



# EARTHBAGS!

also known as  
a manual in self help  
construction using 'flexible  
form rammed earth'  
!!!

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READ & PASS & READ & PASS & READ & PASS & READ & PASS & READ & PASS & READ

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FIRST READ THIS (AND THEN PASS...)

This booklet can be downloaded and shared freely.

Please print only when necessary. Pass that copy to another individual when done! READ & PASS!

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READ & PASS & READ & PASS & READ & PASS & READ & PASS & READ & PASS

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- Earthbags! - a primer in self help construction using flexible form tamped earth
- by Sowabh Phadke
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- Online Version - FREE ([www.mkf.in](http://www.mkf.in))
- Offline / Print version - 20/-

## Earthbags!

- a primer in self help construction using flexible form rammed earth

An Aman Setu Publication

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This booklet does not have an author, but has a medium instead. This is an agglomeration of ideas and actions by various people around the globe, and is part of an effort in free knowledge sharing which shall evolve and empower with every transfer.

This material intends to serve as a primer in self help construction using earthbags, serving just about enough information to enable an entity to execute, experiment and evolve a technique which is a simple variation of rammed earth.

The material presented is not with the intention of propagating another 'wonder technique' which claims to solve all our worldly problems. Instead, it expresses a sincere alternative - which demands further research & experimentation - to neo conventional construction practices which are consumptive and beyond the reach of most.

It is with the notion that only true independence in construction can provide the solution to primary, affordable and safe shelter for all that the following pages are being written.

- a medium

## What came first? Earth (OR) Bag

Building shelter using earth and bags might sound like a novel concept, but it is one which has been around for some time now.

Sandbags have regularly been used for constructing bunds and similar water retention structures. Military bunkers, makeshift bases and even checkpoints have made use of this technique since the first world war.

But how did these elements: earth, bags & barbed wire, transcend this violence and move towards something so peaceful, so basic as providing shelter, is a story by itself.

The idea that dirt filled bags could be stacked to create a permanent shelter was first introduced in the mid 80's by architect Nader Khalili.

(Incidentally, earthbags were not introduced as a low cost or sustainable construction technique, but as a solution for lunar housing!



During a NASA symposium which was exploring ways of colonizing the moon, Khalili proposed that moon dust could be filled in bags to build structures)

He trained people at his institute CalEarth where they developed this technique by using long tubes of polypropylene as courses, and introduced barbed wire between courses to unify the structure. Moistened adobe soil was tamped in these bags or tubes, which would later dry into large adobe: SuperAdobe Earthbags have since been used for constructing a variety of structures.

Several people have refined this technique further.

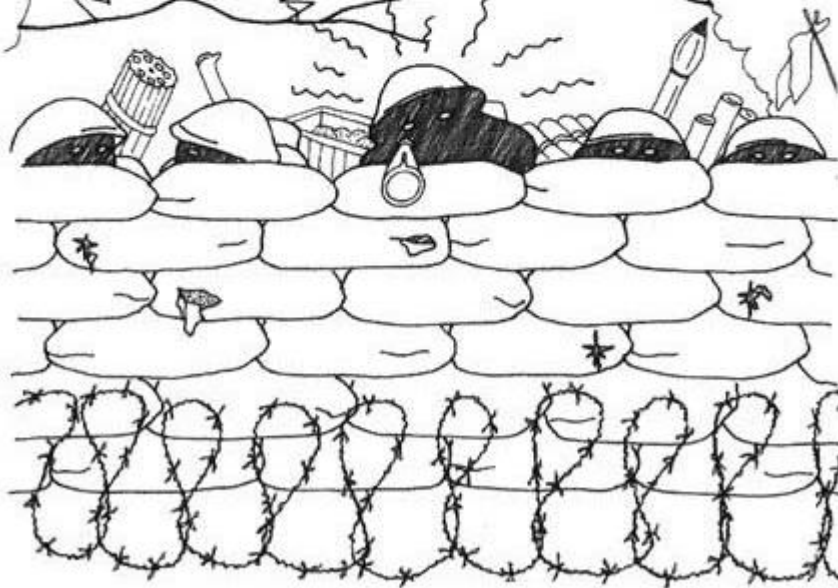
Kelly Hart and Dr. Owen Geiger have been studying, experimenting with, and documenting this technique for years. Their studies, experiments and related information are freely available on the internet and are an invaluable asset for all interested in sustainable construction. Others who have taken earthbags further are Akio Inoue, Kaki Hunter, Doni Kiffmeyer, Joe Kennedy and Paulina Wojciekowska.



# EARTHBAGS?

WHAT THE  
%\*#@#\$  
IS THAT

??

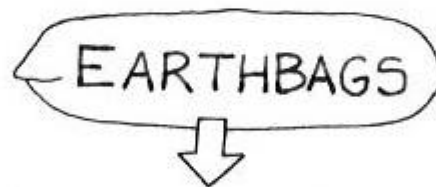




Q.) What is earthbag construction? {2 marks}

Ans. Earthbag construction is a 'Flexible-Form-Rammed-Earth' technique wherein burlap or polypropylene bags are filled with an appropriate earth mix, sealed and stacked in running bond with barbed wire acting as 'velcro mortar' between courses and consolidated by tamping.

EARTHBAGS



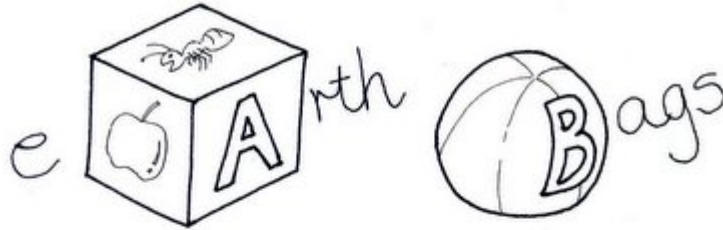
flexible form  
rammed earth

## Self Help, Sustainability & Earthbags

- A sustainable technology should be highly adaptive in order to suit its context. Earthbags are truly versatile since one can modify all aspects of construction including the 'earth' and the 'bag'.
- Earthbags combine discarded material (bags) with location specific material (earth) and thus minimise the carbon footprint. Displacement of resources is thus minimal.
- Use of energy intensive materials (such as cement, steel etc.) is minimised. Appropriate usage is hence encouraged.
- Earthbag construction involves materials and tools of daily use (earth, bags, needles, twine, barbed wire etc.) which are accessible to all, and easy to procure.
- Socially sustainable since earthbags involve semiskilled and unskilled labour. No special construction knowledge required. A bit of common sense goes a long way.

- Earthbag shelters can be built by a small group of people. Even two people can construct their own house!
- No Architects or Civil Engineers needed!
- Allows complete scope for individual innovations and modifications of all aspects.
- Conserves topsoil which is an invaluable asset (and yet one of the most disrespectfully treated resources worldwide).
- Faster speed of construction as compared to other earth construction techniques such as adobe, wattle & daub etc.

## Earthbag FUNDAMENTALS



Even in earthbag construction, there are two varieties which are decided based on the bag fill material and the role of the bag in the long run.

So the bags can be :

- (A) ~~STRUCTURAL~~
- (B) ~~NON STRUCTURAL~~ / formwork

### (A) Structural :

The bag may be filled with dry & loose material such as sand or gravel and tamped. The material is held together only because of the bag.

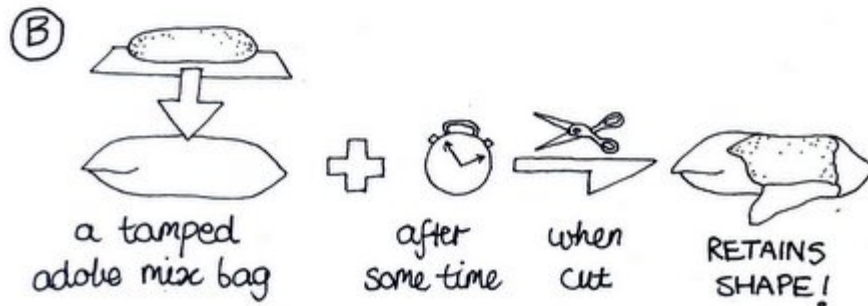
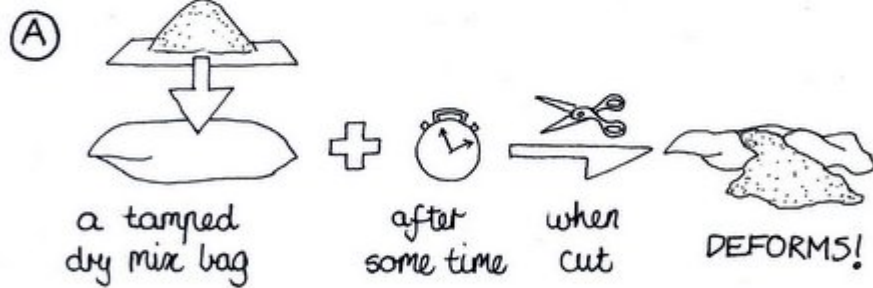
The bags shall retain their shape unless they are punctured or torn, whereby the material shall spill out and the bag shall deform.

The bag material is critical in this case. These polypropylene bags should be preferred due to their strength & durability.

Ⓑ Non structural / Formwork

The bags are filled with moistened adobe soil & tamped. Once the mix dries and hardens, the bag is redundant and the contents shall retain their shape even if the bags are torn.

In this case, the bags serve as temporary formwork till the fill material dries and hardens.



# earth bags

In construction wherein the bags are 'structural', any fill material which can retain its shape and will not deform once tamped dry can be used. Gravel and sand are such materials.

It is when the bags are 'non structural' or 'formwork' that the fill material is to be carefully chosen.

The proportions of various elements which constitute the bagfill material are of utmost importance. It is vital to test and carry out trials with several proportions and mixes before finalising one.

Topsoil or organic soil should never be used for construction. As a thumbrule, if a soil is good for growing plants in it, it should not be used for construction.

Generally speaking, for earthbag construction with a moist mix, the fill material should be 30% clay and 70% sand.

If the amount of clay increases, the superadobe may develop cracks on drying. Inversely, if the sand percentage increases, the superadobe will lose shape & deform.

Hence it is imperative that one tests the site soil and doctors it accordingly to attain the desired proportions.

No laboratory tests are needed (it might be worthwhile if such facilities are readily available or for larger projects), simple on site tests can help unravel the nature of the soil.

Stabilizers such as cement or lime can be added to the mix to ensure better bonding of all the constituents. Generally, 5% cement can be added as a stabilizer to the mix.

The Amount of water to be added in the mix is critical to achieve compaction of the earthbags by tamping. Water should be enough to moisten the mix. A handful of the moist mix when squeezed should retain its shape without wetting your palms.

Throughout the construction process, one must monitor the EARTH MIX PROPORTIONS along with the QUANTITY OF WATER that is added. \*

## earth bags

The bags to be used for construction should be chosen based on the fill material, nature of the structure and availability of the bags themselves.

Burlap/Jute bags can be used, but polypropylene bags are stronger and durable. It must be noted that polypropylene bags suffer damage when left exposed to the sunlight due to ultraviolet radiation. Such bags become brittle and are torn easily. Hence even during construction, one must keep the polypropylene bags covered at all times. Once construction is done, the walls must be plastered.

The size of the bags should be such that is easy to handle. Discarded cement sacks are of 50kg capacity and can become rather cumbersome to work with beyond a certain height due to their weight. So bags filled with lesser material may be used as the wall gets taller. Cement sacks are usually discarded or burnt after regular Reinforced Cement Concrete construction is done. So it should



be fairly easy to procure a large amount of empty cement sacks from any regular construction site at a cheap price or even free. Most bags will have holes & punctures which can be tolerated if small enough. Bags with larger holes can be used for 'half-bags' or must be discarded.

Alternatively, one can use fertilizer or sunla sacks which are of 25 kg capacity.

The sack size should not be too small for it shall make the walls unstable.

One can also use polypropylene tubes to build courses. This will eliminate joints in the masonry and shall increase the stability.

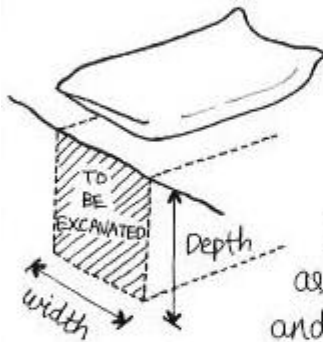
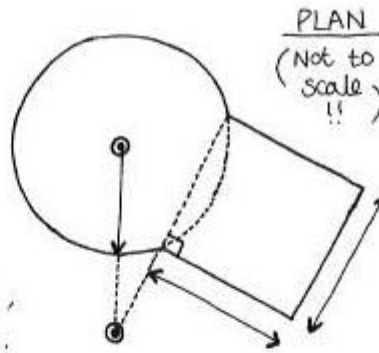
- ① Site is cleared and levelled  
The shelter should preferably be located in a well drained and well ventilated area. This area should be cleared of all debris and other impediments to construction. It should be levelled as required.

INPUT: Pickaxe, shovel

- ② Lineout  
The shape and extents of the shelter should be marked on site with the help of reference points (which should be marked with bamboos or branches) and simple triangulation. Strings can be drawn and lines marked with lime powder. All dimensions should be crosschecked thoroughly.

INPUT: Measuring tape, string, lime powder, branches/bamboos, basic geometrical concepts.

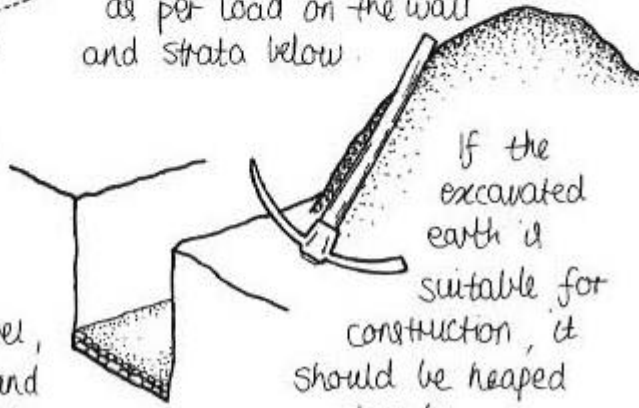
once an appropriate structure has been designed, its shape can be marked on the cleared site using a measuring tape, string & lime powder.



The width of the foundation trench should be slightly larger than the bag width.

Depth of the trench should be as per load on the wall and strata below.

The trench bottom may be levelled using gravel, pebbles and stone dust.



If the excavated earth is suitable for construction, it should be heaped close by.

### ③ Foundation Trench Excavation

The width of the trench should be a few inches more than that of the bags to be used. Depth of the trench shall depend on the strata below as well as the load carried by the walls.

Generally, a 300 mm - 450 mm deep trench should be adequate.

The earth that is excavated should be heaped close by if it is to be used as the fill material for the bags.

The topsoil should be carefully stored separately.

INPUT: Pickaxe, shovel

### ④ Base Preparation

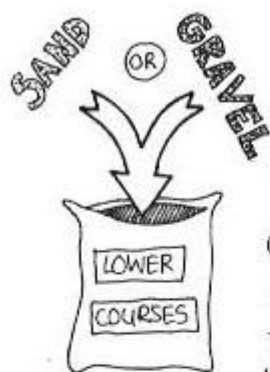
A level base for the earthbags can be prepared by simply tamping the trench base if impediments are absent.

Gravel and stone dust can also be used to prepare a level base. Water should be sprinkled on top to settle the base dust.

If heavy loads are to be imposed on the earthbag wall, a Plain Cement Concrete base should suffice.

INPUT: Gravel, stonedust, cement, water, tamping rod, shovel

One can directly start laying the earthbags on the base of gravel + stone dust



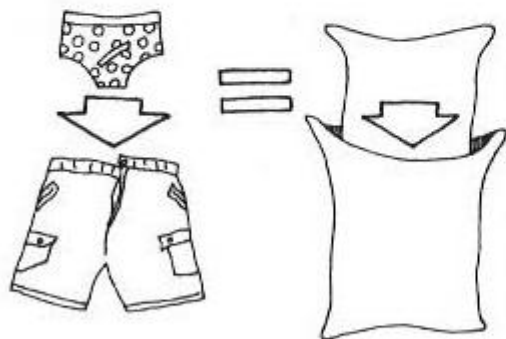
The first few courses of earthbags (all the 'below ground level' courses) should be filled with sand or gravel to prevent water wicking into the walls



sand drains water easily

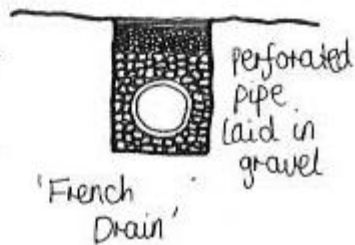


gravel prevents capillary action



The lowermost course can be 'double bagged' for extra protection. Thus the gravel or the trench surface cannot tear the bag and spillages are avoided.

The foundation has to be protected from water in order to prevent settlement and wicking. Provisions for water drainage must be made.



### ⑤ Earthbag Construction Begins : The first course

The first course should be double-bagged (bag within a bag) if heavy loads are to be imposed on the wall.

The fill material below ground level should either be gravel or sand, which will drain water easily and shall prevent capillary action (water wicking into the walls).

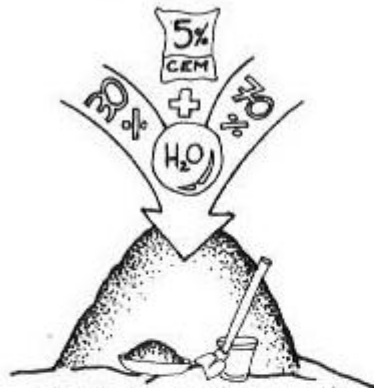
Bags should be filled, stitched and laid along the trench. They should be compacted by tamping.

Two strands of barbed wire should then be stretched along the course while maintaining a distance of about six inches between them.

Binding wire / Packaging straps should be laid on alternate bags in anticipation of the courses to come.

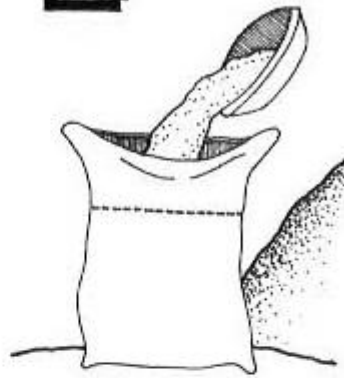
INPUT: Discarded cement bags, twine, needle, barbed wire, gravel/sand, binding wire / packaging straps, tamping rod

I



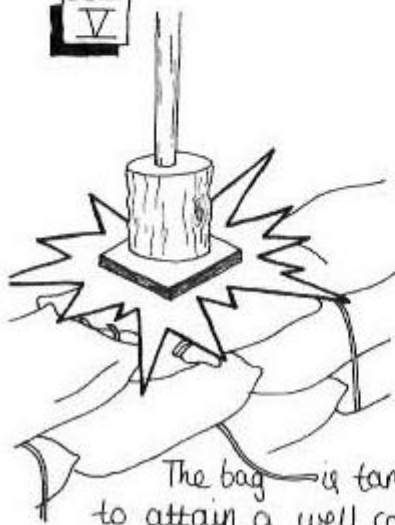
Water is added to the cement stabilised earth mix

II



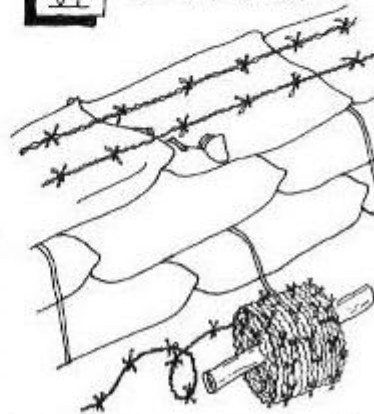
A bag is filled upto 80% of its capacity with the mix

V



The bag is tamped to attain a well compressed and level form

VI



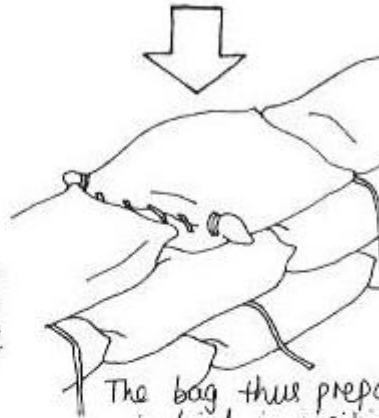
Two strands of barbed wire are stretched on the course

III



The top of the bag is stitched

IV



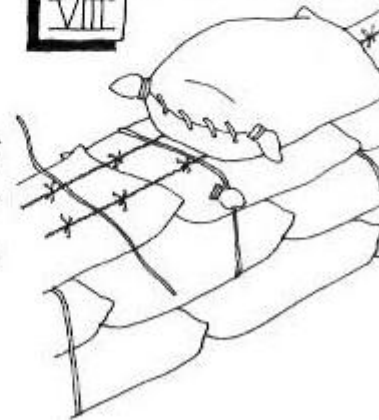
The bag thus prepared is laid in position

VII



Binding wire/straps are placed on alternate bags to tie the courses

VIII



The same procedure is repeated to build the earthbag wall!



## ⑥ Earthbag Construction Continues ...

Bags should then be filled upto 80% of their capacity with the appropriate fill material.

The bags can then be stitched close using a needle and twine. Alternatively, the open end of the bags can be folded under and kept in place facing the previous bag to prevent spillage while tamping.

Each bag should be placed in position and tamped until its contents have been consolidated properly. There is an audible difference between the sound of a loose bag and that of a well consolidated bag when tamped. Adjacent bags should be levelled by tamping together. Successive courses should be staggered to ensure a running bond as in conventional masonry. Barbed wire is stretched over every course while binding wire/straps are placed on alternate bags in every course. These should be tied together every two/three courses in order to hold them together and unify the structure.

INPUT: Fill material, discarded cement bags, twine, needle, tamping rod, barbed wire, binding wire/straps

### ⑦ Openings

Door and window openings can be spanned with conventional lintel or earthbag arches.

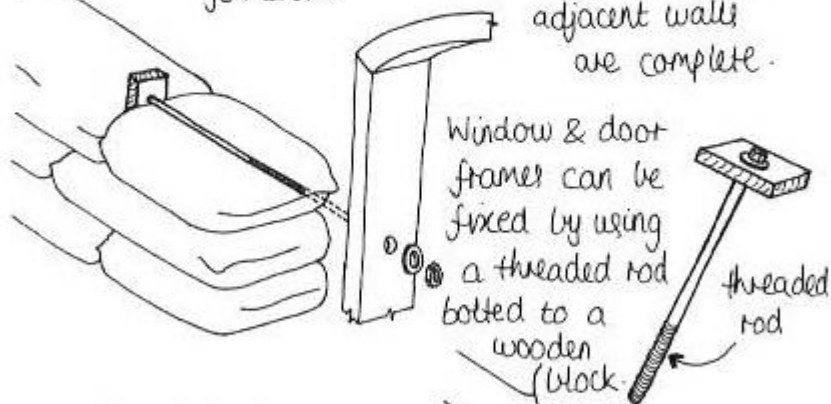
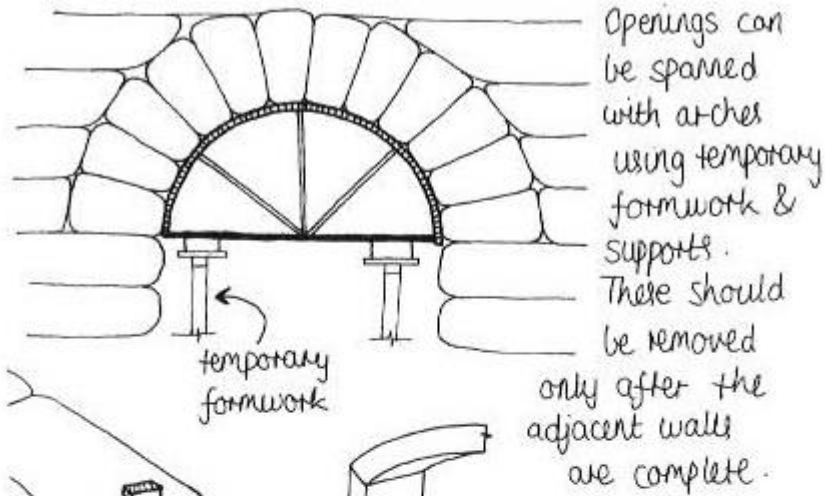
Earthbag arches need formwork support which should be removed only after the adjacent walls are complete.

Provisions for fixing door and window frames have to be made using 'holdfasts' made from a threaded rod and a block of wood which anchors into the earthbag courses.

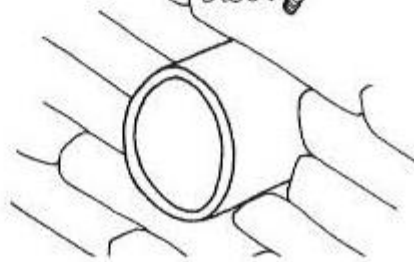
The frame can thus be fixed using a nut and washer on the threaded rod.

Pipes of various sizes embedded into the wall can serve as windows and service sleeves too.

INPUT: Formwork for arches, threaded rod, wooden block, nuts & washers, pipes of various diameters



Discarded pipes can be embedded into the walls to create openings of various sizes.



### ⑧ The Roof

Earthbags can be used to build a corbelled dome. Successive courses are corbelled in to build a conical roof. A rotating arm fixed at the centre of the room serves as a guide for the dome.

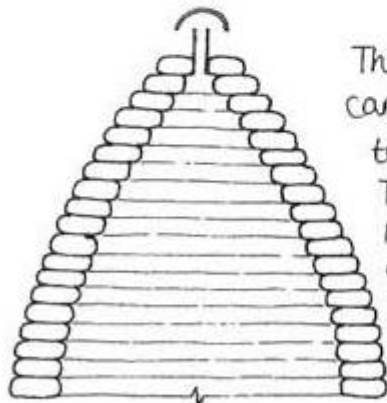
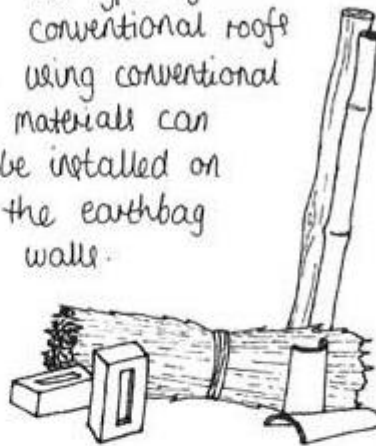
Earthbag domes thus avoid the use of conventional timber for roofs while minimizing the amount of steel needed (barbed wire is still used between courses) for modern roofing techniques.

Earthbag vaults can be constructed for smaller spans (about 2m), but domes which are inherently stronger should be used for larger ones. Conventional roofs in timber, steel or even ferrocrete can be installed on earthbag walls.

INPUT: Earthbags, barbed wire, rotating arm



All types of conventional roofs using conventional materials can be installed on the earthbag walls.



SECTION

The earthbag courses can be corbelled in, to create a dome. This is done with a rotating guide.



'Riceland'  
by Kelly Hart

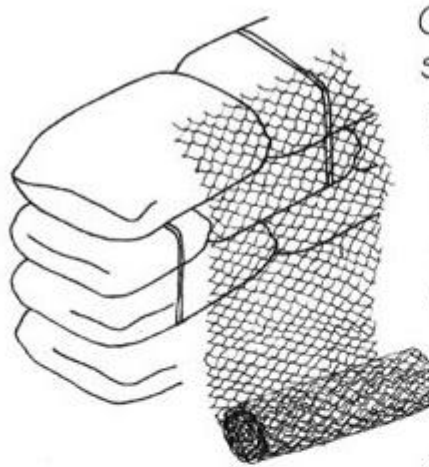
### ⑨ Plastering the Surface

Chicken mesh is stretched over the earthbag surface and held in place by pushing or hammering 'U' shaped pieces of binding wire into the bags.

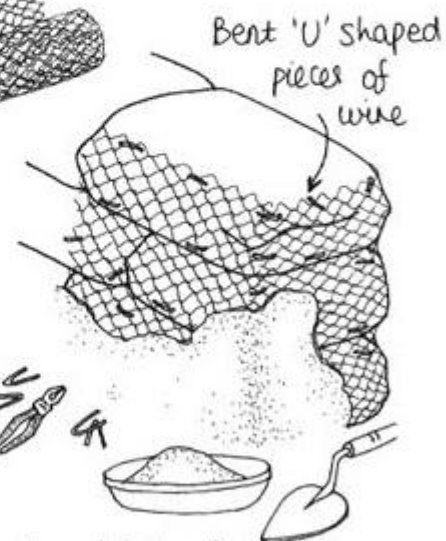
The chicken mesh gives the plaster a rough surface to hold on to. Regular cement plaster or other surface finishes can thus be applied easily to the earthbag walls. The surface can then be painted.

Plastering earthbag walls, especially when the bags are made of polypropylene is essential to ensure longevity.

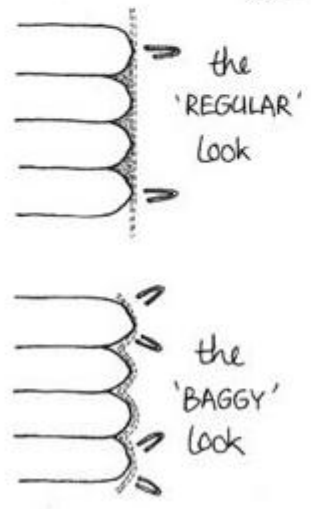
INPUT: Chicken mesh, binding wire, combination pliers, trowel, plaster mix.



Chicken mesh is stretched over the earthbag wall. This provides a rough base for the plaster to hold on to.



Bent 'U' shaped pieces of wire



Any kind of surface rendering can now be applied to the wall!

[www.greenhomebuilding.com/earthbag.htm](http://www.greenhomebuilding.com/earthbag.htm)

[www.calearth.com](http://www.calearth.com)

[www.okokok.org/earthbag.php](http://www.okokok.org/earthbag.php)

[www.earthbagbuilding.com](http://www.earthbagbuilding.com)

[www.davidsheen.com/earthlodge/](http://www.davidsheen.com/earthlodge/)

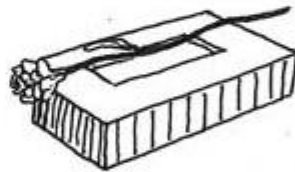
[www.grisb.org](http://www.grisb.org)

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for bouquets & trickbats...



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