

Presentation for the ASEAN Workshop on Green Construction Materials for Communities and MSMEs (TISTR) Bangkok.

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Affordable and sustainable building materials for low-cost housing

- Compressed Stabilized Earth Blocks and Interlocking Stabilized Soil Blocks
 - Adobe Building Blocks



(a)



(b)



(c)



(d)



Short introduction on sustainability

Make a difference between durability and sustainability.

- Planet Earth and Climate targets
- Design of the neighborhood
- House and location/orientation
- Housing design and structure
- Sustainable building materials
- Recyclability of materials after 'life'

"Going Green: A Handbook of sustainable housing practices".
(By UN-Habitat, 2012)

With:

A holistic approach (e.g.):

- Environmental sustainability
- Economic sustainability
- Cultural sustainability
- Social sustainability
- Institutional sustainability

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Compressed (Stabilized) Earth Blocks and ISSBs

Examples from various sources: e.g. from
Uganda, Mali, El Salvador, and India

First: focus on mainstream building materials for housing
(examples from Central and South America).



Mainstream
terracotta
(clay) bricks



Medellín, Colombia

Mainstream: concrete blocks



Example of tradition in Kampala, Uganda, Kimwanyi settl.

- Production of fired bricks in Kampala at 2 km of the city center, in a slum area.
- Negative effects: smoke and smog in the city; logging elsewhere / firewood transport; CO2 emissions; resulting in deep ponds in the land.



Wetland degradation



FUTURE:

The making of fired bricks in Kimwanyi in Kampala is very traditional, and not ecofriendly.

50% of bricks are of low quality.

The City Council has chosen to improve the surrounding slum area, and make it part of the city.

Clay mining and firing of wood for bricks is seen as not sustainable, although it provides jobs.

Search for Earth Technologies!



Compressed Stabilized Earth Blocks (CSEBs) and Interlocking Stabilized Soil Blocks (ISSBs)

The new VISION on the use of local materials is:

- Process locally the raw materials for CSEBs and use local labor; and
- Build houses for and with local groups of households.
- Improve local building practices, with new knowledge and equipment, which are manageable by local actors.



Interlocking Stabilised Soil Blocks
Appropriate earth technologies in Uganda

UN HABITAT
FOR A BETTER URBAN FUTURE

 **Good Earth Trust**
Promoting Sustainable Development

Compressed Stabilized Earth Blocks (CSEBs and ISSBs): State of affairs

- CEBs, CSEBs, and ISSBs are more sustainable than fired bricks
- UN-Habitat promotes the use of Interlocking Stabilized Soil Blocks (ISSB) in Uganda. For schools and houses.
- Example in Jinja, Uganda.
- CEB's, CSEBs, CSSB's, ISSBs, HCEBs, all are different names of the same: Earth-blocks, Loam-blocks, or Improved Loam Bricks.
- The quality depends on the mix of raw materials in the bricks, the manufacturing process, and the addition of stabilizers and fillers.

Earth or Loam are alternatives for fired bricks



- Affordable
- Local resource
- Environmental friendly
- Good indoor climate
- Non-skilled labor possible
- Self-help construction possible

Earth or Loam is a mixture of:

Gravel + Sand + Silt + Clay

Eventually: add stabilizer and filler



Properties of earth materials compared

Properties	I	Materials
<ul style="list-style-type: none"> ○ Compressive strength ○ Water resistance ○ Water conductivity ○ Embodied energy ○ Thermal conductivity ○ Recyclability ○ Density ○ Plasticity ○ Aesthetic quality ○ Costs 		<ul style="list-style-type: none"> ○ BB ○ CEB ○ CSEB ○ ISSB ○ HCEB ○ Concrete block

Parameter	ISSBs	BBs
Wet Compressive Strength (N/mm ²)	1.5	0.5
Dry Compressive Strength (N/mm ²)	2.5 – 6.7	0.27 – 2.2
Thermal Conductivity (W/m°C)	0.8 – 1.4	0.7 – 1.3
Density (kg/m ³)	1700 – 2200	1400– 2400
Embodied Energy of material (MJ/kg)	0.68 @ 5 % cement	3.00

Source: UN-Habitat

UGANDA

HUMID TROPICAL CLIMATE ZONES

Search for CEBS and CSEB's for housing, with examples from Jinja, Uganda



SDI in Jinja, Uganda

Joseph Serunjogi and the Jinja slum dwellers Federation started to ramp up slum upgrading projects in and around the city using their own savings.

They obtained technical support from SDI and built a partnership with the Jinja Municipal Council.

They construct sanitation units and community halls, and began improving the living conditions of Jinja's slum dwellers.

A man with short dark hair, wearing a light-colored checkered shirt, stands in front of a wall made of light-colored bricks. Above him is a corrugated metal roof supported by wooden poles. The background shows some outdoor structures and trees.

**I'm an
Urban
Poverty
Fighter**



The site has become a learning center for the manufacturing of innovative, climate-friendly building materials.

It gives local youth valuable skills, and small but regular income from the sale of their products.

Various forms of CEB building blocks



High quality
walls with
CEBs <- to be
plastered (left)

ISSBs (below)



Straight Double
Interlocking Block



Curved Double
Interlocking Block



Wide Format
Interlocking Block

CEB - manual



ISSB - manual



ISSB - mechanised



Various other projects with CSEBs/ISSBs in Uganda



ISSB Housing Scheme; by Smart Housing Africa

Focus on research Earth – Loam blocks or bricks

- For a wall of one ground floor house: CEB's without stabilizer is possible.
- For load-bearing walls, and extra floors, stabilizers are usually needed in loam mixtures.
- Stones or bricks - with cement mortar - are usually needed for foundations.
- Nowadays, a search is going on, for replacers of cement: some are of inorganic origin such as lime and fly ash; others of organic origin (e.g.: sisal, cassava powder).

About: Earth – Soil – Loam.

- A location where components for loam are mined, must be inspected professionally.
- Required features of the loam mixture depend on the design of homes, site conditions, climate, and spatial planning requisites, and the wanted architecture quality.
- A load bearing wall wanted? -> wall must have sufficient compressive strength.
- An outer wall in a wet climate? -> wall must be water proof.

MALI

DRY ARID
CLIMATE ZONE

MALI, Bamako social housing project, LEVS Architects



BAMAKO

PROJECT: SOCIAL HOUSING
DISTRICT WITH HYDRAULICALLY COMPRESSED EARTH BLOCKS (HCEB)



Social housing in Mali: how to give a small district of three hundred homes character? The design of a new district in Mali's capital integrates local tradition: life happens outside, within the walled grounds of the house.

Bamako Urban development scheme, LEVS Architects



2015 (design)

300 social houses
type F3 and F4

Client: Le Ministre
de l'Urbanisme et de
l'Habitat, Mali

Government of
Mali.



African suburbs are typically fraught with empty, anonymous roads, rendering the neighbourhood largely inhospitable and unattractive. By making smaller streets, little squares, and planting trees, the neighbourhood becomes a friendly place.

Bamako, Mali: 300 social houses

Hydraulically Compressed Earth Blocks (HCEB) are produced using a mobile press.

By using earth-materials from the construction site, transport- and production costs, as well as environmental impact, have been decreased.

In terms of heat- and rain resistance, earth blocks are an improvement on the traditionally used clay. They create pleasant inside climates.



Source: Oskam Co, Netherlands.

Hydraulically Compressed Earth Blocks (HCEB):

Composition:

- 1 Loam/clay stone (clay, silt, sand), usually in natural form.
- 2 Clay limestone (clay, silt, sand), addition of 5% lime (waterproof).

Shape, size, weight

Form. Rectangular (Monastery format).

Dimension: 295 mm x 140 mm x 90 mm

Weight: 7, 5 kg per stone. 2200 kg per m³.

Mechanical properties (depending on the type of clay)

Compressive strength of loam-stone 4-pressure 6Mpa

Compressive strength of loam-limestone 6-18MPa

Moisture absorption.

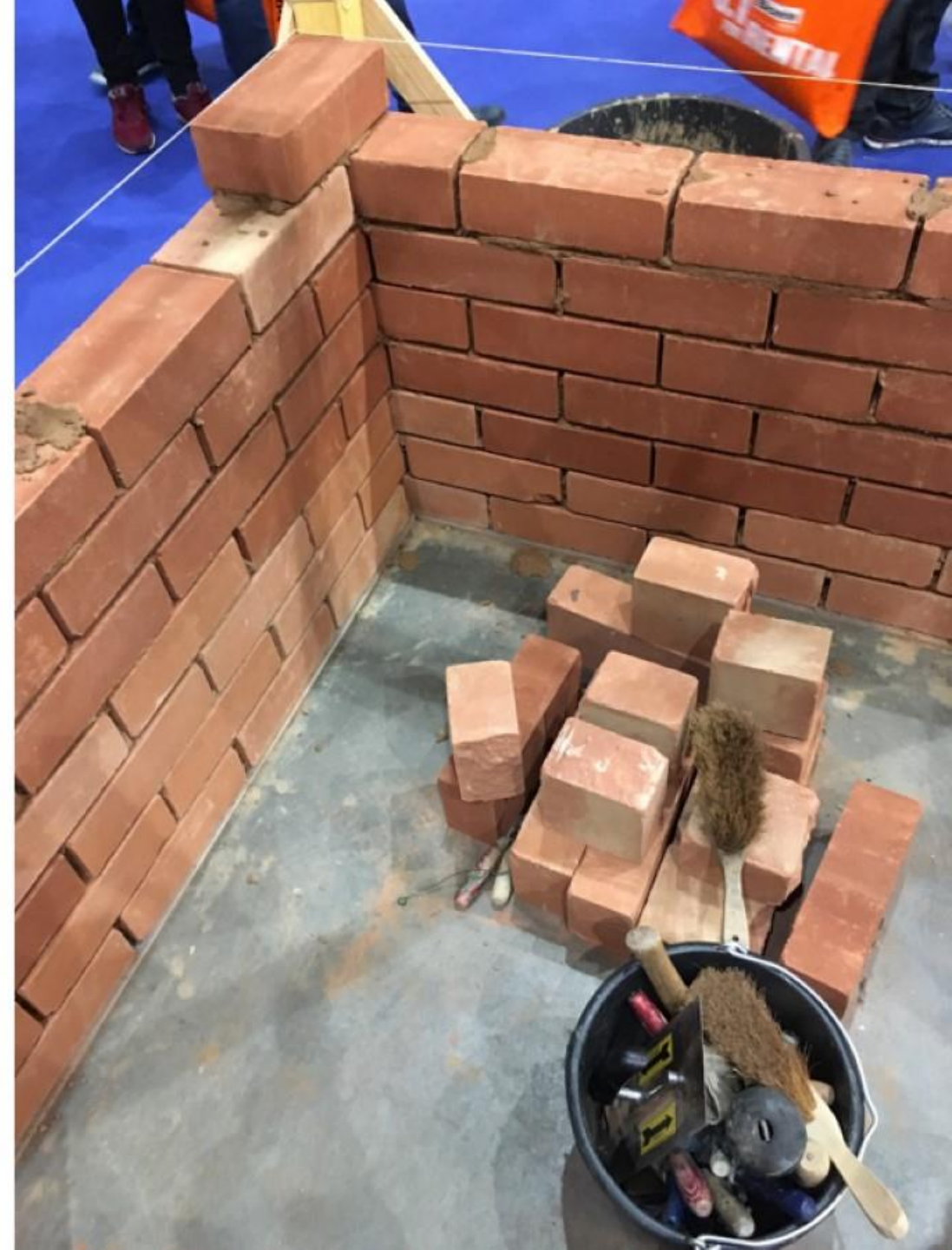
Up to 5 to 7% of the dry weight.

Resistance.

Clay stone is not resistant to running water and rising damp.

The Clay-limestone is water resistant.

See: www.oskam-vf.com



Elementary school Gangouroubouro, Mali, LEVS Architects.

Building vaults and domes with hydraulically compressed building blocks



Francis Keré Architects. Léo, Surgery and Health Center in Burkina Faso.



Francis Keré Architects. Center for Earth architecture, in Mopti, Mali.



INDIA

4-5 DIFFERENT
CLIMATE ZONES

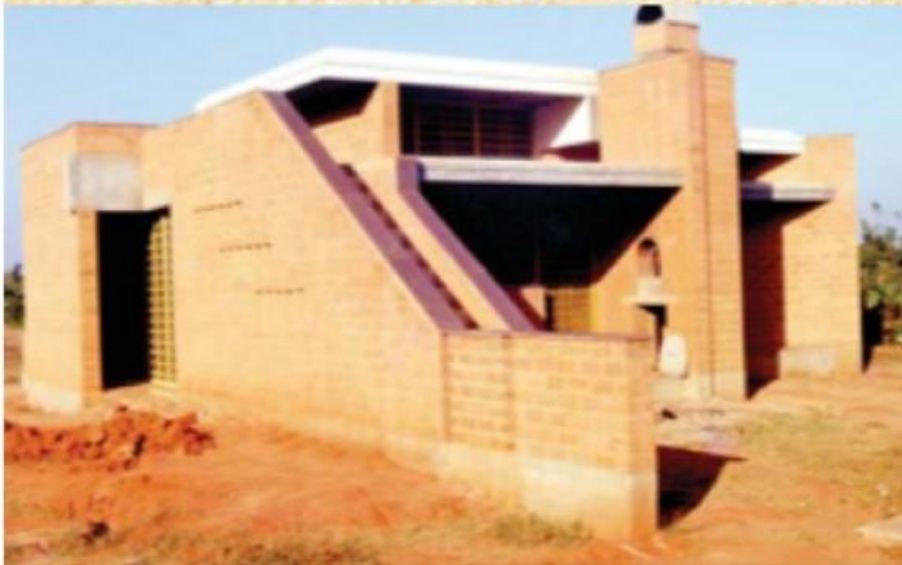
Auroville Earth Institute: Expertise center



Cost effective houses at Kottakarai village



House at Dana community



House at Auromodele community



House at Dana community

Auroville Earth Institute: Expertise center.

Auroville Earth Institute is an important organization for India and the World.

However, it is not specifically focused on housing provision for low-income households.



13 apartments on 4 floors at Vikas Community

Research on building materials such as CSEBs for Rural India

Rural population:
67% of total
population

Contribution to
national Income :
46%

Rural housing
need by 2022:
29.5 million



House in warm humid climate. Walls of Cob

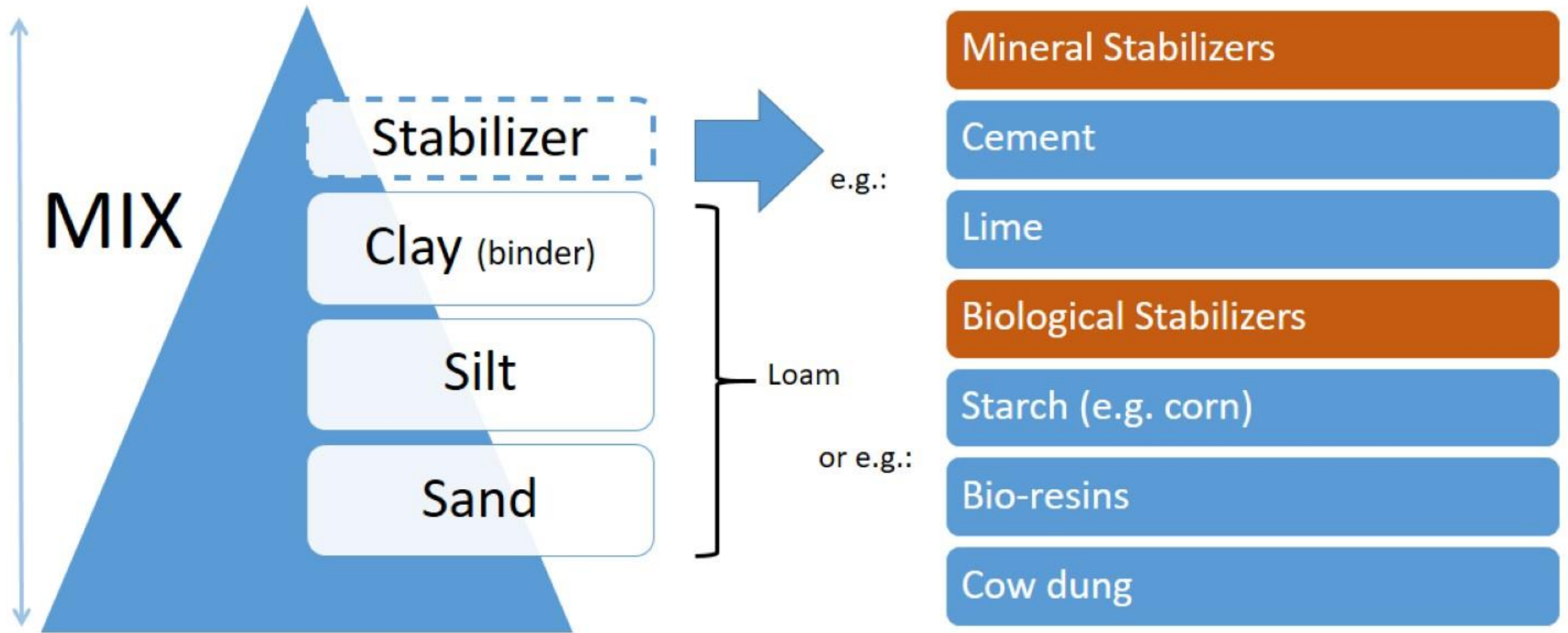
Source: Jask Kulshreshtha, TU Delft, NL

Minimize the use of cement in CSEBs

Stabilizers from plant products and animals

- Plant juices containing oily and latex derived from plants such as sisal, agave, bananas, and Euphorbia herea, usually in combination with lime, are used as a stabilizing coating successfully in many countries.
- Several reports show that cooked starch and molasses can also be used to enhance stability. This effect is more pronounced if a Little lime is also added.

Making low-cost durable mixtures of Earth/Loam



Research on building materials such as CSEBs for Rural India

Research University of Technology Delft, Netherlands.

By: Yask Kulshreshtha, MSc.

Enhancing Durability by using bio-resources as stabilizers in CSEBs

Terminalia Chebula



Jaggery



Cow-dung



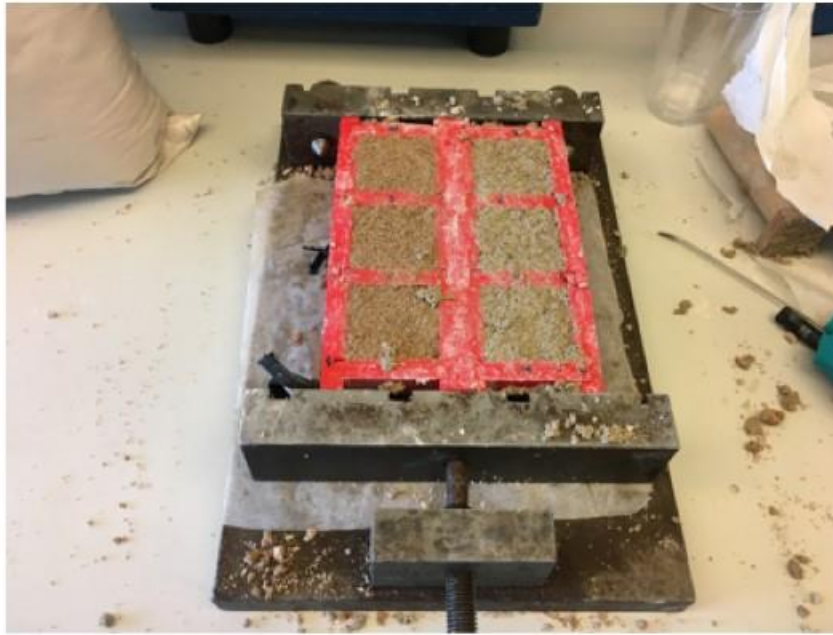
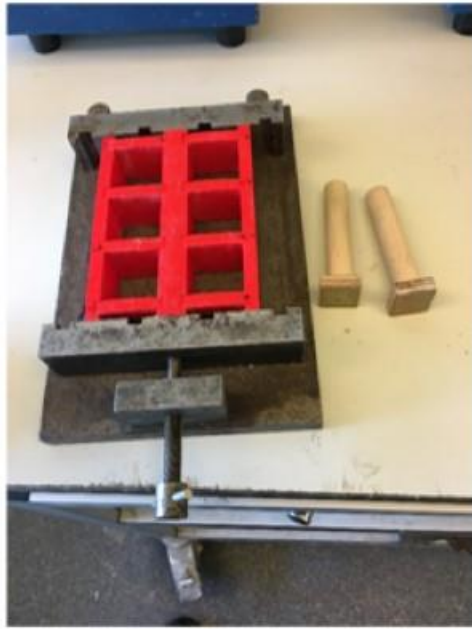
Starch



Ash from Rice husk



Cow dung works as stabilizer.
It is not known why.
Chemical research focuses on the cause of it.



Concerning compressive strength, water proof and resistance, and other tests: Cow dung as stabilizer seems to be promising.

About the image of the walls and the building: the users must be convinced that CSEBs with local available bio-stabilizers give good facades, expressing high quality.

Modern Earth house in Namchi, North of India.

House is built of concrete framework and CSEB for walls.

House in Namchi, North East of India.

It is earth quake resistant.

Source:
Jask
Kulshreshtha,
TU Delft,
NL



Research on building materials for rural India

Main challenges:

- Can bio-stabilizers replace cement in CSEBs for certain usages?
- Can regional expertise centers promote adequately durable and sustainable CSEBs/ISSBs?
- What is the role of building businesses, the education sector, and cooperatives?

ADOBE blocks

Examples from El Salvador

Expertise Center: FUNDASAL

Salvadorian Foundation of Development and Minimal Housing

Research on adobe as building materials for housing

Differences with CSEB's and ISSBs are:

- Adobe blocks have a higher percentage of clay - giving more shrinkage.
- Adobe keeps house cool in hot climates.
- Mostly in rural areas where clay-like soil is available.
- Do it yourself is possible under technical guidance.
- Technical assistance by FUNDASAL (El Salvador) and IDESAC (Guatemala).

The image of adobe for buildings/housing can be good after plastering

Adobe:

Compression by hands or feet.

Dimensions of the blocks: 30 x 30 x 9 cm.

Reinforcement of structures by bamboo

Plastering the walls always necessary to make nice architecture, and:
to avoid the disease of Chagas.



Plastering the walls



Adobe:
earthquake
resistant
houses
(by FUNDASAL)



Improved Adobe for buildings/housing. Source: Fundasal.

Colored adobe blocks; plasterwork; and paint.

Improved mixtures with natural stabilizers: more clay than in 'traditional' ones, 20% versus 40%.



Mixture: 60% sand; 20% silt, and 20% clay (clay of high plasticity).



Adobe: research on adequate dosages of raw materials



Recent buildings with adobe walls



House with adobe walls in Mexico. Ecohabitar.org

Realized buildings with adobe blocks in Central America.

Walls must always be plastered.

Walls are mostly colored.



House by Fundasal

Regular research on Adobe and CSEBs (ongoing)

Knowledge necessary (general):

- Knowledge on local climate conditions and soil types.
- Knowledge on threats of natural hazards (e.g. earthquakes, floods, hurricanes).
- Maintaining contact with local community.

Research on, or near the building site:

- Available raw materials for CEBs or Adobe Blocks.
- Testing the raw materials and testing mixtures.
- Training of local construction workers.

End of presentation Earth Technologies | Thank you.

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