RICE HUSK ASH STABILIZED COMPRESSED EARTH BLOCK–A SUSTAINABLE CONSTRUCTION BUILDING MATERIAL – A REVIEW

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Abstract

Building industry is dependent on endless supply of high quality materials and energy resources. This results in depletion of nonrenewable materials and resources, production of waste byproducts, release of pollutants and deterioration of air, water, soil and habitat that surrounds it. Sustainability and efficiency of a building, depends largely on the sustainability of building materials. The byproducts from industry have to be effectively utilized for making durable concrete. Their basic characteristics that are required in the present scenario should be the ability of natural resource conservation, low embodied energy, and potential of recyclability and low emission levels of toxic substances release in each stage of material cycle. In the growing concern of awareness regarding sustainable building material and environmental issues, cement-stabilized compressed earth blocks gave the view of energy efficient, cost reduction and environmental friendly building material. Commercially available rice husk ash (in India), which is rich in silica content can be used in stabilized compressed earth blocks as a supplementary cementitious material. This paper summarizes chronologically the various studies carried out on stabilized compressed earth blocks by utilizing different cementitious materials like, lime, ground granulated blast furnace slag, and rice husk ash. The paper also describes the state of the art of utilizing stabilized compressed earth blocks.
Key words: Rice husk ash; Unconfined compression tests; Carbon emission; Stabilized compressed earth blocks

INTRODUCTION

The provision of good quality housing is recognized as an important responsibility for welfare of people in any country. For this building materials based on natural resources are often used. The commercial exploitation of these resources often leads to various environmental problems. Therefore the development of much alternative walling material made using different cementitious and pozzolonic materials will be of immense benefit to minimize the impact on the environment. Earth can be used for the 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 rain and poor dimensional stability. These drawbacks can be eliminated significantly by stabilizing the soil either with cement or lime. But for the production of cement, very high amount of energy is needed. The carbon dioxide emission was found to be nearly 1ton for every 1ton production of cement. This harmful effect on environment can be reduced by the effective usage of resources. Hence, the new technology focuses on stabilized compressed earth block development incorporating an industrial byproduct material which is vital for the future construction. The added environmental advantage of utilizing industrial byproducts available in the country will further improve the sustainability of masonry brick production. (Sadek Deboucha and Roshlan Hashim et al 2011).

An attempt has been made in this paper to review the state of the art on the usage of compressed earth block stabilized with commercially available rice husk ash which is a sustainable alternative to cement. This paper also summarizes the various studies done on sustainable materials, and stabilized compressed earth blocks made with various cementitious materials.

OBJECTIVE

The main objective of this review paper is to investigate the potential usage of commercially available rice husk ash, a sustainable construction material for producing stabilized compressed earth blocks. This paper is based on the comprehensive review of available literature on sustainable construction materials and stabilized compressed earth blocks stabilized with cementitious materials. The review is arranged chronologically and covered under 2 broad categories. 1) Stabilized compressed earth blocks with various cementitious materials. 2) Rice husk ash as a stabilizing construction material.

1.0 STABILIZED COMPRESSED EARTH BLOCK STABILIZED WITH CEMENTETIOUS MATERIALS

Fitzmaurice (1958) was first to point out that stabilization of soils normally with asphalt or cement is necessary to maintain the materials integrity when exposed to moisture. Most of the work has since then focused on the durability of the cement-stabilized compressed earth blocks (CEB). After Fitzmaurice forwarding the importance of
compressed earth block stabilization, most research works developed the parameters that provide information on the earth block durability.

George Austin (1984) observed that adobe bricks far from being an obsolete construction material are now recognized as contemporary because of their unique abilities to store heat and moderate extremes of temperature inside the structure.

Robert Cassell (1993) in his research paper revealed that rammed earth construction was first recorded by the Babylonians in 5000 B.C. The 1500 mile long Great Wall of China was built around 300 B.C and parts of the western portion are built of rammed earth. From there rammed earth migrated to India over the Indian Ocean to Madagascar across the continent of Africa to Morrocco. Then the Romans transported the idea to France and the lowland countries of Europe.

Walker, (1995) investigated soil characteristics and cement content on dry density, compressive strength, flexural strength, durability and drying shrinkage of stabilized compressed earth blocks. He suggested an empirical relationship between flexural strength and compressive strength which was recorded as, Flexural Strength = (1/6) x Compression Strength

Gooding and Thomas et.al (1995) conducted some research on dynamic methods of compaction, utilizing impact blows and found that impact blows are also capable of producing high density blocks. Such blocks were noted to have a more uniform distribution of density and require lower levels of applied energy than slowly pressed blocks. Moreover the improved density distribution seen with impact compaction was found to equate to a 24% increase in compressive strength for a given mean density. In combination these factors result in a 50-75% overall saving in the energy required to achieve a given compressive strength.

Walker (1995) in his studies revealed that compressed stabilized earth blocks created 22 kg carbon dioxide/ton compared to that of concrete blocks (143kg carbon dioxide /ton), common fired clay bricks (200 kg carbon dioxide /ton) and aerated concrete blocks (280-375 kg carbon dioxide /ton) during production

Peter Walker and Traver Stace et.al (1997), done some investigations into the effects of soil properties and cement content on physical characteristics of compressed earth blocks and soil mortars. It was reported that for a given compactive effort the strength, drying shrinkage and durability characteristics of compressed earth blocks improved with the increase in cement content and reducing the clay content.

Venkatarama Reddy, Jagadish et.al (1997) discussed the spray erosion test using a standardized shower spray. Spray erosion behavior of pressed soil blocks made out of five different soils were presented. It was found that the spray erosion test, based on a water spray from a shower rose at 0.07 MPa can be used as a conservative indicator of rain erosion resistance of pressed soil blocks. The Pressed soil blocks made from red soils having more than 5% clay content was found to possess good erosion resistance. The erosion ratio decreased rapidly with increase in density of the soil blocks. The pressed soil blocks (using red soil) having dry densities of the order of 1.9 g/cc provided satisfactory erosion resistance. Finally the research revealed that well-stabilized soil blocks (soil-cement and soil-lime blocks) generally possess good erosion resistance and walls made of such blocks normally do not require any extra protection such as plastering or water-proof coatings, against rain erosion.
Walker (1997) investigated the effect of soil composition and cement content to the characteristics of stabilized compressed earth block (compressive strength, drying shrinkage, wetting and drying durability, water absorption and mortar consistency). The source established that compressive strength, drying shrinkage and durability improved with increase in cement content but decreased with the increase of clay content in the soil.

Walker (1999) in his experimental investigations to study the flexural bond strength characteristics in pressed earth block masonry reported that bond strengths decreased significantly with saturation of the masonry and characteristic bond strengths in pressed earth masonry were typically found to be much less than conventional masonry. In general, the study recommended the use of soil cement mortar based on the same soil mix as the block and stabilized with 5% cement and the optimum moisture content for maximum bond strength recommended was approximately half the blocks total water absorption value. The study revealed that the saturation of earth block masonry significantly decreased flexural bond strength, and there was little recorded improvement in flexural bond strength after the initial 24-h set of the cement.

More, Mesbah, Oggero and Walker et.al (2000) carried out research on the process of material selection, design and construction used for a series of small residential buildings in Southern France. The energy consumed in the building of one house was compared to a typical concrete house. They observed that by adopting local materials the amount of energy used in the building decreased up to 215% and the impact of transportation by 453%.

Venkatarama Reddy and Jagadish et al (2001) carried out studies on some issues pertaining to embodied energy in buildings particularly in the Indian context. The conclusions from the study were (1) Energy spent in transporting high energy materials like steel and cement was found negligible when compared to the energy spent in the manufacture of these materials. (2) Lime pozzolana mortar have lowest energy content when compared with other mortars like cement mortar, cement pozzolana mortar etc. (3) Energy content of burnt clay brick masonry was found to be 2141MJ/cum. Soil cement block masonry was found to be the most energy efficient and it consumed only one third the energy of burnt clay brick masonry. (4) Embodied energy of multistoried RC framed structure was the highest at 4211 GJ per 100sqm built up area. (5) Load bearing soil cement block masonry has resulted in 62% reduction in embodied energy when compared to RC framed structure building.

Kevin Heathcote and Gregory Moor et.al (2002) developed UTS erosion test and provided logical basis for acceptance testing of earth building materials. The test consisted of spraying the face of a sample for a period of one hour or until the sample is penetrated. The test was interrupted at 15 minutes interval and the depth of erosion was measured with a 10mm diameter flat ended rod. The total depth of one hour was divided by sixty to get erosion in mm. The maximum permissible erosion rate for all types of earth construction was found to be one mm per minute and the erosion of specimens decreased with cement content above 4%.

Venkatrama Reddy and Hubili et.al (2002) addressed in their paper certain issues pertaining to the technology of lime stabilized steam cured blocks used in masonry construction. Influence of parameters like steam curing period, lime content and fly ash...
content on wet strength of the blocks were studied. Steam curing of lime stabilized blocks at 80°C for about 20 hrs at atmospheric pressure lead to considerably higher strengths when compared with curing under wet cloth under ambient temperature. It was also found out that addition of small quantities of industrial waste products greatly improved the strength of lime stabilized steam cured blocks.

Guettala, Houari, Mezghiche and Chebili et al (2002) carried out research to improve the behavior of stabilized blocks of earth blocks against water attacks. The results showed the influence of the different manufacturing parameters such as compacting intensity, sand content and lime content on the behavior of stabilized blocks with respect to water attacks, the weight loss and the absorption. It was also observed that improving the compactive stress from 5 to 20MPa and the lime content 3 to 12% improved the compressive strength in dry as well as wet state and the water strength coefficient.

Venkatrama Reddy B.V and Gupta A. et.al (2004) studied the various characteristics of soil cement blocks through an experimental investigation. The results indicated that there was 2.5 times increase in compressive strength when the cement content was doubled from 6%. Pore size deceased with the increase in cement content whereas surface porosity was independent of cement content. The compressive strength of soil cement blocks varied between 2000- 6000MPa and elastic modulus increased by 2.5 % when the cement content was increased from 6 to 8%

Walker (2004) in his investigations on pressed earth block masonry reported that unit dry compressive strength improved as clay content increased and wet block compressive strength was found to be consistently lower than dry strength for identical specimens. Soil blocks containing active clay minerals, were found to deteriorate more with cycles of shrinkage and swelling. Flexural testing of blocks provided a simple alternative method to compression testing as a means of assessing quality. The masonry compressive strength varied between 34% and 96% of unconfined block strength. The tangent modulus was found to be 25–50% of equivalent strength fired clay brickwork and peak strains were found to be 200–400% higher. It was also found that erosion resistance improved as the cement content of blocks increased

Carol Boyle, (2004) in his research work recorded that the sustainability of the building requires more than a simple focus on energy consumption over the entire life span of the building. He conveyed the message that builders, architects and developers need to work with local councils to understand the local needs and limitations of the environment, incorporating passive solar heating, reducing or eliminating external energy requirements using local and recycled materials wherever safe and possible.

Ing. Jan Ruzicka (2005 ) in his experimental investigations made unburned bricks of the size 296x140x70 mm at 3 levels of the working pressure (2.0; 4.0; 8.0 N/mm²) and using 3 ways of stabilization (only by pressure, with admixture of lime 5% and cement 5%) . Stabilization by 5% of cement seems to be the best admixture for these basic components. The bending tension strength was tested on specimens of unburned bricks of the size297x140x70 mm. The results indicated negative impacts in case of the use of admixtures which have plasticizing effects. The wet compressive strength results showed that specimens without admixture indicate a significant drop of the compressive strength under the influence of moisture.
Venkatarama Reddy and Ajay Gupta et.al (2006) conducted studies in the area of tensile bond strength of soil cement block masonry using cement soil mortars. Influence of initial moisture content of the block and block characteristics as well as compaction and workability of cement soil mortar on direct tensile strength of masonry couplets has been explored. Major findings of the studies were 1) Initial moisture content of the block at the time of construction affected the bond strength and use of partially saturated blocks was better than dry or fully saturated blocks. 2) As the cement content of the block increased, its strength increased and surface pore size decreased leading to higher bond strength irrespective of the type of mortar. 3) Cement soil mortar gave 15 to 50% more bond strength when compared to cement mortar and cement lime mortar.

Venkatarama Reddy, Richardson Lal and K.S.Nanjunda Rao et.al (2007) conducted studies on the influence of soil grading on the characteristics of soil cement blocks and shear bond strength of soil cement block masonry triplets. Influence of clay content of the soil cement block on strength, absorption and durability characteristics and interfacial mortar block bond strength has been examined. Some of the major conclusions of the studies were 1) Optimum clay content leading to maximum strength was in the range 14 - 16%. 2) Saturated water content of the block increased with increase in clay content of the block. 3) Initial rate of absorption decreased with increase in clay content of the block. 4)Optimum clay content for the highest modulus of the block and for highest shear bond strength was about 16%

Jagadish (2007) in his research confirmed that the performance of soil based building block depended to a considerable extent on its density and he observed that the desirable dry density was of the range 1.80 to 1.85 gm/cc. His other observations were that for soils containing non expansive clays a clay percentage of about 15% was considered as the upper bound and a low clay content of about 5% at the lower end for satisfactory stabilized mud block production. He concluded that with the clay limitation of 15% and a sand requirement of 65% soil can have about 20% silt.

Venkatarama Reddy, Richardson Lal and K.S.Nanjunda Rao et.al (2007) have done investigations on the methods to improve the shear bond strength of soil cement block masonry and also to find out the influence of shear bond strength on masonry compressive strength. The results indicated that rough textured bed faces of the block yielded higher shear bond strength than the plain surface and no significant changes were noticed in the compressive strength and stress strain characteristics of soil cement block masonry due to changes in shear bond strength.

Jagadish (2007) in his research works revealed that the suitability of a particular soil and the adequacy of the stabilization process can be ascertained by carrying out certain performance tests such as saturated (wet) compressive strength test, the alternate wetting and drying test and the expansion on saturation test which will essentially try to assess the strength and durability characteristics of a stabilized mud block. A wet compressive strength of 3.0 MPa was found desirable to ensure long term durability against erosion. The alternate wetting and drying test showed that there were no noticeable loss of strength after 12 cycles and the block durability was considered satisfactory if the loss in weight was less than 2% after 12 cycles of wetting and drying. The expansion on saturation tests revealed that for a good stabilized block the percentage increase in thickness must be less than 15%. The cost analysis study showed that the basic cost per
block was Rs 3.33 to Rs 3.83 and the cost per brick equivalent works out to be in between Rs 1.20 to Rs 1.37

Yogananda (2008) in his studies recorded that compacting a mixture of sandy soil and stabilizer at optimum moisture content in a press resulted in stabilized mud blocks. The overall energy consumption was found out to be one third in comparison with burnt bricks. He also suggested that stabilized mud blocks can be used for load bearing construction up to four storey’s without reinforced concrete columns by adjusting the stabilizer percentage depending on the number of storey’s and roof spans for a particular building.

Nasly, Yassin, Zahrain Zakaria and Khairunisa Abdullah et al (2009) in their studies on interlocking block technique reported that laterite soil has the potential to be used as a compressed stabilized soil load bearing block. They also recorded that to achieve better quality block and reduce production costs the mix proportion between soil and stabilizer need has to be optimized by considering the specific characteristics of soil and sufficient compaction pressure should be applied to the moist soil mix so as to produce block that fit its purpose.

Venkatarama Reddy and Prasanna Kumar et.al (2009) in their investigations to examine the influence of clay content and moisture content on the compressive strength of cement stabilized rammed earth reached on a conclusion that (1) Optimum clay content for maximum compressive strength was about 16%. (2) The strength of cement stabilized rammed earth was found to be sensitive to the moisture content at the time of testing. (3) Strength in saturated condition was less than half of the dry strength and (4) Water absorption increased with the increase in clay content and it was in the range of 12-16% for the cement stabilized rammed earth prisms with 8%cement.

Oti, Kinuthia, and Bai et.al (2009) in their research work recorded that there is a growing interest in stabilized earth building materials with respect to energy conscious and ecological design, which fulfills all strength and serviceability requirements for thermal transmittance. They pointed that the 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 services makes the material an excellent walling material when compared to the burnt earth blocks used in mainstream construction of today.

Venkatarama Reddy, Richardson Lal and Nanjunda Rao et.al (2009) conducted experimental investigations to understand the influence of mortar bed joints thickness on compressive strength of stack bonded stabilized compressed earth masonry prism. The study revealed that the Poisson’s Ratio of SCB and the cement soil mortar was sensitive to the stress intensity and it increased linearly with increase in stress strength ratio. The other findings were the lateral tensile stress developed in the masonry unit were sensitive to Eb /Em ratio and the Poisson’s ration of mortar and the masonry unit.

Fettra Venny Riza, Ismail Abdul rahman and Ahmad Mujahid Ahmad Zaidi et al (2010) in their research work on compressed stabilized earth block noted that the use of compressed earth block promoted healthier living for the building dwellers. Data from related works showed that an average saturated compressive strength of compressed stabilized earth block is 35% less than the average dry compressive strength. Also it was shown that it demonstrated comparable durability with that of normal fired clay bricks.
Oti, Kinuthia and Bai et al (2010) done researches on freezing and thawing of stabilized clay brick incorporating a latent hydraulic binder for the durability assessment and the confirmation of the suitability of the unfired clay bricks for using it in a severe environment. The unfired clay bricks were first dried to a constant weight at a temperature of 40 deg C in a desiccator. A carbon dioxide absorbing compound carbosorb was used during drying. The results showed that the compressive strength values of the industrial-scale bricks were higher than those of the laboratory bricks. The results of the freeze–thaw suggest that both the laboratory and industrial unfired clay bricks were able to withstand 100 (24h) repeated freeze–thaw cycles. These results gave an indication of the feasibility of a durable stabilized clay brick incorporating a lime-activated latent hydraulic binder.

Satprem Maini, 2010 in his research studies reported that compressed earth blocks were more eco friendly and their manufacture consumed less energy and polluted less than fired bricks. A cubic meter of compressed earth blocks found to be 23.6% cheaper than a cum of country fired bricks. Building a sqm of masonry with compressed earth blocks consumed 5 times less energy than a sqm of wire cut brick masonry and 15 times less than country fired bricks. The pollution emission was found to be 2.5 times less than wire cut bricks and 7.9 times less than country fired bricks. He reported that the cost breakdown of a stabilized block in India, with manual equipment (AURAM press 3000), was found to be usually within the following figures:


Fetra Venny Riza, Ismail Abdul Rahman and Ahmad Mujahid Ahmad Zaidi et.al (2011) in their research work revealed that compressed earth bricks demonstrated many advantages compare to conventional fired bricks. Data from related works showed that an average saturated compressive strength of compressed earth bricks was 35% less than its average dry compressive strength. The average density of compressed earth bricks was almost equivalent with the common brick. Also it has shown that compressed earth brick demonstrates comparable durability with that of normal fired clay bricks. Thermal value experiment indicated that thermal conductivity of compressed earth bricks showed compliance with the design thermal requirements for clay masonry and building regulations.

Tabin Rushad, Abhishek Kumar, Duggal, and Mehta et.al (2011) in their studies on the strength and water absorption characteristic of fly ash bricks made of lime (L), local soil (S) and fly ash (FA) reported that none of the L-S-FA bricks satisfy all the requirements of standard codes. While some of the bricks satisfy the provisions in respect of strength only, the L-FA (40:60) bricks satisfy the requirement of Indian Standard Code in respect of strength as well as water absorption characteristics.

2.0 RICE HUSK ASH AS A STABILIZING CONSTRUCTION MATERIAL

Yogananda and Jagadish et.al (1988) carried out researches to examine the puzzolanic properties of different types of rice husk ash, burnt clay and red mud. Rice husk ash obtained from various sources were analyzed by X-ray diffraction method. Compressive strength properties of lime puzzolana mortars with rice husk ash, burnt clay and red mud were
studied. Influence of grinding of rice husk ash and intergrading with lime were also investigated. Results on the compressive strength tests indicated that the lime puzzolana mortars using rice husk ash as puzzolana satisfied the requirements for secondary construction application like masonry and plastering. Results of lime–rice husk ash mortars containing mostly crystalline silica have shown that prolonged grinding of crystalline rice husk ash enhanced its lime reactivity.

Agnus Setyo Muntohar and Gendut Hantoro et.al (2000) in their researches based on pozzolanic activity of cementitious material found that rice husk ash is a potential material to be utilized for soil improvement. The effects of the engineering properties of clayey soil when blended with lime and rice husk ash were studied. The results confirmed that the blend would diminish swell behavior of clayey soils. The CBR value was found to increase from 3.03% to 16.3% and the internal friction angle enhanced from 5.36% to 22.85%. The consolidation settlement was found to be lowered, the bearing capacity increased and the cohesion also increased.

Oyetola and Abdullahi et.al (2006) did research on the compressive strength of commercial sandcrete blocks in Minna, Nigeria. Physical test on freshly prepared mix were also carried out. Hollow Sandcrete blocks of size 150mm x 450 mm were cast, cured and crushed for 1,3,7,14,21,28 days at 0,10,20,30,40,50 percent replacement levels of cement with rice husk ash. Test results indicated that the compressive strength of OPC/RHA sandcrete blocks increased with age at curing and decreased as the percentage of RHA content increased. The study arrived at an optimum replacement level of 20%.

Musa Alhassan and Albaji Mohammed Mustapha et al (2007) in their investigations to study the effect of rice husk ash on cement stabilized laterite with respect to compaction characteristics, California bearing ratio, unconfined compressive strength tests, indicated that there was a general decrease in maximum dry density and increase in optimum moisture content with increase in RHA content (2-8%) at specified cement contents. It was also found that there was a tremendous improvement in CBR and UCS value with increase in RHA content at specified cement contents to their peak value between 4-6% RHA.

Salas, Ospina, Delvasto, Mejja de Gutierrez (2008), investigated the effect of chemical and thermal treatment on the pozzolanic properties of rice husk ash. The rice husks were subjected to chemical and thermal treatments. After the chemical treatment, the husks were burned under controlled conditions in order to obtain amorphous silica to be used as a pozzolanic material. Finally the ash obtained was milled in a ball mill to reduce the size of the particles. All the products obtained were characterized in terms of silica content, amorphous character, particle size distribution, and pozzolanic activity. The silica obtained was incorporated to cement pastes and concretes to evaluate the mechanical, rheological and durability properties. Based on the experimental results, the following conclusions were drawn: 1). The increase in the amorphicity of the silica in the RHA increased the viscosity of the cement pastes. Because of the high amorphous SiO2 content in ChRHA with high activity, a significant increase in the compressive strength of concretes was observed 2). Incorporation of ChRHA in normal concretes enhanced durability properties by refining its pore structure.

Musa Alhassan (2008) conducted studies on the effects of rice husk ash on the soil –lime mixtures with respect to unconfined compressive strength and coefficient of permeability.
The UCS of specimen were found to increase with increasing RHA content at specified lime contents to the maximum values at 6% RHA. The coefficient of permeability of the cured specimens was found to decrease with increase in RHA content to their minimum values of 6% RHA content and beyond this point, the permeability was increasing. The results revealed that no more than 6% RHA could be used to increase UCS and to reduce permeability of laterite soil.

Danupon Tonnayopas, Parapong Tekasakul and Sarawut Jaritgnam et al (2008) investigated the effect of rice husk ash on the physical and mechanical properties of lightweight fired clay bricks. Different proportion of RHA from 10 to 50 % by mass was mixed to the raw brick clay. Higher RHA addition required a higher water content to ensure the right dry density. All test specimens were produced by uniaxial hydraulic press method and fired at 1050 deg C. The samples were tested according to Thai Industrial Standard methods and compared with its specification (TIS). Up to 40% RHA addition was found to meet TIS. The investigation has demonstrated a feasible way of using incinerated RHA as brick clay in producing high quality brick. The most economical firing temperature was found to be 1050 deg C.

Oti, Kinuthia, and Bai, et al (2009) conducted researches in stabilized compressed earth block with materials lower oxford clay, ground granulated blast furnace slag and quick lime. The results revealed that the strength values observed using lime activated GGBS for industrial scale stabilized earth masonry brick production were better, relative to those observed for the laboratory bricks. The results of the freezing and thawing cycles has demonstrated the ability of the stabilized earth masonry blocks to resist damage as a result of freezing and thawing. Throughout the freezing thawing cycle no noticeable evidence of cracks was observed. Based on the results of the thermal conductivity of stabilized earth masonry blocks, it was seen that the thermal conductivity depend on apparent density, residual moisture content and mineralogical composition of clay and other additives. An indication of carbon and energy inventory in terms of energy inputs and emission outputs of the production process of 1 ton of stabilized earth masonry block showed that the energy usage was around 657.1 MJ/t and the carbon dioxide emission was around 40.9 kg CO₂/ton. This environmental performance was excellent when compared with energy usage and emissions of fired clay bricks which is 4186.8 MJ/t and 202 kg CO₂/t respectively.

Robert Brookes (2009) done some researches to upgrade the expansive soil as a construction material using rice husk ash and fly ash. Remolded expansive clay was blended with RHA and fly ash and strength tests were conducted. The potential of RHA-fly ash blend as a swell reduction layer between the footing of a foundation and sub grade were also studied. Stress strain behavior tests showed that the failure stress and strains increased by 106% and 50% respectively when the fly ash content was increased from 0 to 25%. When the RHA content was increased from 0 to 12% unconfined compressive strength increased by 97% while CBR improved by 47%. Therefore an RHA content of 12% and fly ash content of 25% was recommended for strengthening the expansive sub grade soil and a fly ash content of 15% was recommended for blending into RHA for forming a swell reduction layer.

Harunur Rashid, Keramat Ali Molla and Tarif Uddin Ahmed et al (2010) conducted studies on the durability of cement mortar in presence of Rice husk ash. The strength and
durability of mortar with different replacement levels of OPC by RHA were investigated. Test samples were prepared with river sand of fineness modulus 2.72. Samples were kept in controlled environment. The results showed that addition of RHA showed better results for 20% replacement level at 90 days. The durability tests confirmed that all samples passed for 20 cycles except 25% and 30% replacement levels.

Zain, Islam and Jamil Mahmud et.al (2011) carried out researches on the production process of rice husk ash from rice husk and the quality of rice husk ash produced using rudimentary furnace at National University of Malaysia (UKM). Three combustion methods and two grinding methods were used to investigate physical characteristics and chemical aspects of RHA produced. Combustion temperature distribution of the furnace, ash particle size, silica crystallization phase and chemical content of the produced RHA were studied using X-ray diffraction (XRD) analysis and scanning electron microscopy (SEM). From the investigation, it was found that combustion period, chilling duration, and grinding process and duration are important in obtaining RHA of standard fineness and quality. Combustion of rice husk with fire duration of 30 min, air supply duration of 60 min and chilling duration of 2 days (combustion method C) was found to produce good quality ash. Carbon content of the ash was 3.21% and color was white. Although grinding for 30 min produced good result, grinding for 60 min or more was recommended for achieving standard fineness of RHA.

3.0 CONCLUSION

From the aforementioned review done on sustainable construction practices and materials and also on Compressed Stabilized Earth Brick (CSEB) with rice husk ash as a stabilizer, there is a growing interest in stabilized earth building materials with respect to energy conscious and ecological design, which fulfills all strength and serviceability requirements for thermal transmittance. The 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 services makes the material an excellent walling material when compared to the burnt earth blocks used in mainstream construction of today.

Use of traditional Construction materials, non-availability of suitable codes and specifications and suitable mix design method are the main barriers for the use of rice husk ash in construction. To promote the use and to gain confidence in using rice husk ash as a stabilizing agent, these issues need to be addressed. Hence a detailed analysis of Stabilized Compressed Earth Blocks using rice husk ash as a stabilizer by considering various parameters is very much necessary to understand the resultant masonry block properties.

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