Civil Engineering Department

Performance of bio-based insulation panels based on earth, rice husk, gypsum and lime

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Contents

1. Introduction

- One of the biggest issues in the construction sector is the impact of building materials on inhabitants health
- Indoor air quality is one of the major risk for human health
- The use of bio-based materials can contribute to this problem

Bio-based materials

- Low environmental impact
- Ability to regulate the indoor relative humidity, improvimg the hygrothermal performance of buildings
- Low costs

2. Development of earth-rice husk insulation panels

2.1. Materials and methods

- **Earth - quarry fines from washing aggregate sludge** →
- Rice husk
- Hemi-hydrated gypsum
- Air lime

- High hygroscopicity
- Relatively low termal conductivity
- Economical
- Environmentally friendly
- Reusable or recyclable

Contribution to regulate the relative humidity of the environment

2. Development of earth-rice husk insulation panels

2.1. Materials and methods

- Earth
- **Rice husk** → Natural fibres – from literature:
  - Decrease shrinkage
  - Increase deformability
  - Decrease thermal conductivity
- Hemi-hydrated gypsum
- Air lime

Due to high water absorption, contribute to regulate indoor relative humidity levels

2. Development of earth-rice husk insulation panels

2.1. Materials and methods

- Earth
- **Rice husk** →
- Hemi-hydrated gypsum
- Air lime

Boiling natural fibres – from literature:

- Decrease thermal conductivity
- Increase adherence
- Increase tensile flexural strength

Rice husk was boiled for 1 hour

2. Development of earth-rice husk insulation panels

2.1. Materials and methods

- Earth
- Rice husk
- **Hemi-hydrated gypsum** →
- Air lime

From literature:

- Inorganic binder produced at a very low temperature: ~120°C
- Reacts with water, increasing drying speed
- Decrease thermal conductivity
- Increase compressive and tensile flexural strength
- According to the literature an optimized gypsum content can lead to improvements on the performance of earth composites

(Lima et al 2016, Binici et al. 2005)

2. Development of earth-rice husk insulation panels

2.1. Materials and methods

- Earth
- Rice husk
- Hemi-hydrate gypsum
- **Air lime** →

From literature:

- Inorganic binder produced at a relatively low T: ~900°C
- Reacts by carbonation, capturing CO_2
- Increases resistance to water and reduces biological susceptibility
- Need to find an optimized content of lime to earth composites

(Millogo et al. 2008, Gomes et al. 2016, Faria et al. 2013)

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COST FP1303 Performance of bio-based building materials

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2. Development of earth-rice husk insulation panels

2.2. Specimens production

Specimen	Gypsum*	Lime*	Rice husk*	
RH_15D	20%	10%	15%	Dried
RH_30D			30%	Dried
RH_30B			30%	Boiled

* percentages by volume of earth

Mixing

- Mixing of the dry ingredients (earth, gypsum, lime) with a shovel
- Mechanical mixing while water is added until a homogeneous consistency is obtained
- Mixing for 90 seconds more
- Addition of rice husk and mixing until a homogeneous consistency was obtained

2. Development of earth-rice husk insulation panels

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RH_15D	20%	10%	15%	Dried
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* percentages by volume of earth

Curing

- Casting in 200x200x40 (mm) wooden moulds and 40x40x160 (mm) metallic moulds
- Laboratory conditions: 23ºC and 50% RH
- Demoulding after 2 weeks and complete drying for another 2 weeks

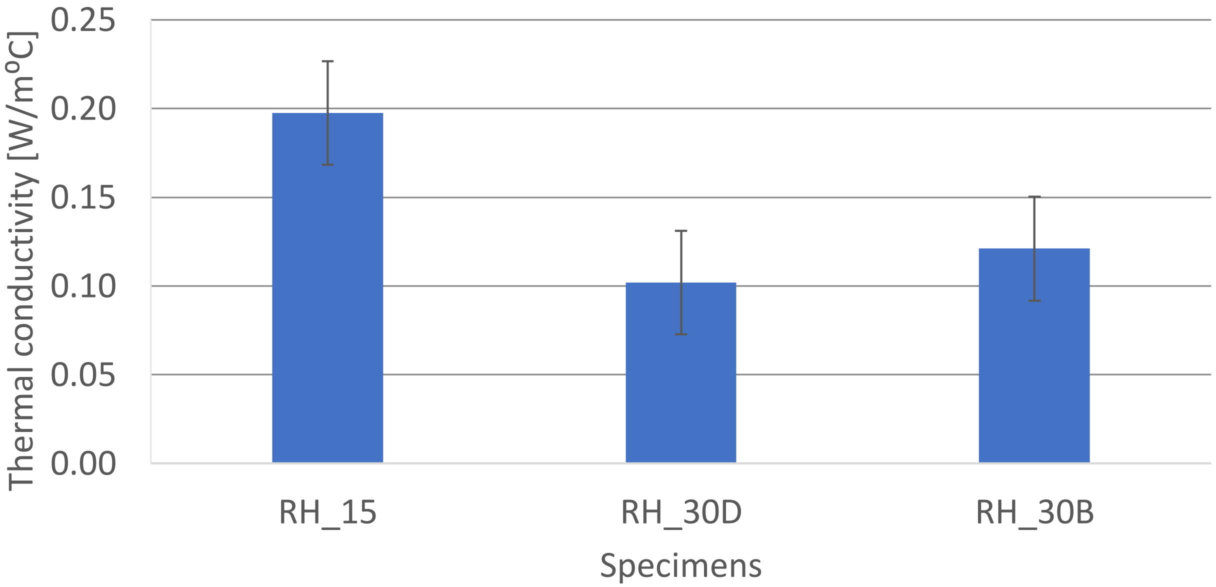
2. Development of earth-rice husk insulation panels

2.3. Experimental campaign and results

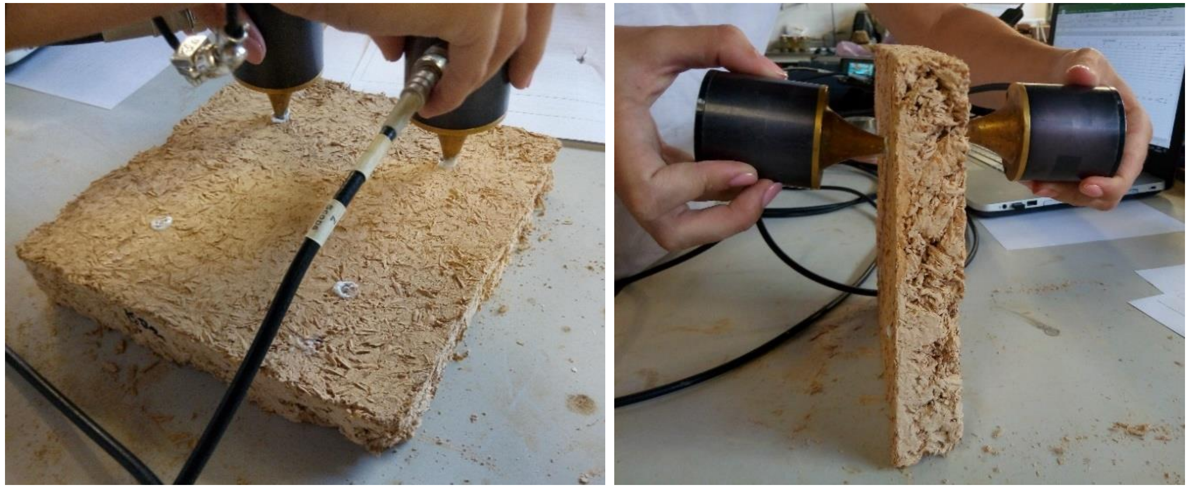
- Thermal conductivity
- Ultra sound propagation speed
- Abrasion
- Tensile flexural strength
- Compressive strength
- Moisture Buffer Value
- Fire reaction test

2.3. Experimental campaign and results – Thermal conductivity

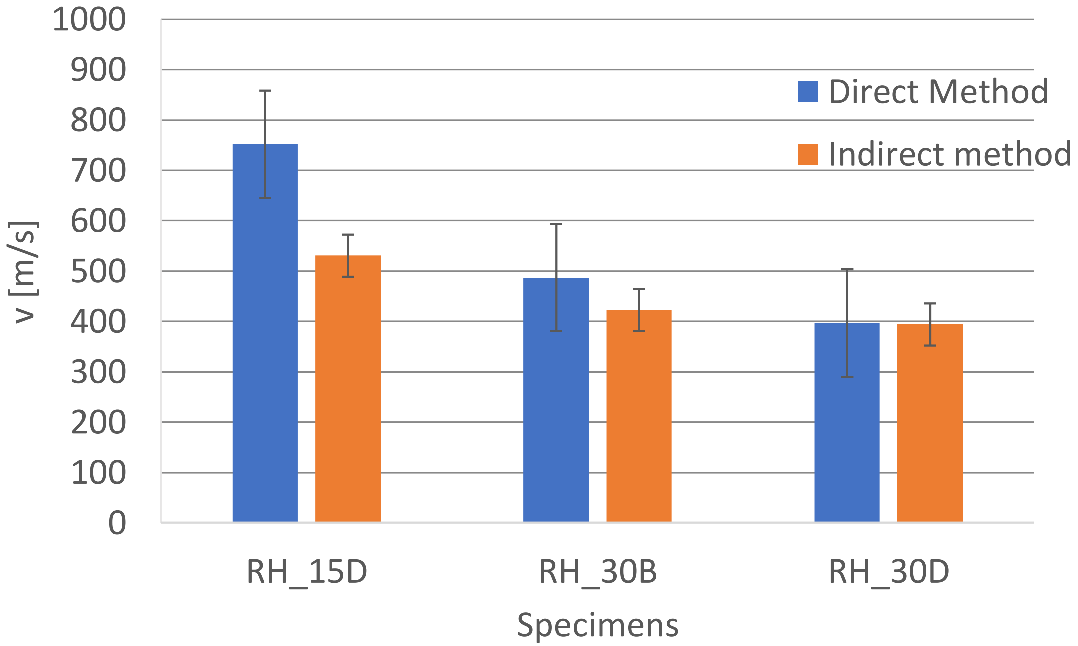
ISOMET 2104 Heat Transfer Analyzer equipment and contact probe



2.3. Experimental campaign and results – Ultra sound propagation velocity (EN 12504-4)



Indirect and direct methods with Proceq Pundit Lab equipment, frequency: 150 Hz



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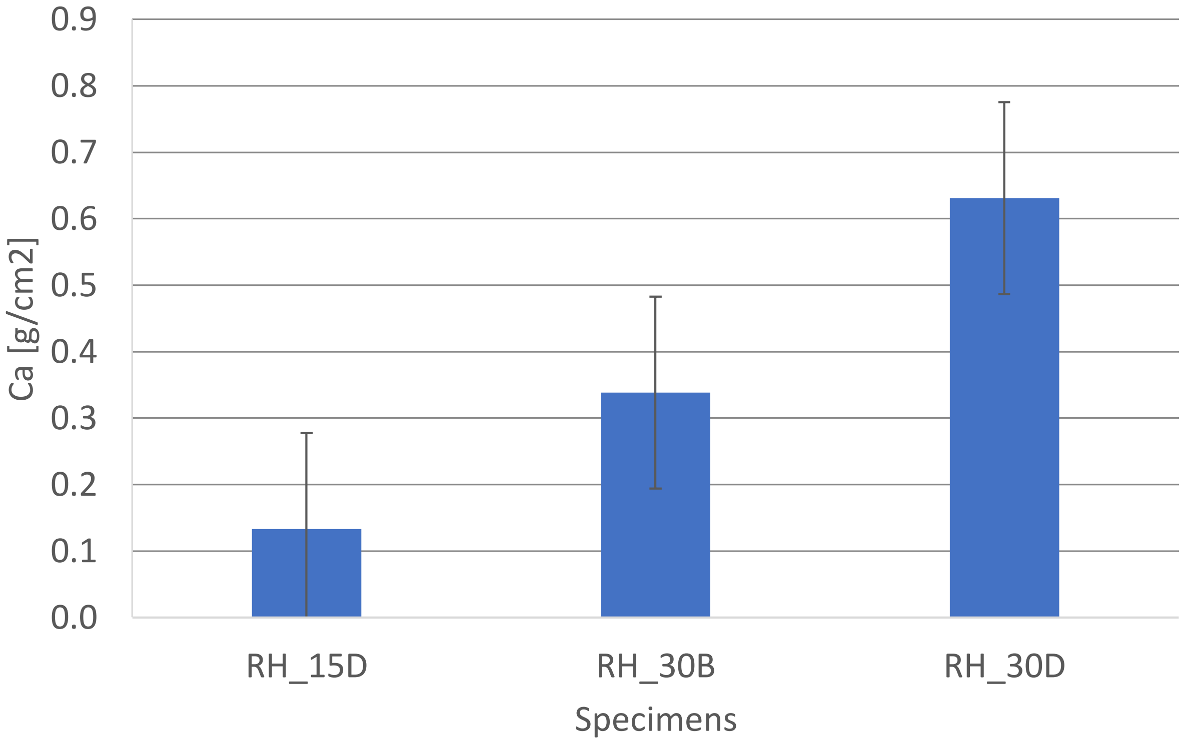
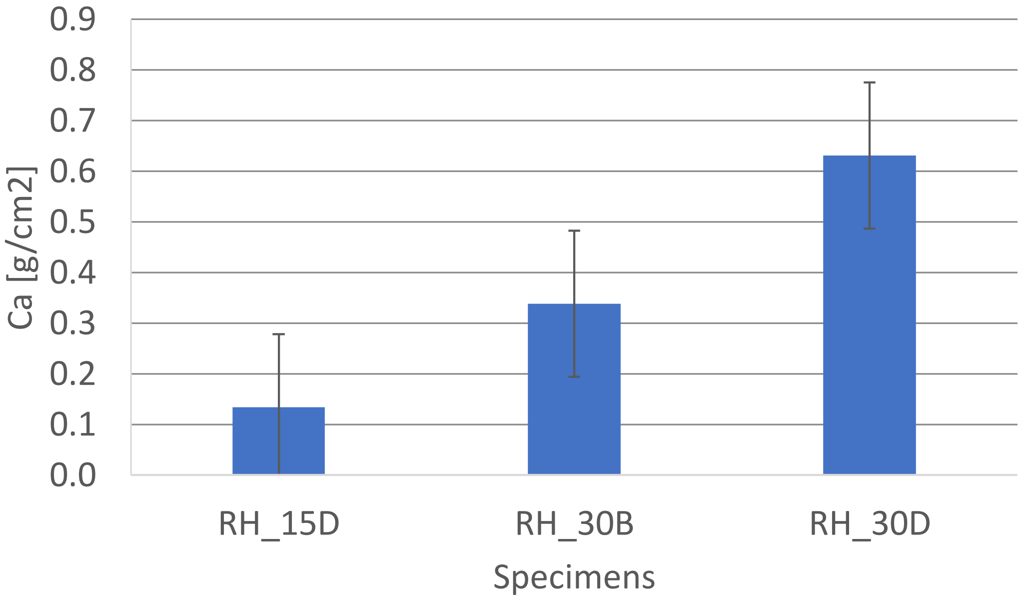
2.3. Experimental campaign and results – Abrasion (DIN 18947 for earth plasters)



Evaluation of weight loss after 20 rotations with a polyethylene brush, with 2 kg making pressure on the surface

2.3. Experimental campaign and results – Abrasion (DIN 18947 for earth plasters)

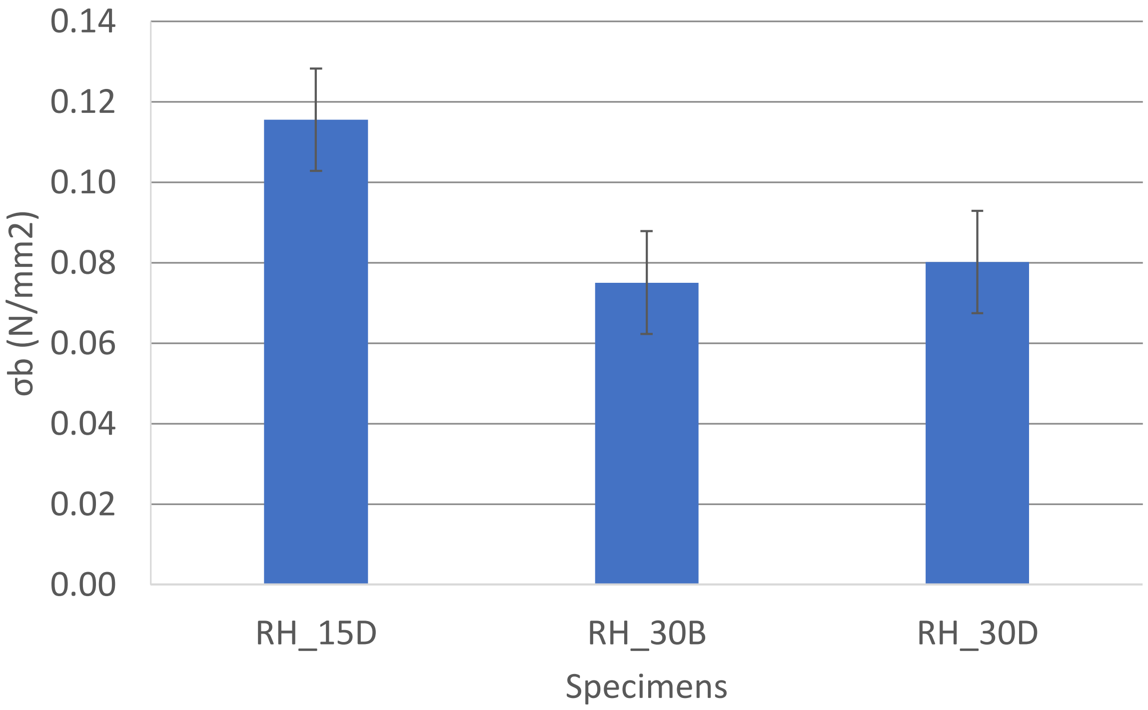
RH_15D RH_30B RH_30D



2.3. Experimental campaign and results – Tensile flexural strength (EN 12089 for thermal insulating products)

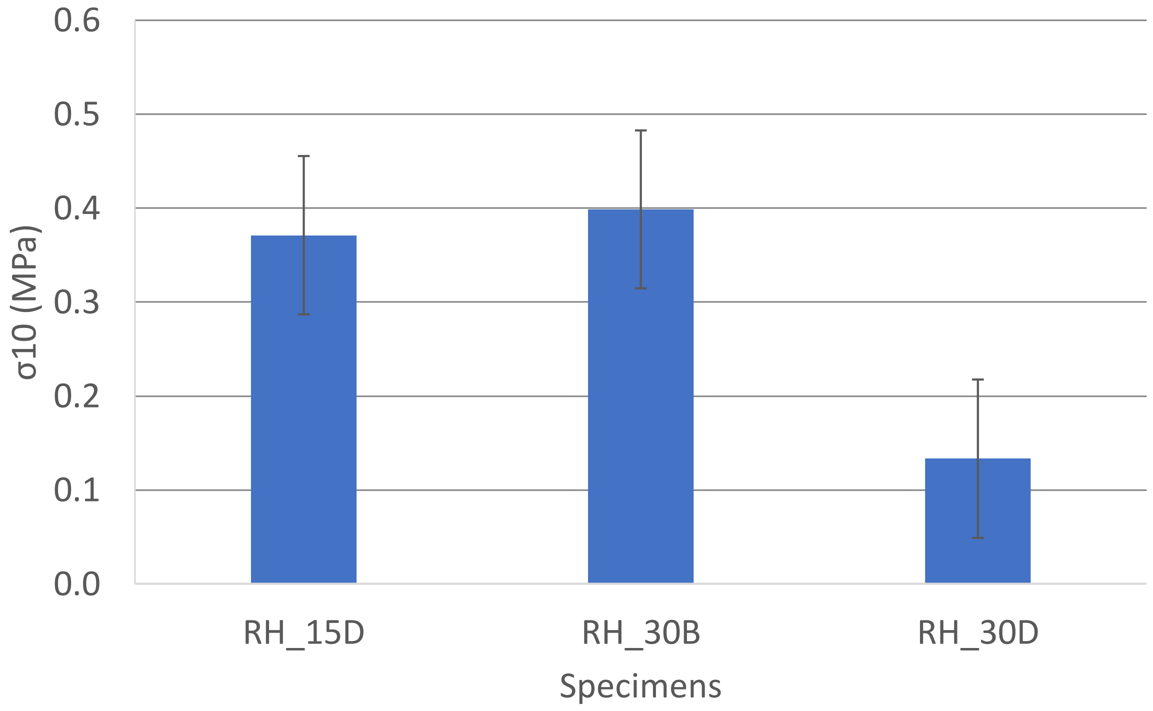
Zwick Rowell Z050 equipment

Support distance: 100 mm



2.3. Experimental campaign and results – Compressive strength (EN 826 for thermal insulating products)

Zwick Rowell Z050 equipment



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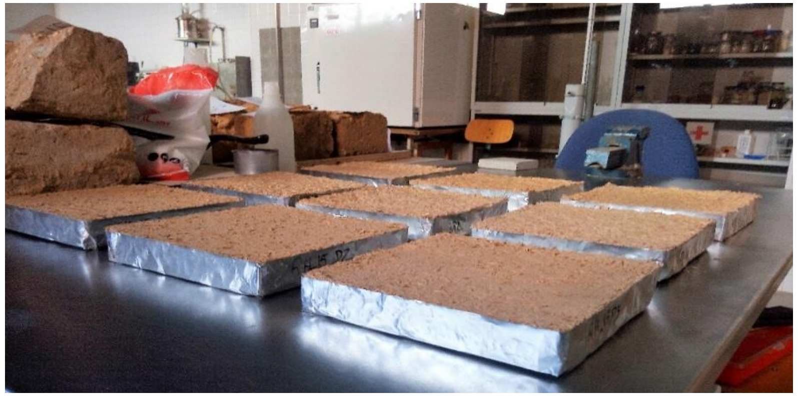
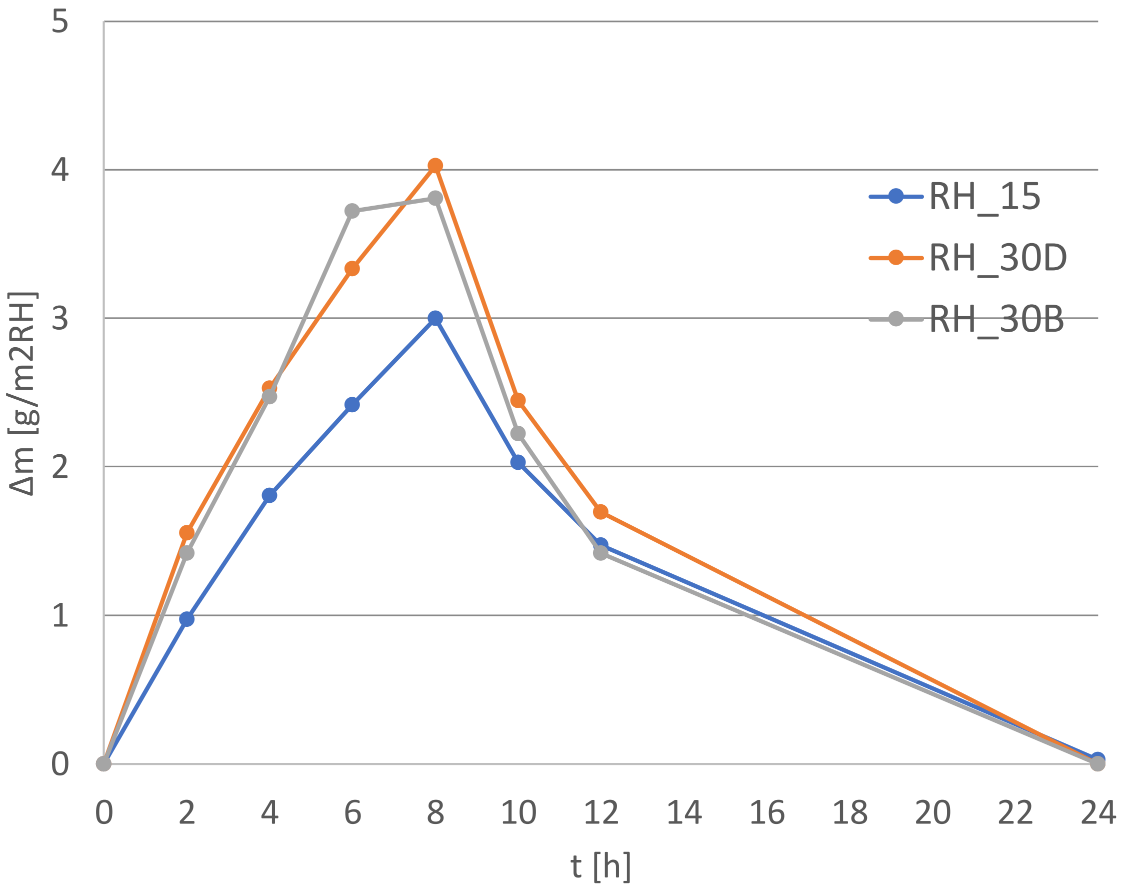
2.3. Experimental campaign and results – Moisture Buffer Value (NordTest but with 16ºC and 60-90% RH)





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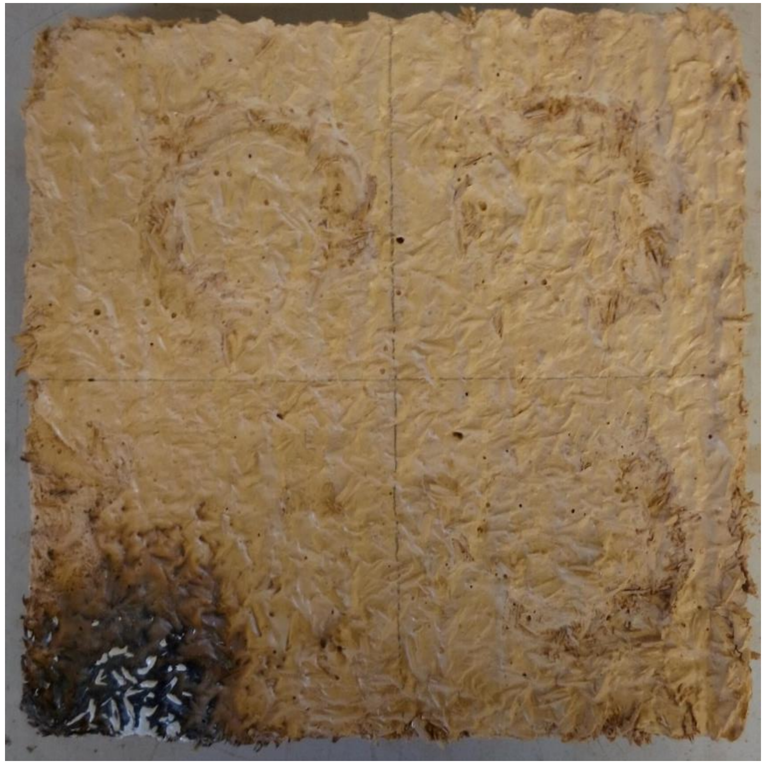
2.3. Experimental campaign and results – Reaction to fire test (based on EN ISO 11925-2)

- Panels placed on a metallic support at 15 cm from the ground
- Flame applied to the edge of the specimen
- Panels exposed to flame for 30 seconds

2.3. Experimental campaign and results – Reaction to fire test

RH_15D



RH_30B

RH_30D

3. Conclusions

	Bulk density	Porosity	Thermal conductivity	Ultra sound propagation velocity	Effect of abrasion	Compressive strength	Tensile flexural strength	MBV	Effect of fire exposure
Increase of rice husk content	↓	↑	↓	↓	↑	↓	↓	↑	↑
Boiling of fibres	↑	↓	↑	↑	↓	↑	↓	-	↑

3. Conclusions

- **Rice husk reinforced earthen insulation panels vs Conventional insulation materials**

  - Synthetic materials: XPS
    - Bulk density: low
    - Fire exposure: highly inflammable → cannot be exposed
    - Acoustic comfort: bad acoustic insulation performance
    - Moisture Buffer Values (MBV): insignificant

  - Natural material: ICB (cork)
    - Bulk density: low
    - Fire exposure: is inflammable but after much more direct contact with flame and is resistant to heat → can be exposed
    - MBV: 0,2-0,3 g/m^2.RH (Janssen & Roels 2009)

  - Earth-rice husk insulation panels
    - Bulk density: higher than the previous
    - Fire exposure: not inflammable except surface fibres → can be exposed
    - Acoustic comfort: better acoustic insulation performance (although not quantified)
    - MBV: 3-2 g/m^2.RH

    - Good for hygrothermal equilibrium !
    - There is a lot yet to test and optimize, like susceptibility for biological development !

Thank you so much for your attention !