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The Experience of Two Workshops on CSEB Attended by MSA University Team at Auroville Earth Institute and MSA Center of Earth

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Abstract

Building with compressed stabilized earth bricks (CSEB) is considered one of the most low cost environmentally-friendly technologies. The future potentialities of the material and building technique in reducing the use of fired bricks and concrete in Egypt are very strong, especially when the bricks are produced using sandy soil, available all over the country. In order to promote the awareness of this technology, many institutions around the world conduct training workshops. This paper aims at comparing between the intensive hands-on training workshops on the production and masonry of CSEB attended by MSA University students at Auroville Earth Institute (Auroville, India) and MSA Center of Earth (6th of October, Egypt). The comparison covers the following points: 1) workshop program, 2) soil identification and sensitive field tests, 2) press machine model, 3) shapes of produced bricks, 4) production process from preparing mixtures to stacking, and 5) masonry. Besides the gathered observations and comments, 6) a questionnaire consisting of these points was developed and handed to the team that attended the two workshops. According to the trainees' observations and questionnaire results, differences in languages and accents were significant issues in understanding explanations and instructions, less theoretical content and in-situ lectures was preferable to all and the large number of trainees results in lack of tools. Based on their experience, manually sieving and mixing the ingredients was easy but using a hydraulic press machine to manufacture CSEB was faster and less labor-intensive. In addition, stacking the units on pallets near the machine made the brick less likely to damage. Using quality control tools such as a penetrometer and calliper was essential for producing good bricks. Producing bricks with various shapes and colors was more interesting and athletically appealing to them. As for the masonry training, although using real bricks was slower and more complicated, it was useful for acquiring practical experience. Finally, the social dimension, such as making new friends, was as important as the other advantages of the workshops.

Keywords

Compressed Stabilized Earth Bricks, CSEB, ISSB, Press Machine, Sandy Soil, Soil Field Tests, Egypt, India, Auroville Earth Institute, MSA Center of Earth, MSA University, Cement Stabilization

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1. Introduction

Affordable sustainable housing is a matter of significant importance. On the one hand, there is an urgent need to find housing solutions that contribute to affordability and satisfy socio-cultural needs. On the other hand, it is essential to find green solutions that address the increase in carbon dioxide emissions due to building practices. In Egypt, almost the only materials used in the housing sector construction are cement, steel and fired bricks and their prices have doubled in recent

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years despite the urgent need for affordable homes [1, 2]. To promote principles of "Green Architecture" and "Affordable Homes' and develop designs with appropriate technologies that are environmentally-friendly, economic and aesthetically appealing, the Faculty of Engineering at MSA University took the initiative of sending to India, in Feb. 2016, a team of staff members and students from the Department of Architectural Engineering to attend intensive training workshops on compressed stabilized earth blocks (CSEB), in Auroville Earth Institute, UNESCO Chair Earthen Architecture.

Later in the same year, the university imported from Brazil a motorized hydraulic press machine "Eco Brava" with high specifications and compression force to produce interlocking compressed earth blocks using the available sandy soil at MSA University, 6th of October Campus.

In numbers, CO_2 emissions of Eco Bricks are 12 times less than red bricks, they need 10 times less embodied energy than red bricks for their production, building with them is 4 times faster and $1m^2$ finished wall is 60% cheaper than a finished conventional wall [1-7]. The machine's productivity is 1600 bricks per 8 hours and creates many work opportunities [8, 9]. In addition, because of the interlocking "Lego-like" feature of the bricks and their high quality and accuracy, neither mortar nor plastering are needed, reducing thus the cost and minimizing the use of cement of which its industry is on the top of the list of pollutants. It is worthy to say that the press machine was the beginning of launching the establishment of "MSA Center of Earth" (MSA CoE) training and research center. The team working in the center is the same team that took the training in Auroville. MSA CoE has already started building an experimental residential unit at MSA campus that will help in the expansion of the technology in Egypt.

In January 2017, the team of MSA CoE took an intensive training by a specialist from the manufacturing Brazilian company "Eco Maquinas" on the maintenance of the press machine and the production of Eco Bricks. The team successfully produced interlocking stabilized compressed earth bricks, molds and colors using the available sandy soil at MSA Campus.

In July from the same year, the center launched 4 rounds for "Intensive Hands-on Training Workshops on the Production and Masonry of Interlocking Compressed Stabilized Soil Bricks ISSB." ISSB stands for interlocking stabilized soil bricks, a special shape of CSEB.

Figure 1. CSEB training workshops team and trainees: above, MSA Center of Earth (MSA CoE), Egypt; below, Auroville Earth Institute (AVEI), India.

2. Aim and Methodology

This paper aims at comparing between the two experiences: the training conducted at both Auroville Earth Institute (hereafter AVEI) in India and MSA Center of Earth (hereafter MSA CoE) in Egypt (Figure 1). The comparison addresses the following points: 1) workshop program, 2) soil identification and sensitive field tests, 2) press machine model, 3) shapes of produced bricks, 4) production process from preparing mixtures to stacking, and 5) masonry. Besides the gathered observations and comments, 6) a questionnaire consisting of these points was developed and handed to the team that attended the two workshops.

3. Workshops Program

The intensive workshop on the production of CSEB at AVEI lasted 6 days with the first two having theoretical lectures and the remaining four days having practical training [10] (Table 1). The lectures were held in a lecture hall near the training site. In day 1: the team was trained on the soil identification with sensitive field tests not laboratory tests. In day 2: masonry bonds and mortar principles. Day 3: introduction to the press machine and how to operate it, measuring ingredients and making mixtures, producing plain blocks and at the end of the day again sensitive field test of soil samples. Day 4: producing other shapes of blocks and at the end of the day sensitive field test of soil samples. Day five: stabilized rammed earth foundations and wall and ending it repeatedly with sensitive soil field tests. In the last day, the team started with the sensitive field tests of soil samples brought from each one/team's country then building arches and test and course evaluation, and finally distribution of certificates. At MSA CoE, the intensive workshop lasted for 3 days all of which had theoretical lectures integrated with the practical part, i.e. the lectures were held on the site of the training using a movable board not in a separate lecture hall [11] (Table 2). In the first day, trainees identified several types of soil through sensitive field tests. In day 2, they calculated mixture ingredients and their percentages, measured them and performed dry and wet mixing, learnt how to operate and maintain Eco Brava machine, produced standard, colored and various shapes of CSEB, and finally stacked them on pallets. Distribution of certificates took place at the end of day 3.

Table 1. CSEB intensive training workshops program of AVEI, India.

DAY	LECTURER	SESSION	CONTENT
	Ayyappan	1 = T	- Registration - Visit of the Auroville Earth Institute and the exhibition
	Satprem		- Sustainability and resources management
1	Satprem	2 = T	- Basic data on CSEB - Raw material and soil identification
	Satprem	3 = T	- Particular earth techniques - Soil stabilization principles and calculation
	Ayyappan	4 = P	- Soil identification (field tests with sensitive analyses and density check-up)
	Satprem	1 = T	- Quality control principles & improving and stabilising soils - Blockyard organisation
2	Satprem	2 = T	- Cost analysis & economic feasibility study - Block-laying & design guidelines
	Ayyappan	3 = P	- Bonds for various walls (straight, corner, T & X)
	Ayyappan	4 = P	- Principles for mortar quality and tests for mortar - Testing typical soils with a press
	Ayyappan	1 = P	- Handling & maintenance of the presses - Safety and demonstration
			- Adjustments of the press 3000 - Changing plates and moulds
3	Ayyappan	2 = P	- Production of plain blocks 240 and quality control
	Ayyappan	3 = P	- Production of plain blocks 240 and quality control
	Ayyappan	4 = P	- Identification of soil samples with sensitive analysis
	Ayyappan	1 = P	- Production of special blocks 240 (U, pipe inserts, chamfer, flashing, coping, tile, etc.)
4	Ayyappan	2 = P	- Production of various blocks: acquisition of know how
	Ayyappan	3 = P	- Production of blocks: acquisition of knowhow and optimization of production
	Ayyappan	4 = P	- Identification of soil samples with sensitive analysis
	Ayyappan	1 = P	- Stabilized rammed earth foundations and wall (1m long)
5	Ayyappan	2 = P	- Building a basement and a composite plinth beam (1m long RCC in U blocks)
	Ayyappan	3 = P	- Pre-casting composite lintels
	Ayyappan	4 = P	- Identification of soil samples with sensitive analysis
	Ayyappan	1 = P	- Identification of soil samples and soil from trainees with sensitive analysis
6	Ayyappan	2 = P	- Building arches
	Ayyappan	3 = P	- Test and course evaluation
	Ayya & Sat.	4 = P	- Summary of the course, documents and certificates
			T = Theory or lecture P = Practical exercise

Table 2. CSEB intensive training workshops program of MSA CoE, Egypt.

Intensive Hands-on Training Workshops on the Production and Masonry of Interlocking Compressed Stabilized Soil Bricks ISSB	
3 days, each day starts at 9:00 am and ends at 3:00 pm with an hour break from 11:30 am to 12:30 pm.	
Day 1: Soil identification and sensitive field tests	Identifying different soil types and recognizing the most suitable ones for producing the ISSB.
Day 2: Preparing Mixtures, Machine operation and Production of ISSB	Calculating mixture ingredients and their percentages, dry and wet mixing, machine operation, production and stacking of ISSB and other molds.
Day 3: Wall and Column Masonry	Building a wall and various column types with ISSB

4. Soil Identification and Sensitive Field Tests

Not every soil is suitable for CSEB production. In general, topsoil and organic soils must not be used. Sandy soils are more suitable for cement stabilization while clayey soils are more suitable for lime stabilization. This is because Portland cement works as a binder between gravel and sand grains which creates an inert matrix restricts thus movement. It works less efficiently with silt and clay. Lime will also bind the grains of gravel, sand and silt, however, it is a weaker binder compared to cement. Lime is more suitable for soil with high clay content as it has a pozzolanic reaction with clay that creates chemical bonds between clay and sand [1, 2, 12].

The aim of these sensitive analyses is to find out in which categories goes the soil sample: Gravely, Sandy, Silty, Clayey or combined soil i.e. sandy clay. Then, according to this classification, one must look into the recommendations for stabilization and soil improvement. Both workshops were more concerned with cement stabilization of sandy soil. Auroville soil had to be corrected by adding sand as the silt/clay content was high. Soil at MSA campus was sandy and suitable.

4.1. AVEI Soil Identification and Sensitive Field Tests

At AVEI, the following basic tests were performed [1, 2, 3] (Figure 2):

Granularity: by looking and touching a dry or humid soil, the percentage and the size of the grain sizes could be observed.

Compressibility: by adding a little water to the dry soil and compressing it by hand to make a ball, one can evaluate how much pressure he needs.

Plasticity:

a. Shaping the ball: by adding more water and making a cohesive ball, the easiness to shape it and how cohesive it is can be evaluated.

b. Stretching the ball: by stretching the ball and pulling it like a rubber and trying to break it, the strength of the ball can be evaluated.

c. Sticking a knife: by sticking a knife into the cohesive ball and pulling it out, one can observe how much soil sticks on it.

d. Cutting the ball: when the ball is cut in 2 pieces by a knife, the aspect of the cross section can be examined.

Water absorption: using the thumb, a small depression on the ball is made. By filling it with water, the time of absorption is then evaluated.

Cohesion:

a. Diluting the ball: by adding much more water to the ball and trying to loosen the cohesion of the soil, the quantity of soil that sticks to the hand is observed.

b. Washing the soil: by adding much more water to the soil and washing away silt and clay, the amount of fine sand, which remains in the palm, can be evaluated.

Humus content: this is evaluated by taking some moist soil and smelling it.

Figure 2. Sensitive field tests at AVEI, India.

4.2. MSA CoE Soil Identification and Sensitive Field Tests

The field tests performed at MSA CoE followed the tests explained in the Egyptian Code for Building with Stabilized Earth [1] (Figure 3).

Wash Test

Place your hand with the soil inside of your palm under a slow trickle of water.

Results:

a. Soil is very granular and easy to wash off – Sandy Soil

b. Soil sticks a lot and does not wash away easily from hand – Silty Soil

c. Soil makes a thin film and if massaged into palm sticks a lot into the lines of hand – Clayey Soil

Pen Test (Plasticity and Cohesiveness)

1. Take a handful of soil and slowly massage in water until the soil reaches bread dough-like.
2. Break off a chunk 1/2 the size of your thumb.
3. Roll it out into a worm the size of a pen (3 to 5 mm) on a slightly moistened nonstick surface or in the palm of your hand.
4. When pen diameter is reached or surpassed pick up the worm and observe the flexibility and cohesiveness by letting it hang off your hand as you move your hand slowly.

Results:

Soil Type

a. Cannot get close to pen diameter – Very sandy with negligible clay content

b. Crumbles just before pen diameter – Sandy with clay content

c. Rolls out smaller than pen – high clay content

Soil Plasticity and Cohesiveness

Try to reach the size of a pen by adding some extra water and then observe:

a. Could not make soil worm – negligible clay content

b. Soil worm has little to no flexibility and breaks quickly – low clay content

c. Soil worm is flexible and sticks together even while being moved around and swung slowly high clay content

Ball Test (Consistency)

1. Follow the same procedures as pen test.
2. If the worm breaks or develops large cracks before it reaches the size of a pen, slowly moisten the soil until the worm breaks only when it reaches the size of a pen.
3. Form a ball.

Results:

a. Could not make a ball – the sand content is too high and the clay content too low.

b. The ball is formed but crumbles very easily – the soil is sandy with clay content.

c. The ball is well formed and needs force to be crushed between the thumb and forefinger – the clay content is high and the soil has to be corrected by adding sand.

Figure 3. Sensitive field tests at MSA CoE, Egypt.

Shine Test

1. Again take moistened soil made into bread dough constancy.
2. Make a ball with a 5 cm diameter.
3. Cut the ball in half.
4. Look at flat surface of cross section and move the ball back and forth in the light observing the shining in the light.

Results:

a. Surface is very rough – Very Sandy
b. Surface is rough but has some smooth dull areas and does not shine in the light – Sandy with Silt
c. Surface is rough but has some smooth dull areas and some parts that shine in the light – Sandy with Silt and clay.
d. Surface is dull and does not shine in the light – Silty
e. The entire surface is very shiny – Very Clayey

Knife Test

Remake the ball and stab with a knife.

Results:

1. Knife is easy to penetrate, no material sticks to knife – Very sandy
2. Some force is needed, small amount of material sticks to the knife – Sandy with some silt content
3. More force is needed, more material sticks to the knife – Silty/Clayey

Water Retention Test

1. Remake the ball (or make another one with 5cm diameter).
2. Make a print with the thumb onto the ball and fill it with water.

Results:

a. Water penetrates quickly – Sandy
b. Water penetrates slowly – Silty
c. Water penetrates very slowly – Clayey

Ball dropping test

a. The mixture to be tested has to be as dry as possible, yet wet enough to be formed into a ball 4 cm in diameter.
b. Drop the ball from a height of 1m onto a flat surface.

Results:

a. The ball flattens only slightly and shows few or no cracks – high clay content (must be thinned by adding sand)
b. The ball develop small cracks – silty/clayey with sand content
c. The ball breaks into few pieces – sandy with silt/clay content
d. The ball breaks into many small pieces – very low clay content. Its binding force is insufficient.

Jar Test (Figure 4)

1. Find a flat bottomed clear jar. Use a permanent marker or a piece of tape for marking purposes.
2. Add dry soil till ½ of the jar.
3. Fill the rest of the Jar with water leaving some space at the top.
4. Shake vigorously until soil is completely suspended in the water.
5. Wait 15 minutes and shake again.
6. Let settle overnight.
7. Do not disturb the jar.
8. Measure how much the settled soil has risen above the fill line.
9. Measure each layer.

Results:

Soil Expansiveness

a. Soil did not expand over the line – Non Expansive
b. Soil expanded 3 mm over the line – Slightly Expansive
c. Soil expanded 6 mm over the line – Expansive
d. Soil expanded 12 mm or more over the line – Very Expansive

If soil is very expansive it is not good for making compressed earth bricks.

Soil Composition

a. Percentage of Sand _____
b. Percentage of Silt + Clay _____
c. Percentage of Silt only (if could be seen) _____
d. Percentage of Clay only (if could be seen) _____

Figure 4. Jar tests at MSA CoE, Egypt.

5. Press Machine Model

Table 3. Specifications of Auram 3000 & Eco Brava press machines used for the training of students [8, 9, 13].

	Auram 3000	Eco Brava
Machine Model/Specification		
Productivity	600-800 per day	1200-1600 per day
labor	3 on machine	1 on machine
Force	15 tons	6 tons
Double Action Compression	Yes	Yes
Weight	365 to 415 kg	174
Maintenance	Greasing	greasing
1/2 brick/block	Yes	No
Changing the mold	Difficult/Slow	Easy/Fast
Container	Filled for each block	Filled for several blocks (64L)
Compression	Double action	Double action

6. Shapes of Produced Bricks

Auram 3000 produces many blocks varying from solid to hollow, interlocking and special blocks as shown in Figure 5. During the workshop, the team produced solid and special blocks. Eco Brava is equipped with 5 moulds, all of which were produced during the workshop at MSA CoE (Figure 5).

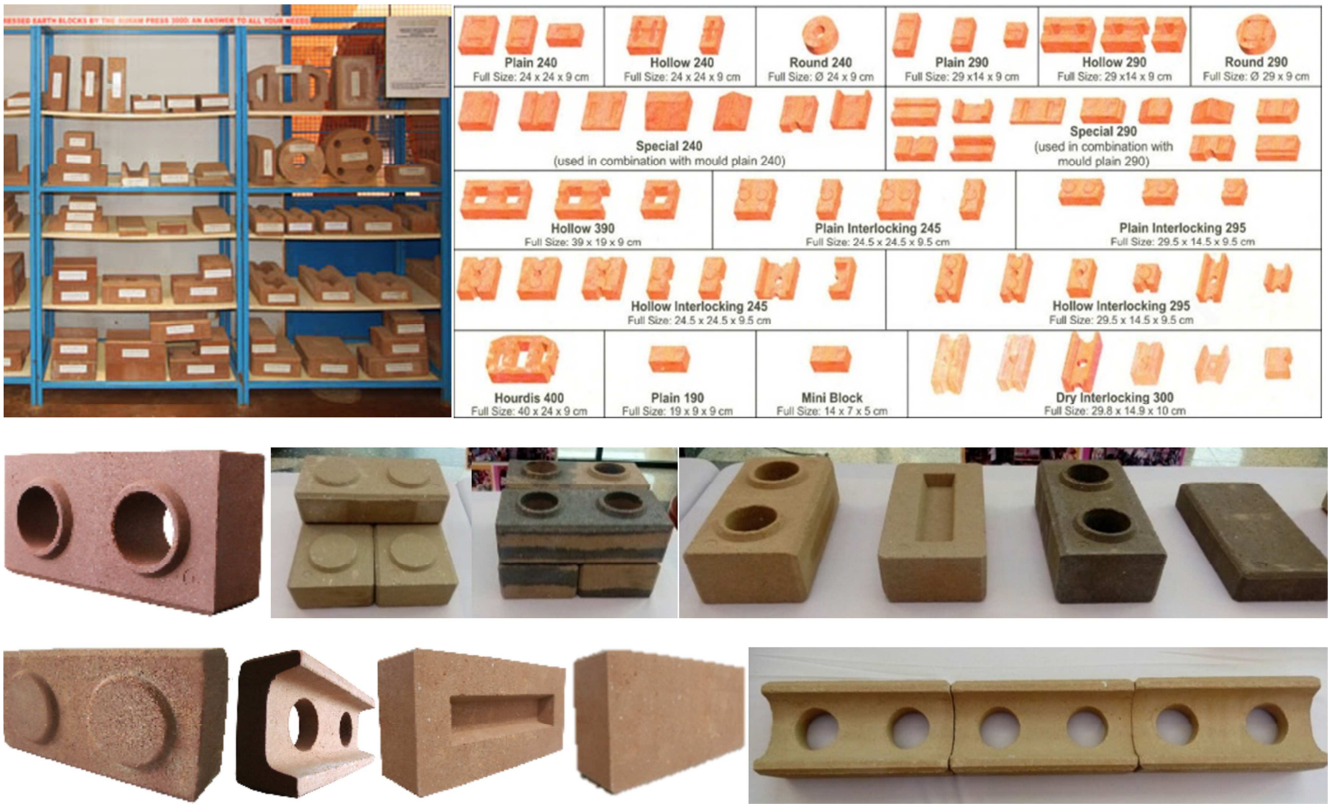


Figure 5. Shapes of CSEB: above, produced by Auram 3000 press machine [3]; below, produced by Eco Brava press machine at MSA University.

7. Production Process from Preparing Mixtures to Stacking

The production starts by sieving the soil, then preparing the mixture ingredients, dry and mixing, pouring the mixture in the press machine, pressing the CSEB and finally stacking them.

7.1. Sieving Sandy Soil

Almost all types of soils have to be sieved. In the training at AVEI (Figure 6), soil was sieved with a mesh of 10 to 12 mm to loosen and aerate the soil. It is important to control the angle of the sieve because a very flat sieve will allow more coarse particles to pass through and a very vertical sieve will remove more coarse particles and the soil will be thinner. A maximum of 15% of gravel or lumps shall be allowed through the sieve. If they are too many lumps or gravel, the sieve shall be laid more vertically. On the other hand, if more gravel is needed, the sieve shall be laid flatter [1, 2]. According to the catalogue of Eco Brava machine, which follows the Brazilian Standards [14-17], sandy soil requires sieving with a mesh of 4 to 6 mm (Figure 6). This is because particles more than 4.75 are not allowed to pass. For the training in MSA CoE, conventional circular sieves, known in Egypt as sand sieves, were used.

Figure 6. Students' training on sieving soil at MSA CoE (left) and AVEI (right).

7.2. Measuring the Ingredients

In general, ingredients are soil, cement and water if it was not necessary to correct the soil by adding sand. Deciding the percentage of cement (stabilizer for sandy soil), depends on [1, 2, 4-7, 12, 14-21]:

1. Shrinkage test results.
2. The percentages of soil components (sufficient clay/silt content)
3. Degree of difficultness to handle the brick after pressing it (breaks easily due to lack of binding: low clay content).
4. The results of the Compressive Strength Test (kg/cm^2, MPa or N/mm^2) performed on the bricks after 28 days of production.

Although the percentage of stabilizer is always calculated by weight, it is impossible to measure the weight of soil in the site. Therefore it is necessary to transform it into volume. In AVEI and MSA CoE, the volume of every container was known and all containers used for soil were filled to the top and levelled with a straight edge. The container in the former was mainly wheelbarrows plus additional buckets if required and in the latter buckets. In the two workshops, the 50 kg cement bag was divided, once opened, into 3 or 4 buckets according to the needed mixture quantity.

a. Up to 8% is considered environmentally friendly and economic
b. From 8% to 10% is considered economic
c. More than 10% cement is considered neither economic nor environmentally- friendly

7.2.1. Calculating the Ingredients at AVEI

Parameters [2, 10]:

Percentage of cement needed (e.g. 5%)

Dry density of the soil (weight of 1 liter) kg/L

$$\text{Soil weight in kg} = \frac{\text{Cement weight (e.g. 12.5kg) X } (100 - \%\ \text{cement})}{\%\ \text{cement}}$$

$$\text{Soil volume in liter} = \frac{\text{Soil weight}}{\text{Soil Density}}$$

The containers are mainly wheelbarrows and additional buckets could be used if needed. The volume of each container is already known so after filling them, the soil volume is re-calculated and if the stabilizer is within the tolerance of 0.03 then no need to recalculate the mixture.

7.2.2. Calculating the Ingredients at MSA CoE

Example: It has been decided to add 7% cement by mixture weight as stabilizer. The percentage of stabilizer is calculated by WEIGHT not volume

Soil: 93% → Cement: 7%

Soil: ? KG→ Cement: ¼ bag, i.e. 12.5KG

This is obtained by dividing the whole bag into four buckets (or 3 if you decide to work with 1/3 bag as a unit, this will however give you a larger mix)

$$\text{Weight of Soil in KG} = \frac{12.5 \text{ KG X } 93}{7}$$

Weight of Soil in KG = 166.07 KG for 12.5KG of Cement (1/4 bag)

$$\text{Weight of Soil in KG} = \frac{\text{Weight of Cement in KG X } (100 - \%\text{ of Cement})}{\%\text{ of Cement}}$$

$\text{Number of needed buckets} = \frac{166.07}{22} = 7.5$ buckets for 12.5 kg of cement (1/4 bag)

Avg. Weight of one bucket filled with soil = 23 kg

Avg. Weight of one bucket empty = 1kg

Avg. Weight of soil in the bucket = 22kg

7.3. Mixing

Dry mixing

The soil is first spread on a flat surface then the cement is poured onto the soil and spread. Mixing is performed using shovels. The pile is then displaced gradually to an adjacent location; this step can be repeated twice to ensure that the mixture became homogeneous and has a uniform color (Figure 7).

Wet mixing

Because not every soil has same moisture content, it is not possible to measure the water quantity needed for the mixture; i.e. a quantity could be suitable for one mixture but not suitable for another mixture of same volume due to differences in moisture contents. It is therefore necessary to pour water onto the dry mixture gradually and uniformly by gently sprinkling it all over the pile. The pile should be mixed by moving its location in the same manner as the dry mixing. In Auroville, lumps of soil are crushed by sitting around the pile and using the palm of the hand to press them as shown in (Figure 7). The mixture will be homogenous when it reaches a uniform color. At MSA, lumps of soil are crushed by sieving the wet mixture using a wide mesh (Figure 7). This is faster than pressing by hands. Making a test is indispensable to check whether the mixture reached the OMC (optimum moisture content). This is explained in the following part.

Figure 7. Dry and wet mixing of soil at MSA CoE (left) and AVEI (middle & right).

7.4. Checking the Moisture Content

At AVEI the test is performed by taking a handful quantity once the humid mixture is homogeneous, compressing it and shaping it into a ball. The ball is then dropped from a height of 1 m onto a hard surface (Figure 8). If the ball breaks into 3-4 pieces, then the moisture content is fine. If the ball bursts apart in many pieces or into powder, then the mixture still needs water. If the ball does not break, in this case it became too wet.

At MSA, two tests were performed to make sure that the OMC is reached (Figure 8). The first one is the drop test which followed exactly what was learnt at AVEI. The second test follows the Brazilian standard. Similarly, once the humid mixture is homogenous, a handful quantity is compressed into the hand. One should press it firmly by hand to compress it to a maximum. The shaped piece, which is not a ball, is then cut it into two parts by the two hands. If it bursts apart, more water should be added; if it is cut into two pieces, then the water content is fine.

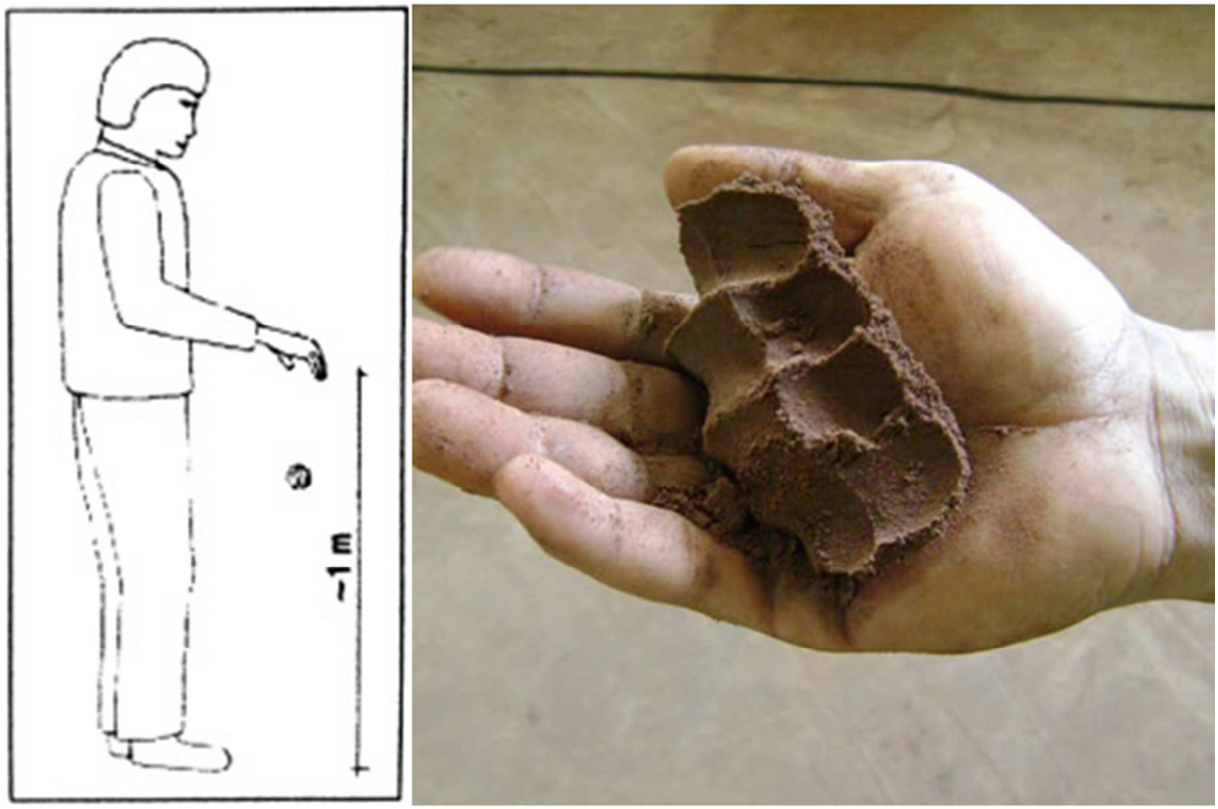


Figure 8. Checking moisture content of the mix: left, drop test; right, press test.

7.5. Pressing

As mentioned earlier, press machines are classified into manual and motorized. Although manually operated presses are widely used, motorized presses recently have been more and more used because of their higher productivity and easier operation. In the case of Auram 3000, the mixture is poured for every block into a container that leads into the mold for being pressed as shown in Figure 9. Eco Brava machine, on the other hand, has a large container (Figure 9) that is filled with a capacity of 64L and produces around 20-25 bricks. The pressing process is very different between the two machines. Because it is manual, Auram 3000 needs two persons (or one strong person) to press each block using a long handle while a person man is operating the machine itself. Eco Brava needs one person for both operating the machine and pressing. After pressing, it is indispensable to check the consistency of the produced CSEB heights and their compaction degree in every batch. Checking the height is performed using a caliper while for the compaction a penetrometer is used. At AVEI, the trainees checked both; at MSA CoE, only the consistency in the sizes was checked due to the absence of a penetrometer.

Figure 9. Producing CSEB using Eco Brava machine (left) and Auram 3000 machine (right).

7.6. Initial Stacking and Curing

At AVEI, immediately after pressing, the construction units are manually transferred to an area with hard ground near the press machine taking care of the edges during transportation and ensuring that they are not exposed to any shocks that could lead to cracks or fractures (Figure 10). They are placed in long piles on top of each other with 7-8 units high and tight gaps (5 cm). Each batch is then covered with plastic sheet to prevent water evaporation for two days. On the third day, the units are uncovered and transported using a flat wheelbarrow to another place with hard ground or on pallets for final stacking and curing. At MSA CoE, the initial stacking and curing are quite different. Immediately after production, the bricks are stacked since the beginning on wooden pallets located near the machine with a maximum height of 4-5 rows (Figure 10). The bricks are placed on their sides. Other method for initial stacking is to place the bricks in a staggered manner, so as to reduce the force on each brick. I this case, they can be stacked higher. There is no need to transport the bricks by a wheelbarrow since they are already placed on pallets, they are easily moved by a fork lift their final stacking and curing area. For further details on the production of CSEB following the Brazilian Standards and using Eco Brava machine, see standards from [22] to [27].

Figure 10. Stacking CSEB units at MSA CoE (left) and AVEI (right).

8. Masonry

Straight, corner, T & X with mini blocks, training was on the bonds patterns without real construction of masonry courses (Figure 11). It was rather an exercise on applying different bonds and dealing with wall connections and lengths. Another workshop was dedicated to the training on CSEB masonry.

At MSA CoE, students constructed real models of a wall (Figure 11) corner and 2 column types, 7 courses high. They started by installing the 1st course then all other courses using stretcher bond. Then the students fixed the steel bars, made the mixture for the grouts and poured it into the holes. At the end, they filled the joints between bricks and finished the wall by painting it with a transparent water based acrylic paint.

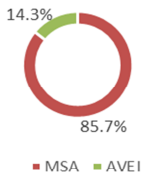
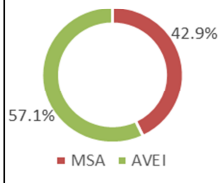
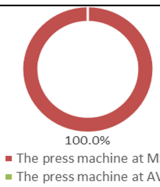
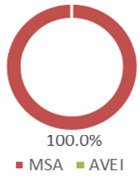
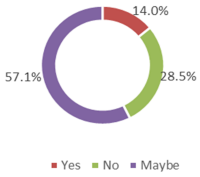
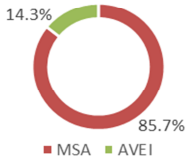
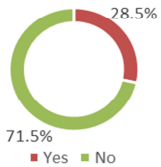
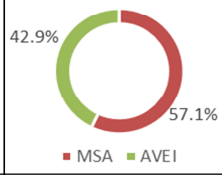
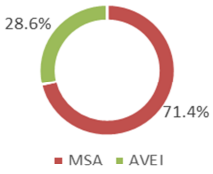
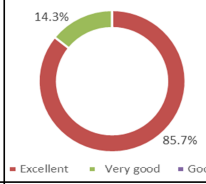
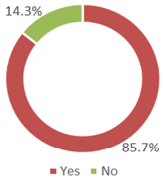
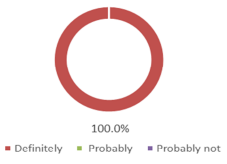
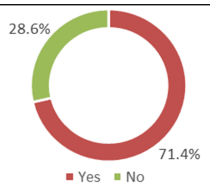
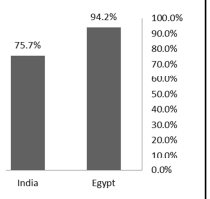
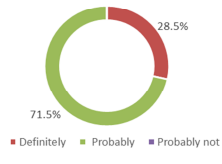
Figure 11. Training on CSEB masonry units at AVEI (above) and MSA CoE (below).

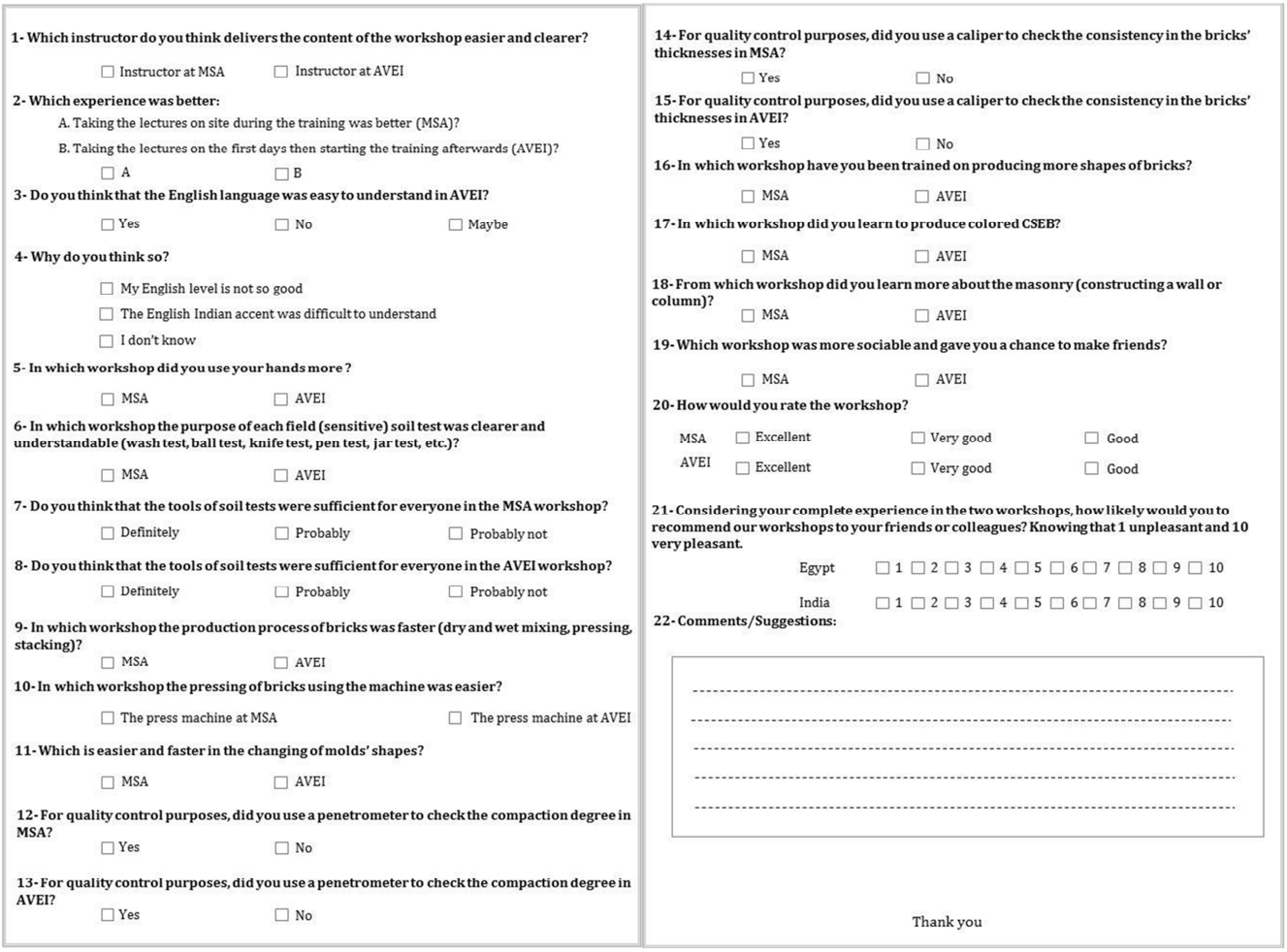
9. Questionnaire

A questionnaire was developed to collect the opinions and feedbacks of the team that attended the two workshops. The results

are shown in Table 4. The distributed questionnaire comprises 22 questions shown in Figure 12.

Table 4. Questionnaire results for the team that attended the two CSEB workshops (at MSA CoE & AVEI).

Questions	Results	Questions	Results	Questions	Results
Q.1. Which instructor do you think delivers the content of the workshop easier and clearer?		Q.9. In which workshop the production process of bricks was faster (dry and wet mixing, pressing, stacking)?		Q.16. In which workshop have you been trained on producing more shapes of bricks?	
Q.2. Which experience was better?		Q.10. In which workshop the pressing of bricks using the machine was easier?		Q.17. In which workshop did you learn to produce colored CSEB?	
Q.3. Do you think that the English language was easy to understand in AVEI?		Q.11. Which is easier and faster in the changing of molds' shapes?		Q.18. From which workshop did you learn more about the masonry (constructing a wall or column)?	
Q.4. Why do you think so?		Q.12. For quality control purposes, did you use a penetrometer to check the compaction degree in MSA?		Q.19. Which workshop was more sociable and gave you a chance to make friends?	
Q.5. In which workshop did you use your hands more ?		Q.13. For quality control purposes, did you use a penetrometer to check the compaction degree in AVEI?		Q.20. How would you rate the MSA workshop?	
Q.6. In which workshop the purpose of each field (sensitive) soil test was clearer and understandable (wash test, ball test, knife test, pen test, jar test, etc.)?		Q.14. For quality control purposes, did you use a caliper to check the consistency in the bricks' thicknesses in MSA?		Q.21. How would you rate the AVEI workshop?	
Q.7. Do you think that the tools of soil tests were sufficient for everyone in the MSA workshop?		Q.15. For quality control purposes, did you use a caliper to check the consistency in the bricks' thicknesses in AVEI?		Q.22. Considering your complete experience in the two workshops, how likely would you to recommend our workshops to your friends or colleagues?	
Q.8. Do you think that the tools of soil tests were sufficient for everyone in the AVEI workshop?					



1- Which instructor do you think delivers the content of the workshop easier and clearer?

☐ Instructor at MSA ☐ Instructor at AVEI

2- Which experience was better:

A. Taking the lectures on site during the training was better (MSA)?

B. Taking the lectures on the first days then starting the training afterwards (AVEI)?

☐ A ☐ B

3- Do you think that the English language was easy to understand in AVEI?

☐ Yes ☐ No ☐ Maybe

4- Why do you think so?

☐ My English level is not so good

☐ The English Indian accent was difficult to understand

☐ I don't know

5- In which workshop did you use your hands more ?

☐ MSA ☐ AVEI

6- In which workshop the purpose of each field (sensitive) soil test was clearer and understandable (wash test, ball test, knife test, pen test, jar test, etc.)?

☐ MSA ☐ AVEI

7- Do you think that the tools of soil tests were sufficient for everyone in the MSA workshop?

☐ Definitely ☐ Probably ☐ Probably not

8- Do you think that the tools of soil tests were sufficient for everyone in the AVEI workshop?

☐ Definitely ☐ Probably ☐ Probably not

9- In which workshop the production process of bricks was faster (dry and wet mixing, pressing, stacking)?

☐ MSA ☐ AVEI

10- In which workshop the pressing of bricks using the machine was easier?

☐ The press machine at MSA ☐ The press machine at AVEI

11- Which is easier and faster in the changing of molds' shapes?

☐ MSA ☐ AVEI

12- For quality control purposes, did you use a penetrometer to check the compaction degree in MSA?

☐ Yes ☐ No

13- For quality control purposes, did you use a penetrometer to check the compaction degree in AVEI?

☐ Yes ☐ No

14- For quality control purposes, did you use a caliper to check the consistency in the bricks' thicknesses in MSA?

☐ Yes ☐ No

15- For quality control purposes, did you use a caliper to check the consistency in the bricks' thicknesses in AVEI?

☐ Yes ☐ No

16- In which workshop have you been trained on producing more shapes of bricks?

☐ MSA ☐ AVEI

17- In which workshop did you learn to produce colored CSEB?

☐ MSA ☐ AVEI

18- From which workshop did you learn more about the masonry (constructing a wall or column)?

☐ MSA ☐ AVEI

19- Which workshop was more sociable and gave you a chance to make friends?

☐ MSA ☐ AVEI

20- How would you rate the workshop?

MSA ☐ Excellent ☐ Very good ☐ Good

AVEI ☐ Excellent ☐ Very good ☐ Good

21- Considering your complete experience in the two workshops, how likely would you to recommend our workshops to your friends or colleagues? Knowing that 1 unpleasant and 10 very pleasant.

Egypt ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

India ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10

22- Comments/Suggestions:

Thank you

Figure 12. Opinions and feedbacks questionnaire form for the team that attended the two CSEB workshops (at MSA CoE & AVEI).

10. Discussion

First, I would like to draw the attention to the fact that the training organized by Auroville Earth Institute was conducted about 17 months prior to the one organized by MSA CoE. Therefore, any obstacles or issues faced during the former were being avoided as much as possible in the latter. According to the questionnaire results shown in Table 4, due to the Indian and French accents of the two instructors at AVEI workshop, many trainees in the team found difficulties in understanding the explanations and instructions. During soil identification and sensitive field tests in the same workshop, it was not very clear why the team is doing the test; i.e. what exactly team members were evaluating was not stated clearly. Moreover, because of the large number of trainees, that exceeded 40, from different places, tools were not sufficient. At MSA CoE, no more than 15 persons were allowed to register and tools were sufficient. Less theoretical content and in-situ lectures were preferable to all trainees. As for the production process, sieving, mixing and calculating the ingredients were similar in the two workshops; it was however faster at MSA because Eco Brava press machine is hydraulic with a simple handle to compress the brick, has a large container and its molds are changed by just installing upper and lower plates. Moreover, stacking on pallets makes the transferring of bricks easier and faster from the initial to the final curing and stacking place. This is possible because a fork lift is used for this process instead of transferring the blocks using a flat wheelbarrow then restacking them. Because of the lack of a penetrometer at MSA CoE, trainees didn't get the chance to measure the compaction degree of the bricks as part of the quality control of the production process; this was performed at AVEI. The consistency in thicknesses was checked in the two workshops using a caliper. At AVEI, the trainees produced more shapes of blocks than at MSA. This is because each shape has a specific function. For example, special bricks are used for electrical installations. The Eco Brava bricks, on the other hand, are hollow, which allows for the electrical and plumbing installations to pass through the holes. The trainees at MSA learnt also how to produced colored bricks, which was not available at Auroville. Because AVEI organizes a separate workshop for CSEB masonry, this part was very short during the

attended workshop and mini blocks were used instead of real blocks. Its purpose was to learn different bonds types. When the team was asked about the new friends they made in the two workshops, surprisingly 57.1% answered that MSA CoE was a better chance to make friends. Perhaps this is due to the temporary nature of their stay at Auroville, although they met various nationalities.

11. Conclusion

In order to promote the awareness of building with compressed stabilized earth bricks (CSEB), one of the most low cost environmentally-friendly technologies, intensive hands-on training workshops on the production and masonry of CSEB were attended by MSA University students at Auroville Earth Institute in 2016 (AVEI, Auroville, India) and MSA Center of Earth in 2017 (MSA CoE, 6th of October, Egypt). This paper aimed at comparing between the two experiences taking into consideration that 17 months separated between them. Therefore, any obstacles or issues faced at AVEI were being avoided as much as possible at MSA CoE. According to the trainees' observations and questionnaire results, differences in languages and accents were significant issues in understanding explanations and instructions in the CSEB training workshop at AVEI, especially during the soil sensitive field tests and the calculations of ingredients. In addition, less theoretical content and in-situ lectures were preferable to all trainees. In general, the large number of trainees resulted in lack of tools. According to their experience, manually sieving and mixing were easy and similar in the two workshops but using a hydraulic press machine to manufacture CSEB was faster and less labor-intensive. The method of calculating the ingredients was also similar in both workshops. According to them, stacking the units on pallets near the machine made the brick less likely to damage. Using quality control tools such as a penetrometer and caliper was essential for producing good bricks. Producing bricks with various shapes and colors was more interesting and athletically appealing to them. As for the masonry training, although using real bricks was slower and more complicated, it was useful for acquiring practical experience. Finally, the social dimension such as making new friends was as important as the other advantages of the workshops.

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