building to learn

the rammed earth project

notes to students

CONSTRUCTIONARIUM®

TURNING THEORY INTO PRACTICE

What is Rammed Earth

Rammed earth is a form of unbaked earthen construction. It is mainly used to build walls but also columns, floors and foundations.

Rammed earth has been used in a wide variety of structures for both load-bearing and non-load-bearing walls over many centuries. Rammed earth walls are found throughout the world with many examples throughout Asia, including sections of the Great Wall of China, in the Middle East, Africa, Latin America and Europe. The traditional rammed earth technique is still used in many developing countries. In industrialised countries, the development of more effective construction methods makes the technique relevant as well. Australia and New-Zealand have seen an important increase in the number of rammed earth buildings being built lately. In some areas of Australia, rammed earth even represents a significant proportion of new buildings work. In the UK, it is also undergoing a renewed interest. Rammed earth was probably introduced to Britain by the Romans and has been used in the UK for around 2000 years. However the most significant period of construction followed its reintroduction into the UK in the early 19th century. Throughout the 19th century a number of rammed earth and rammed chalk buildings were erected in Southern England. In recent years an increasing number of rammed earth projects have been completed in the UK. The most famous applications to date include the Eden Project Visitors Centre and the Centre for Alternative Technology's at AtEIC Building.

Stabilised rammed earth house, Western Australia

Eden Project Visitor Centre (1999)

Grimshaw Architects, In Situ Rammed Earth)

Rammed earth is formed by compacting moist soil inside a temporary formwork. Loose moist soil is placed in layers 100-150mm deep and then compacted. When earth is compacted its volume can reduce by up to 50%. Traditionally manual rammers have been used for compaction but nowadays pneumatically powered dynamic rammers are commonly used. Each time the top of the formwork is reached, it is re-erected higher and the process begins again. As a result of this construction method rammed earth walls often exhibit a distinctive layered appearance that is quite attractive and is undoubtedly one of the appeals of rammed earth construction. As a result, walls are often left without plaster or render.

Rammed earth: Advantages and limitations Advantages

The stimulus for the latest development of rammed earth in the UK has primarily been the desire to reduce the environmental impact of building and explore more sustainable and natural building methods. Also, rammed earth can be a particularly beautiful finished material due to its construction method as explained above and as can be seen on the pictures above. This has also been a reason for an increasing use of the material. Moreover, while it offers the qualities of other earth construction methods, among which regulating the internal relative humidity and providing an important thermal mass, rammed earth construction has higher strength and stiffness than other earth construction methods such as cob and adobe and enables therefore more flexibility in the design possibilities it offers. Also many rammed earth building operations can be undertaken by a relatively inexperienced labour force.

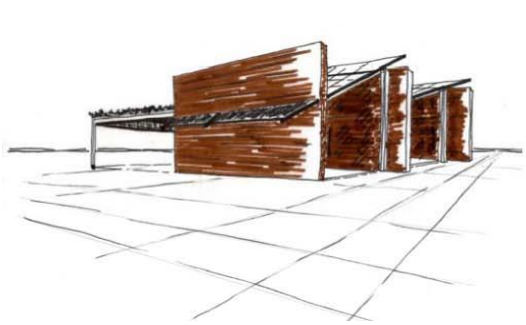
Limitations

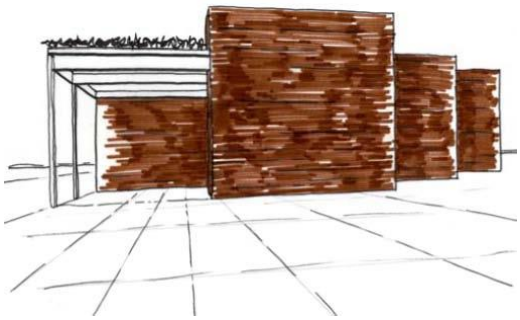
The main limitation of rammed earth is its durability. Indeed rammed earth is susceptible to decay in presence of water. This requires special consideration in design and construction and throughout its service life. To overcome this problem external walls are generally built on upstands and often protected with large eaves extensions. In cases where walls cannot be protected by using such building details, rammed earth can be stabilised. This is done by adding cement to the basic soil mix. Stabilisation enhances material durability and wet strength but at the expense of using cement, a major contributor to global CO2 emissions. This technique has been largely used in USA and Australia with now more than 1000 buildings having been built. Another drawback of rammed earth construction is the important thickness of the walls that is required. To ensure lateral resistance of the walls and allow construction, the walls are typically 300-450mm thick although this can vary largely according to design requirements. This is due to the low strengths of the material. Not all soils are suitable for rammed earth construction and must be carefully selected. Extensive laboratory testing being often needed, many established earth builder take material from quarry sources sometimes resulting in transportation of materials over considerable distances.

The Rammed Earth Building

The Rammed Earth Building is made up of two parts: a “rammed earth part” made of three walls, and a The building is orientated to maximise the amount of sunlight entering the structure through the roof.

“timber part” open on its four sides at the extremity.





The walls carry the loads from the timber roof above. To ensure the durability of the structure, the roof is designed to overhang most of the walls and protect them from the rain. The elements of exposed wall are protected by adding cement to the basic soil mix.

The walls are 350mm thick and respectively 5.6m, 4m, and 2.4m long. Their heights range from 2.3m to 3.5m. Totally 14.6m^3 of earth are used in the building.
Part of the roof is clad with a transparent polycarbonate. The remainder is a green roof designed to retain surface water runoff and enhance biodiversity. The structure of the green roof part is entirely made of timber elements. The green roof element has been designed such that it can be constructed offsite and lifted into place.

The roof experiences significant uplift force. To anchor the roof without increasing the tension in the rammed earth walls, a timber beam has been provided at each point where the rafters connect to the walls and is anchored in the walls by builders bands attached to a reinforcing bar in the wall. The building is braced bays using steel cables and timber posts.

The building is supported on mass concrete strip foundations under the walls and pad foundations under the timber posts.

The Rammed Earth Project has been designed to demonstrate the place of vernacular architecture in the 21st Century built environment.

Brief

Your brief is to construct the building presented over the Constructionarium week. You will have to use different earth mixes (unstabilised for most of the structure and stabilised for the parts left exposed).

You will have to coordinate efficiently the construction of the walls and the erection of the timber roof in the rammed earth part.

You will also have to ensure the offsite fabrication of the green roof.

Site layout at the start of the week

Your site is level. You will use off-site production methods to manufacture the green roof. You need to agree with the client's representative as to the location of your offsite assembly area. You will also have to prepare the earth mixes to be used for the walls.

Plant and Equipment

You will have limited access to suitable mechanical plant, correctly configured for lifting the green roof. You will be provided with pneumatic rammers for construction of walls.

What you will have to do

- Create a GANTT chart of key activities and time for completion; determine need for power tool training of operatives; meet daily with client's representative; submit method statements for approval by site manager; submit list of kit and equipment & plant requirements to store manager.

- Set out and cast foundations.
- The key positions of the timber posts must be set out on the concrete foundation.
- The columns inserted in the walls must be connected to the foundations.
- Each post must be braced with temporary struts for stability.
- Construction of the rammed earth walls ensuring their lateral stability.
- Offsite manufacturing of the green roof.
- Ramming of the walls involves working at height. Safe access must be considered at every stage of the construction to ensure a safe working environment.
- **Stability of the overall structure must be ensured at all times and risk assessment methods statement report produced before each major construction activity commences.**

Friday feature

You will complete the building by lifting the green roof in place**. Great care must be taken as the green roof is lifted in place**: The lifting method might lead to non negligible compression in the roof and as the roof is lifted with some of the beams supporting it missing, a frame will have to be provided or a set of temporary beams installed in the part of the roof being lifted.

References

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