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EARTH MORTARS: A VERNACULAR TECNOLOGY AND A MODERN ECO-EFFICIENT SOLUTION

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ABSTRACT

Earth constructions have been used for millennia by humanity, with an immeasurable accumulation of knowledge to be explored. However, in the last 150 years this material has been systematically replaced by chemically altered industrial materials that are responsible for great environmental pollution, inert waste generation and irresponsible consumption of natural resources. Despite this, since the 1960's, both academic and professional efforts have been perceived to develop more environmentally sustainable technological innovations for civil construction, seeking inspiration from past practices such as the resilient designs of Vernacular Architecture and natural building materials such as earth. Buildings with earth, as well as earth mortars, offer very advantageous properties to buildings, such as aesthetics, thermal balance, environmental comfort, noise absorption, durability and fire resistance, in addition to generating only organic and biodegradable waste. Earth mortars for laying and covering are one of the most used items in a construction and represent great importance for the durability of buildings, and can also be a weak point if they are not carried out correctly. In a country like Brazil where there is still a living tradition of building with earth, and a vast vernacular repertoire of historical heritage in demand for restoration, it is even more important to investigate the properties of earth mortars, develop new technological solutions and publish specific national technical standards to guide its use. Currently, Germany is the first and still the only country to publish a specific technical standard for the analysis of physical and mechanical properties in earth mortars, the DIN 18.947 standart, being an example for the whole world. Thus, this article aims to contribute to the consolidation of the technical and theoretical framework on the subject in Brazil. The text presents an overview of some solutions used for mortar stabilization throughout the vernacular history of construction with earth and concludes that although the materials and solutions of vernacular architecture are subject to transformations and adaptations according to the demands and technological innovations that arise with passing from time, the qualities of these materials already consecrated by the empirical vernacular tradition can justify their return and the permanence of their use.

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INTRODUCTION

Throughout the history of vernacular architecture, many different solutions have been used to increase the durability and strength of earthen mortar (plaster), especially water resistance. According to Eires (2012) ancient people already added different stabilizers to the earth mass such as lime, pozzolans, vegetable oils, wood ash, natural glues, sand and clays, plants, cow dung, urine, milk (casein) and even animal blood. Some of these solutions are still practiced today due to their efficiency in the local context.

Currently, because of the search for ecologically sustainable technologies and the highlight of earth constructions, earth mortars have been the subject of academic research in laboratories focused on building materials in several countries (Correia, 2016). These researches aim to understand the behavior of mortars and the materials that compose them to ensure their use with technical responsibility. Investigations have explored the different types of clays, sands and the consequences of adding the stabilizers used with the intention of improving their mechanical strength and durability in the face of water without losing the properties that earth buildings offer (Faria, 2012). Following this trend, the authors of this papper are developing a reasearch where they evaluate the effects of adding small percentages of different materials with stabilizing potential in earth mortars. The objective is to better understand the behavior of earth mortars produced with Brazilian soils and to compare the performance of natural materials already established by the Brazilian vernacular tradition such as vegetable oils and cow dung, with additions of other industrial materials such as cement, lime and the plaster. The most suitable application for each stabilizing material will also be indicated. As there is still no Brazilian standard for earth mortars and with the intention of generating results comparable with results obtained in other researches around the planet, the research followed the German standard developed by the Deutsches Institutfür Normung to DIN-18.947, published in 2013 and updated in 2018. This is the first specific standard for earth mortars in the world, and defines the requirements, parameters and test methods (Schroeder, 2018). This standart also will be presentend on this review paper.

EARTH MORTARS AND EARTH BUILDING: Earth mortars are a homogeneous mixture composed only of earth (clay, sand and possibly silt) and water. The sand being the aggregate (fine) and the clay acting as a binder. If desired, low additions of stabilizing materials can be performed to alter some characteristic of the earth, such as increasing mechanical resistance or resistance to water action. According to Faria (2016), this mixture is used in many phase on earth construction: to filling bamboo or wooden structures, finishing joints, filling cracks, laying blocks and doing final coating of the internal and external walls to protect the masonry from rain. What is especially important in tropical zones such as Brazil. For each application there will be a specificity to be met by the mortar, either in consistency or composition or in the line. However, according to Faria (2012) for all applications, earth mortars must have good adhesion and compatibility to the support, initial adhesion, mechanical resistance, water resistance, esthetic aspect and durability. Plasterings and renderings made with earth mortars offers advantageous properties that, in addition to saving natural resources, can generate savings of financial and energy resources at home for the user since they can dispense with cooling and artificial heating to provide a comfortable and pleasant environment. According to Minke (2018) in addition to not containing volatile elements toxic to human health, earth plaster has the potential to absorb and release enough water vapor into the environment, thus balancing the relative humidity of the air in the environment and consequently relieving discomfort associated with dry environments. The earth plasters also delay the amplification and reverberation of the sound in the environment, and due to their greater thermal inertia, they transfer heat slowly, providing greater thermal comfort inside the environments by taking a longer time to balance the internal temperature with the external building (Garzon, 2002). Thus, the thicker earth walls also provide more thermal inertia and more potential to absorb the sound and humidity of the environment.

According to COREMANS (2017), the plastering must be carried out with a maximum thickness of 3 cm, to avoid detachment of the support (the wall). Generally, the earth covering mortar is applied in two or three layers, always preceded by a little moistening for better adhesion. The first application will level the surface of the masonry (adobe or *taipa* for example), and should be less than 2 cm thick and preferably made with coarse sand. The second layer should be less thick, a maximum of 0.5 cm is recommended. Finally, the last and thinner layer should preferably be made with fine sand and applied only to finish the surface and cover small cracks (COREMANS, 2017). In addition to the structural and coating functionality, it is also possible to use earth mortar for artistic purposes. With the surface still moist, it's possible to fix shells, stones or even model a sculpture on the clay surface before the final finishing layer. However, as it's a place on the wall where there will be a greater concentrated weight of clay dough, Minke (2018) recommends adding a little vegetable fiber to the mixture, cutted in sizes up to 5 cm to give unity to the sculpture and prevent the detachment of some detail.

EARTH MORTAR'S COMPOSITION: The earth mortars consist of a simple mixture of earth with fine granulometry, (clay and sand) and water. In the case of plastering or laying mortars, Torraca (2009) advises the proportion of 20 to 30% clay and 70 to 80% sand. For this reason, it is advisable to characterize the earth that will be used in the construction to calculate the value of the correct addition of sand to reach the proportions of better performance. However, in the vernacular tradition, in regions where sand is not found easily or for free, locally available earth is used without extra sand. However, when the earth available is predominantly clayey, cracks usually occur due to water evaporation in the mortar drying process. How vegetable fibers are found more easily than sand, it is common to add those in the composition of mortars to try to contain shrinkage (Santos *et al.,* 2019). The addition of dry or green straw is traditionally used in construction with earth in different locations around the world and remains in use today. According to Torraca (2009), there is a great reduction in the compressive strength of mortars with the addition of vegetable fibers, but there is also a decrease in specific mass, less linear drying shrinkage and relative increase in thermal insulation. Therefore, depending on the application, the fibers can be an excellent stabilizer as in sculptures and in techniques for building robust walls such as *cob house's* or thin walls without structural function such as wooden or bamboo panels.

As well as vegetable fibers, other materials can also be added to the composition of earth mortars in order to give some properties to the mixture, however, before exploring them, it is necessary to better understand the characteristics and behavior of the basic components of these mortars: clay and the sand.

THE EARTH - CLAY AND SAND: The clays act on the earth mortars as a binder, uniting the components of the mixture and providing good cohesion, good adhesion to the support, low water resistance and good mechanical resistance. The clayish earth is not an aerial or hydraulic binder, although it can be associated with binders of both types, such as the use of cement or lime in small proportions acting as stabilizers (Faria, 2016).

Sand, on the other hand, acts as an aggregate for the mixture and generally does not influence the hardening characteristics of mortars, unlike binders, but in their structure. The granulometric diversity offered by the mixture by adding the aggregate is very important to create a unity between the materials that make up the mortar. The size and shape of the components influence, for example, the mechanical strength, the permeability and the amount of cracks that appear in the mortar in the hardened dry state, in addition to the workability and consistency in the liquid state (Correia, 2016). Also according to Correia (2016), larger grains of sand with irregular shapes, have a greater contact surface and form more empty spaces in the mortar structure than very polished or round grains. These created empty spaces contribute to thermal comfort, impact absorption, and facilitate the passage of water through evaporation without having to form cracks during the mortar drying. The earth used for construction must be that fraction of the soil with particles size distribution smaller than 0.2 mm, that is, sand, silt and clays (Neves *et al.,* 2011). In addition, it must be free of organic materials such as branches, leaves and roots and preferably have a coloration between red and yellow, characteristic of older and more developed clayish soils whose unstable minerals have already been leached to deeper layers, mostly silica, alumina remaining and also iron oxides (Castro, 2002). However, clays with colors between white, gray and black are also common and can offer good structural stability and low shrinkage.

Generally these earths are found in Oxisol on the Horizon B (Figure 1), that is, below the terrestrial surface and the roots of vegetation, where there is no organic materials, but there are enough granular mineral microparticles (clays and sands). Are classified as Oxisol, very old and well stratified soils. According to Castro (2002) the group of Oxisol is predominant in Minas Gerais, occurring in 47.48% of its total area, including in the entire Belo Horizonte city region.

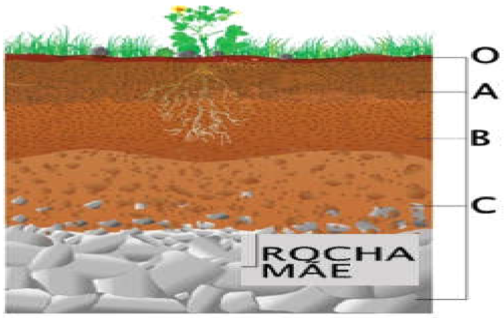

Figure 1. Schematic soil stratification

According to the ABNT granulometric classification (Table 1), clay is the finest fraction of the soil, the result of years of physical and chemical transformations and overlapping of organic matter and saprolite of rocks overlaid and accumulated in layers below the earth's surface. It is composed of different microparticles (less than 0.002mm) of rocky minerals, which, depending on the percentages of their presence, will determine the behavior and classification of clays. According to Oliveira (2011) "Basically the structure of clays is formed by two crystallographic units, silica (SiO_2) and alumina (Al_2O_3), with or without the presence of iron oxide (Fe_2O_3)".

Table 1. Granulometric classification of the soil according to ABNT (2017)

Nomenclatura e dimensão das partículas (mm)
20,0<Pedregulho grosso<60,0
6,0<Pedregulho médio<20,0
2,0<Pedregulho fino<6,0
0,6<Areia grossa<2,0
0,2<Areia média<0,6
0,06< Areia fina <0,2
0,002 < Silte < 0,06
Argila < 0,002

Structurally these particles are laminar, that is, flat and slender and can have a very angular or rounded shape at the edges (Figure 2). The mineral composition, their electrical charges, and the size of these laminar particles are what will define the properties of clays such as cohesion, shrinkage and dimensional expansion and moisture retention.

Figure 2: Schematic representation of laminar clay particles (Santos, 2015)

According Souza Santos (1989) the most common clays are:

- **Montmorillonite-Smectite:** It presents little rigid structure allowing the penetration of water between the particles and high expandability, being, therefore, very unstable for the construction. It is a very useful clay for shoring perfurations and foundations due to its hyper expansive property;
- **Ilite:** This clay has a structure similar to montmorillonite, but much less expansive, being much more stable;
- **Kaolinite:** It has a rigid and stable structure in the presence of water and low retraction and expandability, which is the most suitable clay for construction with earth. Its mineral composition provides it with a balanced electric charge which gives it its stable properties.

The characteristics of the earth mortars strongly depend on the clay type and composition (Lima *et al.,* 2020). The main difference of these clays is their mineral composition. Different free electrical charges are available in each one and exchanges may or may not occur between its components, such as aluminum with magnesium or iron, and silicon with aluminum or iron, neutralizing the residuals charges generated by the differences in electrical charges of ions by cations (Souza Santos, 1989). In kaolinite there are practically no substitutions, keeping its volume stable during water loss and absorption. In Ilite, the substitution occurs and the neutralizing cation is potassium. And in montmorillonite the exchanges also occur and the neutralizing cations can be sodium, calcium, potassium or even other minerals that can balance the free charges in the components of this clay (Souza Santos, 1989). Depending on the composition of each soil, there are more or less stable clays with different behaviors, being more or less suitable for construction. Therefore, depending on the available earth and wich application is it for, there are materials that can be added to promote the stabilization of the available earth, improving some undesirable properties.

EARTH NEEDS SOME STABILIZING ADDITION FOR BUILDING?: According to Hunter and Kiffmeyer (2004), stabilization should be done whenever there are resources available for this, and it is necessary to improve the physical-mechanical characteristics of the earth available for construction, especially in relation to retraction, resistance to compression and the action of water. The clay present in the clayish earths, acts as a strong binder in its natural state, dispensing complex mining, processing and polluting calcination procedures, unlike cement, lime and plaster. However, its resistance to water is not to high. On the other hand, this fragility, gives clayish earth the possibility to return to its plastic state even after drought, if it is crushed and wet. For this reason, the residues generated in demolitions and constructions with earth, have the property of being reused as raw material for other constructions or even used for agricultural cultivation on the land itself (Faria, 2016).

Malavolta (1967), warns that the addition of more than 5% of cement in a fertile soil, makes it inert and inappropriate for cultivation. The addition of higher proportions of cement also impairs the reuse of waste. In other words, an exaggerated addition of stabilizers could increase some properties in the earth mortar, however, it could lose others, therefore deserving a careful consideration in the choice of stabilizers and their proportions. Stabilization can be carried out in several ways, granulometric (physical), mechanical or chemical. Physical stabilization by granulometric correction is a solution that does not require the use of any material other than earth. By changing the proportions of clay or sand (Neves *et al.,* 2011), an equilibrium on particle size distribution in the mixture is promoted, decreasing the dimensional shrinkage, increasing the mechanical resistance and the water resistance. For this reason, this stabilization method is usually called granulometric correction, because only the proportions of sand and clay are corrected for a more stable behavior.

According to the earth, the result can be expressive and dispense other stabilizers (figure 3). For example, in a very sandyish and not cohesive soil, clay proportions can be added for stabilization. On the other hand, if there is an excessively clayish earth (which is more common to find) it is necessary to add sand to decrease the shrinkage and increase the workability and plasticity in the mixture.

Figure 3: The figure illustrates the effects of adding sand to earth mortar. The trace a) has not sand addition; the trace b) has low sand addition; and the trace c) has biggets sand addition and less shrinkage. Fonte: Santos, (2015)

Still without the use of stabilizers, according to Hunter and Kiffmeyer (2004) it is possible to carry out mechanical stabilization of the soil, through compaction as is the case of compacted earth blocks (BTC's) or through the containment of the earth inside plastic bags as is case of the bagged earth technique, popularly known as *super-adobe* or *earth bag building*.

In cases where granulometric correction and mechanical stabilization by compaction are not applicable, the option is to use chemical stabilization. Minke (2018) presents some natural stabilizers traditionally used and other contemporary alternatives to improve the performance and physical and mechanical properties of earth such as mechanical resistance and resistance to water action. Among them, the fermented cactus emulsion, cow dung, horse urine, cow's milk (casein), vegetable and animal oils, tree resin, wood ash, pozzolans (calcined clay), powder rocks and sand. Planning to use the earth as a large-scale building material, it is necessary to investigate and analyze stabilizers, materials and procedures to guarantee quality and homogeneous behavior in the mixtures. In addition is important consider the ease of access in construction stores and the sustainability involved in its production, processing and disposal process, in addition to seeking local solutions of reuse or recycling.

EARTH MORTAR'S STABILIZATION: In order to preserve the properties of earth masonry, such as the ability to balance the relative humidity of the air and hygroscopicity, COREMANS (2017) advises that the coating be made exclusively with earth-based mortar. It is recommended to use stabilizers only in low proportions, giving preference to the use of lime due to better structural compatibility with the clay. In addition, according to COREMANS (2017), especially in restoration works, must be made an analysis of composition of the existing substrate (wall) and of the deteriorated existing mortar. This way can be used compatible materials in the formulation of the new recomposition mortar. Despite its important function of protecting earth masonry from the action of water, earth plastering should not make the wall waterproof. That is, the plaster must be porous to have the ability to allow moisture to pass, but it must also be structurally strong to remain intact in contact with moisture, and to receive impacts and not deteriorate (COREMANS, 2017). Kanan (1999) shows that using cement and sand coating on earth masonry (such as adobe and taipa), generates an impermeable surface that prevents the transpiration of earth masonry. This leads to the retention of moisture between the surface of the earth mansonry and the plaster, creating an environment conducive to the mold proliferation. This combination culminates in the plaster detachment and exposes the wall structures. On the other hand, lime behaves very well with clay. In relation to cement, lime has less rigidity, good permeability and porosity in the hardened state. According to Jalali, Torgal, Coelho (2009), lime has been used by humanity in civil construction for millennia. Its applications stand out as a binder in lime and sand mortars; stabilizer in earth mortars; painting; and as a soil stabilizer for paving roads.

Among conventional binders, lime is the most compatible for stabilizing earth mortars. Faria (2016) explains that the calcium hydroxide (CaO_2) present in the hydrated lime, performs covalent bonds with the hydroxyls (OH) of the clays, promoting ceramic bonds. Thus, as the clay soil retains water by ionic bonds, with the presence of lime in the mortar, the clay has no more electrons available to make bonds with the water, so the water is not retained anymore by the clay mass.

After drying, the addition of lime to the earth mortar makes the structure rigid and resistant and also porous. This contribution is perfectly compatible with the need for earth mortar, as it increases the mechanical resistance of the plaster, makes it resistant to contact with water, and still maintains capillarity, allowing the masonry to release and absorb moisture without deteriorating the structure and rigidity plastering (Faria, 2016). Lime was also widely used for paints, in order to reduce the maintenance of coatings and earth-based paints, mainly on external walls. In addition, because it is an alkaline material, lime acts as a bactericide and fungicide (Coelho *et al.*, 2009). The addition of lime can also help to ward off insects and prevent the formation of nests. It is important to mention that earth mortars are not environments specifically conducive to insect proliferation. A masonry of ceramic blocks, concrete or stones, can also be subject to this if they are not plastered in the correct way, eliminating cracks and flaws in the wall surface. According to Eires (2012), on specific occasions and with greater structural demand, quicklime was hydrated with water and the addition of vegetable or animal oils (such as whale oil waste used in public lighting in Brazil in the 16th century). The mixture of lime and oils was also indicated in the first book of guidelines for architecture, the Vitruvius Treaty for Architecture (1st century BC).

> *Čechová (2009) explains that "the triglycerides present in the constitution of oils, when in contact with lime, result in insoluble salts of calcium from fatty acids and provide greater water repellency" (Eires, 2012).*

Currently, vegetable oils such as linseed and recycled cooking oils are also being investigated. Lima *et al.,* (2016) evaluated the addition of linseed oil to earth mortars and obtained surprising results compared to the performance of the addition in the same proportions of industrialized chemical stabilizers such as cement, lime and plaster. The addition of only 5% of linseed oil in the mixture of soil and sand, has already allowed the mortar to reach the requirements defined by DIN 18947 (NABau, 2018).

In several regions in South America it is possible to find ancient ruins of construction techniques with earth and stone made by ancient civilizations. But in Brazil, it is believed that building systems with earth material were introduced during the colonial period, as there is no evidence that indigenous indigenous peoples used earth as a building material (Rezende *et al.,* 2013). Thus, some vernacular solutions traditionally practiced in Brazil, may not have been developed here. But they were certainly adapted by local practitioners and the materials available. During the process of European invasion of Brazilian territorie, for example, although the colonizers did not initially find availability of limestone, they maintained the use of lime obtained from grinding and calcining corals and shellfish shells in artisanal ovens (Vasconcellos, 1733). The cow farming was also brought during the period of colonization. And the cow dung has also traditionally been used as a stabilizer in earth constructions across the country, from flooring to palsters and renders. Until today its properties are recognized by the popular oral culture in traditional communities (Pachamama, 2018). Recent research (Millogo *et al.,* 2016) now clarifies that bovine excrement is rich in nitrogen, phosphorus, phosphoric acid and potassium. And when added to mortars, these components react with the kaolin and fine quartz present in clayish earth, resulting in "insoluble silicate amine", which joins the components of the mixture together, giving it water resistance and hardness. In addition, the fibers present in cow dung also decrease shrinkage. According to Villane (2010), the addition of 10% (of the total mortar mass) of cow dung is sufficient to improve durability in relation to water and increase the mechanical resistance of earth mortars. For this reason, in the Brazilian context, cow dung proves to be a very suitable option for stabilizing earth mortars. As for other countries with large cultures of this animal. There are many solutions practiced by the vernacular tradition in the construction with earth, however it is necessary to know its characteristics well to recommend its use in the professional field. Through the bibliographic review of research published online, one can perceive a greater availability of information and studies on industrialized materials such as lime and cement. However, for other traditional vernacular solutions, there is still not so much scientific investigation. For this reason, the study of these elements is justified to understand their behavior and evidence their performance. As there are still no standard in Brazil for earth mortars, for a responsible professional practice, the materials and methods of evaluation of earth mortars must follow criteria and requirements established by standards on the subject such as Lehmbau Regeln, the German Association for earth building.

DEUTSCHES STANDART DIN 18947: EARTH PLASTERS -TERMS, DEFINITIONS, REQUIREMENTS AND TEST METHODS: In Europe, perhaps due to the limited nature and available natural resources, earth constructions have received more attention. After devastation of European forests and after large disastrous fires, some more populated capitals and urban centers adopted some governmental determinations for use earth walls between buildings to prevent the spread of new fires (Hunter and Kiffmeyer, 2004). According to Schroeder (2018) also after the Second World War, Germany published the first standards for earth construction in the world. Both because it is a cheap and accessible material for the reconstruction of the affected cities and because it is not flammable. However, after the country's economic stabilization, the standarts were canceled in 1970. Only in the 1980's, with the worldwide trend of searching for sustainable materials for civil construction, the construction with earth took over the attention of the Germans. Until in 1999 the modern 'Lehmbau Regeln' (regulation for earth construction in Germany) was published (Schroeder, 2018). Since then, the country has increasingly institutionalized the material, becoming a world reference in the normalization of construction with earth, and inspired technical standards published in other countries around the planet (Schroeder, 2018). In 2013, again in a pioneering way, Germany published the world's first technical standard specific to earth plasters. The DIN 18947 standard (NaBau, 2018), was updated in 2018, and was developed by the Deutsches Institutfür Normung (DIN). It defines the classification parameters and test methods for the physical and mechanical evaluation of earth mortars, which has also been used as a reference in several countries. According to the DIN standard, earth plaster must be made with clayish earth, aggregates and mineral or vegetable additions. As minerals stabilizers, are accepted additions such as ceramic brick powder (pozzolans), expanded pearlite, expanded clay, expanded glass, expanded shale and stone-poles. And as organic stabilizers, are allowed additions such as bark, vegetable fibers, animal hair and crushed wood. The addition of inorganic pigments according to EN 12878 or vegetable dyes is also allowed.

For the evaluation of earth mortars, the German standard indicates the performance of tests that are referenced in the set of European standards EN 1015 (CEN, 1999):

- Limits of salt content;
- Dry linear shrinkage;
- Preparation of mortars and test samples;
- Flow table consistency;
- Dry bulk density;
- Flexural and compressive strength;
- Adhesive strength;
- Physical abrasion resistance
- Resistance to water vapor diffusion;
- Thermal conductivity;
- Fire resistence;
- Water adsorption capacity;

Comparing the German standard for earth mortars with the Brazilian standard NBR 13281 (ABNT, 2005) for laying and cladding mortars for walls and ceilings, it can be seen that almost the same criteria are required for mortar analysis. However, the parameters presented in the Brazilian standard are based on the performance of mortars produced with cement or lime. For this reason, they cannot be considered for the analysis of earth mortar. That is why it's so important to develop a specific Brazilian standard for the evaluation of physical and mechanical properties of earth mortars. Current Brazilian standards for tests methods may be indicated. And also must be presented the self parameters for the classification of mortars with values consistents with the cultural, climatic and geomorphological context of the country. And finnaly, to support this datas, scientific research on mortars produced with Brazilian soils is so necessary.

Conclusion

The simplicity and quality of clayish earth as a building material were responsible for its survival through time and diffusion throughout the Brazilian territory from Portuguese colonization to the present day. Many solutions emerged and fell into disuse in daily empirical practice, but only those with better performance and convenience remained in use. Currently, building is a complex commercial procedure, ensured by contracts legally and judicially agreed by several involved like designer, bricklayer, master of construction, client and manufacturers of construction materials. For this reason, all materials and structures used must comply with current construction and technical standards. Brazil has an abundant mineral abundance in its territory, and a consolidated and imperialist market for the exploration of these materials. However, despite the lack of available resources, it is the population's right to choose to build with ecological material in a safe and responsible manner attested by ABNT (brazilian association of technical tandards). Therefore, in a country like Brazil, where there is still a living tradition of building with earth, and a vast vernacular repertoire of historical heritage in demand for restoration, it is very important to deepen the studies on earth mortars and publish it's own satandart. It is necessary to investigate the materials available in the country, the traditional materials and the new compatible solutions, because although the materials and solutions of vernacular architecture are subject to transformations and adaptations according to the demands and technological innovations that arise over time, the qualities of these materials already consecrated by the empirical vernacular tradition justify their return and the continued use of them nowadays.

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