Modern Earth Building – the Current State of Earth Building from a German Perspective

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Abstract. Modern earth building today is in quite dynamic development process. While it was a quite “exotic” building material in the end of the last century it is today well know as a sustainable and appropriate building material. This paper will focus on Standards and Regulations, Environmental Product Declarations (EPD), Earth building in teaching and vocational training as well as on innovative earth building products introduced in the market. The new and revised DIN on earth building products will be published within a year as well as the Environmental Product Declarations (EPD). Strategies to embed earth building in teaching and vocational training of building professionals are ongoing and will be presented like introduction of earth building skills in the formal educational framework of building trades. Innovative earth building products are introduced in the market with prefabricated rammed earth elements, a number of clay boards and combined construction techniques of wood and earth panels not to forget the use of straw bale building in combination with earth products to mention just a few aspects.

1. Introduction
Modern earth building is today experiencing a period of dynamic development. While still a rather “exotic” building material at the end of the last century, earth is now widely known as a sustainable and appropriate building material. The increasing application of earth building techniques in building practice brought new challenges, such as the reintroduction of a regulatory framework, quality control, qualified vocational training and education in earth building to mention just a few key aspects.

2. Reintroduction of earth building in the regulation framework
An increasing awareness of ecological issues from the 1980s onwards led to the development of the “Lehmbau Regeln” in the 1990s as a first set of regulations for building with earth. Although it was recognised as part of the German building regulations, and served well in practice for over ten years, the German National Institute of Building Techniques (DIBt) made it clear that for earth building products to be legally recognized in the construction market, the development of DIN codes for earth building products was unavoidable. The Dachverband Lehm e.V. as the German Association for Building with Earth took up this challenge.

The DIN codes for earth building were introduced in Germany in 2013 after an intensive five-year development process that encompassed applied research in cooperation with national institutes along with an extensive multi-stage consultation process involving expert groups and manufacturers, as well as the DIN ratification process itself, which was supported financially by the building material producers. New and revised DIN codes on earth building products were published in December 2018.
Figure 1. Research on testing procedure on earth blocks [1]

DIN codes have been developed for several factory-made earth building products and define the relevant terms and testing procedures.

- E DIN 18942-1:2018-04 Earthen materials – Part 1: Vocabulary
- E DIN 18942-100:2018-04 Earthen materials – Part 100: Conformity assessment
- E DIN 18945:2018-04 Earth blocks – Terms and definitions, requirements, test methods
- E DIN 18946:2018-04 Earth masonry mortar – Requirements and test methods
- E DIN 18947:2018-04 Earth plasters – Requirements and test methods
- E DIN 18948:2018-04 Earthen boards – Requirements and test methods

As these codes are – and currently remain – the only codes on earth building in Europe they are of special interest to our European partners as well as worldwide. The spectrum of the currently available earth building DIN codes reflects the development of and demand for earth building products in Germany today. The availability of quality-controlled earth building materials as defined by the DIN makes it possible to incorporate their codes into application standards of general product categories such as DIN 18550, the German code for internal plastering. As a consequence, earth plasters are now listed alongside cement-, lime- and gypsum plasters and approved for all standard indoor applications. A key advantage of the DIN code is that it defines certain material properties that factory-produced earth building products must adhere to, providing a high level of reliability and therefore consumer protection.

3. Environmental Product Declarations (EPD)

A further important area of demand concerning earth building products today is the broad topic of ecological assessment and certification.

In Germany, the Model Building Code for the States of the Federal Republic of Germany defines general requirements that building materials and building elements have to fulfil with regard to technical quality. This code lists the following aspects as the main requirements for a building materials’ or building elements’ suitability for use:

- mechanical strength and stability,
- fire protection,
- hygiene, health and environmental protection,
- safety in use,
- sound insulation,
- energy conservation and heat insulation.

With the European Parliament and European Council’s regulation “laying down harmonized conditions for the marketing of construction products” published in March 2011 [2], an additional requirement was introduced: the sustainable use of natural resources. According to the regulation, buildings must be
designed, built and also demolished after use in a manner that facilitates the sustainable use of natural resources and guarantees the following:

- The building, its building materials and building elements need to be recyclable after demolition.
- The building must be durable.
- Environmentally-friendly raw materials and secondary building materials must be used in the construction of the building.

This regulation also stipulates that the EU member states apply principles of sustainable development to building activities in their respective countries.

ISO 21929-1 is the international standard defining a framework for the development of indicators and for the compilation of core indicators for buildings, and ISO 15392 formulates general principles for sustainable building. German standards for the assessment of the sustainability of buildings regarding to their environmental, social and economic qualities are set out in DIN EN 15643.

Within this process, life cycle assessment has become a generally accepted methodology for the quantitative evaluation of the sustainability of building materials and building products.

The following standards for conducting life cycle assessment are currently available at a European level: – DIN EN ISO 14040:2009-11 Environmental management – Life cycle assessment – Principles and framework, and DIN EN ISO 14044:2006-10 Environmental management – Life cycle assessment – Requirements and guidelines.

The DVL project “Development of framework conditions to elaborate a model EPD for earth building materials” (EPD Earth), supported by the German Federal Environmental Foundation (DBU) was completed successfully within a period of 20 months from November 2016 to July 2018.

The first Life Cycle Inventory analysis (LCI) conducted as part of the project revealed interesting results when comparing the total use of renewable and non-renewable primary energy resources (PET) for clay plaster mortar (CPM) and other typical mineral plasters and building products (MJ/kg). The LCI for the PET of moist CPM is approximately one tenth of that of concrete (normal) and gypsum plaster. The PET data of pre-dried and post-dried CPM are similar to that of lime-sandstone and normal concrete but even better than gypsum and cement plaster mortar, which are the main “competitors” in practical use. As such both producers and users of clay plaster mortar have a winning argument in the debate on environmental quality of plasters, as detailed in the official EPD which provides certified data.

Figure 2. Storage of clay plaster mortar ready for shipping out [3]
4. Qualified vocational training and education in earth building

To complement the above product quality initiatives, the DVL pursues a number of strategies to embed earth building in the teaching and vocational training of building professionals, as well as in the formal educational framework for the building trades. These ongoing long-term strategies are complemented by parallel strategies for developing educational courses in academic and further education and qualification fields.

Alongside the embedding of earth building skills in the list of subjects of the core curriculum for the vocational training of building professionals and the development of a corresponding training module for earth building, the establishment of the “Specialist in Earth Building” (FKL) further education course is one of the most significant steps towards promoting the introduction of earth building skills at a broader level. The next strategic objective is to incorporate earth building as part of the basic initial training of building professionals.

The Dachverband Lehm e.V. would like to establish earth building as a dedicated training module in the national vocational training curricula. This has gained new impetus through the introduction of the new DIN norms for factory-produced earth building products in 2013 as demand for these newly regulated building materials also necessitates their proper and qualified application by the respective building trades.

All educational courses in Germany have to be classified according to the German Qualifications Framework which corresponds to the European Level EQF and ECVET systems:

| DQR level | Corresponding qualifications |
|-----------|------------------------------|
| 1 and 2   | Preparatory and entry-level vocational training |
| 3         | 2-year initial vocational training |
| 4         | 3 or 3½-year initial vocational training |
| 5         | Further training |
| 6         | Bachelor-equivalent qualification, master, technician … |
| 7         | Master-equivalent qualification |

Figure 3. Rammed earth sample made by participants of the “Specialist in Earth Building (FKL)” training course, Düsseldorf, Germany 2015
The number of courses on earth building in higher education in Germany is increasing steadily, although most of them are currently optional elective modules and not a mandatory part of the respective study programmes. This currently remains a significant shortcoming in the academic teaching of earth building. Looking beyond Germany, there are very few dedicated earth building study courses: the postgraduate course for architects and engineers offered by CRAterre’s DSA (CRAterre-ENSAG) in France along with variations of this programme in India (Auroville, AVEI School) and in Latin America for a recognised master’s degree in earthen architecture. To address this shortcoming, the DVL association has developed an “Earth building today” roadshow to support lecturers and students interested in sustainable construction with information, knowledge and contacts.

Last but not least, the series of LEHM conferences offers a further platform for the academic exchange of knowledge, information and opportunities between experts in the field. Additionally, the DVL Earth Building Prize for Young Academics, awarded by the DVL for the first time in 2016, aims to promote the study of earth building in an academic context. It recognises academic work of excellent quality that demonstrates a firm knowledge of earth building and makes a forward-looking and original contribution in the fields of design, construction, research or development. The next in this series of important academic exchanges will be the LEHM 2020 International Conference on Building with Earth to be held in Weimar from 30 October – 1 November 2020.

5. Innovative earth building products

In recent years, a range of innovative building products have entered earth building market such as prefabricated rammed earth elements, different kinds of clay boards and panels and hybrid construction techniques using wood and earth building products or earth and straw bale building.

![Figure 4](image_url). Prefabricated rammed earth blocks with integrated heating/cooling pipes assembled on site at the new ALNATURA Headquarters in Darmstadt, Germany (construction by Martin Rauch – Lehm Ton Erde Baukunst GmbH)
Figure 5. 1:1 model of construction details using a combination of natural materials such as straw, lime, wood fibre and earth at the North German Centre for Sustainable Construction (NZNB) in Verden, Germany.

It is worth noting that some of these flagship projects in the field of renewable building materials are able to be realised in countries without standardised renewable building materials. The success of these projects is due largely to the knowledge and expertise of individual protagonists. Despite the recognition and positive public resonance they generate, the emulation effects that may follow from these exemplary buildings cannot achieve the same broad scale of accepted use of earth building materials that the establishment of official codes, rules and standards in the industrialised countries can generate.

6. Local and global networking

Nowadays online presentation and communication is a vital means of generating awareness and recognition. Alongside our main association website www.dachverband-lehm.de we also run the platform www.uni-terra.org for academic exchange. We also maintain active partnerships with other earth building associations in Europe and abroad. In addition, we follow and keep in touch with the international community on earth building.

Earth is an essential building material for vernacular architecture, especially in arid and semi-arid climate zones. Earth has excellent potential as low-tech material in rural and remote areas in which most of the global population still lives, and also a means of countering the origins of many of the man-made causes of migration.
Figure 6. Pre-school in Aknaibich in southern Morocco built of nature stone, earth and wood using passive climate control designed by BC architects and MAMOTH [4]

Figure 7. Earthbag clay house for Nepali farmers using the guidelines of Ithake Institute [5]

At the Ithaka Institute, Gernot Minke and Hans-Peter Schmidt published guidelines for constructing houses using the earthbag method just a few weeks after the earthquake disaster in 2015. Such immediately applicable forms of support for stricken and poor populations cannot be overestimated.
Another approach is a modernised form of vernacular architecture using innovative construction methods and different materials. Several impressive examples have been built including the following:

![Guesthouse Xiangshan Campus Hangzhou by Amateur Architecture Studio](https://www.wbw.ch/cms/cache/a252df9e4132db9700519913c2c42e40.jpg)

**Figure 8.** Guesthouse Xiangshan Campus Hangzhou by Amateur Architecture Studio (photo: Iwan Baan) [6]

While the roof is born by a series of frameworks, more than thirty rammed earth wall sections, built on site using locally-excavated earth defines its structure. Bamboo from the surrounding area is used as reinforcement to improve earthquake resistance. Individual concrete elements add additional strength.

### 7. Conclusion

Earth is an essential building material around the world, and especially in developing countries. There are numerous examples of vernacular architecture and appropriate technologies in almost all regions of the world that involve sustainable and resilient construction using earth. All these different types of construction, and the many combinations of earth with other natural and sustainable materials offer us a model that can provide answers to the challenges of providing housing today and in the future.

### References

[1] Ziegert-Roswag-Seiler (ZRS, Berlin Germany)

[2] European Parliament; Council of the European Union 2011 Regulation No. 305/2011 (Construction Products Regulation, or CPR) of the European Parliament and of the European Council is a regulation of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC. Brussels: Official Journal of the European Union L 88/5, 4 April 2011

[3] https://lehmmputz/

[4] https://www.archdaily.com/572207/preschool-of-aknaibich-bc-architects-mamoth/54752336e58ece37940000f4-01-aknibicharchitecture-frankstabel-jpg

[5] http://www.ithaka-institut.org/en/ct/120-20-Earthbag-Clay-Houses-for-Nepali-Farmers

[6] https://www.wbw.ch/cms/cache/a252df9e4132db9700519913c2c42e40.jpg

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