Rammed Earth Construction

By: Jonathan Russell-Anelli and SoilNOW Team

INTRODUCTION

Rammed earth construction is a building technique that uses locally sourced materials such as clay, silt, sand, gravel, or other aggregates. These earthen materials are then compacted within a form work or form to create durable, sound and thermally insulated structures with natural fire and pest resistance. This practice is experiencing a revival due to its sustainability and energy efficiency. It is best suited for side walls and interior partitions and should not be used for below-grade foundations or basement walls. Due to structural considerations, projects may require an engineer to design.



Image Credit: GLS Rammed Earth; https://glsrammedearth.com/

PROS

- *Sustainability:* Rammed earth uses natural, locally sourced materials, reducing environmental impact and energy input compared to concrete or bricks.
- *Durability:* Properly constructed rammed earth walls can last for centuries, resisting moisture, wind, and other elements.
- *Thermal Mass:* Rammed earth has excellent thermal mass, which helps regulate indoor temperatures, leading to energy savings.
- *Fire Resistance:* Rammed earth is naturally fire-resistant, making it a safe building material.
- *Unique Aesthetics:* Rammed earth homes can have a unique, natural look that blends well with the landscape.
- *Load-Bearing:* Rammed earth walls can be load-bearing, reducing the need for structural supports and potentially lowering construction costs.
- *Low Maintenance:* Once built and adequately cured, rammed earth walls require little maintenance.
- *Recyclable*: Rammed earth is a recyclable material.

CONS

- *Specialized Skills and Equipment*: Construction requires specialized knowledge, skills, and equipment, potentially increasing costs and time.
- *Potential for Cracking*: Rammed earth walls can be prone to cracking if not compacted correctly or if subjected to significant loads.
- *Moisture Sensitivity:* Rammed earth walls are sensitive to moisture and require proper protection from rain and water damage.
- *Cost:* Rammed earth construction can be more expensive than conventional methods, especially outside of areas where it's a common practice.
- *Build Time:* Construction can be time-consuming, as the process involves multiple steps: footings, plinths, forms, mixing, ramming, form removal, and post-processing.
- *Limited Insulation:* Rammed earth itself is not a good insulator, requiring additional insulation for colder climates.
- *Renovation or Upgrade Challenges*: Adding electrical outlets, plumbing lines, or other features to rammed earth walls can be difficult and costly. Their inclusion should be considered at the beginning of construction.

SUSTAINABILITY

Rammed earth construction offers many environmental benefits, including:

- Low carbon footprint and maintenance costs
- Use of locally sourced materials reduces transportation emissions
- Lower cement content compared to conventional concrete
- Long-lasting structures minimize the need for reconstruction
- Minimal deconstruction waste and disposal costs

DESIGN CONSIDERATIONS

Rammed earth offers versatile building options with unique and natural looks. The material's high thermal mass provides natural temperature, sound, and humidity control.

When designing rammed earth structures, you may consider consulting an engineer as large projects may have issues related to:

- Combined compression and bending loads
- Concentrated compression loads
- Out-of-plane flexural capacity of walls
- Shear capacity and design of shear walls
- Torsional forces

As mentioned earlier, rammed earth is best suited for side walls and major interior partitions and should not be used for below-grade foundations or basement walls.

Be sure to follow modern construction standards and meet local building codes.

HOW TO BUILD WITH RAMMED EARTH

Building with rammed earth requires four essential components: the appropriate soil texture, a stable form work for framing the construction, a correct soil to water mixture ratio and a consistent and accurate compaction density throughout construction.

SOIL SELECTION

Proper soil mixes are crucial for successful rammed earth structures. An ideal soil mix includes a variety of particle sizes, with smaller grains filling the voids between larger ones. Typical mixes consist of 30-40% clay and 60-70% sand, silt, and gravel, with little to no organic matter. Stabilizers like lime or cement can be added to improve water resistance, durability, and strength.

Finding the Right Soil

The ideal soil textures for rammed earth construction are 1) sandy clay and 2) sandy clay loam. Clay acts as a natural binder, helping the soil to hold together when compacted. Sand and gravel provide structure and strength to the rammed earth walls. If possible, find a soil near you to maximize the sustainability benefits of this technique.

Select

- Coarse sands with a good distribution of particle sizes (usually perform better than fine or uniform sand).
- Cracked or crushed gravel (better than "pea" or river gravel because the sharp edges will "lock" in place under pressure).

Avoid

- Soils with a lot of silt (more than 30% silt is problematic).
- Organic matter (will decompose within the wall).

Other Considerations

- The appearance and performance of rammed earth walls depends on the soil and aggregates used.
- In areas of high rainfall, the walls will need extra protection from the water.
- In cold climates, rammed earth walls may require additional insulation.

BUILD THE FRAMEWORK

Lay out formworks on top of suitable and secure footings or plinths in the desired design to pour the mix in. Make sure that there is easy access to the forms. The forms are typically made on site from plywood but can also be rented. The forms need to be strong enough to withstand the repeated ramming needed to transform the soil mix into rammed earth.

MIX THE SOIL AND ADD WATER

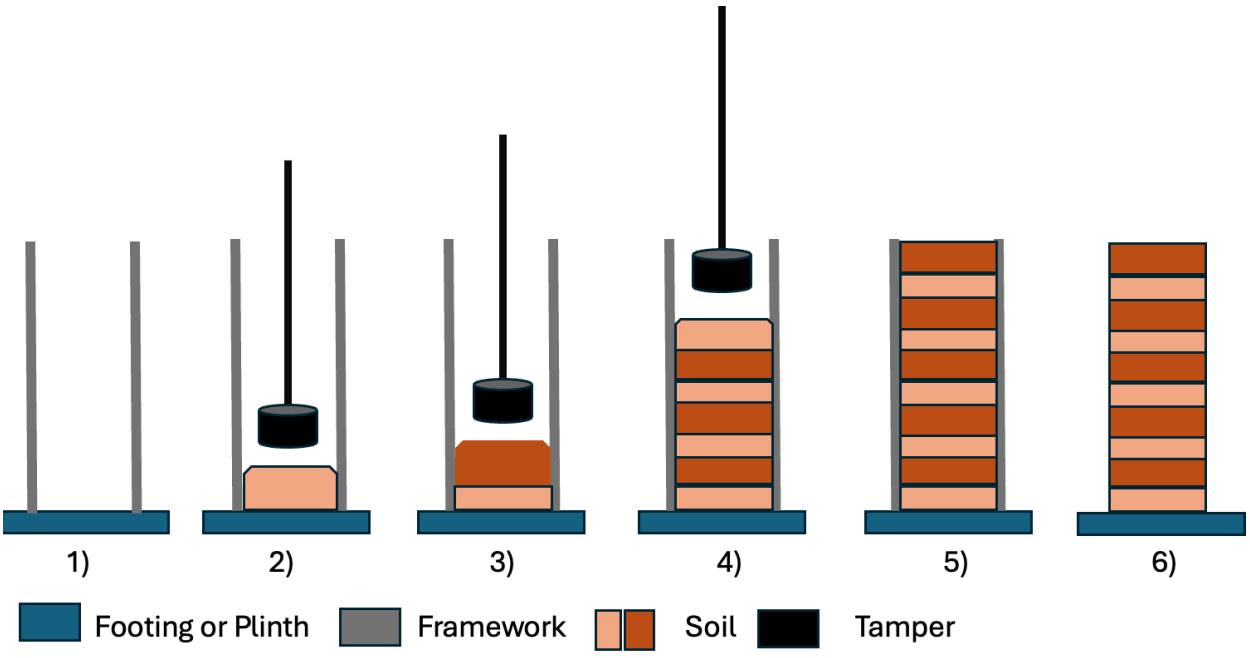
Mix the soil thoroughly to a uniform distribution of materials.

Add water until the mixture (mix) is damp. The ideal damp mix should be moldable and break into a few pieces when dropped. If the mix is powdery and doesn't hold its shape when squeezed, it is too dry. If the mix leaks moisture when squeezed or stays in one piece when dropped, it is too wet.

THE CONSTRUCTION PROCESS

- Pour soil mix into the prepared form to a depth of 4-5 inches.
- Compact the material by ramming it repeatedly, until it holds its shape and doesn't crumble or fall apart. In general, each layer should be approximately half its original volume after it's compacted. When complete, the entire layer should feel dense and uniform.
- Repeat the pouring and compacting sequence while adding forms incrementally until the desired dimensions are reached.
- After completion, leave the forms in place to allow the compacted soil to harden or cure.
- Once the materials have fully dried, carefully remove the forms.
- Repair minor imperfections using the soil mix as a plaster, then sand smooth.

Steps of Construction



1. Place a secure footing or plinth where the rammed earth will be formed. Build a framework above to hold soil to be rammed.
2. Fill the inside of framework with 4 to 5 inches of prepared soil mixture. Compact by ramming repeatable with a tamper. Volume should be reduced by about ½ upon completion.
3. Fill the inside of framework with a new layer of prepared soil mixture and compact again.

4. Repeat step three until desired height is achieved.
5. Once desired height is achieved let soil cure before removing framework. The time will depend on the materials, width and climate, but removal is generally left for the subsequent day, with full curing being up to one month or more.
6. Repair minor imperfections using the soil mix as a plaster. Monitor and maintain to prevent any structural issues.

MAINTENANCE AND PROTECTION

Once complete, to ensure longevity limit direct water contact to the top or surface of the rammed earth structure. Install a concrete plinth (support) at the base of walls to protect from water erosion. Consider expansion joints to prevent flaking or other damage from frost expansion.

Additionally, you can apply surface treatments if necessary to help stabilize flaking as well as enhance aesthetics.

CONCLUSION

By following these guidelines, engineers, builders, and others with the necessary skills can create durable, sustainable, and energy-efficient rammed earth structures that meet modern construction standards.

For further information or if you have any questions, contact your local Cornell Cooperative Extension office or visit the SoilNOW website at https://blogs.cornell.edu/soilnow/.

Acknowledgements

SoilNOW team: *Jonathan Russell-Anelli, Hannah Shayler, and Isabella Colucci.*

References

1. GLS Rammed Earth – professional contractor website with examples of rammed earth construction projects and other information: https://glsrammedearth.com/
2. South Dakota State University – Agricultural Heritage Museum website with information and resources about rammed earth: https://www.sdstate.edu/south-dakota-agricultural-heritage-museum/rammed-earth
3. Martin-Antunes, M.A. et al. (2025). Recent developments in stabilized rammed earth: Testing protocols and the recommendations for standardization. Journal of Building Engineering, Volume 106, 15 July 2025, 112436 - https://www.sciencedirect.com/science/article/pii/S2352710225006734