



## RAMMED EARTH WALL



A technical document detailing the process of stabilised rammed earth construction. The documentation illustrates the process through a workshop conducted on a construction site at *Shoolagiri*. The Earth, Water, Air, Fire workshop was an immersive, hands-on workshop conducted as part of the Masons Ink Site School. The session delved into Earth Construction 101, followed by a hands-on experience in rammed earth construction with Masons Ink and Landartistry.

The document outlines the ratios of mixes and materials based on the soil conditions at the construction site. The proportions of materials used depend on the soil conditions and are subject to change.

*Shoolagiri, Tamil Nadu*

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# RAMMED EARTH CONSTRUCTION

## Introduction

The rammed earth technique is a sustainable building method in which soil is compacted within formwork to create solid, monolithic walls. The resultant walls offer excellent thermal mass, durability, and environmental benefits.

Rammed earth construction dates to the Neolithic Period. The process was applied to ancient monuments and vernacular architecture, with the Great Wall of China serving as a notable example.

The technique uses soil with a stabiliser, which is rammed into layers within a wooden formwork using rammers.

The technique produces in-situ walls free of joints, utilising the local resources and soil from excavation. The walls, when mixed with water, form a homogeneous, humid mixture with low embodied energy, resulting in minimal waste.

## Materials used

### 1. Earth:

The soil has been excavated from the construction site or sourced from within a 5-kilometre radius.

### 2. M-Sand:

M-sand is used as an aggregate to enhance the compactness of the mixture, thereby improving the stability of the mix.

### 3. Stabiliser - cement/ lime:

The stabiliser used on-site is cement, which provides additional strength and enhances water resistance.

### 4. Water:

Water with lime slurry is added to the mixture to create a humid mix.

## Tools used

1. Rotary Sieve
2. Bandli
3. Shovel
4. Automatic mixer
5. Hand rammer
6. Formwork
7. Clamps
8. Pocket penetrometer
9. Hand gloves



## Process

### 1. Soil Excavation

- **Preparation:**

- i.Remove topsoil, as it is unsuitable due to the presence of organic matter.
- ii.Store soil in compact, weather-protected heaps.

### 2. Sieving

- a. Sieving of the soil is necessary for use in stabilised rammed-earth construction.
- b. Remove the large stones manually, i.e., stones greater than 50mm.
- c. In the next step, the Earth is sieved through a rotary sieve.
- d. Organic matter and gravel are sieved through it to obtain a well-graded soil mix.
- e. The sieved Earth is now ready for mixing (with stabilisers) and subsequent compaction in the form work.



Figure 4: A rotary sieve has been used to filter the soil; the sieved soil is then used in the dry mixture.

### 3. Material Preparation – Mixture

The mixture is prepared in two steps – the first step involves dry materials, and the second step uses water to make the mix humid in nature.

#### a. Dry Mix

A dry mix typically consists of dry materials, such as soil and m-sand, and the proportion of the dry mix is based on the soil's composition.

- i.Cement or lime is used to stabilise and provide durability and strength.
- ii.The mixture consists of cement, m-sand, and sieved soil in the following proportions:

Cement	Sand	Soil
<b>1.2</b>	<b>2.9</b>	<b>5.9</b>

All the materials are mixed to set a uniform colour.

- iii.An automatic mixer has been used to optimise the process of dry mixing.



Figures 5 & 6: (Left) An automatic mixer is used for mixing the dry mix composed of earth, sand and cement. (Right) The photograph depicts a worker mixing water and lime slurry.

### b. Humid Mix

A homogeneous mix is used in the making of the walls. This homogenous mix is humid, containing just enough water that when the mixture is made into a ball and dropped on the ground, it should not splatter but break into 4-5 distinct pieces.

- i. The dry mix is moistened with water and lime slurry based on the soil condition and the moisture content of the dry mix.
- ii. Here, for every 100 kg of dry mixture, 8 litres of water and lime slurry are used.

**Note:** The amount of water required will vary depending on the type of soil. It's better to approach a sensorial understanding of a humid mix with the mud ball test, as mentioned above.

### 4. Preparation of Formwork

- a. **Panel Dimensions:** Each horizontal formwork generally contains two plywood panels — usually around 210cm long, which produces wall strips that are roughly 90cm high.
- b. **Precise Alignment:** Accurate horizontal and vertical alignment is essential. This guarantees not only a consistent wall finish, but also that vertical grooves (for tongue-and-groove details) end up where you intended them to — at seams and corners.
- c. **Panel Preparation** – Panels are bolted together at multiple intervals to secure the shutters tightly together.
- d. **Release Agent:** Grease or diesel oil is applied to the inner faces of the panels, facilitating demoulding after compaction, and thereby reducing surface damage.
- e. **Assembly for creating continuous rammed earth walls:** When assembling the formwork, special inserts or strips are attached at necessary intervals to form the vertical grooves in the rammed earth. These inserts shape the soil to create the ‘tongue’ side of one wall and a ‘groove’ in the neighbouring wall, ensuring that the seams align in subsequent panel positions. This helps create seamless spans of the required length.



Image 7: The image shows workers bolting the formwork.

**Note:**

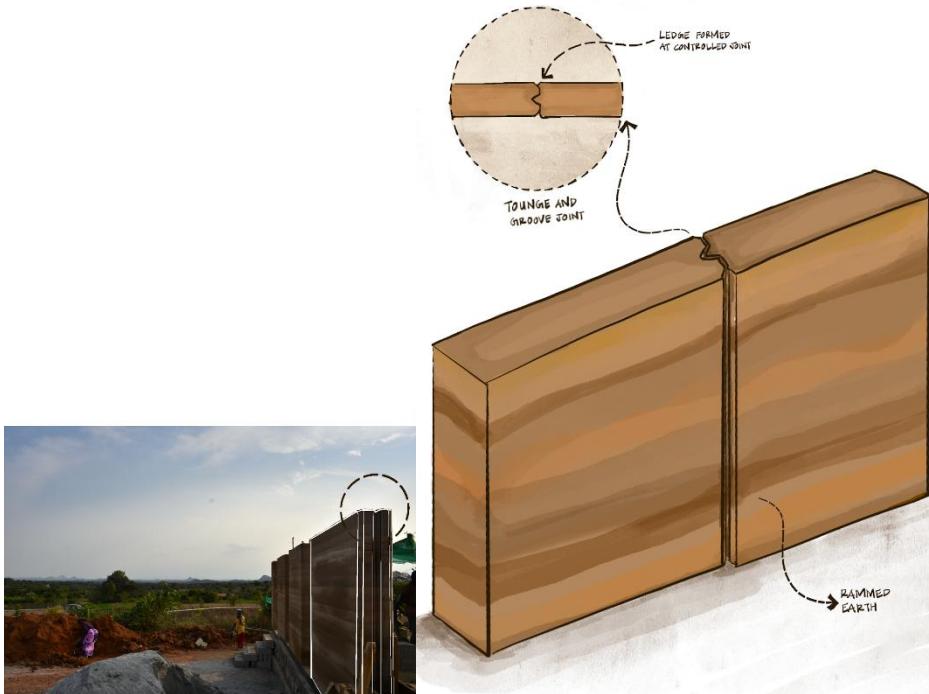
1. **Why is it needed?**

The tongue-in-groove detail controls structural movement and stops uncontrolled cracking at joints in monolithic earth walls.

2. **Formwork Setup:**

If formwork is well-prepared, aligned, and released, these details are executed precisely, and rammed earth structures are built in situ at right angles, maintaining plumb.

This blend of carefully articulated joints and high-precision formwork is the hallmark of long-lasting, crack-resisting rammed earth walls that age beautifully and perform impeccably in both timeless and modern contexts.





### 3. Preparation of Formwork

#### Compacting/ Ramming

- a. The prepared humid mix is transferred into the formwork in layers, usually of 10–15 centimetres in depth.
- b. A rod marked with 12 centimetres is used to measure the quantity of mixture poured into the formwork. Each layer should be carefully checked and marked for consistent thickness.
- c. Each layer is compacted manually using metal rammers. The mixture is rammed approximately 1/3rd of its original height. The soil reaches the required compaction as it starts to produce a metallic ringing sound during ramming, a sign that the soil is becoming monolithic and dense.
- d. A pocket penetrometer is used to check the density and compactness of each rammed layer. The specification states that the penetrometer should not penetrate more than 6mm with a pressure of 5kg/cm<sup>2</sup> from the metal rammers.
- e. Proper compaction is crucial for eliminating voids, thereby ensuring the material's structural integrity and durability.
- f. If the penetrometer does not pass through the layer:
  - i. This means the layer has reached the required density and compactness.
  - ii. The next step is to proceed with the next layer: sprinkle water over the completed course, add a fresh layer of mix, level, and start ramming again.
- g. The layers are added and compacted until the wall reaches a height of approximately 250 centimetres—the maximum height possible with the formwork used.

#### Note:

##### 1. Construction Practice:

The formwork is removed the next day after the wall is completely dry. The subsequent section utilises the exposed groove as a locating and bonding guide, continuing the wall seamlessly.

##### 2. A penetrometer check ensures that the rammed-earth is compacted to its maximum strength.



Figures 8 & 9: (Left) The image shows a participant pouring the earth mixture into the formwork. (Right) The participant is seen ramming the mixture firmly and steadily into the formwork, creating a compact and stable wall.

### 6. Removal of the Formwork

- a. The walls are allowed to set and gain initial strength for 24-48 hours before the removal of the formwork.



- b. Carefully dismantle formwork panels to avoid damaging the newly compacted walls.
- c. Inspect and rectify minor surface imperfections or cracks by smoothing or patching with the same rammed earth mix.

## 7. Curing and Protection

- a. Since the rammed earth in this case was stabilised, curing is necessary for it to gain maximum strength. Maintain the moisture content by continuously damp curing the walls for 7 to 14 days after removing the formwork, ensuring optimal strength and stability. To maintain the dampness, the walls are covered in jute sacks soaked in water.
- b. Protect walls from weather exposure using extended roof eaves or temporary coverings to minimise erosion risks from rain, wind, and splashing.

### Points to Note

- **Vertical Grooves:** Ensure vertical grooves between adjoining wall segments to accommodate independent wall movement.
- **Layer Markings:** Consistently mark and monitor the height of each layer before compaction to ensure consistent layer heights.
- **Damage Repair:** Post-formwork imperfections must be promptly rectified to preserve wall integrity.

### Material Checklist

- Soil
- Sand/ M-sand
- Cement or Lime (stabiliser)
- Water

### Tool Checklist

- Shovels
- Sieves
- Measuring Buckets and Containers
- Rammers
- Mechanical Mixer
- Trowels
- Protective Gloves and Boots
- Wooden Formwork (210 cm standard length)



Figure 10: Excavated soil from the site being filled into Bandli for sieving.



Figure 11: Excavated soil sieved for being used in the preparation of the mix.



Figure 12: An automatic mixer used for mixing the dry mix consisting of cement, m-sand and sieved soil.



Figure 13 (Left): Manual removal of lumps and loosening the mixture.

Figure 14 (Right): Mounting the formwork.



Figure 15 (Left): Pouring the mixture into the formwork.

Figure 16 (Right): Ramming the mixture.



Figure 17: De-shuttering



A finished rammed-earth wall.



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