

Earth plasters

The influence of composition for IAQ and comfort

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CENTRO da TERRA

What is a render ?

What is a plaster ?

EN 998-1 (2016) → A plaster is applied indoors and a render is applied outdoors

The main function of plasters and renders is to protect the substrate they cover

But others functions are also important → for plasters, the contribution for IAQ and comfort

What is an eco-efficient plaster ?

- A plaster that **fulfils its main function** (protecting the substrate), contributing to **increase the substrate durability**
- A plaster that is **durable** (without jeopardizing the previous)
- A plaster that is formulated with **low embodied energy materials** and have **low consumption of virgen raw materials**
- A plaster that contributes to **aesthetics, IAQ and comfort**, reducing energy consumption

• ...



What is an earth plaster ?

As you all know, it is a plaster made with an earth mortar

Earth mortar → mix of earth (clay, silt, sand, after removal of coarser particles) with water

If the **earth** is **highly clayish** → **additional sand** is added to reduce plaster drying shrinkage



For **pure (“chemically” unstabilized) earth plasters** final volumetric proportion of 1:1 to 1:3 (clayey earth : sand) are frequent

Can an earth plaster be efficient when applied on different masonries? <https://doi.org/10.1016/j.jobe.2019.02.011>



Earth plasters can be applied manually or mechanically on different substrates

(right side credits: Embarro company)

What is an earth plaster ?

Pure earth plasters can have added plant fibres
(wastes from agro-industry)



The main reasons is aesthetics

In that case, drying has to be quite
ventilated to avoid biological colonization



Earth plasters may have **different colours and textures**, depending on the earth and other composition, and on the finishing

When a **low content of binder**, such as air lime or hemihydrate gypsum, or **bioproduct**, such as linseed oil or biopolymers are added, they are called **stabilized earth plasters**

Stabilized earth plasters have **increased durability towards water**, although their environmental impact increases and reusability may be compromised

Depending on the type and content of addition, mechanical performance also change

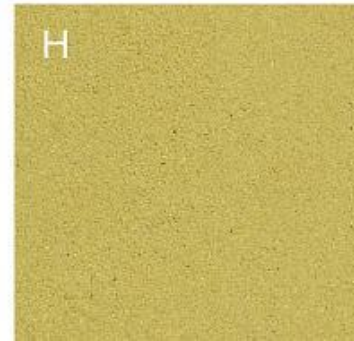
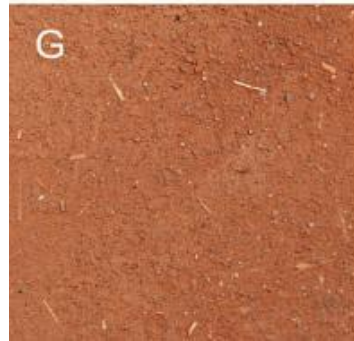
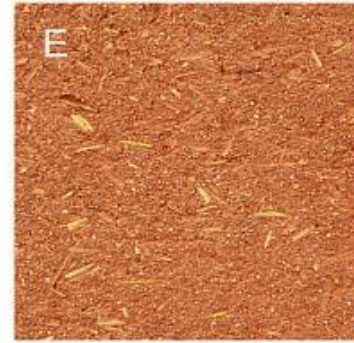
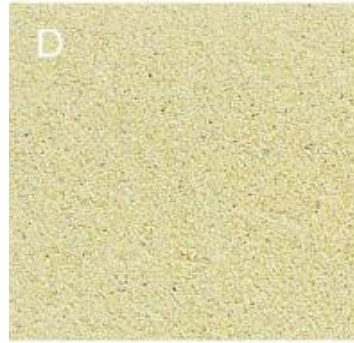
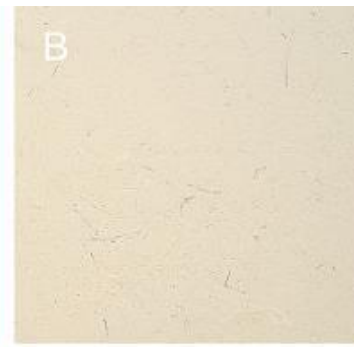
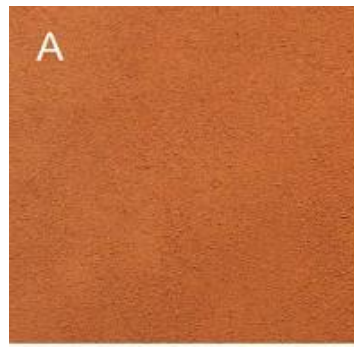
Their colour may also change with stabilization

Examples of different aesthetics of earth plastering mortars

Differences due to:

- Different earths (lighter, reddish, chocolate colour,...)
- Addition of fibers
- Addition of low content of limes

Earth plasters (in Portuguese),
Argumentum



Examples of different colour earth plastering mortars



Earth plasters (in
Portuguese),
Argumentum



So we know that earth plastering mortars...

- Have low embodied energy (no firing associated to binder production)
- Have good aesthetic and do not need to be painted
- Are compatible with old and new masonries
- Are reversible and the materials are reusable (if not chemically stabilized)
- Are vulnerable to water, if not stabilised
- Are highly hygroscopic and contribute to IAQ and comfort
- But they also have to fulfil plasters' function of protecting the masonry and be durable

As for other plasters, testing is performed to confirm those conditions



Can an earth plaster be efficient when applied on different masonries? <https://doi.org/10.1016/j.jobe.2019.02.011>

Addition of plant fibres on earth plasters

Different plant fibres can be used, such as **oak** (coarser) and **typha fibres** (very thin and short)



a



b



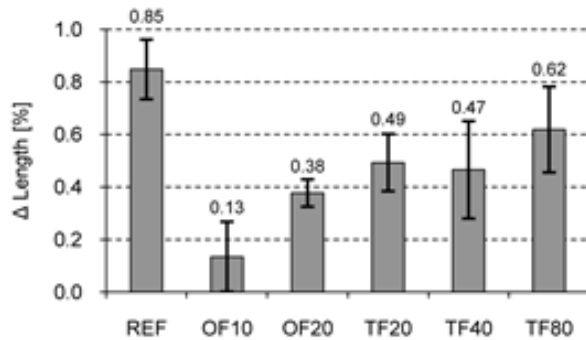
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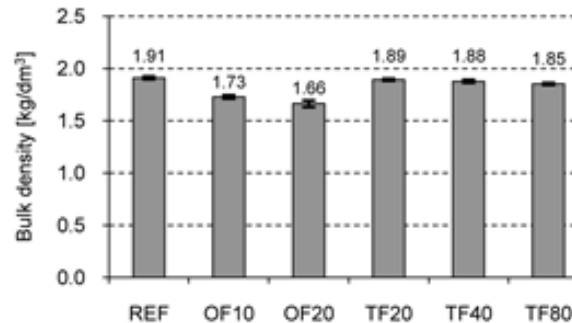
d

To be comparable, the same % of volume (not mass) should be added

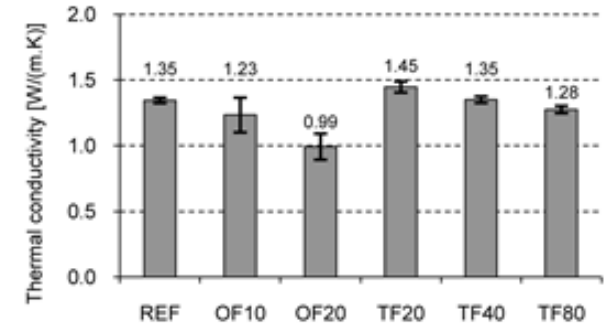
Effect of different type and content of plant fibres



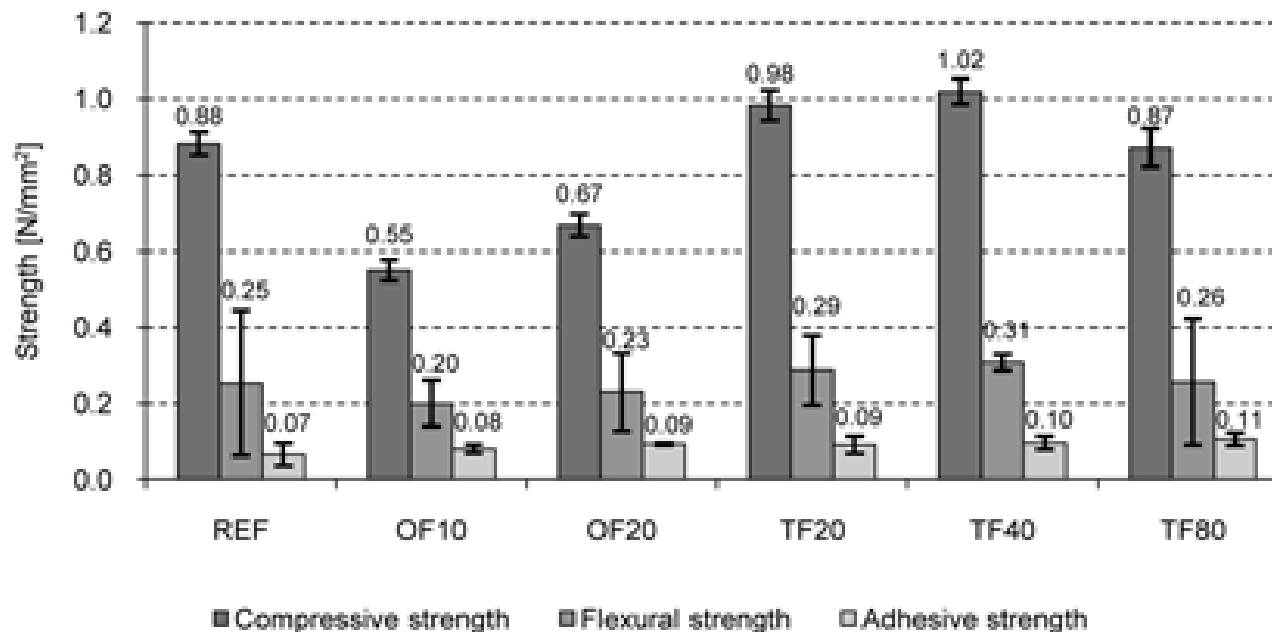
Dimensional stability increases



Density slightly decreases



Thermal conductivity depends



OF – with **oak** fibres (10, 20%)
TF – with **typha** fibres (20, 40, 80% vol. Clay+Sand)

Mechanical performance depends

Additions of low binder content on earth plasters

No need to think on cement !

Cement is needed for structural mortars, not the case of plasters

Better to think on low embodied energy binders, such as gypsum and air lime

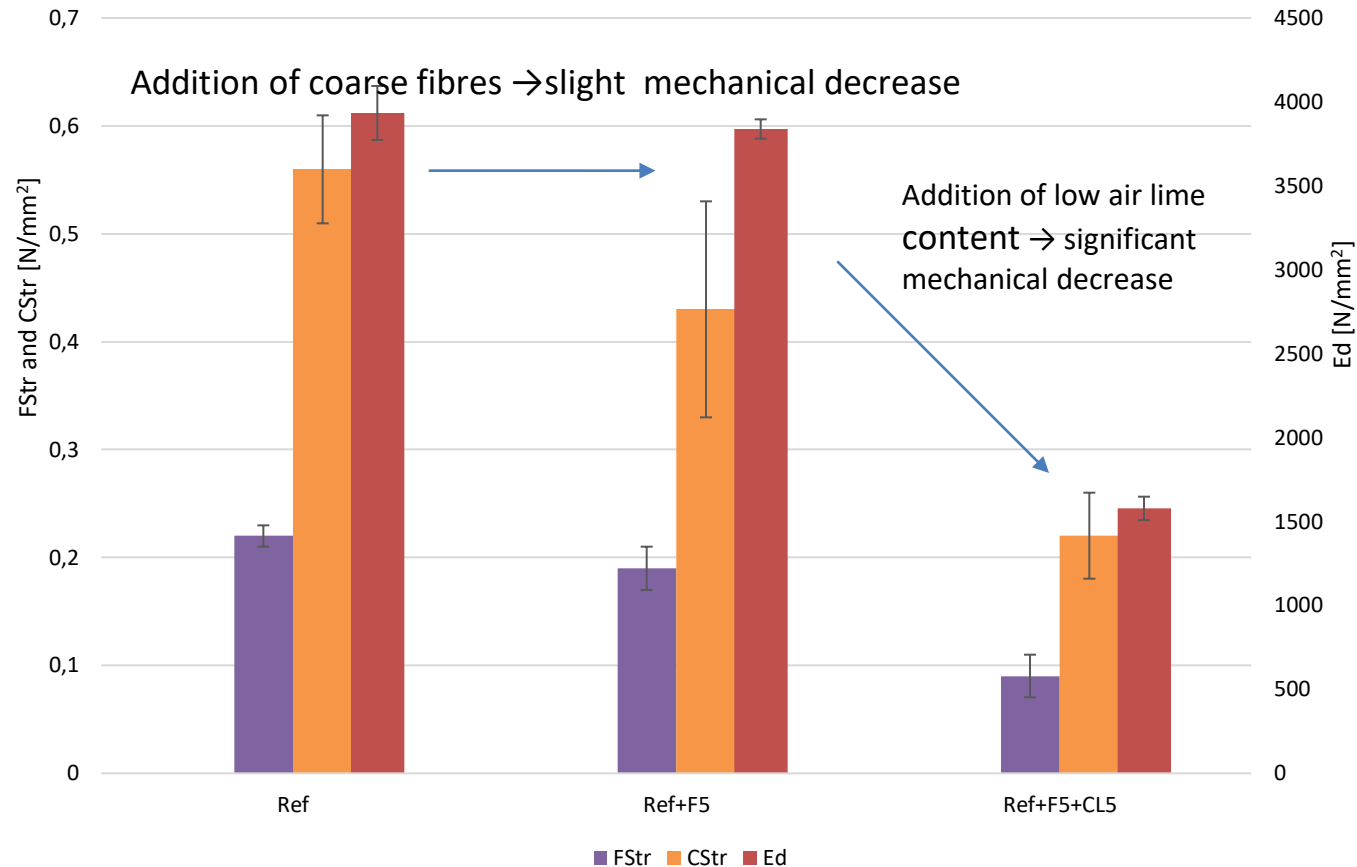
Additions of bio-stabilizers on earth plasters

Many different possibilities of natural ones are being studied

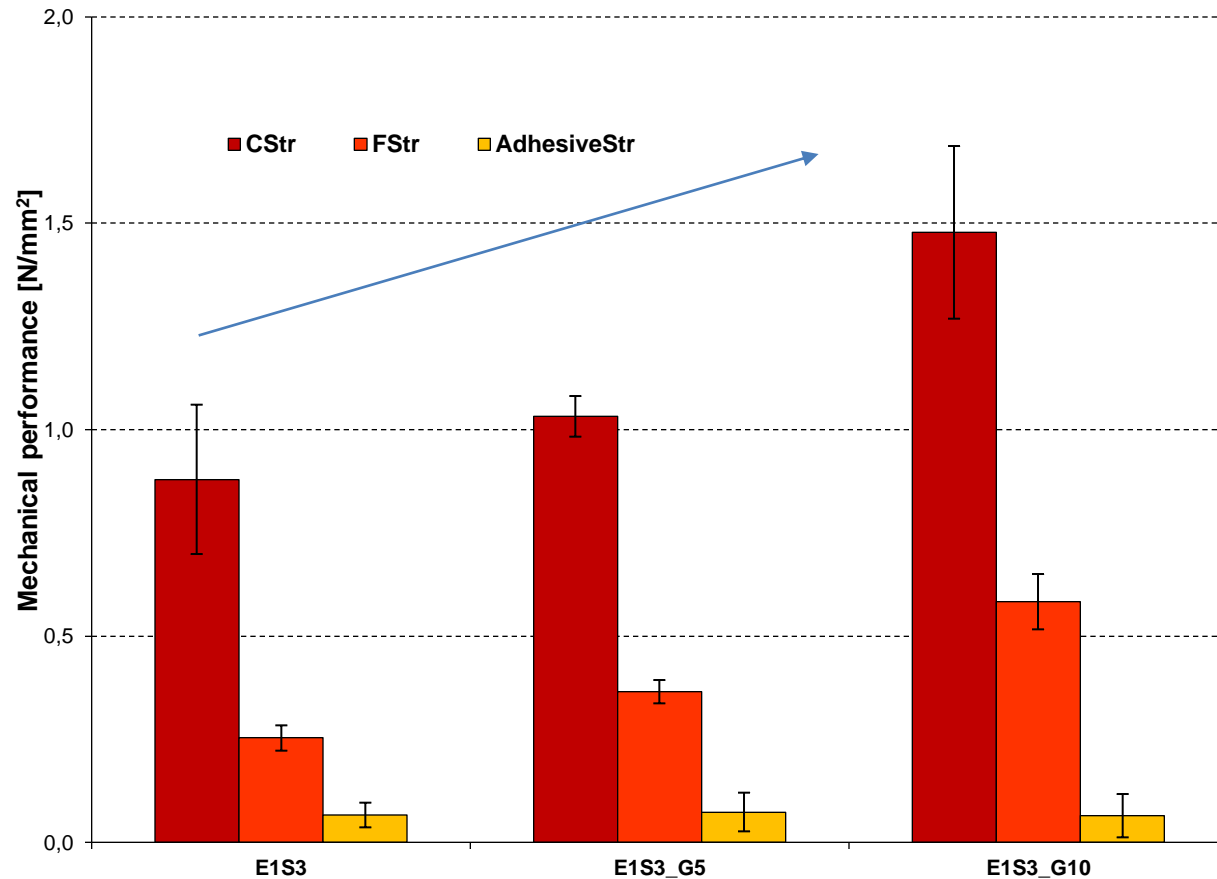
No need to think on synthetic ones

With both these additions, embodied energy is increased but resistance to water also increases, turning mortars available also for renders

Effect of plant fibres and fibres+low air lime addition on an earth plaster



Effect of low gypsum addition on an earth plaster



Earth plasters: the influence of gypsum addition and added sand granulometry (in Portuguese). Argamassas 2016

Earth plastering mortars hygroscopicity

Hygroscopicity can be assessed based on the DIN 18947 standard, other CEN standards and other methods

Based on the DIN 18947, there are three classes of plasters hygroscopicity: WSI, WSII and WSIII depending the moisture adsorption up to 12h

For the DIN, plaster samples in metallic moulds are used

For **sorption**:

Samples in mass equilibrium at 50% relative humidity (RH), are placed at 80% RH and the weight variation measured along the time

For **desorption** (not in the DIN standard):

After being weighted at 80% RH, samples are placed at 50% RH and weighted along the time

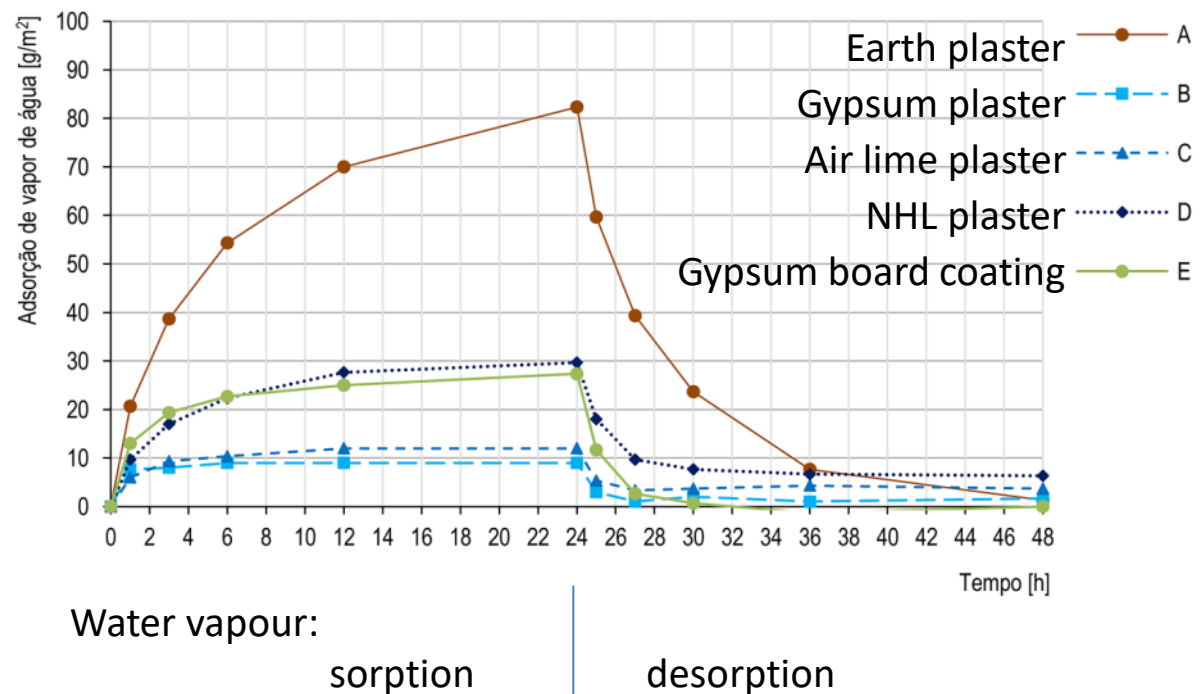
Earth plastering mortars hygroscopicity

Hygroscopicity is very high in **comparison to others plasters** and finishings → earth plasters act as passive water vapour buffers

After 12 h (and 24 h) the earth plaster adsorb water vapour:

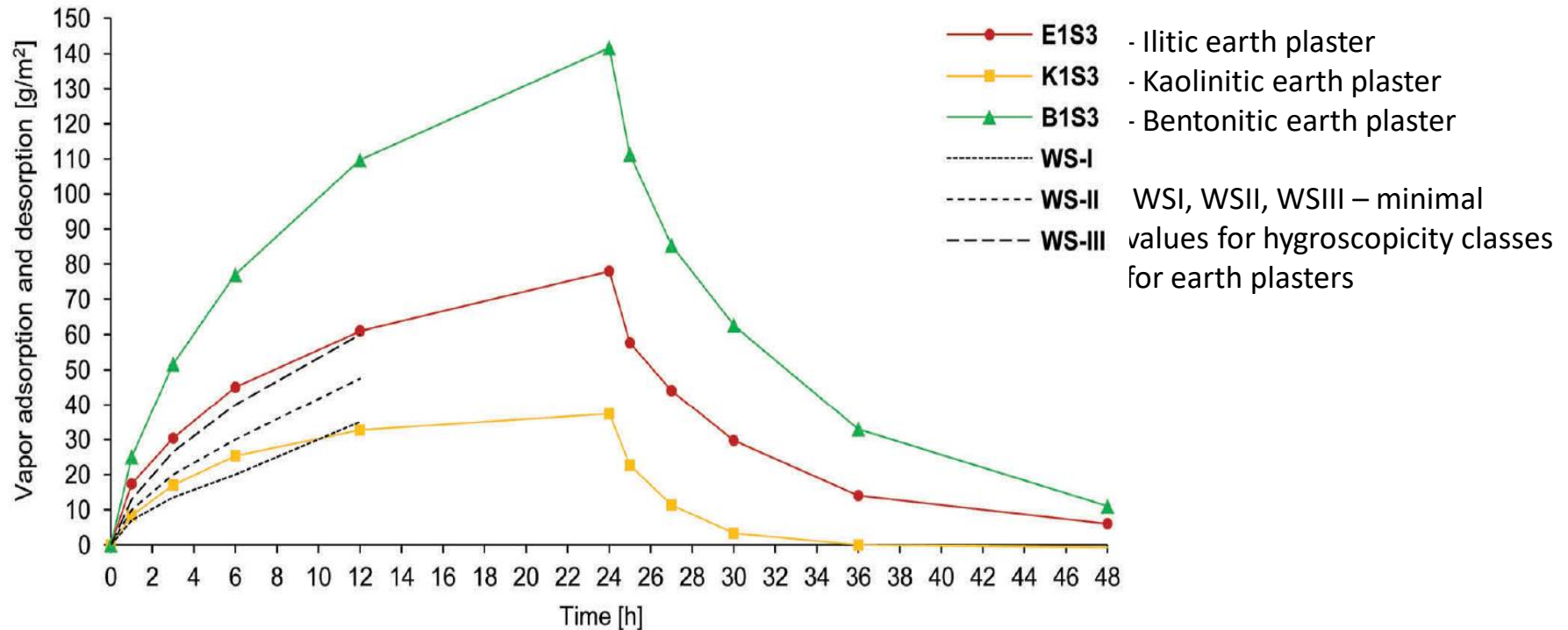
- more than the double of gypsum board coating
- 7-8 times more than a gypsum or air lime plaster

In 24 h it can desorb all the water vapour it has adsorb previously



Earth plastering mortars hygroscopicity

Earth plasters hygroscopicity depend on the **type of clayish** earth



But other characteristics also depend on the type of clay

Bentonitic/montmorillonitic clays have high shrinkage, producing cracks on the plaster

Earth plastering mortars hygroscopicity

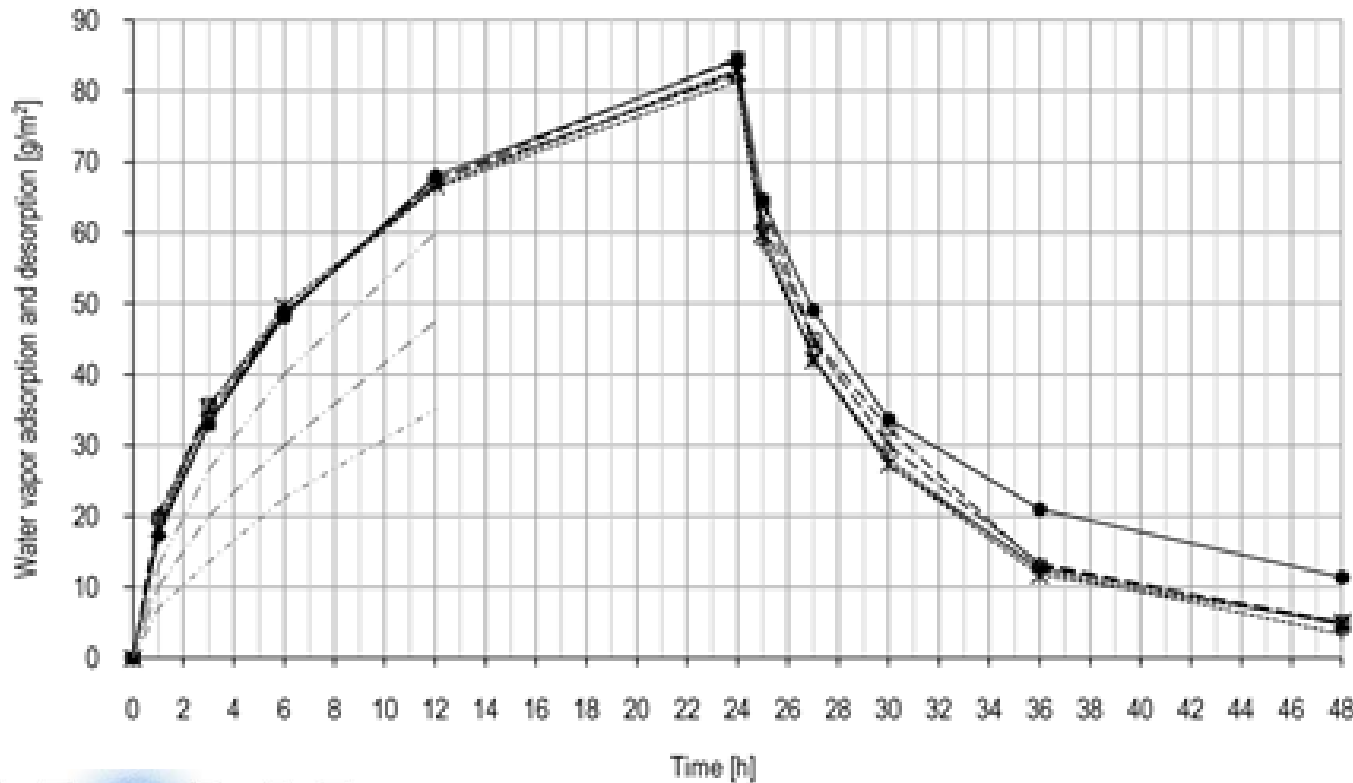
Earth plasters hygroscopicity is so high that the **effect of plant fibres** is slight

—●— REF - - - ▲ - - - OF10 - - - ■ - - - OF20
- - - + - - - TF20 - - - ✕ - - - TF40 - - - ✕ - - - TF80
- - - · - - - WS-III - - - · - - - WS-II - - - · - - - WS-I

OF – with **oak fibres** (10, 20%)

TF – with **typha fibres** (20, 40, 80%)

WSI, WSII, WSIII – minimal values for hygroscopicity classes for earth plasters (DIN 18947)

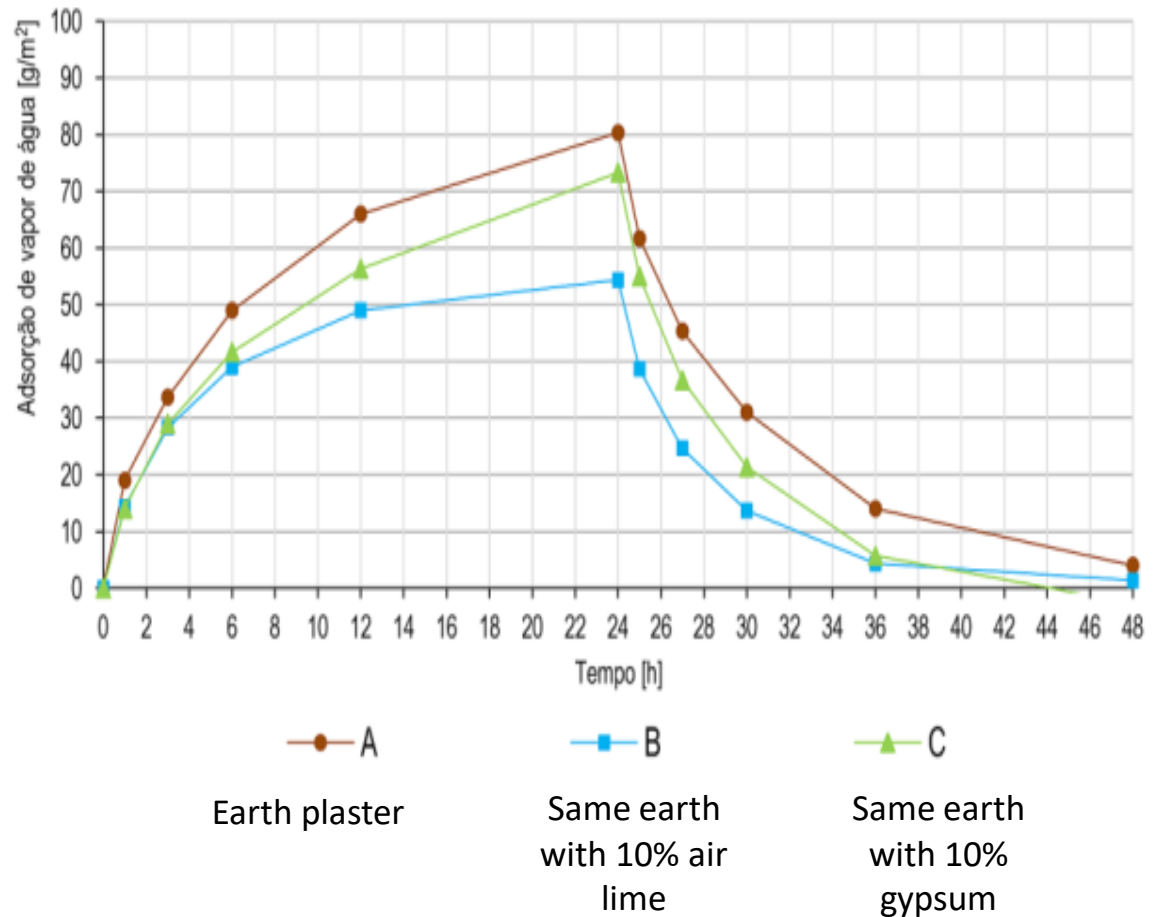


Earth plastering mortars hygroscopicity

Addition of low content of **binders** → reduces its hygroscopicity

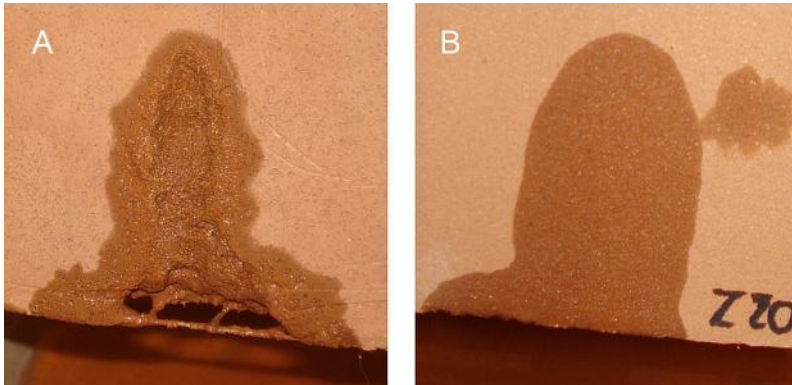
Depending on the colour of the earth, it can also turn it lighter

Depending on the type and content of binder, can increase or decrease strength



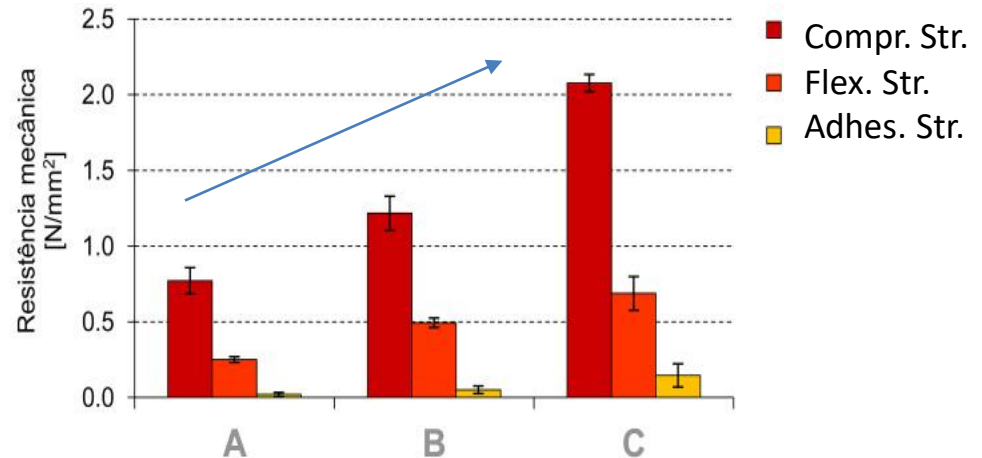
Bioproduct-stabilized earth plastering mortars

Low amount of **natural fats** (such as linseed oil) → decreases hygroscopicity (but also **reducing vulnerability to liquid water** and turning them viable for renders)



Depending on the colour of the earth, it can also turn it darker

Strength also increases



Mechanical properties [N/mm²] testing

A – Earth plaster

B – Earth plaster with 1% linseed oil

C – Earth plaster with 3% linseed oil

Earth plastering mortar finishings

Do not need to be painted → to profit from hygroscopicity and aesthetics, without increasing embodied energy

When not stabilised, a humid sponge can change the surface texture; therefore, earth plasters are dynamic and versatile

But the surface can be protected with a:

- Consolidant, without forming pellicula - for instance, linseed oil or other bioproducts
- Paints, changing colour (preferably a lime wash)
- Thin layer of a clay finishing or a binder-filler paste (based on air lime putty or gypsum)

Different surface applications have different protective actions and different hygroscopic decrease

Assessment of natural aging and ecological surface treatments in clay-based renderings (in Portuguese). <https://doi.org/10.14568/cp2019005>

Efficacy of iron-based bioproducts as surface biotreatment for earth-based plastering mortars.

<https://doi.org/10.1016/j.jclepro.2019.117803>

Mauffre (2022)

Earth plasters – examples of surface treatments



Applications of surface treatments

Effect of a surface biotreatment
on the water absorption of an
earth plaster



Changes in colour due to surface biotreatments

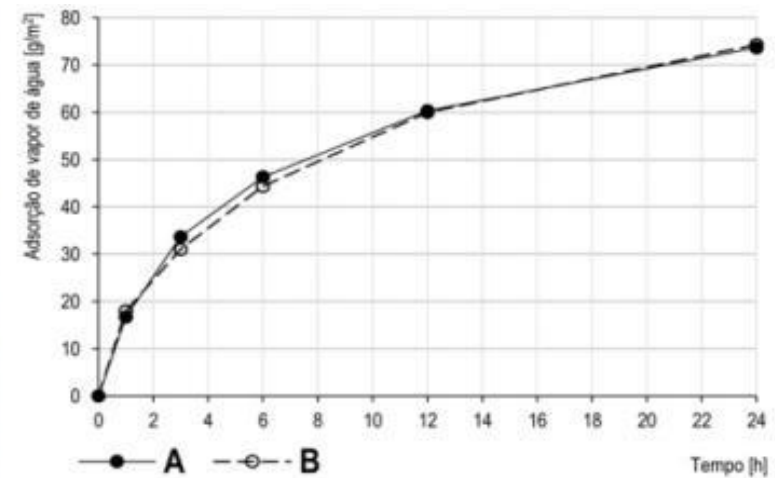


Limewashes

Applications

Increases
durability to
water

Changes
aesthetics with a
slight effect on
hygroscopicity



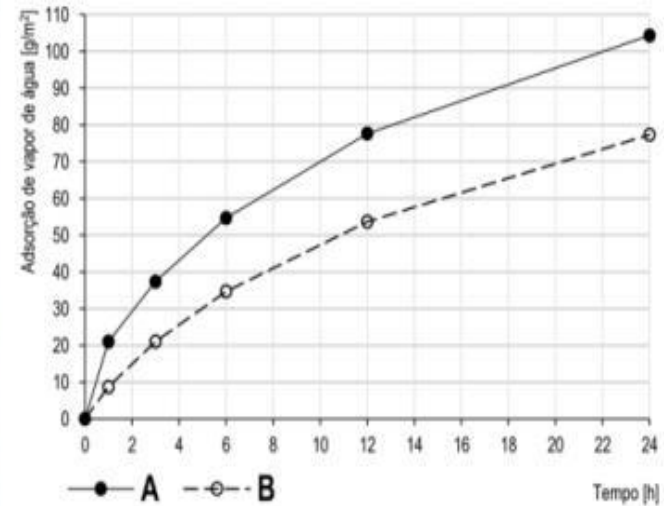
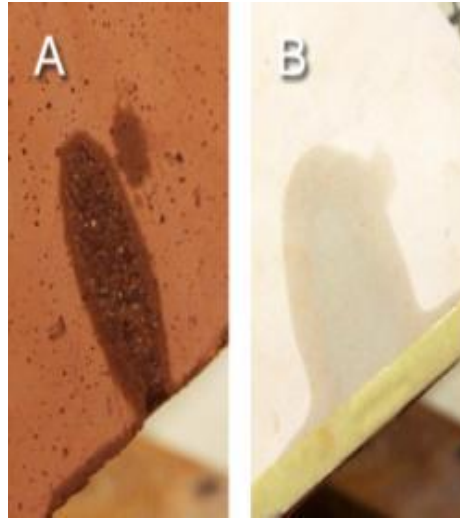
Thin finishing layer



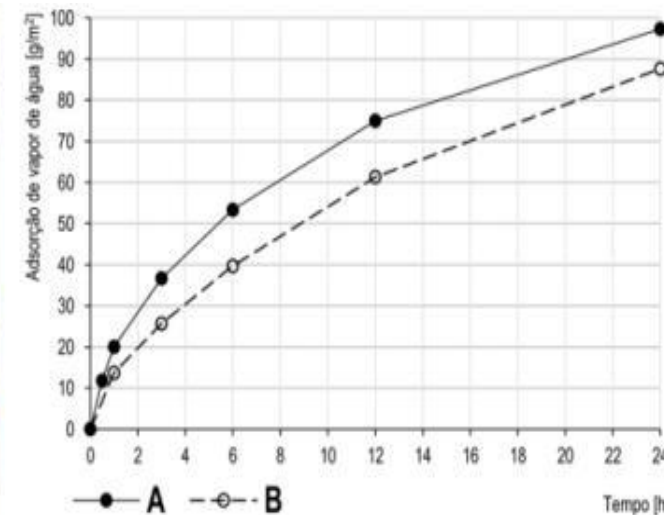
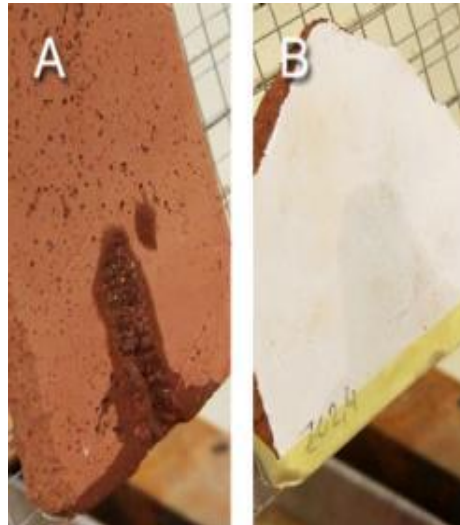
Application of a thin lime putty finishing on an earth plaster

Effect of thin finishing layers on hygroscopicity

Thin layer of gypsum paste



Thin layer of lime putty paste



Ongoing and future research

The contribution that earth plasters may have to further improve IAQ by **pollutants capture** is a main issue for the next years, as it has been said but not already quantified with scientific evidence

The optimization of **eco-efficiency** replacing added natural sand by recycled aggregates

The effect of biostabilization on durability and reusability at the end of life

...

Conclusion

Earth plasters can be highly eco-efficient because:

- they can have low embodied energy
- due to high hygroscopicity they can strongly contribute passively to IAQ and comfort
- they have protect the substrate
- they can be durable, if adequately design and applied

But a lot of research is still needed so they can be further optimized !!!

Thank you so much for your attention!



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