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## **EARTH** as a contemporary design object



# 1. Abstract

Unfired earth materials present an opportunity for sustainable architecture on different levels. From an environmental point of view, earth has a triple benefit in the life cycle; the resource being abundantly available, the low need of energy to process the material and the potential for harmless disposal at the end of life. Additionally, in order to create a successful sustainable design, the material needs to be appreciated by its users, whether it is used for a building, building component or an object.

This research aims to put forward ways of using earth in a contemporary way through the method of Material Driven Design. The aim is to propose unfired earth material applied in a way that is attractive to the user and, meanwhile, taking into account environmental aspects. Exploratory interviews and a survey with a public of laymen and architect/designers were done to analyse the way they experience (unfired) earth. This input was used during the designing and building of an earth object; a combined phone vault and bedside lamp.

Rather than designing a building or building part, an object allows to go more profound into refining the shape, texture, production process and finishing method. Meanwhile, the deliberate choice of making a daily object, allows to introduce a more general public in order to provoke discussion on the material experience of earth. This way the object design can potentially function as a catalyst, between raw material and full-scale construction.

This paper gives an overview on the former steps (interviews, survey) and following reflections on potential tracks of using earth when applied in a contemporary western European context. The research for design phase guided the design process towards a specific shape and materiality. The process of materialisation is briefly presented, from material tinkering to a very defined production process. Lastly, a further example on how to apply a similar research and design process in future earth designs or applications on an architectural scale will be presented.

## 2. Introduction

### Earth as matter of research

Due to the pressure of the construction sector on environment and society, sustainability has become a mainstream concern in architectural theory and practice (Khan & Allacker, 2015). Within the field of sustainable building, there has been an evolution from a discourse about energy efficiency to broader environmental and social concerns (Owen & Dovey, 2008; Vezzoli, 2014). Environmental concerns have led to an increased awareness on the environmental impacts associated with a material and building's life cycle and an increased interest in natural and bio-based materials (such as wood, hemp, earth, bamboo, mycelium,...) (Bahrudin et al., 2017; Harries & Sharma, 2016; Laborel-Préneron et al., 2016; Peñaloza et al., 2016). Unfired earth has the potential to contribute to buildings with a low environmental impact. This claim is based on its triple benefit in the life cycle: the resource being abundantly available; the low need of energy to process the material; and the potential for harmless disposal at its end of life (Arrigoni et al., 2017; Pacheco-Torgal & Jalali, 2012).

Although earth building is an experimental niche in Flanders (Lefebvre, 2018), the material received significant interest; exhibitions specifically about earth construction (Terra award in Mons, Brussels, Tienen) and contemporary architectural projects using unfired earth (rammed earth tower Negenoord, bioclass Edegem,...) have emerged the past decade. However, the appreciation of sustainable and natural materials stays limited to niche user groups (Sauerwein et al., 2017). In order to create a successful sustainable design, the material needs to be appreciated by its users, whether it is used for a building, building component or an object. The aim of the ongoing PhD project is to investigate how the material earth can contribute to a sustainable, contemporary, architectural design, based on a research by design methodology. The more specific question that arises is: 'how can we design and build with earth, in a way that is attractive to the user and, meanwhile, taking into account environmental aspects?'

## 3. Methods

### Material Driven Design (MDD) as method of research

Active participation in, and creation of, contemporary design and build projects with earth is a preferred method of creating knowledge and insights. In order to investigate how we can design and build with earth in a way that takes into account the desires of the user, a focus on material experience has been introduced. The term material experience has been widely used in the field of product design, and is concerned with investigating how a material is received, what it makes people think, feel and do (Karana, Pedgley, et al., 2015).

A method to facilitate designing for material experiences has been developed by Karana, Barati, et al. (2015): Material Driven Design (MDD). Four main action steps are used in this method (as shown in fig.1). These steps are applied for using a material, in this research unfired earth, as the point of departure in the design process.

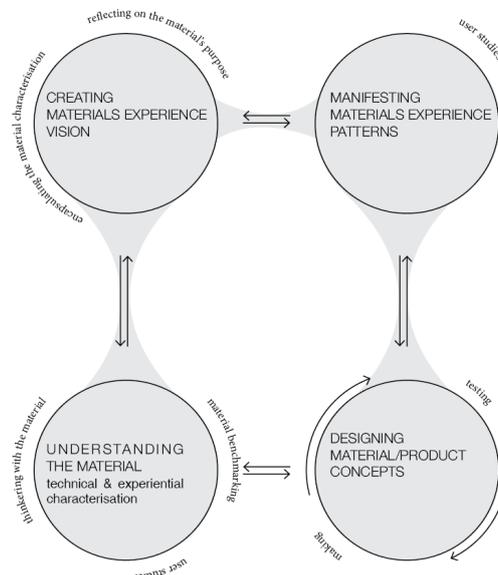


Fig. 1: a scheme of the material driven design (MDD) method. Based on Karana, Barati, et al. (2015)

### **Terramigaki design competition**

In this paper, a design and build process has been performed, applying the Material Driven Design method. As input for the design brief, a yearly design competition (organised by Politecnico di Milano) was used. The Terramigaki design competition focusses on designing contemporary products manufactured with unfired earth (TMD, 2019). In short, the aims as described in the competition brief are the following:

- create an object or furniture with unfired earth
- it should be sustainable
- it should use the specific properties of unfired earth
- it should be contemporary

The final result of the design and build process is the earth design object Monk; a phone vault and bedside lamp. Throughout this paper, different steps of the Material Driven Design process will be pointed out, applied on the development of the Monk design.



Fig. 2: the Monk, final prototype as submitted for the Terramigaki competition

## 4. Results and discussion

This chapter is structured along the different steps of the Material Driven Design method, as applied during the design process of the MONK. The goal of the method is to facilitate a conscious way of designing with earth materials, while taking into account material experiences.

- 4.1. Understand the material through a technical and experiential characterization.
- 4.2. Create a vision on the design, based on reflections of the potential purpose of earth material and the given constraints of the design task.
- 4.3. Do user studies to verify if the desired material experience vision is indeed received as such.
- 4.4. Build the design into an actual physical object, taking into account the former steps, but make practical decisions during the building process.

### 4.1. Understanding the material: technical and experiential characterization

#### State of the art on earth materials

A first aim is to gain an understanding of the main technical properties of earth materials, the constraints and opportunities and the most convenient manufacturing processes to form the material. Hands-on workshops with earth, building case studies and interviews with architects, experts and users have been used to gain empiric knowledge on the topic. Some conclusive findings have been summarized in the paper: 'Potential of contemporary earth architecture for low impact building in Belgium' (Van der Linden et al., 2019). In this paper, the potential of contemporary earth architecture in Belgium is investigated by means of a literature study and a case study analysis of two projects using unfired earth, recently built in Belgium. Resulting in a reflection on the application of earth in Belgium from an economic, technical and environmental perspective.

#### Tinkering with earth

Through a process of material tinkering, a series of material samples from unfired earth were developed. These samples present a variety of tactile and visual properties through variation in mixture, polishing, colouring of material, grain sizes, etc. Material tinkering is a practical and creative approach through experiential learning (Parisi et al., 2017). On a material sample scale, the goal was to create a variety of sensorial and experiential qualities. Therefore, the gathered raw materials included clays in different colours, sand and gravel in different grain sizes and fibres in different length and thickness (fig. 3). All samples were produced in a formwork, varying in mixture of the raw materials, amount of water added and amount of ramming. This resulted in a series of samples (fig. 4), which could be categorised in difference in colour, roughness and fibrousness. The material samples are later on used in user studies (4.4) to investigate the sensorial and experiential qualities.



Fig. 3: a selection of the raw materials, used for the material samples, all gathered from Belgium and categorized according to grain size, colour, sourcing distance, etc.



Fig. 4: a selection of the material samples, varying in colour, roughness, fibrousness, size & shape, etc.

## 4.2. Create material experience vision

### function

For the Terramigaki competition, it was a demand that the object should use specific characteristics of unfired earth. Based on the state of the art of earth materials, a distinctive technical characteristic of unfired earth is its hygrothermal buffering; the potential to slowly take up or release heat or moisture. After analysing the design proposals of former competition editions, it was clear that several of the winning designs already used the valorisation of the thermal buffering potential, usually by integrating a heating element. Also the potential to buffer moisture had been valorised in the winning design of last year in the form of a moisturizer. This meant that, when wanting to point a unique opportunity of earth, another characteristic had to be selected.

In the book *building with earth: design and technology of a sustainable architecture* (2007), Minke refers to experiments that pointed out the potential of earth as a shelter against high-frequency electromagnetic radiation. The idea of a phone case from unfired earth that can block the radiation and sound of your phone, for example while sleeping, would originally point out technical properties of earth. Meanwhile it could also be interpreted as a very contemporary function, as a reaction to the ever increasing presence of technology, wireless signals, sounds and impulses. Unfortunately, the current prototype did not succeed in fulfilling this function of effectively blocking the radiation and sound.

### materiality

**attraction.** The intended experience for this earth design is that the material elicits attraction. The proposal was to reach this by striking a balance between refinedness and imperfections, which can both be reached with earth materials, thanks to the variety of possible mixtures and shaping processes.

**refined.** Material tinkering resulted into several samples with a very irregular texture due to the use of bigger gravel particles (e.g. 1,2,3) or the use of big fibre particles (7). These 4 samples were given the lowest score for 'attraction' during user studies (see 4.3.). Based on these results, it was decided that refined seems an interesting property to reach attraction.

**imperfections.** Aiming for a material that is refined does not automatically mean that it should resist as much as possible to become imperfect. The goal is that the material has a finishing that is still associated to the original earth material. This goal derives inspiration from the concept of Wabi-Sabi; a philosophy that embraces three basic realities of the material world: 'nothing lasts', 'nothing is finished', and 'nothing is perfect' (Tsaknaki & Fernaeus, 2016). In the case of earth, it is intrinsic to the material that there are certain imperfections in its texture. An approach based on imperfection and graceful aging of materials has been proposed in 'Toward a New Materials Aesthetic Based on Imperfection and Graceful Aging', by Rognoli and Karana (2014). They propose that the consideration of imperfection and graceful aging can lead to create an 'aesthetics of sustainability'. In other words, the goal is the creation of unique, positively experienced, aesthetically pleasing products that can elicit long-term user attachment.

**naturalness.** Following the Wabi-Sabi philosophy, it is suggested that a natural material should communicate its naturalness (till a certain extent). Based on exploratory interviews, it was concluded that a materiality that is perceived as natural is related to more ecological materials, which is positive in the sense that through such an association the material can communicate its ecological value, and it might be a trigger for material selection.

### shape

When envisioning the shape that the phone vault should have, it was the will to create an object that could appeal to a larger public than the people that are already enthusiastic about earth. To do so it was envisioned to develop a daily object that fits in the living environment of people. In parallel to what conventional materials often offer, it was envisioned that the object would follow a contemporary style of straight lines and corners. With these ideas in mind, the design of the MONK grew; a bedside design object with a built-in lamp, inspired by popular minimalistic design lamps.

### 4.3. User studies: experiential characterization and manifesting material experience characters

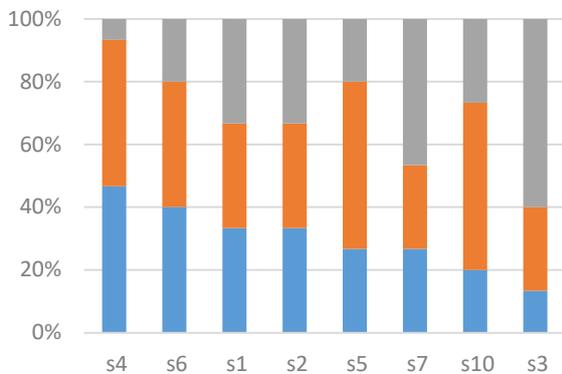
User studies have been used to verify if the intended material experience vision has indeed been successful for the material sample that was used in the Monk design (sample 4). A survey and a series of semi-structured interviews were done to unravel the material experiences of users as proposed in the MDD method; what are certain associations or elicited emotions? A wide range of experiential characteristics have been gathered based on 120 surveys with 30 different persons, on 8 selected material samples (fig. 5).



Fig. 5: The studied materials 1,2,3,4,5,6,7,10

Sample 4 (s4) is the sample that has been used for the Monk design. As can be read from fig. 6, the respondents state that sample 4 has some attractive characteristics that were not present in the other samples. The Monk sample (s4) was experienced as not too rough, while it still has some texture and incoherencies. Also it's rather soft with a warm colour. Meanwhile the colour is coherent with the natural earth colour that is predominantly present in the area where the survey was done, which might have influenced the association of a natural material to the respondents. S4 also scored the highest in trust, which might be related to the particle sizes, being smaller than a regular rammed earth, making it more solid, more trustworthy. An addition of cellulose fibres adds to this strength, while making the material slightly fibrous as well. This in turn recalls the natural and ecological image of the material. All participants associated S4 with natural (as shown in fig. 7).

(rather) attraction    neutral    (rather) disgust



(rather) natural    neutral    (rather) innatural

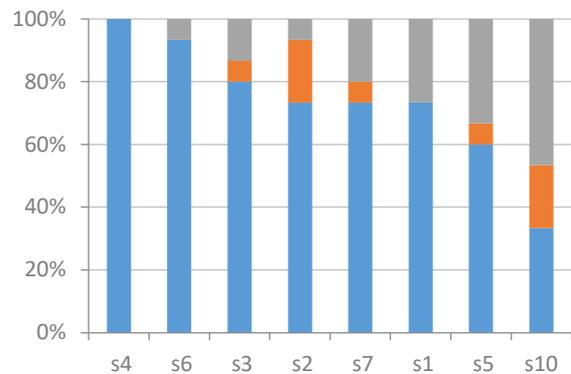


Fig. 6: attraction of the studied material samples (N=15)    Fig. 7: naturalness of the studied material samples (N=15)

#### 4.4. Design/build earth object

##### The shaping process

Based on the experiences during the material tinkering, the use of a formwork turned out to be very thankful. It allows to work rather precise, create straight surfaces and relatively sharp corners. Further design factors were the technical material restraints such as the minimum size that seemed feasible to make a solid earth object as well as functional restraints such as the size of a phone, and the incision of an electrical element.

##### The mixture

The choice of mixture was based on a typical rammed earth mixture of clay, sand and gravel. But the gravel size used was much smaller than usual, with the maximum size being 4mm. This to create surfaces that are not as irregular or rough as sample 1,2,3, while still showing some of the granular texture of rammed earth. To allow the creation of rigid corners and to improve the strength of a rather thin top lid, cellulose fibres (recycled newspaper) were added. Also the idea that the design should be sustainable has been defined as a prerequisite by both the design competition and the PhD project. In order to have a low environmental impact, the target was to avoid the addition of stabilisers (such as lime or cement). This would negatively affect both the environmental impact of both the production phase and the end-of-life (Van der Linden et al., 2019).



Fig. 8: overview of the used ingredients for the Monk mixture



Fig. 9: the creation process of the Monk design

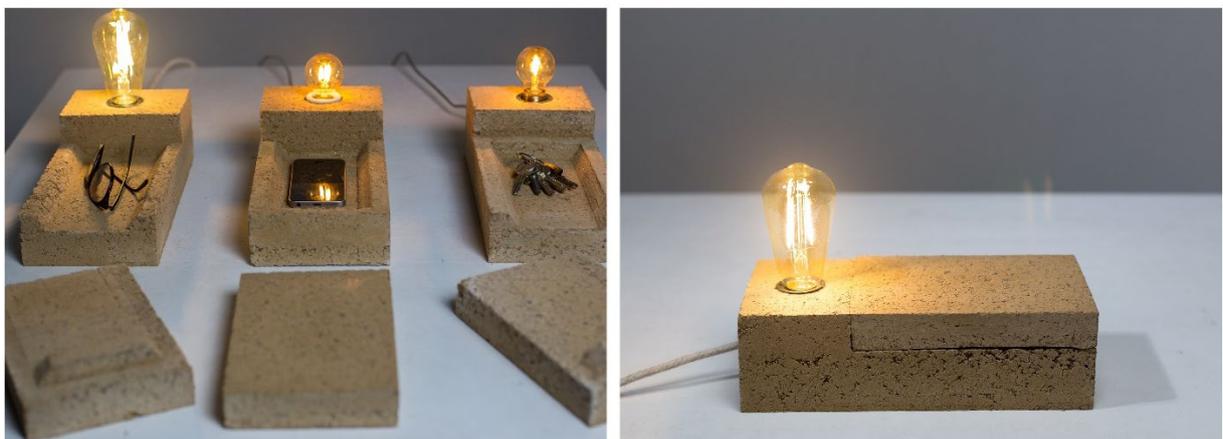


Fig. 10: the final prototypes of the Monk design

## 5. Discussion and further steps

In this paper, the Material Driven Design method has been used as a guideline to discover ways of designing and building with earth for material experience. The Monk design is one design example that uses earth, designed to elicit attraction in a contemporary context through refinedness, imperfection and naturalness. Although this is just one example of applying earth in a contemporary context, it did clarify technical possibilities of earth and insights in how people experience earth.

To create additional insights on the potential use of earth, both on a technical and experiential level, some more design exercises took place on the scale of an object or building component. Such series of designs happened notably during the advanced rammed earth construction workshop in August 2019, Brussels (fig. 11). The strength is here the repetition of the design and build process with earth for material experience. Repetition, but through different scales and different designers. This way a more elaborate understanding of potential tracks of using earth when applied in a contemporary Western-European context, gets created.

An essential further steps is to explore the user experiences of earth, also on the scale of a building, embracing the complexity of influences that an architectural scale offers.



Fig. 11: results from the advanced rammed earth workshop, August 2019, Brussels

## 6. Conclusions

Throughout this paper, the designing and building of an object out of earth object has been put forward. The use of the Material Driven Design method guided the design process, consisting of several consequent steps: a technical and experiential characterization of unfired earth, followed by the creation of a material experience vision and concluding with a design and built prototype of the design.

The design brief, and state of the art of the material led to the development of a contemporary earth object; a phone vault and bedside lamp. Earlier steps of technical characterization and material tinkering guided the production and design phase. Next to technical understanding of the material, the environmental impact was also taken into account. As a material experience vision, it was envisioned to create an object that is attractive, striking a balance between refinedness and imperfections. This goal derives inspiration from the concept of Wabi-Sabi; a philosophy that embraces the reality of the material world: 'nothing is perfect'. This philosophy is related to maintaining a sense of naturalness, consequently it was also desired that users would associate the design with naturalness.

Based on an experiential user evaluation of 8 different earth material samples, the material sample used for the final design scored the highest for attraction, refinedness and naturalness. This confirms that the pre-set intentions were successful, although the results only deal with the material sample, not with the final object. Such inquiry could be useful for further research, especially in an approach where material experience insights of earth are built up step by step; starting from the level of the material, to an application on an object, to the use as part of an architectural space.

The Monk design responded to humanistic demands of design thinking, documenting in which way the material earth can contribute to a sustainable, contemporary design. The value of such design exercises can only grow when not one, but a series of design projects are developed or studied to bring forward new avenues to design with unfired earth based on the material experiences. More research will be useful to reflect on the purpose of earth material in a contemporary context, and to create valuable material experience visions. Currently ongoing research includes the further analysis of the user responses to the material samples in order to extract more general outcomes and the investigation of the material experience in architectural projects using earth.

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