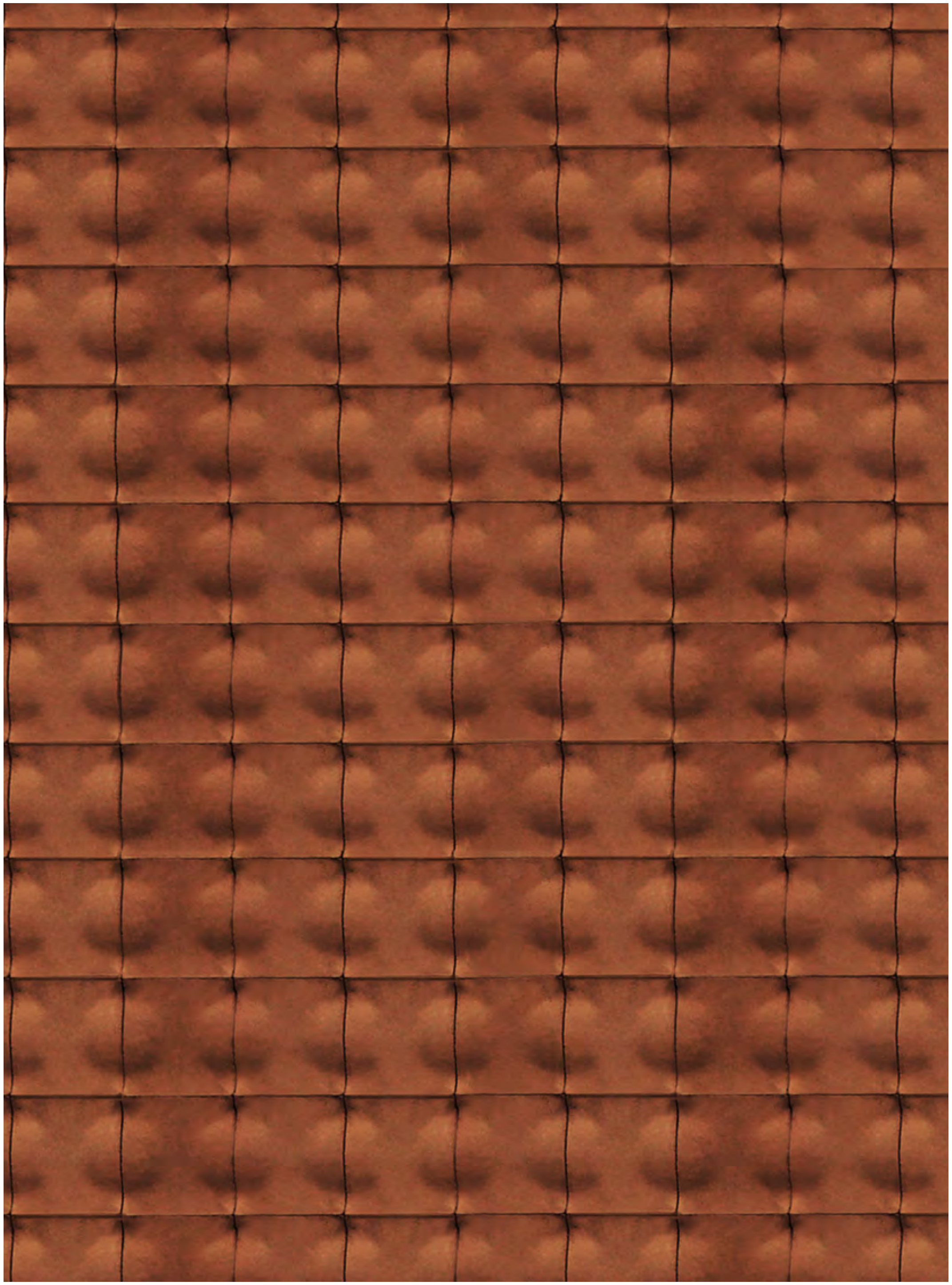


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# Mockups

# Revealing the Potential of Compressed Earth Blocks

*A Study in the Materiality of Compressed Earth Blocks (CEB): Lightness, Tactility, and Formability*

## REVEALING THE POTENTIAL OF COMPRESSED EARTH BLOCKS: A VISUAL NARRATION (INTRODUCTION)

Plain CEB Blocks
24x24x9cm

Interlocking Blocks
24x24x9cm

Half Interlocking

U Blocks (Beams)

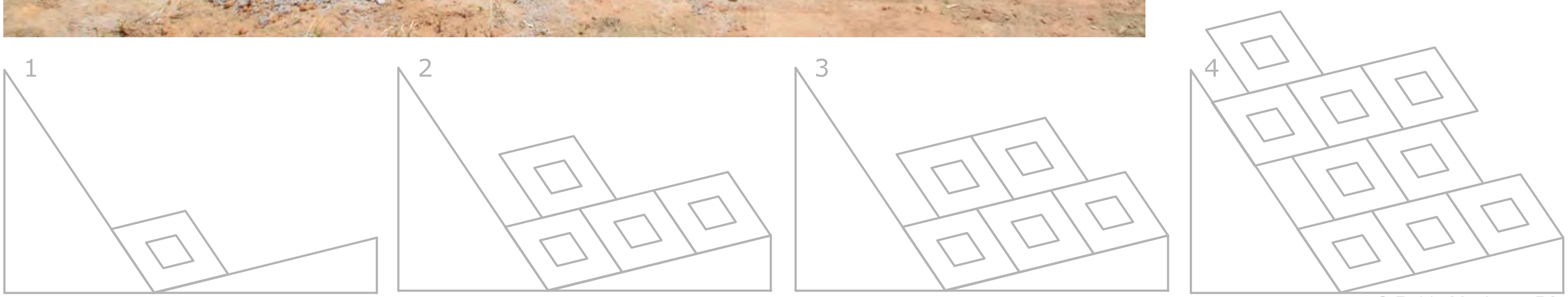
### Introduction

All over India, the villagers burn mud brick, which is made of top soil that is rich in organic substance for three continuous days in the open. The waste of brick is huge (around 15%). The CO2 emission and energy consumption are extremely high. Using top soil means waste of soil suitable for agriculture. This is clearly an extremely harmful practice to our continuously degraded environment. What would happen if all the adobe villages in India and many other developing countries were rebuilt with village fired brick? Compressed Earth Blocks pollution emission is 2.4 times less than kiln fired bricks, and 7.8 times less than country fired bricks. Moreover, its energy consumption is 5 times less than kiln fired bricks, and 15 times less than country fired bricks (according to a study from development alternative in New Delhi). I believe CEB is an underused material, however can provide viable sustainable, affordable, water resistant, and strong construction material (1200-1600 psi compressive strength, and 9-11% water absorption). In order to encourage villagers, developers, and architects to use this sustainable material, we need to evolve the way we use it and reveal its hidden potential and unseen capabilities. This is what I tried to do working on the following experimental mockups.

# REVEALING THE POTENTIAL OF COMPRESSED EARTH BLOCKS: A VISUAL NARRATION (MOCKUPS)

## In Pursuit of lightness

Compressed soil blocks is by default a very heavy material, yet within its heavy nature lies the chance to achieve lightness; the highly dense compressed soil enabled the production of these thinner perforated blocks laid with a uniquely slanted bond. After a process of trial and error, we managed to successfully produce these perforated rhombus CEB blocks with a 19th century technique to compress blocks manually (rejuvenated merely for these experiments). Eventually the blocks will be produced using a hydraulic compressing machine. While constructing this mockup wall, we discovered that the heaviness of the CEB provided enough friction for the blocks not to slide on the slanted joint, even with no mortar. The perforated slanted units gives a feeling of unusual lightness and openness for earth construction.



# REVEALING THE POTENTIAL OF COMPRESSED EARTH BLOCKS: A VISUAL NARRATION (MOCKUPS)

*Tactility; Single Curve and Three Walls*

While working on the production of Compressed Earth Blocks on site, I had a deeper understanding of the process of the material production, as well as the capabilities of the machines, tools, and craftworkers. This developed understanding inspired a simple curve to generate variant experimental blocks and walls. Working with the carpenter to carve additional wooden forms to be added to the machine, we used this curve to make the first block and wall, inverted the curve to make the second, and used both simultaneously to make the third. The walls appearance changed radically in relation to natural light. I intended to use such a textual undulated earth walls in the natural resort, in order to enforce a feeling of connection to typically unnoticed natural phenomena, like the movement of sunlight on surfaces. Eventually in my thesis, I used this example as evidence of the opportunities such a material manufacturing process and mode can offer to the designer: a process completely controlled by the architect using affordable machinery and raw materials. I discovered that I can reveal the nature of a material through understanding and practicing its production process, and here we compress soil returning it to its original primordial stony state. Thus I emphasized a feeling of compressibility and sculpturality.

In these two experimental mock-ups, I explored the different possibilities of bondings using one block. I specifically investigated how can the shape of the single block influences the block bonding patterns, and how the architect sometimes needs to use the material himself, in order to discover the most fitting bond of every specific shaped block.

Wall 1- *Stack Bond*
This wall is constructed using the stack bond. It is not a strong bond because it allows continuous vertical mortar joints; however, the bond could be improved with vertical reinforcement hidden in the joints. Additionally, this wall was designed to be a double wall, which means that the second layer can shift to strengthen the whole wall.

Wall 2 - *Running Bond*
The running bond is a stronger bond, but difficult to reinforce unless the wall is constructed of more than one layer.


*1*

*2*

*3*

*4*

*5*

*6*

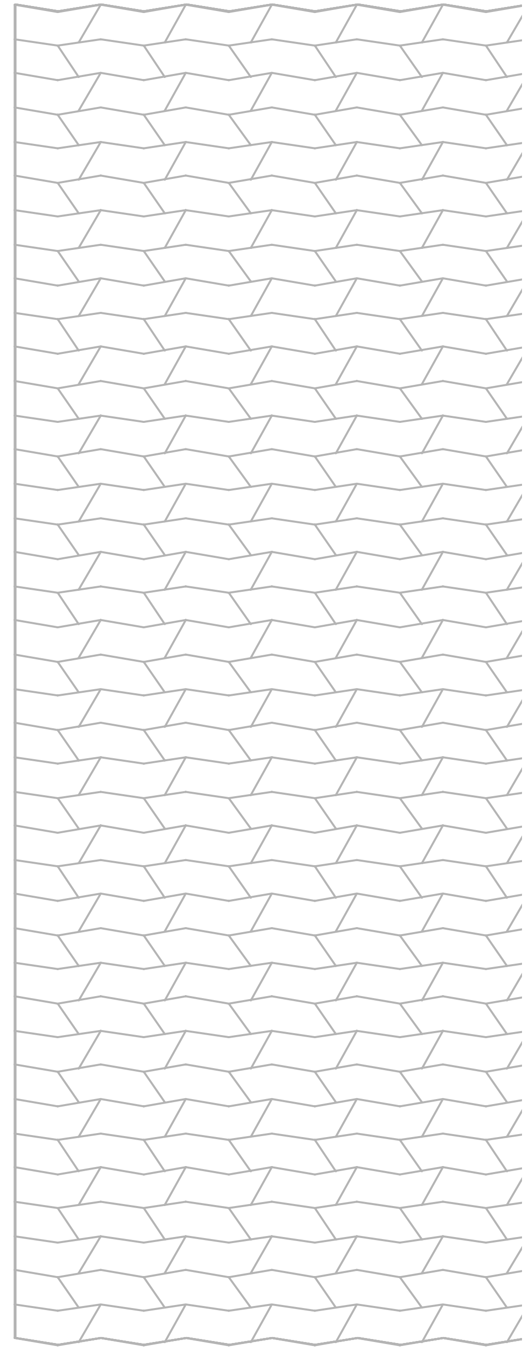
*7*

Wall 2 - Running Bonds (two types)
While the first one is the usual running bond, the second one is completely dependable on the curve profile of the blocks. This wall is constructed using two different bonds. These bonds are stronger than the stack bond especially for a single layer wall, because these two bonds do not produce continuous vertical mortar joints. The only problem with this bond is the difference between the overlapping curves of every two adjacent blocks, which might make this wall more susceptible to weathering. Such a difference is reduced to minimum in the curve dependent bond. Taking the rule of the mason, I learned that there are important factors that have to be taken into consideration while designing a block as well as a bond: the weight of the block, its texture; and its handling ease.

Bond 2
Curve Dependent Bond

Bond 1
Usual Running Bond

# REVEALING THE POTENTIAL OF COMPRESSED EARTH BLOCKS: A VISUAL NARRATION (MOCKUPS)



This fraction of a wall is built of a group of especially formed interlocking blocks to increase friction, hoping that this high friction masonry wall will highly resist lateral loads in comparison to walls constructed with standard blocks. This is a preliminary trial; no sufficient tests have been conducted yet to verify the previous assumption. In this case, the blocks are interlocked in the long direction of the wall. Interlocking in the short direction may have an even more influence on the behavior of the wall during earthquakes. This experiment proved that it is possible to freely form more complex Compressed Blocks and build walls with an unusual bonds, like this strong zigzag bond. These experimental blocks were produced manually. This is the beginning of a series of coming investigations.

# REVEALING THE POTENTIAL OF COMPRESSED EARTH BLOCKS: A VISUAL NARRATION (MOCKUPS)

## PROCESS

Aiming to integrate the new natural resort in the fabric of the surrounding vernacular villages, I worked collaboratively with a representative group from these villages (around 50 farmers, masons, and carpenters, both men and women, as well as the sponsors and engineers). During this month-long workshop, I supervised the material production of the blocks needed for the first phase of the project (plain blocks, earthquake resistant interlocking blocks, U-blocks for beams), in addition to special experimental blocks and mock-ups. In order to make sustainable earth technologies standup as a valid substitute for unsustainable materials and technologies, we tried to stretch the capabilities of compressed earth blocks (CEB). We experimented with different soils, stabilizers, compressions techniques, and forms, expanding the design process to include the design of the units, in this case blocks, as an integral part of a holistic system. Interestingly, villagers, already planning to develop their traditional mud brick houses using the unsustainable village fired brick and concrete, asked me to visit the village to tell them if the sustainable CEB can be used to do the job. This proved to me that sustainability can only be brought to people through an interactive integrative process, in which they actively participate during the design and construction processes. Sustainability is a process.








# Experience of Masonry Shells at the Auroville Earth Institute

# IN AUROVILLE EARTH INSTITUTE

This vault was my first experiment with masonry shells. While practicing building traditional arches, vaults, and domes at the Auroville Earth Institute, I was asked to build a typical barrel vault. Instead, I asked this question: what if I tried to build a vault connecting between two different arches? The thrust line at any vertical section of the vault will always be somewhere in between the thrust lines of the two arches. Thus the vault will be strong and stable, if the two arches are stable. So, I built this vault (with compressed earth block), connected between a segmental arch and a semicircular arch. I used the free standing nubian vaulting technique (no forms). Using the same simple principle, if we connect between a group of different catenary arches for example, we can create complex free form masonry shells. Using form finding techniques like graphic statics to design and optimize masonry shells, we can build wide span shells with minimum thickness.

I worked as a Mason to Build these Optimized Pointed Vaults

Different Vaults by Auroville Earth Institute

Segmental Vault

Semi-Circular Vault

Free Standing Vaulting

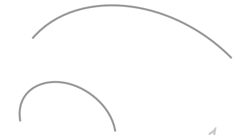
Catenary Vault

Segmental Groined Vault

Training Center

Egytian Vault

# IN AUROVILLE EARTH INSTITUTE



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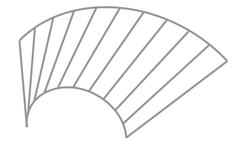

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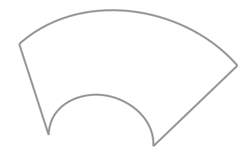

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## Free Form Masonry Shells

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