

La paille comme matière à bâtir

Straw as a building matter



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STRAW

Straw is a byproduct of critical food sources (wheat, rice, oats, barley, rye) and can be found throughout the world. After the seeds have been harvested, straw is the residual stock and not to be confused with hay, which is feedstock. Straw is about 40% carbon, and is transformed into a more useful form for construction by baling machines. Although globally it absorbs a massive amount of carbon dioxide each year, straw is left to decompose or is burned returning the CO₂ to the atmosphere. As a fast growing, inexpensive, ubiquitous, minimally processed, agricultural byproduct, straw has enormous capacity to sequester carbon as a building material. Primarily used as insulation with an R-value of 1.5 to 2 per inch, it can also be a load bearing material. In either condition, its clay, lime, or cementitious plaster skin is critical to its performance and aesthetic, and the source of much of its labor and cost as a building system.

HARVEST

Cut close to the ground, straw is the stock remnant after the seeds have been removed by harvesting equipment. Mechanical hay baling machines compress and strap straw into rectangular or circular units for easier distribution and use.

GROWTH

The growth cycle of all cereal grains is less than a year, significantly shorter than any other plant used in building. More importantly, straw is the waste product of these food grains.

PLANT

The impact of straw is directly related to its place in larger agricultural practices, and their impacts. The industrial farming of wheat and other cereal grains often involves the use of fertilizers, herbicides, and pesticides.

BALING

The size of the bales is contingent on the type of baler. These can range in size from a two-string rectangle weighing about 50 lbs (22 kg), to large round bales that can weigh over a ton. Larger bales can be compressed to much higher density, beneficial to being used as a load bearing structure.

PREFABRICATION

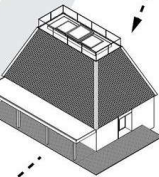
Straw as insulation can be combined with wood frames into prefabricated units in more controlled off-site factories. This avoids some of the moisture challenges of on-site construction with straw. Dry or wet skins can be applied off-site.

PLASTERING

Clay, lime, and/or cement is frequently used as a plaster skin, applied directly to the rough surface of both sides of straw-bales. Plaster skins are typically the air, water, and vapor controls of the assembly, as well as integral to the structural capacity of the straw wall.

CONSTRUCTION

Straw can be used as a load bearing structure, as infill to a structural frame, or within prefabricated units. The size and type of bale or prefabricated cassette has a significant impact on the geometry of the building.



USE

Given their thickness, straw-bale walls have excellent thermal values (approximately R-25 to 35), while their hygroscopic attributes helps balance interior humidity. With careful selection of the material for their skins, straw-bale walls can improve indoor air quality, and can have many times the thermal mass of a conventional stick framed wall.

DISASSEMBLY

Prefabricated panels can be designed to be detachable and reused. Straw-bale walls can decompose, particularly if their skins are clay-based or removable.

MULCH

Straw can be ground into mulch, to be used for landscaping or to biodegrade back to soil.

BIOFUEL

Straw's end of life can also be as fuel for heat or energy generation.

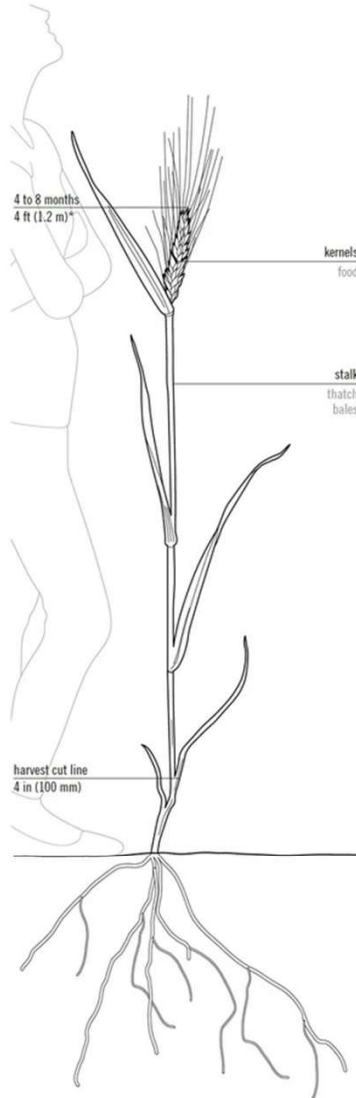


STRAW HARVESTING
4 TO 8 MONTHS

Prefabricated panels can be reused in other projects

STRAW CONSTRUCTION

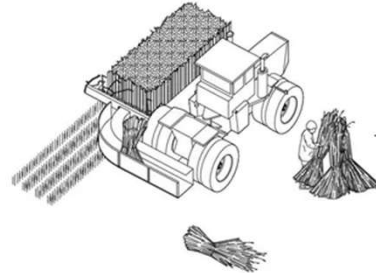
STRAW



*Height and timeframe are averages; actual values vary by planting season and environmental factors

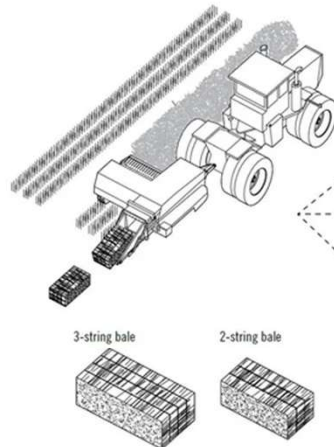
HARVESTING

Reeds for thatching are harvested into carefully formed bundles, while sea grasses are gathered from the shoreline. Straw is typically gleaned from fields after the cereal grains have been removed.



BALING

The most common grains used to make straw-bales are wheat and rice. Both are harvested and formed into bales after the seed kernels have been extracted and the stocks are sufficiently dry. Although bale sizes vary depending on the baling equipment, two-string bales are roughly 14 by 18 by 36 in (360 by 460 by 910 mm) while three-string bales are roughly 16 by 23 by 46 in (410 by 580 by 1170 mm). Jumbo rectangular and circular bales can also be used. Most commonly, the bales are positioned flat with the strings within the walls, allowing the outer sides to be notched for posts.



PLASTERING

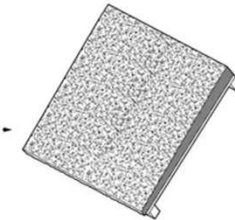
The plaster skin is a crucial component of straw-bale construction, contributing significantly to its structural capacity, and its resistance to fire, moisture, and vermin. Although slower drying, clay and lime plasters avoid the higher carbon emissions of portland cement-based plasters.

THATCH

Tightly-packed long reeds or straw are fastened in overlapping bundles to a steeply pitched roof with horizontal straps producing a thickness that sheds water and can serve as insulation.



THATCHED ROOF

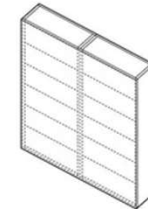


PRE-FABRICATED PANELS

Straw-bales can be inserted into structural wooden frames to make pre-fabricated panels, increasing moisture control and construction precision. Skins can be added off-site or on-site.

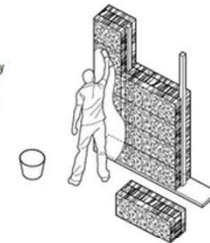


PREFABRICATED ASSEMBLY

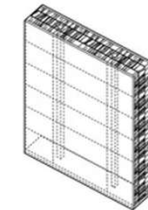


WOOD FRAME INFILL

The most common approach, straw-bales are stacked around or within a structural wood frame, serving primarily as insulation. With proper treatment of the skin, the straw-bale walls can also provide lateral bracing.



INFILL WALL

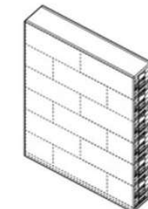


NEBRASKA LOAD-BEARING

Referencing the location of its first use in the late 1800s, Nebraska-style walls use the combined sandwich of thick plaster skins and straw-bales to be the load bearing structure. Typically just a single story, the straw-bale walls are compressed before the plaster is applied. A wooden top plate or ring beam transfers the roof load to the plaster skins which carry it to the foundations.



STACKED WALL



Du champs au chantier

From field to the construction site

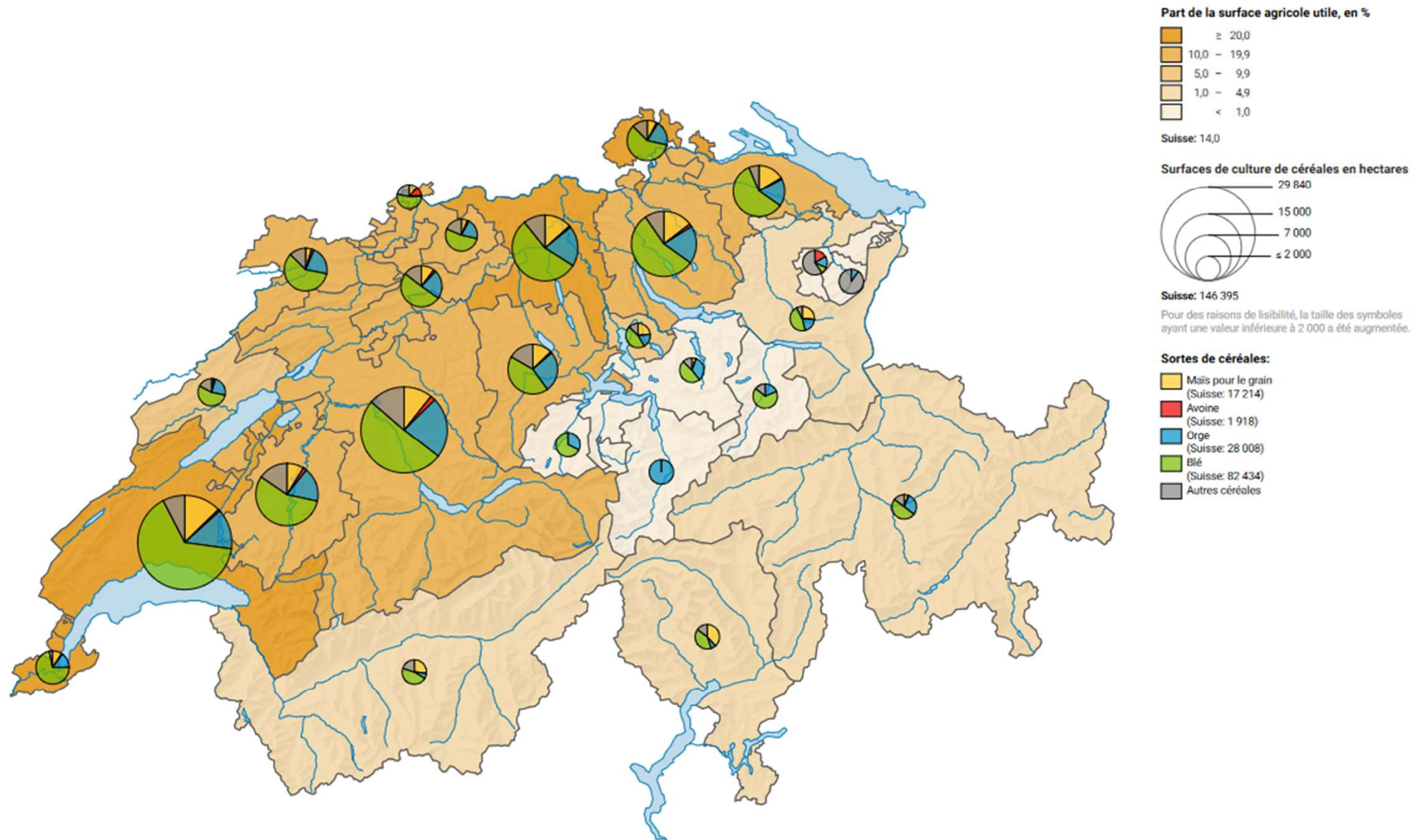


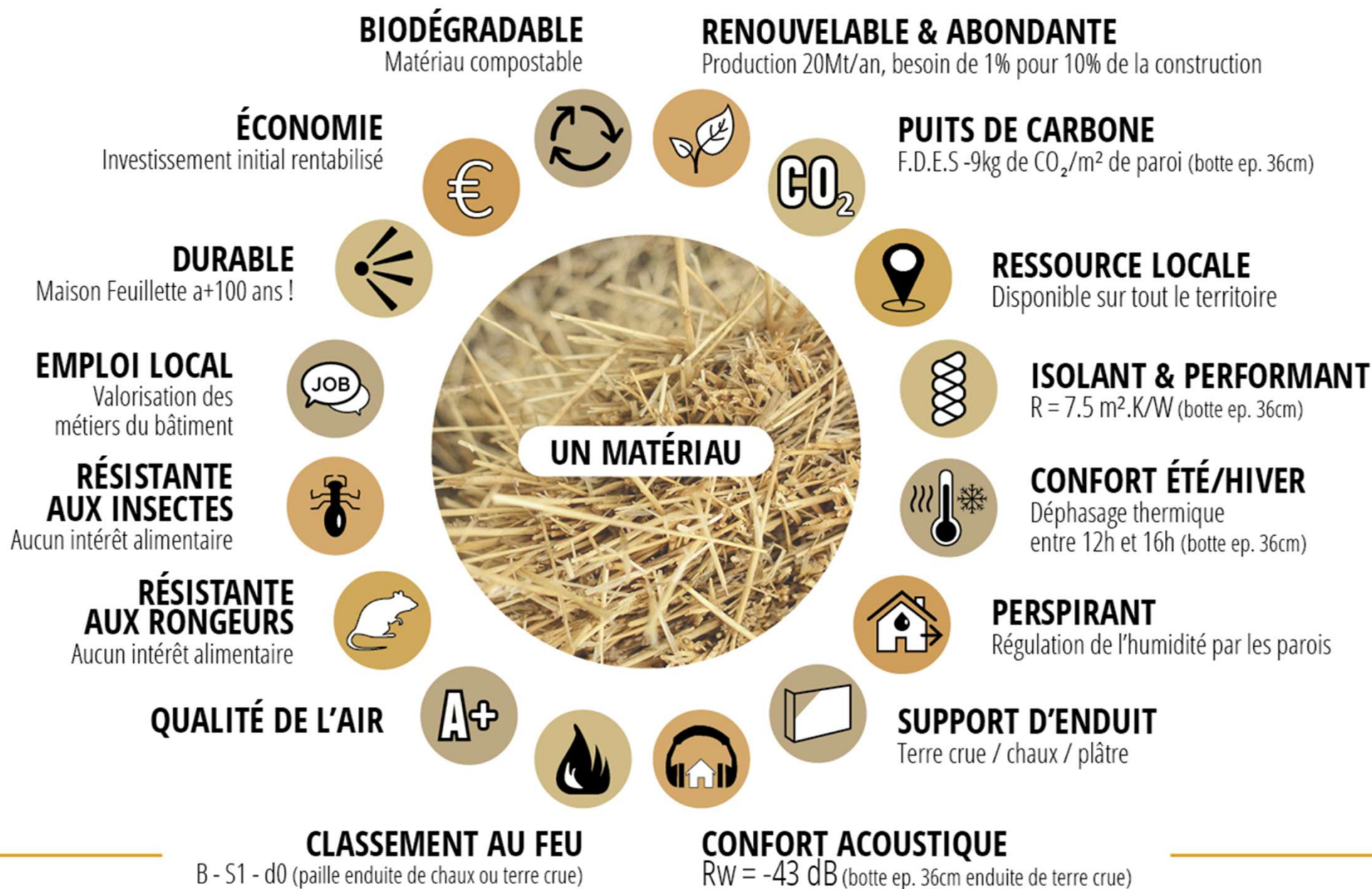
Du champs au chantier

From field to the construction site



Surfaces de culture de céréales, en 2021





Disponibilité

Availability

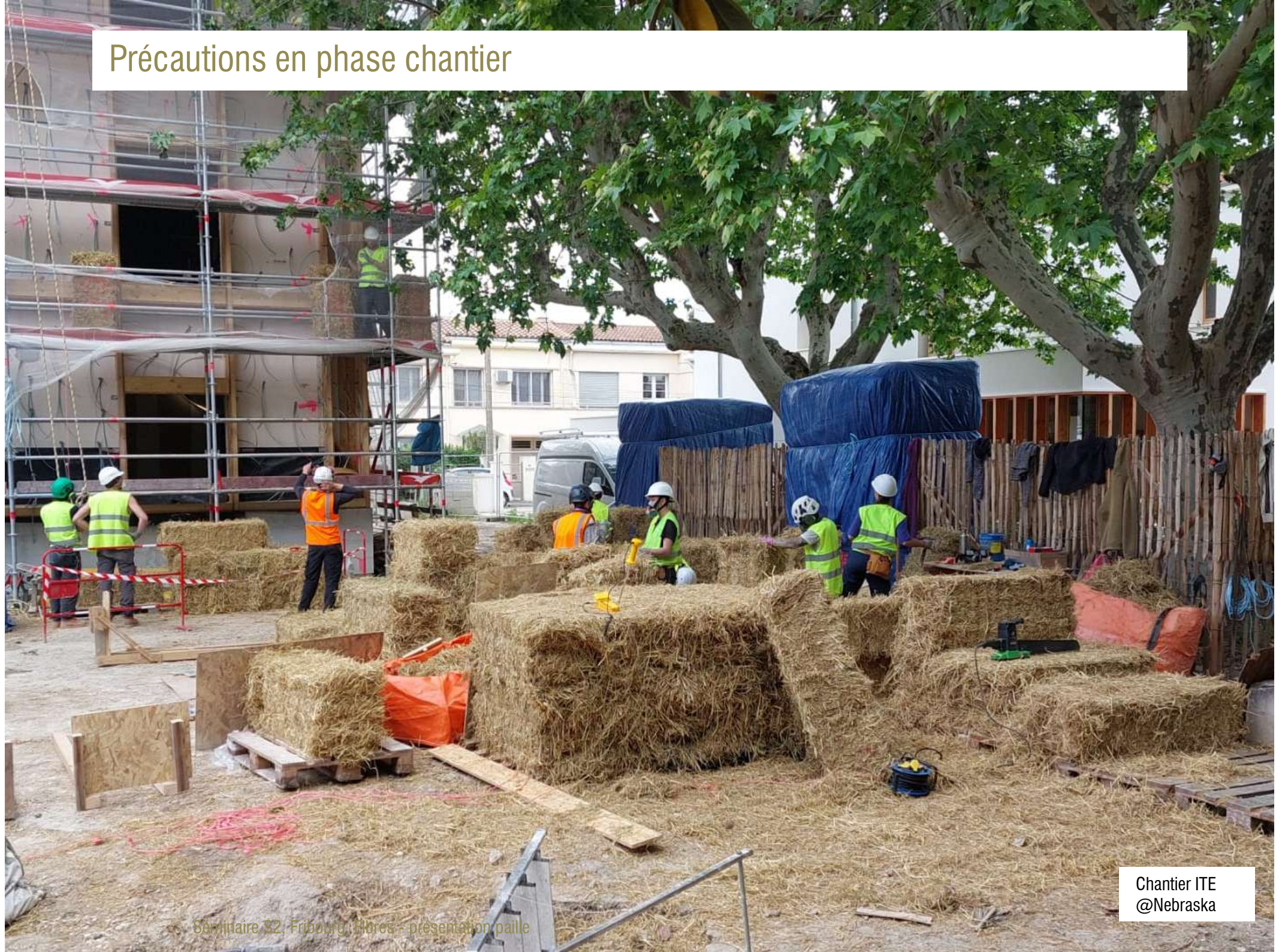
Duchosal Matteo / Terrapon Pauline

Roland Sansonnens

Culture de la paille

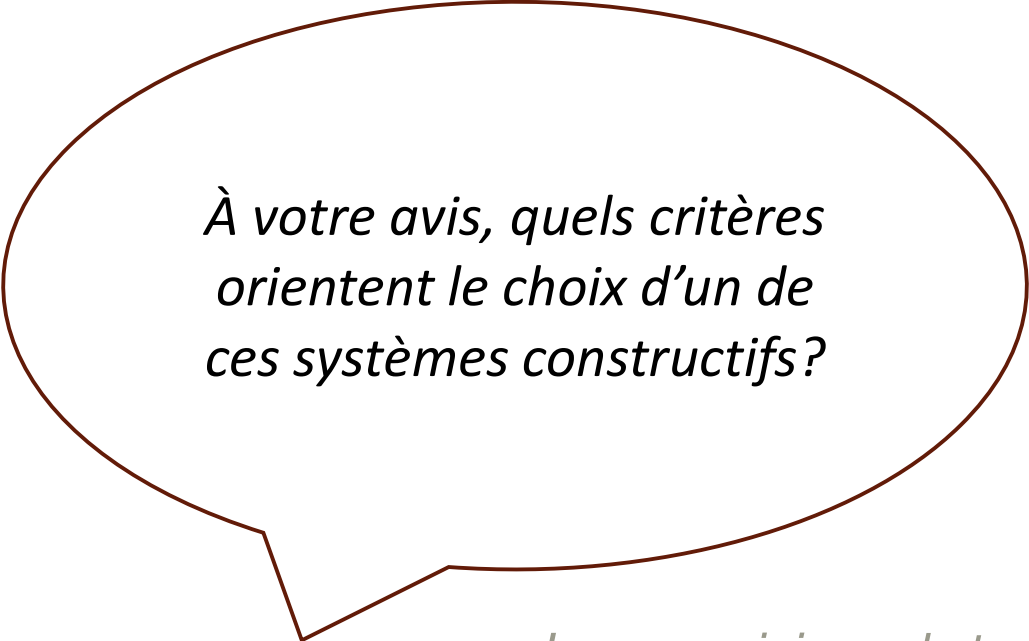
Séminaire Matières durables 2025

Précautions en phase chantier



Protection incendie (et pluie)





*À votre avis, quels critères
orientent le choix d'un de
ces systèmes constructifs?*

*In your opinion, what criteria guide
the choice of one of these
construction systems*

Elément de base = bottes de paille

Basic element = straw bale



Teneur
en eau

*Water
content*



46x36x90cm
(B*H*L)

Dimensions



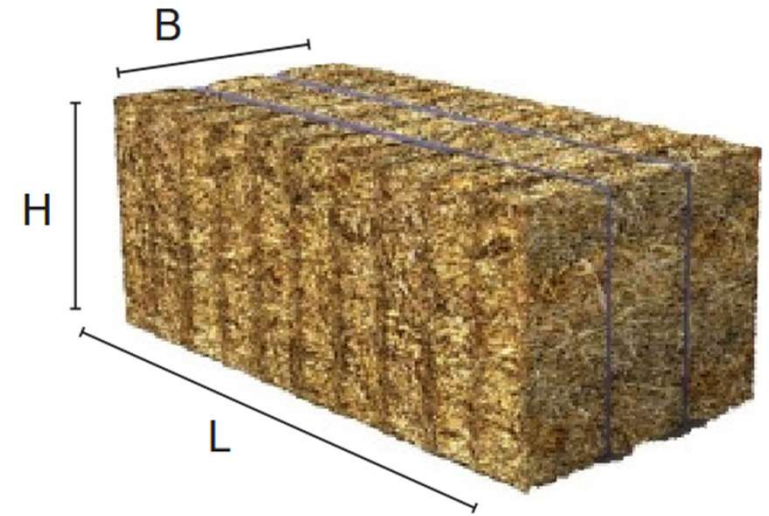
Densité
sur base
sèche

*Dry basis
density*



Orientation
des fibres

*Fiber
orientation*



Epaisseur d'isolant
46cm



Bottes posées à plat

straw bales laid flat

Epaisseur d'isolant
36cm



Bottes posées sur chant

Straw bales laid on edge

Les principaux systèmes constructifs / bottes de paille

Main building system based on the use of straw bale



RFCP

Caisson bois isolés en paille

Wooden boxes filled with straw bales



Ossature bois isolés en paille

Wooden structure filled with straw bales



RFCP

Paille structurale

Load bearing straw bale walls



Wooden Cassetts + straw

Caissons bois + paille

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



- | | | | |
|---|--------------------|---|---------|
| 1 | OSSATURE BOIS | 4 | CAISSON |
| 2 | BOTTES DE PAILLE | 5 | BARDAGE |
| 3 | PANNEAU PARE-PLUIE | | |

RFCP

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



Séminaire S2, Fribourg, Fibres - présentation paille

Coop. Equilibre & Lucioles, Genève
@ Atba / CARPE

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



Séminaire S2, Fribourg, Fibres - présentation paille



Coop. Equilibre & Lucioles, Genève
@ Atba / CARPE

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



Coop. Equilibre & Lucioles, Genève
@ Atba / CArPE

Caissons bois isolation paille + enduits



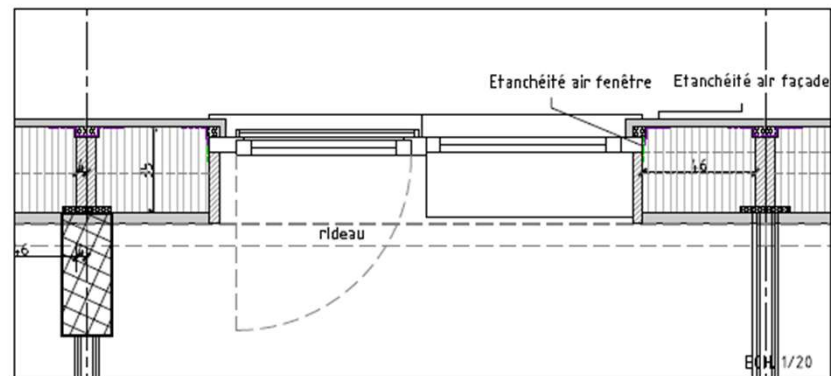
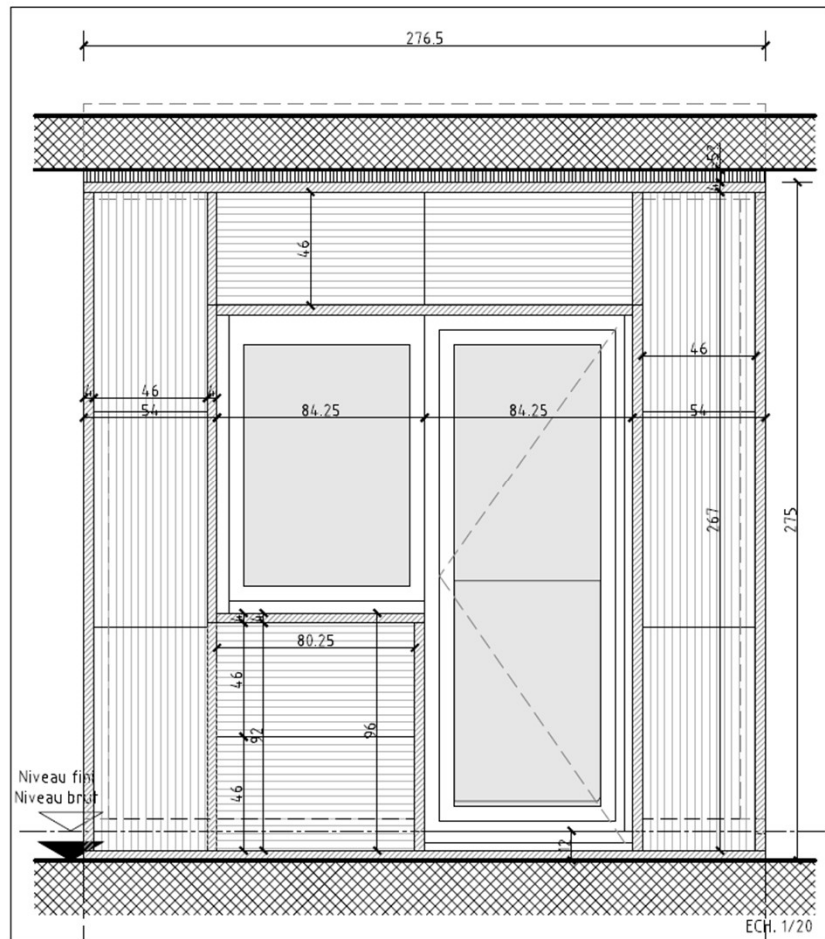
Caissons préfabriqués + paille

Wooden cassettes + straw bales

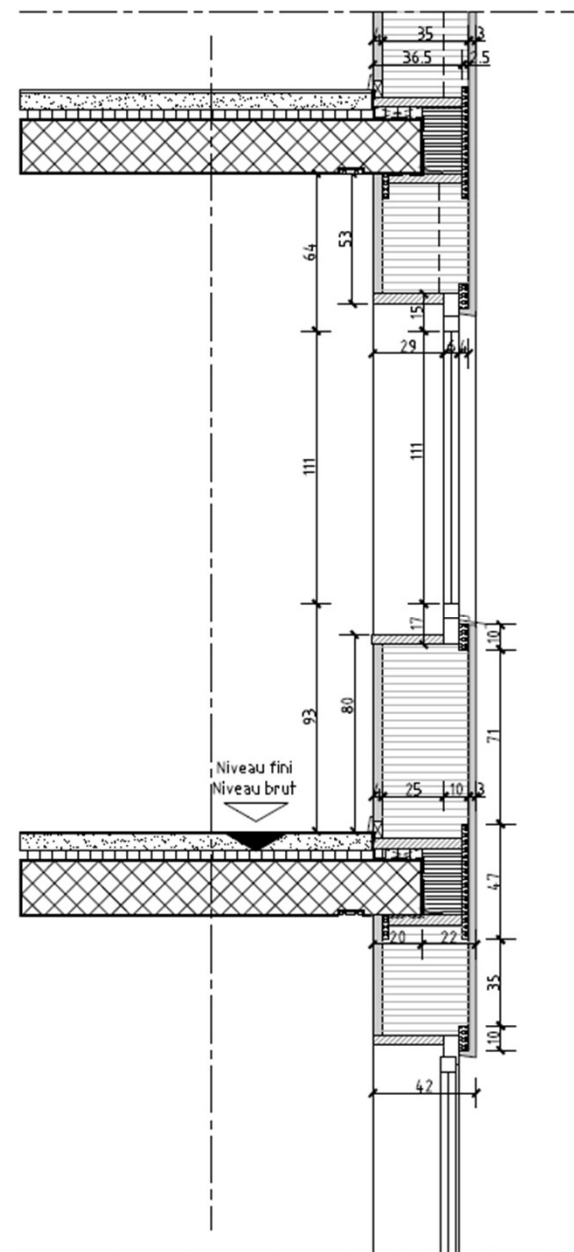


Coop. Equilibre & Lucioles, Genève
@ Atba / CARPE

Caissons préfabriqués + paille



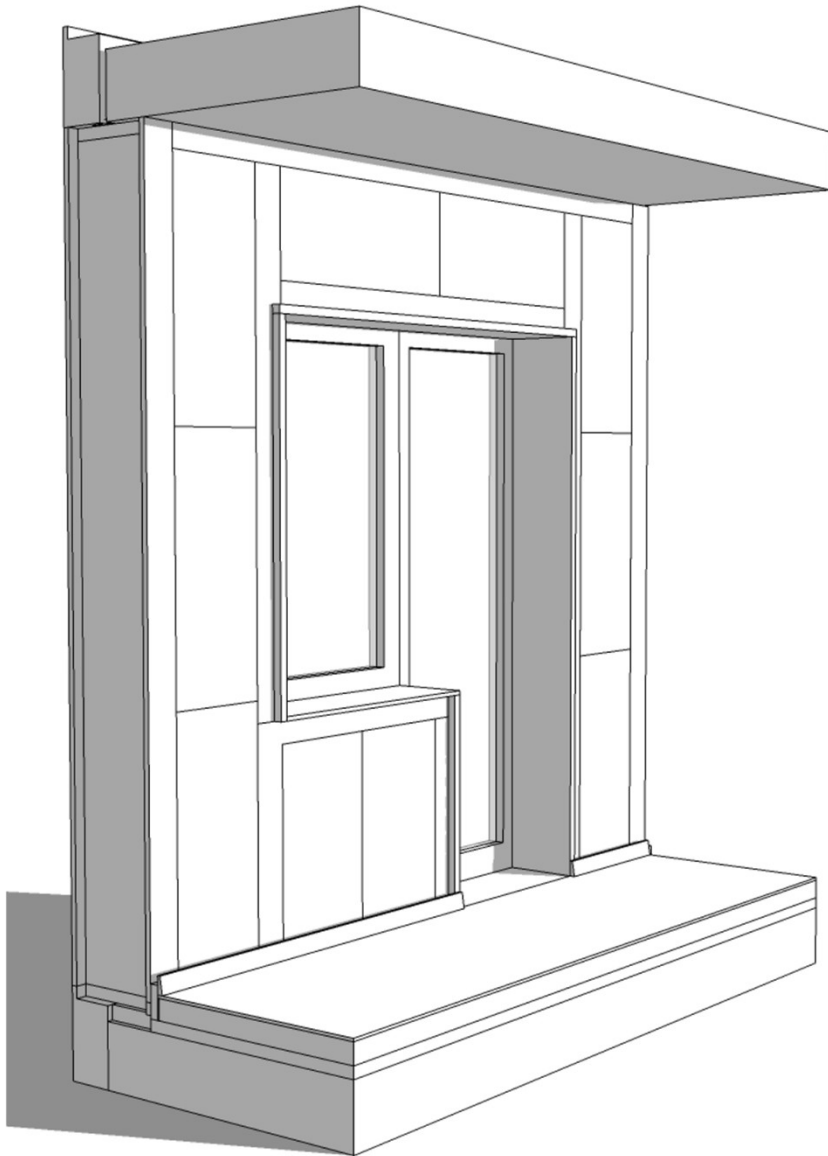
Wooden cassettes + straw bales



Coop. Equilibre & Lucioles, Genève
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Caissons préfabriqués + paille

Wooden cassettes + straw bales



Caissons préfabriqués + paille insufflée



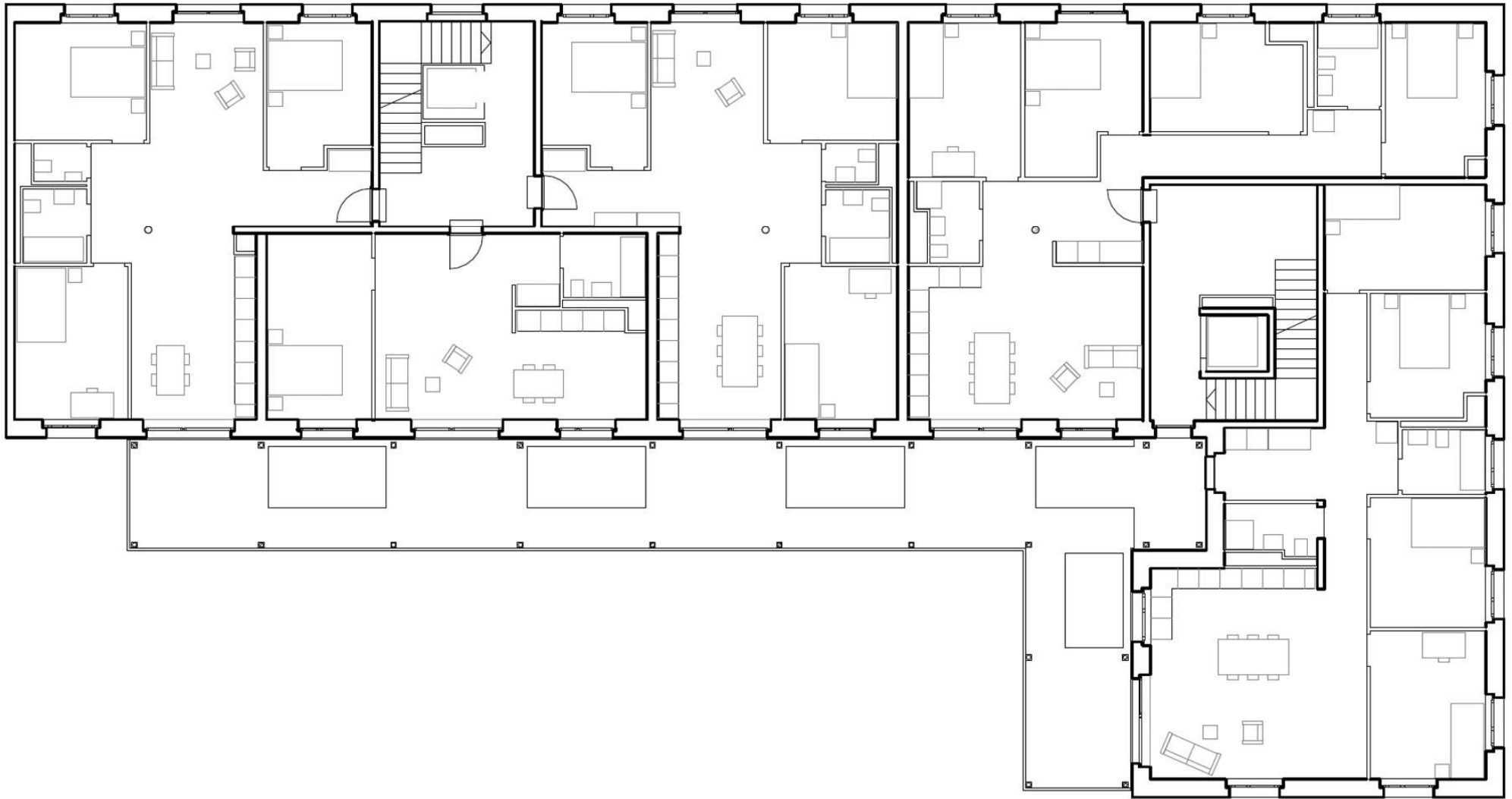
Lausanne @ atba, Coop. Ecopolis

Caissons préfabriqués + paille insufflée

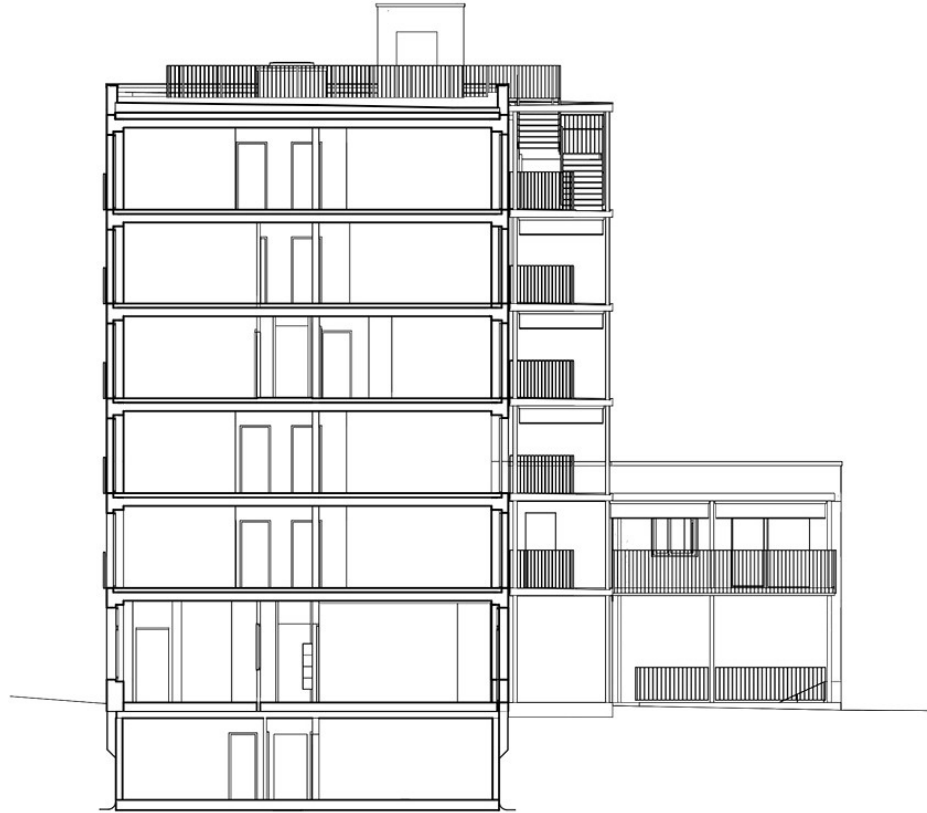


Lausanne @ atba, Coop. Ecopolis

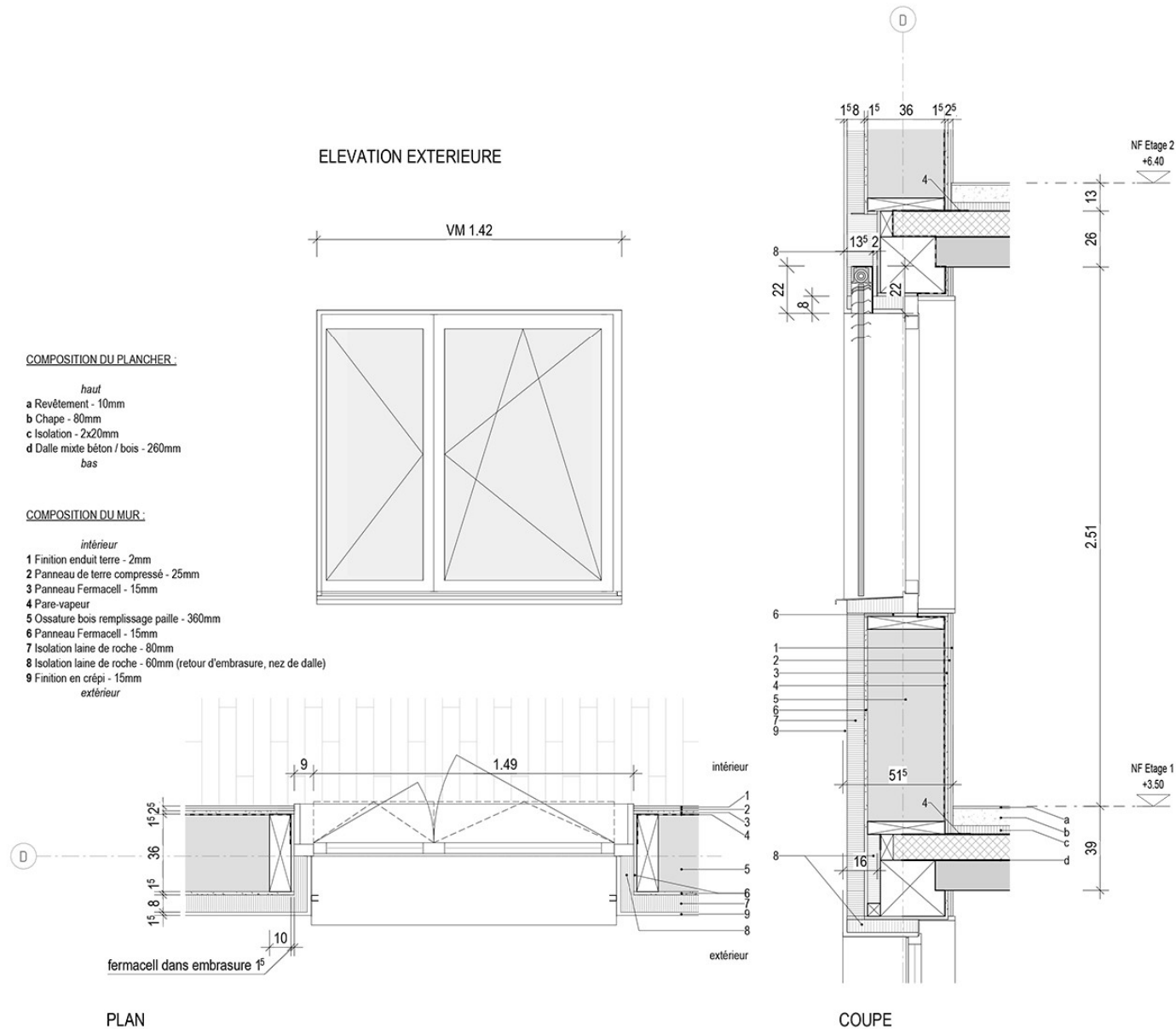
Caissons préfabriqués + paille insufflée



Caissons préfabriqués + paille insufflée



Caissons préfabriqués + paille insufflée



The image shows the interior of a building under construction. The walls are made of straw bales, which are stacked vertically. A wooden frame is visible, with vertical studs and horizontal beams. The floor is made of concrete. In the background, there is a yellow object, possibly a piece of equipment or a bag. The text "Wooden structure + straw bales" and "Ossature bois + bottes de paille" is overlaid on the image.

Wooden structure + straw bales

Ossature bois + bottes de paille

Ossature bois + paille

Wooden structure + straw bales



- 1 OSSATURE BOIS
- 2 BOTTES DE PAILLE
- 3 PANNEAU DE CONTREVENTEMENT

- 4 PARE-PLUIE
- 5 BARDAGE

Ossature bois + bottes de paille

Wooden structure+ straw bales



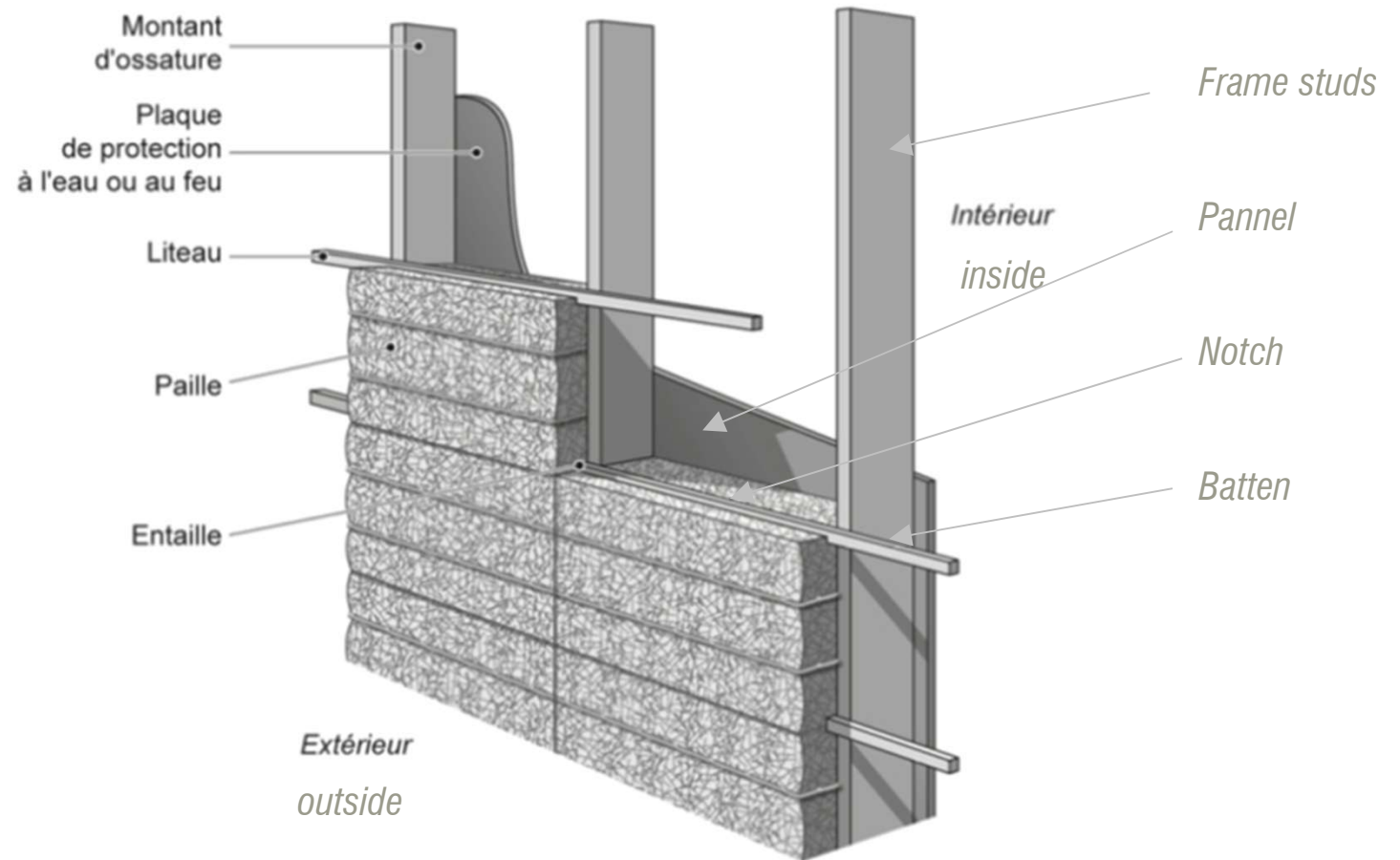
Ossature bois + bottes de paille

Wooden structure+ straw bales



Ossature bois + bottes de paille

Wooden structure + straw bales



Commentaire : le maintien des bottes de paille peut être assuré par des liteaux enfoncés dans les bottes. Ces liteaux sont fixés aux montants d'ossature.

The straw bales can be held in place by battens driven into the bales. These battens are fixed to the frame studs.

Ossature bois + bottes de paille

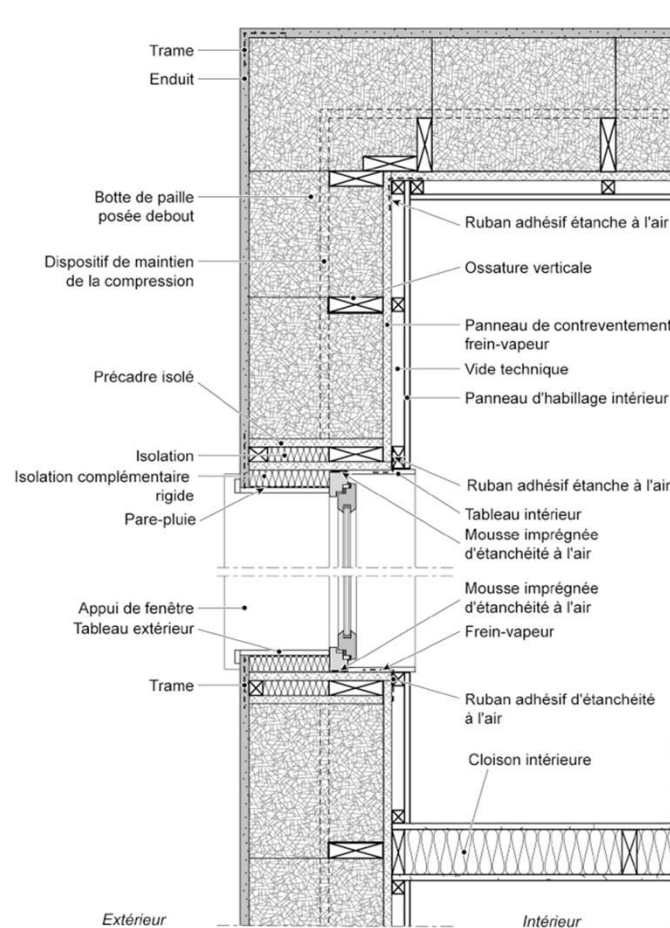


Fig. 4.15. Exemple de coupe horizontale d'une paroi avec ossature simple désaxée vers l'intérieur

Wooden structure+ straw bales

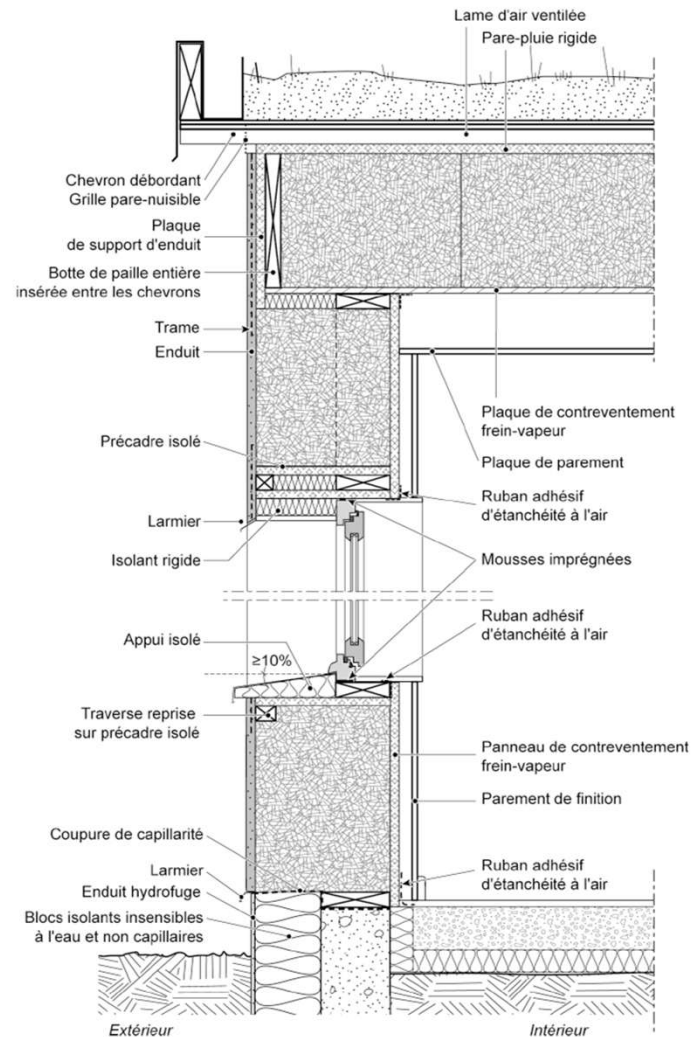


Fig. 4.16. Exemple de coupe verticale d'une paroi avec ossature simple désaxée vers l'intérieur

simple frame offset inwards

Ossature bois + bottes de paille

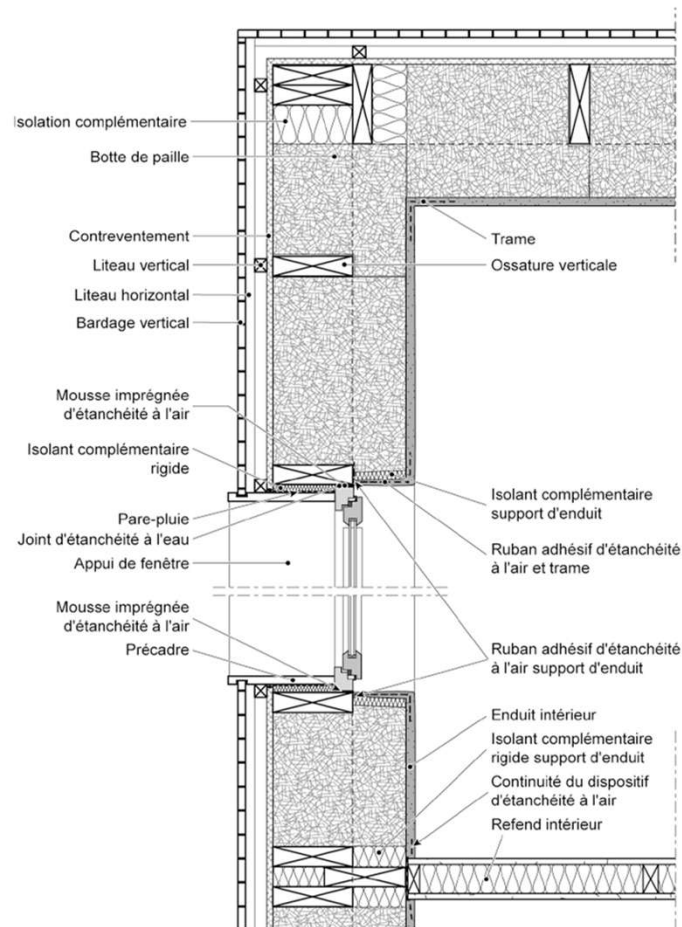


Fig. 4.13. Exemple de coupe horizontale d'une paroi avec ossature simple désaxée vers l'extérieur

Wooden structure+ straw bales

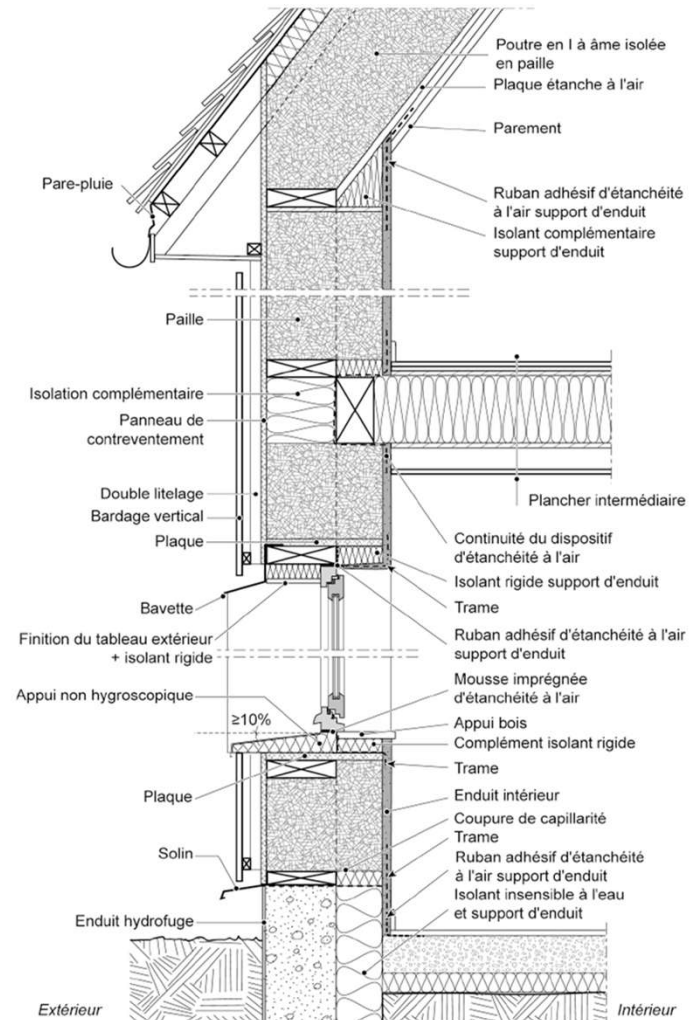


Fig. 4.14. Exemple de coupe verticale d'une paroi avec ossature simple désaxée vers l'extérieur

simple frame offset towards the outside



Load-bearing straw bale

Paille porteuse

Elément porteur en botte de paille

1. Sill beam
2. Stud
3. Window frame
4. Straw bales
5. Wall beam
6. Compression strap
7. Outer facing

Load-bearing straw bales component



RFCP

Eléments porteurs en botte de paille

Load-bearing straw bales components



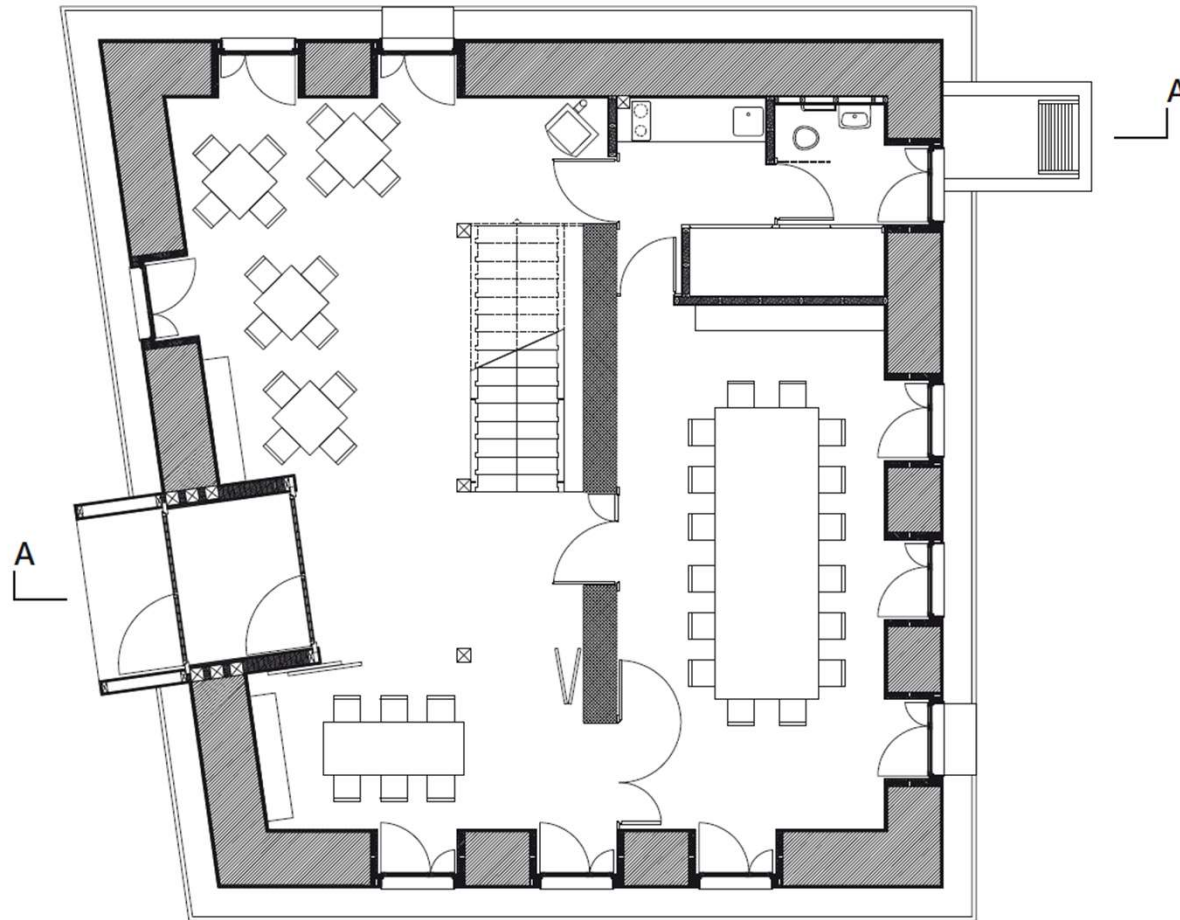
Éléments porteurs en botte de paille

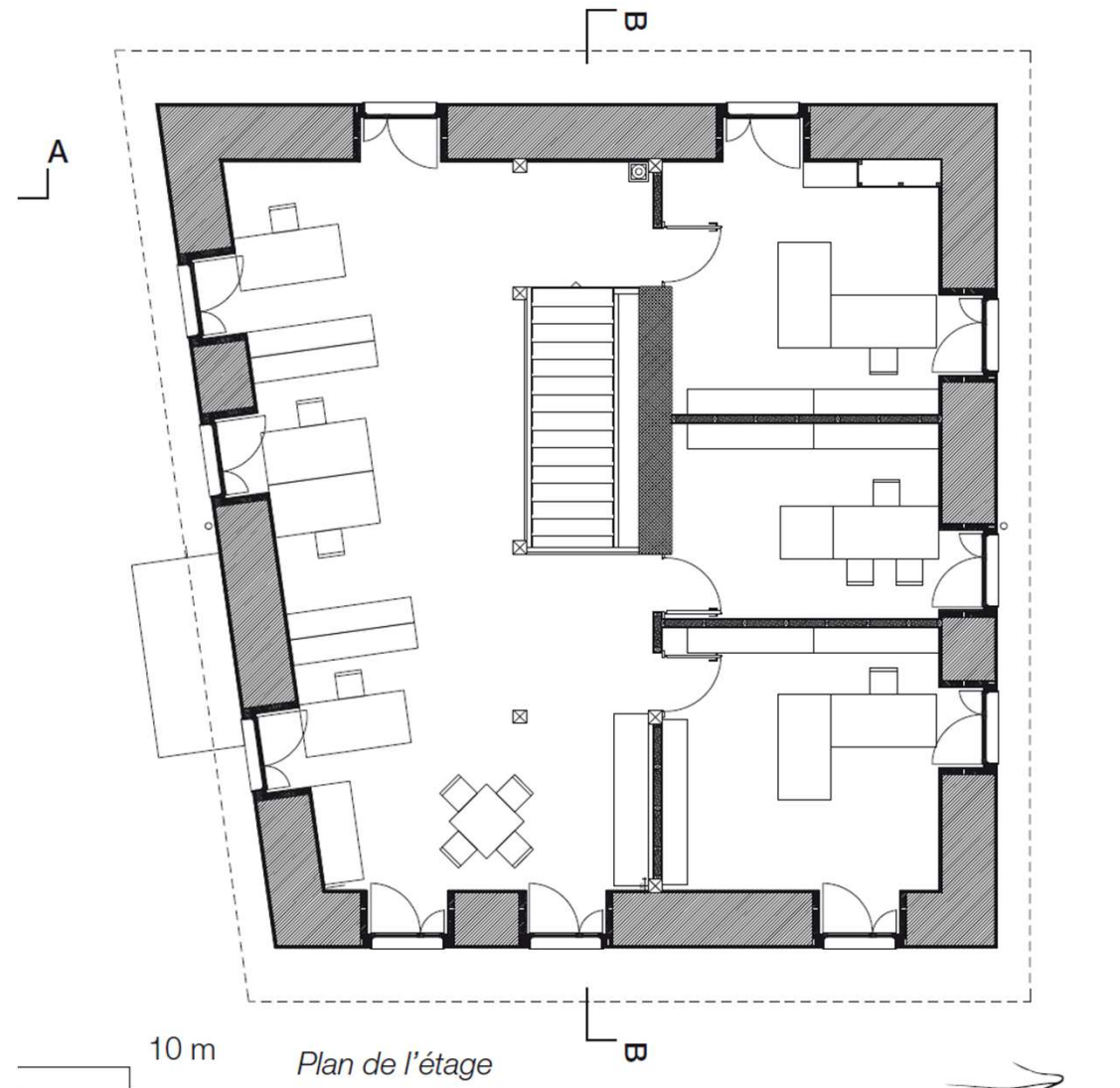
Load-bearing straw bales components

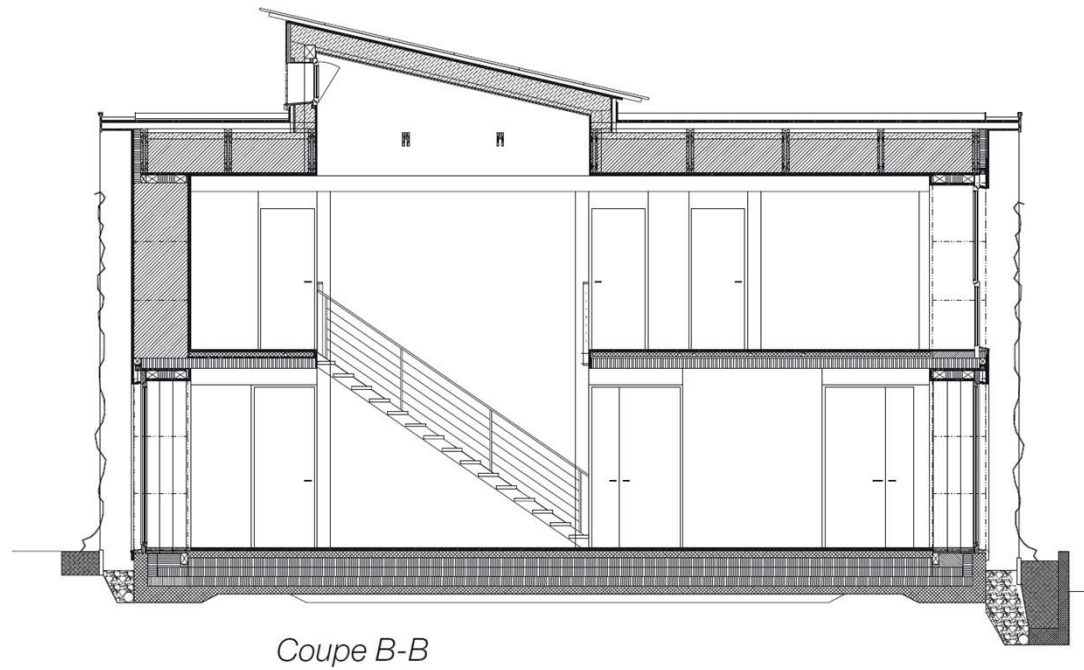


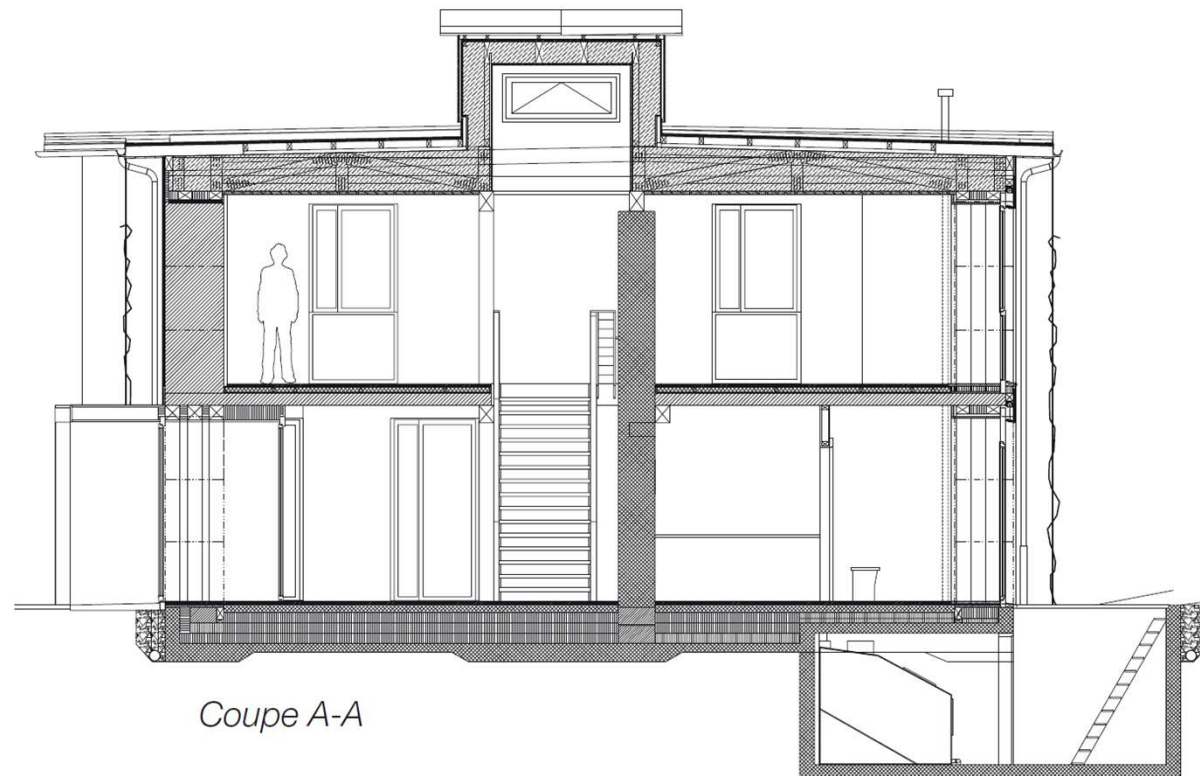
- > Bois des forêts de Lausanne
- > Paille Locale
- > Terre d'excavation
- > Sable local

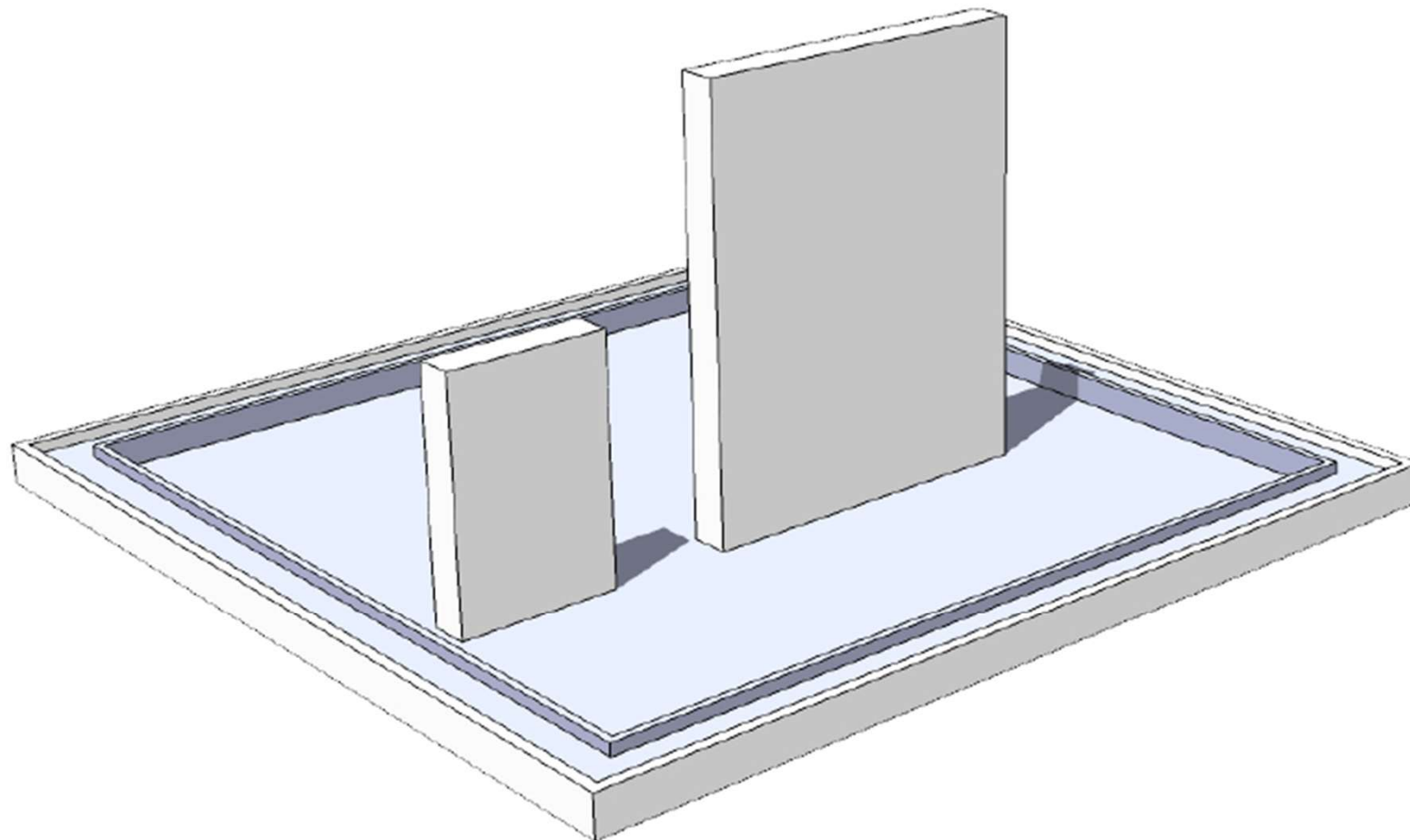
ECO46 / bâtiment démonstrateur en paille porteuse
CARPE / Normal Office

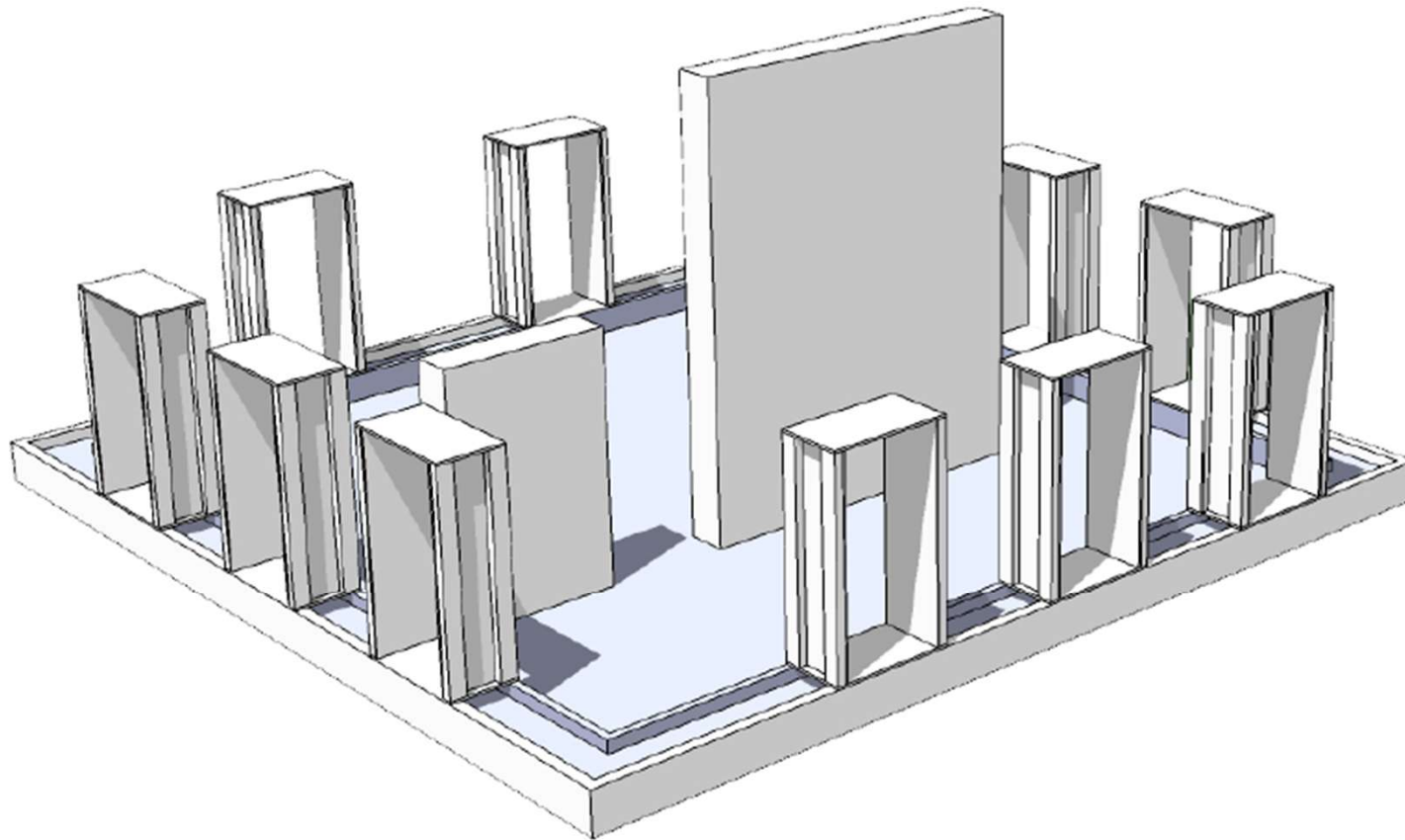


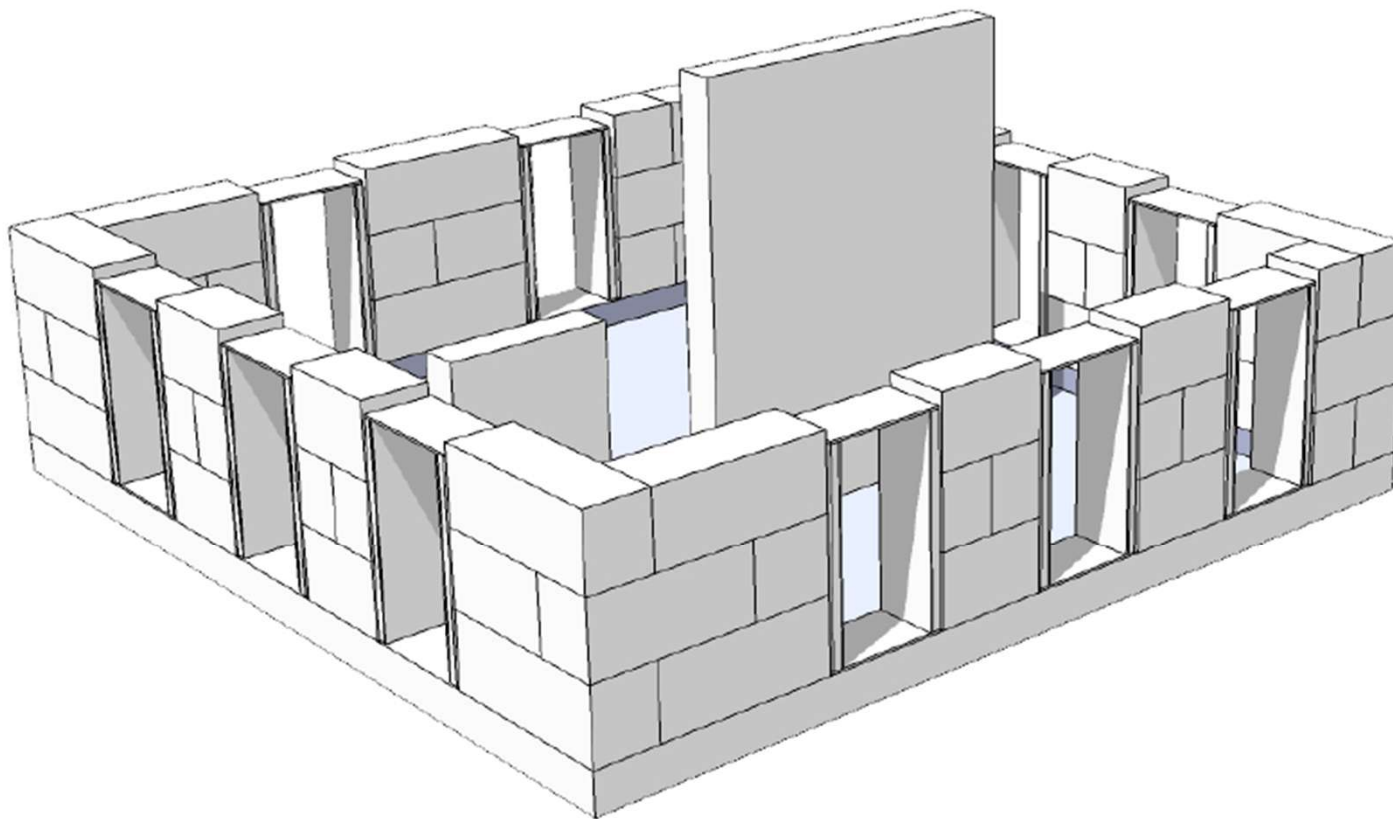


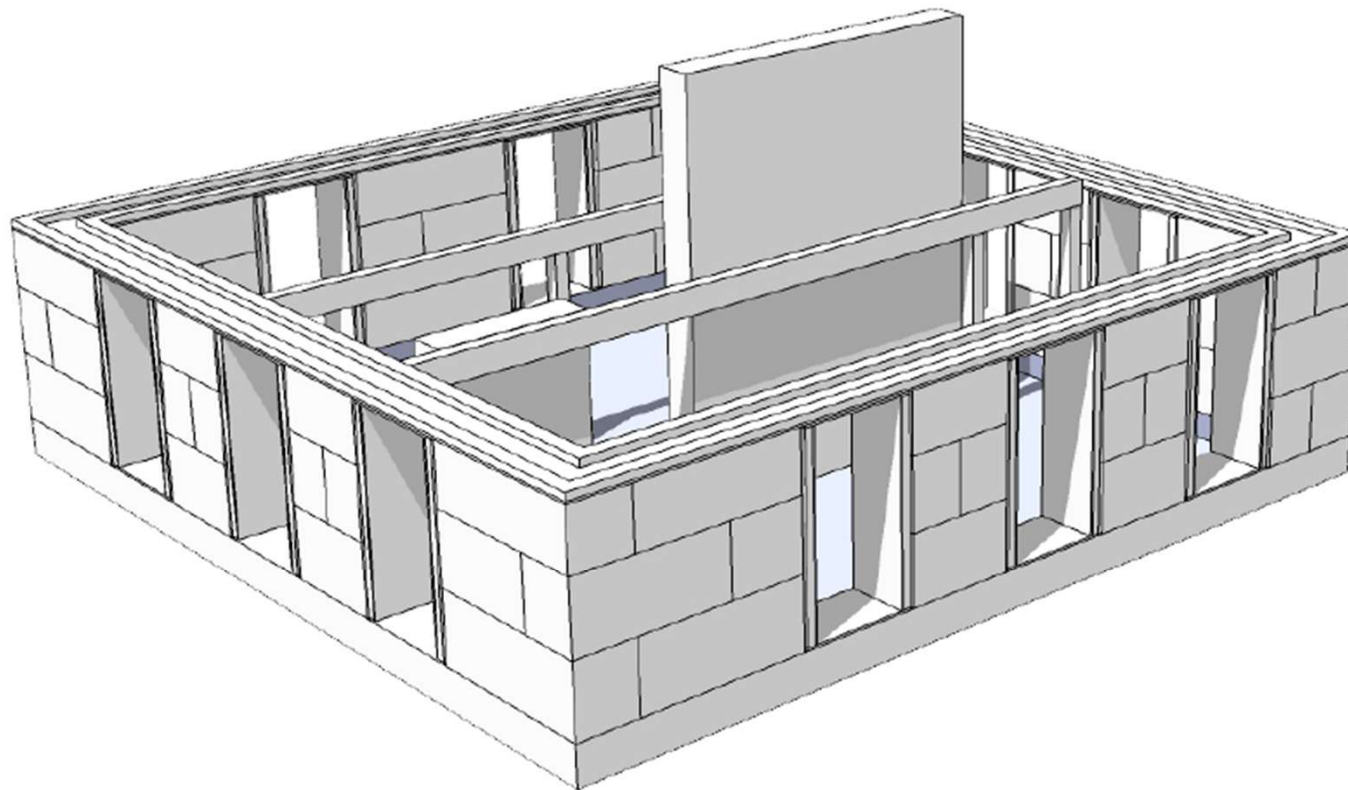


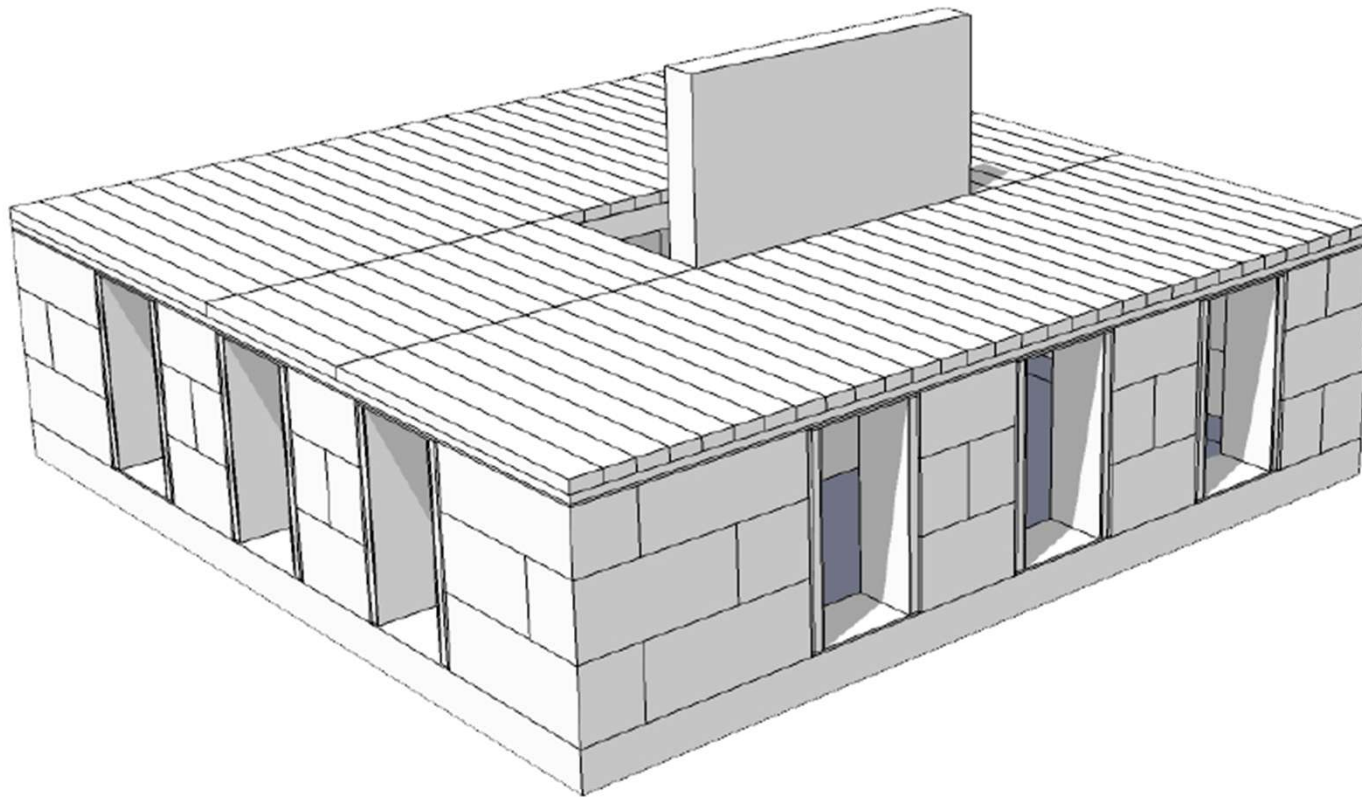


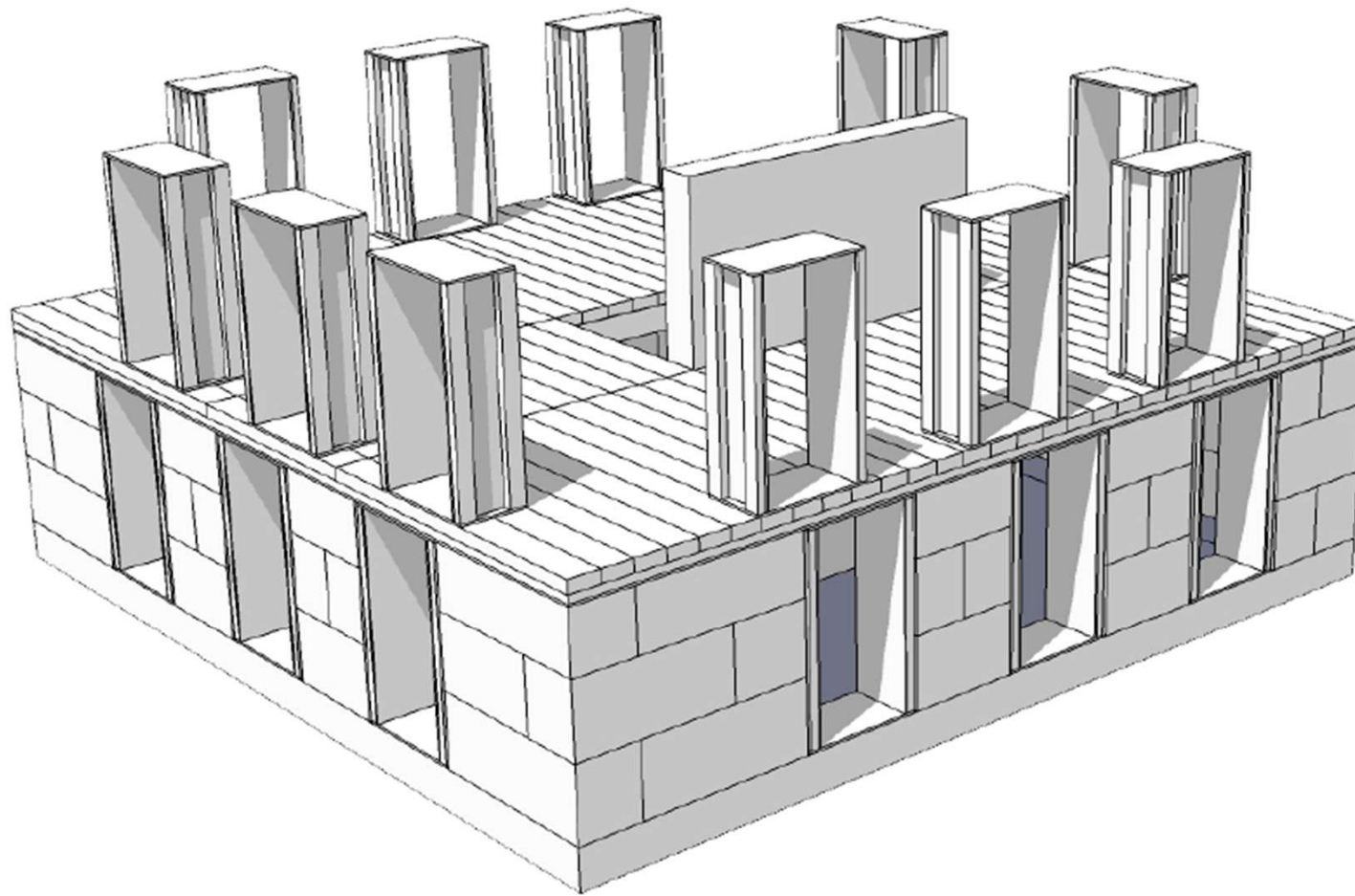


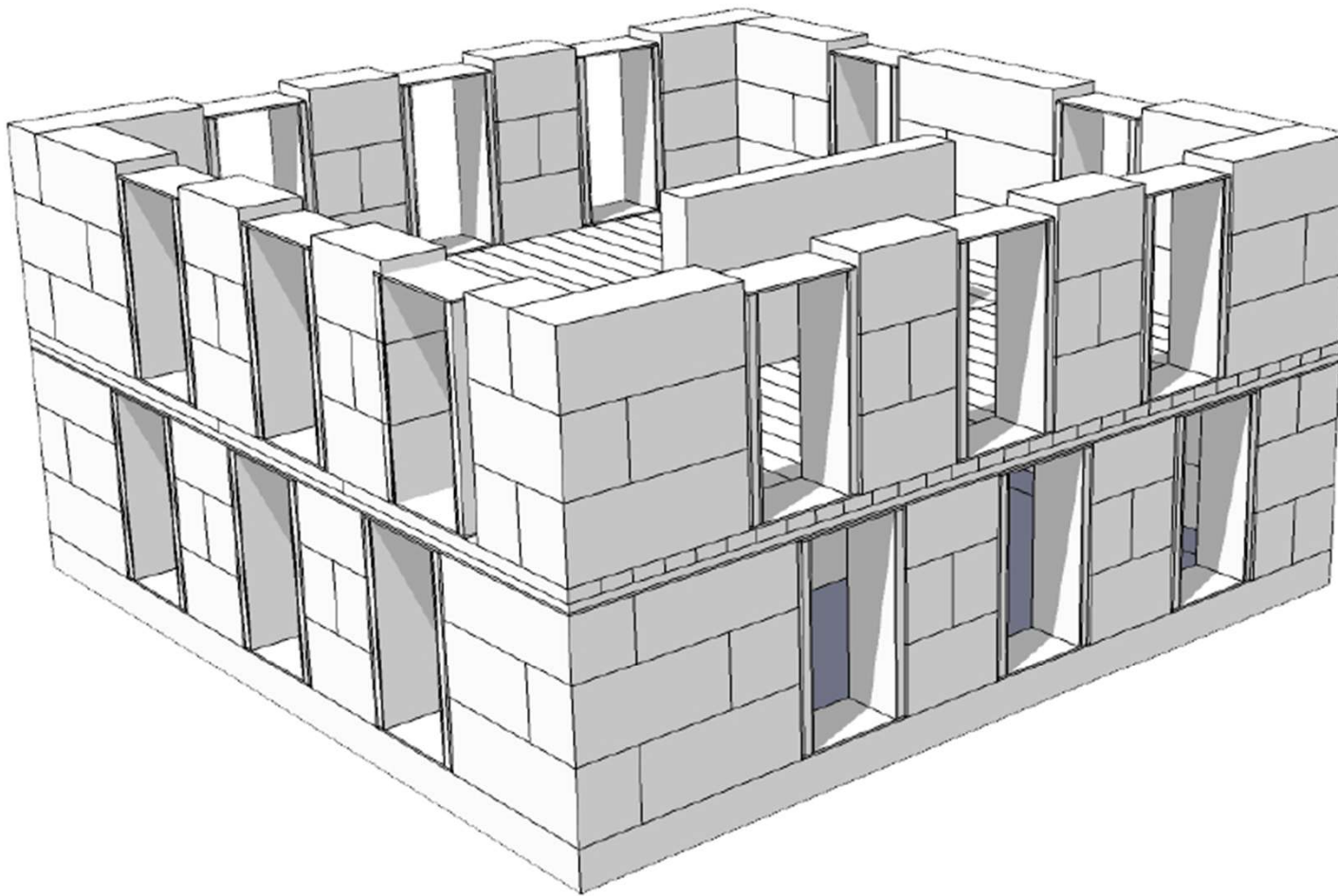


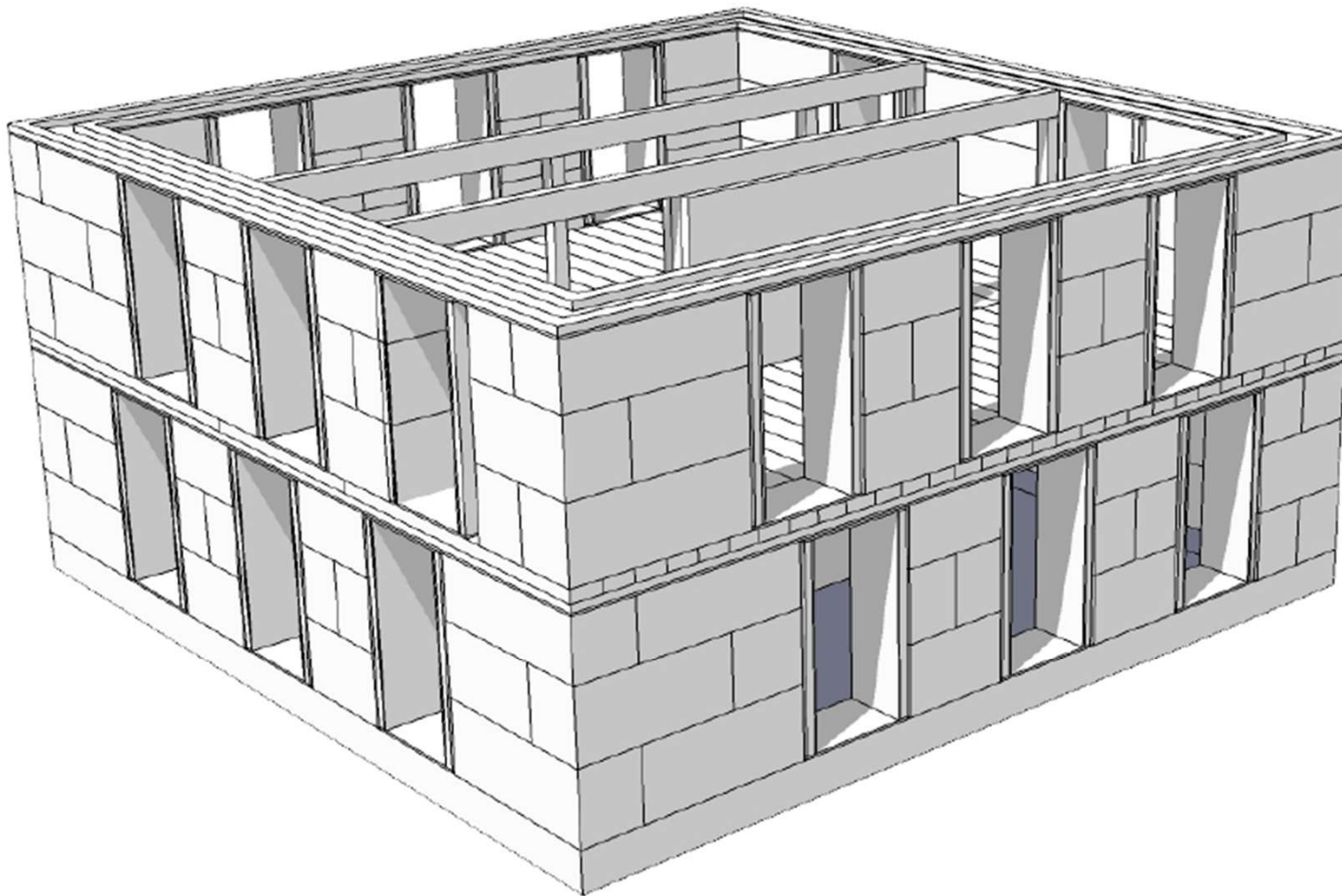


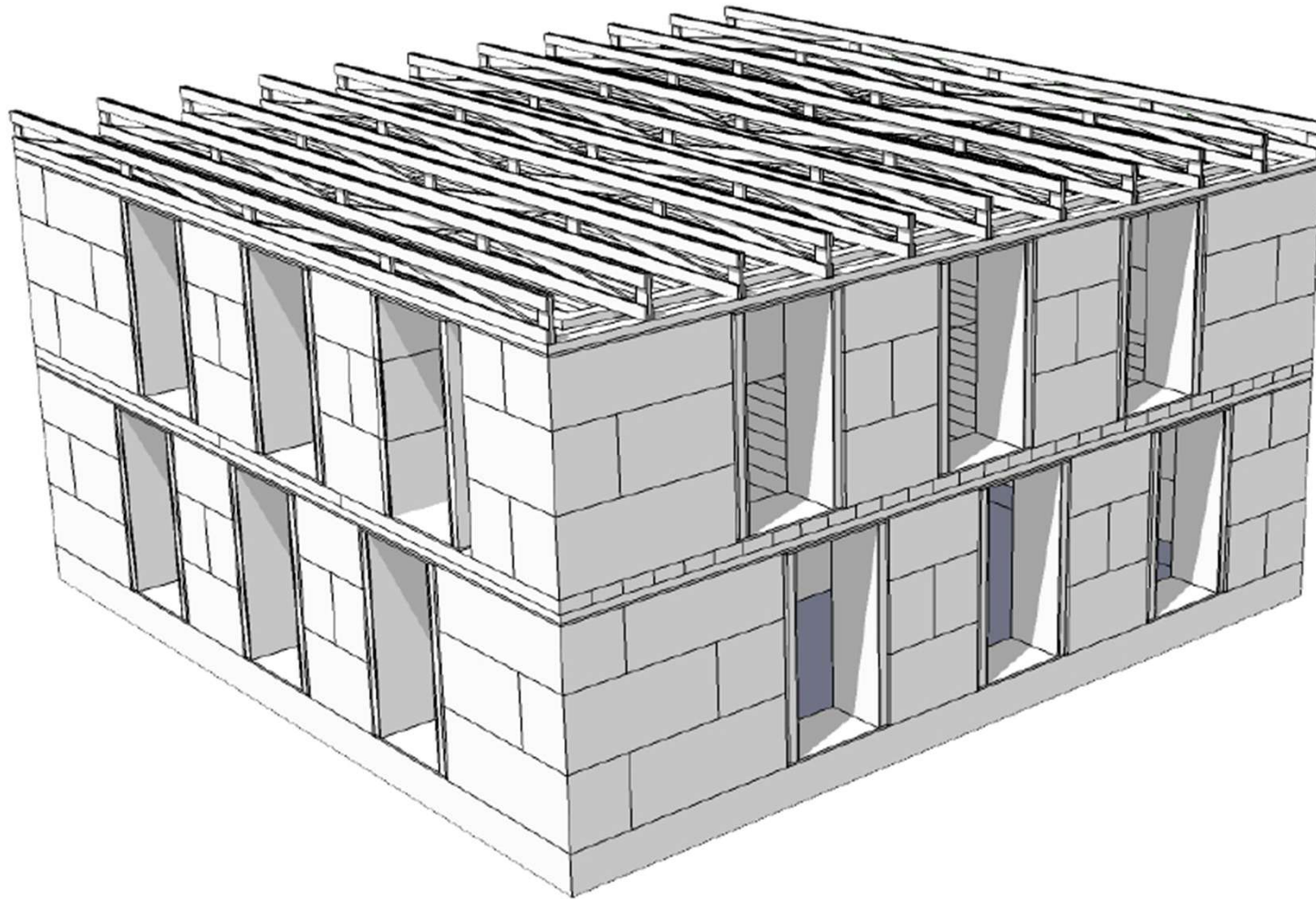


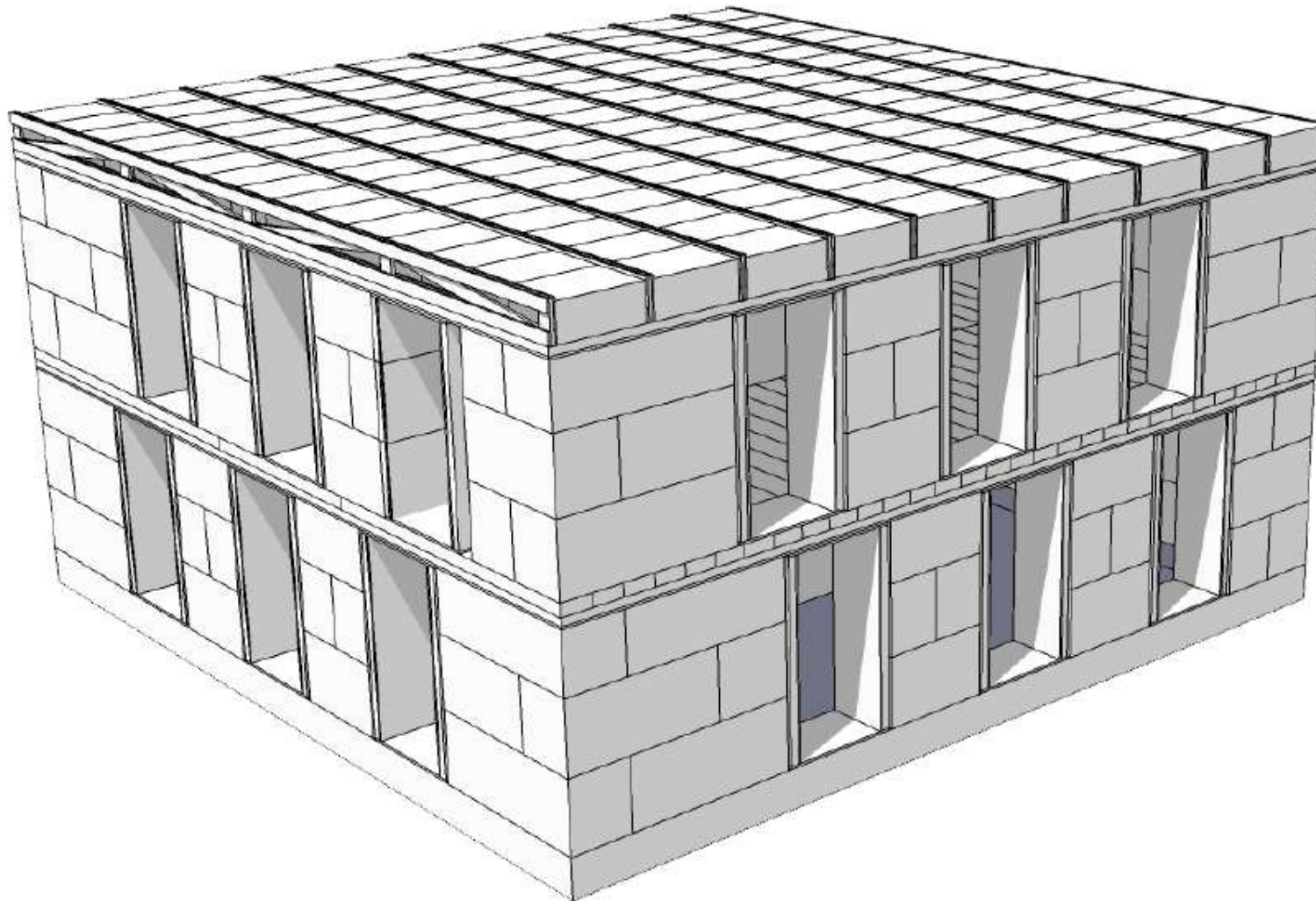








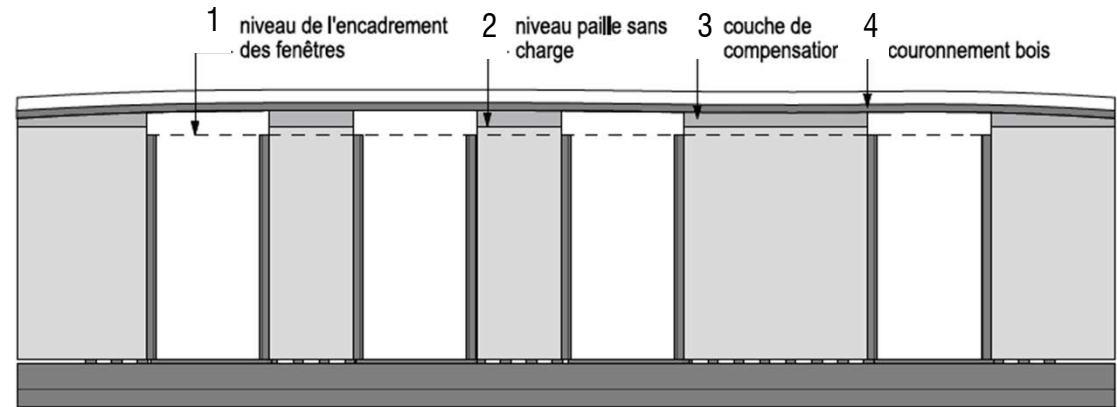




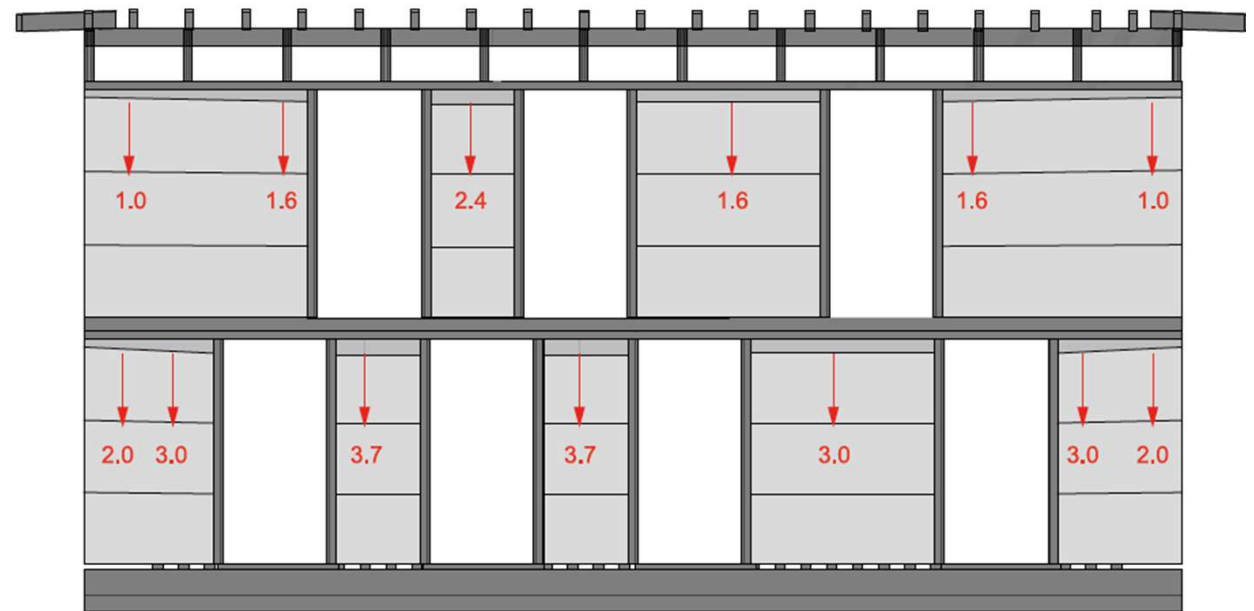
Éléments porteurs en botte de paille

Load-bearing straw bales components

1. window frame level
2. level of straw bales without loads
3. compensation layer
4. Wall beam



Façade sud après la pose de la dalle de l'étage south façade after the floor slab has been laid



Façade sud après la pose de la toiture (poids propre définitif en t/m)

south façade after roof installation (final dead weight in t/m)

Structure primaire + elements autoportants *Primary structure + selfbearing straw bale elements*



Pavillon collectif, Jardins familiaux, Vernier
@ CArPE / atba / Mayor+ Beush

Structure primaire + elements autoportants *Primary structure + selfbearing straw bale elements*




Pavillon collectif, Jardins familiaux, Vernier
@ CARPE / atba / Mayor+ Beush

Structure primaire + elements autoportants *Primary structure + selfbearing straw bale elements*



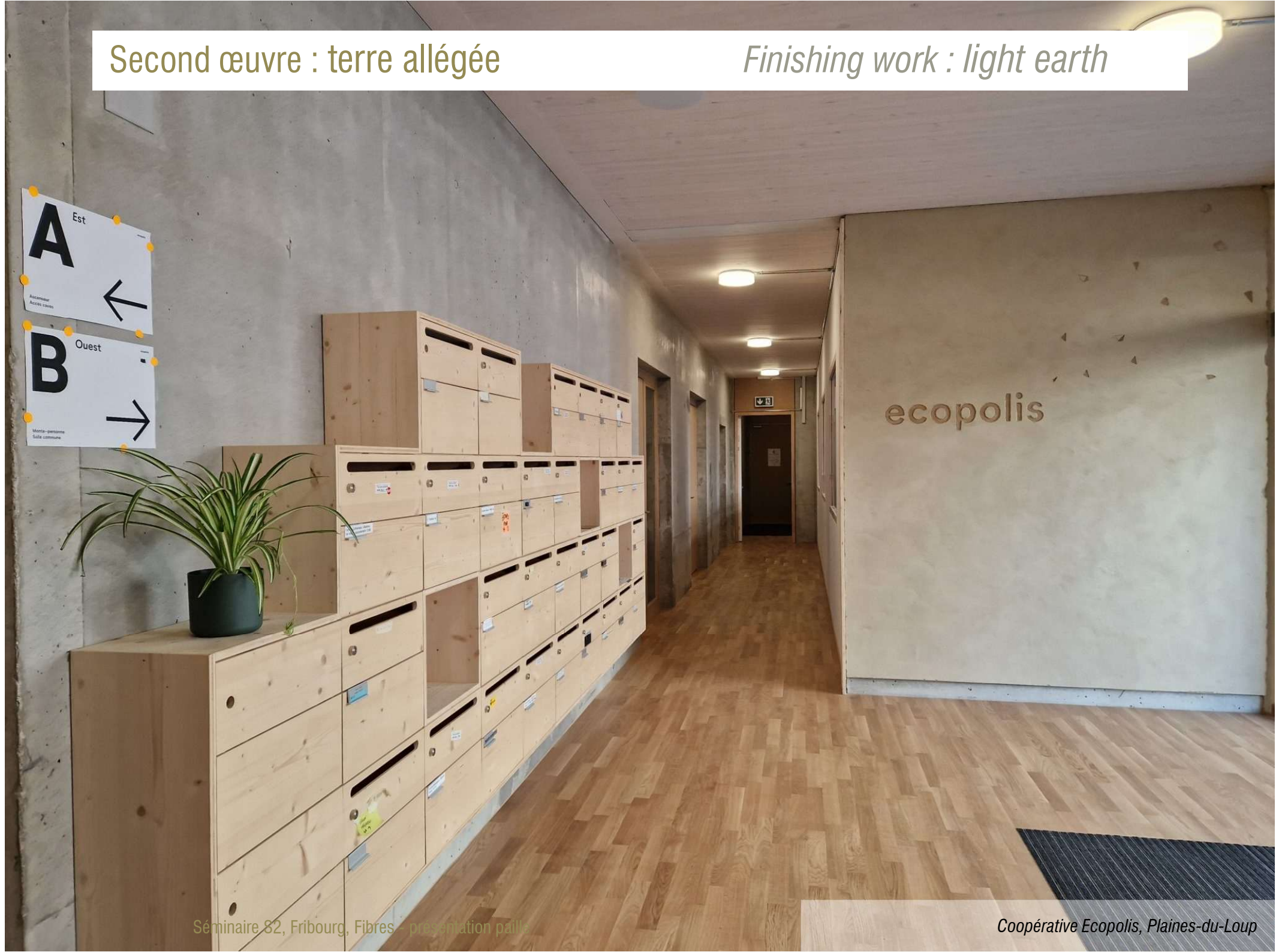
Pavillon collectif, Jardins familiaux, Vernier
@ CARPE / atba / Mayor+ Beush



Terre allégée
Light earth
Tierra aligerada

Second œuvre : terre allégée

Finishing work : light earth



Second œuvre : terre allégée

Finishing work : light earth



Second œuvre : terre allégée

Finishing work : light earth



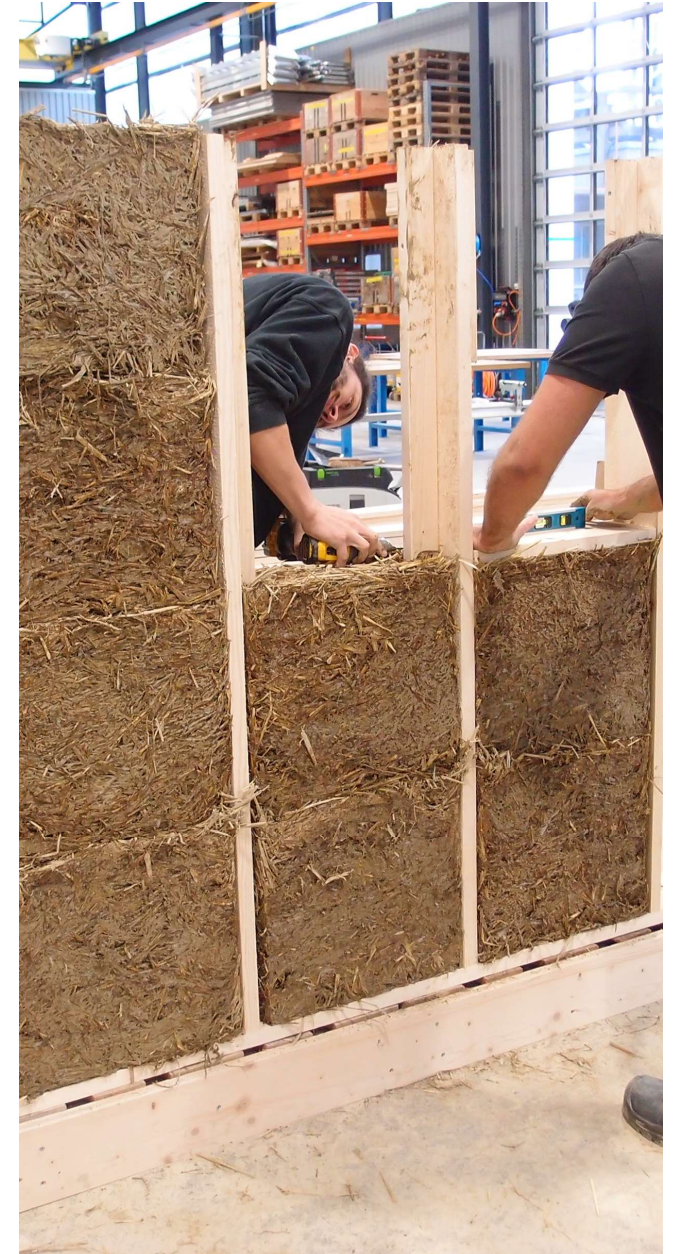
Second œuvre : terre allégée

Finishing work : light earth



Briques/panneaux de terre allégée insérés dans une ossature

Lightweight earth bricks/panels inserted into a framework



Terre allégée – panneaux préfabriqués

Light earth - prefabricated panels



Terre allégée mise en œuvre sur site

Lightearth soil – implementation on site





Torchis
Wattle and daub
Bahareque
Clissage

Second œuvre : Torchis



Finishing work : Wattle and daub



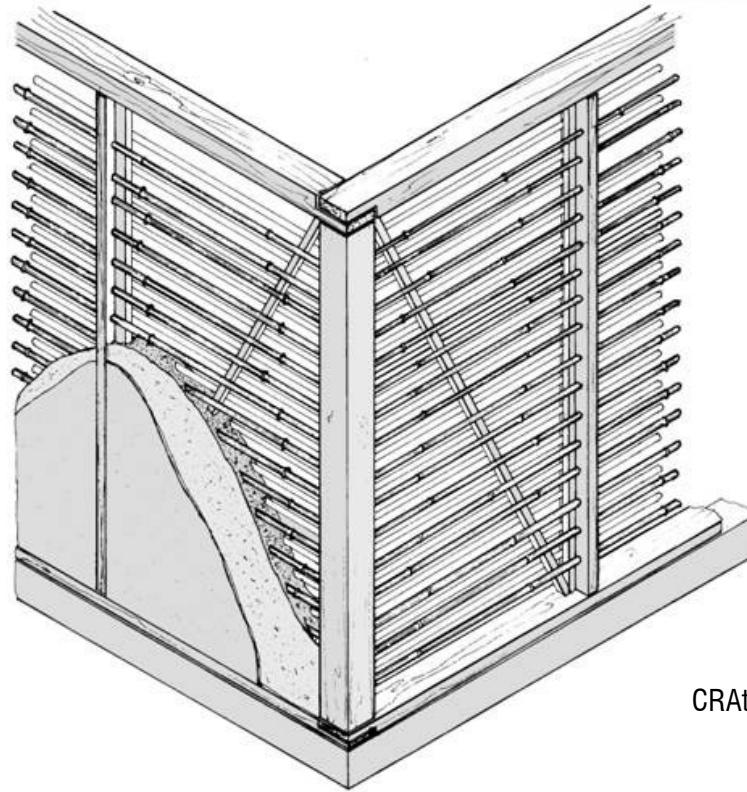
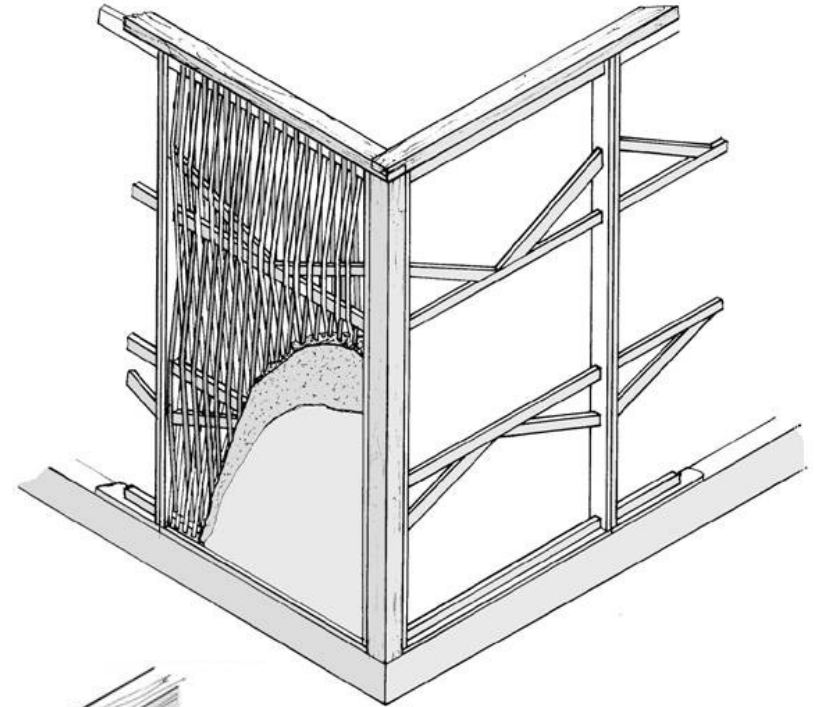
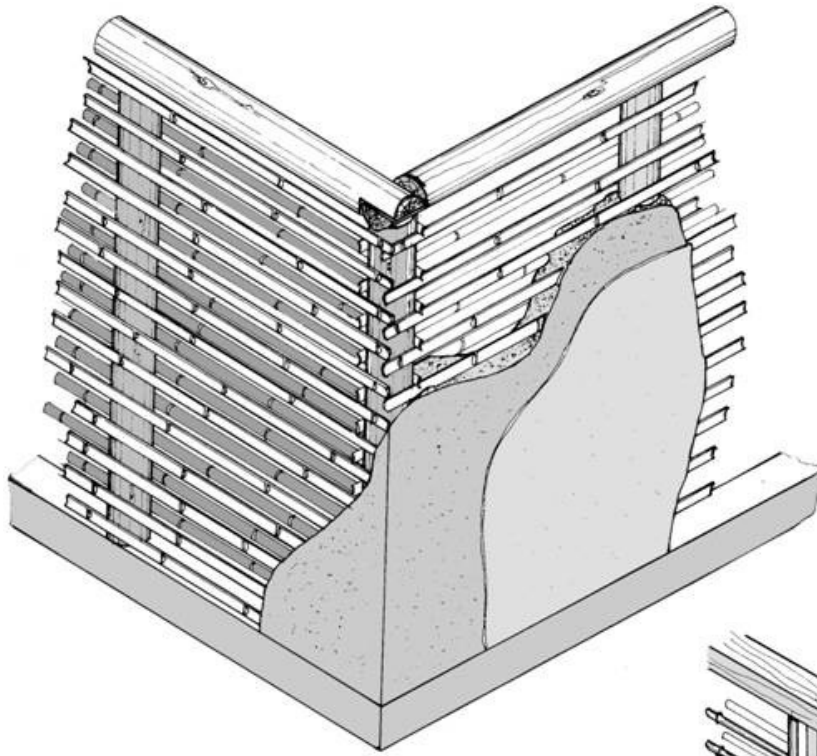
Second œuvre : torchis

Finishing work : wattle and daub



Second œuvre : torchis

Finishing work : wattle and daub

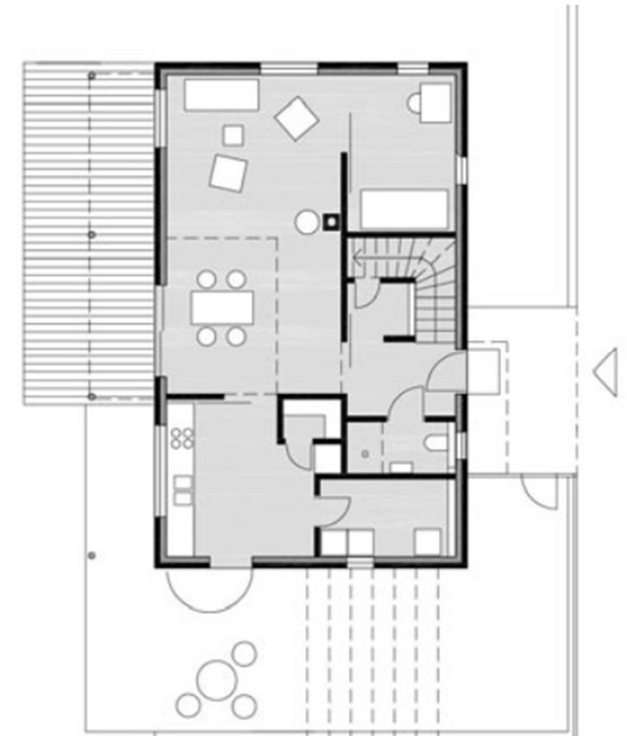


CRAterre

Maison J, 1996, Autriche



| | |
|--------------------|---|
| Lieu | Darmstadt, Autriche |
| Programme | Maison |
| Année | 1996 |
| MO | Franz Volhard |
| Architecte | Schauer + Franz Volhard architecte BDA |
| Réalisation | Lehmbau Breidenbach, Viersen |
| Technique | Terre allégée |



Maison J, 1996, Autriche



Maison J, Darmstadt, 2013, Autriche



Séminaire S2, Fribourg, F lattis 24x30 a=12cm



"panneaux"
épaisseur 36 mm

