Starch-based composites for construction (beet pulp, grape marc)

Chadi MAALOUF,

Boussad ABBES, Céline BADOUARD, Christophe BLIARD, Fabien BOGARD, Mohammed LACHI, Guillaume POLIDORI

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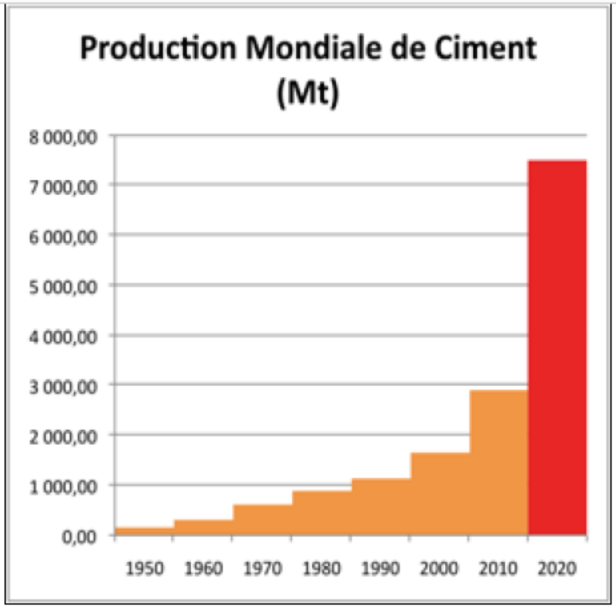
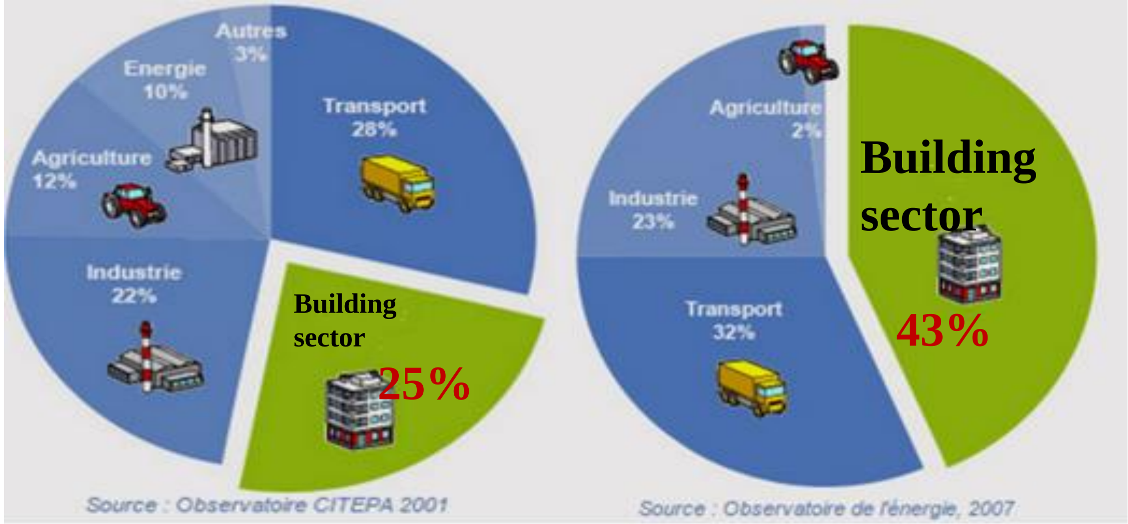
Cement production is responsible of 5 to 7% CO_2 emissions in the world

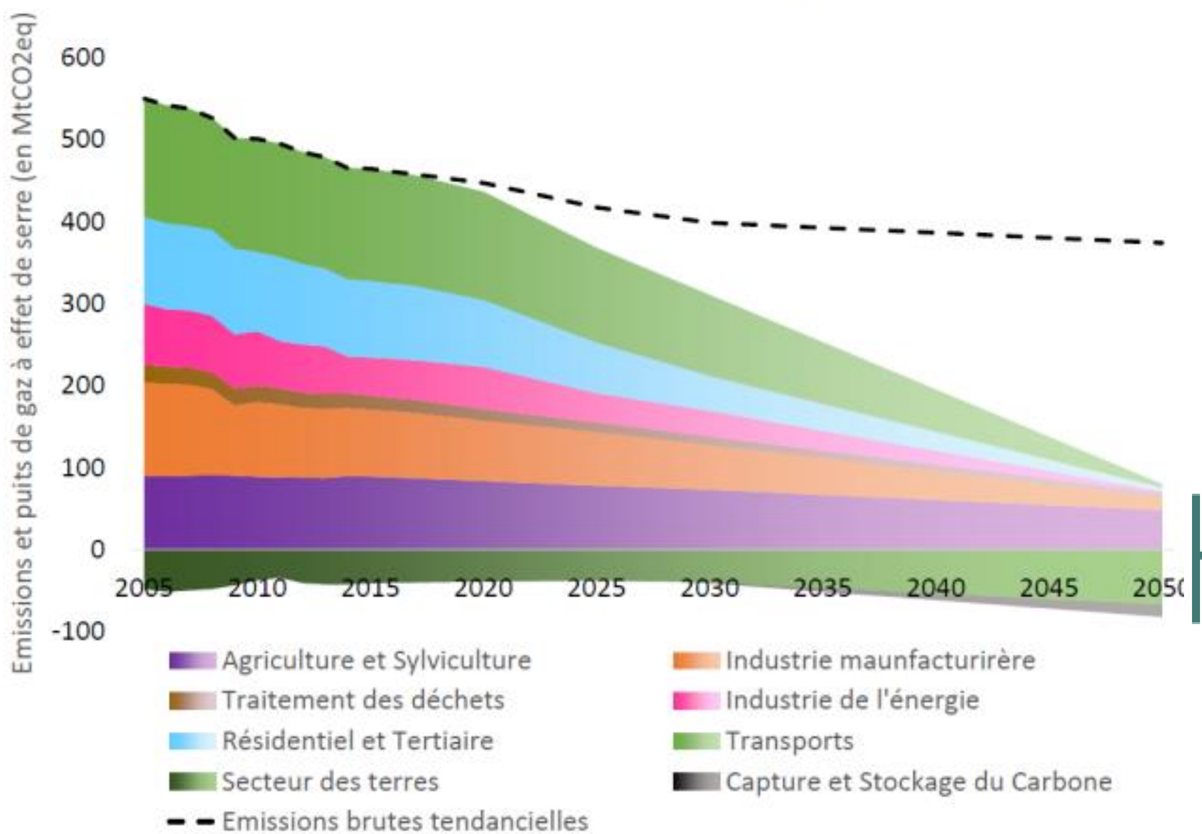


Sand is increasingly becoming scarce in many regions


Autres
3%
Energie
10%
Transport
28%
Agriculture
12%
Industrie
22%
Building
sector
25%
Source : Observatoire CITEPA 2001
Agriculture
2%
Building
sector
Industrie
23%
Transport
32%
43%
Source : Observatoire de l'énergie, 2007

Buildings -95%   Industry -81%

Trajectoire des émissions et des puits de gaz à effet de serre sur le territoire national entre 2005 et 2050 dans le scénario AMS



e : estimation. Source (données 2015 à 2017) : inventaire CITEPA 2018 secten – format Plan Climat Kyoto – avril 2018

Since 2015
SNBC: Carbon neutrality around 2050

« Neutralité Carbone »
=
« Zéro Émissions Nettes »
=
0 Mt_{CO2e} en 2050

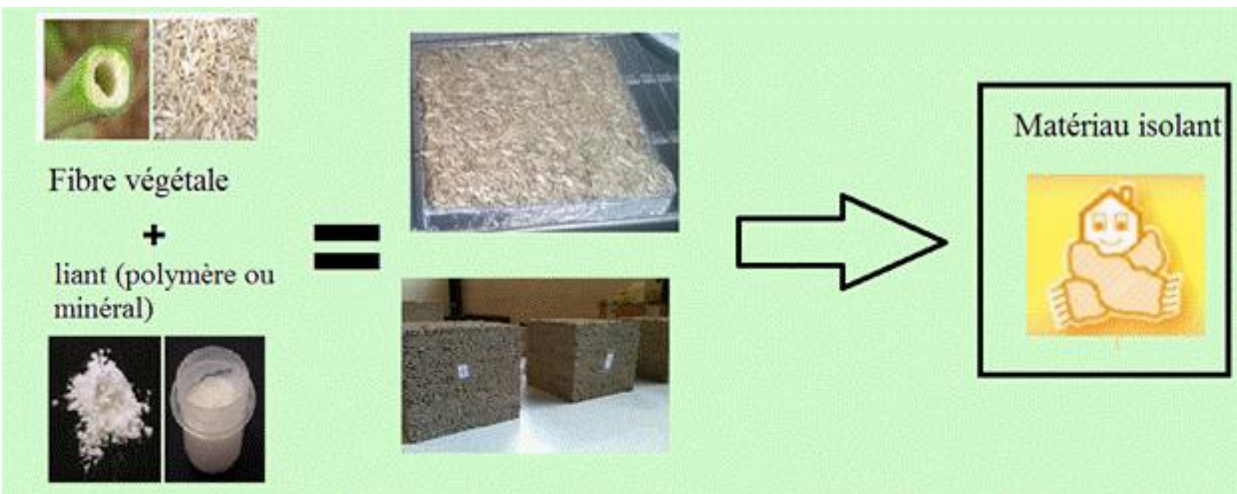
https://www.ecologique-solidaire.gouv.fr/strategie-nationale-bas-carbone-snbc

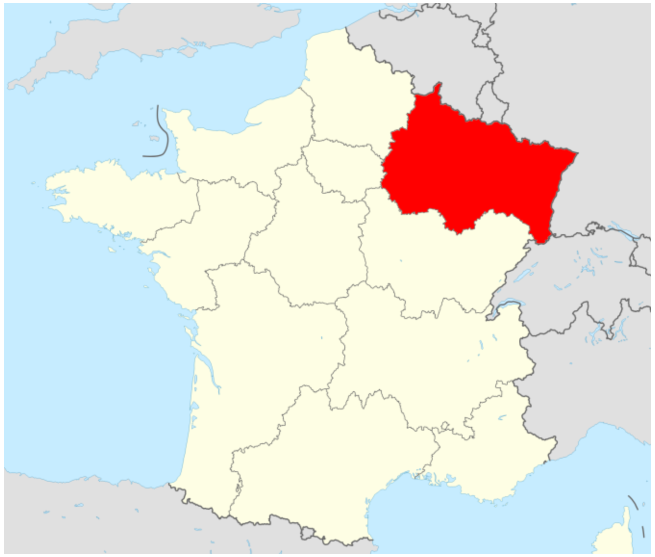
What is a bio-based concrete?

Biosourced aggregate + **Binder** + **Water**

Hemp, Flax
Typha, beetroot pulp…etc

Lime, clay, cement
starch…





- 8 Mt de beetroot/year (2nd region) 23% of national production
- 12% of potato national production (2nd region)

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Beetroot starch composite

(a)

(b)

(c)

(d)

a) The extruded pulps were soaked in distilled water to ensure saturation.

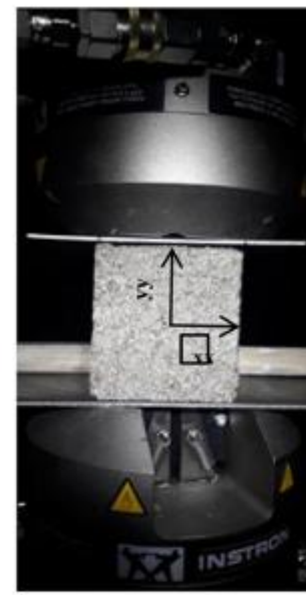
b) The wet BP was mixed with starch powder.

c) The mix was put in an autoclave to dissolve the starch under water vapor pressure.

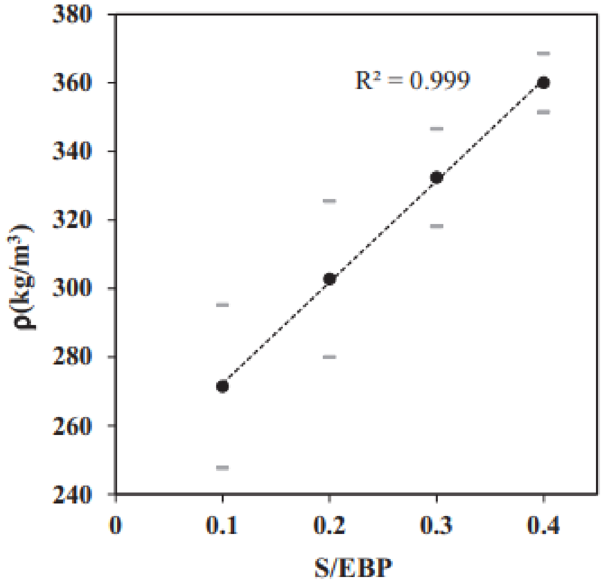
d) the samples were compacted at 44 kPa.

Physical Characterization

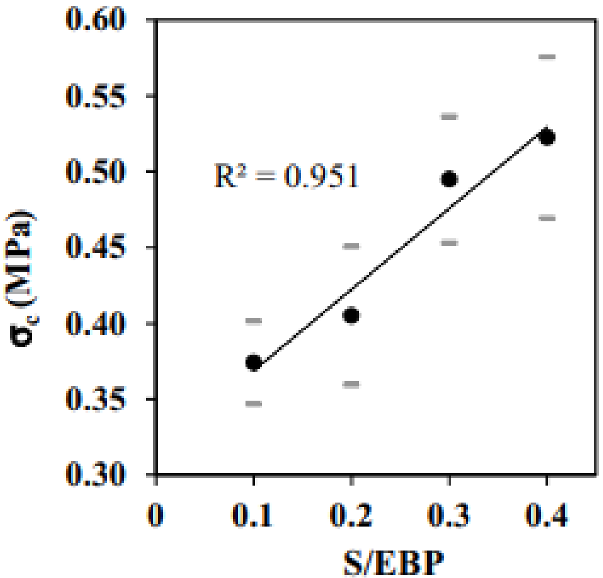
- Porosity
- Mechanical properties (compression and flexural strength,…)
- Hygrothermal properties (thermal conductivity, sorption isotherm, vapour permeability, MBV…)
- Acoustical properties (absorption coefficient…)
- Dynamic hygrothermal behaviour in biclimatic chamber

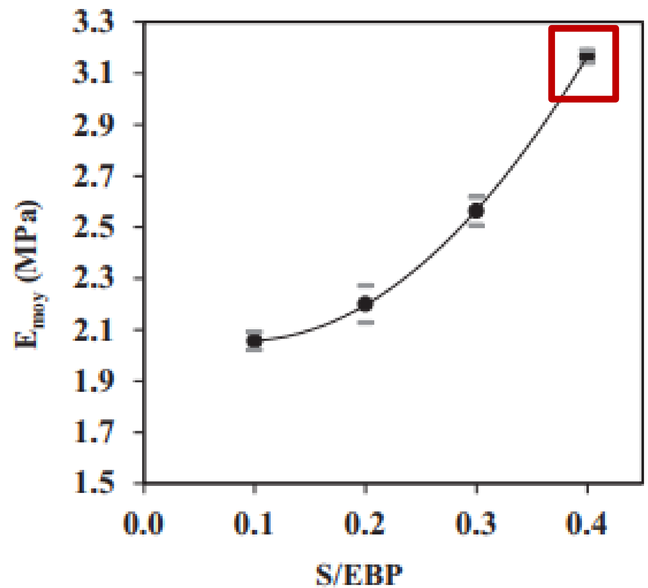


Effect of S/EBP ratio



Mass ratio (S/BP)	λ (W. m^{-1}. K^{-1})
0.1	0.069 ± 0.0006
0.2	0.071 ± 0.0005
0.3	0.072 ± 0.0003
0.4	0.075 ± 0.0002





H. Karaky, C. Maalouf, C. Bliard, A. Gacoin, M. Lachi, N. El Wakil, G. Polidori, Characterization of beet-pulp fiber reinforced potato starch biopolymer composites for building applications, Construction and Building Materials, 2020, https://doi.org/10.1016/j.conbuildmat.2019.01.127.

Drying process for full and hollowed bricks

Hot air Tower

Lyophilisation for sublimation

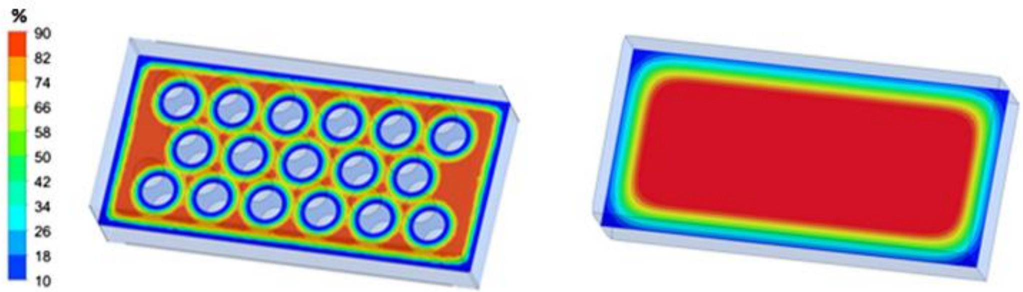
Shrinkage 12.5%

Shrinkage 2.5%

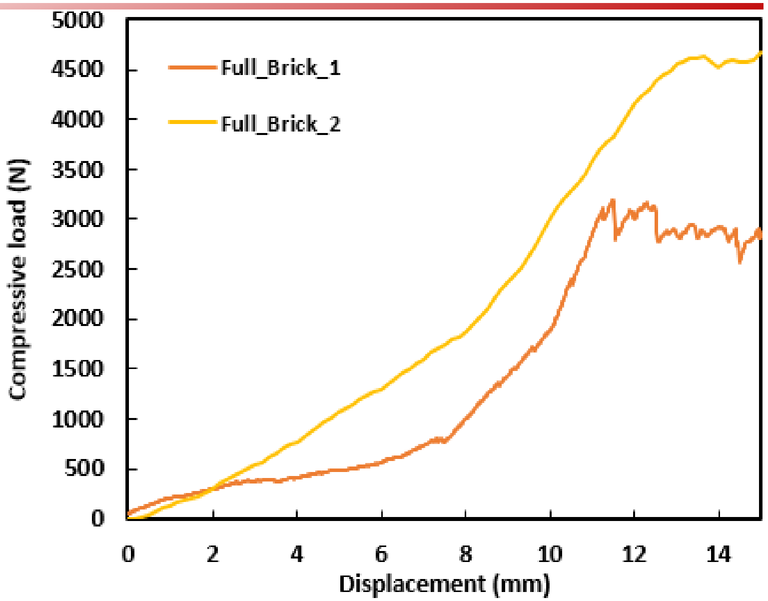
Hollowed brick advantages

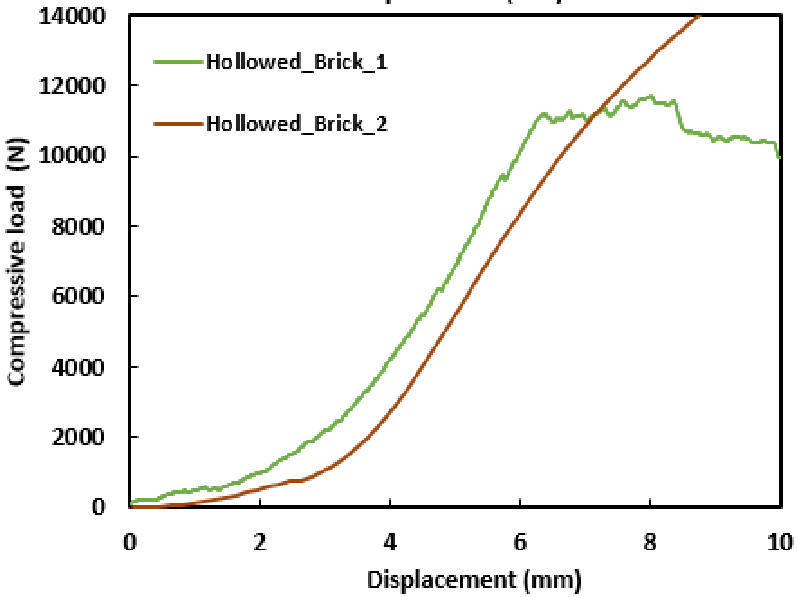
- Fast drying time (reduced by 50%)
- Improved mechanical properties
- Improved thermal resistance

	Compression strength (kN)	Young Modulus (MPa)
Full brick	**3.75±0.75**	**2.15±0.20**
Hollowed brick	**13.0±1.0 kN**	**8.14±0.8**



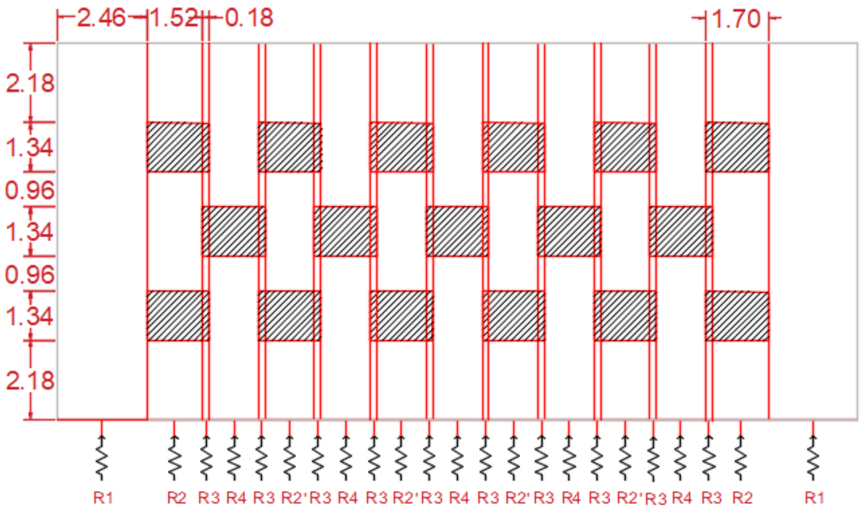
Relative humidity (%) in the horizontal center plane of the whole and hollowed brick at t = 12 h after the start of the drying process.



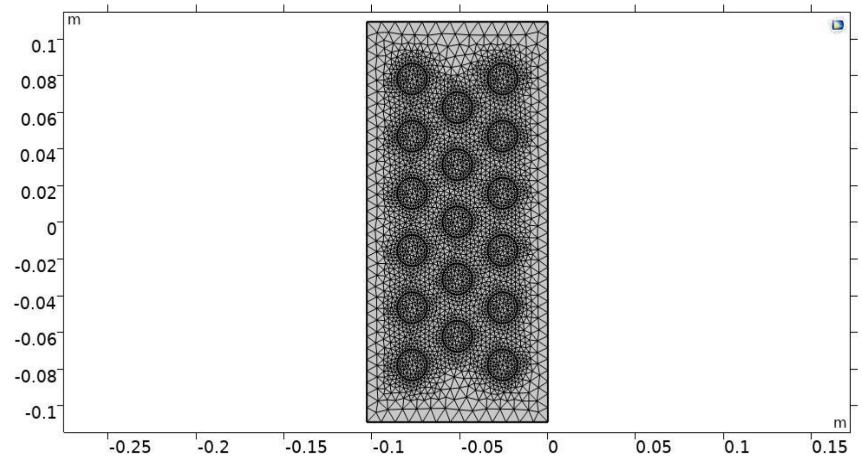


G. Costantine, E. Harb, C. Bliard, C. Maalouf et al., Experimental characterization of starch/beet-pulp bricks for building applications: Drying kinetics and mechanical behavior, Construction and Building Materials, Volume 264, 2020, https://doi.org/10.1016/j.conbuildmat.2020.120270.

Calculation method using NF EN ISO 6946:2017 based on electrical analogy as well as numerical method using COMSOL software



Equivalent simplified scheme of S/BP brick



Physics-controlled mesh for “finer” mesh size in COMSOL of the design

R Iso = 1.218 m² . K / W

R Comsol = 1.18 m² . K / W

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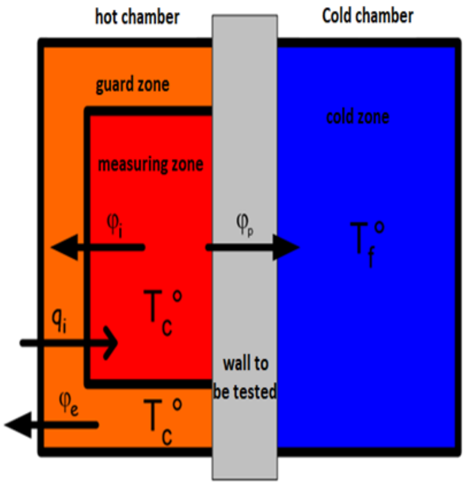
Experiment on wall level (undergoing investigation)



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- BP/S composites are an interesting thermal insulation solution for buildings especially the hollowed bricks
- More investigations are needed to improve material durability, drying process and optimize physical properties
- Future investigations will also focus on the hygrothermal performance on building level as well as on social and economical aspects,

Thank you