INDUSTRIAL UNFIRED LOAM BRICK BUILDINGS WITH PASSIVE HOUSE STANDARD

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Summary

Together with partners from industry, science and building practice, Wienerberger realised a research project, called **LEHM.konkret (LEHM: loam; konkret: tangible).** The target was to develop building solutions for passive houses on the basis of unfired, improved, industrial produced – and load bearing used – loam bricks in order to reach the highest possible level of sustainability. The project was financially supported by the national program protec NET plus (FFG).

Keywords: Industrialisation of unfired loam bricks; Passive house standard; Energy-efficiency in production and use stage; Health and comfort

1 Introduction

The old building material loam, its ecological and healthy properties, especially the improved living quality, is re-discovered by a continuously growing consumer-group.

Another development can be realised: The increasing need for low energy house concepts. Main benefits of the building system on the basis of unfired loam bricks with passive houses standard are:

- optimum indoor climate due to high mass and high humidity absorption
- minimised use of fossil fuels (during building-material production and use of the building)
- minimised CO_2-emission and minimised emissions of SO_x, NO_x, OrgC, HF
- full recycling of the unfired loam bricks possible

Loam construction has an old tradition – in many ancient cultures impressive examples of loam architecture were built. It is only in the recent past – approx. since World War 2 – that loam construction has been driven out of the industrial building sector. Today it is only very seldom used in Europe as a niche product in the handicraft sector. The challenge of the project is to combine the advantages of the traditional building material loam with the

advantages of an industrial production and meet the current needs concerning energy use of the building.
The four main targets of the research project have been:

- **Improvement of unfired loam bricks:** In the past loam mixtures and brick geometries were developed under consideration of the firing process, unfired loam bricks open new possibilities. It was the aim of the research to develop new a new industrial produced unfired loam product with better structural and physical performances.
- **Building execution:** Further aim of the project is to work out recommendations for execution and construction details of load-bearing inner and outer walls. A central requirement in loam construction is a durable protection against moisture during construction and in use. To reach passive-house standard (U-values between 0,1 and 0,15 W/m²K) was also part of the project.
- **Construction of pilot building project**: A two storey one-family house was realised in the second project phase using the new unfired loam brick and applying the construction details and execution recommendations.
- **Networking and dissemination**: The research results and experiences from the prototypes were disseminated in workshops, excursions, fares and conferences.

2 The project LEHM.konkret

2.1 Improvement of the unfired industrial loam brick

By the drop out of the firing process the unfired loam brick needs different configurations in comparison to the classical fired brick. It was the aim of the research project to develop an industrial produced, unfired loam brick with an optimised performance, like e. g. edge strength, abrasion resistance, bending tensile strength, mechanical resistance and swelling and shrinking behaviour. The optimisation was reached by improving the brick geometries, loam mixtures and by new formats.

2.1.1 Analysis

First step was the analysis of a conventional loam brick before firing process, the study of its material mixture and performance concerning technical and mechanical resistance as well as swelling and shrinking behaviour. The results were demonstrating that the main issues for improvement had to concentrate on comprehensive and flexural strength.

2.1.2 Material mixture

Tests with different additives like straw, sodium silicate, special two component silicate, wooden ash and tennis sand in different mixture proportions were leading to an improved comprehensive and flexural strength of the unfired loam brick. The tests have been made with humidity conditions between 40 % and 80 %.

2.1.3 Brick geometries

Main focus during the development of the final perforation design (see **Fig. 2**), with the perforation percentage of 33 %, was the improvement of:

- Comprehensive and flexural strength
- Thermal capability
- Dermal transfer
- Sound insulation

- Drying properties
- Processing

Fig. 1 Unfired loam brick before optimisation, used not load bearing

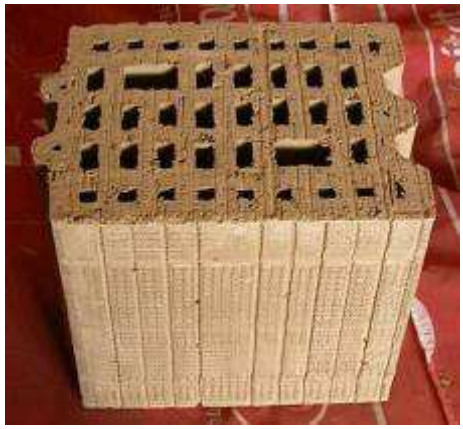


Fig. 2 First prototype of optimised unfired loam brick

2.1.4 Format

The format of the unfired loam was developed by considering the optimised performance concerning comprehensive and flexural strength, processing and brick weight. Final result was the measures of 20 / 25 / 23,4 cm. The final draft of the product was transferred to a prototype-mould with which the first brick prototypes were produced.

2.1.5 Result

With a structural analysis of the building constitution the new product can be used load bearing in two-storey houses. This opens opportunities for several utilizations, especially for one- or two-family houses and terrace houses.

2.2 Building execution, construction details of load-bearing inner and outer walls

The challenge was to meet the special requirements of the building material “unfired loam” as well as the special requirements of the “passive house standard”.

2.2.1 Protection against water and moisture

A central requirement in unfired loam constructions is a durable protection against water or long-term, intense moisture during construction and in use of the building. This concerns different parts of the walls (see **Fig. 1**) such as the ground course or the supports of concrete floors and of course the wall parts with water pipes inside. It is recommended to construct the first two layers with fired bricks to prevent the walls from water of flooded floors e. g. by rain during the execution or rather by the washing machine, bath tub during use of the building.

During the construction of walls their top layer needs to be covered with a waterproof material e.g.

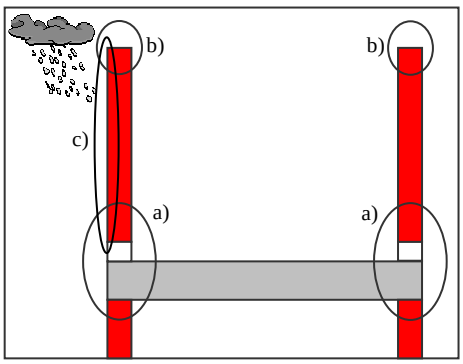


Fig. 1 Different parts of the unfired loam brick walls need durable water protection

bituminized felt, weight down with bricks to avoid rain water penetrating the brick perforation. Water has to be lead off in a controlled way. During a long lasting rain period the weather side has to be protected with a waterproof cover. (See **Fig. 4**)

The supports of the concrete floors have to get a waterproof levelling course. (E.g. bituminized felt on a levelling concrete course) The parts of the walls around water pipes have to be constructed with fired bricks or need to be covered with a sealing coat.

Fig. 3 Durable water protection during execution

Fig. 4 Fired window and door lintel with 25 cm bearing support at each side

2.2.2 Passive house standard, static

For airtight fixing of the windows or doors a levelling concrete course around the wall opening is recommended. The heavy windows and doors with passive house standard have to be fixed at the top (fired window/door lintel) and bottom (concreted window sill) instead of being placed to the side parts of the wall openings. (See **Fig. 5**) Tests confirmed that isolation foil has the same adhesion quality on unfired loam bricks as on fired bricks.

For the fixing of insulation systems, conventional bonding-technologies are recommended instead of screwed fastenings techniques.

In the case of static conditions point loads should be avoided. If this is not possible, integrated columns will allow for additional support. (See **Fig. 6**)

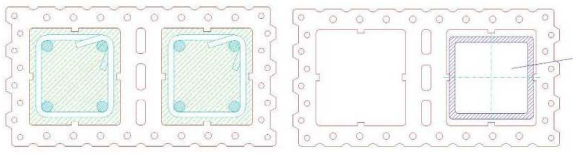


Fig. 5 Opportunities for integrated colums inside the unfired loam bricks

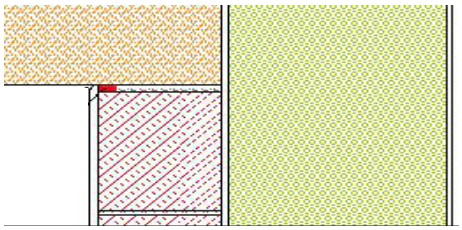
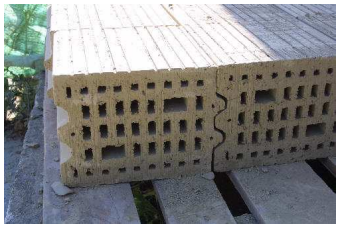


Fig. 6 Support of sanded bituminized felt on a levelling course

For the support of the ceilings, tests with different materials have been done. The best results have been achieved with a combination of sanded bituminized felt on a levelling course of mortar which gives an even surface and a steep connection between walls and ceiling. In addition the solution provides a water protection of the top layer. (See **Fig. 7**)

The complete descriptions of the construction details and execution recommendations are available in the final report of the research project. (Contact author)



Load bearing and not load bearing inner and outer walls are constructed with unfired loam bricks

The first 1-2 layers on ground level and on the floor slab are constructed with fired bricks

The unfired loam bricks were processed as fast as conventional bricks

During the construction of the unfired loam brick walls the top layer were protected of rain with a cover.

The top layer of the walls were protected of water which arises by the concreting of the floor slab

Finished building shell of the LEHM.konkret pilot building project

Fig. 7 Mini picture diary of the LEHM.konkret pilot building project

2.3 Construction of pilot building project

Part of the research project LEHM.konkret was the realisation of a two-storey family house. All walls of the building, load bearing and not load bearing, have been constructed with the optimised unfired loam brick. The main experiences are listed below:

2.3.1 Fixing of windows

The windows have been fixed in the described way. To the sides the windows have only been attached with spacer screws. (7,5×152 mm, each 80 cm). One third of the window frame is positioned to inside of the insulation level.

2.3.2 Peak loads, ceiling supports

Due to the element ceiling the inner side of the top brick layer is burdened by a high knife-edge load. (~ 800 kg/m) For a better load distribution the top of the walls were topped with a levelling course of concrete.

2.3.3 Electrical installations and other works at the walls

Horizontal electrical installation lines in the brick walls have been avoided, beside a few exceptions, which have a maximum deepness of 10 % of the brick wall. Water pipes are mainly lead in the floor. Standard fixing works can be done with usual dowels.

2.3.4 Internal plaster

As the inner layer of the wall construction has the highest influence on the indoor air quality, loam plaster was used for the inner sides of all walls. Conditions for a fast drying of the loam plaster had to be guaranteed. Due to the time constraints of the project the plasterwork has been done during winter time, although it is recommended that the plasterwork be done during the warm season. To avoid cracks resulting from the outside

temperature and the air tightness of the building a ventilation system was used. (The filter was changed afterwards)

2.3.5 User experience

After completion of the project in summer 2006, the feedback of the house owners was very positive. The energy consumption fulfils the expectations on a passive house. Concerning the balance of indoor air humidity the house owners approved that "the bathroom mirror never becomes fogged due to the sorption performance of the unfired loam" The sorption ability of the unfired loam of course is limited by the humidity availability inside the house which means that during winter time the air became dry even in the pilot project.

Fig. 8 Finished LEHM.konkret pilot building project

3 Conclusion

For the successful planning and execution of this kind of building system certain rules, based on the special properties of the building material and the special needs of the passive house standard have to be considered. With the consideration of these requirements the final result is very satisfying and a consequent example for sustainability.

Nevertheless there is the need and a lot of potential to extend the technological and scientific experience concerning this construction system. Especially the performance of the unfired loam brick in the case of comprehensive strength and water resistance will get improved by an extended research activity of Wienerberger. Further investigations will also be done concerning detailed construction solutions, standardisation criteria, training tools for architects and labours.

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