



# EARTHBAG STRUCTURE

A technical document detailing the process



The Masons Ink team had an immersive workshop on earthbag structures at Hosur, supervised by the principal architects and assisted by DA India.

This is a document detailing the techniques and processes attempted during this workshop.

Hosur, India

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EXTERNAL WORKSHOP



# EARTHBAG STRUCTURES

"Earthbag technology" is a wall system with structures composed primarily of ordinary soil found at the construction site. The soil is stuffed inside polypropylene bags, which are then staggered like masonry and solidly tamped; barbed wire is laid between the bags' layers for additional adhesion and mortar.

## THE STRUCTURE

**1. Marking and levelling:** The structure to be constructed using earthbags during this workshop was a platform (*katte*) seating around a tree. The height of the platform was marked on the circumference of the tree bark using nails. An accurate height was achieved using a tube level. The nails were then taken as reference points to mark a circle around the outer edge of the platform. A mock-up was done by placing empty bags along this line to understand the approximate number of bags required.



Positioning of nails



Checking of levels



Marking boundary

## 2. Marking on the bags:

A marker pen is used to demarcate the height up to which the sack is to be filled. For ease of handling, the bag was not filled to the top.

## THE INFILL

### 3. Preparation of mix Materials:

1. Mud
2. Sand
3. Jalli
4. Slaked Lime

5	5	10%	10%
Mud	Sand	Jalli (small)	Lime

### Method:

1. All organic matter is removed from the mud and the sand.
2. First, a dry mix of equal parts (or five mortar pans) of mud and, sand, and jalli is prepared.
3. One mortar pan of slaked lime is mixed with the dry mix.
4. One or two mugs of lime water are mixed to achieve the desired gravelly consistency.



Removing of organic matter



Dry mix of mud and sand



Mixing with lime

#### **4. Filling of earthbags:**

The bags are placed vertically and filled with the mix-up to the demarcation made earlier. Two sections of bamboo are driven into the mix for the bag's stability.

#### **5. Sealing of the bag:**

Any excess bag length is cut off, and the remaining length is rolled up to the edge of the demarcation line.

#### **6. Stitching:**

Stitches using plastic thread were drawn through the rolled top of the bag, crossing and looping over it in a running stitch to seal the bag.



Filling the bags



Rolling the bag edge



Stitching the bag

#### **7. Ramming:**

One course of the bags is laid flat according to the marking line, and they are rammed on the top and sides with wooden rammers to spread the mix evenly in the bag and achieve a flat and even brick-like shape for the next course to be laid.

#### **8. Filling with mortar:**

Any crevices, nooks or gaps between two bags are filled with a mortar and jalli.

### 9. Laying of barbed wire:

Two lines of barbed wire are run over the top surface of the bags. It is first held in place with a stone before hammering the barbs into the bag to fix it in place. This helps cohesion between two courses of bags and brings the structure together as a single unit. Bamboo pegs of 2-3 inches were also hammered between courses like nails.



Ramming the earth bags



Laying of barbed wires



Filling in the gaps

### 10. Second course:

The second course of earthbags is laid in place by staggering the joints so they do not align. This leads to interlocking and adds to the structure's stability. The second course of bags is also rammed, gaps are filled in with mortar, and barbed wire and bamboo pegs are laid on top.

### 11. Subsequent courses:

The remaining courses of bags are laid similarly until the desired full height of the structure is achieved.



Laying of second course



Finished second course



## EARTHBAG TRIALS

Three variations of the earthbag were used to determine the best type. They are detailed as follows:

### **Earthbag trial 1:**

- Bag used: Polypropylene woven rice bags
- Height: 21, 1/2"
- Stitching thread: Plastic thread
- Observations: Due to the low porosity of the bag, it was observed that the earth mixture inside dried poorly and did not hold its shape from the ramming.

### **Earthbag trial 2:**

- Bag used: Polypropylene woven rice bags
- Height: 21 1/2"
- Stitching thread: Nylon thread
- Observations: Though more robust and durable, the nylon thread caused the polypropylene bags to tear at the holes made for sewing. It was noticeable, especially when the bags were lifted.

### **Earthbag trial 3:**

- Bag used: Polypropylene woven mesh bags/ Onion bags
- Height: 20 1/2"
- Stitching thread: Plastic thread
- Observations: The mesh bags were used so that the mud filling inside the bag could dry faster and solidify, which would lend to the stability of a course before the next one is put in place. Due to the large size of the mesh used, it was noticed that the material spillage was frequent, especially during the lifting and transporting the bag and ramming. Smaller mesh-size bags, however, showed desirable drying time and compaction results.

These bags were later on used in the main structure of Earthbag dome.



Polypropylene woven mesh bags



## EARTHBAG DOME - MAIN STRUCTURE

From the learnings and observations made during the trials of the different earthbags and the construction of the katte during the workshop, the main structure - consisting of two earthbag domes was constructed.



Rolling the bag edge



Stitched bags



Laid Earthbags



Ramming the course of bags with a wooden rammer



Earthbag wall



Completed earthbag dome with walls finished and plastered.





## POINTS TO NOTE

### **Before step 1 (marking and levelling):**

- Bags selected for use should be checked for damage and ensured strong enough for use.

### **During step 3 (mixing):**

- Different batches of the mix should be ensured to maintain consistent ratios.
- The consistency of the mix must be gravelly, with a slight moisture content, but not wet. It is the ideal mix for ramming.
- Larger clumps in the mix should be broken down as they will cause uneven surfaces when filling the bags.
- The addition of straw to the mix was observed to have hindered the compacting. Hence, any straw or fibre was avoided in the mix for the infill, and jalli was used instead as a binding component.

### **Before step 7 (ramming):**

- There are two procedures for laying and ramming the earthbags: the first involves laying and ramming the bags individually, one at a time. The second consists of laying the entire course of bags before ramming them together. The second method was observed to work better and prevent the formation of gaps between adjacent bags, ensuring that the structure was well compacted and held together.

### **During step 7 (ramming):**

- Two types of tools were tested for ramming the bags. Wooden tools performed better than metal rammers. The vibration generated by metal rammers is more significant, causing particles to loosen and never fully compact or hold in place.



## Material Checklist:

- Bags (Cement bags or rice bags)
- Mud
- Sand
- Stone
- Lime
- Jelly stones 20mm
- Water
- Plastic thread
- Barbed wire

## Tool Checklist:

- Tube level
- Nails
- Hammer (2-3)
- Protective gloves
- Mortar pans (4-5)
- Hoe
- Buckets (1-2)
- Trowel (2-3)
- Metal rammers (2-3)
- Rubber boots
- Needles
- Chalk and markers



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