Jayasinghe and Kamaladasa, et. al. 2007:

Studied on stabilized earth masonry bricks/blocks revealed that there is a growing interest in stabilized earth building materials development with respect to an energy conscious and ecological design, which fulfils all strength and serviceability requirements for thermal transmittance. There are previous researches studies reported on compressive strength and erosion characteristics of earth blocks/rammed earth wall.

Reddy et al. (2007):

reported on enhancing bond strength and characteristics of soil-cement block masonry. This resurgence of renewed research interest in recent years in stabilized earth building bricks may be partially due to its potential as a commercial construction material.
The fact that, a single element can fulfill several functions including structural integrity, thermal transmittance and durability in service makes the material an excellent walling material when compared to the fired earth bricks used in mainstream construction of today.


Continued interest in CSBs (Cement Stabilized Blocks) will in the future evolve around the several merits and attractions associated with its use. Firstly, as the basic raw material is soil, its source will remain abundant. This facilitates direct site-to-service application, thereby, lowering costs normally associated with acquisition, transportation and production. Home ownership can then be delivered at comparatively low costs. Secondly, the initial performance characteristics of the material such as the wet compressive strength (WCS) dimensional stability, total water absorption (TWA), block dry density (BDD) and durability are technically acceptable.

METHODOLOGY

Production of earth materials

Clay bricks

Brick is a ceramic material mainly used in construction industry. Its production process involves forming of clay into rectangular blocks of standard size, followed by firing to temperature ranging from 900 - 1200°C. It is made of clay or shale and when given desired shape is dried and fired into a durable ceramic product. Brick is one of the most important building materials. Energy consumption and pollution are the two important environmental and cost concerns related to the brick industry. A report, in 1993, indicated that more than 3000 brick kilns in operation in the country with an annual growth of 3% (Egbert, 1993). Old rubber, low quality coal, wood and used-oil were reported as fuel in most brick kilns. Consumption of these fuels, combined with inefficient combustion process produces large quantity of hazardous gases that threaten the environment as walls as those working in brick kilns.

The history of brick industry is very old and can be traced back to about 5000 years old. Understanding of the brick, microstructure as influenced by the range of temperature during
firing cycle has been enhanced by the experimental work in this area. For example, Convile et al. (2005) investigated the micro-structural evolution of various clays using XRD and TEM. They observed that, the pseudo-hexagonal morphology of the kaolinite changed to pseudo-hexagonal meta-kaolin at around 550°C with meta-kaolin broken down at temperatures > 900°C to γ-alumina-type spinal and a silica-rich phase. The spinal type phase started to transform into mullite at > 1000°C. At 1300°C, mullite increased in size to ~1 µm and in some regions, cristobalite formed from the silica rich matrix (Convile et al., 2005; Lee et al., 1999). XRD, TGA/DTA and EF-TEM studies of clay have revealed that meta-kaolin partially transforms to γ-alumina at 920°C (Peters and Iberg, 1978) Figure 1. On further increase in the firing temperature to > 940°C, the crystallization of Al2O3-rich mullite began and excess amorphous silica was discarded into the matrix (Peters and Iberg, 1978). Mullite begins to crystallise at 1050°C and its crystal size increases with increase in firing temperature (Convile et al., 2005).

**Clay brick strength**

Compressive strength of brick is important as an indicator of masonry strength and as a result brick strength has become an important requirement in brickwork design. A considerable amount of past research and studies on masonry indicated that stronger bricks contribute to greater brickwork strength.

In Singapore, Standard SS 103 (1974), compressive strengths are classified as First, Second and Third Grade with minimum compressive strength of 35, 20 and 5.2 N/mm², respectively. Figure 2 shows the relationship between strength of brick and strength of wall. The British standard (BS, 3921, 1985) categorized compressive strength into classes of engineering A and B presented in Table 1. These classifications of bricks commonly used
Figure 2. Mean compressive strength of walls against strength for 102 mm thick brickwork in various mortars Hendry, (1990).

Table 1. Classification of bricks by compressive strength and water absorption (BS 3921: 1985)

<table>
<thead>
<tr>
<th>Class</th>
<th>Average compressive strength (N/mm²)</th>
<th>Water absorption (5 h Boiling) % by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering A</td>
<td>≥70</td>
<td>≤4.5</td>
</tr>
<tr>
<td>Engineering B</td>
<td>≥50</td>
<td>≤7.0</td>
</tr>
<tr>
<td>Damp-proof course 1</td>
<td>≥5</td>
<td>≤4.5</td>
</tr>
<tr>
<td>Damp-proof course 2</td>
<td>≥5</td>
<td>≤7.0</td>
</tr>
<tr>
<td>All others</td>
<td>≥5</td>
<td>No limits</td>
</tr>
</tbody>
</table>

for construction with aesthetics and strength requirements. All other brick and damp proof-course bricks should have strengths not less than 5 N/mm². However, the damp-proof course is divided into two in accordance to water absorption.

Clay brick water absorption and durability

The effects of brick absorption property due to variable raw materials used in its manufacturing Surej et al. (1998). Water absorption of bricks is usually measured by 5 h boiling and 24 h cold immersion test. The 24 h cold immersion test allows water to be absorbed into pores, which are easily filled under cold condition while the 5 h boiling test gives fully saturated condition where all pores are filled up with water. The saturation coefficient ranges from about 0.4 - 0.95; the lower value of around 0.4 indicates high durability and higher values of around 0.95, low durability (Khalaf and Venny, 2002). Other durability indices have also been developed based on relationship of porosity and water
absorption. Table 4 shows the durability indices developed by Surej et al. (1998).

**Table 2.** Physical requirement for building bricks (ASTM C62-89a, 1990).

<table>
<thead>
<tr>
<th>Designation</th>
<th>Minimum compressive strength</th>
<th>Maximum water absorption (5 h boiling), %</th>
<th>Maximum saturation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average of 5 bricks</td>
<td>Individual</td>
<td>Average of 5 bricks</td>
</tr>
<tr>
<td>Grade SW</td>
<td>3000(20.7)</td>
<td>2500(17.2)</td>
<td>17.0</td>
</tr>
<tr>
<td>Grade MW</td>
<td>2500(17.2)</td>
<td>2200(15.2)</td>
<td>22.0</td>
</tr>
<tr>
<td>Grade NW</td>
<td>1500(10.3)</td>
<td>1250(8.6)</td>
<td>No limit</td>
</tr>
</tbody>
</table>

**Table 3.** Characteristic compressive strength in accordance to Australia Standard AS 1225, (1984).

<table>
<thead>
<tr>
<th>Ratio of manufacturing height to manufacturing width</th>
<th>Characteristics compressive strength, Mpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.7</td>
<td>7.0</td>
</tr>
<tr>
<td>≥ 2</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Table 4.** Limit of durability indices (Surej et al, 1998).

<table>
<thead>
<tr>
<th>Index</th>
<th>Limiting values</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAP(C)</td>
<td>&gt; 90</td>
</tr>
<tr>
<td></td>
<td>&lt; 75</td>
</tr>
<tr>
<td>DIAP(S)</td>
<td>&gt; 85</td>
</tr>
<tr>
<td></td>
<td>&lt; 70</td>
</tr>
</tbody>
</table>

initial rate suction.

**Clay brick density**

Raw materials and manufacturing process affect bricks density, which could vary between 1300 - 2200 kg/m³. The density of bricks influences the weight of walls and the variations in weight have implications on structural, acoustical and thermal design of the wall. Incorrect assumptions on wall weight can result in inaccurate dead loads and seismic loads, reduced factor of safety in shear walls and overestimate of acoustical transmission loss (Grimm, 1996).

**Stabilized compressed earth blocks**

The new technology focuses on stabilized earth masonry brick development incorporating an industrial by-product material, which is vital for the future of construction. The stabilized earth masonry brick technology relies on the use of an activated industrial by-product (Ground Granulated Blast-furnace Slag – GGBS) and natural earth. Due to the use of a by-product material in the formulation, it is anticipated that the final pricing of the stabilized earth masonry building brick will be reduced. The added environmental advantage
of utilizing industrial by-products available in the country will further improve the sustainability profile of masonry brick production. The use of a cement replacement material (GGBS) with a lower environmental burden offers opportunities for significant reductions in energy use and carbon dioxide emissions. One of the most effective alternatives to Portland cement is GGBS, which has the potential to typically replace up to 80% of the Portland cement (Oti et al., 2008a). GGBS has extremely low energy usage and CO₂ emission when compared with PC. The energy usage of 1 ton of GGBS is 1300 MJ, with a corresponding CO₂ emission of just 0.07 ton Higgins (2007), while the equivalent energy usage of 1 ton of PC is about 5000 MJ Higgins (2007), with at least 1 ton of CO₂ emitted to the atmospheres (Wild, 2003).

**Compressive strength**

The compressive strength of compressed stabilized earth building blocks (that is, the amount of pressure can resist without collapsing) depends upon the soil type, type and amount of stabilizer and the compaction pressure used to form the block. Maximum strengths (described in MN/m²) are obtained by proper mixing of suitable materials and proper compacting and curing.

In practice, typical wet compressive strengths for compressed stabilized earth building blocks may be less than 4 MN/m². However, some Sudanese black cotton soil when stabilized with hydrated high calcium lime to give wet compressive strengths in the range of 6 - 8 MN/m², strength suitable for many building purposes. It also competes favourably, for example, with the minimum British Standard requirements of 2.8 MN/m² for precast concrete masonry units and load bearing fired clay blocks and of 5.2 N/m² for bricks.

**Table 5.** Properties of compressed stabilized earth blocks versus other walling materials (Adam, 2001).

<table>
<thead>
<tr>
<th>Property</th>
<th>Compressed stabilized earth blocks</th>
<th>Fired clay bricks</th>
<th>Calcium silicate bricks</th>
<th>Dense concrete blocks</th>
<th>Aerated concrete blocks</th>
<th>Lightweight concrete blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet compressive strength (MN/m²)</td>
<td>1 - 40</td>
<td>5 - 60</td>
<td>10 - 55</td>
<td>7 - 50</td>
<td>2 - 6</td>
<td>2 - 20</td>
</tr>
<tr>
<td>Moisture Movement (%)</td>
<td>0.02 - 0.2</td>
<td>0.00 - 0.02</td>
<td>0.00 - 0.035</td>
<td>0.02 - 0.05</td>
<td>0.05 - 0.10</td>
<td>0.04 - 0.08</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1700 - 2200</td>
<td>1400 - 2400</td>
<td>1600 - 2100</td>
<td>1700 - 2200</td>
<td>400 - 950</td>
<td>600 - 1600</td>
</tr>
<tr>
<td>Thermal Conductivity W/m°C</td>
<td>0.81 - 1.04</td>
<td>0.70 - 1.30</td>
<td>1.10 - 1.60</td>
<td>1.00 - 1.70</td>
<td>0.10 - 0.20</td>
<td>0.15 - 0.70</td>
</tr>
<tr>
<td>Durability Against rain</td>
<td>Good to Very poor</td>
<td>Excellent to Very poor</td>
<td>Good to Moderate</td>
<td>Good to Poor</td>
<td>Good to Moderate</td>
<td>Good to Poor</td>
</tr>
</tbody>
</table>
Advantage of compressed earth blocks (CEB)

(i) Soil is available in large quantities in most regions.

(ii) Cheap and affordable - in most parts of the world soil is easily accessible to low-income groups. In some locations it is the only material available.

(iii) Easy to use - usually no specialized equipment is required.

(iv) Suitable as a construction material for most parts of the building.

(v) Fire resistant - non-combustible with excellent fire resistance properties.

(viii) Environment appropriateness - the use of this, almost unlimited its natural state involves no pollution and negligible energy consumption, thus, there is further benefit of the environment by saving biomass fuel.

CONCLUSION

Based on the review of both experimental and filed investigation on clay bricks and stabilized compressed earth blocks, the following concluding remarks can be drawn:

- Major usage in the world for construction is clay bricks; many researchers are presently looking for newer options because they need low cost materials, which are also environmentally friendly. The process of manufacturing clay bricks also requires high energy to burn due to the emission of CO$_2$ gas from this process.

- Stabilized compressed earth blocks include; uni-formed building component sizes, use of locally available materials and reduction of transportation. Uniformly, sized building components can result in less waste, faster construction and the possibility of using other pre-made components or modular manufactured building elements. Such modular elements as sheet metal roofing which can be easily integrated into a CEB structure.

- The use of natural, locally-available materials makes good housing available to more
people, and keeps money in the local economy rather than spending it on imported materials, fuel and replacement parts.

- The earth used is generally subsoil, leaving topsoil for agriculture. Building with local materials can provide employment for local people, and definitely considered more sustainable in times of civil economic difficulties.

- People can often continue to build good shelters for themselves regardless of the political situation of the country.

- The reduction of transportation time, cost and attendant pollution can also make CEB more environmentally friendly than other materials.

REFERENCES


