

# Alternative Building Material For Incentivize Contemporary Vernacular Architecture

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**Abstract-** There has been a steady growth of construction in the urban areas of the country. However, some of the backward rural areas receive no such attention in terms of construction. What little construction done is either incomplete or not of the highest quality. This is due to two main limitations: cost of construction and availability of materials. Most of the people living in rural areas are either below poverty line or have very low income. They cannot afford the construction of their house and resort to making kutchha houses made of mud that is readily available to them. Then there are other select few households which can deal with the construction costs but not quality construction. The pakka houses in the rural areas have no plastering, uses cheap construction techniques which sacrifices on quantity and quality of materials and high maintenance costs. Therefore, these constructions are not much better than the kutchha house construction. This calls for a building material that combats the two limitations and is effective for construction purposes in rural areas. This study has been undertaken to investigate the effectiveness of Compressed Stabilised Earth Blocks as a building material in central rural India.

**Index Terms-** Compressed Stabilised Earth Block, central rural India, kutchha, cost of construction, quality construction, availability of materials

## I. INTRODUCTION

A compressed earth blocks (CEB), otherwise called a compressed soil block, is a building material made principally from moist soil compressed at high strain to frame blocks. Compressed earth blocks utilize a mechanical press to shape blocks out of a suitable blend of genuinely dry inorganic subsoil, non-expansive mud and aggregate. In the event that the

blocks are stabilized with a chemical binder, for example, Portland cement they are called compressed stabilized earth block (CSEB) or stabilized earth block (SEB). Generally, around 3,000 psi (21 MPa) is connected in pressure, and the first soil volume is diminished by about half.

The contribution of soil stabilization enabled individuals to manufacture higher with more thinner walls, which have a vastly improved compressive quality and water resistance. With cement stabilization, the blocks must be cured for a month in the wake of assembling. After this, they can dry openly and be utilized like basic blocks with a soil cement stabilized mortar.

## II. CASE STUDY

- Project name: Sharanam Centre for Rural Development
- Project location: Puducherry
- Site: 5 acre plot, 10 kms west of Puducherry
- Client: The Sarvam Charitable Trust, Puducherry
- Architects: Jatin Lad & Trupti Doshi
- Project timeline: 2007-2014

The Sharanam Rural Development is established to be a training and administrative centre of a large rural development programme which is a part of a larger rural development programme initiated by Sri Aurobindo Society (SAS) for the Sarvam Charitable Trust in the surrounding villages of Villupuram district, Tamil Nadu. This centre will be the main venue for a lot of different programmes concerning rural development of these villages.

These programmes cover a wide range of topics including rural health and hygiene, sanitation, education, income-generation, teacher training, self-development among women, youth and children promoted through psychological development.

The project was conceived after the tsunami of 2004 that destroyed much of the south east coast of India. Cadbury felt obligated to extend their corporate social responsibility beyond their normal vision to start a project that would improve life for impoverished communities which were affected by this natural disaster.

*Planning:*

A topographical survey was conducted to select the region with the lowest contour level. This region was dug up to form a pond so that during the monsoon season, the rainwater will flow in this direction to collect in the pond. The soil which was obtained from this region was used to make the CSEBs to construct the rural development centre. The team which was leading this project had decided early on to use the minimal amount of steel and cement for the centre.

Approximately, around 2, 00,000 CSEB of nine different dimensions were made for the walls, piers, and vaults. These earth blocks were cured under the sun and have only 5 percent of cement was used to stabilise the blocks. The masonry piers and walls which used stabilised earth mortar as a construction material were built on rammed earth foundations which minimised cement consumption.

The main multi-purpose hall with an area of 550 m<sup>2</sup> has a vaulted ceiling. These segmented masonry vaults were hand-built by the labourers in approximately nine weeks. These are only 9cm thick at the keystone and the vaults which weigh around 140 tonnes were constructed without centering and used simple nylon laundry lines as guides. The entire structure is earthquake resistant and steel tension ties were used to counter the lateral thrust. These vaults span 9.5 m and are 42 m in length. Stabilised earth mortar was used for the vaults only 1mm thick which resulted in using only 33 bags of cement. Around 38,000 blocks were used to make these vaults in 760 courses with no supporting formwork. After conducting a cost analysis, it was found out that the technique used in this centre was 50 percent cheaper than the equivalent reinforced concrete frame used throughout the region.

In addition to the multi-purpose hall, the centre also has administrative offices, a newspaper office, meeting spaces, community radio station, stores and a kitchen.

The primary structure of the centre has six segmental masonry vaults which are defined and separated by folding walls, level changes and ornamental ponds. One enters the main hall using granite slabs which step down to it. This hall is skirted by a 21.5 m x 11 m granite thinnai (a sit out in front of a house in south India), which can be used by small groups for workshops for 50-60 people or an audience of 200. The thinnai extends to the east to form a deep stage, beyond which sits a smaller circular hall under a detached vault.



Figure.1. Main hall of the centre with vaulted ceiling

III. DATA COLLECTION

There is a particular kind of soil composition that is required for CSEB. But with some knowledge and experience many soils can be used for producing CSEB.

One of the most important thing to keep in mind is that the top soil and organic soils must not be used. Top soil generally contains component like vegetation and rubbish which may react with the stabilisers used for the CSEB. The same goes for organic soils. Therefore the top soil must first be removed and only the inner, deep soil should be used as the major component.

Soil, is the earth's concrete and therefore it should have the ideal proportions. For CSEB, the suitable soil must be more sandy than clayey. It should have the following proportions:

- Gravel: 15%
- Sand: 50%
- Silt: 15%
- Clay: 20%

According to the percentage of these four components, we can determine whether the soil is gravelly (with more gravel), sandy (with more sand), silty and clayey. Testing the percentage of these components would determine what additions to make in the soil so that it is ideal to be used for CSEB.

One more important step to be kept in mind is the checking of seismic zones. For low seismic zones, dry stacking without mortar can be possible. But for high seismic zones, mortar of dirt, sand and cement mixture is made. Every fifth row of the stack should be mortared with cement.

#### *Soil Stabilisation*

Like concrete contains gravel, sand and cement in its composition that act as binder, in the same way soil also contains gravel, sand, and silt & clay as binders. These binders (silt & clay) are not suitable under water. Therefore the main purpose of stabilisation is to stabilise silt and clay against water. The input of stabilisers in the CSEB, allow to build higher with thinner walls. Stabilised soil also has a much better compressive strength and water resistance. When using cement as stabiliser, the blocks must be cured for four weeks after manufacturing. After this they can dry freely and be used like common bricks with a soil cement stabilized mortar.

The selection of a stabilizer will depend upon the soil quality and the project requirements. Cement will be preferable for sandy soils and to achieve quickly a higher strength. Lime will be rather used for very clayey soil, but will take a longer time to harden and to give strong blocks.

Soil for cement stabilisation: more sandy than clayey

- Gravel: 15%
- Sand: 50%
- Silt: 15%
- Clay: 20%

Soil for lime stabilisation: more clayey than sandy

- Gravel: 15%
- Sand: 30%
- Silt: 20%
- Clay: 35%

The average stabiliser proportion is rather low:

- Cement
  - Minimum: 3%
  - Average: 5%
  - Maximum: No technical maximum
- Lime
  - Minimum: 2%
  - Average: 6%
  - Maximum: 10%

These low percentages are part of the cost effectiveness of CSEB.

Numerous stabilizers can be utilized. The nature of the stabiliser will depend on the soil quality, the need and the sort of system utilized: Fibres (normal or engineered), natural products (straw, hide, juice of plants, latex, and so forth.) can be utilized for strategies which require a great deal of water (adobe, wattle and smear, cob, and so on.).

For CSEB and rammed earth, the most widely recognized stabilizers are concrete and lime. Different stabilizers like chemicals, saps can be utilized too. Cement will be ideal for sandy soils and to accomplish rapidly a higher quality. Lime will be favored for exceptionally clayey soil, however will set aside a more drawn out opportunity to solidify and to give solid squares. Concrete or lime adjustment of soils will expand a ton the quality, and balanced out earth could be presented to water or even inundated. The densification of soils by pressure (slammed earth, CSEB) or by including water (formed, cob, adobe, and wattle and smear) will likewise give cohesion and more protection. For this situation the earth ought not stay in contact with water for long.

#### *Manufacturing*

There are 6 phases for the manufacturing of CSEB. The accompanying subtle elements are given for an Auram Press 3000 (by Auroville Earth Institute) which can produces 1000 squares 240 every day:

- Preparation (Digging + Sieving): 2 to 4 people
- Measuring: 1 person
- Mixing: 2 people
- Pressing: 3 people
- Initial curing and first stacking: 1 person
- Final curing and stacking: 2 people
- Total No.: 11 to 13 people

Light manual gear introduces the benefit of being shabby, yet the hindrance of a low durability, a low

yield and not compressed squares. Overwhelming manual gear exhibits an all the more intriguing proportion, with more yield, greater durability and more quality for a consequent increment of expenses. Motorized gear ventures into another class of cost: it will create better quality squares with more yield, yet more costly.

In this manner, overwhelming manual presses are more often than not the best decision as far as advancement for the speculation/quality/proportion. Versatile units are continually coming a long ways behind. Industrialization isn't adjusted to the creation of CSEB. Semi industrialization is the best: it offers the preferred standpoint to be more adaptable and effortlessly adjusted to a nearby setting. It expands the quality without expanding massively the cost of a square. Semi industrialization ought to be comprehended here as an incorporated generation, but instead with manual presses than motorized ones.

Comparison with conventional building materials

Pollution emission (Kg of CO <sup>2</sup> /m <sup>2</sup> )	Energy consumption (MJ)
2.4 times less than wire cut bricks	4.9 times less than wire cut bricks
7.9 times less than country fired bricks	4.9 times less than wire cut bricks
Initial embodied energy (MJ/m <sup>3</sup> of materials)	Carbon emission (Kg of CO <sup>2</sup> /m <sup>3</sup> of materials)
CSEB are consuming 11 times less energy than country fired bricks: CSEB produced on site with 5% cement = 548.32 MJ/m <sup>3</sup>	CSEB are polluting 13 times less than country fired bricks: CSEB produced on site with 5% cement = 49.37 Kg of CO <sup>2</sup> /m <sup>3</sup> Country fired bricks = 642.87 Kg of CO <sup>2</sup> /m <sup>3</sup>

Table.1. Energy effectiveness of CSEB

#### IV. ANALYSIS ON CSEB

##### A. Advantages of CSEB

- A local material: Ideally, the production is made on the site itself or in the nearby area. Thus, it will save the transportation, fuel, time and money.
- A bio-degradable material: Well-designed CSEB houses can withstand, with a minimum of

maintenance, heavy rains, snowfall or frost without being damaged. The strength and durability has been proven since half a century.

- But let's imagine a building fallen down and that a jungle grows on it: the bio-chemicals contained in the humus of the topsoil will destroy the soil cement mix in 10 or 20 years.
- Limiting deforestation: Firewood is not needed to produce CSEB. It will save the forests, which are being depleted quickly in the world, due to short view developments and the mismanagement of resources.
- Management of resources: Each quarry should be planned for various utilisations: water harvesting pond, wastewater treatment, reservoirs, landscaping, etc. It is crucial to be aware of this point: very profitable if well managed, but disastrous if unplanned.
- Energy efficiency and eco friendliness: Requiring only a little stabilizer the energy consumption in a m<sup>3</sup> can be from 5 to 15 times less than a m<sup>3</sup> of fired bricks. The pollution emission will also be 2.4 to 7.8 times less than fired bricks.
- Cost efficiency: Produced locally, with a natural resource and semi-skilled labour, almost without transport, it will be definitely cost effective.
- An adapted material: Being produced locally it is easily adapted to the various needs: technical, social, cultural habits.
- A transferable technology: It is a simple technology requiring semi skills, easy to get. Simple villagers will be able to learn how to do it in few weeks. Efficient training centre will transfer the technology in a week time.
- A job creation opportunity: CSEB allow unskilled and unemployed people to learn a skill, get a job and rise in the social values
- Market opportunity: According to the local context (materials, labour, equipment, etc.) the final price will vary, but in most of the cases it will be cheaper than fired bricks.
- Reducing imports: Produced locally by semi-skilled people, no need import from far away expensive materials or transport over long distances heavy and costly building materials.
- Flexible production scale: Equipment for CSEB is available from manual to motorized tools

ranging from village to semi industry scale. The selection of the equipment is crucial, but once done properly, it will be easy to use the most adapted equipment for each case.

- Social acceptance: Demonstrated, since long, CSEB can adapt itself to various needs: from poor income to well off people or governments. Its quality, regularity and style allow a wide range of final house products. To facilitate this acceptance, banish from your language “stabilized mud blocks”, for speaking of CSEB as the latter reports R & D done for half a century when mud blocks referred, in the mind of most people, as poor building material.
- B. Some limitations of CSEB
- Proper soil identification is required or unavailability of soil.
  - Unawareness of the need to manage resources.
  - Ignorance of the basics for production & use.
  - Wide spans, high & long building are difficult to do.
  - Low technical performances compared to concrete.
  - Untrained teams producing bad quality products.
  - Over-stabilization through fear or ignorance, implying outrageous
  - Under-stabilization resulting in low quality products.
  - Bad quality or un-adapted production equipment.
  - Low social acceptance due to counter examples (By unskilled people, or bad soil & equipment).

## V. CONCLUSION

The production of CSEB is relatively easier than conventional building materials like bricks, concrete blocks, etc. it can be easily done by people of a community without the need for skilled labour. The equipment and materials required for production of the CSEB is also cheap. When constructing using CSEB, no additional skill is required and CSEB has low CO<sub>2</sub> emissions when compared to bricks and concrete blocks. The materials required for the production of CSEB are easily available and can be procured without any difficulty. CSEBs reduce energy consumption in homes, due to their excellent thermal performance courtesy of the thermal mass of

earth blocks, reducing heating and cooling costs. It regulates humidity: clay plasters on the interior and lime plasters on the exterior allow the walls to breathe. This is another way that the energy consumption of the structure is reduced. The regulation of humidity through the breathability of the walls reduces the need for air-conditioning systems.

Thus, CSEB is economic and easily available material; the solution to two main problems that were found and discussed. Based on the data collected it is also effective for hot and dry climate. The practical proof of this data and claims were found out through the literature case studies, both of which are based in Auroville, in the southern part of India. Thus, the location had one thing in common with the location in mind for this dissertation, the hot and dry climate. Furthermore, the first case study’s site is situated in rural southern India, another common point with the problem. Through both the case studies, it was concluded that CSEB can be used as an effective building material in central rural India.

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