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Rammed earth wall lining – Leibniz Institut in Potsdam

The new Research Centre for Technology and Knowledge Transfer on the campus of the Leibniz Institute of Agricultural Engineering and Bioeconomy (ATB) in Potsdam/Germany opened in Autumn 2019 and includes laboratories, rooms for meetings, conferences and user training, spaces for workshops and seminars for staff and guests, as well as a cafeteria.

The two-storey building marks the entrance to the campus and gives the Leibniz Institute of Agricultural Engineering and Bioeconomy e.V. a new public face.

We were approached by agn Niederberghaus & Partner GmbH in Halle as the lead architects at an early stage, not least because the clients at the Leibniz Institute were looking for an appropriate expression of their ecological principles in the new building. In addition, the wall lining contributes to the indoor room climate and adds a dramatic colour contrast to the otherwise white interiors of research centre.

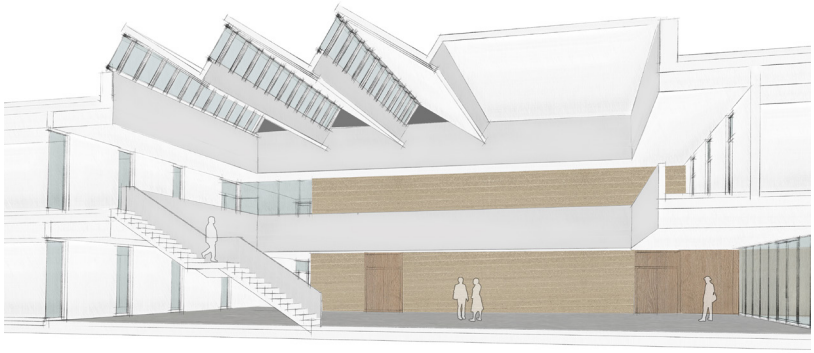
The project was of interest to us as an interesting alternative to earth plasters in the context of conventional office buildings, and because it presented an opportunity to use rammed earth in a non-freestanding and non-loadbearing situation at a larger scale. It opens up new, interesting potential for rammed earth construction.

Entrance area and foyer

During our first inspection of the completed shell of the building, including the large shed roof openings cast completely in concrete, we could not really imagine what the future foyer would look like with an approx. 111 m² rammed earth wall lining along one side of the ground and first floors.

The excavations for the foundations of the research centre produced a large quantity of soil with clay-marl content. After determining its suitability, we were able to take up the client's wish to use as much

01 ATB Research Centre for Technology and Knowledge Transfer



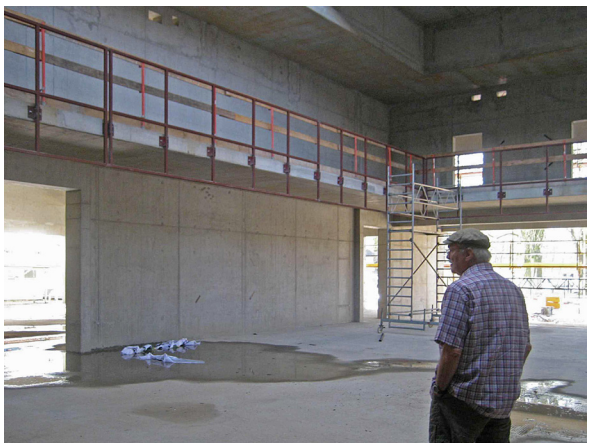
02 Drawings of the foyer
(agn Niederberghaus & Partner GmbH)

as of the excavation material as possible for the two rammed earth wall linings.

One-sided sliding formwork

The first problem was to develop a formwork that could fulfil multiple criteria: it needed to be space-efficient but not be attached to the concrete walls by means of formwork anchors. It should not use inclined struts and be able to "climb" reasonably quickly, without great rebuilding effort. For this it needed to be quickly movable, relocatable in modular sections, easy to work with and transport, but also able to withstand the force of the rammers and be reusable.

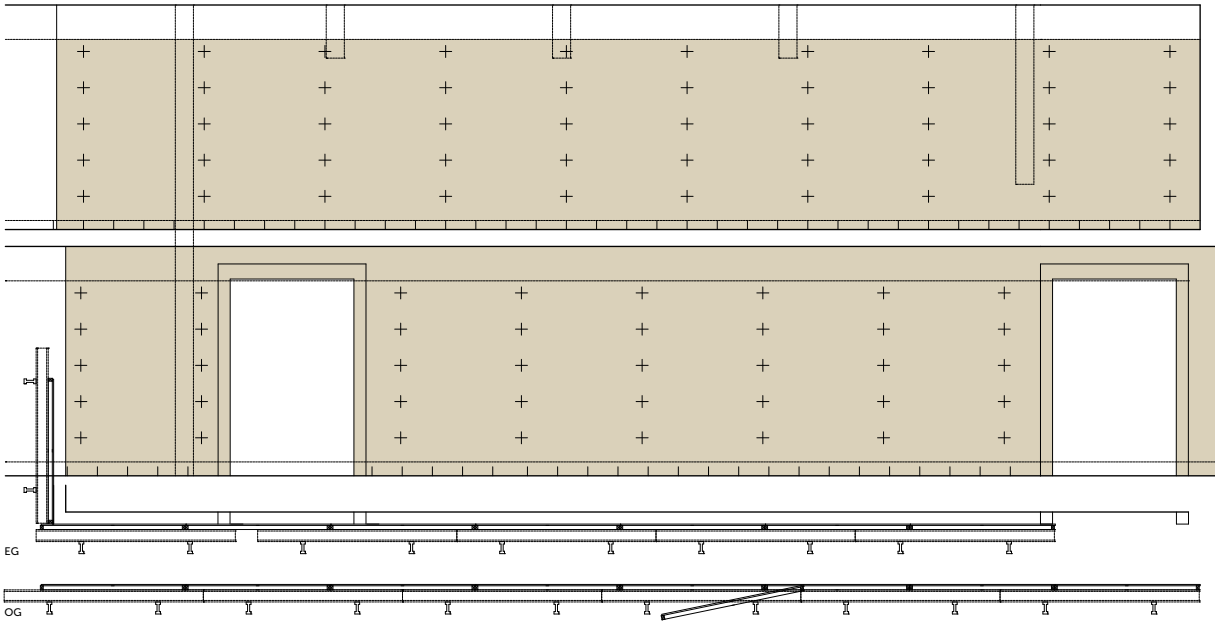
04 Concrete shell of the foyer



In cooperation with the Brandenburg-based architect Gereon Legge and a team of architecture students, a formwork system was developed which, as a universal "ladder formwork", can be adapted to the very confined conditions on site, and is able to extend to a height of two storeys and was also sufficiently safe and stable.

This formwork system was developed with the particularly confined spatial constraints of the upper floor in mind. The passage width was just 2 metres which made the use of diagonal bracing impractical as transporting the heavy rammed earth mix horizontally across a length of 19 metres past diagonal braces would have been almost impossible.

The resulting formwork concept responds to these specific requirements: Doka beams are fixed as horizontal and vertical members to the concrete floor and ceiling. The columns are clamped at the top and bottom with horizontal members cantilevering to the left and right. They support the formwork on the side facing the wall and create a walkway on the other side for transporting the material and for the "rammers". This 70 cm wide passage is roughly the same as that of scaffolding boards.



05 Elevation of the ground and mezzanine floors

This basic construction made it possible to shift the formwork successfully upwards up to the top of the wall without having to constantly rebuild it. Simple timber spacers were used to ensure a constant wall thickness of 20 cm.

The work process

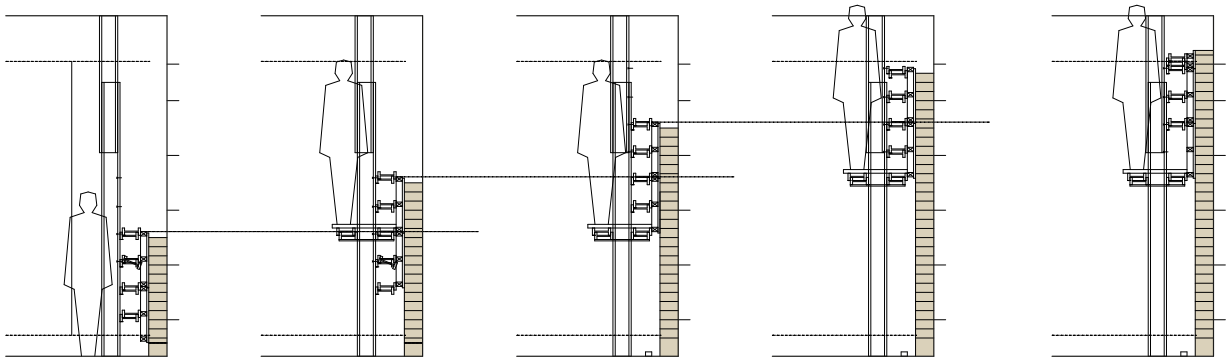
The earthen material was transported essentially by hand. It was particularly important that the layers of the rammed earth extended uniformly along the entire length of the wall.

The ground floor section of the wall also had a slightly different colour texture due to the local earth used, which added to the visual impression of strata. After the wall had dried, the wall surfaces were treated with carnauba wax.

A total of 44.2 tonnes of rammed earth material was used. To ensure structural stability and integrity, geogrid strips were inserted into the wall and anchored back to the concrete wall behind at regular intervals.

The final wall is 17 metres long on the ground floor and 19 metres on the upper floor. Each floor is 3.10 metres high and the wall lining is 20 cm thick. The light brown rammed earth mix had a bulk density of 1900 kg/m^3 and grain sizes ranging from fine to 22 mm.

06 Drawing of the climbing formwork



07-09 The construction process showing the travelling formwork principle

10-11 The finished result: ground floor (left), upper floor (right)

12 Foyer and main entrance

Rammed earth elements in architecture for climate change?

Requirements for rammed earth walling in modern earth building

LehmBauWerk has been building larger and smaller rammed earth walls in Germany since 2003. With every project we try to improve our rammed earth construction technique and to realise cost-effective building constructions. As with straw bale construction, a typical characteristic of this old, venerable construction method is the large number of working hours and associated labour costs, as well as the costly and complex technical equipment required, which can be put such work out of reach of smaller earth building companies.

There are few companies in the German-speaking countries with extensive experience and know-how of earth building. A notable exception is the Austrian but internationally active company "Lehm Ton Erde" who have realised a string of successively larger and functionally more elaborate rammed earth projects and continue to innovate with each new venture.

Criteria

Rammed earth walls should be exposed on both sides, be sufficiently well-insulated when used as external walls, be resilient against weathering and act as a thermal mass to transfer warmth in winter and keep interiors cool in summer.

Modern rammed earth construction in Germany must, in our view, be of good quality, stable, of predictable cost, functional, possibly prefabricated for easier integration into work process, exhibit a unique design and texture, act as a thermal insulator, be quick to realise and safe to transport.

At the same time, current proponents of rammed earth building are giving thought to the future of rammed earth construction and rammed earth elements.

Is (rammed) earth building ready to make the leap to the large scale? A few months ago, a Swiss architectural journal asked this question in connection with the report on the Parisian "Grand Paris Express" construction project, where the vast quantities of clayey soil excavated as part of construction works for the new "Circle Line" metro are to be processed directly on site into earth building materials for a new residential quarter that will arise in the coming years as part of the project.

Vocational training

Aside from entrepreneurial and pioneering spirit – which is still a characteristic of earth builders today – training and vocational skills are fundamental for the sustainable development of rammed earth construction in Germany. And, in the last few years, there have been some developments in this sector.

Between 2016 and 2018 we were involved in the PI-RATE project (Provide Instructions and Resources for Assessment and Training in Earthbuilding), where we worked together with the Dachverband Lehm (DVL) and other national and seven European partners on the development of a training plan for rammed earth construction. The aim was to develop a joint training programme that can conform to the framework of the European Credit System for Vocational Education and Training (ECVET Earth building) but also reflects the often quite different rammed earth building traditions of the participating countries.

14 ECVET skills assessment worksheet for rammed earth construction

ECVET unit **Br**	**Building with Earth** **Rammed Earth**	Level **3**
F required	Qualification: **COMPLETE**	Credit %

Specific Knowledge	Specific Skills

- Equipment for compacting
- Protection against movement or shrinkage cracks
  - Traditional: layers of lime, etc.
  - Contemporary: mesh frames, geotextiles, etc.
  - Spacing of construction joints
- Factors influencing the final rammed wall surface quality
- Prefabrication
- Formwork
- Specific safety works at height; pneumatic equipment
- Stripping: close holes, faults correction, finishing
	- Lift and place mix inside the formwork avoiding disaggregation
	- Check and manage the depth of fill before compacting
	- Manage the number of passes with the rammer
	- Identify the right time to stop the ramming process (touch, visual and auditory control)
	- Periodically check the position and stability of the formwork (lifting, plumb, alignment, tightness)
	- Compact the earth using pneumatic or manual rammers
	- Carry out remedial work after stripping
	- Build demonstration wall on site

	Criteria for the Evaluation of Skills	Credit %

Criteria	Indicators
Infill	- The choice of equipment (transport, lift, placing) is appropriate - The moisture content is controlled - Infill thickness allows sufficient compaction of each layer - The infill agrees with requirements of the surface design
Compacting	- Mechanical and manual rammer are appropriate and well used - Each layer is sufficiently rammed by regular successive passes, from the exterior to the interior - The right time to stop the ramming process is clearly identified
Quality of details	- Structural elements (reinforcements, lintels, ring beams, frames) are set up and laid correctly - Services, fixing points, block outs are laid correctly - Corners are well chamfered, shaped or reinforced - Shrinkage joints are executed correctly - Structural joints (between 2 earth walls and different materials) are tight
Finishing works	- Small repair and filling of holes are not visible - Surface treatment is done with appropriate products on the dry wall - Aesthetic requirements are respected
Protection	- Propping ensures stability before wall dries or bracing is fixed - The top of the wall is protected against rain, daily and after finishing - Efficient appropriate protection of the work during and after completion - The adjoining surfaces are protected
Workplace Management	- Experience

Ensure that standards of work and materials comply with relevant codes of practice and to current standards.

Workshops and courses in rammed earth building in Germany

At a national level, only the DVL and the European Training Centre for Earth Building (EBfL) offer qualifications in rammed earth construction. In the DVL "Specialist in Earth Building" (FKL) course, rammed earth is one topic of its broader theory and practice-oriented advanced vocational training course. Since 2016, the EBfl in Wangelin/Mecklenburg-Western Pomerania has started running a one-week rammed earth building workshop, at the end of which the participants are able to take an ECVET earthen building examination. The ECVET earth building certificate aims to offer a comparable indicator of proficiency throughout Europe and corresponds to level 3 of the European and German qualification framework (DQR).

Material stabilisation in rammed earth construction

We are observing a growing tendency, especially in international rammed earth construction projects in countries such as the USA, India, Australia and China, to add stabilising additives such as cement to rammed earth.

In our opinion this looks set to intensify in the coming years and will, no doubt, lead to considerable contentious debate, with fundamentalists on the one hand and pragmatists on the other.

Ultimately, however, it may come down to whether the cement industry/lobby "co-opt" the natural material earth and in the process transform it into something that is no longer ecological.

While the addition of cement can strengthen the loadbearing capacity of rammed earth and its weather resistance, it also compromises its sorption capacity, its reusability and its natural appearance. This may be the subject of much research and development in the years to come and could endanger the realisation of rammed earth building projects as we know them today.

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Image credits

Photos: Jörg Depta / Gereon Legge
Architecture drawings: agn Niederberghaus & Partner
Construction drawings: Gereon Legge

15 Rammed earth workshop, European Training Centre for Earth Building in Wangelin, D