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Self-supporting rammed earth summerhouse in Falkensee

With our relocation from Berlin to the garden city of Falkensee arose an interest in working with the land. After years of wonderful urban projects, we were longing for the freedom of rural life. Framed on three sides by buildings, the plot featured an old woodshed that blocked the view of the rest of the garden. There was nothing for it: it had to be turned by 90°. Originally, our intention had been to retain it and encase it in a shell of rammed earth, but we soon came to the realisation that combining an already load-bearing timber structure with a self-supporting solid wall made little sense. We would have to decide for one or the other. In the end, the desire for an idealised single-space summerhouse made entirely – walls and roof – of monolithic rammed earth won over, and the woodshed had to go.

It is not often that a project like this presents one with an opportunity to try out all those challenging architectural details one has read about. We wanted a single space enclosed by a monolithic gabled roof at a pitch of 1:5 with an opening spanning the breadth of the room, set low down so that one has to sit down to properly enjoy the view out onto the garden. In addition, we would need a door, a small round window in each gable and a skylight. Every detail had its own specific technical and structural requirements.

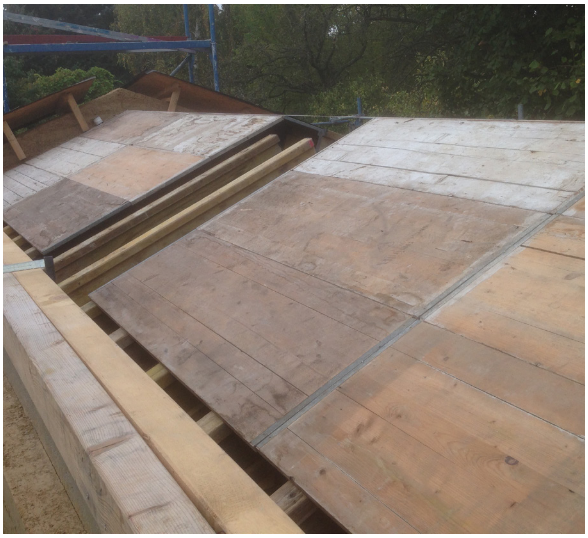
For the wall thickness, the design of the wall base and the choice of formwork system, we followed the earth building guidelines. In addition, we were able to bring in Christof Ziegert from ZRS as a structural engineer and Jörg Depta as an earth builder.

The design of forms and openings in rammed earth requires special consideration. To create an opening in a rammed earth wall across the entire breadth of the house requires the insertion of a proper reinforced concrete lintel. To create a door opening in such a way that the door is inset into a set of tiered shallow rebates in the wall violates the rules of earth building and requires that the lintel extends at least as far as the weakened wall thickness: in the end the lintel was as long as that used for the wide opening. Positioning the round windows at the architectonically optimal position in the gable ends entails creating a step in the ring beam, not least because we wanted to avoid the need for tie rods. To dispense with this simple means of countering outward forces, as often seen in old churches, we had to include a ring of concrete running around the periphery of the building.

For the formwork, we chose traditional rough-sawn timber planking. The dimensions were chosen so that it was possible to have only one primary formwork dimension plus a shorter corner piece and the corresponding internal dimension without the wall thick-

nesses. Just enough formwork sections were produced to complete the walls with four shifts of the formwork. The formwork panels were offset by half a length for each new ramming layer. The formwork tie rods were placed on the rammed walls so that the formwork panels could be shifted upwards with one plank overlapping the top of the previous rammed layer. Pairs of timber uprights were arranged at 60 cm intervals to brace the formwork panels, in accordance with the earth building regulations. At the corners, the 60 cm grid doesn't quite match due to the wall thickness of 32 cm. It is also difficult to place the tie rods right into the inner corners while also conforming to the grid intervals. The formwork was shifted around the floor plan four times and then raised and offset four times to produce the full wall height. At the gable ends, the formwork rose higher beyond the eaves to extend the walls up to the shallow roof incline while also incorporating the round openings.

How were these round openings fashioned? A mortar mixing bucket provided the solution. Not only is it of the right size, but it is already tapered, making it removable, and has a lip at its rim that can be used to produce the bead into which the round glass pane will later be fitted. As we already had the round glass panes, we needed to find an appropriate mortar bucket … and we were in luck. To ensure the bucket would not collapse under the force of compaction, it was first filled with concrete into which a rod was inserted to assist in removing it after use. Its tapered, conical form was very helpful in removing the concrete plug from wall, however it separated from the plastic bucket, which had bonded to the earth wall so firmly that we had to cut the plastic apart and peel it out like an old bicycle inner tube.



The gable walls had to end in an incline corresponding to the pitch of the roof so that the wall crown can bear the load of the massive earth panels. And this was the next lessen we learned.

One would be forgiven for believing one could simply tamp at the appropriate slant but the reality tells a different story. While it is possible to tamp earth horizontally to press it against the leading edge of a ceiling slab, rammed earth is less willing to stay in place when tamped diagonally. Our solution was to slice off the wooden tamper at the appropriate angle and then to tamp vertically as before. After completion it was sliced off again at 90° so that it could be used for the next step: prefabricating the roof slabs.

This step is tantamount to a technological leap from the middle ages to the modern era.

To fabricate the roof slabs, we built a covered tamping formwork platform for producing the 43 individual slabs. The year was already fairly advanced, and the slabs needed to be mounted on the roof before the onset of winter. The tamping platform allowed us to fabricate six slabs in one batch. As we had neither a conveyer system or a large-scale cutting device at our disposal, we had to tamp the slabs one by one, placing a strip of geogrid between each layer so that it hangs out between each individual shuttering board. Consequently, we only needed to add formwork layer by layer on one side.

In the end, six slabs were tamped relatively quickly. To produce the next six slabs, they first needed to be removed from the formwork and left out to dry. However, the 10 cm thick slabs proved to be too fragile to survive removal and simply cracked at one or other of the tampling layers. There was nothing for it: we needed to change our strategy! This time, we developed a mobile form that can be removed and reused so that the slabs can remain in place to dry and harden. The slabs, however, still needed supporting at their ends to prevent them bending. To this end, numerous timber boards and corresponding clamps were required. To reduce the risk of the slabs tipping over, harnessing straps were used, but it was often easier to place timber uprights between them.

By the end of the summer, all 43 slabs had been prefabricated and stood packed close together to dry under every possible roofed-over space. The next step was to raise them onto the roof. To this end, we constructed inclined formwork "tables" at the requisite roof pitch, using shuttering boards resting on beams held in place with formwork props. It was necessary to think carefully about how these would be removed later to avoid creating connections that could no longer be removed from beneath.

Access to the backyard from the street is constrained by the existence of an old walnut tree on the site, and the passageway has a width of just 1.20 metres. A crane or alternative mechanical means of hoisting the slabs onto the roof would have to pass through this gap. We found a solution in a micro-crane produced by Uplifter that was designed to be small enough to fit in an elevator for hoisting sections of facade in high-rise buildings. Folded together, it passed successfully through the gap, while unfolded it looks a little like a scorpion. Most importantly, it was strong enough to hoist the slabs onto the roof.

But even then, it still proved difficult to secure the slabs against breakage. The "tongues" of geogrid hanging out of each layer offered a means of distributing the forces. The anchor rods of the formwork were threaded through the geogitter mesh and held in place with the end pieces. These were then lifted horizontally off the ground using heavy-duty straps. To crane them diagonally into place a specially welded lifting rig was used. Only a few of the slabs broke and the smaller sections were placed around the opening for the skylight. In the end the approach worked out well.

After lifting the slabs into place, reinforcement bars for the subsequent casting step to hold the earth roof slabs in place were installed as specified by the structural engineer. The individual rods were threaded through the holes of the geogrid tongues and fastened in place. A solid reinforced earth ring was cast around the skylight to ensure the rigidity of the opening.

To stabilise the massive earth roof, a layer of in-situ cast concrete was to be cast on the upper side. Casting concrete at an angle is a technique generally avoided by contractors and usually entails high costs. We were fortunate enough to find a screed layer who as an apprentice had installed earth floors with his father. For us, this meant he was up for the challenge. And indeed, the screed laying technique with its special settling applicator proved to be an effective means of concreting and smoothing the upper roof surface in two work steps. The screed technique also provided an effective means of creating a straight ridge. To begin with the surface of the incline is levelled manually with a straightedge without paying much attention to the ridge. After levelling the other roof pitch, an exact ridge line results without the need for further corrective repairs.

By this time, it was late November. In the remaining weeks before Christmas, the roof truss was added along with the roof covering of plain tiles. To avoid the need for columns beneath the ridge purlin, a system of tie rods has been used in the roof truss so that vertical loads are transferred via the eaves purlins into the wall.

The construction took place of a period of almost two years. With the help of social networks and earthship, it was possible to recruit many students interested in the building method as well as migrants looking to put their arduous journey behind them. An international group of participants came together united by their interest and enthusiasm. A total of 34 Big-Bags of rammed earth material was installed: that equates to 44 tons of raw material for a summerhouse measuring 4 × 8 × 3 metres up to the eaves.

The building unites traditional wall-forming methods and modern prefabrication techniques with the resulting slabs being hoisted into place with the help of lifting equipment. Both ramming or tamping techniques have their own specific difficulties. Prefabrication adds a level of complication through the need for safe transportation and a means of dealing with the weight of the elements. The travelling wall formwork, on the other hand, is limited to upright wall-like construction elements. This is the primary reason why rammed earth buildings rarely have completely monolithic interiors and are typically comprised of vertical walls on which a separate linear roof structure rests.

After completing the outer shell, we invested in four further Big-Bags of raw material for the rammed earth floor, which incorporates a minimal form of underfloor heating. But that is another story.

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Image credits

Completed building: © Gui Rebello

Site photos: Gereon Legge