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SOIL TESTING

GUIDE TO SOIL SELECTION & PROPORTIONS FOR BLOCKS PRODUCTION

Earth as construction material, is more properly described as '**loam**' in scientific terms. The term loam indicates a paste of **clay**, **sand** and **silt** plus occasionally other **aggregates** (such as stones and gravel).
Clay represent the binder, or more simpler, the 'glue' that holds the loam parts together.
Sand, silt and aggregates (stones, gravels) represents the skeleton, the structure of the earth mixture.

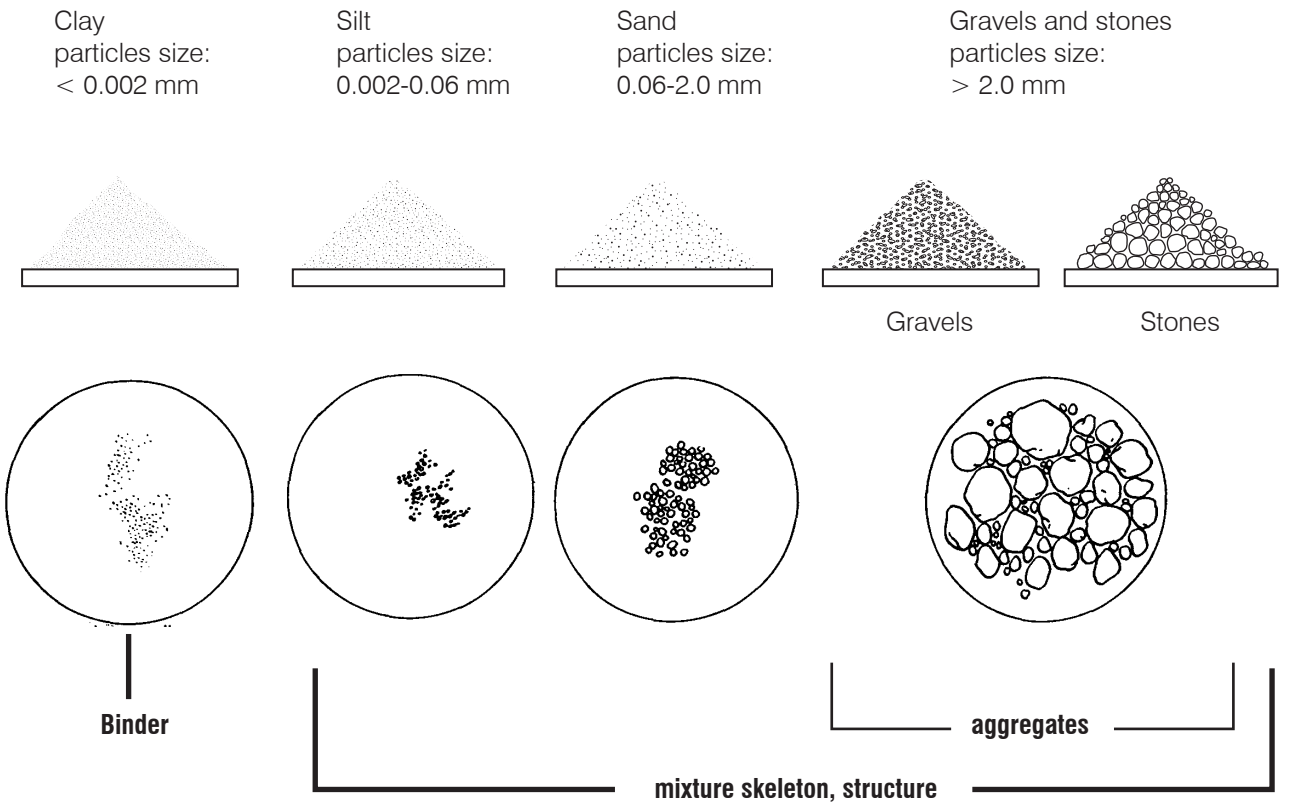
Clay= binder, glue, it holds the loam parts together.
Sand, silt and aggregates (stones, gravels)= mixture skeleton, structure

Depending on the site where the loam is dug out, it will be composed of differing amounts and types of clay, silt, sand and aggregates. Its characteristics therefore, may differ from site to site, and the preparation of the correct mix for a specific application may also differ. Different amount and proportion of the main elements of clay, silt, sand means a variation of the blocks strength.
In order to find the optimal mixture with the available sources of the site, it is necessary to know the specific composition of the loam involved and which factors affect the final quality and strength of the final compressed blocks. In order to obtain the optimal result it is possible to effectuate some changes in the mixture composition like varying the proportion of the main elements or/and the addition of stabiliser (lime/ cement) if necessary.

! *The soil selected must be free of organic material, must not contain harmful quantities of salts or other chemical substances.*

Independently from the type and quality of production equipment available, the choice of a good soil mixture is fundamental:

GOOD MIXTURE + GOOD EQUIPMENT = OPTIMAL RESULTS +++
MEDIOCRE MIXTURE + GOOD EQUIPMENT = MEDIOCRE RESULTS + -
BAD MIXTURE + GOOD EQUIPMENT= TERRIBLE RESULTS !!! - - -



CLAY

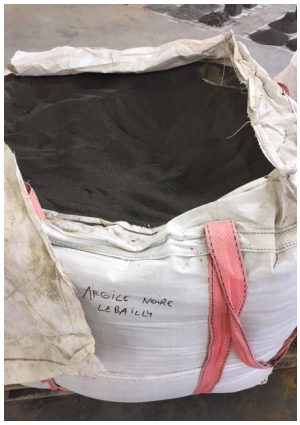
Clay working as binder of the earth mixture, is the most important element to be considered when searching for the right earth mixture. Compressed earth blocks can be produced with mixture having a clay content between **8-30%**.

! *If the clay content is too low, the earth mixture elements will not bind together and the blocks will not reach the required compression strength.*
! *If the clay content is too high, the earth mixture might stick too much to the press mould and it will be difficult to remove the block from it. It is also possible that the block will look perfect with sharp edges and smooth texture but during the curing (drying) process it might form cracks on the block surface. This is due to the very high shrinking proprieties of clay.*

Clay soil presenting cracks due to shrinking

Block presenting cracks due to clay shrinking during curing phase. In this case, it is possible to add some sand to the mixture to reduce the percentage of clay. Also important to keep the blocks moist for at least the first 3 days of the curing process and to cover them with plastic foil to retain moisture. This will allow the blocks to dry homogeneously. If the blocks become too dry too quickly, they will crack.

There are different types of clay with different colors and binding strengths. Clay colors are caused by impurities. For instance, red clay generally contains a high level of iron and black clays contains manganese.



CARAZAS TEST

Invented by Wilfredo Carazas, the Carazas test looks at the relationship between the the amount of water in the soil, and its level of compaction (how much the soil is compressed inside a mould).
Each earth construction technique requires a determinate balance between amount of water and compaction of the soil.

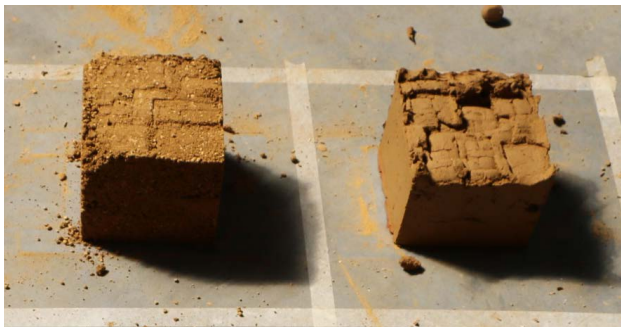
For instance, in order to produce compressed earth blocks, the soil has to be at its 'HUMID state' this means that the soil is moist enough to be easily modelled but it is not too sticky or too wet. In this case the soil would be at its viscous or liquid state.
If too wet and sticky, the soil will not be able to be compressed properly and it will stick to the press mould. In this case, the soil is not suitable for earth blocks production.

Soil at humid state. (suitable for earth blocks production)

Soil at plastic state. (NOT suitable for earth blocks production)

Tamped soil at humid state. (suitable for earth blocks production)

Tamped soil at plastic state. (NOT suitable for earth blocks production)



Compacted soil at humid state. (suitable for earth blocks production)

Compacted soil at plastic state.(NOT suitable for earth blocks production)

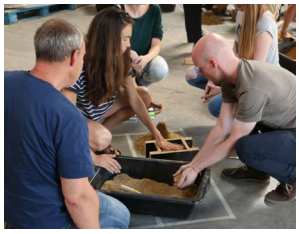
In order to prepare the Carazas test, you need a wooden mould, water and measuring cup, a stick to compact the soil and enough material to fill the mould with soil at least 9 times.
In order to have a good overview and understanding of the way each soil reacts depending on different amount of water added and level of compaction, it is necessary to bring the soil to its DRY, HUMID and PLASTIC state.

To obtain soil at its DRY state, make sure that the material is free from humidity. To do so, it is possible to expose the soil sample in a sunny spot to let evaporate the water included completely.
1. place the mould on the ground and fill it with dry soil
2. carefully remove the mould
3. repeat the first step of the procedure with the same type of dry soil. This time tamp a little bit the soil with your hands before removing the mould
4. repeat the first step of the procedure with the same type of dry soil. This time compact well the soil with the help of a wooden stick before removing the mould

To obtain soil at its HUMID state, mix it with a small amount of water just enough to make it moist and to make possible to model a ball of soil with your hands. The ball will have a rough, crumbly surface.
- repeat steps 1 to 4 from above using humid soil.

To obtain soil at its PLASTIC state, mix it with a moderate amount of water just enough to make possible to model a ball of soil with your hands. The ball will have a fairly smooth surface but make sure that the soil will not be too sticky and wet otherwise the sample will achieve a state closer to viscous/liquid.
- repeat steps 1 to 4 from above using soil at plastic state .

Step 1: place the mould on the ground and fill it with soil.



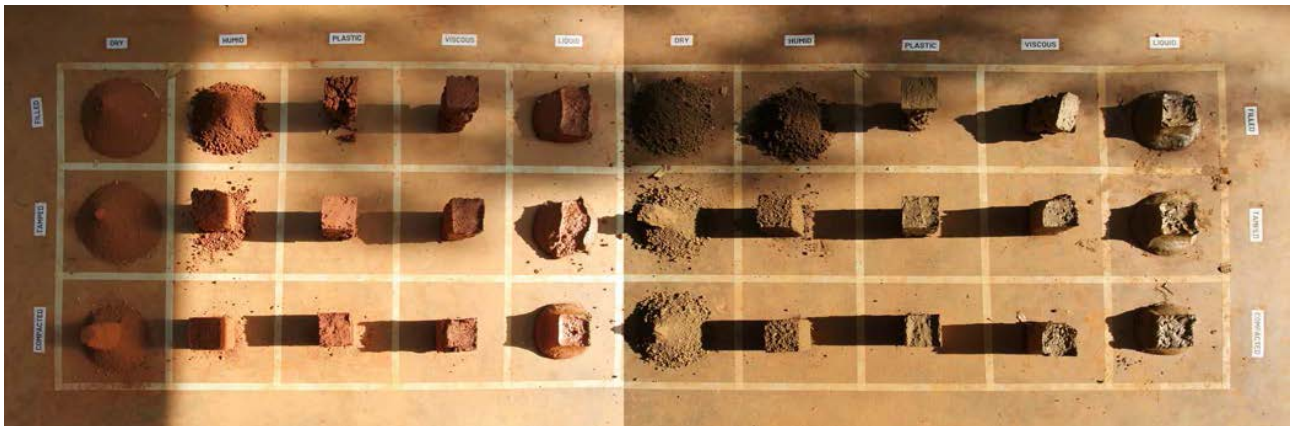
Step 3: tamp a little bit the soil with your hands.

Step 4: compact well the soil with the help of a wooden stick.

Mix well the soil with water to achieve humid and plastic states.

With the Carazas test, it is also possible to test diverse types of soil mixed with vegetal fibres such as straw. In this case it will be visible how certain fibres can strengthen the structure of the soil. However, in case of straw for instance, the fibre need a generous amount of water to mix homogeneously with the soil. The material then will have to reach the PLASTIC state, suitable for production of adobe bricks but not for compressed earth blocks.

! *While doing the Carazas test, write down the various amounts of water added in the soil. In this way you will be able to compare and notice the differences with other soil types: some soils will require more or less water to reach the different states (humid, plastic etc.) and they will react differently. This is because of their different compositions that means different size of the particles, different proportions of clays, silts, sands, aggregates in the soil etc.*



Carazas test Auroville Earth Institute.

SOIL TESTING

Every soil, in every different location, will have a certain composition and balance of the elements (clay, silt, sand, aggregates) composing its structure. Each specific composition can be determined through laboratory analysis. However, in order to obtain a first approximation and understanding of the type of soil we encounter on site, it is possible to perform some simple field tests.

Before starting any type of soil test, it is necessary to collect samples of soil. The topsoil containing organic matter is removed. The soil sample is extracted from layers above the rock strata.
For each soil sample note on the bag: ''location, depth, date''.

SMELL TEST

This test can be done by smelling the soil immediately after it has been collected. Pure loam is odourless, in case it smells musty it means that the soil contains organic matter. In this case the soil is not suitable for production of compressed earth blocks.

TASTE TEST

To effectuate this test it is necessary to nibble a small portion of soil. Generally, sandy soil produces a disagreeable sensation as opposed to silty soil, which gives a less objectionable sensation. Clayey soil, on the other hand, gives a sticky, smooth or floury sensation.

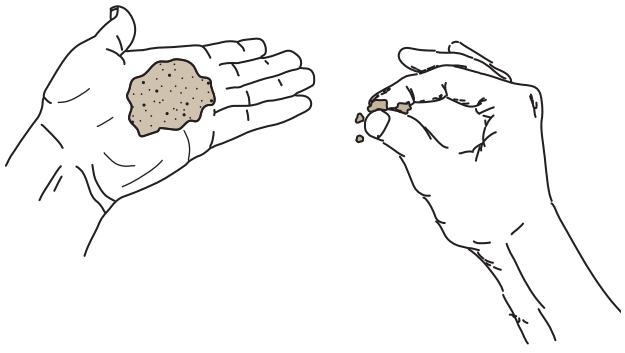
TOUCH TEST

Place a portion of dry soil on the palm of the hand.
Crumble the soil by rubbing the sample between the fingers and between the fingers and the palm of the hand.
Repeat the same operation adding some drops of water in the soil. If the soil is:

- Rough, non sticky and the different grains can be distinctly felt, the soil is SANDY.

- Fine texture, easy to crush into a slightly sticky powder, the soil is SILTY.

- Difficult to crush, slow to disintegrate in water, very sticky when moistened with water, the soil is CLAYEY.



WASHING HANDS TEST

Rub the hands with moistened soil, then rinse gently with water.
- If the hands are easy to rinse clean, this implies that the soil is SANDY.
- If the soil appears to be powdery and the hands can be rinsed clean fairly easily the soil is SILTY.
- If the soil has a soapy feel and the hands cannot be rinsed easily the soil is CLAYEY.

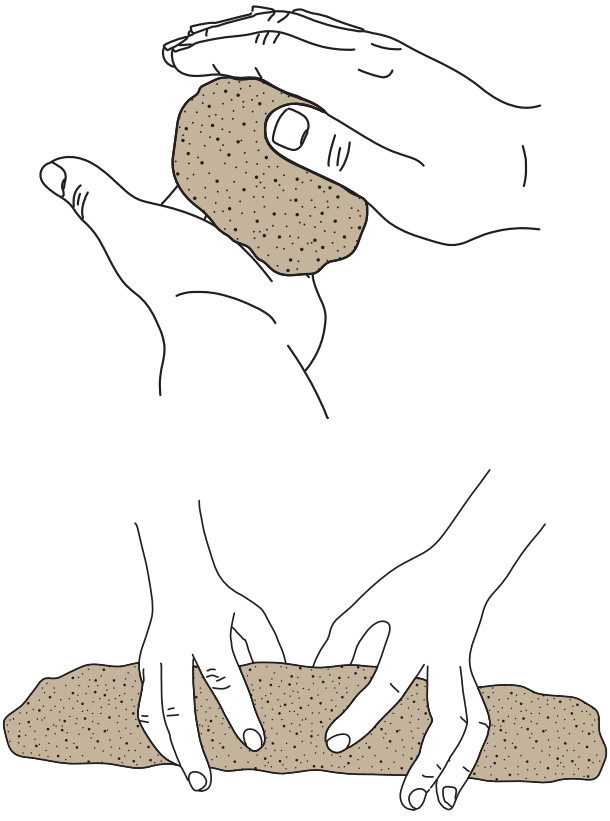
COHESION TEST (CIGAR TEST)

The clay represents the binder which holds together the other particles of the soil mixture. This test will help to verify if the quantity of clay of a certain type of soil is suitable for earth blocks production.

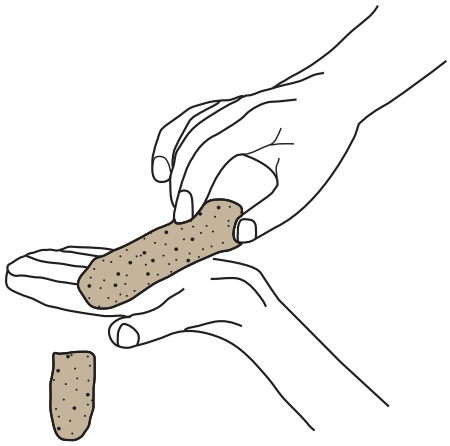
Take a loam sample, make sure to remove the thicker parts, such as aggregates larger than 4mm diameter. (Use a sieve if necessary).
Make the soil moist enough to be able to shape a ball with the dimension of an orange. The soil has to be at the plastic state, in other words:

- easy to be modelled
- not crumbly
- does not stick to fingers

From the ball created, shape a cylinder shape by pressing homogeneously the ball. Do not roll the cylinder but simply model it by pressing it multiple times in different points with both hands.
The cylinder will be from 2 to 3 cm in diameter and at least 30 cm long.

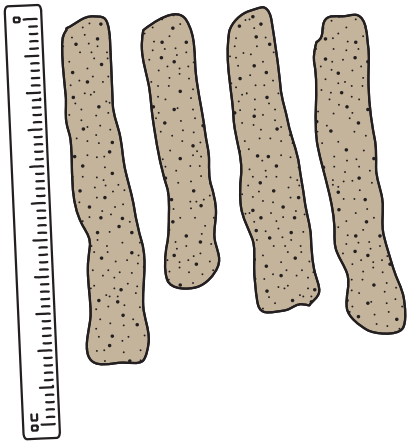


Place the cylinder on the palm of your hand and push it until it breaks and falls down.



Measure the part of cylinder that fell from your hand and repeat the test with at least 2 more samples of the same type of soil. (In order to have more accurate results, it is advisable to perform the test with 5 different samples for each type of soil).
After having measured all the fallen pieces from the same type of soil, calculate the average.
If the average is:

- less than 5cm: we have a poorly cohesive SANDY soil
- between 5-15cm: we have an average cohesive soil
- more than 20cm: we have a very cohesive CLAYEY soil



In case of a poorly cohesive soil, it is necessary to add more clay to improve the soil cohesive proprieties.
In case of a very cohesive soil, it is necessary to add sand to reduce the cohesive strength of the soil.

BISCUIT TEST

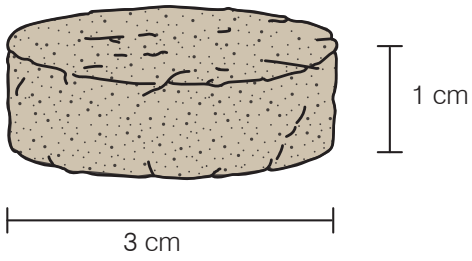
Proceed as with the cigar test, by removing all the thicker gravels and model the sample well until a smooth paste is obtained.

- Mould it into flat biscuit-shaped disc approximately 3 cm in diameter and 1 cm thick. Use a mould such as a metal ring if available. Make a biscuit with each type of soil you intend to test.
- Let it dry in the shade until the sample will be completely dry. It might take few up to 24 hours depending on the type of soil, temperature and humidity of the room.

When the samples are dry, observe any signs of shrinkage by:

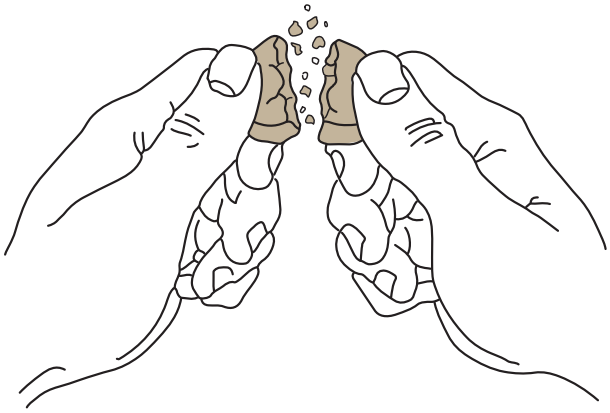
Checking if the biscuit is cracked or/and there is a gap between the dried sample and the sides of the mould. If so, it means that the soil contains a considerable amount of clay which made the sample cracking and shrinking while drying.

In this case some sand will have to be added to the soil to make it suitable for earth blocks production. After adding sand you can repeat the biscuit test again.



Using the same dry biscuit samples, it is possible to perform an additional test by cracking them with your hands. In doing so, observe how easily the biscuit breaks. If:

- very hard to break and difficult to reduce to powder, then the soil has a HIGH CLAY content.
- brittle, but it breaks fairly easily, then the sample is made of a good SANDY-CLAYEY soil.
- breaks readily and it is easy to reduce to powder, then the soil has high SAND or SILT content. If when crushed in between the fingers, only very fine powder is left, then the sample is for the most part SILTY.



In case there is no rounded mould available to make the biscuit and to check the clay shrinkage, it is possible to perform this alternative simple test:

- spread a layer of earth 1 cm thick (similar to chocolate spread consistency) on a plate and let it dry in the shade.

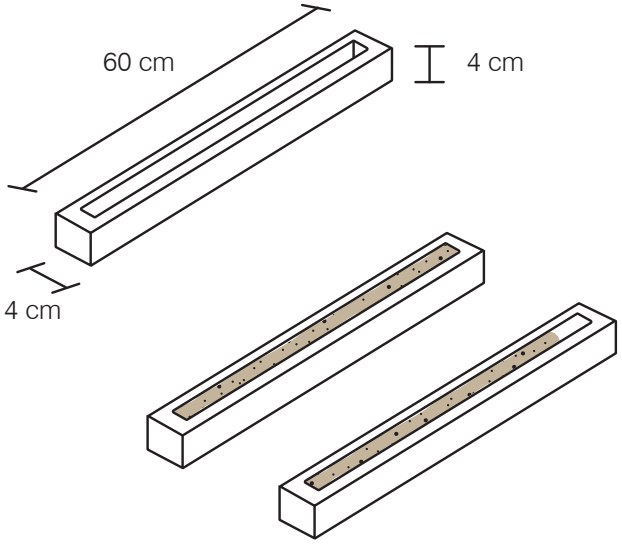
When the soil sample is dry, check for cracks:

- if there are many cracks, the soil is very CLAYEY, some sand will have to be added in the mixture.
- if there are only few cracks, the soil is moderately CLAYEY, add only a small amount of sand in the mixture.

LINEAR SHRINKAGE MOULD TEST

The linear shrinkage test, is performed using a wooden mould, 60cm long, 4cm wide and 4cm deep.

- moist the inside surfaces of the mould with a thin layer of humid soil.
- fill the mould with moist soil and ensure that this is pressed into all corners of the box, you can help yourself by using a small wooden spatula that can also be used to smooth the surface.
- expose the mould to the sun for a period of three days or in the shade for seven days. After this period measure the length of the hardened and dried soil as compared to the length of the mould and calculate the shrinkage length of the soil.



SEDIMENTATION TEST

The mixture is stirred with a lot of water in a glass jar and then is let to rest on a flat surface.
The largest particles will settle at the bottom, the finest on top. Analysing the different layers in the glass jar allows to have an approximated idea of the composition and the proportion of the different particles types included in the soil examined.

! *This test provides only a rough approximation of the soil composition, it is a wrong to assert that the height of each layer corresponds to the proportion of clay, silt, sand and gravel in the soil sample. Taking this assumption could lead to a very large margin of error.*