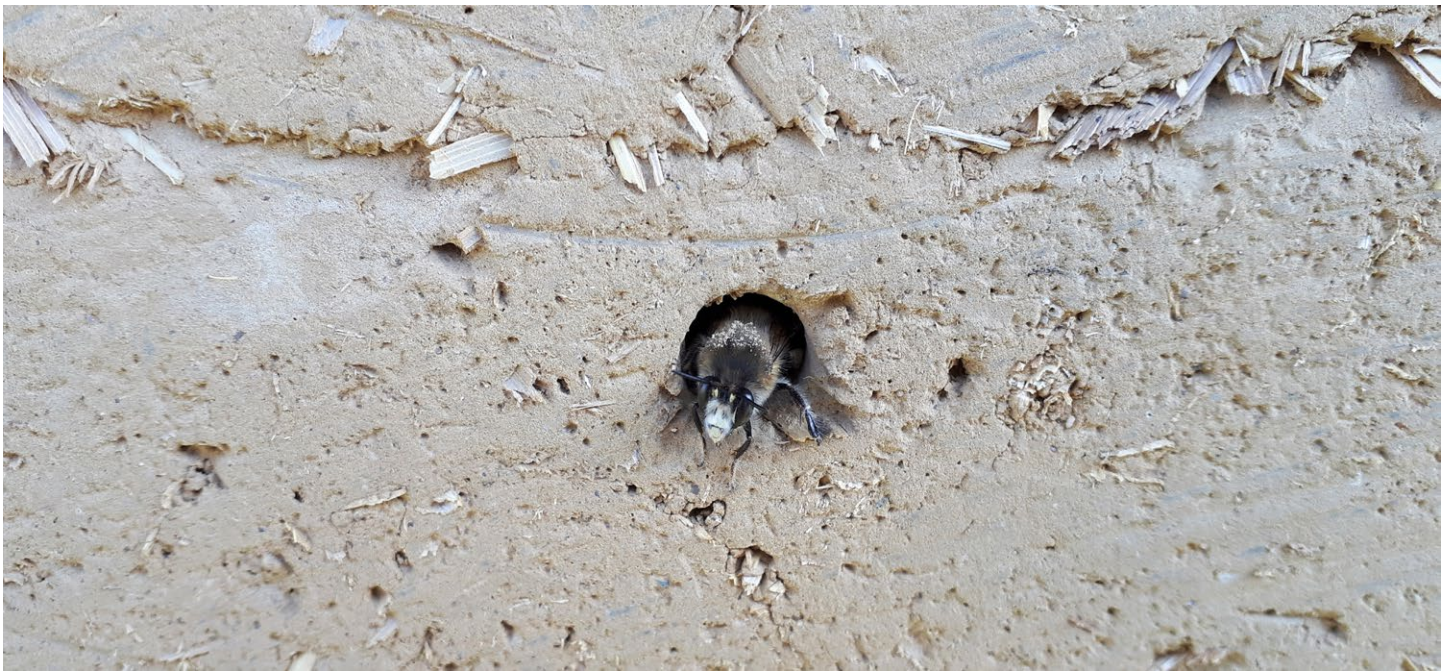


Brandenburg's Alhambra

A loam building ensemble as a prototype for climate-neutral, durable and life-friendly loam construction technology and future-oriented building culture

The bundle of innovations developed as part of the feasibility study for noise protection made of loam in 2020 and 2021 is presented here. In cooperation with the Bundesstiftung Baukultur (Federal Foundation for Building Culture), the Bundesanstalt für Straßenwesen (Federal Highway Research Institute) and the Elbe River Landscape Biosphere Reserve, the idea-finding workshop took place in January 2021 and the planning workshop *'Brandenburg's Alhambra' – a petrol station and service area as a pilot project* in July 2021.



A solitary bee in a cob wall
Photo Christian Hansel

The A14 autobahn will cut through the biosphere reserve and a region that lives, among other things, from soft tourism. As an alternative, the expansion of federal roads would have been possible. This situation was the reason for the project that seeks solutions to mitigate the negative aspects of motorway construction in a landscape- and people-friendly way. The starting point was the potential of the region and the aim is to preserve its special beauty and quality of life and to initiate a forward-looking development.

Soil as the basic raw material for the building material



Loam pit in the Prignitz region (PS Kieswerke Perleberg). Photo Daniel Beltrán

Loam consists of clay, silt and sand and is present in the soil below the fertile layer of earth in large parts of Germany (and Europe). Both the building materials rammed loam and cob are primarily based on loam as a binder and filler. At many construction sites, as also in the case of the noise barrier and the service area on the A14 autobahn near Nebelin, the excavated loam from the construction site can be used for rammed loam and cob construction.

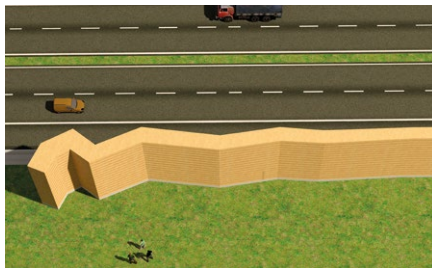
The construction section of the A14 from kilometre 14+000 to 17+450 is only slightly covered with upland sand compared to the sections to the south and north; in the aforementioned section, the till is directly under the topsoil and is often expressed as loam. In general, the Quaternary boulder clay in the region is up to about 5 metres thick. Underneath, there is older bedrock.

Calculated erosion

Both cob and rammed loam initially weather superficially. As a result, the plant fibres of cob emerge and increasingly act as erosion protection. Similarly, in rammed loam, the clay is washed out superficially; the stony material that emerges then prevents further erosion.

Experience has shown that weathering of both rammed loam and cob amounts to about 20 millimetres in 100 years. Therefore, in the current project, already during the design and construction phase, a weathering additive of two centimetres wall thickness will be added to wall surfaces exposed to the weather.

Example for the design of a loam noise barrier



Graphic representation of the shaping at the end of a solid noise barrier wall made of rammed loam. This shaping is statically, acoustically, ecologically and aesthetically effective. Conception of the form: Ute Reeh based on calculations by Jan Mittelstädt. Illustration Sebastian Bertalan

The relevant static stress on a noise barrier is wind. Due to the typical wall geometry, in the edge areas of the construction there is an increased, horizontally acting pressure and suction effect.

By means of geometric adjustments to the height and folding of the wall, stress by wind force in these areas can be reduced to have a more uniform load by horizontal forces on the wall.

Statics: At the ends of a noise barrier made of loam, the shape follows the static specifications regarding the required thicknesses of the wall and their possible reduction through a zigzag shape. This absorbs the higher stress caused by wind in these areas.

Ecological function: At the same time, the shape creates diverse micro-climates favourable for colonisation by insects.

Aesthetics: The form also creates a structured space that is aesthetically pleasing.

Acoustic effect



Surface texture of hempcrete

Loam walls are acoustically insulating. Heavy-duty loam walls are practically sound impermeable. However, flat surfaces reflect sound. In order to prevent sound reflection at the surface, that is, to improve the absorptive properties of the noise barrier, various technical solutions specifically applicable for loam walls are currently being tested by the Bundesanstalt für Straßenwesen (Federal Highway Research Institute).

Hempcrete plating

Hempcrete, a so-called agrarian concrete, is a composite material made of hemp and lime as a binder.

Due to its high light wood content, hempcrete (or hemp-lime) is a carbon-binding material. Because of its high porosity (enclosed air chambers), it has very good sound-absorbing properties. These vary depending on the degree of compaction.

Heraklith plating

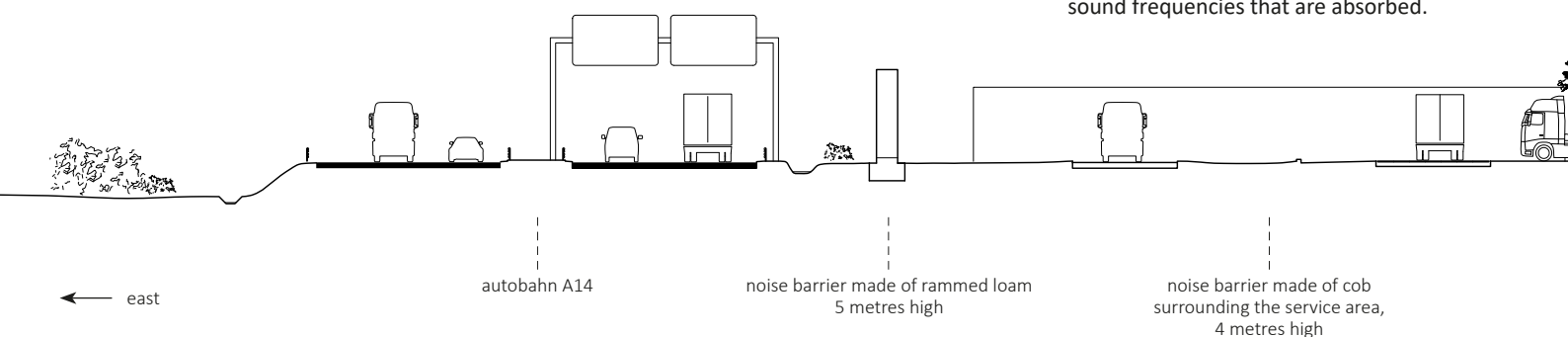
Very similar to hemp-lime in terms of principle and materials is Heraklith. In this case it is wood wool that produces the cavities in the material which make it insulating and sound-absorbing. As it contains a high proportion of organic material, Heraklith also binds carbon and has thus a favourable CO₂ balance.

Natural surface roughening

Both cob and rammed earth walls acquire strongly textured (uneven and bumpy) surfaces due to surface erosion over the course of a few years. The extent to which this natural roughening reduces sound reflection by scattering is subject of investigation.

Reed

The length of reed stalks incorporated into the Weller clay can be used to influence the sound frequencies that are absorbed.



Bee stones – ,insect hotels‘ as erosion dampers



‘Bee stones’ for non-burrowing wild bees, made by children from the Prignitz region. Photo Ute Reeh

The team of experts developed dual-function elements that protect rammed loam from erosion and additionally offer breeding space to insects. Baked at lower temperatures than normal, laterally perforated clay slabs provide a habitat or breeding sites for non-self-digging insects, especially various species of wild bees. They have become rare in the human-shaped agricultural landscape, which has a negative impact on the populations of these ecologically important insects.



‘Bee stones’ lines integrated into the surface of a wall of rammed loam. Photo Ute Reeh

The primary, well proven function of these ,bee stones‘ is to act as erosion dampers when it rains, thus reducing the flow velocity of water running down the wall and directing it away from the wall.

Bee loam as breeding sites for solitary wild bees



Wild bee (red mason bee). Drawing by a pupil of the Montessori School Wittenberge

Of the well over 500 wild bee species living in Germany, around 380 are found in Brandenburg, and about half of these are considered endangered. The majority of wild bees nest endogeneously (in the ground) and create cavities below and/or above ground. Some bee species prefer to colonise steep walls and build their brood cells independently by digging into vertical loamy substrate (steep walls, break-off edges). The existing brood cavities are also used by other insect species in subsequent years.

In order to offer breeding space to self-digging wild bees in the noise barrier loam walls, elements made of only slightly compacted natural loam are built into the wall at suitable locations on the outer side (the side not facing the traffic lanes). The only purpose of these ‘bee loam’ elements — as the research team calls them — is its ecological function, namely to serve as an artificial bluff for certain species.

Unlike the proper material of the loam wall, ‘bee loam’ elements contains neither ballast nor straw, since these would represent a barrier for burrowing insects. In the manufacturing process, suitable hardness is ensured to allow self-burrowing bees to dig through, while still being sufficiently stable. Organic substrate is not added, as it promotes fungal growth in the brood cells. Sharp-edged substrate such as crushed sand is also considered unsuitable, as it would cause faster wear of the bees’ mandibles, their mouth-parts.

Cavities for bats

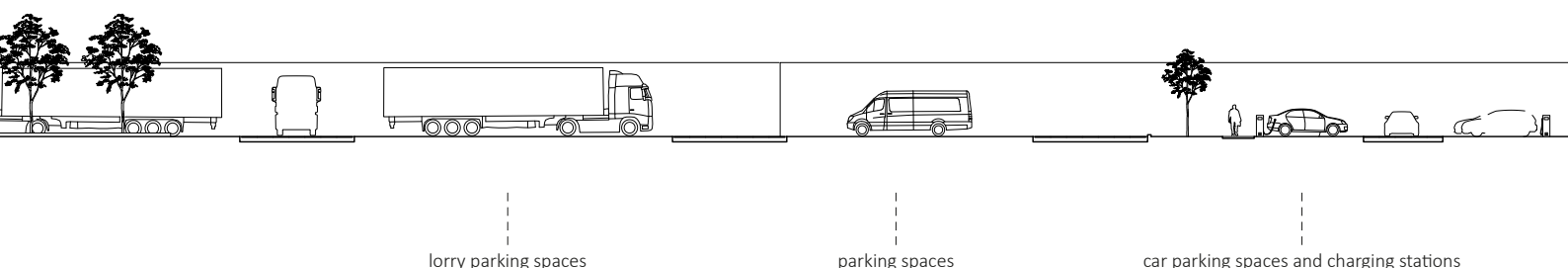


Common pipistrelle. Drawing by Martin Ryll, Montessori School Wittenberge

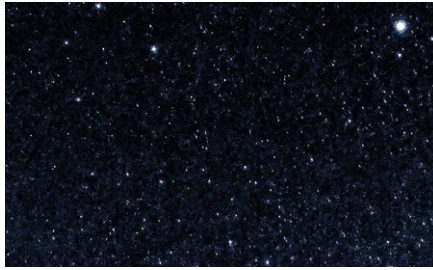
Endangered bat species can be promoted through targeted measures in the cob noise barrier surrounding the motorway service area close to Nebelin.

According to the assessment of the nature conservation expert Andreas Hagenguth, potential colonisation can be assumed for the following bat species that have already been mapped in the vicinity and are all threatened with one exception: pipistrelle, common serotine bat, barbastrelle, grey long-eared bat, brown long-eared bat, common noctule.

For potential colonisation, it should be noted that integration of nest boxes or structures into the clay noise barrier is only considered at suitable locations on the wall (lowest risk of collision, low noise and light).



Illumination concept



Night sky

The lighting of the parking area should be realised by insect-friendly LED lighting to prevent attracting insects, who in turn could attract bats. Artificial lighting represents interference with the species-specific way of life of insects and can have serious negative effects on insects, like especially the trapping effect, but also effects on life cycle, reproduction, etc.

At night, the Prignitz region is today one of the least 'light-polluted' areas of Germany, and on a clear day a magnificent starry sky can be seen here.

Photovoltaic coverings



Solar cells

The one-metre wide area on top of the noise barriers can be easily and safely used for photovoltaic panels. With a wall length of 4.2 kilometres, there is an area of about 4200 square metres available for a PV system.

Cob building construction

The higher compressive strength compared to traditional cob and the considerable logistical improvement resulting from prefabrication by pressing into standardized blocks make cob suitable for use in ecologically more sustainable building construction.

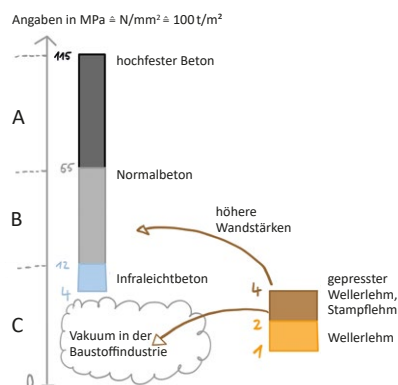
For the fabrication of cob mass, the requirements for the quality of the clay are low. The results of our pressing tests have shown that the right relation of moisture, viscousness of the loam, proportion of straw and pressure can achieve a compressive strength that makes cob usable for certain contemporary building construction.



Sketch by architect Martin Haas for the 'Brandenburg's Alhambra' service area building

Pressure strength of building materials

In some domains of construction, to use concrete, which is indeed mostly used, is like using a sledgehammer to crack a nut. With appropriate wall thicknesses, constructions made of fully recyclable solid loam such as cob or rammed loam can be used in low and medium load applications and replace concrete there.



Application ranges for material strengths:
 (A) High-performance constructions (e.g. dams, tunnels), (B) Medium and highly loaded constructions (e.g. bridges), (C) Lightly loaded constructions (e.g. halls, noise protection). Diagram by Max Dom-browski, TU Berlin, solid construction

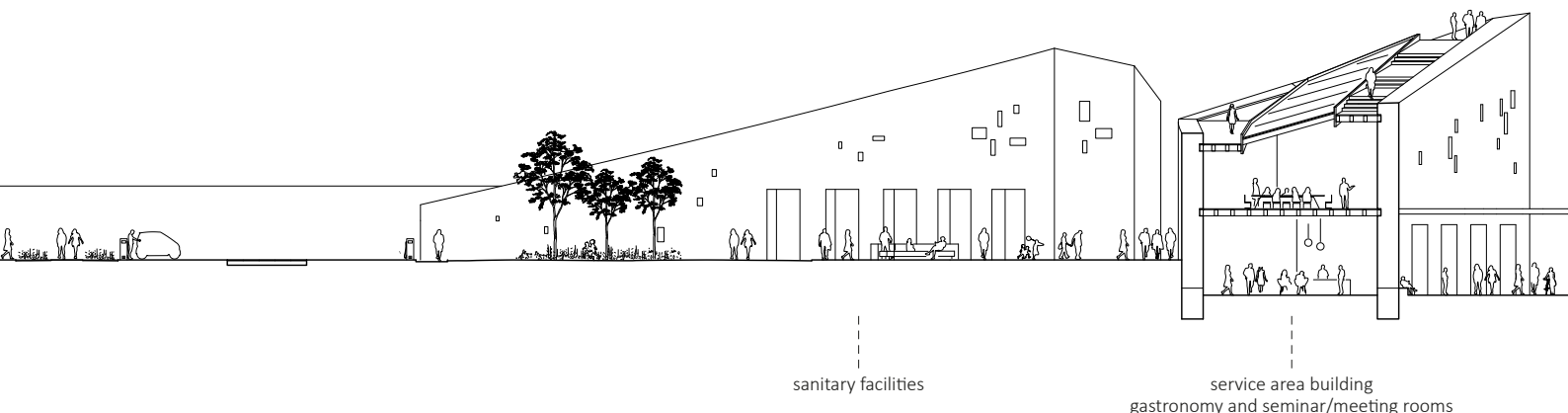
Seminar and conference area



Concept and world. Drawing Ute Reeh

One of the rest area buildings can optionally have a seminar and conference area where, on the one hand, seminars and workshops thematically related to the concern of the project 'Brandenburg's Alhambra' can take place, organised by the 'Academy for Agile Processes' (AAP). This area could also be available to be booked for conferences.

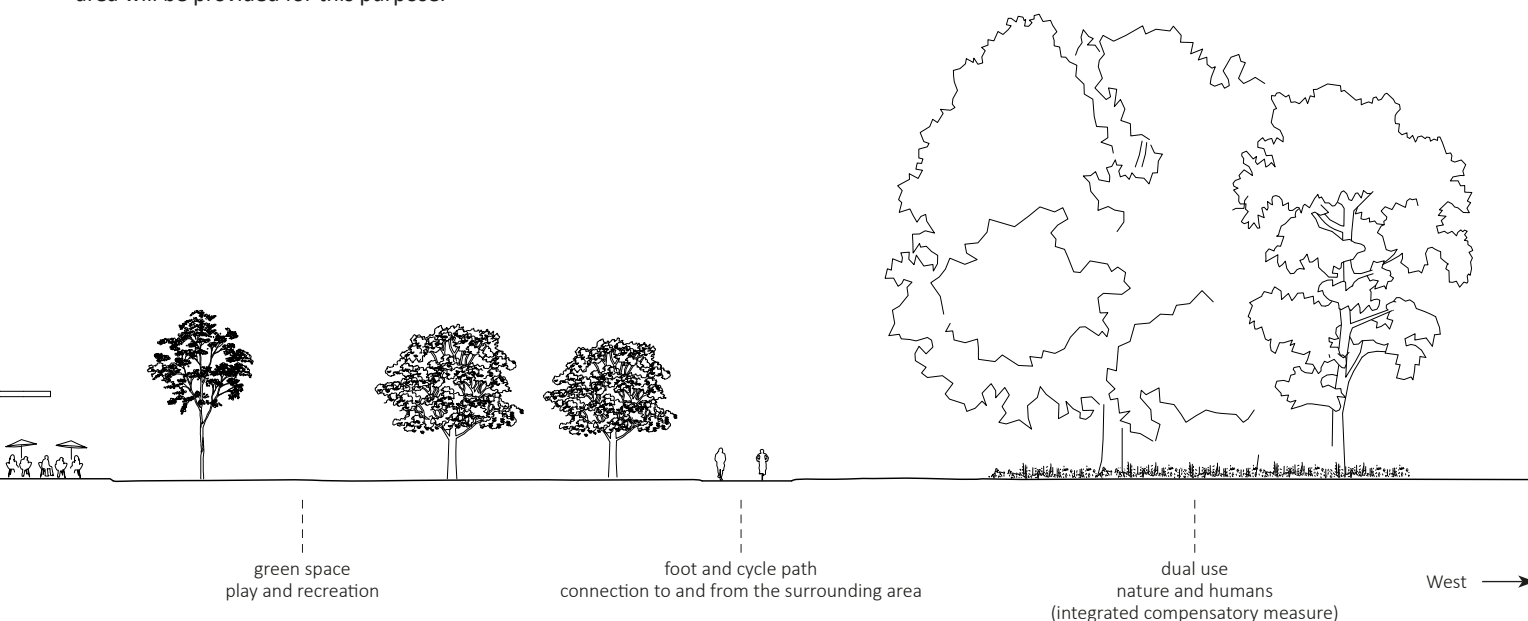
This peripherally located site is precisely between the metropolitan areas of Berlin and Hamburg, between the cities of Magdeburg, Schwerin and Rostock, and can be quickly reached over the autobahn or by shuttle from the Karstädt and Wittenberge railway stations. Compared to the metropolises, this is a locational advantage because you can get there and away quickly, hold concentrated meetings in inspiring surroundings and, if necessary, find inexpensive and relaxing overnight accommodation in the nearby vicinity.



Embedding into the landscape



Aerial view of the surroundings of the future service area, looking east. In the foreground, the land earmarked for the service area. Photo Daniel Beltrán



Cob



Cob block after removal of the reusable formwork.
Photo Fabian Lehmann

Cob construction was particularly widespread in eastern Germany. Numerous over 200-year-old houses and barns with cob walls are still in use today in Saxony, Saxony-Anhalt and Thuringia.

The base material cob is a mixture of clay and straw (or other long-fibre plant stems). Structurally, the straw functions as reinforcement fabric and, on the surface, as weather protection. Since cob contains exclusively plant fibres as an additive, it can be recycled indefinitely or returned to the soil without further processing.

Rammed loam

A well-known example for the durability of rammed loam (also termed 'rammed earth') are the high enclosing walls of the 16-hectare Alhambra in Granada, Spain, which stand since the 13th century — and one must consider that it's in a mountainous landscape with rain and snow.



The Alcazaba, the fortress of the Alhambra city castle in Granada, Spain

Rammed loam is made from a mixture of loam and gravel. As the name implies, the mass is compacted into formwork by pounding. This gives the material a high degree of strength. Surface erosion is limited by the gravel it contains.



Façade of rammed loam, Alnatura Campus Darmstadt, haas-cookzemmrich STUDIO2050/Lehm Ton Erde Baukunst GmbH

Recycling or disposal of cob



Mixing cob mass, in this case using a wheel loader in a gravel pit in Prignitz district. Photo Dieter Günnewig

Both cob and rammed loam are building materials without synthetic additives, such as for instance cement. Apart from clay representing the base material, both cob and rammed loam mass contain only natural additives, a fact that enables either their entirely unproblematic disposal — in some circumstances directly on site by returning them to the ground — or else even repeatedly by recycling for new building structures.

During the first pilot test in 2021 to prefabricate cob blocks by means of a hydraulic press, recycled historical clay from a former Thuringian building dated 1711 was very successfully used as one of the test materials. This proves the full recyclability of the cob material without compromises whatsoever. Due to its specific loam composition, the block proved to be even more pressure resistant than local loam from Nebelin.

Cob is a carbon-binding material

Cob contains a high proportion of plant fibres — usually straw — and thus binds the carbon contained in the organic material. This prevents the release of carbon dioxide which would occur during the natural oxidation of these plant fibres (by either biodegradation or combustion).

Hence, cob is not only a building material made of purely naturally occurring raw materials that can be returned to nature without further processing, but also a material that contributes to the reduction of global warming.



Mischen einer Wellerlehm-masse mittels Radlader Videostill, Kamera Daniel Beltrán

Development of a cob press



Block in 1:4 scale pressed from recycled cob mass from a Thuringian building dating 1711 during a pilot test. Photo Ute Reeh

In order to bring cob technologically up to date, the project team is working with regional partners to develop a hydraulic cob press for the production of prefabricated cob building elements. Cob construction technique, formerly widespread in eastern Germany and originally a purely manual craft, had largely fallen into oblivion or was no longer considered up to date.

The production of prefabricated elements represents an innovation especially in terms of large-scale applicability and productivity. Several aspects make prefabricated cob a modern and versatile building material, such as: high compaction and the resulting compressive strength that is several times higher than traditional cob, lower processing moisture, achievable logistical improvements concerning drying, intermediate storage, transport, mechanical shoring, standardisability, etc.

Loam as a building material of the future

Loam, especially cob, has a hitherto unused potential as a building material that optimally combines the requirements of quality of use, environmental friendliness, sustainability, climate relevance, pleasant and healthy indoor climate even under temperature extremes, integration into the surrounding nature and urban nature as well as liveability in a comprehensive sense. The long lifespan of earthen buildings is today not yet taken into account in economic and political considerations; the advantage of complete recyclability at very low energy costs is also hardly taken into account in project decision-making. As the Bundesstiftung Baukultur (Federal Foundation for Building Culture) puts it, the climate crisis makes clear that "loam is a building material of the future".



Clay quarry in Prignitz district (PS Kieswerke Perleberg). Photo Daniel Beltrán

Why 'Alhambra'?

The project title was chosen as a metaphor for durability and building culture in reference to the rammed earth enclosure wall of the Alhambra in Granada, Spain, which is up to 20 metres high.

'Brandenburg's Alhambra' is a complex of sustainable noise protection construction and a service area on the A14 motorway near the village of Nebelin. It is designed as a structure that protects people, landscape and nature and combines innovative and economical process technology with a contemporary design language.

At the same time, its location adjacent to the biosphere reserve and its function as part of the A14 autobahn ensure its long-term accompaniment as a research and monitoring task of the Elbe-Brandenburg River Landscape Biosphere Reserve and the Federal Highway Research Institute. This way, knowledge about this construction technique can be gained and the expertise about its applicability, further development and ecological impact can be extended.

Sustainability

The noise protection construction ensemble shows how a large infrastructure project (construction of the A14 autobahn) can be monitored in a diverse landscape characterised by both near-natural structures and agriculture, and how the detrimental effects can be reduced while pursuing sustainability goals. This becomes clear in reference to the 17 Sustainable Development Goals (SDGs) to which the Federal Government has committed itself:

SDG Goal 9 – The development and construction of an earthen noise barrier strengthens regional economic performance and local expertise in loam construction. The innovative capacity of small and medium-sized enterprises is strengthened through cooperation with scientific institutions.

SDG Goal 12 – The noise barrier wall uses regional, natural and infinitely reusable building materials with a favourable CO₂ balance.

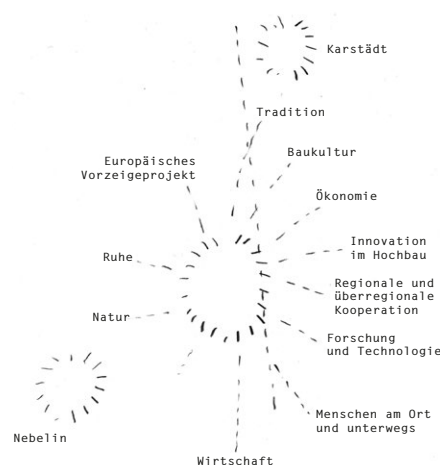
SDG Goal 15 – The loam noise barrier wall provides nesting sites for wild bees, other insects and other protected species.

SDG Goal 17 – The construction of the loam noise barrier stands for intergenerational cooperation for the benefit of the region, such as the participation of the day-care centres and schools from Karstädt and Wittenberge.

Multi-functionality and contextuality

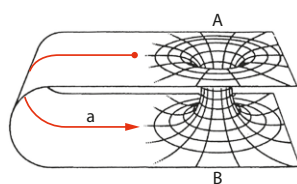
It has long been insufficient to develop spaces or technologies in a conceptually one-dimensional way for singular functions. Multi-functionality and system interconnection are in the focus of current research and represent fundamental tasks in engineering. Functional and constructive ideas must be combined with ecological tasks and economic possibilities.*

The project 'Brandenburg's Alhambra' is conceived as a multifunctional ensemble that combines national transport infrastructure with regional and local infrastructure elements, and that also fulfils service, recreational and protective functions. Under the regulatory and technical specifications, the construction integrates best possible into the natural environment and largely uses raw material from site for the building structures (roughly estimated at 85 to 90 percent of the building mass), which furthermore is processed in an energy-saving manner and is fully recyclable.



Artistic illustration of some relations. Drawing by Ute Reeh

Representing a federal transport infrastructure element in a rural and thinly populated zone, the motorway service station connects urban and rural space. A communication shortcut is created, similar to a so-called wormhole from the theory of relativity, where the curvature of space-time connects two completely different places in the universe.



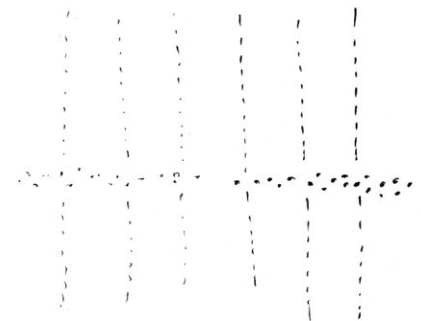
Schematic representation of a wormhole: a represents the normal route from A to B, while b "tunnels" from A to B..

* Excerpt from a text by Peter Köddermann, Managing Director of the *Baukultur Nordrhein-Westfalen*

Process innovation

Infrastructure decisions and construction projects—due to their embeddedness in globalisation processes and factors like for example climate change—are areas in which future developments cannot reliably be predicted, even with the best planning.

Innovative solutions to the complex tasks we face are found through true cooperation, collaboration between very different disciplines, and by interweaving and connecting ideas. Through the participatory planning and creation process in this project, the region is being acknowledged for a pioneering model of nature conservation, innovation and culture. The fact that children and educational institutions from the surrounding area have been involved in the development of ideas from the very beginning has made it clear in a natural way that the future is at stake.



Kategorisierung in Fächer führt zu parallelen Welten. Zeichnung Ute Reeh

All the innovations of this project trace back to the artistically accompanied development process. Visual art, thanks to creative freedom, can initiate new developments, take a pioneering role and have a beneficial social impact. Artistic work involves, among other things, to explore the discrepancy between *weltanschauung* and the real world. In practice, this means to follow ideas and intuitions, to keep an eye on them in their entirety, to combine them in an interdisciplinary way, to develop them further, to implement them concretely and to accompany them with research.

The pressures of the ecological crisis, the lack of equal opportunities for young people, the mutual lack of understanding between East and West in Germany (and in the EU) and between different social groups are all issues that weigh heavily on our society.

The current project is exemplary for the coexistence of local people, culture, landscape and building culture as an extendable and complex system of inventions, ideas, contributions and agreements that can be co-designed or modified by very different social groups. Another function of the artistic process guidance is to keep the ideas and the project in its entirety in view and to present them.



General plan of the concept for 'Brandenburg's Alhambra' on the A14 federal autobahn near Nebelin (montage). The satellite image shows a section of the area surrounding the planned service area. The motorway will run along the existing high-speed train line between Hamburg and Berlin.

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- Dr. Heike Ellner, Elbe-Brandenburg River Landscape Biosphere Reserve (monitoring of bats and wild bees)
- Anika Kristin Gathof, M. Sc., Institute for Ecology, TU Berlin (wild bees habitat)
- Dr. Dieter Günnewig, Bosch & Partner GmbH (Evaluation as ecological compensation measure)
- Christian Hansel, Lehmbau Lovis UG (cob construction)
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- Prof. Arch. DPLG CEAA Heiner Lippe, TH Lübeck (tests and analyses, until 2021)
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- Dr. Sören Müller, Research Centre Extrusion, TU Berlin (mechanical Engineering)
- Mag. Martin Rauch, Lehm Ton Erde Baukunst GmbH, Schlins, Austria (rammed earth construction)
- Ute Reeh, Zentrum für Peripherie (process and form)
- Dr. Fabio Strigari, Michael Chudalla, Federal Highway Research Institute, Department for Environmental Protection (acoustic measurements)
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- Dipl.-Ing.-Arch. Maria Pegelow, Brandenburg Chamber of Architects
- Stefanie Rasche, Baukulturinitiative Brandenburg

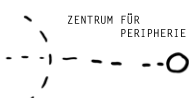
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- Baukulturinitiative Brandenburg (Ministry for Infrastructure and Regional Planning, Brandenburg Chamber of Architects and Brandenburg Chamber of Engineers)
- Matthias Behrendt, head of the village of Nebelin
- Andreas Ditten, Head of Business and Construction, Prignitz District
- PS Kieswerke, Perleberg
- Agricultural cooperative Karstädt
- Montessori School Wittenberge
- Building company Lange, Wittmoor



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**Biosphärenreservat
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