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EXPERIMENTAL STUDY ON COMPRESSED STABILIZED EARTH BLOCK

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Abstract - *From pre-historic period, people use earth as building material. The manufacture of those building blocks is varied according to the conditions of weather and structural load coming from the top. Even though clay brick has proven its effectiveness as a building material in construction industry, it has some defects like cracking, carbon emission and embodied energy in the production phase etc. In comparison with another building material, Compressed Stabilized Earth Block (CSEB) offered number of advantages like increase in strength, utilization of local material, insulation and thermal properties, healthy environment for the occupant, durability etc in the most economical way. Some works are already going on about the utilization of locally available soil to make earth blocks. The work is aimed to introduce a new building material which can be made from locally available soil. The highlight of the work is that the soil which is considered as a waste or just a solution for landfill after the excavation for the foundation and wells can be used for making a new sustainable and economical building material. This study demonstrates the properties and benefit of CSEB reinforced with synthetic fiber compared to conventional brick especially in strength, durability and cost. After the identification of properties of the soil, laboratory tests are conducted to determine the optimum content of stabilizers (cement, lime and flyash) which gives maximum compressive strength. In this work, we are introducing another material like Polypropylene fiber is mixed in various percentages to get the optimum for the crack resistance. This study is purely an experiment oriented work as per the IS standards so that we could compare the effectiveness of the work with old methods of manufacturing the clay bricks.*

***Key Words*: cseb, fly ash, cement, lime**

1. INTRODUCTION

1.1 General

Building industry is dependent on endless supply of high quality materials and energy resources. This results in depletion of non-renewable materials and resources, production of waste by-products, 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. 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. 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 by-product material which is vital for the future construction. Stabilization of earth is the set of processes which permit to ameliorate its mechanical characteristics. In other to solve a stabilization problem, it's necessary to know the properties of the earth to treat and the ameliorations wish for. Stabilization permits to reduce the volume of the gap between particles of the solids, to plug up the gap which one cannot cancel and to create links or to ameliorate existing links between particles. In our work, after manufacturing Compressed Earth Blocks (CEB) and stabilizing it, we evaluate their mechanical properties, experimentally. Before any experience, we must first proceed to the identification of the properties of the earth materials.

In everyday conversation, the word brick and block sometimes refer to the same object and has ambiguity. The definition of brick and block depend upon the country of origin but British Standard BS 3921: 1985 Clay brick defines a brick as "a masonry unit not exceeding 337.5 mm in length, 225 mm in thickness (referred to as width in one of the standard) or 112.5 mm in height". As for block, BS 6073: Part 1: 1981 Pre-cast concrete masonry units defines a block as "a masonry unit which, when used, in its normal aspect exceeds the length or width or height specified for brick" (Thomas). CDI (Compressed Earth Blocks, 1998) defined compressed earth block as "masonry elements principally made of raw earth, which are small in size and which have regular and verilied characteristic obtained by the static or dynamic compression of earth in a humid state followed by immediate demoulding". Even give lighter definition for brick and block as a small masonry unit, lift able with one hand and a large masonry unit lift able with two hands, for the latter. Considering the definitions for both words are not really strictly categorized, thus for the convenient purpose of this publication, the word brick will be used to point out the masonry unit which made out basically of soil and stabilizer such as cement and lime, fully or partly combined. A third of world population living in earthen architecture as the most widespread construction forms. It's simple technologies survived when modern building materials and advance methods flooding the industrialization era. In line with science development, earth technologies also evolved to find

better form which satisfied newest standard. Moreover, growing concern and interest about environmental and ecological issue globally also increased the used of earth as a building material. In comparison with another building material, CSEB offered numbers of advantages. It increases the utilization of local material and reduces the transportation cost as the production is in situ, makes quality housing available to more people, and generates local economy rather than spending for import materials. Faster and easier construction method resulted in less skilled labour required, good strength, insulation and thermal properties, less carbon emission and embodied energy in the production phase, create extremely low level of waste and easily dispose off, cause no direct environmental pollution during the whole life cycle. Earth brick also have the ability to absorb atmospheric moisture which resulted create healthy environment inside a building for its occupant. The earth used is generally subsoil, thus the topsoil can be used for agriculture. Building with local materials can employ local people, and is more sustainable in crisis.

2. LITERATURE REVIEW

Fetra Venney Riza (2011) Have demonstrates the properties and benefit of compressed stabilized earth block compared to conventional brick especially in strength and durability. The compressed earth block is defined as "masonry elements principally made of raw earth, which are small in size and which have regular and virilised characteristic obtained by the static or dynamic compression of earth in a humid state followed by immediate demoulding.

In comparison with other material, compressed stabilized earth block offered numbers of advantages:-

- It increases utilization of local materials.
- It reduces the transportation cost as the production is in situ
- It generates local economy rather than spending for import materials
- Faster and easier construction method resulted in less skilled labour required, good strength, insulation and thermal properties, less carbon emission
- Embodied energy in the production phase, create extremely low level of waste and easily dispose off
- It cause no direct environmental pollution during the whole life cycle
- Earth brick also have the ability to absorb atmospheric moisture which resulted create healthy environment inside a building for its occupant

The main function of the stabilizing medium is to reduce the swelling properties of the soil through forming a rigid framework with the soil mass, enhancing its strength and durability. The soil with plasticity index below 15 is suitable for cement stabilization and cement binder is added between 4 and 10 % of the soil dry weight. If the cement content is greater than 10% then it becomes uneconomical to produce compressed stabilized earth blocks. For the soil has plasticity index above 15% or have clay content, it is suggested to use lime as a stabilizer. When the lime is added to the soil, first it adsorbed by the clay mineral, then lime fixation and an amount between 1 to 3% lime added by weight. For laterite soil, the lime stabilization is suitable. The plasticity index is greater than 20%, it is not suitable for manual compaction.

The determination of compressive strength in wet condition will gives the weakest strength value due to the development of pore water pressures and the liquefaction of unstabilized clay minerals in the brick matrix. The strength of the blocks are increased by adding fibres where it can improve the ductility in tension.

The moisture content affect the strength and durability of the material. The drying shrinkage of the block was primarily governed by the plasticity index and the additives used. If the plasticity index is less than 20%,the drying shrinkage shows steady increase with the increase of clay content, but for plasticity index beyond 25-30% drying shrinkage increased rapidly as the clay content also increased. So plasticity index less than 20% is good for the stabilization and commonly used drying shrinkage limit from .008% to .10%.

The basic principle of the stabilization is to prevent water attacks and it could be achieved if a durable material can be obtained with limited loss in mechanical strength in a wet state. From the tests concluded are very severe compared to natural condition ,the clay material still have potential to damage from rising damp, freeze/thaw cycles and surface erosion caused by wind-driven rain as clay mineral tend to disrupt the cement action.

Raju Sathish Kumar (2012) In this paper cement stabilized compressed earth block gave the view of energy efficient cost reduction and environmental friendly building material. Rice husk is commercially available in India, rich in silica content which can be used in supplementary cementetious material. By increasing the cement content reducing clay content this improves dry shrinkage and durable characteristics. Pressed soil block made from red soil have more than 5 % of clay content. Possess to good erosion resistance. The bond strength decreases when saturation increases normally it will be lowered in the case of compressed earth block. Improving compactive stress from 5-20 Mpa and the line content 3-12% it will improve the compressive strength in dry as well as wet state.

S.A.Kakade(2015) The high cost of materials for anyconventional building is a major factor that affects the housing delivery worldwide. This has necessitated research for alternative cost effective materials in construction. The paper aims at analyzing characteristic compressive and tensile strength of coconut shells of concrete produced. By partial replacement using crushed, granular coconut shells as a substitute for conventional coarse aggregate in M20 grade concrete. The cube and cylinder are casted, tested then physical and mechanical properties are determined. In this

studies, three different concrete mixes with different the combination of natural material content namely 0%, 25%, 50%. Three samples specimen will be prepare for each concrete mixes. The parameters will be tested are compressive strength, tensile strength. This paper analyzed an investigation on the behavior of concrete specimens produce from coconut shell aggregate. A total of 36 specimens with varying percentage of replacement were casted and tested. The attempt is made to prove in all respect the serviceability and durability, experimental study is satisfying and can be implemented in rural areas by considering all technical aspect

Sadek Deboucha (2011) In their paper gives a comparison between clay bricks and compressed stabilized earth blocks. According to the compressive strength of the clay bricks are classified as first, second and third grade with minimum compressive strength of 35, 20 and 5.2N/mm2 respectively. The raw materials and the manufacturing process of bricks affect the density and it vary between 1300-2200 kg/m3 .And also it influences the weight of the wall and the variations in weight.

For the compressed stabilized earth blocks, due to the use of a by-product material in the mix, its final pricing will be reduced. The soil, raw or stabilized, for bricks is slightly moistened, poured into press and then compressed either by mechanically or manually.

The compressive strength of compressed stabilized earth block depend upon the soil type, type and amount of stabilizer and the compaction pressure used to form the blocks. A typical wet compressive strength for compressed stabilized earth blocks may be less than 4MN/m2.Normally compressed stabilized earth blocks are denser than a number of concrete masonry products. Low density blocks have an advantage over high density ones of acting as better thermal insulators.

The advantages of compressed stabilized earth blocks are:-

- Soil is available in large quantities in most regions
- Cheap and affordable
- Easy to use
- Suitable as a construction material for most part of the building
- Fire resistant
- Beneficial climatic performances in most regions due to its high thermal capacity, low thermal conductivity and porosity
- Low energy input in processing
- Environmental appropriateness

Vignesh Kumar Nagarajan (2014) The environmental impact of OPC is significant because its production emits large amount of CO2. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes for reducing the consumption of natural raw materials as resources. The volume of wastes generated in the world has increased over the years due to increase in population, socioeconomic activities and social development. One of the most attractive options of managing such wastes is to look into the possibility of waste minimization and re-use. The cost of cement used in concrete works is on the increase and unaffordable, yet the need for housing and other constructions requiring this material keeps growing with increasing population, thus the need to find alternative binding materials that can be used solely or in partial replacement of cement. Agricultural waste material, in this case, coconut shells, which is an environmental pollutant, are collected and burnt in the open air (uncontrolled combustion) for three hours and that product is incinerated in muffle furnace at 800o C for 6 hrs to produce coconut shell ash (CSA), which in turn was used as pozzolana in partial replacement of cement in concrete production. Concrete mortar cubes were produced using replacement levels of 0 and 5 percent of OPC with CSA. The Coconut Shell ash is used for the partial replacement of cement. Further, use of coconut shell ash as a value added material as in the case of binary blended cement concrete, reduces the consumption of cement. Reduction of cement usage will reduce the production of cement which in turn cut the CO2 emissions. The time has come for the review of progress made in the field of development of binary blended cement concrete.

3. PROPERTIES AND MATERIAL USED

3.1CEMENT

Ordinary Portland cement is used in this work which has the following properties given by the manufacturer.

Table 1 The Properties of OPC

Fineness	
Specific surface(m2/kg)	312
Setting Time (Minutes)	
Initial	180
Final	290
Normal consistency	31.5

3.2 LIME

Locally available lime is used in this work and the properties are as shown:

Table 2 The Properties of Lime

Components	**Amount (%)**
Calcium hydroxide	90
Silica	1.5
Ferric oxide	0.5

Magnesium oxide	1
Alumina	0.2
Carbon Dioxide	3.0

3.3 FLY ASH

The material is collected from Hindustan News Print Ltd. Velloor, Kottayam. It has the following properties which are given by the manufacturer.

Table 3 The Properties of Fly ash

Property	Value (%)
Loss on ignition	3-7.5
Insoluble residue	78-85
Fineness	470-600
Residue on 90 micron	28-55
Residue on 45 micron	18-30
Alkali	0.5

4. MIX DESIGN

4.1GENERAL

Mix design is defined as the process of selecting suitable ingredients of soil and determining their relative proportions with the object of producing soil bricks of certain minimum strength and durability as economically as possible.

4.2 MIX DESIGN AND SPECIMEN PREPARATION

Table 5 represents the mixture proportions of cement, flyash and lime. Specimens of 20cmX 20cm X10 cm were prepared and properly compacted with a mechanical press and all these works are done manually. After casting, the bricks were removed from the mould, and were kept for air drying for 2 days and after that the bricks were kept for curing by water spraying or by membrane curing for 3 days. The compressive strength value for a typical mixture at a particular age is based on the average of 4 specimens. PP fiber is added to the optimum percentages of stabilizers which we have got the maximum strength from the test.

Table 4 Mix Design of Stabilization and fiber reinforcement

Soil	Flyash (%)			Lime (%)			Cement (%)			
	5	10	15	1	2	4	8	15	23	31

PP fiber (%)	Soil+flyash (optimum%)	Soil + lime (optimum %)	Soil+OPC(optimum %)
	0.5	1	1.5

5. CONCLUSIONS

By detailed literature survey proposed in the project phase 1 gives as a theoretical knowledge about the utilization of fly ash, lime, polyproplyen, coconut fiber in compressed soil block. From the literature it is understood that the partial replacement of cement shows a good physical and mechanical properties in the block

From the results and discussions effectiveness of stabilisers in improving the engineering properties of clayed soil were studied. The conclusion from the test results are listed below:-

- The compressive strength of soil increases with increase in amount of stabilizers which reach an optimum value and then it decreases..
- As per 1077:1992, the water absorption shall not be more than 20% by weight up to in first class. And from the test found that all the bricks are in first class category.
- From the efflorescence test found that it does not contain any soluble salts in the bricks.
- It lead to low cost of production, which is eco friendly, and energy saving.
- After the test results we can understand the variation and proportional changes, thus we can understand at which mix we get the best comparative result.

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