

# PRODUCTION MANUAL FOR STABILIZED COMPRESSED EARTH BLOCKS

SCEB PRODUCTION



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Agency for Development  
and Cooperation SDC

**skat** Swiss Resource Centre and  
Consultancies for Development  
**PROECCO** PROmoting Employment through  
Climate Responsive COnstruction

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# 00

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# 01

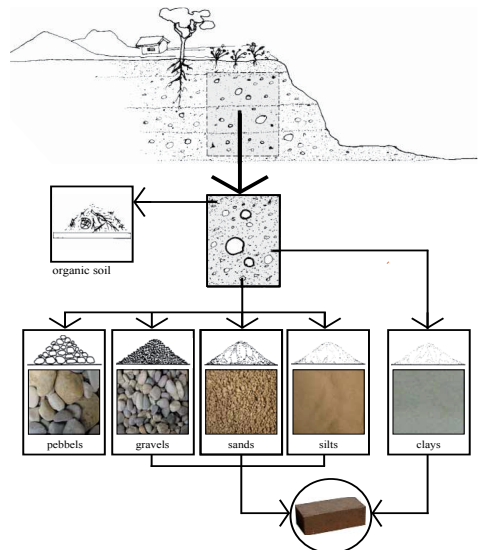
## SOIL

### 01.1 - SOIL CONSTITUENTS

A good stabilized compressed earth block soil should consist of a sandy soil (larger quantity of sand as silt, clay, or potential small gravels). The part of clay must be small : clay action is contrary to the action of cement to introduce. Using organic soil should be avoided (proportion by weight !).

Lateritic soil is suitable for CEBs production too.

#### SOIL CONSTITUENTS



# 01

## 01.2 - SOIL SELECTION / IDENTIFICATION

With a solid experience, it is not necessary to practice laboratory tests.

Field trials are then often more than enough to understand the behavior and the specific characteristics of soils, so long as diagnostics marks agree. If discrepancies are noticed, further laboratory tests will be mandatory.

In this way it is possible to :

- know how to choose a soil in function of its intended use;
- or, conversely, know how to use optimally soil according to its characteristics.

The soil sample must be representative of the soil that has to be analyzed.

In order to do this, it is necessary :

- to extract very localized samples, that will not be corrected (add or remove elements from it);
- to multiply the samples when the soil is heterogeneous, rather than trying to make an average (which may never be exact).

It is always useful to refer to local knowledge. Information can be gathered by interviewing former masons and elders. It is important to be able to interpret this collected information, particularly through observation of existing buildings.



### TEST

Beware : if a sandy soil has little cohesion, and therefore little dry strength, it has the advantage not to crack (minimum withdrawal).

On the other hand, clayey soil has a high cohesion, and therefore high dry strength, but it may crack significantly.

Proper soil for producing SCEB adobe is rather a sandy soil, which naturally presents little clay: it does not stick.

In its composition, it is similar to the soil used for interior plasterwork or stabilized moulded earth blocks stabilized adobes).

Its lack of natural resistance will be improved by adding a small proportion of cement. The amount of clay should be very small not to cause cracks, but a small amount is necessary to link the earth before the action of the cement, which requires time.

## SMELL TEST

This test consists in smelling wet soil. Smell a moistened quantity of soil. If it has a musty odor, similar of that of wet agricultural soil, it is organic and should be rejected. As the humidification increases, the smell will be more intense.

Recall that the section of organic soil is unsuitable for construction.

## PRELIMINARY ANALYSIS OF THE TEXTURE

Visual examination:

It initially helps to get an idea of the relationship between large elements, but also of the sandy fraction and the fine fraction (limit of visibility to the naked eye); the dominant fraction determines the fundamental properties of the material.



Touch test\* :

- Rough and without cohesion : sandy soil;
- Silky appearance, and once wet moderately plastic: silty soil;
- Presence of resistant and plastic clods, and once wet sticky and malleable : clayey soil;



Hand washing test\* :

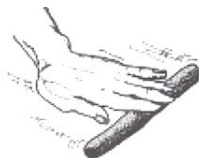
- Easily rinsed off: sandy soil;
- Rest of powder on the skin: silty soil;
- Soapy and difficult to rinse off: clayey soil.



\* Tests done with the finest particles of the soil only (particles  $\leq 2$  mm) : from the sands to the clays.

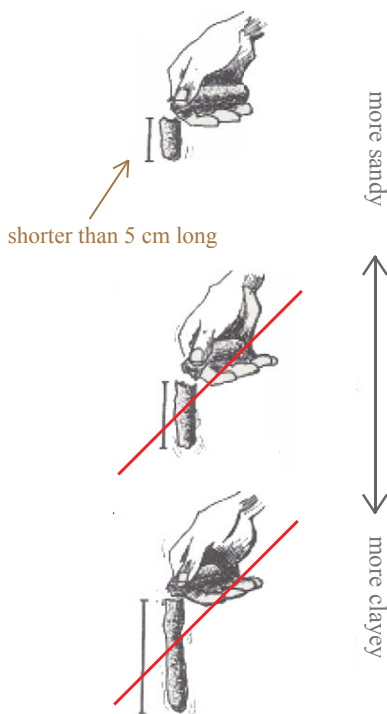
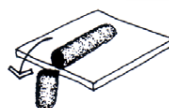
## COHESION TEST (CIGAR TEST)\*

Roll a cigar (not sticky) of 3 cm in diameter (with particles less than 5 mm diameter) and more than 20 cm long.



Then drag it into the vacuum from a flat surface. This test evaluates the clay content in function of the length of the detached portion:

- Short (less than 5 cm) : sandy soil (low soil cohesion).
  - Very long (more than 15 cm) : clayey soil (good soil cohesion but significant risk of cracking).
- Repeat the test 3 times in order to derive an average.



In theory to produce a stabilized compressed earth block, during the soil identification tests, the cigar has to break below 7 cm.

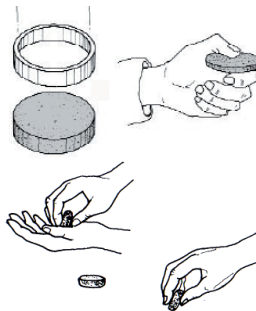
If the cigar would break beyond 5 cm, the soil would be too clayey. If it is not possible to form the cigar (not enough cohesion), the earth will not be used: the brick un moulding will not be possible.

\* Tests done with the finest particles of the soil only (particles  $\leq 2$  mm) : from the sands to the clays.

## DRY STRENGTH TEST\*

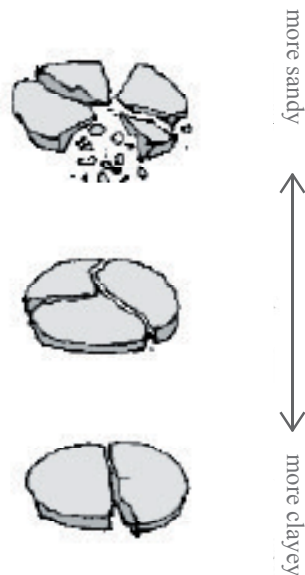
Form a pellet using a ring (from a PVC tube for example).

Formed pellets (with the portion of fine particles  $< 2$  mm diameter) that are completely dry : try to crush and pulverize it between the index finger and thumb.



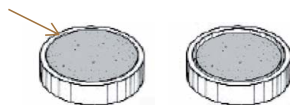
The pellet breaks easily and reduces itself into powder without difficulty : silt or fine sand, little dry strength.

- The pellet breaks and finally, after some efforts but without too much difficulty, reduces itself into powder : silty clay or sandy clay, average dry strength;
- The pellet is very difficult to break and it is impossible to reduce it into powder: a lot of clay or almost pure clay, high dry strength, but significant risk of cracking.



## SHRINKAGE TEST (SUN-DRIED PELLET)\*

- No shrinkage and cracking : sandy soil;
- Little shrinkage and cracking : low clay soil;
- Important shrinkage and cracking : clayey soil.



\* Tests done with the finest particles of the soil only (particles  $\leq 2$  mm) : from the sands to the clays.

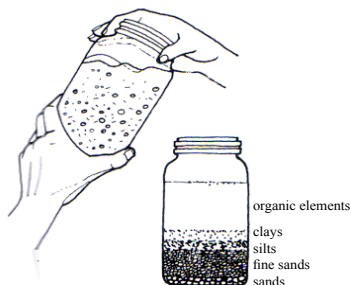


## SEDIMENTATION TEST\*

The advantage again is to analyze the percentage of fines present in the earth by comparing superimposed layers of different grains and to check that no expansive clay are in the soil (expansive clay can induce heavy damage and destruction of buildings).

### Protocol :

- In glass transparent jars or bottles : have  $\frac{1}{4}$  of the volume of soil (note pitch) and  $\frac{3}{4}$  of clean water;
- let stand for a bit, then shake and decant for 1 h. Shake again and decant during 8 hours;
- measure the total height of sedimentation and observe whether there has been a swelling of soil volume (swelling land) or not;
- then measure the height of each layer to assess the proportion of different grains : sands, silts and clays. If the soil selection is good to produce adobe (the best test to perform is still to produce a brick and control her quality before launching a large-scale production), these measures can constitute a reference throughout production. For that it is important to conserve this « reference bottle ».



Before launching a large-scale production, the best test to perform is still to produce a brick (or more with mixtures of different earth with different proportions of cement) and let it dry to do a quality test and evaluate its behavior. This minimizes the risk of mistake in the choice of raw material and therefore :

- the loss of blocks in case of too clayey soil;
- the poor quality of the items.



\* Tests done with the finest particles of the soil only (particles  $\leq 2$  mm) : from the sands to the clays.

more sandy  $\longleftrightarrow$  more clayey

# 01

## 01.3 - SOIL STABILIZATION

The lack of natural cohesion of the soil is compensated by the action of cement. Cement is probably one of the best stabilizers for CEBs. Adding cement before compaction improves the characteristics of the material, and particularly its resistance to water.

This action is not possible if the raw material is not inert enough (no cracking). If there are cracks, cement can not build its roots network through grains in earth. In this case, the cement action is canceled and produced bricks present a very poor quality: blocks production is lost. If the soil is too clayey (cracking) may be added to sand to make it inert and no longer crack.



The cement stabilization does not prevent having to select a suitable earth:

- a good soil (sandy) even weakly stabilized can give high performance blocks;
- an unfi t soil even if strongly stabilized will give poor blocks.

Generally, a small amount of cement is enough to obtain good results, meaning a dosage between 5 and 10% of stabilizer (meaning 1 volume of cement for 10 to 20 volumes of sandy soil).

The cement used for production must not have been exposed to humidity before use (due to storage conditions, transportation, etc.). No bag containing hard lumps is accepted. The water must be clean and not contain suspended matter or salts.

# 02

## SCEB STABILIZED COMPRESSED EARTH BLOCKs

### 02.1 - SCEB GENERAL SPECIFICATIONS

#### DEFINITION OF AN SCEB / MAIN CHARACTERISTICS

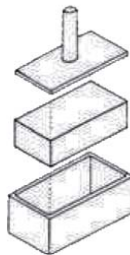
Stabilized compressed earth blocks are small parallelepipedal masonry elements, obtained thanks to the compaction of selected and stabilized earth with a press.

Compacting the soil using a press improves the quality of the material.

Builders appreciate the regular shape and sharp edges of the compressed earth block. The higher density obtained thanks to compaction significantly increases the compressive strength of the blocks, as well as their resistance to erosion and to damage from water.

The wide range of presses and production units available on the current market makes the material very flexible to use. With production ranging from small-scale to medium and large-scale semi-industrial or industrial.

CEBs can be used in rural and urban contexts and can meet very widely differing needs, means and objectives. The financial burden tooling depends on the type and scale of production.



# 02

## 02.2 - BLOCK TYPES

Blocks can differ in dimensions according to the type of press.

Compressed earth block production has typically used block dimensions consistent with a unit weight in the order of 6 to 8 kg.

Mainly prismatic in shape, the most common size in use today is 29.5 x 14 x 9 cm (l x w x h), that means blocks easy to handle and very flexible in their use for many configurations of wall as load-bearing masonry or as in-fill and roof systems (jack-arch floors, arches, vaults and domes).

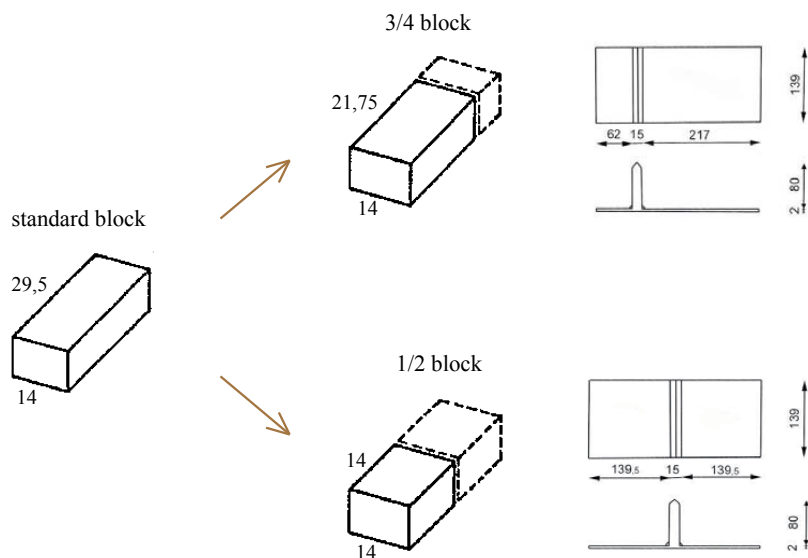


## COORECT BONDING

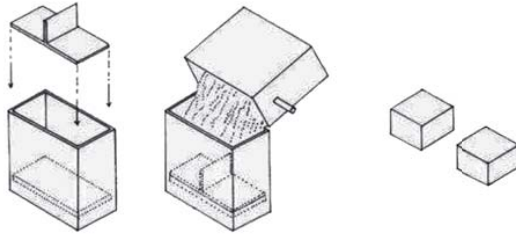
For correct bonding, it is useful to have blocks varying in length. Thus 3/4 blocks,  $l = 21.75$  cm, and 1/2 blocks,  $l = 14$  cm, are in common use.

The width of the block may also vary to obtain wall thicknesses ranging between 14 and 29.5 cm.

Indeed, blocks can not be cut after production as adobe, especially as the SCEB are generally chosen for their attractive finished appearance and are not covered by a plaster.



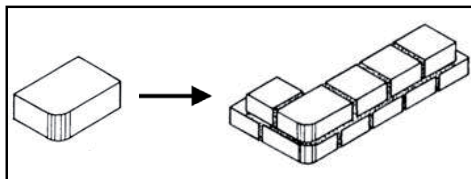
## TYPE OF BLOCKS & PRESS



## SPECIAL BLOCKS

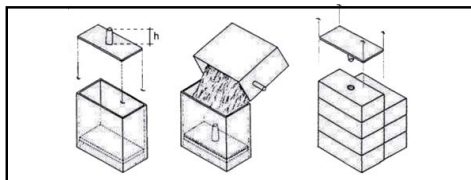
Usually, this kind of blocks are produced to fulfill a specific task, but they can also serve to make the blocks lighter and to reduce the amount of material required.

A wide variety will require interchangeable moulds for each shape, which is not always possible on all machines, but it is also possible to integrate frogs into a mould to modify the way the force is applied.



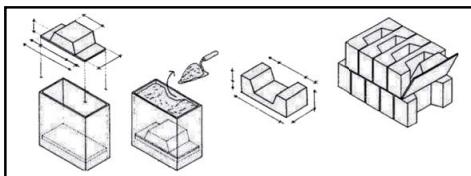
Chamfered blocks :

These are characterized by a rounded edge which can be useful, as it prevents wearing at the corners of walls.



Perforated blocks :

These are lighter but require fairly sophisticated moulds and greater compressive force. They are suitable for reinforced masonry (in earthquake areas) and for the laying of electrical cables.



# 03

## PRODUCTION

### 03.1 - PRODUCTION ORGANIZATION

The quality of CEBs depends on good soil selection and preparation and on the correct choice of production devices.

Production requires quite a lot of space, because of the different stock requirements (raw materials and blocks). Depending on the type of project, production will be carried out either directly on site or in a workshop which is not directly linked to the site, and this needs to be decided at the outset. The choice will be influenced by parameters which include the duration and volume of production. Transport distances should be kept to a minimum.

The fact that production of CSEB requires a wet cure (instead of a quick drying) has to be taken into account too; since it affects :

- delay before blocks can be used;
- busy space for storing blocks during wet cure.

Target productivity must first be set in the light of product demand :

- High productivity is not necessary if the rate of demand for the blocks is low, as this will only lead to the storage area becoming congested;
  - Low productivity is harmful if demand for the blocks is high. There is a risk that blocks will be put into use without having completed the curing time.
- Once the productivity target has been set, calculating consumption is easy. This in turn defines the sizes of the various storage areas needed.

TYPES OF PRODUCTION LINE ACCORDING TO EQUIPMENT USED						
TYPES	TYPE 1 Manual	TYPE 2 ¼ motorized	TYPE 3 ½ motorized	TYPE 4 ¾ motorized	TYPE 5 motorized	TYPE 6 automated
Specific pieces of equipment	1 manual press	2 manual presses 1 mixer (250 l)	2 manual presses. 1 mixer (250 l). 1 crusher	1 motorized press 1 mixer (250 l) 1 crusher	1 motorized press 1 mixer (250 l) 1 crusher Mechanized transport	1 automated unit Automated transport
Production/day 29.5x14x9 blocks	600-1000	1200-1500	1200-1500	1500-2000	1500-2500	5000-6000
Labour	9-10	11-13	10-12	9-11	8-10	8-10
Production area: Total (m²)	380	630	630	805	2300	4900
Secure space	10	15	15	15	25	100
Covered space	30	100	100	55	50	300
Open air space	340	515	515	735	2225	4500
Investment in equipment	1	X 5	X 7	X 11	X 23	X 46
Infrastructure (excl. land)	1	X 1,8	X 1,8	X 2	X 4,5	X 17
TOTAL	1	X 3,3	X 4,4	X 6,5	X 13	X 28,5



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# 03








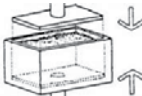
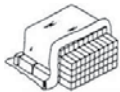
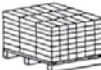
## 03.2 - PRODUCTION LINE

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### PRODUCTION SITE PREPARATION

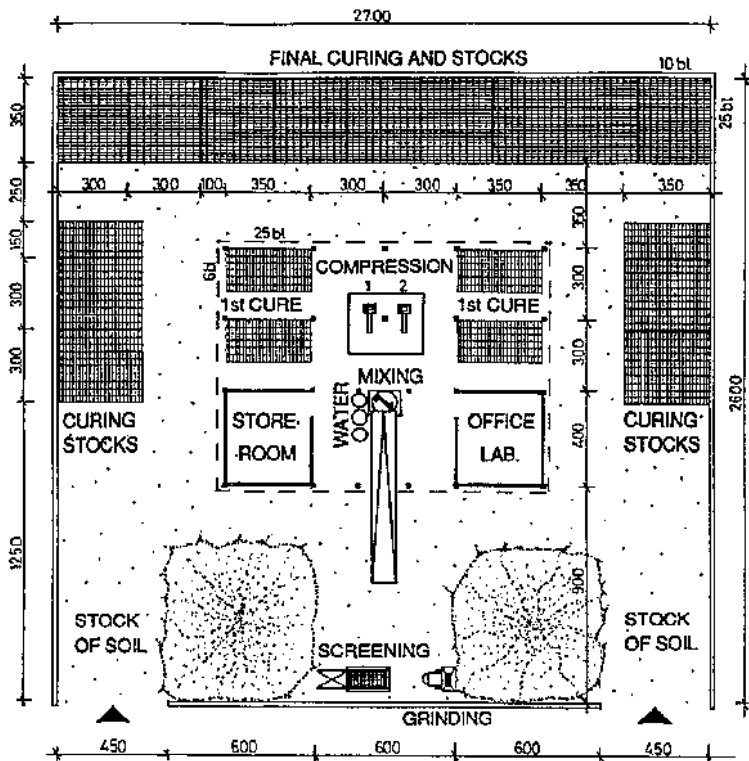
All the operations which the manufacture of the blocks requires must be defined. The need for various processing operations should be evaluated in context.

Any intermediate operations which take up space and manpower then have to be assessed -transporting, stocking, removing the blocks.

TASK		PERIOD	TOOLS	CRITICAL POINTS
1 Soil Identification		1 hour	<ul style="list-style-type: none"> <li>- Water</li> <li>- Bottle</li> <li>- Bucket</li> <li>- Mould</li> </ul>	Ensure that the sample tested is representative of the extracted soil.
2 Extraction		2 hours: 1 m <sup>3</sup>	<ul style="list-style-type: none"> <li>- Pickaxe</li> <li>- Shovel</li> <li>- Wheel barrow</li> <li>- Water</li> </ul>	Check periodically that the soil properties remain the same.
3 Drying			<ul style="list-style-type: none"> <li>- Dry and level drying surface</li> </ul>	This operation could take a long time and is a function of the state of the soil coming out of the quarry.
4 Sieving		2 hours: 1 m <sup>3</sup>	<ul style="list-style-type: none"> <li>- 20 mm sieve</li> <li>- Shovel</li> </ul>	Check the sieve inclination to assure the desired grain size and do not allow soil to accumulate on it.
5 Cement proportion		Mix for 20 bricks : 5 minutes	<ul style="list-style-type: none"> <li>- Shovel</li> <li>- Bucket</li> <li>- Wheel barrow</li> </ul>	Each time use the same volume. Check the weight of the soil to assure a correct stabilisation.
6 Dry mix		Mix for 100 bricks : 45 minutes	<ul style="list-style-type: none"> <li>- Shovel</li> <li>- Bucket, clean and resistant</li> </ul>	Mix thoroughly with the shovel, starting from the top of the heap so as to facilitate the removal of undesirable elements and assure a uniform colour.
7 Wet mix		Mix for 20 bricks: 10 minutes	<ul style="list-style-type: none"> <li>- Shovel</li> <li>- Waterproof base</li> <li>- Watering can</li> </ul>	One should take into account the humidity level of the soil before adding extra water.
8 Compression		50 - 100 bricks per hour	<ul style="list-style-type: none"> <li>- Manual press</li> <li>- Measuring container</li> <li>- Moulds</li> <li>- Balance</li> </ul>	Fill the mould with a constant volume of earth that and always apply the same force. Check regularly the weight of the bricks.
9 Cure		7 days under plastic	<ul style="list-style-type: none"> <li>- Plastic</li> <li>- Plane surface</li> <li>- Chalk</li> </ul>	Check that there are no holes that allow the passage of air and mark the production date on the bricks.
10 Dry Curing Stocking		Drying for 14 days	<ul style="list-style-type: none"> <li>- Plane surface</li> <li>- Light roof</li> </ul>	Rapid drying can damage the bricks.

A small structure of posts roofed over with straw, canvas, tiles etc. and a hard, fl at ground surface will be required. Blocks need not necessarily to be stocked under a roof as such : canvas can suffice.

A hard, flat ground surface, such as rammed stabilized earth or a concrete slabs, is however essential for the piles of blocks to be stable.



### little production site example

## STOCKING RAW MATERIALS

### SOIL AND SAND :

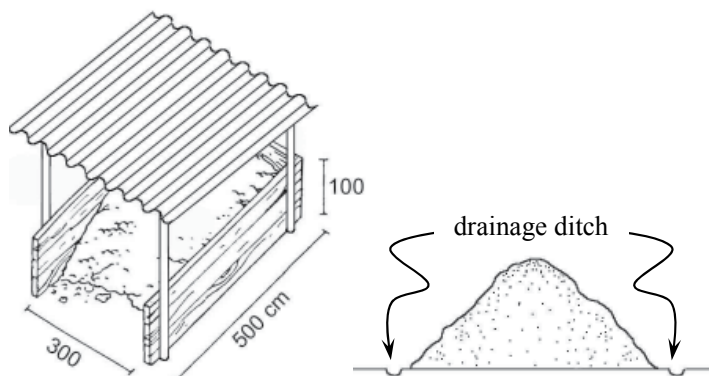
Both of these are generally stocked in bulk, but they can also be kept in storage bays if space is limited and to avoid them flowing and mixing together.

The contents of a 5 m<sup>3</sup> lorry will take up 9.5 m<sup>2</sup> on the ground, or approximately 1.7 m<sup>2</sup> per m<sup>3</sup> soil or sand (taking account of settling).

Storage bays can be used for stocking. The sides must be strong enough to contain the soil

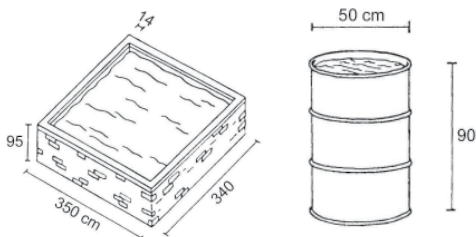
### SPACE NEEDED FOR STOCKS ACCORDING TO SCALE OF PRODUCTION

BLOCKS 29,5 x 14 x 9 cm	SOIL (heaped)	SAND (heaped)	WATER (vats/in litres)	CEMENT (piles 9 sacks)
for 100 blocks	0.7 m <sup>2</sup>	0.2 m <sup>2</sup>	0.3 m <sup>2</sup> /100 l	0.08 m <sup>2</sup>
for 1 000 blocks	7 m <sup>2</sup>	2 m <sup>2</sup>	1.5 m <sup>2</sup> /1 000 l	0.25 m <sup>2</sup>
for 10 000 blocks	70 m <sup>2</sup>	20 m <sup>2</sup>	15 m <sup>2</sup> /10 000 l	2.6 m <sup>2</sup>



## WATER:

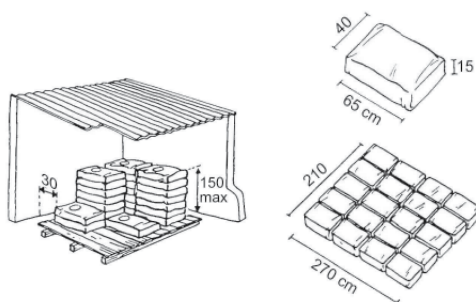
Water is often stocked in 200 liters barrels. These are easy to find, cheap, and transportable. They can, for example, be placed under a roof gutter to catch rainwater.



## CEMENT (AND LIME):

Both of these are generally supplied in sacks, particularly cement. Here we use a «standard» 50 kg (= 42 l) bag of cement as a base.

The sacks should preferably be stocked in a secure area and protected from humidity, i.e. raised above the ground and kept away from walls to prevent cement from absorbing humidity and to avoid destabilizing the walls. Temporary external storage areas, protected by tarpaulin or plastic sheets, can also be used.



## CONTROL OF THE HOMOGENEITY OF THE RAW

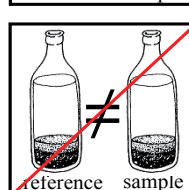
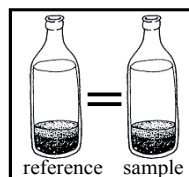
It is important to always check that the extracted earth to produce blocks remains homogeneous throughout the production. Digging deeper or two meters further than the first extraction point, the quality of soil can significantly change.



For that, and for not having to redo every time all the tests to determine the quality of soil, it is possible to reuse the bottle containing the sedimentation test with the selected earth : previously analyzed and considered suitable for its use.

This first bottle serves as a «reference bottle» to compare with the new soils extracted, by making identical bottles regularly carried out from quarry during successive samples. If the the separation of the different layers remains similar, we can deduce that the quality of new extracted soil has not changed and remains suitable to produce SCEB.

However, if the 2 bottles do not represent the same characteristics, all the various tests must be repeated to ensure that the new soil is suitable.



## PULVERIZATION / SIEVING

### DRYING :

Using dry raw materials improve pulverization and screening, which is the basic condition to achieve a good mix.

### PULVERIZATION :

The object here is to either break up lumps which are held together by clay (crushing) or to fragment stones and gravel (grinding). Applying fairly high pressure is sufficient for crushing, whereas grinding demands a hard impact.

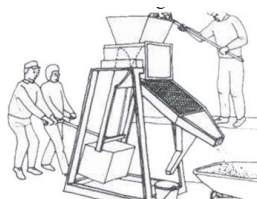
Pulverizer: to break lumps of soil and to homogenize the mix. A properly pulverization should bring to get a soil with at least 50% of the particles held together by clay (lumps or nodules) which are less than 5 mm in diameter.

The choice of the more suitable machine will be dictated by the kind of soil and the climatic conditions.

- Grinder: it will break up not only clay lumps, but also gravel and small stones, making them closer in particle size to sand. They work well with gravelly and stony soils;
- Crusher : are more suited to finer soils which contain no gravel or stones, but mostly lumps of clay.



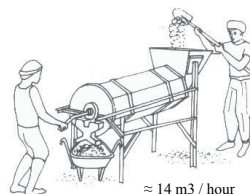
1-2 m<sup>3</sup> / day / person



3-4 m<sup>3</sup> / day / person



2-4 m<sup>3</sup> / day / person



≈ 14 m<sup>3</sup> / hour



4-6 m<sup>3</sup> / day / person



### SIEVING :

In general, this is done to remove the particles which are too coarse.

Mesh sizes typically go from 10 mm for presses which are sensitive to compression, to 20-25 mm for less sensitive presses, because of their higher compression force ( $F > 10$  MPa).

Screening is crucial either when the texture is incorrect (excessively large constituents or too much organic material) or when pulverizing is inadequate.

Diameter varies between 5 and 20 mm depending on soil specificities and the type of blocks to be produced.

The system which gives the least rejected material should be chosen.

## PROPORTIONING

### MEASURING OUT :

by weight :

The amounts to be used are calculated as dry weights, but measuring out in the brickworks must take account of the moisture content, which is difficult to check in the case of materials such as sand, gravel, or earth.

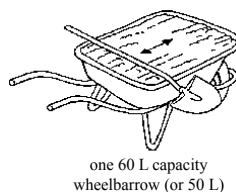
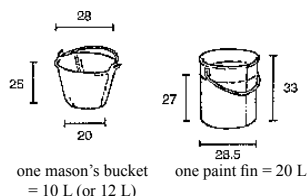
by volume :

This is the most common and the simplest method. It has the disadvantage of being a little imprecise, depending on how wet and how loose the material is. This imprecision can be compensated for, however, by quality controls and by an experienced operator. Above all, measuring out containers of known capacity must be available.

When using existing equipment (buckets, wheelbarrows, etc.), check the volumes with a relatively precise instrument (e.g. graduated bucket).

These volumes are measured at the startup of production and will be used as the basis of calculations of quantities to be used.

After filling the measuring container, the surface must be flattened out by using a straight edge (the handle of a shovel for example) to scrape it level with the top of the sides of the container, without pressing the down.



## PREPARATION OF THE SOIL:

Soil preparation operations will play a crucial part in the ultimate quality of the blocks. These operations can sometimes make it possible to use soils which are unusable in their natural state, but available and less expensive on site. Bearing in mind that extraction and transportation costs are generally high, this can allow useful economies to be made.

One must also bear in mind that modifying a soil by repeatedly adding measured quantities of material needs to be controlled by a skilled person and that any losses due to inaccurate measuring out also need to be evaluated.

























Procedure: whether a particle fraction has been removed by screening or added by mixing, the procedure for determining the proportions is almost identical: several series of blocks are manufactured using different proportions, and finally the proportions resulting in the best blocks are retained.

Testing: approximately 20 blocks are made for each differing proportion, making sure that the moisture content is at the optimum (using the drop test). The freshly moulded blocks are examined:

- if they are cracked when the moisture content is optimum, the proportions used are rejected;
- blocks which are in good condition when freshly moulded are allowed 2 to 3 days of wet curing and one day's drying. At that point, the proportions resulting in the best blocks are retained.

### EXAMPLE OF PARTICLE SIZE CORRECTION OF SOIL USING SAND

Assuming: total volume of mixed material = 120 l of soil-sand + 8 l of cement (10 kg), 6 % stabilizer,  
1 wheelbarrow = 60 l, 1 bucket = 12 l  $\Rightarrow$  120 l = 1 wheelbarrow + 5 buckets

WHEELBARROW OF SOIL	BUCKET OF SOIL	BUCKET OF SAND	CEMENT (10 kg)	DRY BLOCK	OBSERVATIONS
	+		+	 = 	BAD BLOCK very smooth very large cracks not brittle very difficult to break
	+		+	 +  = 	BAD BLOCK very smooth large cracks not brittle very difficult to break
	+		+	 +  = 	BAD BLOCK very smooth small cracks not very brittle difficult to break
	+		+	 +  = 	GOOD BLOCK smooth no cracks not very brittle difficult to break
	+		+	 +  = 	BAD BLOCK fairly rough no cracks brittle easy to break



## TESTING FOR THE AMOUNT OF STABILIZER AND FOR CURING TIME :

Generally, at least 5 to 6% cement will be needed to obtain satisfactory results, generally between 5 and 10 %. Compressive strength is highly dependent on the amount used.

With a low rate of cement (2-3%) certain soils perform worse than if not stabilized. However, economic considerations should not be neglected. The cost of cement can, for example, represent up to 50%, generally 20 to 40%, of the total cost of production.

Proceed as for adding sand, gradually increasing the cement quantity used and the length of the curing time, and then examine the dry blocks in order to determine the results which are the closest to those required.

Approximately 20 blocks are produced for each different amount used.

For each sample of 20 blocks :

- 6 or 7 blocks are given, for example, 3 days wet curing + 11 days drying out;
- 6 or 7 more blocks : 5 days wet curing + 9 days drying out;
- and the final 6 or 7 blocks, 7 days wet curing + 7 days drying out.



The dry blocks are then examined for appearance, weight, measurements, breaking point, immersion, etc. The lowest amount of stabilizer and shortest curing/drying times giving the results required at the lowest production cost will be retained.



## DRY MIXING

Mixing is particularly important for the quality of the blocks and an homogeneous mix is essential. A dry mix must be done first and water should be added by sprinkling.

The more homogenous the mix, the more the degree of stabilization can be reduced, reducing costs without affecting quality.

The best way to proceed is to turn the pile over at least three times for the dry mix, and then a further two or three times gradually adding water. No more than 1/3rd of a sack of cement should be mixed in at a time.

The mix should have a uniform colour.

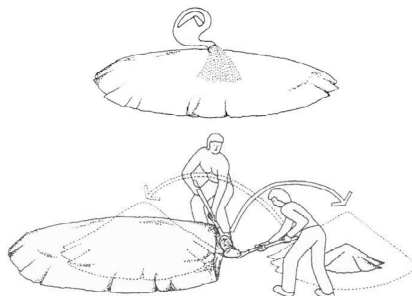


## WET MIXING

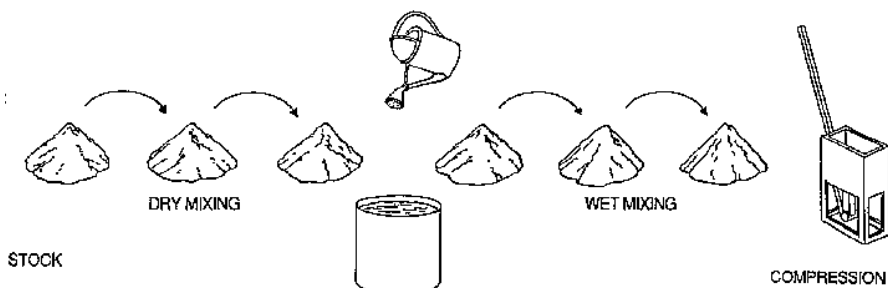
Wet mixing should be done spraying water gradually. If water is added too quickly, it will be difficult to mix the dry and wet parts together.

Obtaining a mix with the optimum moisture content for compaction is crucial to the quality of the product. The cement will begin to act on contact with water, that's why water should be added to the dry mix at the last moment in order to keep the time before compaction to a minimum.

Ordinary cement mixers are not suitable, as earth is highly cohesive when wet.



Turning the soil can be exploited as a way of transporting the soil towards the press. This means locating stocks of dry materials 6 or 8 meters from the press and the water stocks or supply halfway between the two. This approach ensures that the piles are well turned the required number of times.

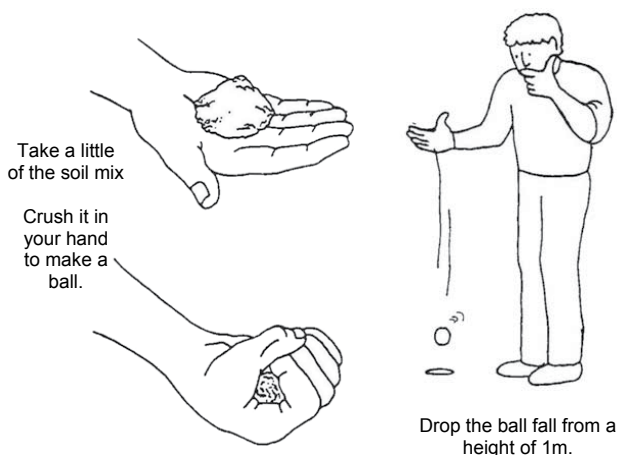


## OPTIMAL WATER CONTENT (DROP TEST)

It is difficult to calculate beforehand the precise volume of water which will be needed to reach the optimum moisture content for compaction.

The operator must determine the optimum quantity of water using simplefield tests and by experience.

Its use does not require so much water which corresponds to the humid compression state of CEBs, without sticking to the mold.



If the ball doesn't break - the mixture is too humid.



The ball breaks into several pieces. The moisture content is optimum.



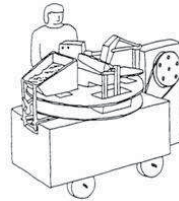
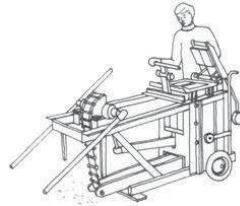
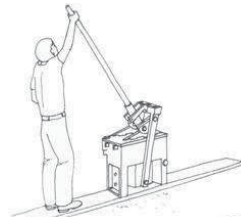
It collapses into particles - the mixture is too dry.

## CATEGORIES OF PRESSES

There is a wide choice of machinery and equipment available. The quality of the equipment used is important, but the quality of the soil remains of paramount importance.



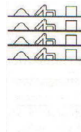







- Press : to compact the material and increase its density;
- Manually operated presses will rely on the strength and endurance of the operator and this is why differences in the quality of product can often be observed over several hours;
- Motorized presses significantly reduce irregular quality and allow higher forces to be applied. (accessibility and repairs often pose a problem).

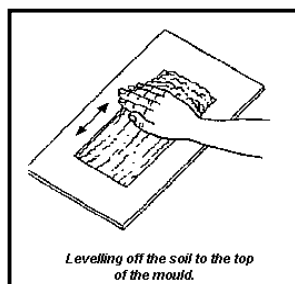
Mould interchangeability is a bonus if it is easy and simple.



For the same number of blocks to produce, it is sometimes cheaper to implement several small production lines that operate simultaneously with simple manual presses and more manpower, rather than establish channels motorized productions or even automated (more expensive equipment). Money is invested in local labor instead of in machines, often imported.

example to produce 6000 blocks in one day, with assuming a 3 years amortisation period :

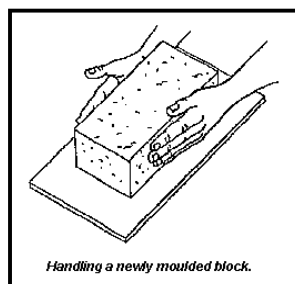
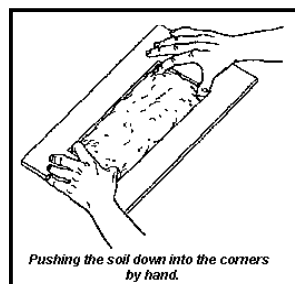
		
9 production lines	4 production lines	1 production line
		
		
		



For manual presses, the force which has to be applied to the compression lever depends on the amount of soil in the mould. This force should be neither too high nor too low. If too high, the operator will be quickly get tired or the machine will get broken. If too low, the block will be insufficiently compressed.

### Filling :

Generally, moulds are designed to be completely filled with the mixed material. The soil therefore has to be scraped level with the sides of the mould.

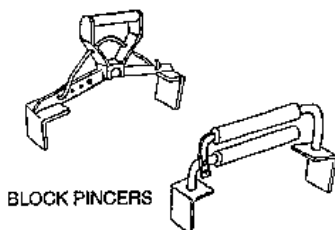


## REMOVING THE BLOCK FROM THE MOULD :

Once the block is ejected, it must be picked up carefully because still fragile.

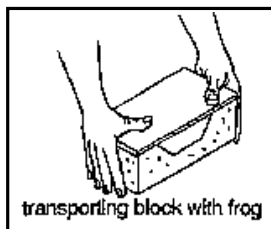
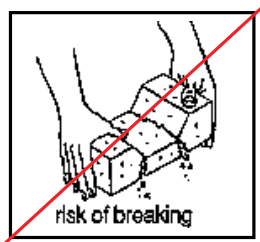
The area of contact between blocks and hands should be as large as possible to keep pressure on the block to a minimum. The edges, which are brittle, should not be touched.

There are block pincers which reduce the risk of damaging the newly molded block and which also enable one operator to carry two blocks at a time.



## TRANSPORTING SPECIAL BLOCKS :

To prevent weak blocks from breaking, they should be transported with the frog, which should be removed after the blocks have been stacked for curing. At least two of each frog are needed, otherwise the production will be slowed down.



## WET CURING / DRY CURING

Cement (and lime) stabilized blocks must be kept in a humid environment for at least 7 days (14 if possible). The surface of the blocks must not get dry too quickly, as this causes shrinkage cracks. The blocks must be sheltered from direct sun and wind and kept humid covering them with waterproof plastic sheets.

For lime stabilization, curing takes theoretically 6 months, but blocks can be used after 2 months.

Then, drying out will take approximately 14 days.



## STORAGE

Whichever way the blocks are laid out, it is important to be able to count them easily. It should also be easy to find their date of manufacture in order to be able to check on the duration of the curing stages.

Separate stacking (curing, drying, storage):

If the freshly molded blocks are fragile, they cannot be stacked very high.

A specific area will have to be set aside for wet curing close to the press (3 to 5 m) to reduce handling distance which can damage the blocks. The blocks can be handled after 2 days' curing. The curing areas therefore need to be able to hold the equivalent of 2 days' production.

Direct stacking :

If the blocks are strong enough as they come out of the press, they can support being stacked 10 to 15 high. This type of stacking will require transporting straight from the mould over a greater distance than for separate stacking (10 to 50 m).



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# 04

## QUALITY CONTROL

### 04.1 - SHAPE CONTROL

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#### GENERAL APPEARANCE

Check the freshly molded block for dimensions, and also any deviation from right angles : these should not vary by more than 1 to 3 mm. Measurements should be taken using a ruler and a mason's set-square.

An orthogonal gauge can also be made from wood or metal and used to measure dimensions and parallelism at the same time, with small nicks at the ends showing acceptable tolerances.

#### SHRINKAGE

At this stage the objective is to check out any changes in the dry blocks compared with their state when freshly molded. A variation in moisture content can be observed in the block's lower weight.

Cracks can appear; they are not allowed.



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# 04

## 04.2. - DENSITY TEST

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### THUMB TEST

Verify that the thumb can not sink into the fresh block.

If the thumb sink into the block, the compaction is not sufficient: it means that the quantity of moisture inserted into the mold was insufficient.

Only a very slight mark with the thumb can be accepted.

It is also possible to use a penetrometer to verify the proper density of the block.

# 04

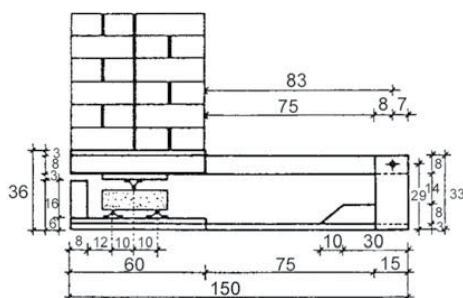
## 04.3 - STRENGTH TEST

This test enables to find the bending strength of the block and its compressive strength. This is an important criterion as it is the one which is most commonly used for most materials. The test is carried out using a site block-breaking apparatus.

This gives a satisfactory estimate of bending strength.

The block is placed on its lower face, compression side downwards, perpendicularly across two tubes laid 20 cm apart. A third tube is placed across the middle of the upper face, parallel to the first two, and a plate attached to it is loaded with blocks or sacks of cement at a rate of approximately 250 kg/minute. Bending strength is calculated from the load required to break the block.

A formula is used for measuring the strength of the block, but a minimum acceptable load can also be set. For example, the tested block should withstand a load of 15 blocks to be acceptable.



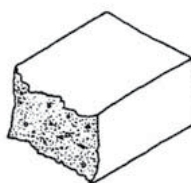
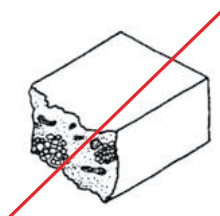
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# 04

## 04.4. - TEXTURE TEST

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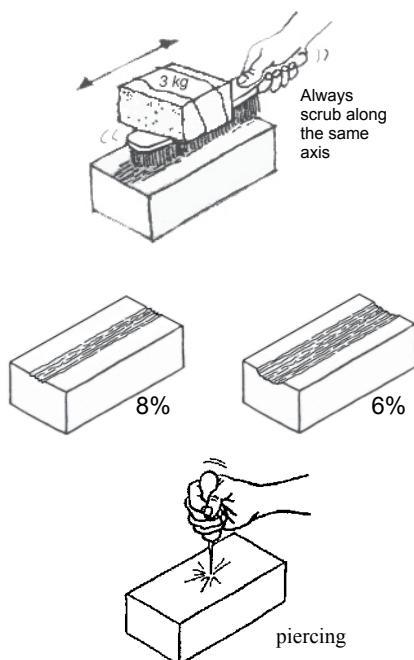
Examine the internal texture of the broken blocks. Different soil grains should be evenly distributed, with an uniform colour. If they are not, generally as a result of poor mixing, there will be concentrations of gravel or of coarse sand, or stained or lumpy areas. In all cases, such blocks should be rejected.



# 04

## 04.5. - SIMPLIFIED ABRASION AND PIERCING TESTS

Each broken block is divided up into two samples, one kept as a control and the other used for testing. A style is jabbed into the block faces. For brushing, a metal brush is applied to two or three sides, using equal force and an equal number of backwards and forwards movements. These tests give an idea of the surface strength of the blocks. Acceptability limits will be set according to the intended use of the blocks and whether they will be exposed to abrasion and knocks.

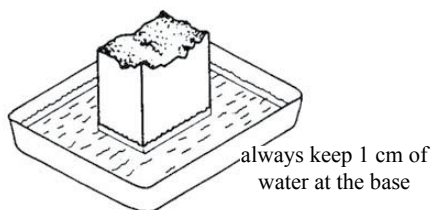


# 04

## 4.6. - SIMPLIFIED EROSION TEST

Use the half blocks which have been subjected to brushing and piercing in order to obtain a worst case result. The half-blocks are completely immersed in water for 6 hours, then allowed to dry for 42 hours, giving a 48 hour total dry-wet cycle. The cycles can be repeated several times.

Immersion can be replaced by fine sprinkling using a spray head



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