SELF-HELP SERIES

GUIDE TO SOIL-CEMENT BRICKMAKING

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☐ FOREWORD

The intent of this article is to provide the reader with all the information required for him to make his own soil-cement bricks with a Ellson Blockmaster block or brick making machine. It is aimed at the Transkeian layman who has little or no knowledge of using brickmaking machines or making soil-cement bricks.

Although the technique of stabilizing soil with cement is a simple one, it nevertheless requires some degree of competence if the resulting bricks are to have the qualities needed for optimum use. There are numerous technical documents on soil-cement and its use. These, however, are generally aimed at engineers and experienced builders. This document has been prepared to meet the requirements of local builders and communities who are not normally faced with difficult technical problems but who wish to build with soil-cement. A further objective is to promote the wider use of soil-cement, which can lead to a reduction of costs, because of the low cost of the material and also because it can be used by communities and families to build their own homes, schools, clinics and other buildings unassisted.

This booklet is the first in a series of publications by TATU on soil-cement construction techniques and design. Two other booklets will deal with solar design including orientation and active and passive solar systems and the other with design and construction of building with soil-cement blocks.

W.G.Soal

part 1

☐ INTRODUCTION

The use of simple compacted soil (natural earth) as a building material dates from time immemorial. Over the ages earth has been used as a building material, because of its constructive qualities. Yet despite its good insulating and resistant properties, there are limitations to the use of earth owing to its lack of strength and its vunerability to moisture and the erosive effects of wind and rain.

Provided natural soil possesses a combination of certain characteristics, however, it can be subjected to a process known as "stabilization". The effect of adding a stabilizing agent like Portland cement, for instance, is not only to enhance the best qualities of soil but also to impart other properties which soil alone does not possess.

The stabilization process consists of taking soil from the earth, pulverizing it, adding to it a small amount of cement, adding water until the optimum moisture content is reached, and subjecting it to moderate pressure, thus producing a mass which, when set, possesses great strength. The result is a material able to bear a much higher work-load that could be carried by soil without cement, and durable enough to withstand the continuous effects of atmospheric agents.

The compound of soil, cement and water, mixed in the proper proportions and compacted to the proper degree, constitutes "soil-cement".

Soil-cement has acquired a good name as a building material, and it can compete in technical quality with materials commonly used in low-cost construction. Its use is progressively increasing in all countries, particularly in rural and suburban areas. The simplicity of the technique involved means that untrained rural people and self-help builders, without special training, can build their own homes inexpensively and without the need for complicated and time-consuming skills.

The use of natural soil in the traditional adobe or wattle and daub is limited because of its low strength and its vulnerability to atmospheric agents, especially the effects of erosion. With most soil however, it is possible, by adding a small proportion of cement, mixing it with water to make it damp, and finally compacting it to produce a material of adequate strength when cured.

When this is done, the resulting material can bear much greater work-loads than could be carried by soil without cement, and provides a more durable product. This combination of soil, cement and water, mixed in the right proportions and well compacted, constitutes a superior soil-cement building material.

part 2 ☐THE SOIL

The ideal soil for stabilization with cement is one which gives high strength and does not shrink too much when dried. It should be easily compacted and contain the proper proportions of sand, silt and clay for the best results

Preparation of Soil- Cement

The preparation of soil-cement should be restricted to the following stages:

(a) Components
(b) Mixing of the components.
(c) Compaction of the mixture
(d) Drying and curing.

a. components

1. The Soil

Sandy soils are the best because they produce the strongest bricks when stabilized. However, there should be some clay in the soil, at least 10%, to bind the particles together. Generally speaking the best soils for soil-cement construction work are those ranging from 45% sand, with 55% clay and silt to 80% sand with 20% clay and silt.

Note: If your soils do not fall into this range or your are unsure of their sand/clay content get advice from TATU befor making any blocks or bricks. Topsoil and other soils containing organic matter should not be used.

In its natural state, soil may possess some moisture. This should be reduced by turning the soil and exposing it to air. This is done to make the soil easier to sieve and later mix dry with cement.

You can test if the soil is dry enough by taking a handful and squeezing it into a ball. No water should appear on the surface of the ball and upon releasing it it should disintegrate without lumps forming.

Once the soil is dried and in the condition described above, the the next step is to pulverize the soil to break down the clods it contains. This is done by striking them with a shovel (figure 1), after which the soil is sieved through a screen held horizontally. This screen should consist of 4,76 mm wire mesh in a wooden or iron frame. The screen should be shaken while the soil is being sieved (fig 2).

Only the material that passes through the screen can be used for making soil-cement. This should then be used immediately or stored in a damp-proof place near the brick machine.

2. The Cement

The cement must be stored indoors in a place with waterproof walls and ceiling. The floor should also be waterproof and raised above ground level. Prolonged storage of cement causes gradual reduction of its strength.

In the field, the percentage of cement to be used in soil-cement mixtures in determined experimentally, varying the proportion of cement by volume between 5% and 13% and using the same type of soil.

The percentages mentioned must be adjusted according to the type of soil used, in accordance with the following table:

Figure 1 Breaking Up the Soil

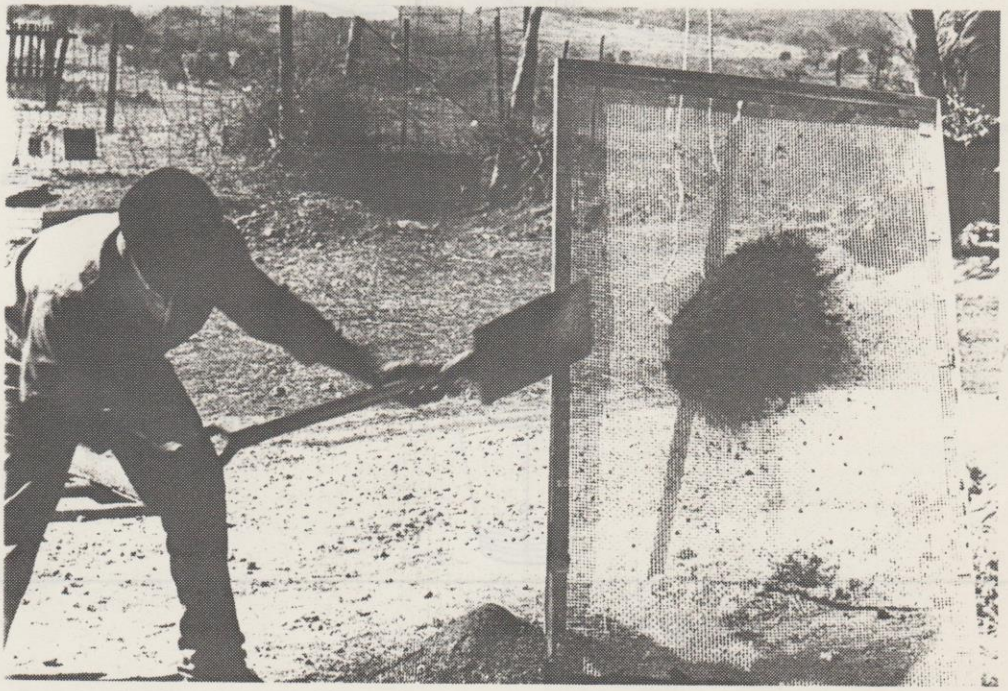

Figure 2 Sieving the Soil

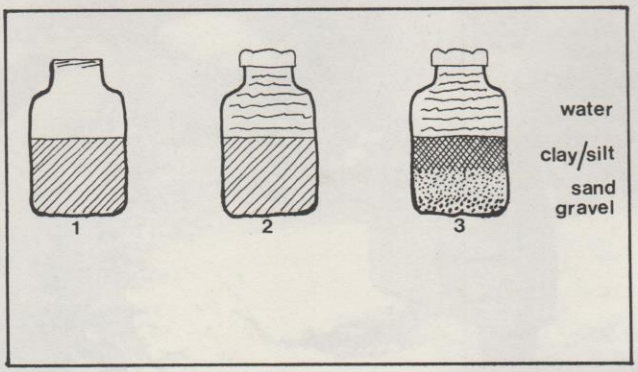

Figure **3** Particle Determination Test

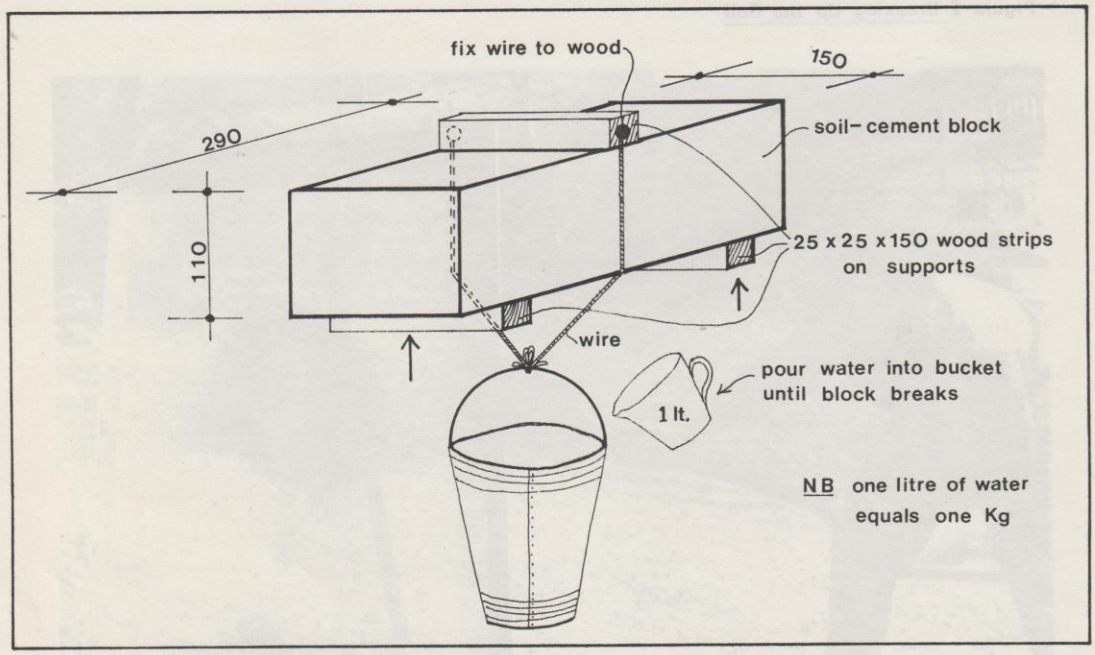

Figure **4** Tensile Strength Test

TYPE OF SOIL	NORMAL % OF CEMENT
Sandy	5 - 9
Silty	8 - 13
Clay	13 - 15 (not good to use)

---

1) A simple field test for analyzing the soil to find the ratio of sand to clay and/or silt is as follows: **(Figure 3)**

Step 1 Pass the soil through a 6 mm screen
Step 2 Half fill a wide-mouth jar (coffe jar) with the soil
Step 3 Now fill the jar up with water
Step 4 Add two teaspoons of salt to help the clay/silt particles settle faster and put the lid on
Step 5 Shake the jar vigorously for 2 minutes
Step 6 Place the jar on a level spot

The soil should settle in about half an hour. The sand will settle quickly to the bottom. The clay/silt particles will settle last. Measure the layers to determine the ratio of sand and clay/silt (see figure 3).

Use soil that is at least one-third sand and between 5% and 30% clay/silt. If the soil is not suitable, it can be made suitable by adding sand or clay.

Test blocks (measuring 150 x 110 x 190mm) should be made using different amounts of cement. These should then be cured for 15 days as described under "Drying and curing". After 15 days the blocks can be tested as follows:

a. Tensile strength: (figure 4) Place the soil-cement block on two supports, (as shown in figure 3) 25mm x 25mm x 150mm and place these 200mm apart. In the center and on top of the block. A third support of the same measurements as the others is placed centrally on top of the brick. Strings are attached to each end of this support for a bucket to hang from.

   Now gradually fill the bucket with water until the block breaks. The block which takes the most water before breaking is the one made with the best mixture. (N.B. several blocks should be tested for each mixture to give an accurate indication of average strength. TATU will test the relative strengths of different soil-cement mixtures using a SABS calibrated brick crusher. Be sure to mark the cement content on the blocks).

b. Unit Weight: The block weighing the most is the best block and the mixture used to make it should be chosen.

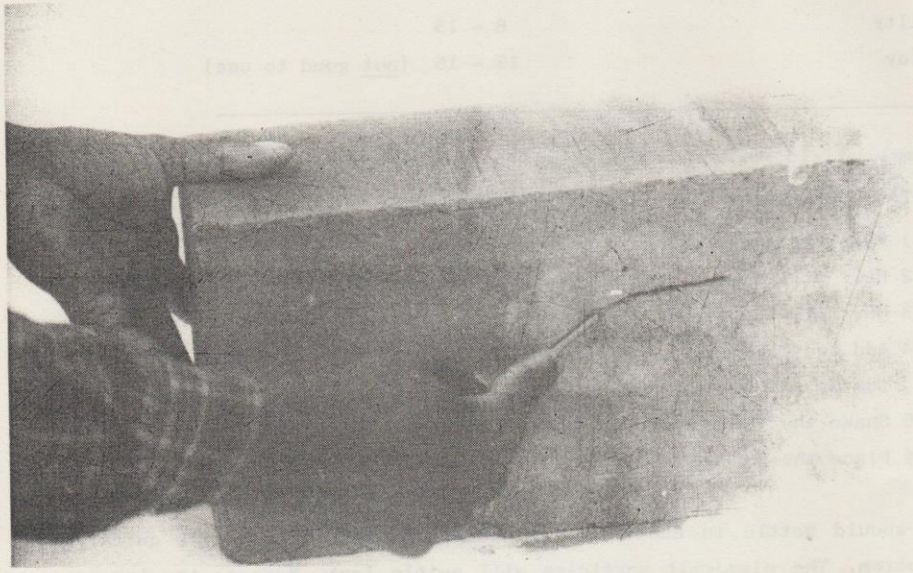

Figure 5 Hardness Test

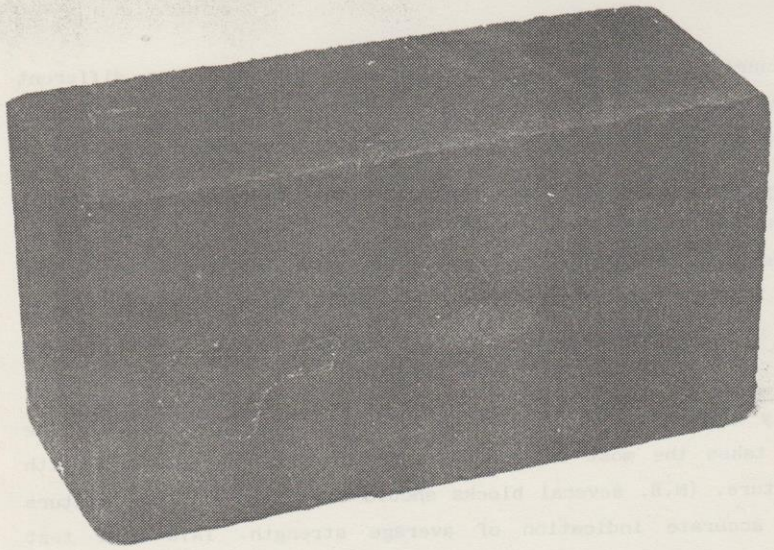

Figure 6 Good Block

c. Hardness test: Take a 10cm nail and strike the block at an angle with it. If the nail does not penetrate further than 5 mm then it is a good block (figure 5).

d. The block should have sharp, firm edges. (figure 6).

e. Submerge the block in water for eight hours. The block should show no signs of disintegration (figure 7).

3. The Water

The amount of water used is very important because, if the mixture is either too wet or too dry, it will not be good for brick making nor will it be strong enough to build with.

Every type of soil requires a specific amount of water if it is to be compacted correctly. Generally, the total amount of water should vary between 8% and 16% by volume. The water used should be clean.

b. mixing the components

A "mixing base" should be prepared close to the water, cement store, soil excavations and seive. It should consist of a hard level, non-absorbent floor.

Before the components are mixed they should be measured out in the right proportions. For measuring purposes, bucket is best.

If, for example, you are going to make a 5% soil-cement mixture with 10% water content then you will need

1 bucket of cement
2 buckets of water and
17 buckets of prepared, sieved soil (figure 8).

First put the soil on the mixing base and spread it out evenly, not deeper than 100 mm. Now sprinkle the cement evenly over the soil. Next begin mixing it with a spade until the colour of the material is uniform throughout (figure 9).

When the dry soil and cement are well mixed, spread the mixture out again and sprinkle water on it, from a watering can for even distribution (figure 10).

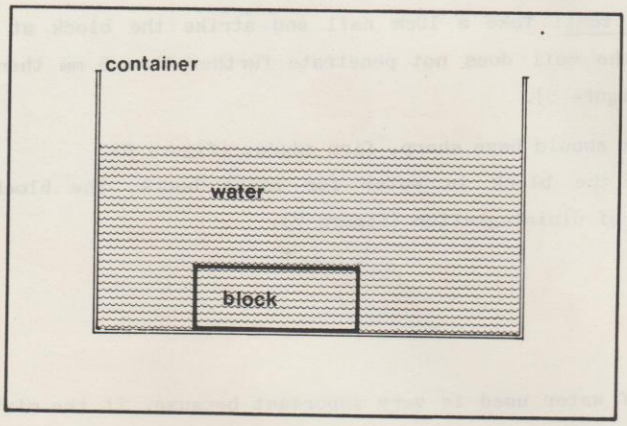

Figure 7 Water Test

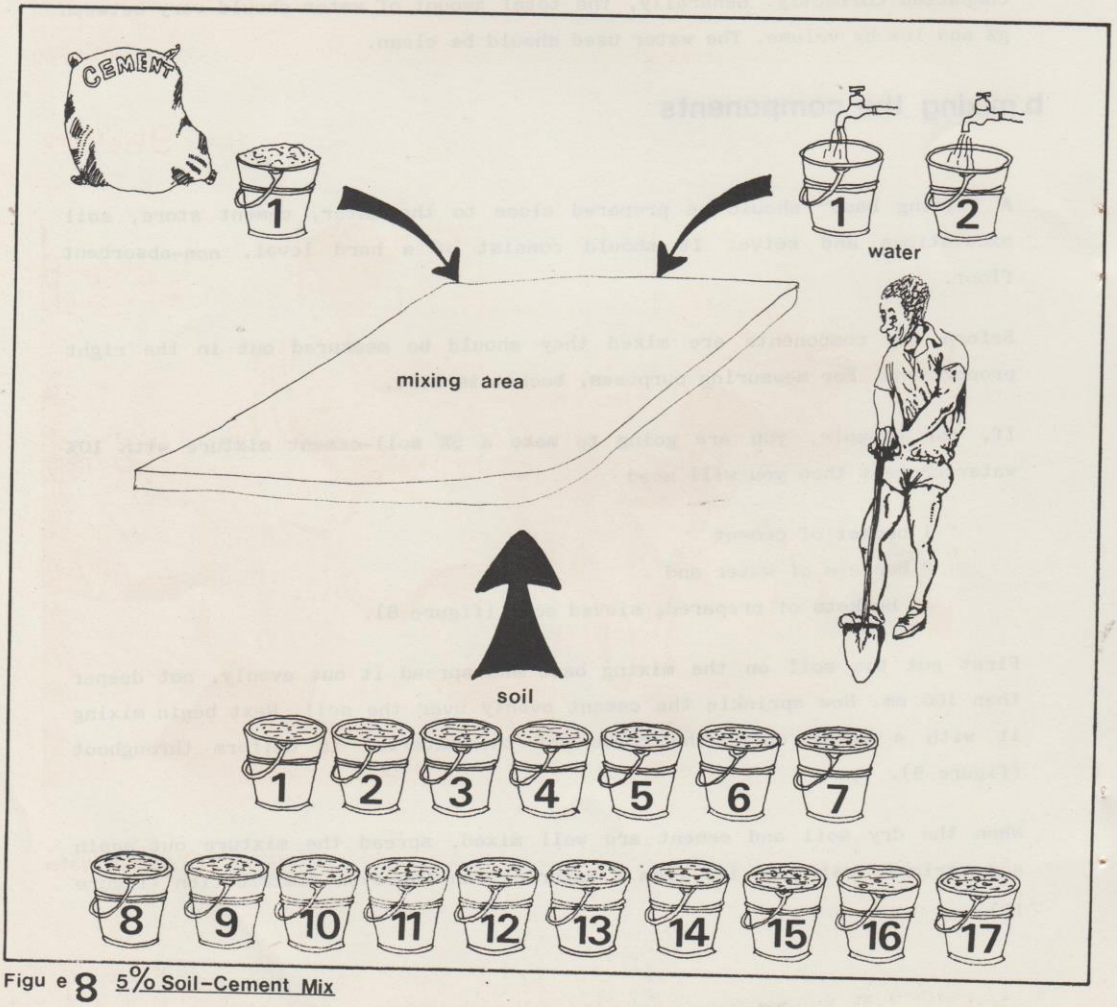

Figure 8 5% Soil-Cement Mix

Figure 9 Dry Mixing

Figure 10 Adding Water

Figure 11 Right Mix

Figure 12 Right Mix

Figure 14 Wrong Mix

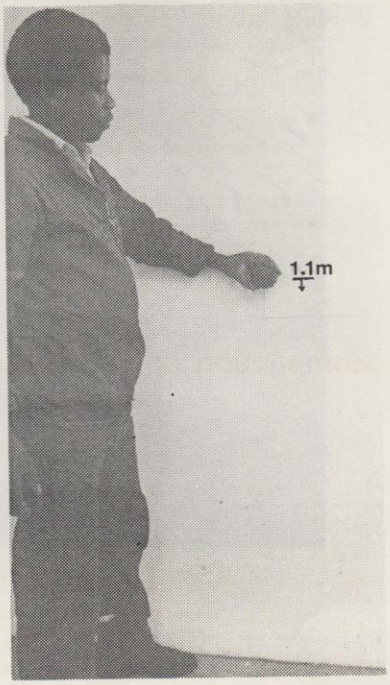

Figure 13a Drop Test

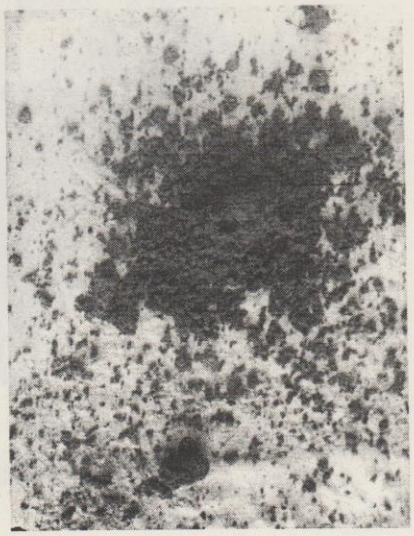

Figure 13b Right Mix

You will know that you have added the right amount of water, when you take a handful of the wet mixture and squeeze it. When you open your hand the correct mixture will:

1) retain the shape of your hand (figure 11) without making it dirty.
ii) can be pulled apart without disintegrating (figure 12) and
iii) if dropped from a height of 1,1 m onto a hard surface it will disintegrate as shown in figure (13a).

Figures 14 and 15 show incorrect mixtures.

c. compaction of the mixture

The mixture can now be compacted into blocks or bricks in a wooden mould or mechanical moulder. This document will only deal with compaction in a hand-operated Ellson mechanical moulder.

This moulder (figure 16a and 16b) is operated as follows:

i) The moulder machine should be set up in a level place inside the "brick preparation area" and near the "mixing base".

ii) Now using the scoop supplied with the machine fill the moulder box with the mixture (figure 17).

Note: Make sure the scoop is not overfilled or underfilled each time otherwise your bricks will be different sizes, i.e. use the same amount of mixture for each block/brick. This can be ensured by levelling the contents of the scoop.

iii)Close the cover over the moulder box (figurel 18).

iv) The handle operator now releases the lever (figure 19) and pulls down on the compression stroke (figure 20).

Note: If the handle operator needs help to pull the lever down then too much mixture has been put into the moulding box.

v) Once the compression stroke is complete the lid is released and the brick pushed up (figure 21).

vi) The brick must now be carefully removed with the palms of the hand and taken to the drying area (figure 22).

1. Brick Production

When making bricks with the Ellson machine you should have at least 6 people to do the work most efficiently, These people should each have a job as follows:

Figure 15 Wrong Mix

Figure 17 a Filling the Scoop

Figure 18 Closing the Lid

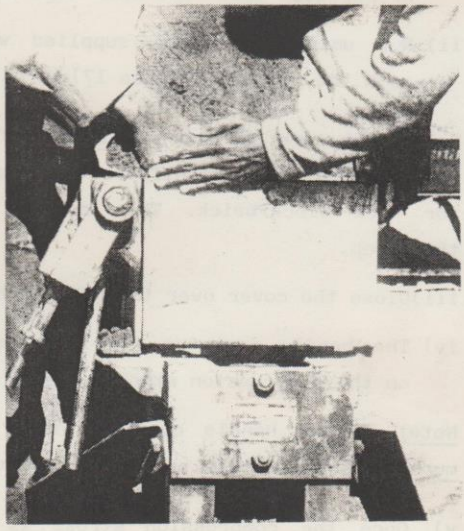

Figure 17 b Filling the Box

Figure 16a Ellson Block Master

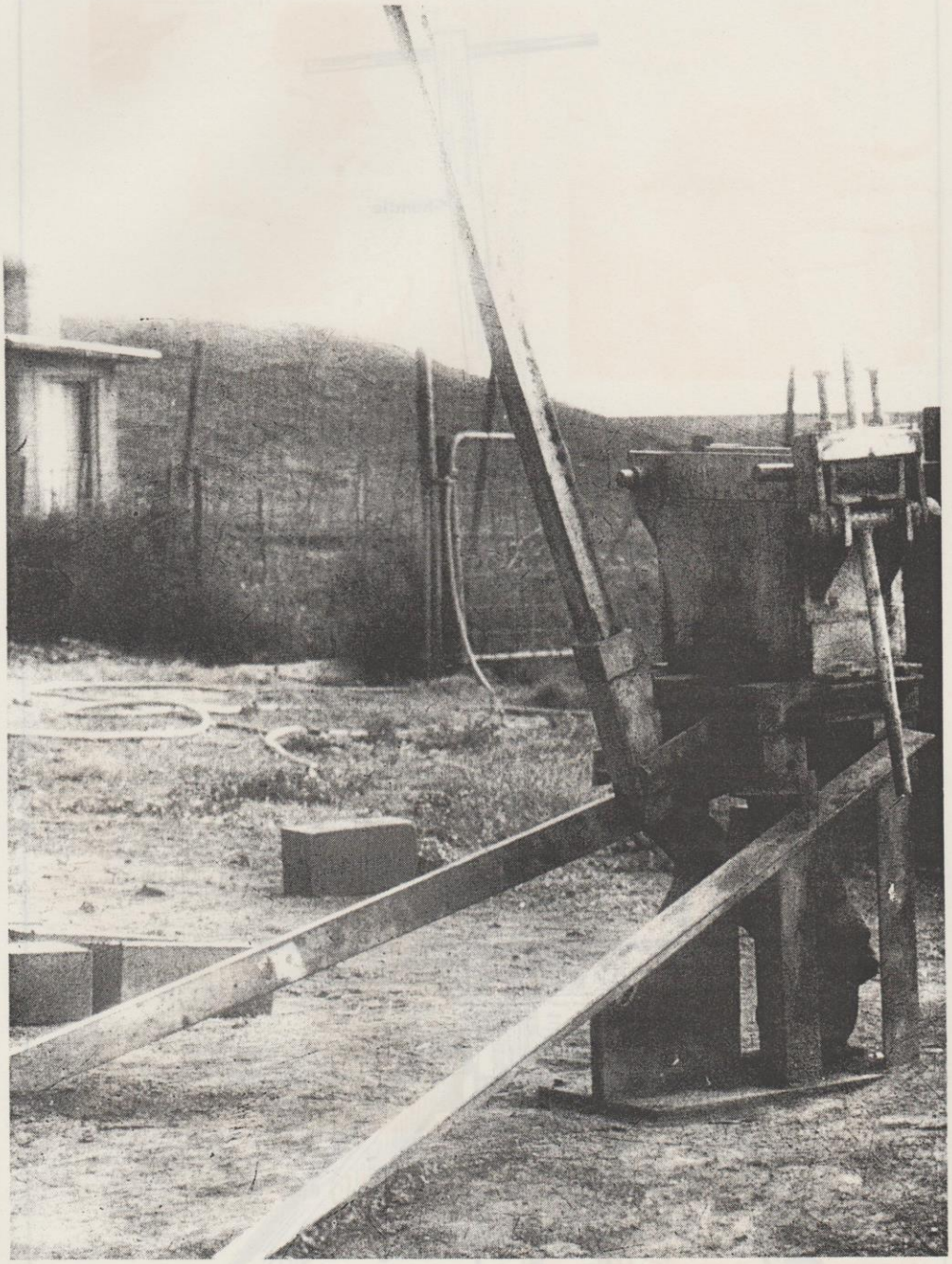

Figure **16b** Diagram of Brick Machine

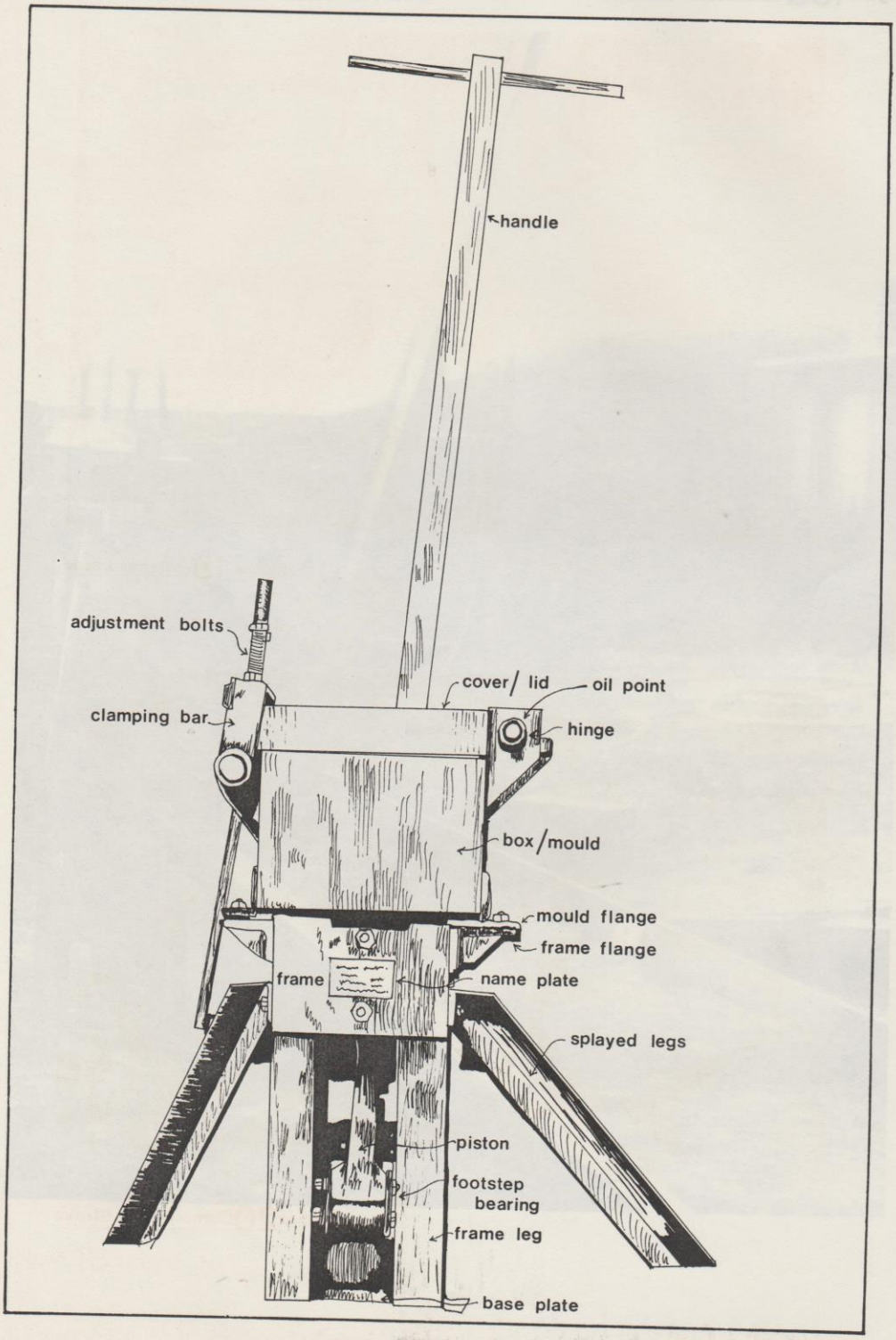

Figure 19 Release Lever

Figure 20 Compression Stroke

Figure 21 Removing the Block

Figure 22 Covered Curing Area

* two people (the mixers) should collect soil and mix it correctly ready for compaction.
* one person (scoop person) should fill the scoop. This person should practice filling the scoop so that he always gets the right amount of mixture.
* one person (the mould person) should be at the mould head.
* one person (the handle operator) should compact the brick by pulling down on the handle.
* one person (brick carrier) should carry away the made bricks and deposit them at the curing area.

A team of six brickmakers working as described should be able to make between 400 and 600 bricks in an 8 hour day. These bricks are the standard 110 x 150 x 290 bricks. However, there are a variety of moulds for making different size bricks and so production rates will differ depending on the mould being used.

A typical production process, using the team describe above, would be as follows:

1. Once the first batch of mixture is ready the mixers should begin collecting sieving and mixing the next batch. (figure 9 & 10).
2. The scoop person fills the mould with a scoop full fo mixture (making sure that it is the right amount), then returns to get another scoop full, (figure 17)
3. Once the scoop person has filled the mould with 1 scoop full of mixture the mould person closes the lid and locks it. (figure 18)
4. The handle operator now pulls the handle through the compression stroke. (figure 20)
5. The mould person now unlocks the lid and opens it.
6. The handle operator ejects the brick (figure 21)
7. The brick carrier removes the brick and takes it to the curing area. (figure 22)
8. The handle operator raises the handle to the starting position and the process is repeated.

2. Adjustments

a. block depth

There is a coarse adjustment and a fine adjustment. The coarse adjustments are seldom employed and require spacer plates to be produced.

b. coarse adjustments

For a thinner brick/block lift up the linkage bracket by inserting a spacer plate (usually 3 mm or 4 mm) between the footstep bearing and the machine

base plate.

For a thicker brick/block fit spacers between the bottom of the mould flanges and the bolting flanges on the frame.

c.fine adjustments

There are two fine adjustments.

a) The adjustment of the bolts through the clamping bar. The purpose of these is to ensure that when the platen is at compression point then the under surface of the lid plate is parallel to it along the 230 mm length. These adjustment bolts control the limit of rise in the lid as the mix is forced up under pressure. Screw back the bolts and the front of the lid will lift further and the front of the brick/block will be thicker; tighten down the bolts so that more of them project below the clamp and the opposite effect results. This adjustment is very obvious and easily applied. It should not be carried to absurd lengths.

b) The 15 mm thick lid plate is apparently screwed to the lid body by no less than 5 srews (9 in case of Model "SB2")

Along the certon line there are two such screws. They pass right through from the underside of the frogs to the top of the lid channel body and these two are "pull-up" screws. They alone hold the lid plate to the channel line of the hinge end, two close up to the channel flanges near the lid end.

By slacking the 'pull-up' screws right off, and then setting the adjustment screws well below the underside of the lid channel one can then tighten up the 'pull-up' screws causing the lid plate to lie against the points of the three adjustment screws, and in effect, set it in any plane one likes purely by altering the extent to which the various adjustment screws pass below the level of the lid channel.

By an intelligent use of both fine and coarse adjustments the brick or block can be made the same height at all corners and also the correct overall depth.

d.ejection control

It is important that during brick or block ejection the platen is not ejected out of the mould thereby hanging up on the mould top when the handle is returned to the vertical position. At the front of the frame on the right of the centerline a screw projects horizontally towards the claw of the pressure arm. This controls the extent of lift during ejection of the platen. By means of this screw adjustment always ensure that at least 3 mm of the platen is below the top of the mould wall when the handle is in the "fully" ejected position.

3.Machine Maintenance

The following procedures must be followed to keep your machine in good operating order and to prolong its useful life.

1. Clean the hopper and other working parts of the machine at the end of each days use. In particular wash off the foot step bearing all exposed surfaces.
2. At least once a week lightly oil all the working parts of the machine.
3. Once every month, grease the piston lightly. Do <u>not</u> grease the foot step bearing.
4. Cover the machine during periods of non-use to protect it from rain to minimize rusting.
5. Once a week tighten up all loose bolts, particularly the ones attaching the mould to the base of the machine. Do <u>not</u> over tighten.

d.drying & curing

1. The drying time of cement is very important in soil-cement; for this reason, the mixture must be used within two hours of it being mixed.
2. Correct drying of bricks is also very important and if this is not done carefully bricks will break and not be structurally sound. Soil-cement bricks or blocks usually take a minimum of 14 days to dry.

   To ensure proper drying, the blocks must be stored must be stored with adequate protection against sun and rain. They should be placed on a dry, level and raised surface.

Figure 23 Watering the Bricks

Figure 25 Oiling the Machine

Figure 24 Greasing the Piston

The blocks must be allowed to dry slowly and without violent changes of temperature. THEY MUST DRY SLOWLY. After 24 hours, the blocks should be watered regularly with a watering-can (figure 22) and kept out of the sun. On the third day the bricks should be stacked and then be watered a further 8 days.

There are several ways to ensure that soil cement blocks are damp cured:

(1) Cover them with a sheet of black plastic making sure the edges are held down. The plastic cover should be pulled back at least once every 2 or 3 days and the blocks watered. (figure 23).

(2) The blocks can be kept covered with hessian or cloth which can be made from feed bags;

(3) A thin 25 mm layer of thatching grass can be spread over the blocks and kept damp. The block maker should choose the most convenient, lowest cost method for damp curing. An inferior quality block results if soil cement blocks are allowed to bake in the sun because they dry out too rapidly.

part 3 ☐ REMEMBER

DO train your labourers thoroughly before starting work.

DO fill the scoop as instructed - it takes longer in the beginning but produces consistent quality bricks (see figure 17).

DO show your labourers how to mix the sand/soil and cement thoroughly before mixing the water in.

DO keep the mould walls scraped clean - a scrape is better than a wipe DON'T USE AN OILY RAG.

DO attend to faults and effect repairs immediately they occur.

DO remember to wash or hose off the machine every day especially the footstep bearing. Although the machine will start to rust, old sand/soil and cement are very abrasive and are the worse of the two evils.

DO keep the piston cleaned and lightly greased.

DO oil the moving parts where holes are provided (mould only).

DON'T let the moulder pat the earth smooth in the mould before closing lid - this can halve your production.

DON'T let the handle operator enlist helpers pull the hand down (mould overfilled) as something will break.

DON'T let the moulder pick up bricks/blocks by gripping them between the fingers, he/she should use his or her palms (see figure 21).

DON'T waste time making bricks of extreme trueness to size - they are going to be laid in mortar anyway. (We set machines to leave our works correct to 1,6 mm tolerance in the case of bricks and 3 mm in the case of blocks).

DON'T use violence to correct a fault on the press. It is a very simple machine and faults can usually be seen at a glance.

DON'T oil or grease the footstep bearing - this allows sand/soil and cement to stick to it and thereby become a nuisance as abrasives.

Finally, when using these blocks for building construction make sure that you have a good strong foundation and that unsupported walls are not too long. If you are uncertain and need advice write to or visit TATU. TATU also has a number of plans already drawn up for different buildings and provide a plan drawing service.

APPENDIX

TROUBLE SHOOTING (I)

Trouble	Probable Causes	Eliminating the Difficulty
Sticking to the lid	i) Mixture too wet ii) Clayey, sticky soil.	Make a drier mixture Fill the mould as usual. Close the lid and immediately re-open. sprinkle some dry cement or dry mixture on the partially moulded brick.
Sticking to the platen	i) Mixture too wet ii) Clayey sticky soil.	Make a drier mixture Sprinkle dry cement or mixture into the mould before filling. With interlocking blocks it may be necessary to cut paper strips about 1" shorter than the mould and 4" width. Insert these into the mould first. The strips can be removed at the stacking ground and returned for reuse. If the paper is strong (e.g. one layer of cement bag paper) the strips will last for about 50 bricks.
"Tell Tale" operates with normal force applied to handle	i) Mixture too wet (dry) ii) Sandy nature of soil	Make a drier (wetter) mixture A certain amount of scrape of the "TellTale" is permissable in this case but the lid clamp must still be able to be pulled free with a jerk rather than by a blow.
Mould dirty after ejection	i) Mixture too wet ii) Nature of soil iii) Uneven water distribution in the mixture	Make a drier mixture This rarely happens, but when it does there is no preventative remedy apart from scraping the mould walls clean with a paint scraper every few operations. Inspect the mixture heap and test for wet lumps in drying soil.

Continued /...

Trouble	Probable Causes	Eliminating the Difficulty
Bricks/blocks rise in the centre to become convex	i) Mixture too wet	Make a drier mixture.
	ii) Mould overloaded	See how much mixture is being put into the mould. See "Tell Tale operates" on Page 13.
	iii) Sandy soil	
Difficult to start ejection stroke	Sticky soil	A slight misuse of the handle is permissable. When starting the ejection stroke lift the handle about 1 foot and bang down on it. The brick/block will then be "punched"out.
Brick/block falls apart on removal from mould	Mould Man	Check whether removing with palms. Equip the mould man with wooden slats for use instead of his palms.
	Sandy soils	
	Dry sandy mixture	An increase in water content will assist borderline cases but if not then sand equip must be purchased.
Interlock remains in the groove of the platen	Sticky nature of soil	Try a slightly drier mix, but be sure to keep these blocks wetter than usual throughout the curing period. See also "Sticking to Platen"
	Sandy nature of soil	See "Brick/block" falls apart on removal from mould.

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