Recycled and bio-based materials for sustainable constructions

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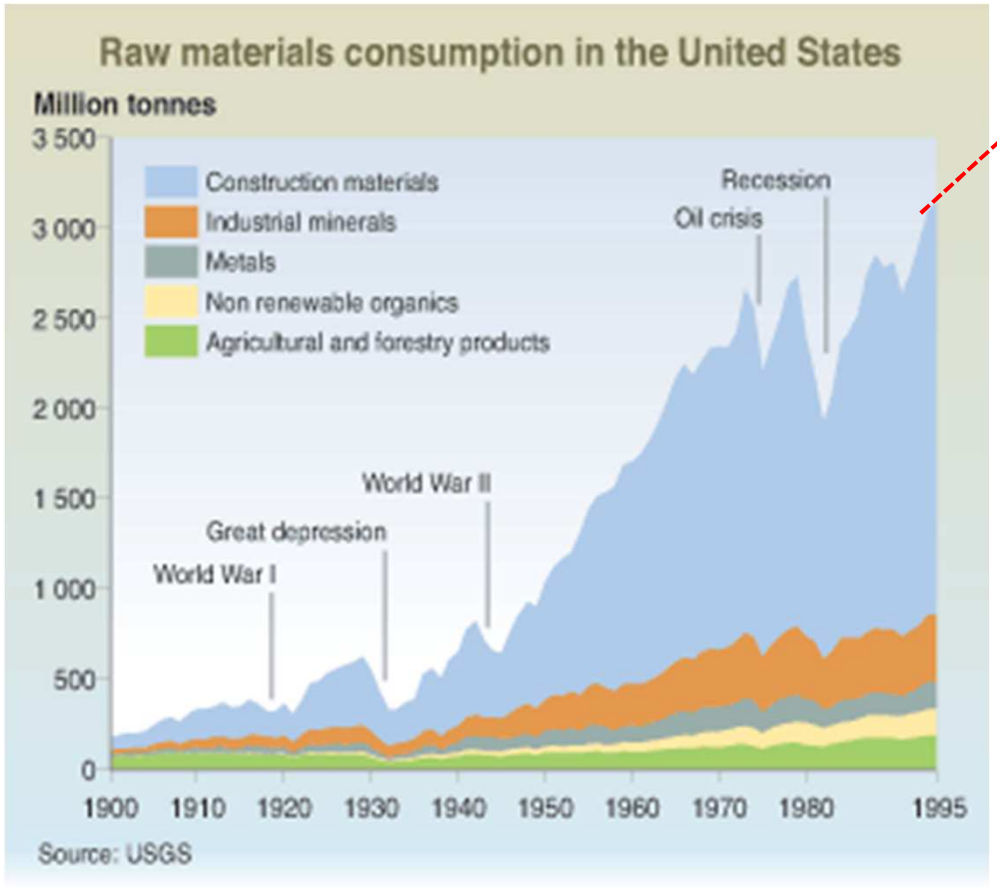
Jubilee Symposium 3R, Warsaw, June 13th, 2016

Ascertainment

We need materials



?

Ascertainment

We need materials

construction consumes between 40 and 50% of natural resources (materials),

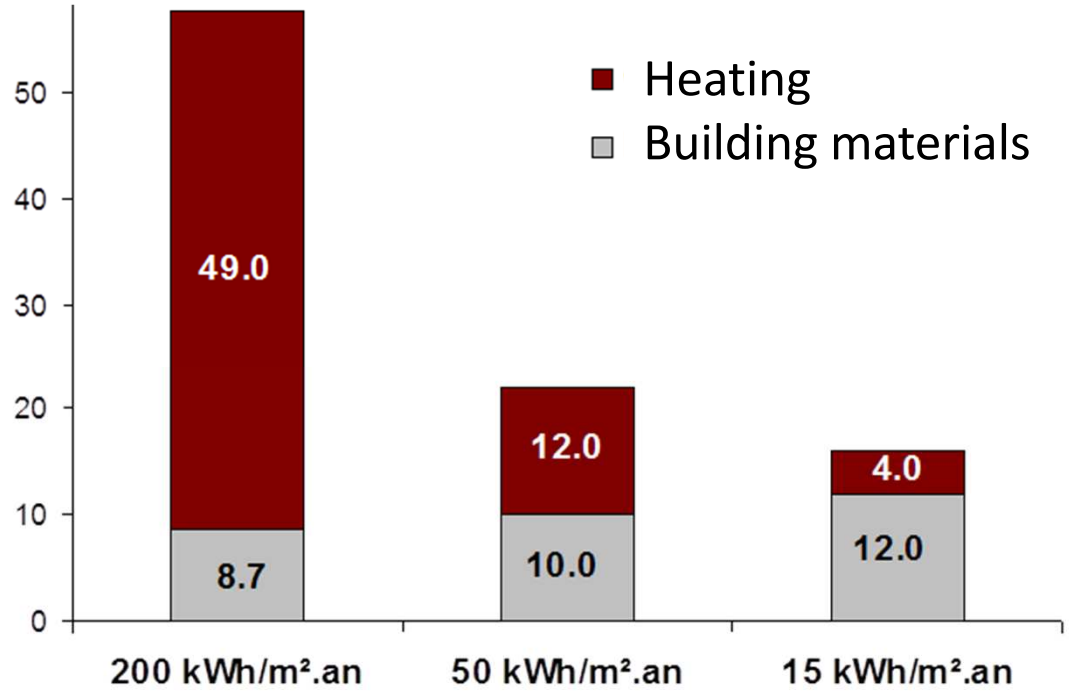
construction consumes 40% of energy and produces 40% of CO_2

Ascertainment

We need materials for improving the energy performance of buildings

Increasing relative weight of building materials *vs* environmental impacts

Needs for new materials



Source : G. Escadeillas, Métamorphoses, Liège, 2011)

Ascertainment

We produce a lot of wastes

Between 3.4 and 4 billions tons/year, (80 to 126 tons/sec!)

Each day, human activity produces more than 10 billions kg wastes

Wastes produced in 2010 in EU: 2.5 billions tons

According to Pike Research, we produced 74 millions tons/year electrical and electronical wastes in 2014 (2,346 kg/sec)!

Construction produces more or less 50% of all the wastes

http://www.planetoscope.com/dechets/363-production-de-dechets-dans-le-monde.html

Ascertainment

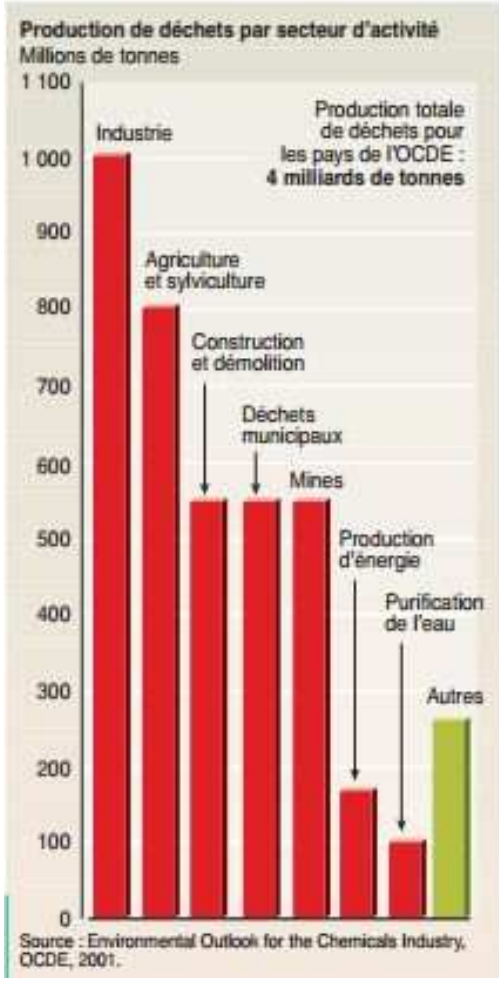
We produce a lot of wastes

Wastes (different shapes and conditioning)

- 83% solid wastes
- 10% « paste »
- 7% liquids

Industrial by-products

- inorganic wastes (70%)
- organic wastes (25%)
- *not classified*



Direction générale Statistique et Information économique (DGSIE) www.ccfee.be (2012)

Ascertainment

- Ascertainment
  - We are living in a **limited world**
    - energy
    - natural resources
    - space (urban development)
    - nature’s resilience
- Ascertainment → behaviour
  - Consuming
  - Architecture
  - Civil engineering
  - ….

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coming home

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Bio-based materials

Coming home

Bio-based materials

materials from biomass of plant or animal origin. They now cover a wide range of products and found many applications in the field of building and construction, as:

- insulation (wool plant or animal fibers, recycled textiles, cellulose wadding, straw bales, etc.),
- mortar and concrete (hemp, wood, miscanthus, etc.),
- panels (particles or vegetal fibers, compressed straw, etc.),
- fibers reinforced plastics (matrix, reinforcement, fillers),
- building chemistry (glues, admixtures, paints, etc.).

Bio-based materials

Wooden concrete: wooden chips « mineralized » for light aggregate production

Wooden concrete λ = 0.09 W/m.°K

Cellular concrete λ = 0.12 W/m.°K

Silicate brick λ = 0.27 W/m.°K

Bio-based materials

Constructive system CEMWOOD, ATG 13/2932

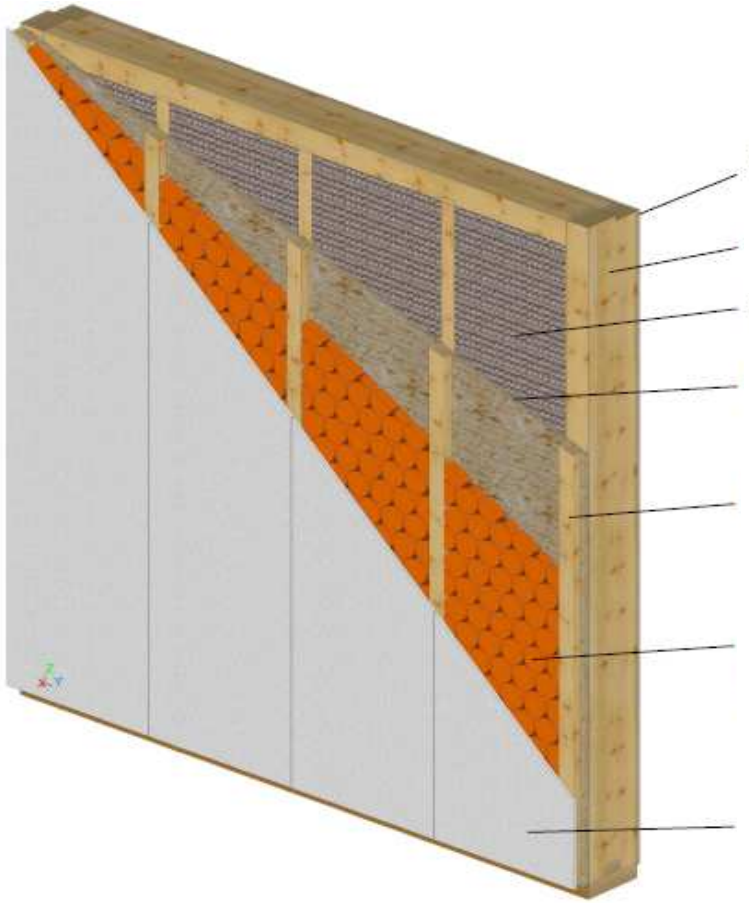
Bio-based materials

Raw clay (earthern construction)

Increasing thermal inerty of wooden structure for building by using bio-based materials (ArgiMob product)

AGROMOB (2012-2014) Research Program Cwality (MOBIC/ULg) - Wallonie

Technique

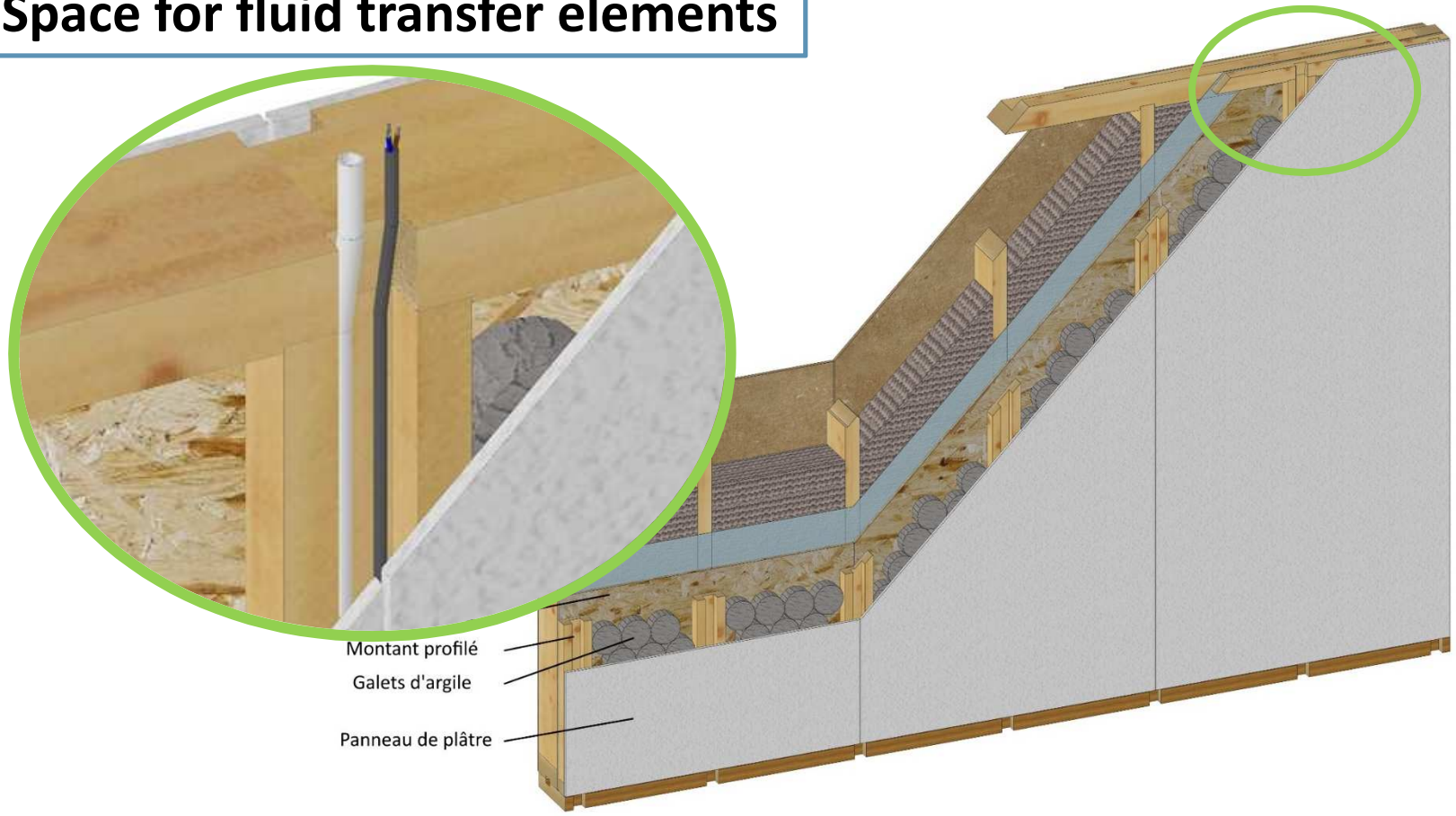

External panel
Wood structure
Insulation
Internal panel
Wood support
Technical space fulfilled with inerty material
Finishing internal panel

Technique

GeMMe Université de Liège

mobic l'innovation en ossature bois

Space for fluid transfer elements



Bio-based materials

Straw bales

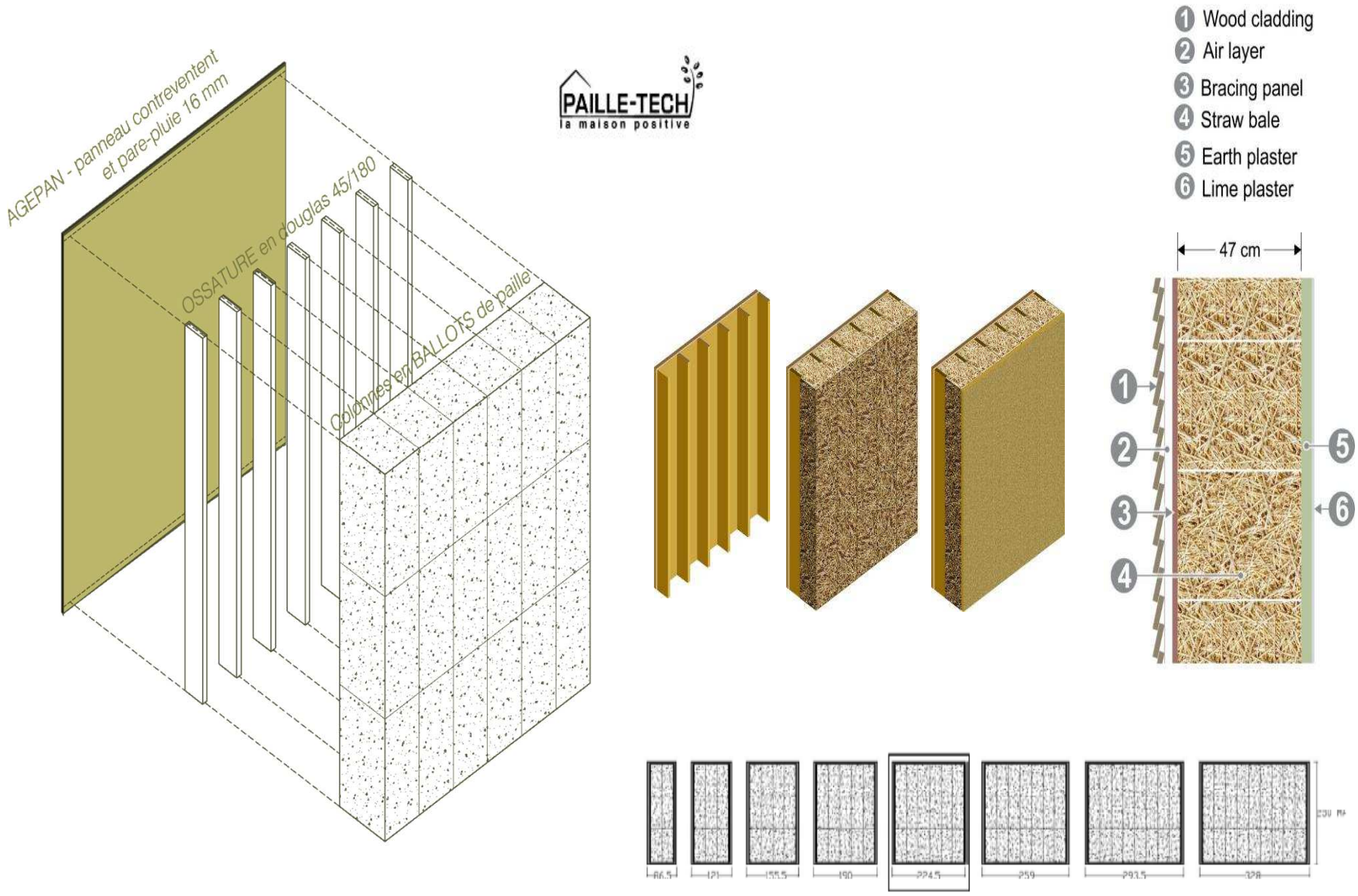
Better knowledge of straw bals for using as insulation material in construction

aPROpaille (2012-2014) Research program Erable (UCL/ICEDD/PailleTech/GbxAgroBioTech) - Wallonie

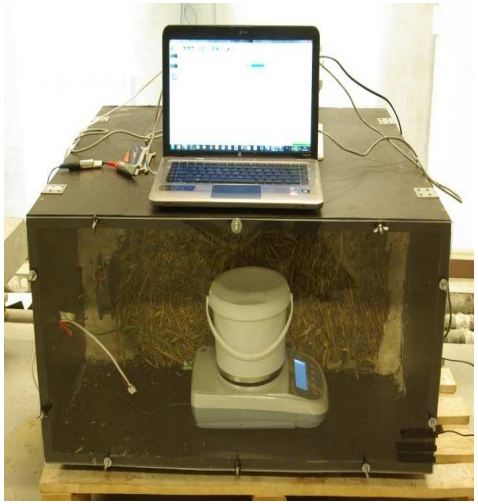
Bio-based materials

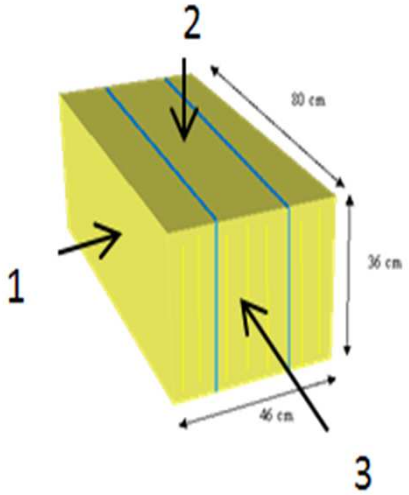
Bio-based products

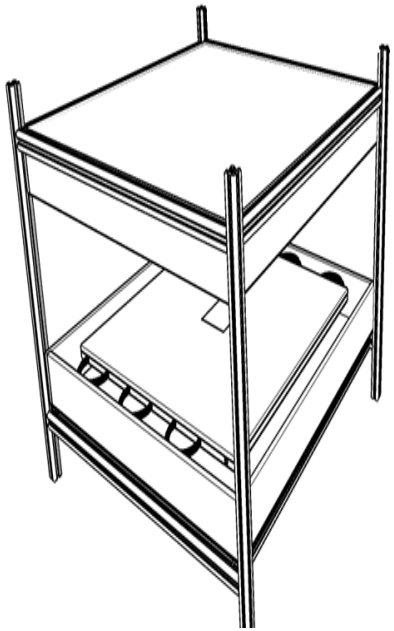
Straw bales



Analysis of a precast solution

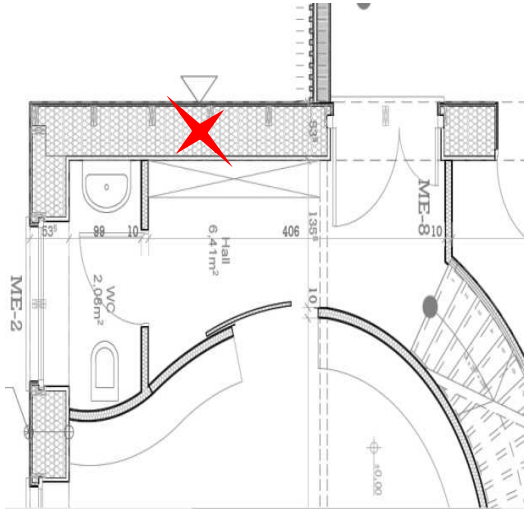


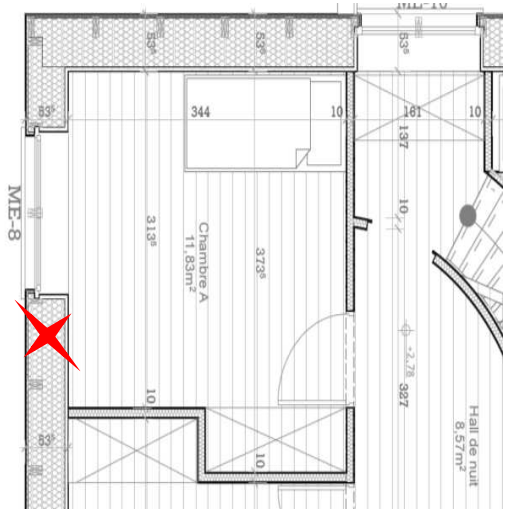


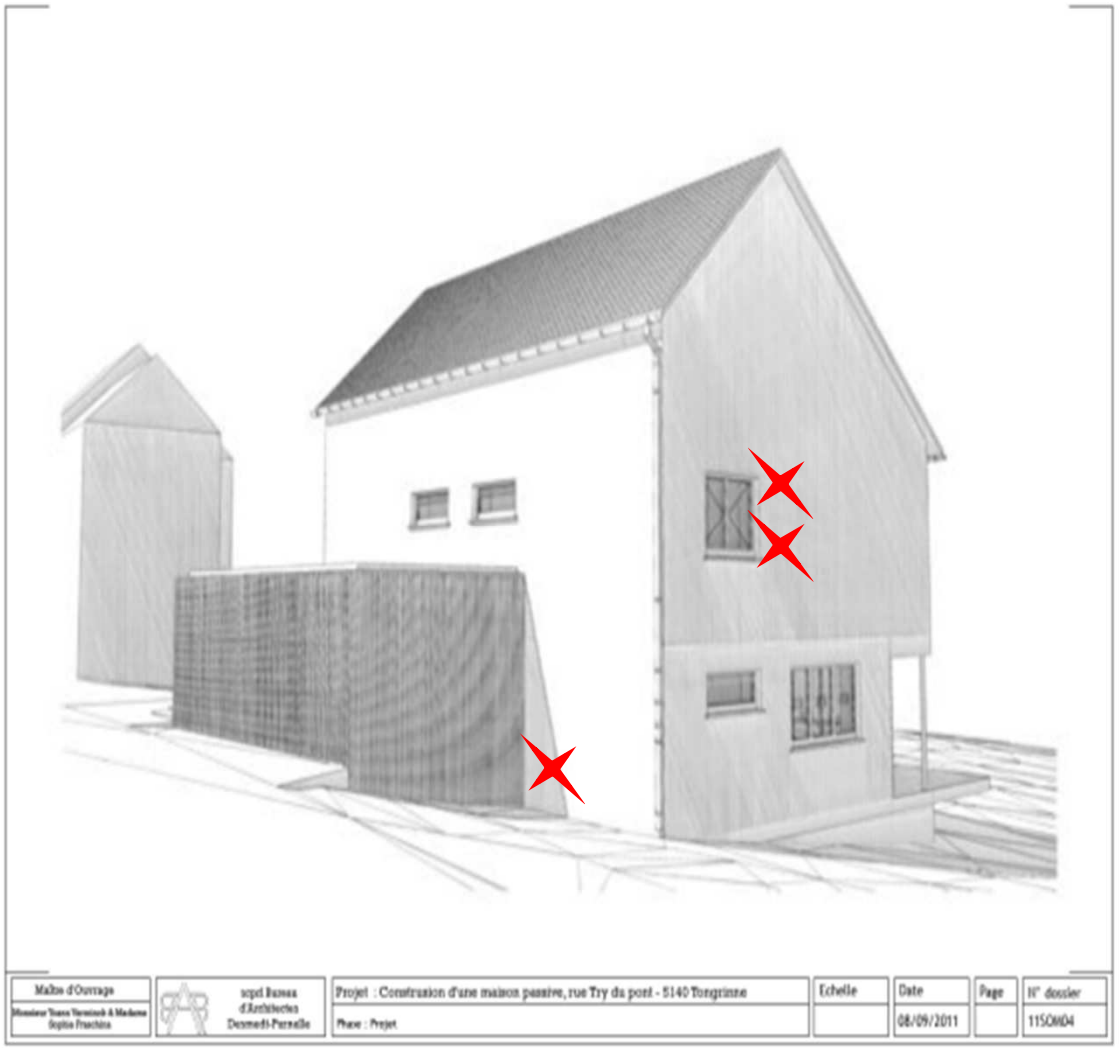


Measurement of hygro-thermal parameters

Monitoring devices







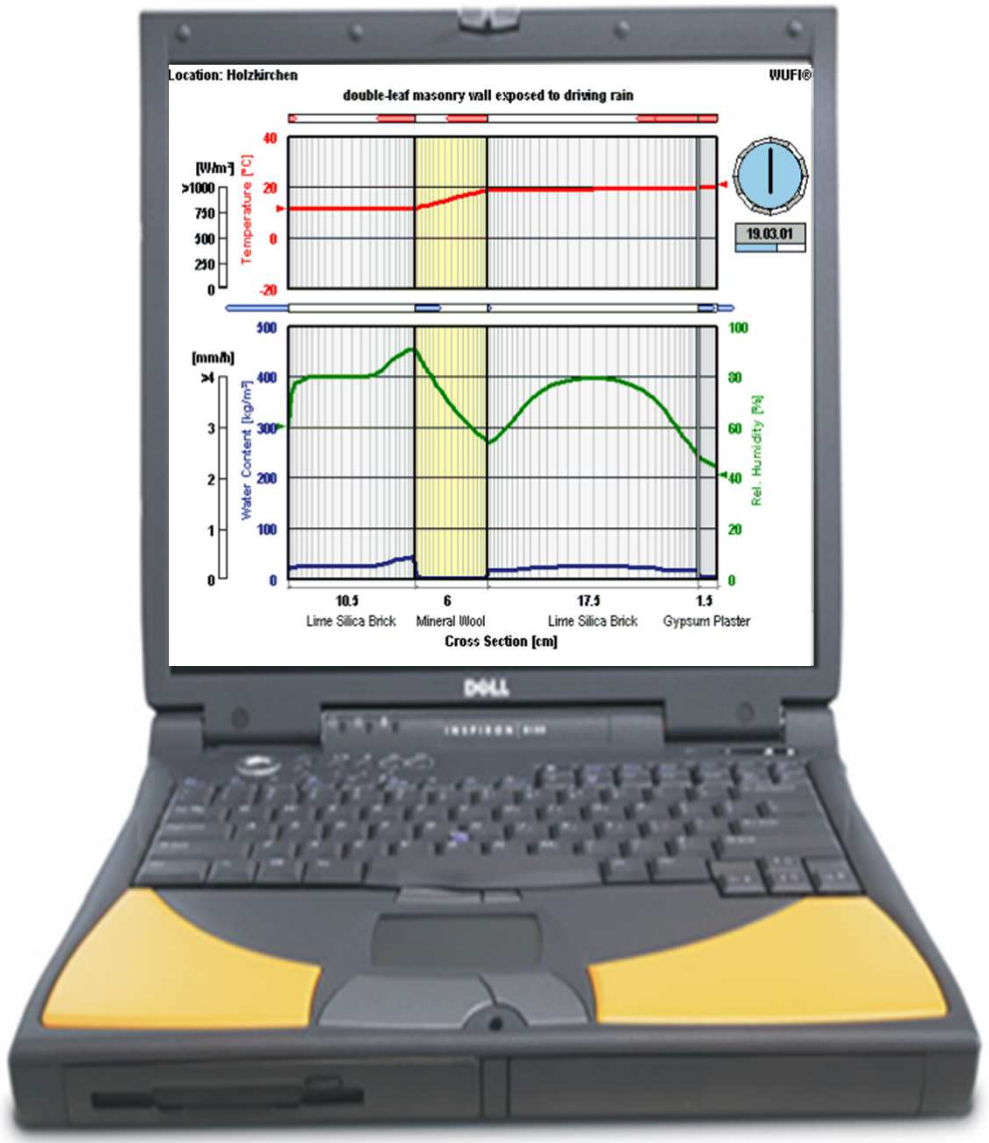
Monitoring of buildings

Heat Balance

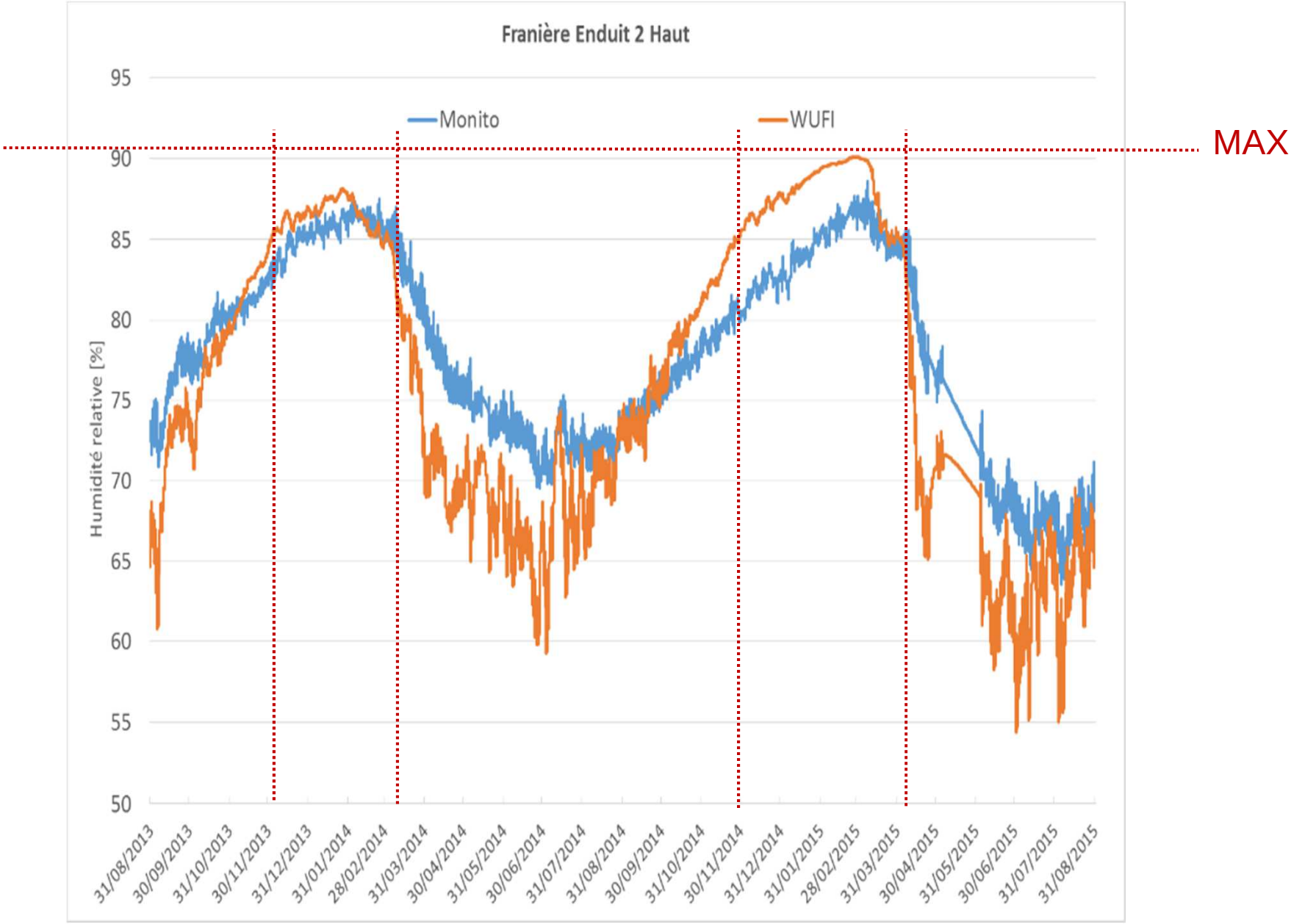
$$\frac{\partial H}{\partial T}\cdot\frac{\partial T}{\partial t}=\nabla\cdot\left(\lambda\nabla T\right)+h_v\nabla\cdot\left(\delta_p\nabla\left(\phi p_{sat}\right)\right)$$

Moisture Balance

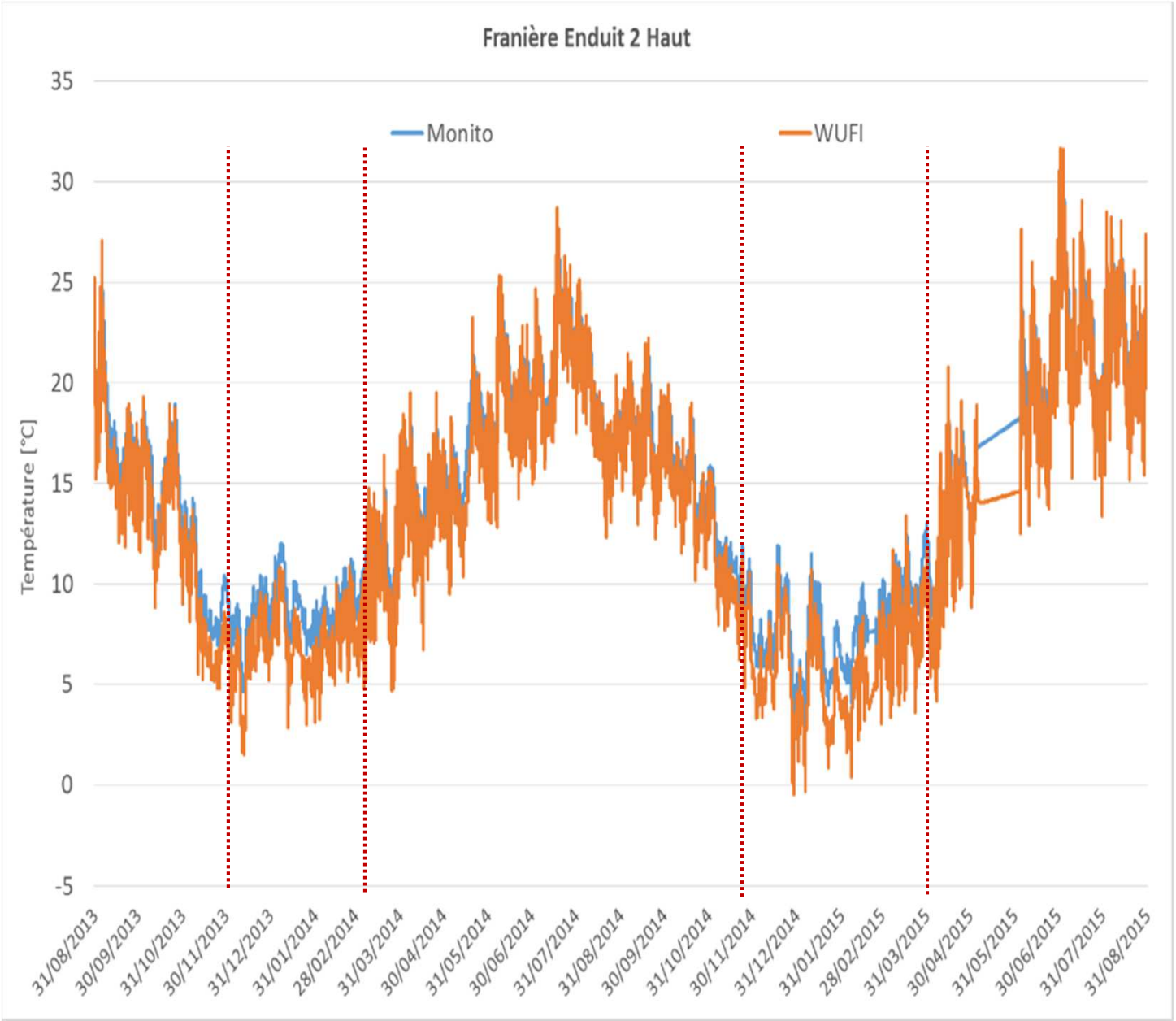
$$\frac{\partial w}{\partial \phi}\cdot\frac{\partial \phi}{\partial t}=\nabla\cdot\left(D_\phi\nabla\phi+\delta_p\nabla\left(\phi p_{sat}\right)\right)$$



Numerical simulations with WUFI



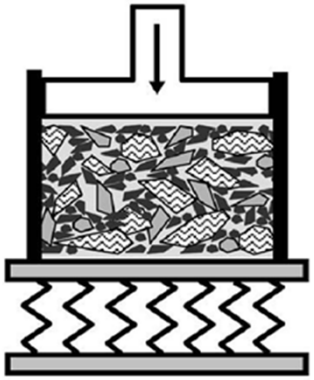
Numerical simulations (WUFI Pro) and monitoring



Numerical simulations (WUFI Pro) and monitoring

Bio-based materials

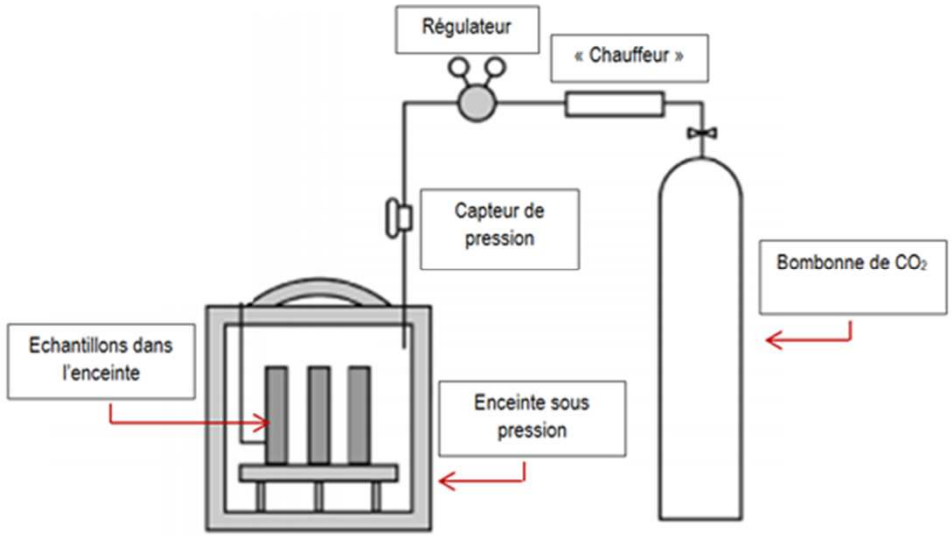
« Mineralized » miscanthus constructions blocks



Bio-based materials

CO_2 captation

Manufacturing concrete blocks with mineralized miscanthus aggregates + CO_2 injection

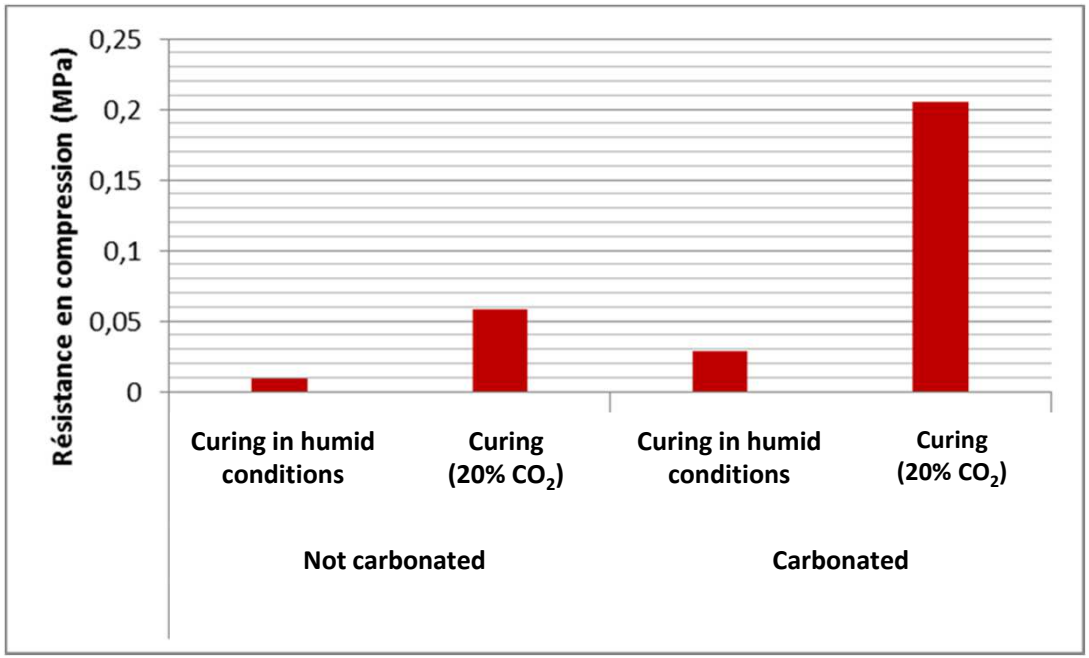


Carbonated miscanthus mineralized aggregates for reducing environmental impact of concrete blocks. L. Courard, V. Parmentier, F. Michel. International Journal of Sustainable Built Environment (under reviewing)

Bio-based materials

Effect of carbonation on mineralized miscanthus concrete blocks

Compressive strength after 7 hours



Secondary raw materials

Recycling and durability

Urban waste recycling

Municipal solid wastes

Burning at 900-1000°C

Post-combustion treatment

Approvisionnement

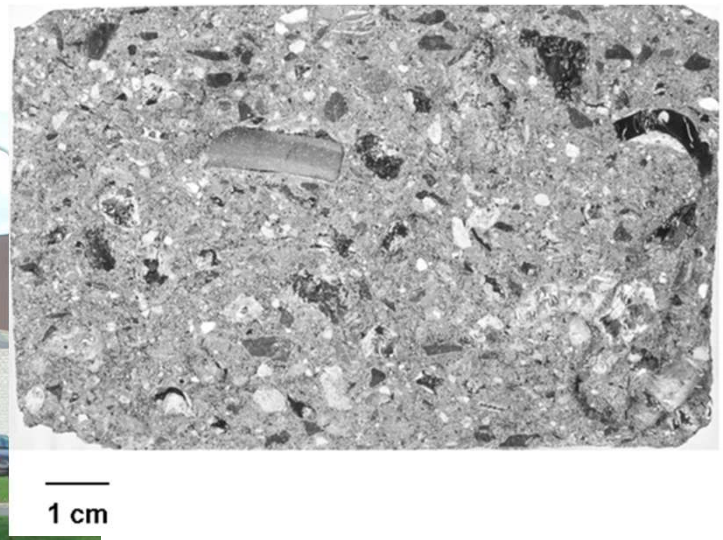
Cribling

Magnetic separation

Maturation (10 – 20 weeks)

Urban waste recycling

Precast concrete pavements



Industrial process – 10% MSW slags

Splitting resistance(N/mm²)	4.05 ± 0.53
Water absorption (%)	6.61 - 6.29
Abrasion (mm)	0.98 - 1.36

Utilisation des mâchefers d'incinérateur d'ordures ménagères dans la fabrication des pavés en béton. L. Courard, R. Degeimbre, A. Darimont, A.-L. Laval, L. Dupont et L. Bertrand. Mater. Struct., 35 (Juillet 2002), 365-372.

Urban waste recycling

APPEROUT (2013-2015): Increasing properties of recycled materials for roads by means of treatment units optimization (Wallonia grant - BRRC, CTP, ULg)

CONREPAD (2014-2016): Concrete design with recycled aggregates by means of Particle Packing Density concept (Wallonia/EU grant – PREFER company, ULg)

ECOLISER (2016-2021): Development of eco-binders for soils treatment and public works (FEDER – CTP, Inisma, Materia nova, BRRC, ULg)

VALDEM (2016-2021): Integrated solutions for the valorization of raw materials from demolition wastes: border approach towards a circular economy (INTERREG V A – CTP, Mines Douai, ULg)

Conclusions and prospect

Tomorrow, materials

Conclusions

Materials for future …..

Free of “toxic products”, …

From alternative resources

Urban mining (reuse, recycling)

Appropriate selecting criteria and requirements

Adaptative and evolutive materials and structures

Nature did it …, why not human?


Dziękuję
Merci
Danke
Takk
Hvala
Thank you
Dank u
Grazie
Gratias
Arigato
Efkaristos