Doctoral Thesis Resume
"Earth as a building material. Constructive tradition and ecological innovation"

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1. Resume

The doctoral thesis "Earth as a building material. Constructive tradition and ecological innovation" proposes a critical overview regarding the current tendencies in terms of local constructions that do not follow the architectural regulations of the built environment in which these are located and highlights the traditional techniques, starting with the use of local earth as a building material. Considering the concept of sustainability as an interdisciplinary method of study, the current thesis creates an analysis in which the earth and the traditional construction techniques represent an ecological alternative for the contemporary building materials. By articulating a point of view that triggers the history of the place, analytical sciences and concrete applications, this study helps to determine an informed opinion regarding the qualities of the construction material, as well as it presents some innovative ways to implement earth as a local resource in the studied environment, the region of Banat in the Western province of Romania.

Therefore, starting from the tradition of earth construction techniques that began in the eighteenth century, with the colonization of the territory by the Habsburg Empire, the approach aims to document the local specificity and re-evaluate the traditional material through its ecological character. Aware of the need for a feasible approach in the current context, the study is aimed at determining the properties of the earth material, namely the contemporary interpretation of wall layering, able to meet the new comfort requirements imposed by current housing standards. There are also ways to capitalize on construction practices and traditional materials, based on this specific construction culture of the Banat region. In this context, the social, economic and environmental benefits associated with the reintroduction of traditional practices are presented. This approach allows an overview of the earth potential and the construction techniques associated with this material, compared to conventionally used materials.

The environmental benefits of natural materials are analyzed in detail to suggest how they correspond to new trends regarding reduced built-in energy, pollutant absorption and improved interior comfort through hygroscopic properties. This present study is part of a broader action regarding the capitalization of the elements related to the cultural landscape of the region, having as personal contributions, the presentation of a contemporary technical variant of reinterpretation of the local constructive tradition. In this way, an environmentally friendly construction option is offered that aligns with international sustainability practices, as well as the general trend towards research and design.

2. Extended resume

Currently, architects, engineers and builders are once again using local resources and methods, not only for construction, but also as a strategy for sustainable developments by supporting social involvement, economic development, cultural continuity, etc. Regarding the latter aspect, the constructive tradition is transmitted directly through the act of edification, but often this authenticity or continuity with the past is not preserved [1], as contemporary materials and practices advance. As a rule, construction methods and techniques have been transferred and adapted to local economic and social conditions. With the reconsideration of constructive traditions, their takeover was often formal. The constructive stages facilitated communication, knowledge transfer, direct contact with traditional materials and constructive practices.

Traditional constructions are based on techniques developed and defined by previous generations and, over time, have been adapted to a wide range of climatic and cultural contexts. Traditional materials involve a simplified construction process, which made it easy to install. In this context, community participation has often played a key role in buildings made using traditional techniques. These activities act as social and economic catalysts, causing a direct connection to the local resource systems.

Traditional materials offer, in this scenario, possibilities that those conventionally used do not have, because the materials originating from the surrounding landscape create strong links with the geography and culture of the place [2]. The availability of natural materials offers valuable opportunities for involvement and experimentation. The most convincing integration of old and new technologies occurs when the physical properties of the material are well understood and are fully used in contemporary constructions.

The transition from traditional to modern methods has not occurred in all regions equally, nor has it been transposed at the same time. Traditional construction techniques have been developed and defined by previous generations and continues to be adapted to suit a wide range of climatic and cultural characteristics. In this context, earth constructions have returned to the forefront of architects at the end of the twentieth century and have received increasing attention from the scientific community in recent decades, highlighted by the large number of publications [3]. The latest scientific research comes to mediate precisely this discontinuity between traditional and contemporary construction practices, using technology to innovatively implement the natural principles and notions of bioclimatic design developed in vernacular architecture.

Earth is a natural construction material, available in the majority of regions of the world. Earth constructions have a basis in terms of millenial traditions, evidence

[1] Elizabeth M. Golden, 2018, „Building from tradition. Local Materials and Methods in Contemporary Architecture";
[2] Laetitia Fontaine, Romain Anger, 2009, „Bâtir en terre: du grain de sable à l'architecture", ISBN : 978-2-7011-5204-2, pag.13;
[3] F.Pacheco-Torgal, Said Jalali, 2012, „Earth construction: lessons from the past for future eco-efficient construction";

of this fact being the remarcable constructions, ilustrated in the annexes 9.1. *Earth architecture in different geographical regions*. There are parts of the world where the existing building fund has been preserved in terms of residential constructions and big scale developments. Even today, a third of the human population [4] lives in earth buildings. In developed countries, more than a half of the building fund is made out of earth as the main building material. Considering these facts, the demands regarding housing facilities can be atteined by using local construction materials and techniques.

After World War II, out of social and economical considerations, earth constructions have become a cheap and available material used for the reconstruction of the destroyied housing fund, especially in Europe. Earth constructions come back to the recent interest because they represent ecological responses to the local conditions, suggesting the need to adopt sustainable solutions. An important aspect of this endeavour refers to the local tendency to reduce the embedded energy of materials as a current demand regarding resource economy [5].

Earth constructions represent the advantage of continuing traditional construction techniques, while, in parallel, innovative solutions for implementing the material have increased. New constructions made using contemporary earthen construction elements represent models for reinterpreting traditional construction techniques in a way that uses the properties of the material, while the proposed shapes can be framed in a current and abstract architectural language. Contemporary research allows a better understanding of the properties of earth materials, and the new implementation options are a source of innovation to create environmentally friendly buildings, taking into account the low impact on the environment associated with traditional building materials. The knowledge regarding the thermotechnical properties of the material allow a better use of these characteristics and the new variants of implementation are a source of innovation in the constructions field.

In Romania, as well as in Central Europe, earth construction was a common technique until a century and a half ago. The question is whether this constructive tradition must be continued or whether the material itself needs a fundamental reconfiguration in order to explore its possibilities from a social, technical and environmental point of view. From this point of view, the subject of earth as a building material can be treated from the perspective of adopting traditional construction techniques, or contemporary construction techniques can be considered as alternatives to the currently used materials, by implementing current technologies such as 3D printing.

In order to ground the current study in the initial phases, the research started from the analysis of the building fund in the Banat region, developed since the period of colonization of the territory by the Habsburg Empire (beginning of the 18th century). The constructive typologies from the colonization period have been preserved until today, presenting various formal typologies over time. In the content presented in the annex 9.3. *Earth as the main local resource. Constructive techniques and architectural characteristics of the constructions from the Banat region*., the evolution of the constructive techniques and the architectural characteristics of the specific constructions from Banat were highlighted. Starting from these elements that directed the study in the first phase, the research focuses

[4] Hugo Houben, Hubert Guillaud, 2006, "Traité de Construction en terre", pag.16;
[5] Atishay Jain, 2012 , "Performance of Earth as a Building Material";

on the way in which the constructive elements made out of earth can be reintroduced, in this case considering the particular example of unburned brick masonry walls as an ecological variant for the conventional option used locally: ceramic blocks with vertical hollows. In order to achieve a complete perspective on the subject, it is proposed to analyze traditional materials through the concept of sustainability in the construction field. This concept allows an interdisciplinary method of study by addressing socio-cultural aspects, technical properties, as well as data on the environmental impact of specific materials.

In the introductory part, there is a review of how the earth as a building material is used and researched now. The presentation of the notions regarding the symbolism of earth as a construction material used for the construction of the first human shelters since prehistoric times, respectively the evolution of earth constructions on the European continent. Complementary to these notions, it is necessary to present the qualities of the construction material and the manner in which it represented a feasible construction option over the centuries. Along with highlighting the most commonly used traditional construction techniques, a parallel is made on contemporary buildings and practices. In order to direct the study to a specific topic, the option of analyzing walls as constructive elements in more detail, has been used.

By analyzing current research at an European level, it was considered necessary to promote the constructive tradition, respectively the innovative solutions implemented. Considering the current trends in the construction industry regarding energy efficiency, it is necessary to approach the subject from the point of view of ecological and sustainable aspects. For this reason, an analysis from the point of view of thermal, ecological and economic properties is considered necessary, following the possibility of reintroducing a constructive tradition based on technical studies. Relying on the existing constructive tradition in Banat, this approach can determine further development based on technical foundations, as well as socio-cultural considerations by joining the existing local initiatives.

Therefore, the study of earth construction is a complex issue for several reasons, as it is not strictly a new building material or a new application of an existing material. The use of new materials is considered as a contemporary reinterpretation of the local construction tradition. In this context, contemporary tradition and development should not be seen as diametrically opposed to each other. However, the imposition of new building standards in terms of thermal insulation and the reduction of energy requirements may eliminate the specific characteristics specific to traditional building materials [6]. For example, the need to insulate buildings for energy savings can reduce the ability of massive earth walls to regulate humidity and temperature in indoor spaces.

As part of the application of this study, there are proposals to combine traditional materials, such as soil with other aggregates, in order to improve the qualities of strength, so as to meet current standards of stability and thermal comfort, but having a low impact on the environment. The aim is to analyze the feasibility of using site-specific ecological materials through the concept of sustainability as an interdisciplinary method of study. Therefore, the socio-cultural, economic and environmental benefits, associated with the use of local traditional materials and how they represent future directions of study, are emphasized.

[6] Otto Kapfinger, Marko Sauer, 2015 , „Martin Rauch. Refined Earth Construction & Design with Rammed Earth", pag. 6-12;

2.1. Main ideas presented in the research endeavour

In the introduction part, the thesis relies on a presentation of the symbolic and theoretical considerations of the earth material, given the fact that it is one of the first resources used in the construction of human shelters. For this reason, from an architectural point of view, earth as a building material awakens other values besides the purely technical ones. Therefore, a presentation of the symbolic aspects associated with the earth material, the explanation of the need to relate to natural forms and the integration of bodily perceptions in the experimentation of architectural space is made. Through notions of architectural theory, such as regionalism and critical regionalism, it is demonstrated the way in which traditional materials are used in different historical stages and why it is necessary to resume them. Although general, this first step helps to set up a complete discourse, able to make references to considerations that can allow a further understanding of traditional properties (in this case, earth as a building material) and its possibilities in the field of architecture.

Earth is associated with traditional rural techniques, which are based on local materials and knowledge, on a community spirit. The discourse relies on historical references that demonstrate the need to resume traditional construction practices and how they are brought up to date in different times of economic crisis. In the specific case of earth as a building material, the emphasis is on the organic character and materiality, in order to achieve a critical look of contemporary architecture.

The presentation regarding the remarkable earthen settlements allows the awareness of the development of these constructions in various regions, admitting the universal character of the material. The examples presented in annex 9.1. *Earthen architecture in different geographical areas* reveals the way in which different cultures have created inherently ecological environments, using their intuition and the material at hand to build shelters adapted to the environment in which they are located [7]. The study of these elements is the basis of many international research initiatives that today found their approaches starting from elements of the vernacular, analyzed through current technologies. From this mixture of archaic knowledge and new technological possibilities, innovations are being developed that are able to meet the requirements of ecology and sustainability.

The study reviews the elements that define the constructive specifics of the Banat region, starting with the colonization of the territory, respectively the systematization of the entire built fund. Following this investigation, a specific regional identity is observed through the coherence and functionality of the new settlements. The efficiency of the colonization process is transposed, first, at the urban level through the systematization of the localities, and later, at the level of individual residential constructions, by introducing specific constructive typologies. Due to the transfer of knowledge between the various nationalities encountered in the territory, the regional development of the Banat province becomes sustainable in the long term.

One of the main problems is the depopulation of the rural environment, a phenomenon that has led to the disappearance of constructive practices and specific cultural traditions. Local initiatives aim to transform these construction techniques

[7] Rania Daher, 2015, „L'Architecture en terre crue dans la vallee du Jourdain; Une filiere en reconstruction...temporaire", pag. 36-37;

into an element of local identity, in order to provide continuity to a diffuse rural territory. However, without a clear analysis of the performance of the material compared to the competing alternatives on the market, as it was done in the applicative part of this study, promoting earth constructions remains the responsibility of a few enthusiasts, without practical arguments to support the frequent use of the material as an ecological alternative.

Fig. 1.,2. Interior architecture – Lorna de Santos, Madrid, Spania.
An interiorized way of life, subjective, making reference to natural elements, sursă https://worldarchitecture.org/article-links/efzfc/lorna-de-santos-creates-topography-of-interiors-with-smooth-surfaces-for-a-house-in-madrid.html, 11.2020;

In the Western countries, where attention is directed to heritage through actions aimed at its conservation, restoration and rehabilitation, initiatives that refer to values of local traditions are encouraged and valued for the socio-cultural importance they bring to the community. The impersonal landscapes of contemporary architecture require a much stronger connection with nature, with everything related to basic human needs, implicitly with the tradition of the place [8]. From this point of view, the reconsideration of natural materials takes into account the need to reconnect with the history and constructive traditions specific to a place, as well as the ability to provide a refuge in a contemporary, technological and impersonal world.

Constructive techniques, used internationally, are presented in Chapter 4. *Constructive techniques using earth as a building material*, achieving a gradual presentation between traditional features and contemporary possibilities in terms of implementation. Next, the particularities of the earth material are presented by referring to the way in which, through walls as a constructive element, experiments

[8] Paulo Costa, 2013, "Vernacular Heritage and Earthen Architecture: Contributions for Sustainable Development", CRC Press/ Taylor & Francis, pag. 727-729;

are performed regarding the technique of precast earth elements, 3D printing or design according to parametric principles. In order to create a link between the traditional properties of the material and the innovative possibilities of application, the physico-chemical properties of the earth material are analyzed in the annexes of this study - 9.4. *Properties of earth used as a building material*.

2.2. Earth as an ecological and sustainable material: general considerations regarding the subject

"*Sustainable development is the process of development that responds to current needs without jeopardizing the ability of future generations to meet their own needs. [.....] In order for the goal of sustainable development to be achieved, environmental protection will be an integral part of the process.*" [9]

The practice of sustainable architecture has been largely understood as a matter of technology and energy performance, considering that convenient living standards can be achieved. While current rules address the important goal of energy efficiency, the definition of sustainability becomes too limited to capture the specific character of a place, an important component in defining the concept in a broader context, where issues of regional and cultural adequacy are addressed. For this reason, the social and cultural components of the local architecture can be exploited to determine solutions that determine a sense of belonging, encouraging the formation of communities with common interests related to the promotion of elements linked to traditional local practices.

The debates on sustainability have remained somewhat separated from the theme of architecture as a cultural project, but architecture must be understood in the broad sphere of the culture it embodies. Consequently, the architectural cultural traditions and the regional materials define the constructive practices specific to a certain population, as answers to the existing conditions found in the territory. In order to define sustainability, not only in terms of quantity but also in terms of quality, the characteristics of regional and local culture must also be taken into account. According to this approach, architecture must first relate to the specific conditions of the place, to be authentic. The responsibility is to resist the phenomenon of globalization, predominant in contemporary culture, because sustainable architectural proposals based only on technology, do not always coincide with the cultural values of a place [10].

Local traditions have inspired vernacular construction techniques, being ways of adapting to the specific conditions of a particular environment. For this reason, traditional buildings, in essence, respond to a wide range of physical and spiritual needs, being perfectly integrated in the context of the communities in which they are located. Also, the notion of being a native in a place implies a more complex relationship with the environment, adopting a wider range of habits. The

[9] Volker Hauff, Raport Brundtland din 1987 al Comisiei Mondiale a Mediului și Dezvoltării (WCED);

[10] Paola Sassi, 2006, "Strategies for Sustainable Architecture", pag.6-12;

listed elements define the common base of values that form the cultural practices specific to a community [11].

In conclusion, the issue of sustainability as a cultural discourse, defines a broader perspective from which to look at architecture, from a regional to a local level, outlining the idea that the most appropriate way to design is by being aware of all aspects that depend on the local conditions of the area. For this reason, a study was conducted in the context in which earth constructions were developed in the Banat region. In order to frame the earth constructions in accordance with the ideas of sustainability, viewed from the point of view of culture and local heritage, it is necessary to have an awareness of the specific conditions of a place, starting from aspects related to history, political and social context, constructive techniques and contemporary developments in the use of traditional materials. Without this concern for current trends, there is a risk of limiting research objectives to single interventions, without proposing strategies or elements that are appropriate to a broader context, capable of creating long-term beneficial effects. The simple approach to the technical aspects must not be limiting, in the idea that the bases of the cultural and material traditions specific to a population must also be considered.

It is important to note the advantages of earth constructions, both in the short term and their evaluation over a longer period of time, in order to determine to what extent these constructions have survived over time. The aim is to demonstrate the way in which traditional techniques using earth as a building material, have led to sustainable solutions, even before this contemporary concept existed. Sustainability is perceived at an early stage as an adaptation to local conditions, namely a saving of resources and a continuity of cultural traditions. The examples of earth constructions made in all regions of the world, demonstrate the way in which the limited resources have determined ingenious solutions from an ecological point of view, adapted in time to the local conditions. Emphasis was placed on the development of construction techniques in Europe, presenting the way in which they have developed over time, respectively characteristic examples from various regions of the continent.

The natural connection between the material and the built environment, based on observations and traditions repeated over the centuries, capture the aspects related to sustainability through the use of local resources in an efficient way. By studying the local context, namely, the characteristics of earth constructions in Banat, the aim is to apply these international research approaches to a specific construction existing at the local level. The relief of the identity elements of earth architecture allows the realization of a general image on the studied area, with the possibility to transpose the traditional values within some contemporary developments. The main characteristics and disadvantages of using earth material in a traditional context are exemplified, as well as innovative solutions for creating earth walls, such as 3D printing, parametric modeling or new casting options (plaster spraying, for example).

The study undertaken comes in the context in which the current approach to natural resources, in an intensive way, is not sustainable. Reducing the impact associated with the design, construction, operation and management of the built environment requires a concentrated effort on the part of several professionals involved in all stages of the life cycle of buildings. Contemporary construction methods are characterized by performance threshold models, which assess the

[11] Vintilă Mihăilescu, 2017, "De ce este România astfel? avatarurile excepționalismului românesc";

environmental impact of a construction through a series of indicators. These issues have aroused new interests in alternative construction systems that use natural materials of local origin. The reevaluation of traditional materials is stimulated internationally through the concepts of ecology and sustainability, and develops around topics such as low built-in energy, thermal performance, creating a healthy indoor climate, etc.

Environmental and sustainability issues are current in construction due to the environmental impact of this industry. Buildings are increasingly demanding more energy and the efficiency proposed by new standards (nZEB and Passive House) aims to reduce operational energy consumption, but leaves open the subject of energy incorporated in building materials. In this respect, earth as a building material is of particular interest, as it has low values of embedded energy [12]. Other relevant characteristics of earth as a building material are:

- The ability to store heat (inherent thermal mass),
- Indoor air filtration and humidity control,
- Adaptability in any climatic zone.

In contrast, the use of load-bearing earthen construction elements is the most controversial topic because conventional materials, such as fired bricks and concrete represent easier-to-implement construction solutions with a much better compressive strength. Structural engineers are in favor of adding cement in order to increase the stability and to bring earth as a construction material to current standards.

In order to have the lowest possible ecological footprint, similar to traditional constructions, the materials must be as little processed as possible [13]. The constructive elements made out of earth represent an ecological variant because of the raw materials that can be found in the immediate vicinity and has an great number of life cycles - constructions can be demolished and the material can be reused several times or returned to its original state. Due to the special properties associated with clay in the composition of the building elements, earth plasters and mortars can be re-plasticized and reused.

The environmental quality of a building material is mainly assessed by comparing the consumption of resources and the flows that are used in the manufacturing process, having a different impact on the environment depending on these variables [14]. Compared to cement or other materials conventionally used in the construction market, earth-based construction elements have great ecological and economic potential due to their low built-in energy, as presented in subchapter 6.3. *The life cycle of earth constructions. Ecological indicators on environmental impact and resource use*. The option of incorporating earth materials in combination with other locally available resources, such as natural fibers, represents the opportunity to achieve a saving of embedded energy, while the new implementation options (3D printing, for example) propose to streamline the construction process.

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[12] Rania Daher, 2015, „L'Architecture en terre crue dans la vallee du Jourdain; Une filiere en reconstruction...temporaire", teză de doctorat susținută în cadrul Universite Paris-Saclay – Universite Versailles Saint-Quentin en Yvelines, Școala doctorală Științele Omului și ale Societății, specialitatea: arhitectură, pag. 19-25;

[13] Goodhew, Steve, 2016 , „Sustainable construction processes: a resource text";

[14] Lola Ben Alon,, Vivian Loftness, Kent A Harries, Erica Cochran Hameen, 2020, „Integrating earthen building materials and methods using perception surveys and life cycle assessment (LCA)", LEHM Erde International Conference on Building with Earth, Weimar, Germany;

The research centers mentioned in this study, develop the idea of introducing earth around the concept of sustainability in order to justify the resumption of this traditional material and its related construction practices. Therefore, it is necessary to study the characteristics of natural materials through sustainability, also recalling the potential of recycling materials that are part of various layers. The aim is to achieve an overview of the feasibility of introducing traditional construction variants, adapted to current ecological requirements, without neglecting the aspects related to comfort. Subsequently, by including a study that includes all stages of the life cycle, one can assess the benefits resulting from the small ecological footprint [15], specific to the construction elements made out of earth.

2.3. Adapting traditional techniques to contemporary construction solutions

Sustainability in the context of this thesis, allow the study of aspects related to socio-cultural, economic and environmental character starting from a single material, the analysis being focused on the study of thermotechnical properties, ecological and cost indicators, in terms of materials and stratifications of proposed walls. The experimental part starts from the study of the local earth used as a main material for creating walls, in order to evaluate the characteristic properties of the raw material, and focuses on the widespread technique used in the territory, unburned bricks (local soil mixed with natural fibers). Therefore, the theoretical study presented in this paper proposes a comparative analysis of possible wall stratifications, in order to solve the thermal comfort inside a house. The conventional alternative of making walls using hollow ceramic blocks, used for most constructions, respectively unburned bricks with the addition of natural fibers, used both in rural and urban areas, are compared.

A comparative analysis of two wall stratifications is proposed: the first stratification is made out of ceramic blocks with vertical hollows, while the second stratification is composed of unburned bricks produced at contemporary standards, insulated with wood fibers. At each stage of the study, elements with similar properties or optimal compatibility with the basic materials used were considered. The aim is to highlight the fact that by using local traditions with ecological materials, the current standards of stability and thermal comfort can be achieved. Using thermotechnical calculations, the analysis showed how the traditional properties of the material can be exploited to provide solutions according to current needs, by considering thermal properties such as indoor temperature and relative humidity, thermal storage capacity, heat transfer value, etc. This first analysis is accompanied by the presentation of the ecological benefits by referring to the environmental indicators, respectively the economic potential associated with the reintroduction of these constructive elements in the local context of Banat.

[15] Conform https://www.britannica.com/science/ecological-footprint, accesat on-line: 04.2021, The ecological footprint measures the requirements of a person or a group over the natural resources at a global scale. It has become one of the most frequently used measurements in terms of the antropical efects over the environment and it is used in order to highlight the unsustainable character of current practices as the inequalities in terms of consumption between and in the particular case of each nation.

2.4. Research objectives

By articulating a point of view that mobilizes history, science and significant examples, this analysis presents the qualities of the construction material and the way of implementating traditional techniques within the studied area - the Banat region in western Romania. The study addresses the issue of sustainability by referring to the socio-cultural cohesion determined by the common traditions, the thermotechnical properties of the earth material, as well as by highlighting the economic opportunities to reevalue some industrial activities that existed on a local scale. The traditional techniques and the existing building fund is presented and promoted within the local communities as a specific element, as well as new ways of reinventing the earth material by using contemporary technical means.

This paper lays the foundations for a thorough examination of the material and its use in the construction industry. The important dilemmas that arise relate to the way in which traditional construction techniques are reintroduced into a constantly changing world. Also an important aspect of the study shows that the industry has negative repercussions on the environment due to materials that consume a lot of energy during production and lead to significant greenhouse gas emissions, issues that contribute to the phenomena associated with climate change. After an overview of the existing earth constructions, the properties of the material are discussed, its advantages, as well as traditional techniques and how earth as a building material is reinvented to meet new challenges related to the concepts of sustainability, ecology and life cycle assessment.

In the current context, a contemporary approach is needed to adopt sustainability strategies, as it is a necessary trend in the current conditions, in terms of cultural and technological developments in the architecture practice. Adaptation is needed, not only from a technical point of view, but also from a cultural one. By mentioning the notion of cultural landscape [16], the characteristics that define the territorial identity at a regional level are promoted. The creation of an overview of the earth theme and how it was used as a building material is presented through the concept of sustainability, the way in which different societies have adapted to specific climatic conditions, resulting in formally and functionally coherent responses, aspects presented in:

- Chapter 3. *Outstanding earth constructions in Europe* and
- Annex 9.2. *The use of traditional techniques in urban settlements*.

The study undertaken comes in the context in which the current use of natural resources in an intensive way is not sustainable. Reducing the impact associated with the design, construction, operation and management of the built environment requires a concentrated effort on the part of several professionals

[16] https://whc.unesco.org/en/culturallandscape/:
The notion of cultural landscape refers to the variety of landcapes which are representative in different regions of the world, by combining the elements that make up for the natural characteristics and those regarding human resources, expressing a particular link between humans and the surrounding landscape. Some archaeological sites present this close connection between people and and nature.

involved in all stages of the life cycle of buildings. Contemporary construction methods are characterized by performance threshold models that assess the environmental impact of a building through a series of indicators. These aspects have aroused new interests in alternative construction methods that use natural materials of local origin.

The applicative part of this study demonstrates how the local construction technique is reinterpreted to meet the new standards of thermal comfort, trying to offer an ecological alternative to current construction options. It highlights the way in which a constructive tradition represents a coherent response both culturally, with social implications on the communities concerned, and technically, by using the potential in terms of thermotechnical properties, specific to these traditional materials. The theoretical study performs a detailed analysis of a proposal for the use of construction materials, respectively the way in which conventional materials can be replaced with ecological options in order to have the same benefits in terms of thermotechnical properties [17], but with a much lower impact on the environment. Long-term aspects related to the life cycle are considered in terms of an low embedded energy value, the potential to recondition, reuse and recycle.

By using earth as a construction material, a few advantages in terms of ecology and sustainability can be taken into consideration:

- considering the traditional practices found in the Banat region;
- the availability of raw materials expands as earth can be excavated from the site,
- time is saved as well as storage space (75% of construction waste is soil of different types) [18].

All these advantages of earth as a building material are the subject of a more extensive analysis related to the whole life cycle of the material, while in this case, the study focuses on the product stage, using the "Cradle to Gate" method. Therefore, by conducing further stufies, the different stages of the life cycle can be quantified and interpreted according to specific cases. The simulations regarding the thermal properties and the life cycle analysis performed during this study demonstrate the low impact on the environment of unburned bricks, without sacrificing the standards regarding thermal comfort.

Taking into account the intrinsic qualities of the material, a new perspective of energy efficiency can be defined, in which the mass of the material is again considered a value, not an unnecessary consumption of material. The thickness of the wall allows thermal storage with the possibility of releasing heat over an extended period of time, respectively through the ability to regulate humidity and indoor temperature. Therefore, the subject of the doctoral thesis aims at a presentation of earth as a construction material, the way in which it can be used:

- the social advantages (reintroduction of a construction technique by considering traditional practices in the Banat area) and practical ones (thermal properties, environmental impact and financial considerations), questions that are brought into the front.

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[17] Bruno Andres, Philippe Devillers, Eric Defrenne, 2018, „Influence de la conception architecturale et du climat sur les transferts d'humidité dans une paroi„ ,Joffroy Thierry, Guillaud Hubert, Sdozai Chamsia, Articole selecționate pentru publicare on-line, Villefontaine, CRAterre;

[18] Isabelle Moulis, Mary Jamin et Alain Marcom 2018, „Quand les travailleurs de la terre apprennent à la bâtir„, articole selectate pentru publicare on-line Villefontaine: CRATerre, ISBN:979-10-96446-12-4.

In order to achieve this objective, an extensive study was needed on what earth constructions mean, their evolution and the main typologies encountered in the territory. In the case of the earthen constructions made in Banat, a particular practice has developed between what can be identified as a local constructive tradition and the external influences introduced during the colonization period of the territory.

From the point of view of the research objectives considered in the initial phase, the study is based on pedagogical premises, as implemented by the CRATerre institute in France and Getty Institute in the United States, by considering the specifics of earth constructions made in Banat. The objectives refer to the presentation of the techniques and properties of the earth material in order to understand its importance in a historical context, starting from the development of the first human settlements, to more recent ensembles. The main objective addressed in the thesis is to conduct an analysis of the sustainability of the reintroduction of earth buildings, following the three main aspects implied by this concept, namely socio-cultural considerations, environmental impact and identification of opportunities for economic exploitation of these traditional construction practices.

The present study focused on the technical side with the aim of obtaining an ecological construction alternative for the existing conventional construction methods and materials found at a local level. In this way, the reuse of these traditional techniques was justified by the multidisciplinary approach of sustainability (socio-cultural, economic and environmental aspects), in order to clarify some of the complex notions associated with this concept and how a traditional material can adapt to current trends existing in the contemporary architectural practice.

2.5. Conclusions of the research endeavour

Starting from the fact that it is one of the most used building materials, earth awakens symbolic values regarding the first shelters made, as well as information about the traditional construction practices specific to a region. If historically, the use of earth as a building material has been favored since it was a cheap and available option to build, it has been found that the return to these traditional techniques was a good constructive option in times of economic crisis. The recent challenge is the need to compare the technical properties of traditional materials with those of conventional building materials. It is also necessary to streamline the production process in order to improve the costs of traditional building materials.

It is important that, in the context of innovative solutions for the various methods of implementation, the known properties of traditional earth materials should be exploited, especially:

- the regulating effect in terms of humidity and temperature in the interior space,
- absorption of pollutants such as sulphates and phosphates from the atmosphere,
- reduced embedded (built-in) energy compared to other analyzed materials.

The purpose of the analysis performed in this study was to find a solution that would become an ecological alternative to conventional masonry construction techniques (ceramic blocks with vertical hollows). In the thesis, the "Cradle to

Gate" method (up to product stage A1-A3) of the life cycle assessment was used, because it represents the stages that consume the most energy in the entire considered life span of a building, being able to compare values of the indicators related to the impact on the environment. These considerations may change as taxes on carbon and other pollutants are imposed.

For this reason, the reintroduction of traditional construction techniques with earth in the Banat region was studied through the concept of sustainability. This concept relies on a socio-cultural side of using the elements that define the specific architectural characteristics of a place, as well as the alignment with existing local initiatives. The activities undertaken at a regional level prove the growing interest for these traditional techniques and future studies will support the inclusion of the existing built fund and constructive practices as elements related to the cultural landscape specific to the area.

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