

Producing Interlocking Stabilised Soil Blocks

A Flexible Learning Course



Acknowledgements

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Producing Interlocking Stabilised Soil Blocks

Introduction

Welcome to this course on brick making. In this module you will learn how to produce interlocking stabilised soil blocks (**ISSB**). As you well know, soil is one of the main materials used for the construction of traditional low-cost houses in rural areas. This is because it is cheap and locally available. Some houses are constructed entirely or partially with soil, depending on the local traditions, climate, available skills and cost. One disadvantage of traditional soil-based construction is that they require regular maintenance and protection. This has led to the development of new methods or technologies that improve the quality and durability of soil construction methods. One such method is brick making. There are two basic types of bricks used for construction, namely:

- fired bricks which are compressed and baked in a type of oven known as a kiln;
- unfired bricks which are compressed and laid out in the sun to cure.

There are many types of unfired bricks. However, in this course we shall discuss the type known as interlocking stabilised soil blocks. These are stabilised soil blocks made of moistened soil mixed with a little cement. The blocks are then compressed either manually or mechanically and cured. You will learn about the tools and equipment used to make the soil blocks and how to select and test the soil used for making them. In addition, we shall examine how to produce blocks and use them for construction. Let us start by reviewing the module outcomes.



Module Outcomes

On completion of this module you should be able to:

- discuss the advantages and limitations of using ISSB;
- list the tools and equipment used in the production of ISSB;
- select suitable soil for the production of ISSB;
- conduct soil tests to establish whether it is suitable for block making
- describe the steps used in the production of ISSB;
- describe the areas that require special attention when building with ISSB.



Module Content

This module is divided into the following four topics:

Topic 1: Introduction to interlocking stabilised soil blocks;

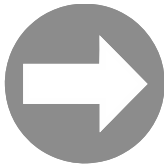
Topic 2: Tools and equipment used in ISSB production

Topic 3: Soil selection

Topic 4: Soil testing

Topic 5: Production of ISSB

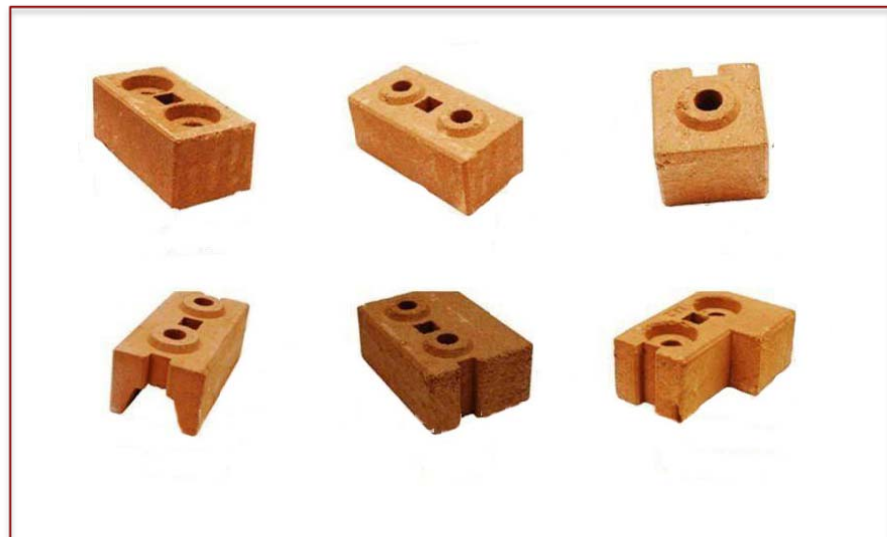
Topic 6: Basic building guidelines



Topic 1

Introduction to Interlocking Stabilised

Figure 1: Various types of interlocking blocks. (Source: aliimg.com)



Soil Blocks

Interlocking stabilised soil blocks (ISSBs) are compressed blocks which are made of a mixture of soil, cement and water. They are then compressed using manual or mechanically operated machines. The technology is designed to produce blocks with an interlocking mechanism or the ability to join together without using any cement for bonding. The interlocks increase the strength of the wall and reduce the amount of cement needed as mortar. Almost any soil can be used to make ISSBs except black cotton soil, see Figure 1 for examples

Advantages of ISSB

What are the advantages of ISSB?

Think about this question for a minute and then complete the following activity.



Activity 1

Advantages of ISSB (Time: 4 minutes)

List at least 3 advantages of ISSBs in the space provided below.

1. _____
2. _____
3. _____

Now compare your answers with the following advantages of ISSBs.

The following are the main advantages of ISSBs:

- Low cost and affordable to produce. Soil is easily accessible in most parts of the world. Also due to its interlocking mechanisms, little cement is needed between the block joints.
- Can be produced near the site of construction thus reducing transport costs.
- Can be used to build all types of houses.
- They are an alternative to fired bricks which cause environmental degradation due to afforestation.
- They have excellent fire resistant properties.
- Reduce construction time due to the blocks having a male and female interlocking system.
- The ISSB machine is easy to use and to maintain.

Those are the advantages of ISSBs. Let us now look at the limitations of these ISS blocks.

Limitations of ISSBs

Can you think of any limitations? Take 2 minutes to think about it and then complete the following activity.



Activity 2

Limitations of ISSBs (Time: 3 minutes)

Write down at least 2 limitations of ISSBs in the space provided below

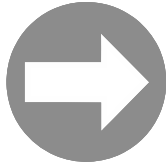
1. _____

2. _____

Well, we believe your list included the following limitations of ISSBs:

- Low acceptability among certain social groups
- Requires a certain amount of training to determine the correct type of soils, correct mix proportions and produce uniform-sized blocks.
- Even with the greatest care in assembling the walls, the joints are not entirely resistant to wind and rain penetration. Therefore, it is necessary to plaster the interior wall surfaces.
- They require the use of cement which can be expensive.

That brings us to the end of our introduction to ISSBs. We hope you now understand what they are and their advantages and limitation. Let us proceed to the next topic on the tools and equipment used in ISSB production.



Topic 2

Tools and Equipment used in ISSB Production

In this section, you will learn about the tools and equipment used in making stabilised soil blocks (SSBs). Let's start with the equipment.

Equipment used in SSB Production

There are two types of machines used to make stabilised soil blocks. These are:

- The manually operated machines
- The motorised machines

Let us look at each in further detail starting with the manually operated block machine.

Manual Interlocking Block Machine (Action Pack)

The manual interlocking block machine is manually operated. It is cheap, long lasting and easy to operate. The machine uses a mixture of soil and cement to make stabilised blocks at a ratio of between 5 and 10% cement to soil, depending on the soil type available.



Figure 2: Manually operated interlocking block machine.

The interlocking blocks produced by this machine do not need mortar for bonding. Figure 2 below shows a picture of manual interlocking stabilised soil block making machine (action pack)

Motorised Stabilised Soil Block Making Machines

Motorised block making machines are either operated by a diesel engine or electrical motor. A good example is the hydraform machine. They can be divided into two main groups:

- those that are simple and sturdy with a fixed table and single mould capable of making one block at a time;
- those with 2 or more single moulds capable of making more than one block at a time. These tend to be more expensive.

Figure 3 below shows a picture of a single mould motorized soil compacting machine.



Figure 3: Single mode motorised soil compacting machine.

Next let us look at the hand tools that you will need to produce ISSBs.

Hand Tools

The following are the main tools that you will need for producing interlocking blocks:

1. Bucket – for carrying water and batching
2. Oil can – for lubricating the internal surfaces of the mould
3. Watering can – for the sprinkling of water during the mixing stage.
4. 6mm sieve – for grading the size of the aggregates
5. Shovels – for mixing of the materials
6. Trowels – for feeding the mortar in to the block mould
7. Hoe – used during the excavation and mixing stages
8. Pan – for loading the mixture into the machine
9. Rammer – for crushing soil crumbs
10. Broom – for cleaning

Figure 4 below shows the various tools that you require to make interlocking blocks.

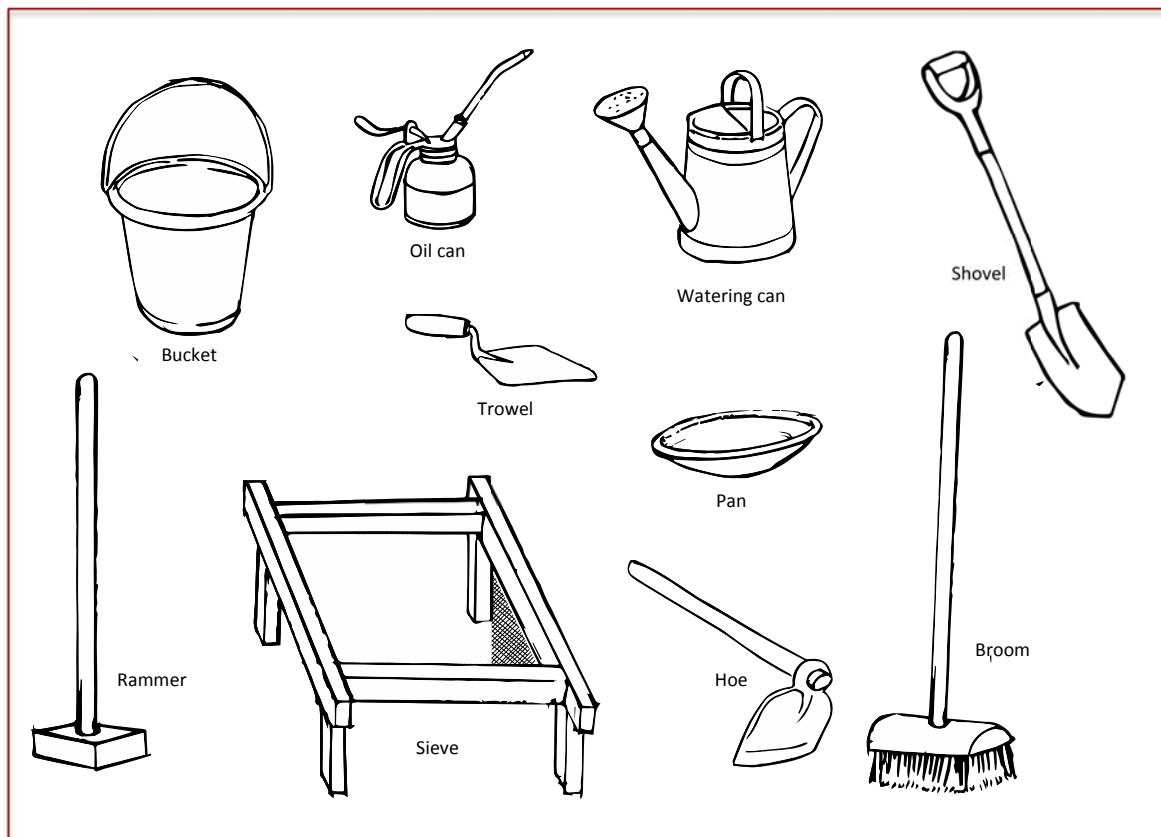
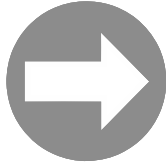


Figure 4: Tools used for making interlocking stabilised soil blocks.

We hope you now know the equipment and tools used in the production of stabilised soil blocks. Before you continue to the next topic, complete the following activity to evaluate your progress so far.




Topic 3

Soil Selection

As you may have noticed from our discussion so far, soil is one of the main ingredients of stabilised soil blocks. It is therefore very important to understand the characteristics of soil before you start making SSBs. It is also important to assess the climatic condition of an area before you produce soil blocks. This is because a dry climate requires different soil blocks from those used in wet climates. In this section we shall identify the different types of soil and its composition.

What is Soil?

Let's start with your thoughts on this. How would you define soil? Think about it for 1 minute and then complete the following activity.



Activity 4

Meaning of Soil

Write down your definition of soil in the space provide below.

Well, we believe your answer mentioned that soil is simply the upper layer of earth on which plants grow. It is made up of decayed remains of plant and animal origin, broken rocks and minerals.

If you dig a hole in the ground, you will find that there are several layers of soil as shown in Figure 4 below. These are:

1. **Top soil:** the soil that contains organic matter. This is not suitable for ISSB production or any other building purposes. It is best for agricultural purposes.
2. **Sub soil:** the layer of soil found immediately below the top soil. This soil is naturally stable and in many cases the one most suitable for production of ISSB.

- 3. Bed Rock:** the layer immediately below the sub-soil. It may be broken into finer particles which can be stabilised. It is generally not suitable for ISSB production.

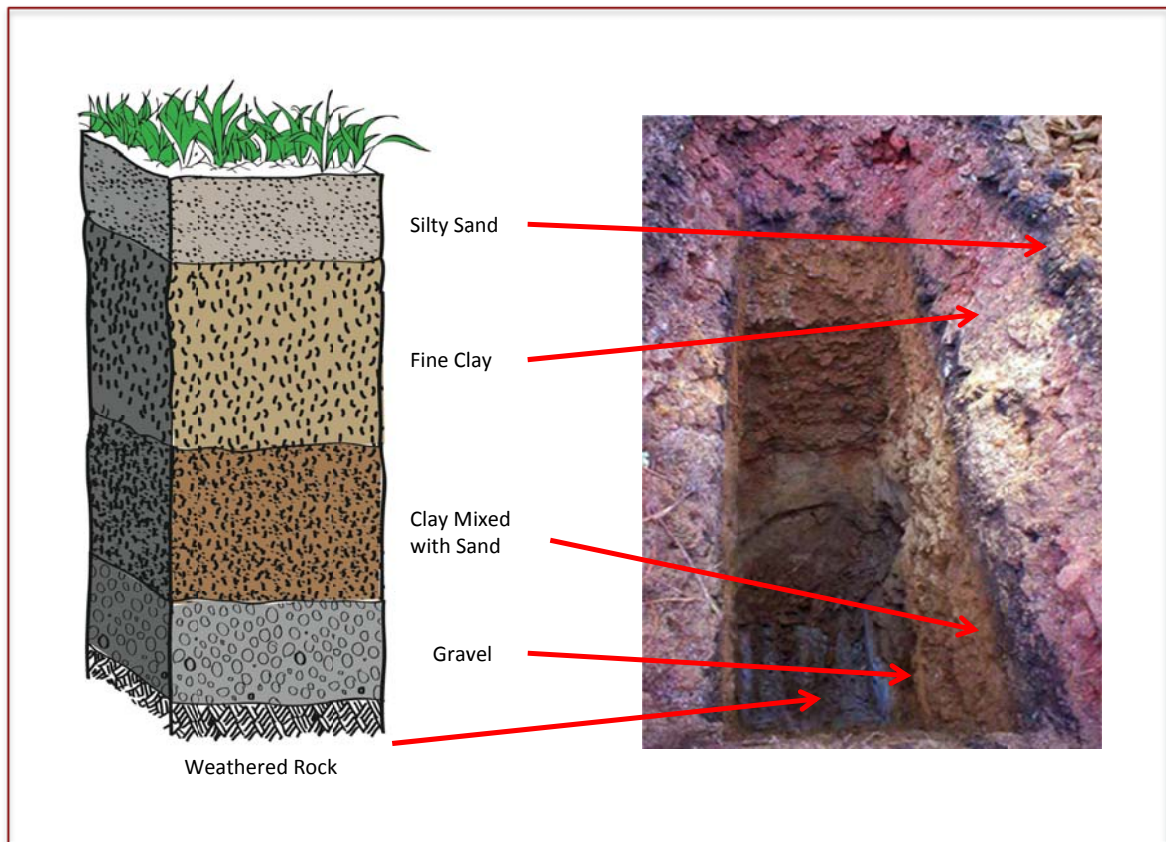


Figure 5: The different layers of soil.

Types of Soil

Soil types are graded according to the size of the soil particle. There are four types of soils:

- **Gravel:** this has soil particles bigger than 2mm
- **Sand:** this has soil particles smaller than 2mm and bigger than 0.06mm
- **Silt:** this has soil particles smaller than 0.06mm but bigger than 0.002mm
- **Clay:** this has soil particles smaller than 0.002mm.

The first three, that is gravel, sand and silt can further be classified as coarse, medium and fine.



Activity 5

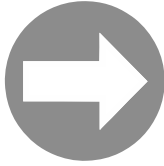
Types of soils suitable for making of ISSBs

Which soil types are good for making stabilised soil blocks? Write them in the space provided below.

If you wrote sand, silt, clay and gravel, then you are right! The production of good quality, durable compressed stabilised soil blocks requires the use of soil containing fine gravel and sand for the body of the block, together with silt and clay to bind the sand particles together. It should have a ratio of approximately 30-40% clay and 60-70% sandy soil. The soil used should also have particles not exceeding 6mm big. In addition to soil, one must use a good stabiliser. The main stabilisers used for ISSBs are cement, lime and chemicals. Of the three, cement is the most common stabiliser used in many parts of this country. One bag of cement can produce between 90 and 110 blocks.

Gravel, sand and silt though made from different soil particle sizes have similar characteristics in the sense that they retain the same size and shape when wet and dry. Silt is a little different because it tends to swell more and hold together when wet. Clay on the other hand is sticky when wet and hard when dry. It swells a lot when wet and shrinks when dry, resulting in cracking. Clay is very important because of its ability to provide cohesion within a soil. By cohesion we mean the action of soil particles sticking together.

We hope you now know the best types of soil to use for the production of stabilised soil blocks. Next we shall look at how to analyse soil in order to make sure that it is suitable for block making.



Topic 4

Soil Testing

Before any block making commences, you need to analyse the properties of the soil to determine its suitability and the amount of stabilizer that needs to be added. There are two basic field tests which must be carried out on every soil.

These are:

- The bottle or sedimentation test
- The shrinkage test

The Bottle or Sedimentation Test

The aim of this test is to help determine the approximate amount of clay, silt, sand and gravel in a soil sample. With many soils, it is very difficult to differentiate between silt and clay, however it is easier to determine the percentage of sand or clay.

Testing Procedure:

1. Start by sieving the soil to be tested with a 6mm sieve
2. Find a clear bottle with a flat bottom and reasonably straight sides
3. Fill it quarter full with soil
4. Add clean water until you completely cover the soil
5. Add a pinch of salt to the bottle contents. The salt helps to accelerate the settling and segregation of particles.
6. Firmly close the lid of the bottle and shake until the soil and water are well mixed - about 1 minute.
7. Allow the bottle to stand on a flat surface for about 30 minutes so that the contents can settle.
8. The heaviest particles, that is gravel, will settle at the bottom followed by sand, silt and clay.
9. To work out the percentage of clay in the soil, you should use the following procedure:
 - Measure the total height of soil from the bottom of the bottle to the top of the soil and record it as **X** mm.
 - By looking closely at the soil layers, you will be able to determine where the clay content starts. Measure the height of the clay and record as **Y** mm.
 - To work out the percentage of clay in the soil, use the formula described below:

$$\frac{X\text{mm}}{Y\text{mm}} \times 100 = \% \text{ of clay in the soil.}$$

The Shrinkage Test

This test will help you to calculate the amount of cement you need to add to the soil. The test procedure is as follows:

1. Make or buy a wooden box that is 60cm long, 4cm wide and 4cm deep and grease the inside surfaces of the box.
2. Fill the box with sieved moist soil. Make sure the soil is compressed in all corners of the box using a small wooden spatula that can also be used to smoothen the surface.
3. Leave the wooden box to dry for a week in a shaded area.
After the soil has dried, note the shrinkage and record. The shrinkage can be determined by subtracting the length of the dry soil sample from the length of the wooden box. This shrinkage is usually expressed as a percentage of the original length of the wooden box. See Figure 5 below which shows boxes in different stages of the shrinkage test.

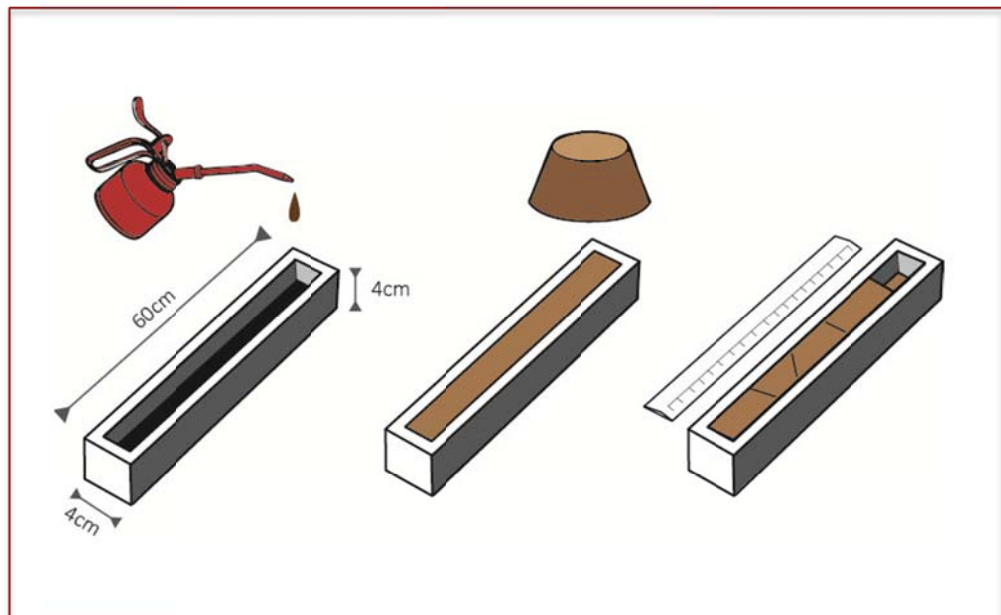


Figure 6: The Shrinkage test (Source: UN Habitat, 2009)



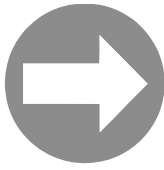
Activity 6

Soil Tests

What is the difference between the bottle test and the shrinkage test? Write your answer in the space provide below.

Compare your answers with those given at the end of this module.

Once you conduct soil tests and establish how much cement you will need, then you are ready to start making the soil blocks. We shall consider that in the next topic.



Topic 5

Production of ISSB

As we have mentioned before, the basic materials required for production of ISSB are soil, stabiliser (cement) and water. The following are the steps to follow in production of interlocking stabilised soil blocks.

1. Dig or excavate the soil:

- **Tools:** You will need to have a hoe and a spade.
- **Method:** With the use of a hoe excavate or dig out the identified soil and crush the big lumps by hitting them with the back of the spade.

2. Sieve the soil:

- **Tools:** 6mm sieve and a spade
- **Method:** The simplest sieving device is a screen made from 6mm wire mesh, and nailed to a supporting wooden frame and inclined at 45 degrees to the ground. See Figure 5 below. Using a spade, you should throw the soil against the screen. The fine material will pass through while the coarse oversized material will run down the front.

Once you conduct a soil test and estimate the amount of cement you will need, the next step is to start making the stabilised soil blocks. Let us learn how that is done in the next topic.



Figure 7: Sieving the soil with a wire mesh screen.

Note that the particles which are retained on the sieve can be further crushed and sieved again.

3. Batching and Mixing

- **Tools:** Shovels; Bucket; Watering can
- **Method:** Once you establish the right proportions, identify a measuring device, such as bucket, for your materials.
 - Using the bucket, measure or batch out the soil and cement required for a particular production.
 - Using the shovels, mix the dry cement and soil three times until the mixture has one uniform colour.
 - With the use of the watering can, add water gradually to the mixture of soil and cement until it is moist but not too wet. When you squeeze a handful of the soil mixture in your hand, no water should run between your fingers.

4. Loading the Press

- **Tools:** You will require the following equipment and tools; Soil press machine; Shovels; Brush.
- **Method:** Open the press cover of the brick making machine.
 - Check the piston cover to ensure that it is sitting on the adjusting knob.
 - Using a brush, apply oil inside the mould. This is only done at the start when the blocks tend to stick.
 - Fill the mould box flush on top with the soil/cement mix as shown in figure 7 below.
 - Drop the mould cover gently to cover the mould box. In so doing, the soil inside is pre-compacted.



Figure 8: Filling the mould with soil/cement mixture.

5. Compacting the Block

At least two people are required for this operation.

- **Method:** Open the lever latch as the person on the other side takes over the handle to compact the block.



Figure 9: Block compacting machine.

- The handle is brought down by the person compacting the block until the lever arms touches the compaction stop.
- This indicates that maximum compaction has been achieved.



Figure 10: Worker bringing down the handle of a compacting machine.

6. Ejecting the Block

Once the block has been compressed, the next step is to eject the block.

- **Method:**

- Pass the handle to the person on the opposite side of the press to start the ejection stroke.
- Ensure that the lever latch is locked in position, while the handle is moved from the vertical position so that the cover can be opened.
- Bring the handle all the way down as the block is being ejected.
- Remove the block gently by holding it along the sides and take it to a well-sheltered area for curing as illustrated in Figure 10 below.



Figure 11: Removing the block from the machine.

- To make more blocks, repeat the same process again.

6. Curing

The last process in block making is curing. This starts the following day after production when the blocks are approximately 24 hours old. Curing is the process of controlling the setting or hardening of the soil block, so that it can gain maximum strength. This is a common requirement for materials with cement. If a product with cement dries very fast in the sun, it loses all the strength and start disintegrating. To acquire maximum strength, any cement product with cement must be laid out to dry slowly in wet or humid conditions for a few days. This is what is referred to as curing. If curing is not done properly, the surface material will lose its moisture and the clay particles will shrink. This will cause surface cracks on the block faces. The final blocks will be of poor quality and all the time and money spent in producing the blocks will have been wasted.

There are two methods of curing stabilised soil blocks:

Method 1: Covering blocks with grass or leaves.

Cover the blocks with grass, leaves or any other suitable material to protect them from direct sunlight. See Figure 11 which illustrates blocks covered with grass during the curing stage.



Figure 12: Curing blocks covered with grass

The blocks are then watered every morning and evening for a minimum of 7 days.

Method 2: Covering blocks with polythene paper

Water the blocks after 24 hours. Then cover the blocks immediately after watering with a transparent polythene paper ensuring that the polythene sheet is well stacked to stop any moisture from escaping. Figure 12 shows a picture of blocks covered with a polythene sheet.



Figure 13: Blocks covered with polythene sheets.

8. Stacking the Blocks

When the blocks are three days old, they should be stacked together to create space for more blocks. Stack the blocks as shown in the Figure 13 below.



Figure 14: Stacking the blocks

9. Testing The Blocks

As you know, stabilised blocks are used for building and therefore it is important to submit them to testing procedures to ensure that they have achieved the minimum performance requirements. The tests are carried out after the blocks are a minimum of 28 days old

How do you pick blocks for testing?

Pick any two blocks randomly from every day's production and label them 'for testing'. No special treatment should be given to the blocks you have picked.

There are two tests that you can conduct on the blocks. These are:

Test 1: The dropping test

- Lift the block up to a height of one meter from a hard ground.
- Drop the block from your waist height and allow it to hit the ground.
- If the block falls and remains as one piece, only breaking the edges, then the block has passed the test.
- If the block breaks down into pieces, then something went wrong with the production.

Test 2: The Three Point Bending Test

- Place a block between two other blocks (bridged) as shown in figure 14.

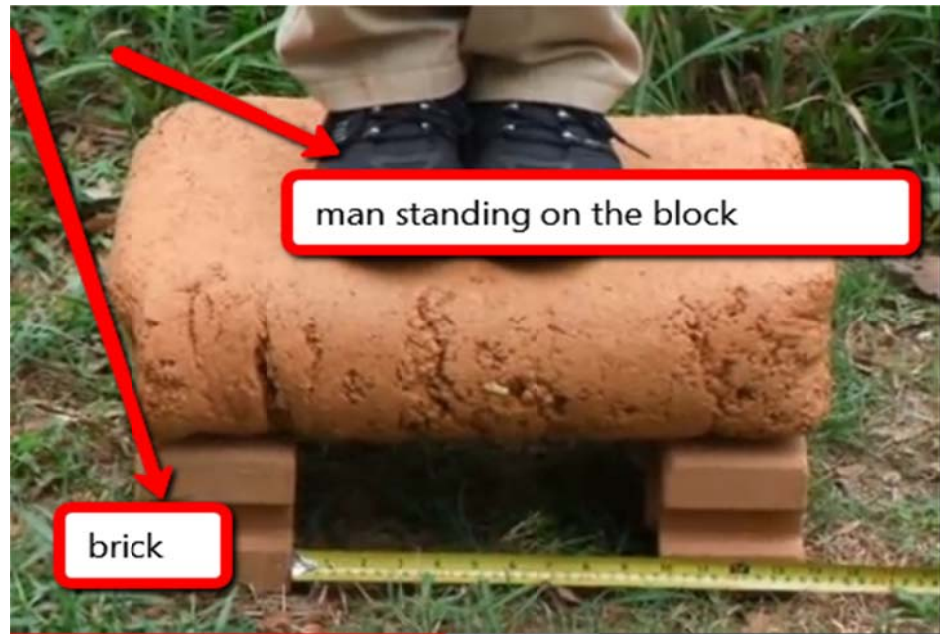


Figure 15: The three point bending test.

- Hold two blocks and step in the centre of the block or get somebody with a minimum weight of 90 Kgs to stand on the block.
- If the block holds the weight without breaking then it has passed the test.



Activity 7

Process of Block Production

Arrange the following steps of block production in the right order.

- Stacking the Blocks
- Sieve the soil
- Dig or excavate the soil
- Batching and Mixing
- Curing
- Loading the Press
- Testing The Blocks
- Compacting the Block
- Ejecting the Block

Compare your answers with those given at the end of this module.

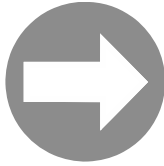
Next let us discuss the common problems one is bound to encounter during block making and their solutions.

Common Problems Encountered During Block Making

While producing blocks, you might encounter some minor problems, which you might not know of their immediate cause. The Table 1 below summarizes some of the possible problems with the machine and the solutions.

NO	PROBLEM	SOLUTION
1	Compaction of blocks is too hard	<ul style="list-style-type: none">• Check if you are loading too much soil in the press. Adjust the volume of your moulding box using the adjusting knob• The other possible cause for this problem is if the mixture is too dry. Check your water content
2	Compaction of blocks is too easy	<ul style="list-style-type: none">• You are probably not putting enough soil in the moulding box. Adjust the volume of your mould box.• Your mixture might have excessive water. Check your water content
3	The blocks have broken edges when ejected	<ul style="list-style-type: none">• Oil the mould box.• Check whether your mixture is too wet• Check whether your soil might be containing too much clay.
4	Block disintegrates while testing.	<ul style="list-style-type: none">• Check whether the curing procedures was strictly followed.• Check whether the soil is sieved before production

That brings you to the end of this topic on block production. We hope that you are now well informed about how blocks are made. In the next section we shall look at basic building guidelines when using ISSBs.



Topic 6

Basic Building Guidelines

When building a house with ISSBs, you should take special care in the following areas:

- The foundation
- Cement/sand mortar to be used
- Corners and around openings
- Roof overhangs

This is because the foundations, corners and openings are the areas which are most vulnerable to water damage and erosion. Let us look at the guidelines for each starting with the foundations.

Foundations

When building the foundation walls, you should use quarry stones or concrete blocks. If you must use ISSB's then it is recommended that you use special blocks which are made with twice the amount cement used on the basic blocks used for the super structures.

Cement/Sand mortars

When laying the blocks, you should not use cement or sand mortar that is stronger than the blocks themselves. This can cause the mortar to crack thus exposing the block to rain. The mortar strength should be slightly weaker or equal strength to the blocks. Mud mortars can also be used and later on raked externally to make the joints waterproof. Generally, the bed and vertical joints should not be bigger than 12mm.

Corners and Openings

Since the corners and openings are more vulnerable to erosion, it is recommended that all corners and the areas around openings should be plastered, see Figure 15. This applies also to the base of the building which must be plastered at least 300mm above the ground level. Again, you should make sure that the cement/sand is not stronger than the blocks themselves. Otherwise the plaster may crack.



Figure 16: Protection around the base and corners with plastering.

Roof Overhangs

Buildings constructed with ISSBs should be provided with big roof overhangs all around them in order to give the walls adequate protection. The minimum roof overhang recommended is 600mm all around the building. Figure 16 below shows a house with a big roof overhang.



Figure 17: Roof overhang

You have now come to the end of this topic on building guidelines for construction with ISSBs. Before you move on, complete the following activity to remind yourself of what you have learnt.



Activity 8

Building guidelines with ISSBs (Time: 5 minutes)

List the four areas that require special attention when building with ISSBs in Column A and write the reasons why care is needed in Column B.

Column A	Column B
1.	
2.	
3.	
4.	

That brings us to the end of this course. Let us now review what you have learnt in this course.

What have we learnt?

In this course we have learnt that:

- ISSBs are made of soil, water and stabilizer (cement) and then compressed using a manual or motorized block-making machine. Compared to other technologies of brick making it is affordable, environmentally and user friendly among other advantages. However, care must be taken to ensure quality.
- The production of ISSBs requires a block making machine and tools such as a shovel, bucket, sieve, oil can, among others
- The best soil for production of ISSBs comes from the sub-soil layer and that the production of good stabilised soil blocks requires the use of soil containing fine gravel, sand, silt and clay.
- Before you start block production you should test the soil to assess its suitability and also to help you calculate the amount of cement you need to add.
- The production process of SSBs has many steps that start with digging, sieving of the soil, batching and mixing, compacting of the block, curing, stacking and testing. You also learnt about common problems that may be encountered during this process and possible solutions.
- When constructing with ISSBs you should take care when building the foundation and when using cement or mortar. You should also protect corners and openings with plaster and build roof overhangs to protect the walls from erosion.

Congratulations! You have now come to the end of this course. We hope you have found it interesting and informative and that you now have the necessary knowledge to make interlocking stabilised soil blocks. To check if you have mastered the content of this course, go back to the outcomes at the beginning of this course and check if you have achieved them. If you have, take time to practice what you have learnt because practice makes perfect! Good luck!

Answers to Activities

Answer to Activity 3

- (1) What is the difference between a manually operated and a motorised interlocking stabilised soil block making machine

The motorised machine uses diesel or electricity to run while the manual ones does not. The manual machine produces one block at a time while some motorised machines can produce 2 or more blocks at a time.

- (2) List the tools that are used for making interlocking stabilised soil blocks.

1. Bucket; 2. Oil can; 3. Watering can; 4. Sieve; 5. Shovels; 6. Trowels; 7.Hoe; 8. Pan; 9. Rammer; 10. Broom.

Answer to Activity 6: Soil Tests

What is the difference between the bottle test and the shrinkage test?

The bottle test assesses the quality of the soil in terms of the proportions of each particle. While the shrinkage test is performed to help you calculate the amount of cement that should be added to the soil.

Activity 7: Process of Block Production

Arrange the following steps of block making in the right order:

- 1. Dig or excavate the soil:*
- 2. Sieve the soil:*
- 3. Batching and Mixing*
- 4. Loading the Press*
- 5. Compacting the Block*
- 6. Ejecting the Block*
- 7. Curing*
- 8. Stacking the Blocks*
- 9. Testing The Blocks*

Activity 8: Building guidelines for ISSBs

List the four areas that require special attention when building with ISSBs in Column A and write the reasons why care is needed in Column B.

Column A	Column B
<i>1. Foundation</i>	<i>Foundations are vulnerable to water damage and so require quarry stones or concrete blocks or ISSBs with twice the amount of cement used in ordinary blocks</i>
<i>2. Use of cement/sand mortars</i>	<i>Cement or sand mortar should not be stronger than the block to avoid cracking</i>
<i>3. Corners and openings</i>	<i>Should be plastered to protect from erosion</i>
<i>4. Roof overhangs</i>	<i>To provide protection to the walls</i>

Glossary

Compress	To squeeze the soil mixture with a machine
Stabiliser	Material added to soil to make it stronger and water proof, such as cement or lime.
Interlock	To fit or join two blocks closely together
Mortar	A paste made up of cement and sand used to bind blocks together
Compacting	To exert force on a soil mixture in order to compress it
Mould	A container used to give shape to something
Lubricating	To oil something
Decayed	To rot or decompose
Batching	The process of measuring and combining ingredients for block making.
Curing	Keeping blocks moist so that they can achieve maximum strength.

References

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2. UNESCO (2001). *Compressed Stabilised Earth Block Manufacture in Sudan*. UNESCO, Paris.
3. Weinhuber, K. (1995) *Building with interlocking blocks*. German Appropriate Technology Exchange, GTZ (GATE), Eschborn.
4. Teach a Man to Fish, *Income Generating Activity Information Sheet*, Stabilised Soil Brick (SSB) Brick Making