

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.

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

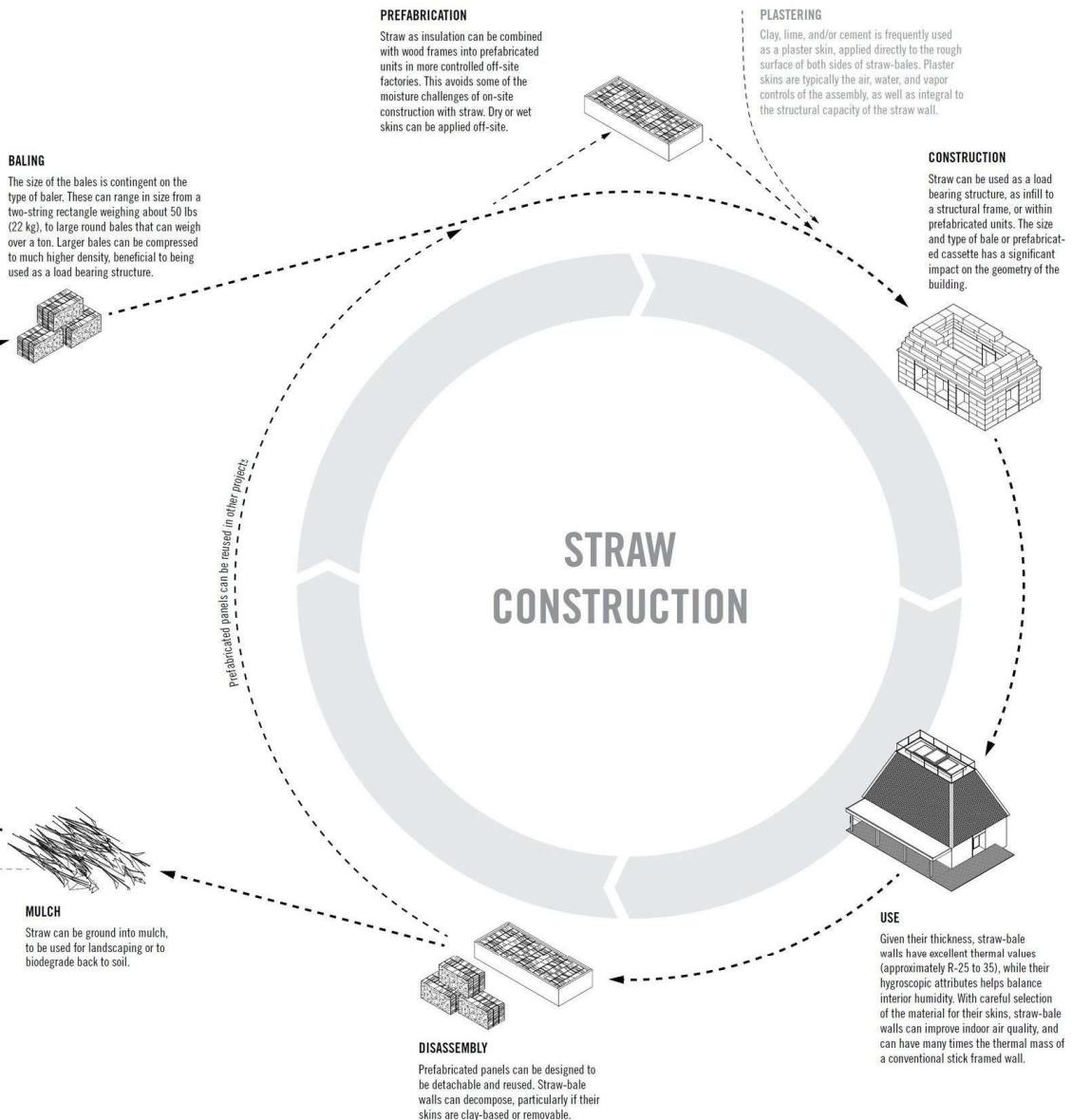
MULCH
Straw can be ground into mulch, to be used for landscaping or to biodegrade back to soil.

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.



STRAW HARVESTING 4 TO 8 MONTHS

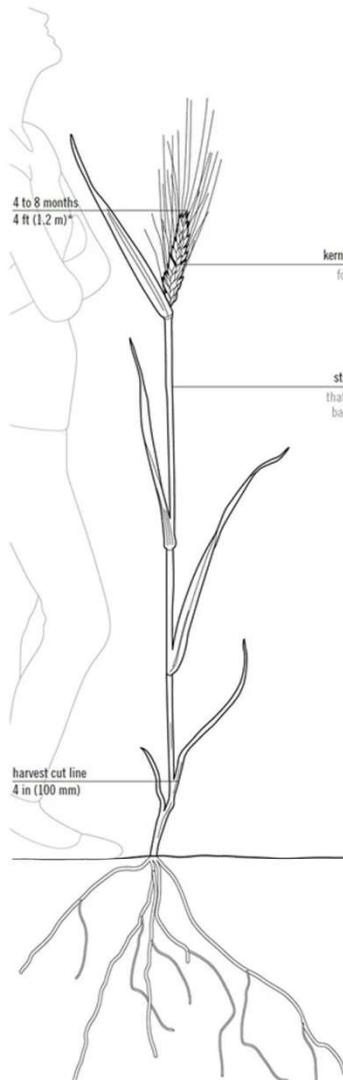


De la plante à l'élément de construction

From plant to building component

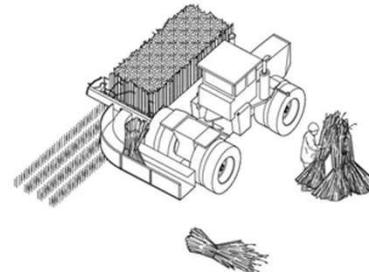
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STRAW



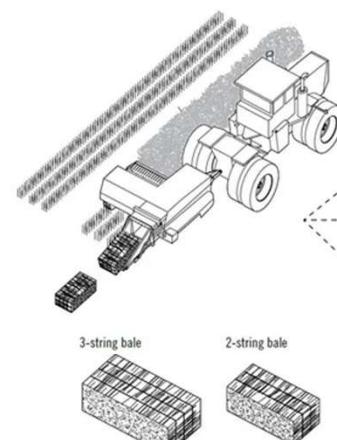
HARVESTING

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

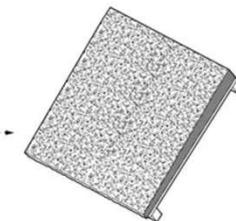
The plaster skin is a crucial component of straw-bale construction, contributing significantly to its structural capacity, and its resistance to fire, moisture, and vermin. Although slower drying, clay and lime plasters avoid the higher carbon emissions of portland cement-based plasters.

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.

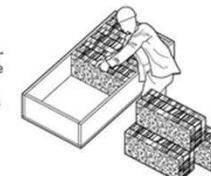


THATCHED ROOF

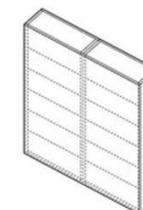


PREFABRICATED PANELS

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

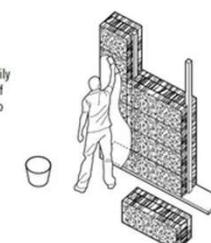


PREFABRICATED ASSEMBLY

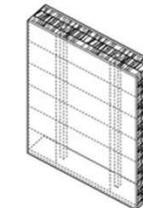


WOOD FRAME INFILL

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.

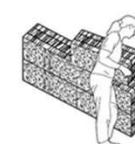


INFILL WALL

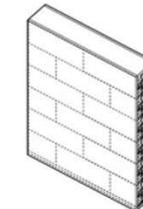


NEBRASKA LOAD-BEARING

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

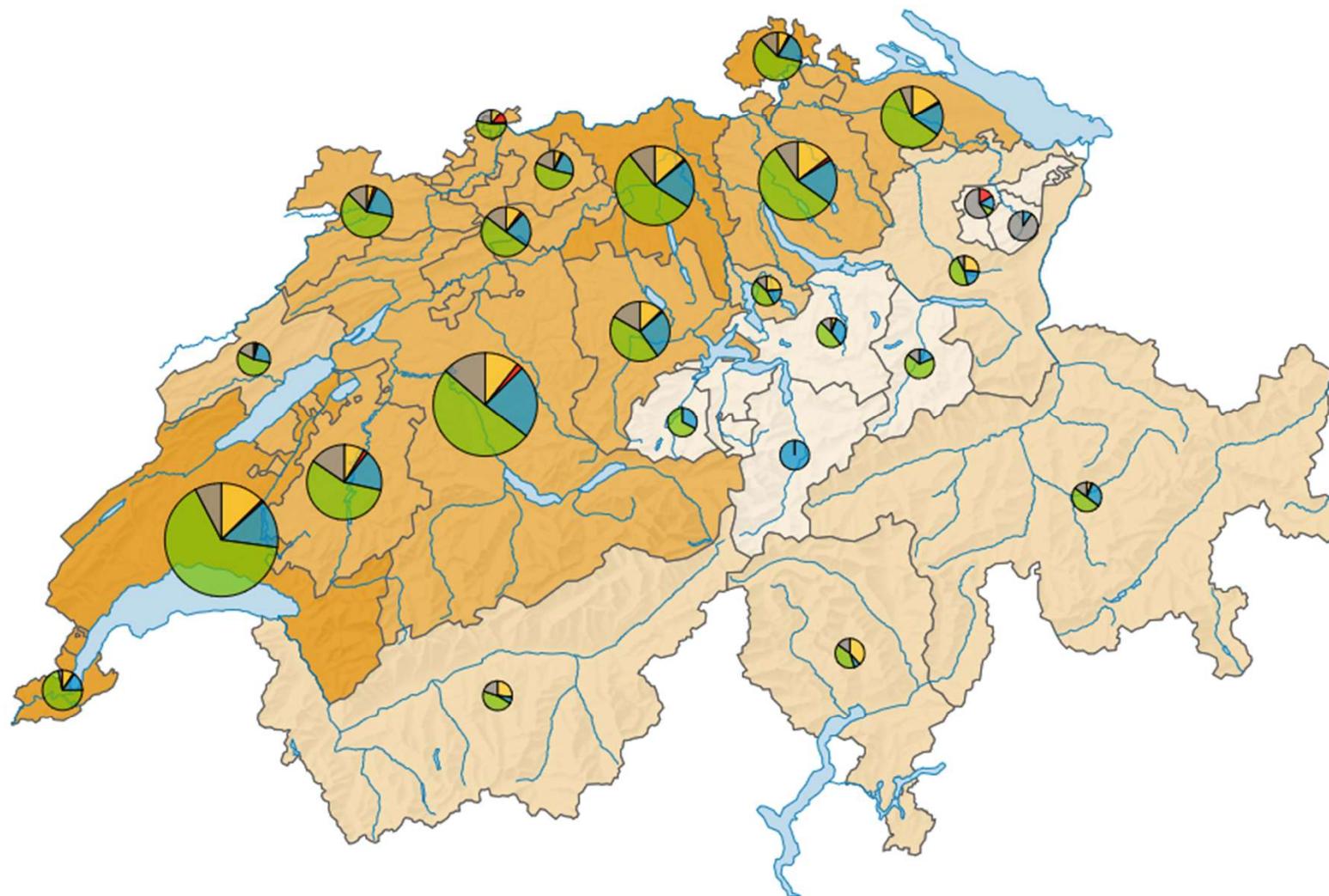
From field to the construction site



Disponibilité

Availability

Surfaces de culture de céréales, en 2021

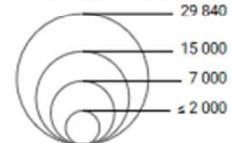


Part de la surface agricole utile, en %

≥ 20,0
10,0 – 19,9
5,0 – 9,9
1,0 – 4,9
< 1,0

Suisse: 14,0

Surfaces de culture de céréales en hectares



Suisse: 146 395

Pour des raisons de lisibilité, la taille des symboles ayant une valeur inférieure à 2 000 a été augmentée.

Sortes de céréales:

Mais pour le grain (Suisse: 17 214)
Avoine (Suisse: 1 918)
Orge (Suisse: 28 008)
Blé (Suisse: 82 434)
Autres céréales

Qualités

Virtues

BIODÉGRADABLE

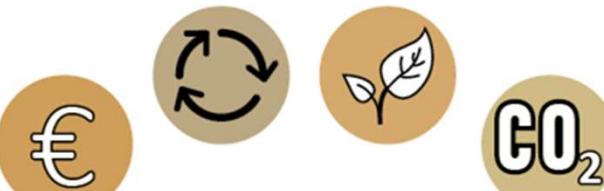
Matériaux compostables

RENOUVELABLE & ABONDANTE

Production 20Mt/an, besoin de 1% pour 10% de la construction

ÉCONOMIE

Investissement initial rentabilisé



PUITS DE CARBONE

F.D.E.S -9kg de CO₂/m² de paroi (botte ép. 36cm)

DURABLE

Maison Feuillette a+100 ans !



EMPLOI LOCAL

Valorisation des métiers du bâtiment



RÉSISTANTE AUX INSECTES

Aucun intérêt alimentaire

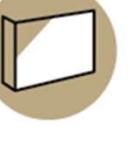


RÉSISTANTE AUX RONGEURS

Aucun intérêt alimentaire



QUALITÉ DE L'AIR



CLASSEMENT AU FEU

B - S1 - d0 (paille enduite de chaux ou terre crue)



CONFORT ACOUSTIQUE

RW = -43 dB (botte ép. 36cm enduite de terre crue)



RESSOURCE LOCALE

Disponible sur tout le territoire



ISOLANT & PERFORMANT

R = 7.5 m².K/W (botte ép. 36cm)



CONFORT ÉTÉ/HIVER

Déphasage thermique entre 12h et 16h (botte ép. 36cm)



PERSPIRANT

Régulation de l'humidité par les parois



SUPPORT D'ENDUIT

Terre crue / chaux / plâtre

Disponibilité

Availability



Duchosal Matteo / Terrapon Pauline

Roland Sansonnens
Culture de la paille

Séminaire Matières durables 2025

Précautions en phase chantier



Chantier ITE
@Nebraska

Protection incendie (et pluie)



Les principaux systèmes constructifs

The main construction systems

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



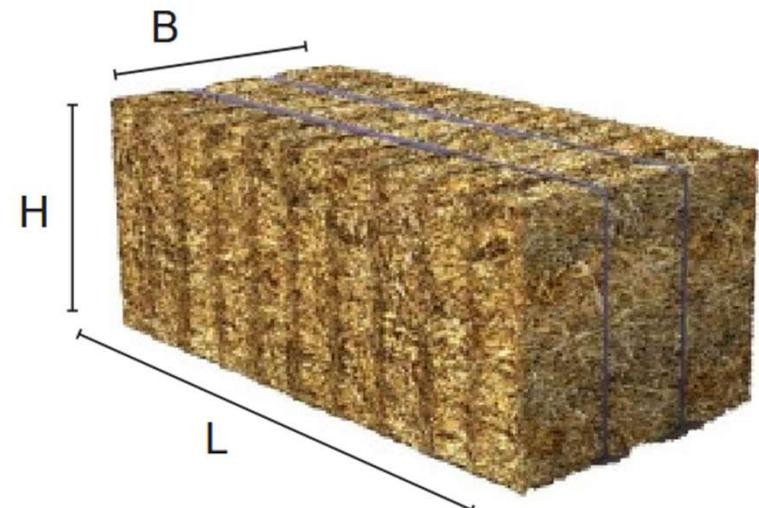
46x36x90cm
(B*H*L)



Densité
sur base
sèche



Orientation
des fibres



Water
content

Dimensions

*Dry basis
density*

*Fiber
orientation*

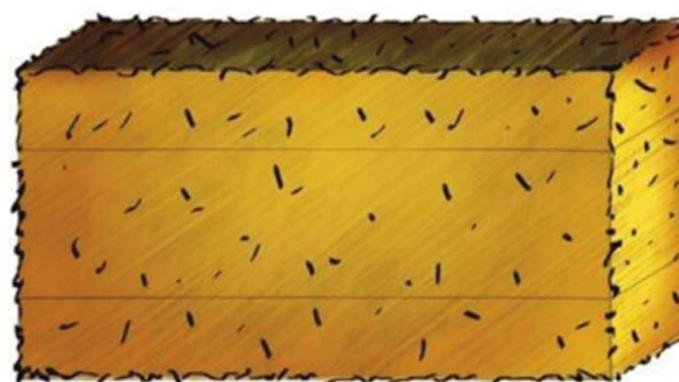
Epaisseur d'isolant
46cm



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



RFCP

Ossature bois isolés en paille

Wooden structure filled with straw bales



RFCP

Paille structurelle

Load bearing straw bale walls



Wooden Cassettes + straw

Caissons bois + paille

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



1 OSSATURE BOIS

2 BOTTES DE PAILLE

3 PANNEAU PARE-PLUIE

4 CAISSON

5 BARDAGE

RFCP

Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales



Caissons préfabriqués + bottes de paille

Wooden cassettes + straw bales

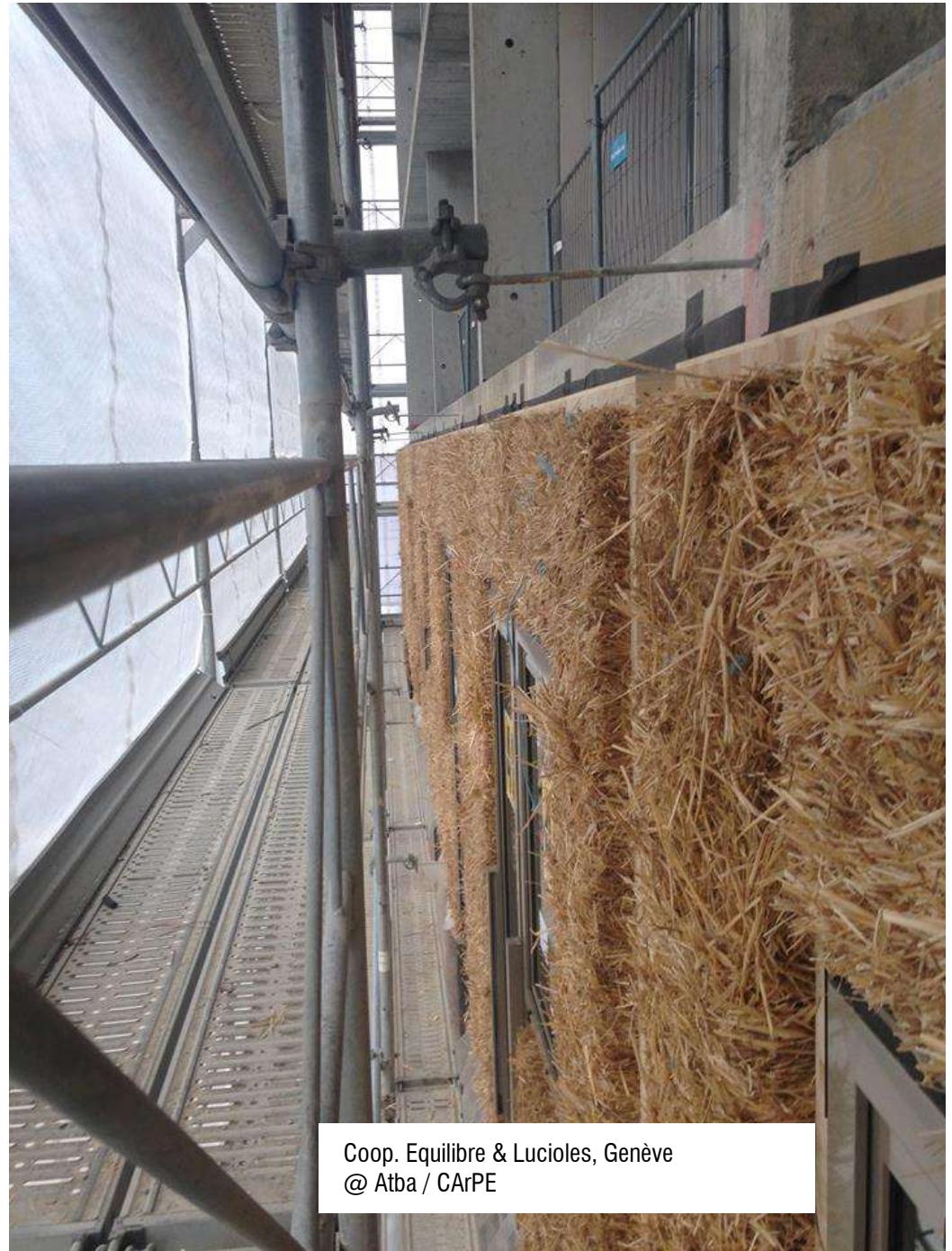


Caissons préfabriqués + bottes de paille



Séminaire S2, Fribourg, Fibres - présentation paille

Wooden cassettes + straw bales



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



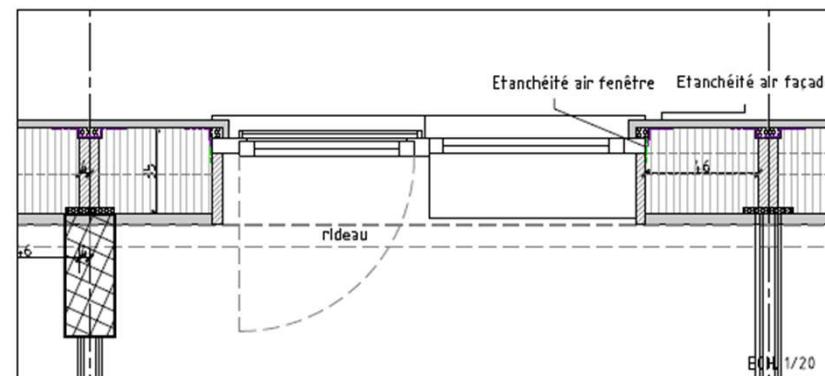
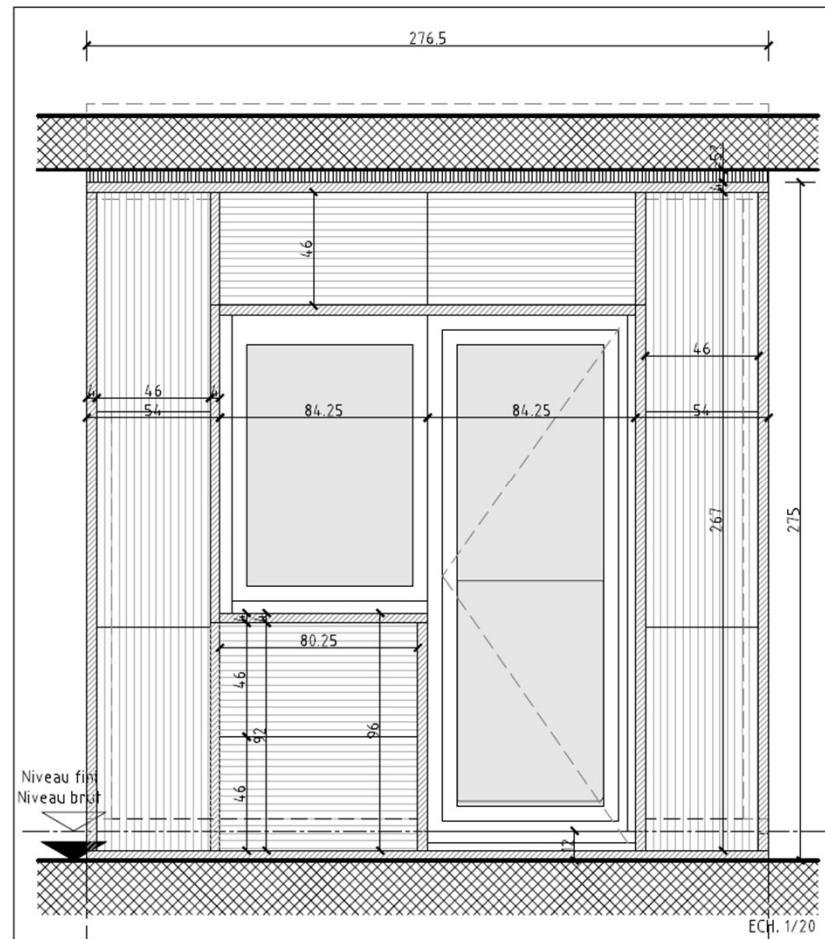
Caissons préfabriqués + paille

Wooden cassettes + straw bales

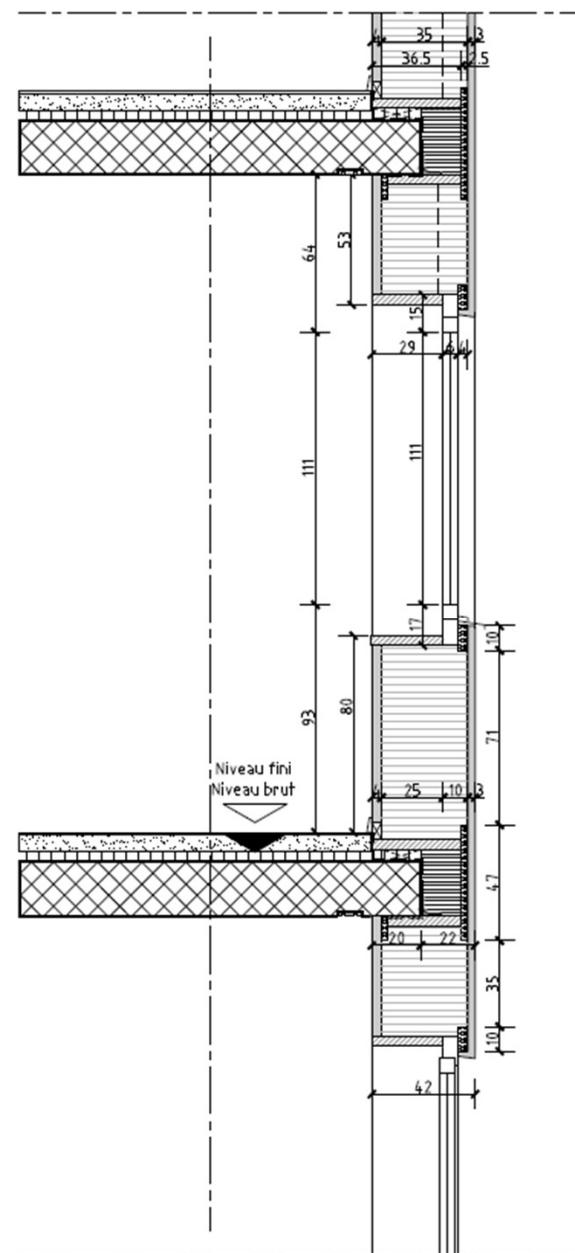


Caissons préfabriqués + paille

Wooden cassettes + straw bales



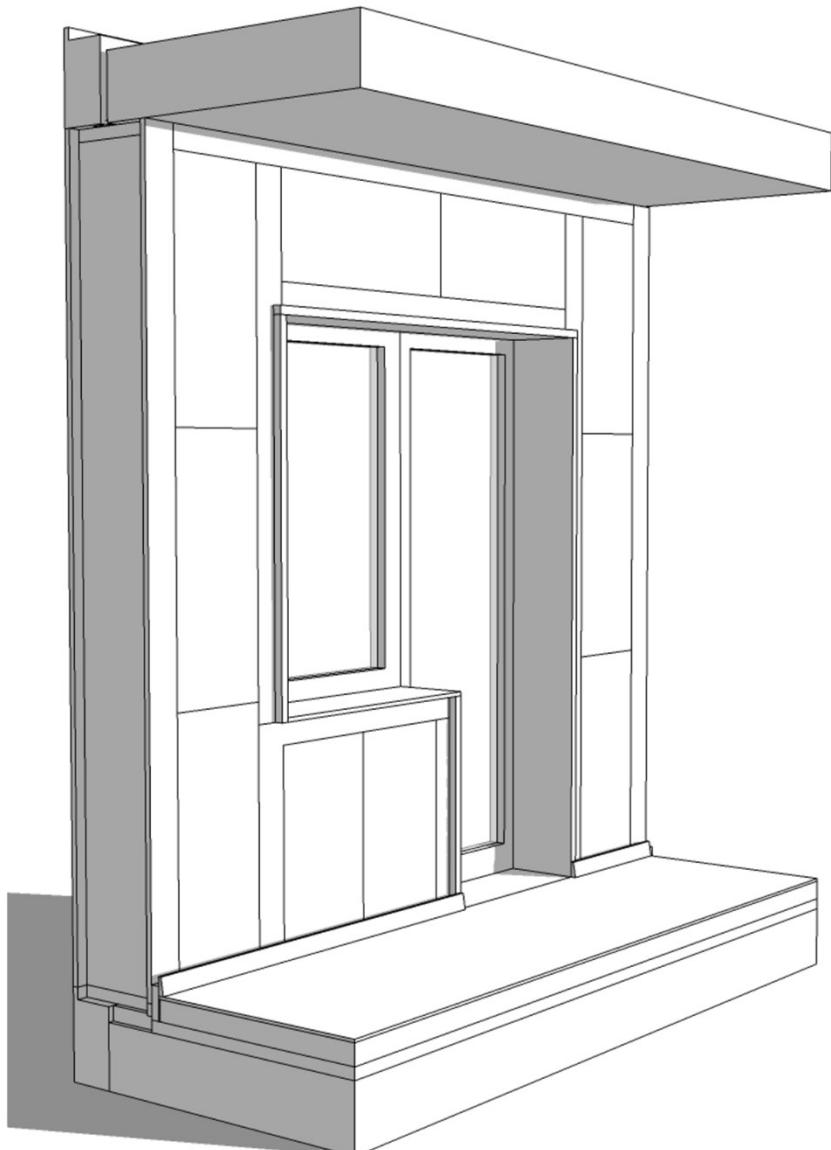
Séminaire S2, Fribourg, Fibres - présentation paille



Coop. Equilibre & Lucioles, Genève
@ Atba / CArPE

Caissons préfabriqués + paille

Wooden cassettes + straw bales



Caissons préfabriqués + paille insufflée



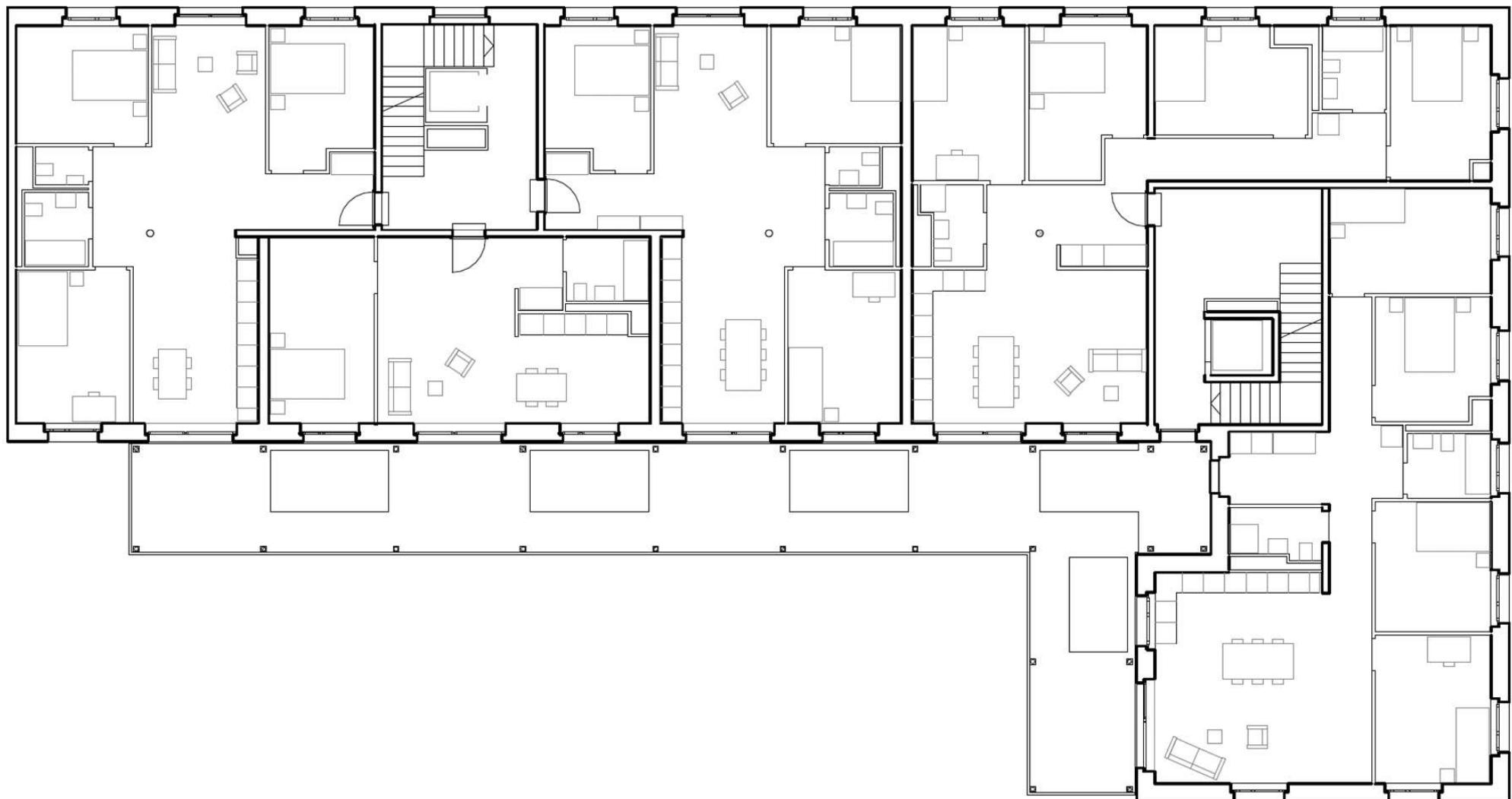
Lausanne @ atba, Coop. Ecopolis

Caissons préfabriqués + paille insufflée



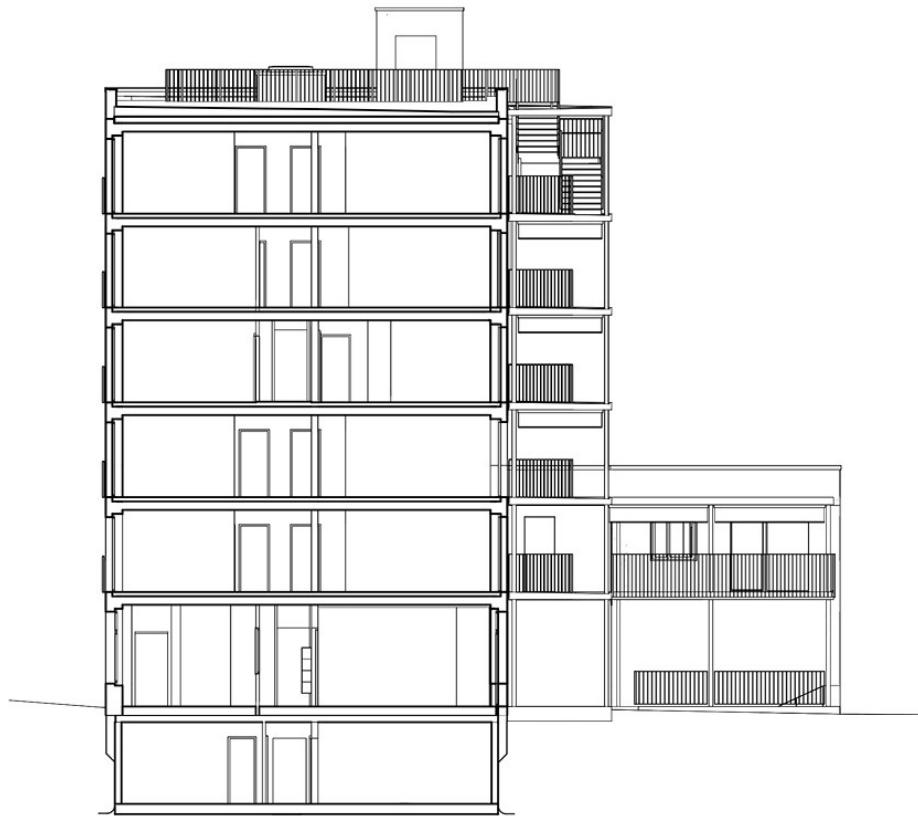
Lausanne @ atba, Coop. Ecopolis

Caissons préfabriqués + paille insufflée



Lausanne @ atba, Coop. Ecopolis

Caissons préfabriqués + paille insufflée



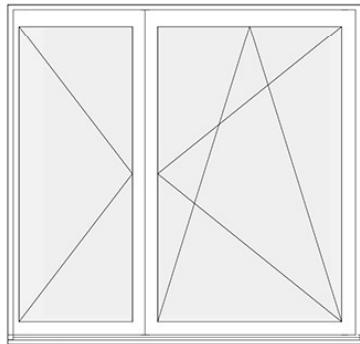
Caissons préfabriqués + paille insufflée

ELEVATION EXTERIEURE

VM 1.42

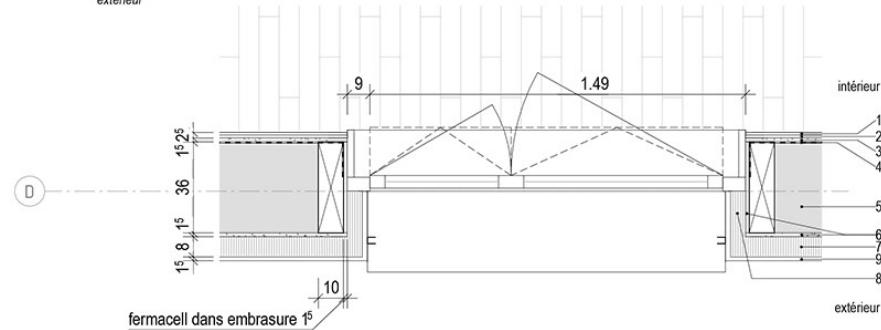
COMPOSITION DU PLANCHER :

- haut*
 a Revêtement - 10mm
 b Chape - 80mm
 c Isolation - 2x20mm
 d Dalle mixte béton / bois - 260mm
bas

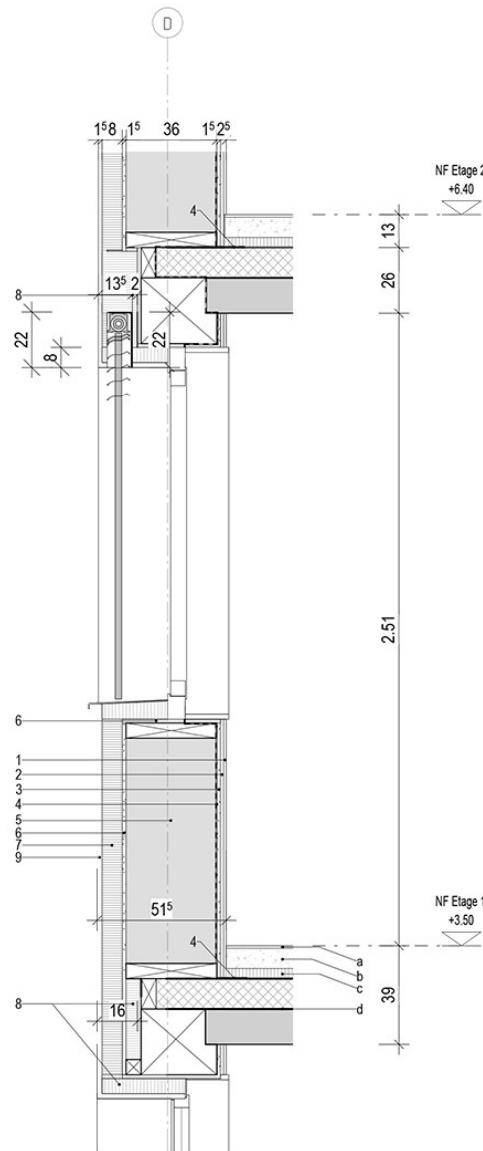


COMPOSITION DU MUR :

- intérieur*
 1 Finition enduit terre - 2mm
 2 Panneau de terre compressé - 25mm
 3 Panneau Fermacell - 15mm
 4 Pare-vapeur
 5 Ossature bois remplissage paille - 360mm
 6 Panneau Fermacell - 15mm
 7 Isolation laine de roche - 80mm
 8 Isolation laine de roche - 60mm (retour d'embrasure, nez de dalle)
 9 Finition en crépi - 15mm
extérieur



PLAN



COUPE



**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



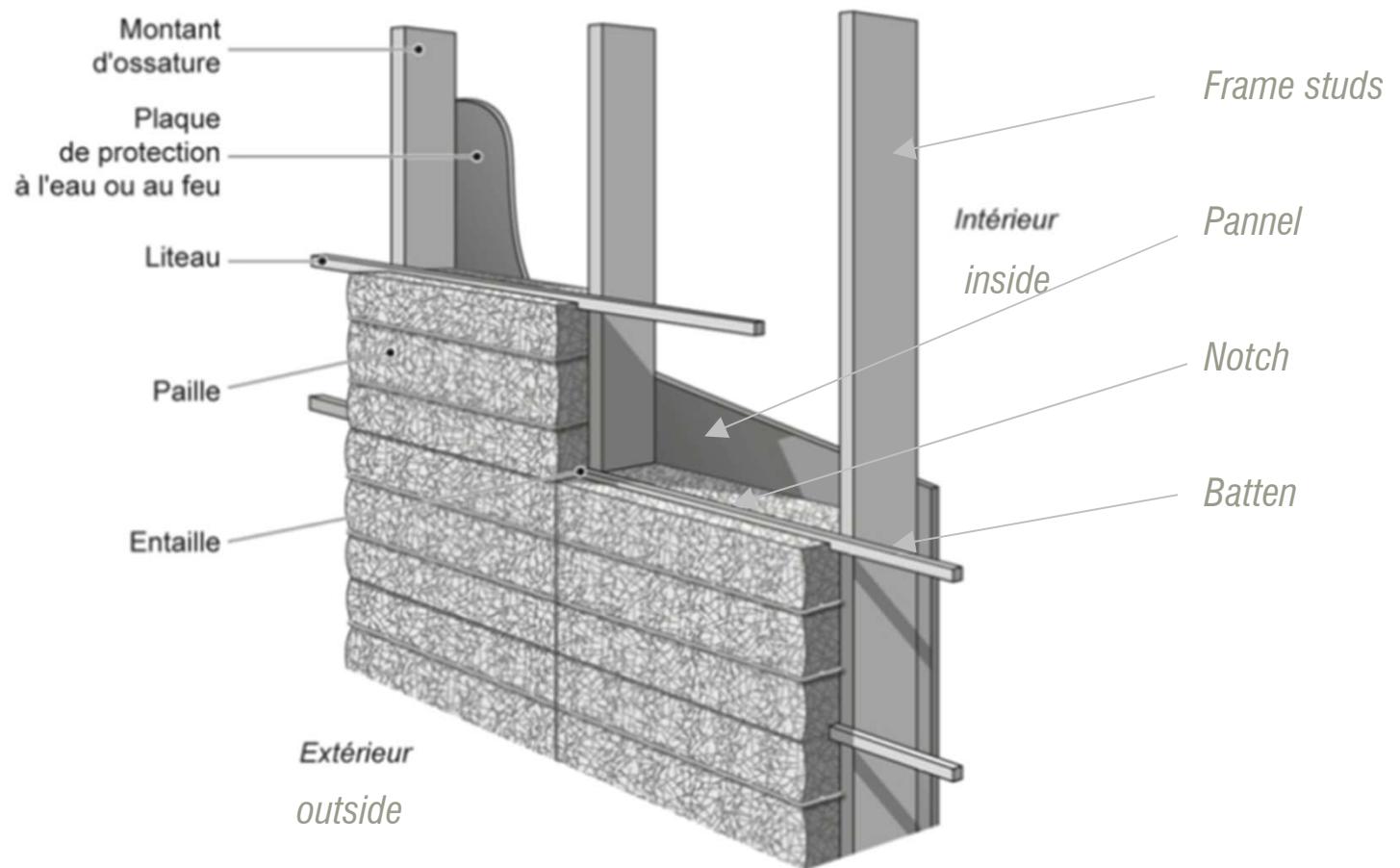
Ossature bois + bottes de paille

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

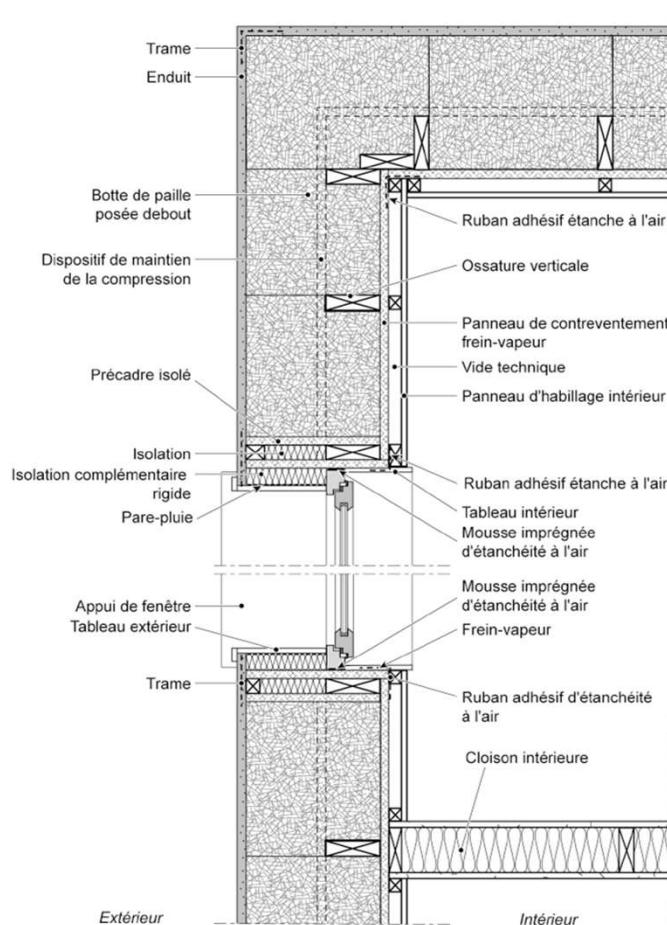


Fig. 4.15. Exemple de coupe horizontale d'une paroi avec ossature simple désaxée vers l'intérieur

simple frame offset inwards

Wooden structure + straw bales

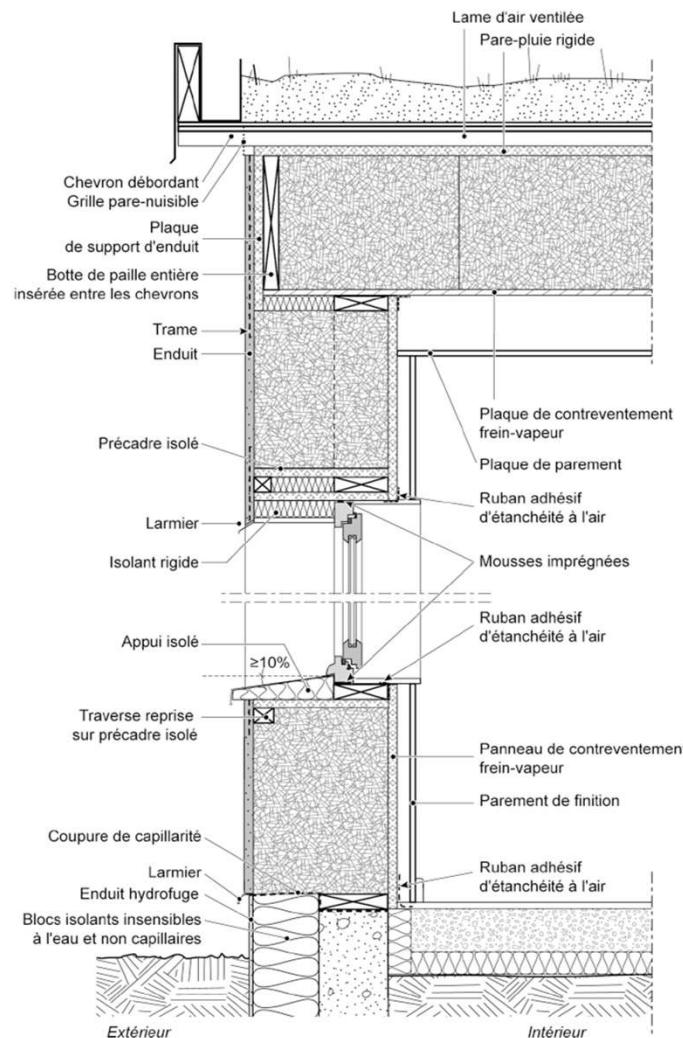


Fig. 4.16. Exemple de coupe verticale d'une paroi avec ossature simple désaxée vers l'intérieur

Ossature bois + bottes de paille

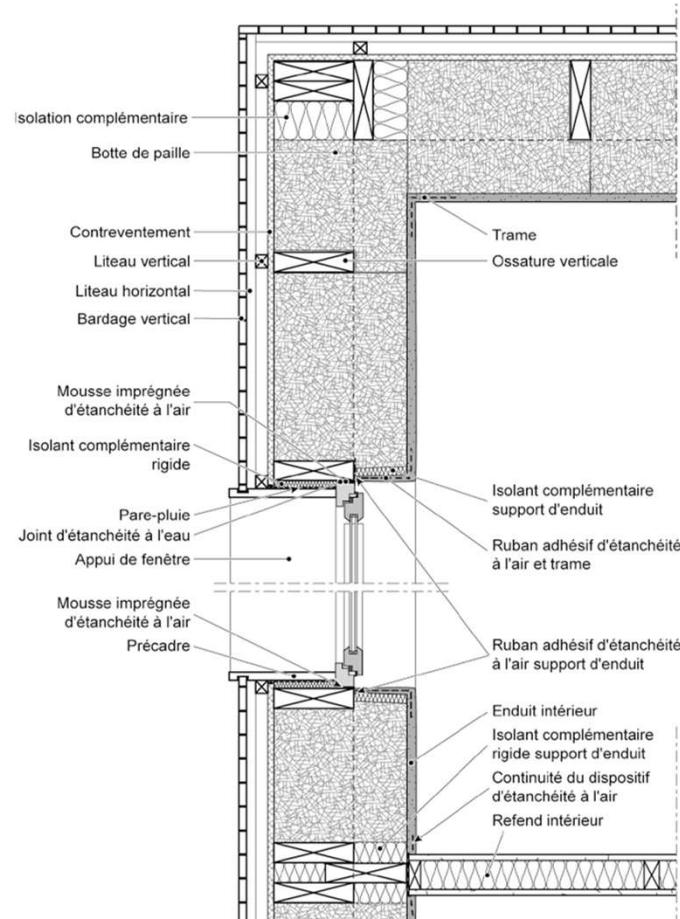


Fig. 4.13. Exemple de coupe horizontale d'une paroi avec ossature simple désaxée vers l'extérieur

simple frame offset towards the outside

Wooden structure + straw bales

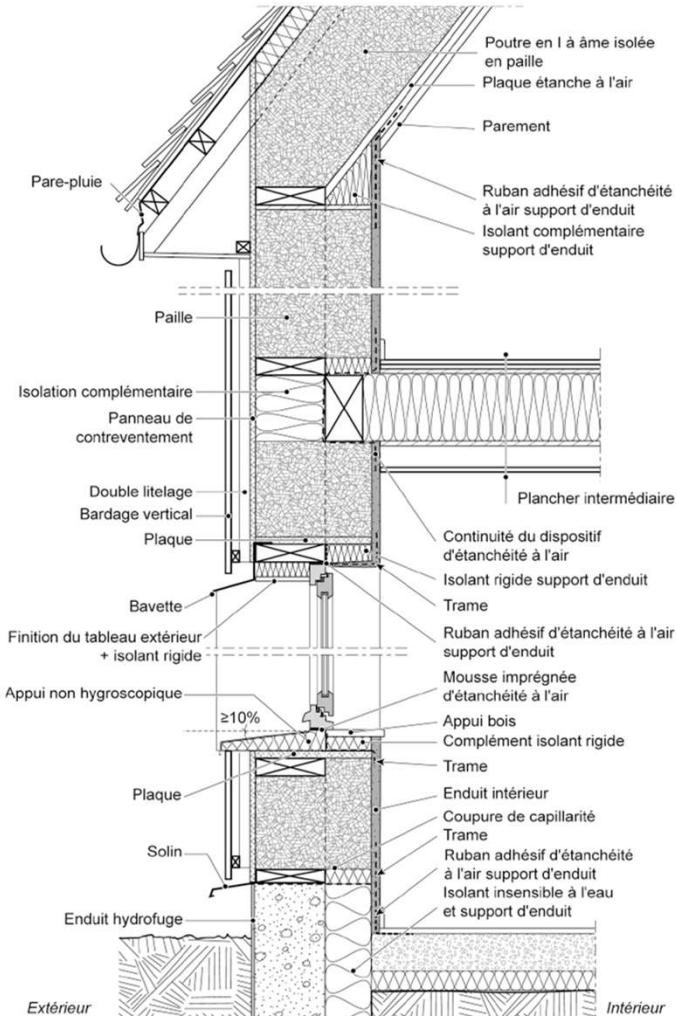


Fig. 4.14. Exemple de coupe verticale d'une paroi avec ossature simple désaxée vers l'extérieur



Load-bearing straw bale

Paille porteuse

Elément porteur en botte de paille

Load-bearing straw bales component

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



1 LISSE BASSE

2 MONTANT

3 PRÉCADRE DE
MENUISERIE

4 BOTTES DE
PAILLE

5 LISSE HAUTE

6 GROSSE SANGLE
DE COMPRESSION

7 PAREMENT
EXTÉRIEUR

RFCP

Eléments porteurs en botte de paille

Load-bearing straw bales components



Eléments porteurs en botte de paille

Load-bearing straw bales components

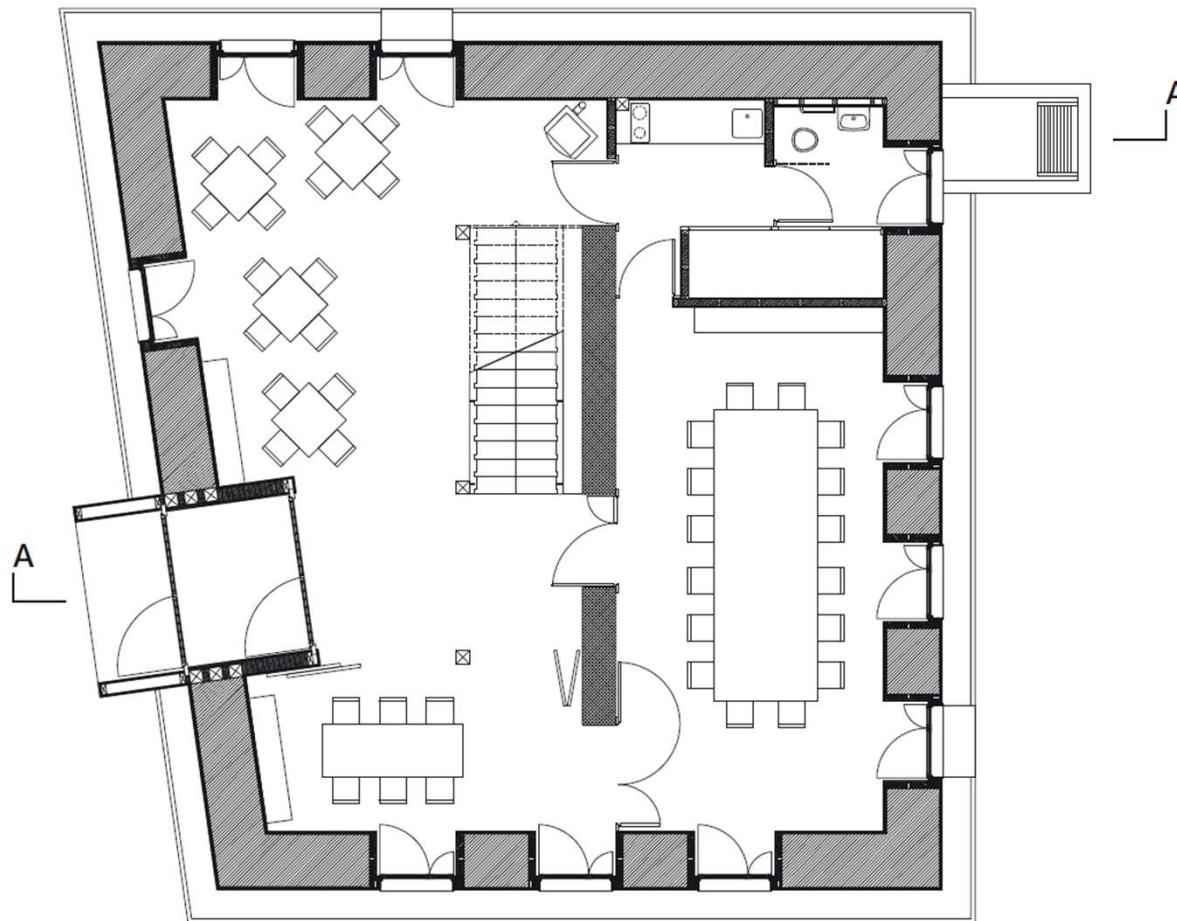


- > Bois des forêts de Lausanne
- > Paille Locale
- > Terre d'excavation
- > Sable local

ECO46 / bâtiment démonstrateur en paille porteuse
CArPE / Normal Office

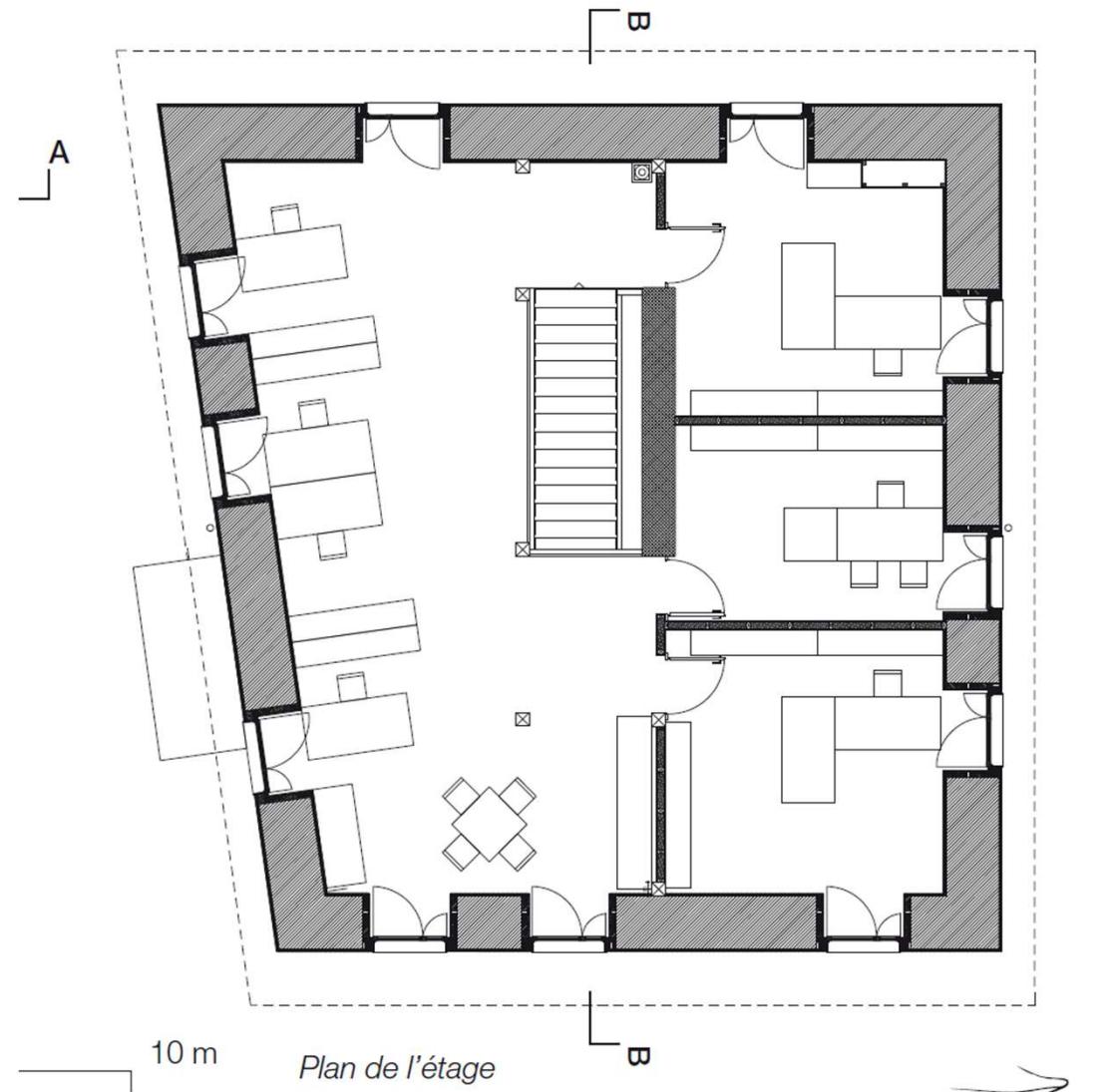
Eléments porteurs en botte de paille

Load-bearing straw bales components



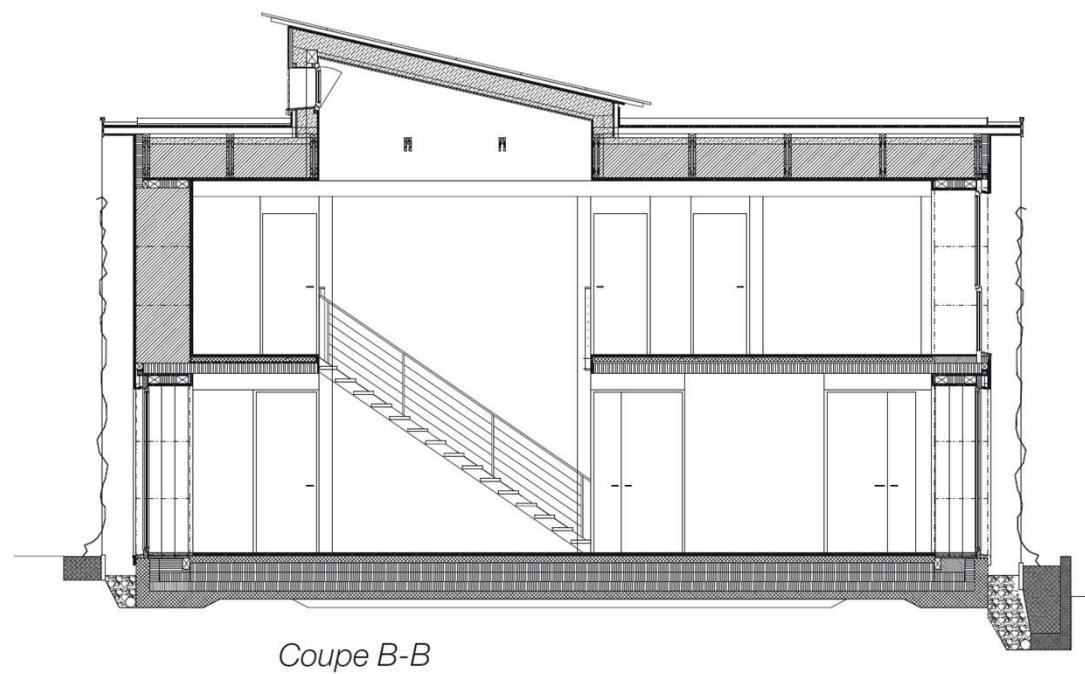
Eléments porteurs en botte de paille

Load-bearing straw bales components



Eléments porteurs en botte de paille

Load-bearing straw bales components



ECO46 / bâtiment démonstrateur en paille porteuse
CArPE / Normal Office

Eléments porteurs en botte de paille

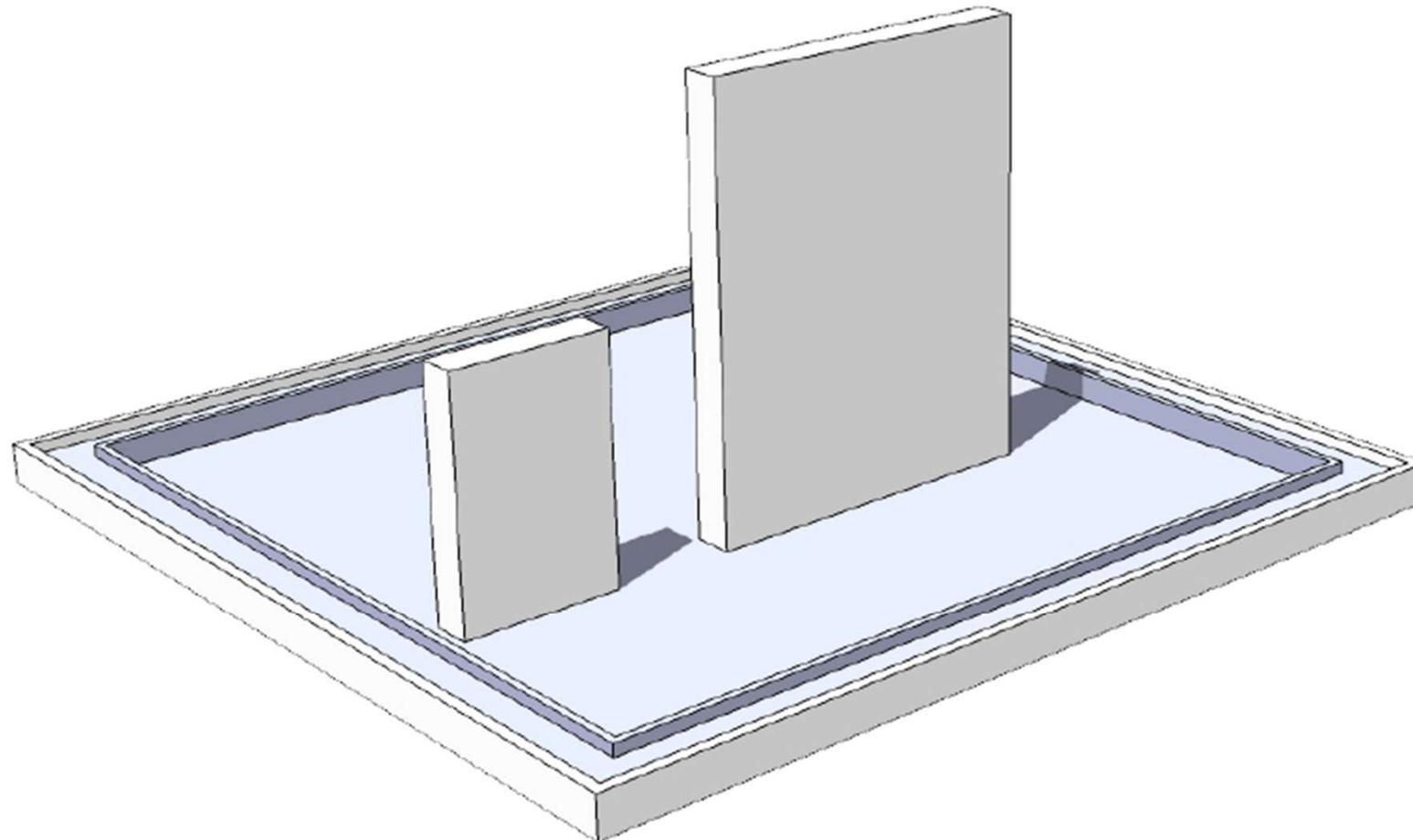
Load-bearing straw bales components



ECO46 / bâtiment démonstrateur en paille porteuse
CArPE / Normal Office

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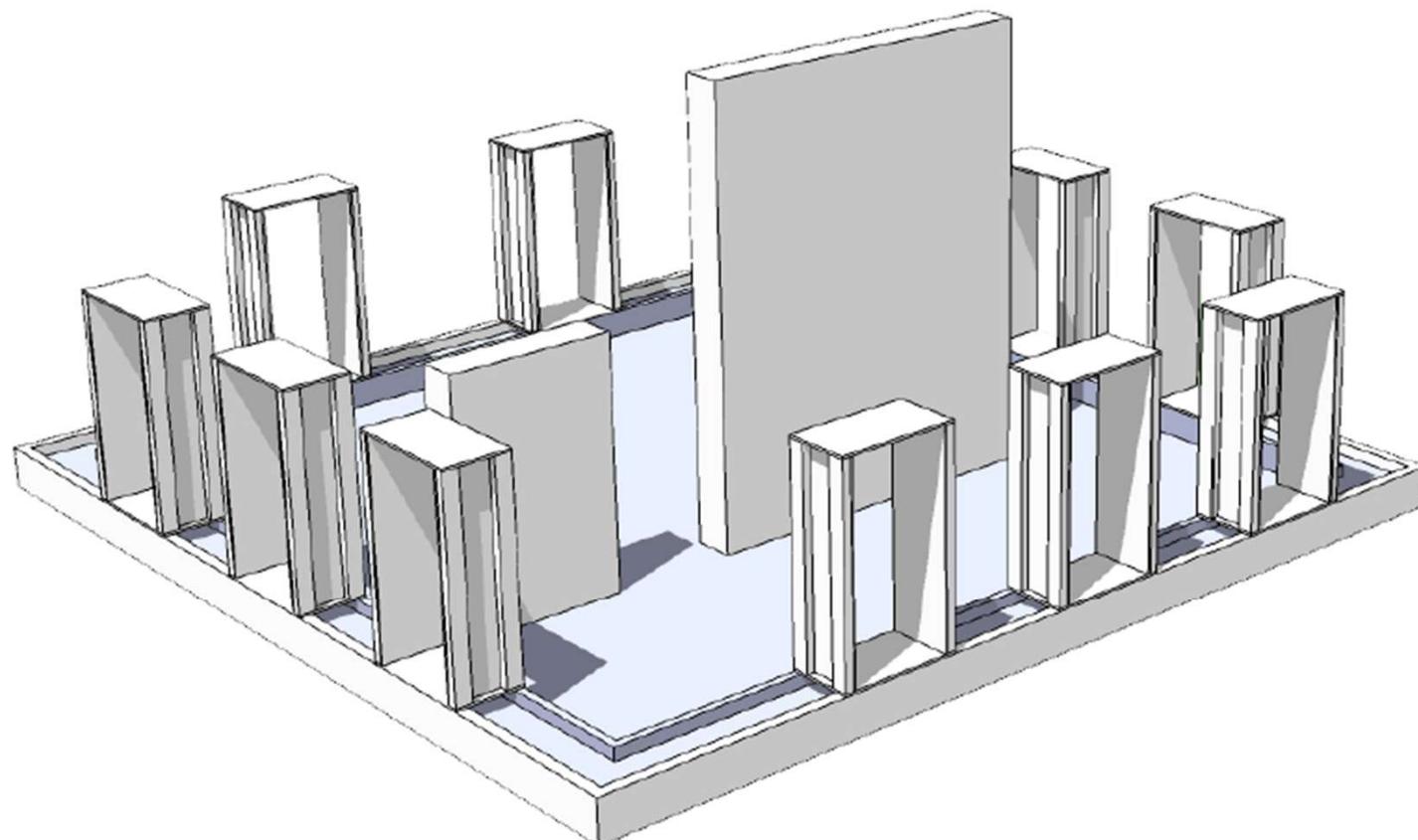
Load-bearing straw bales components



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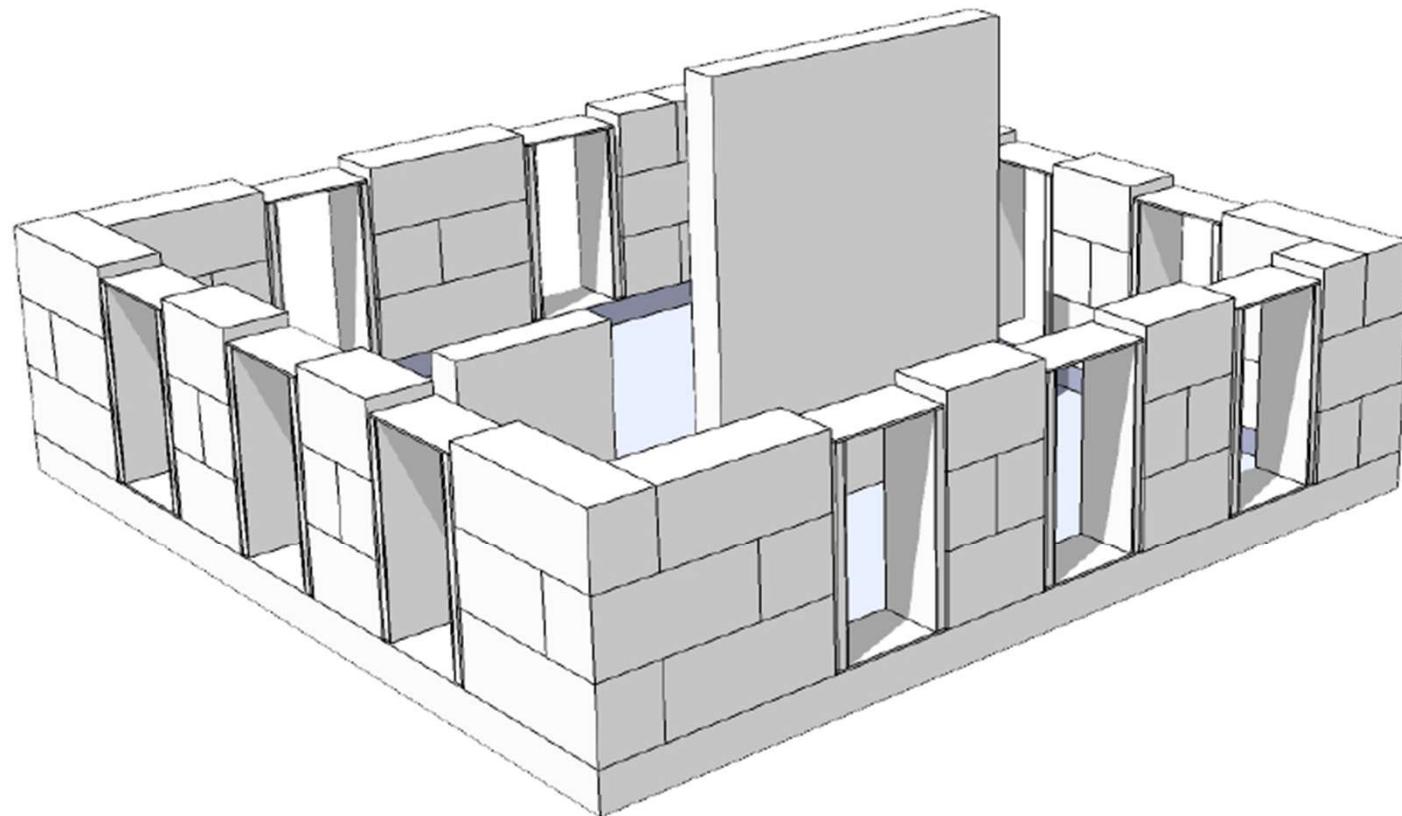
Load-bearing straw bales components



ECO46 / bâtiment démonstrateur en paille porteuse
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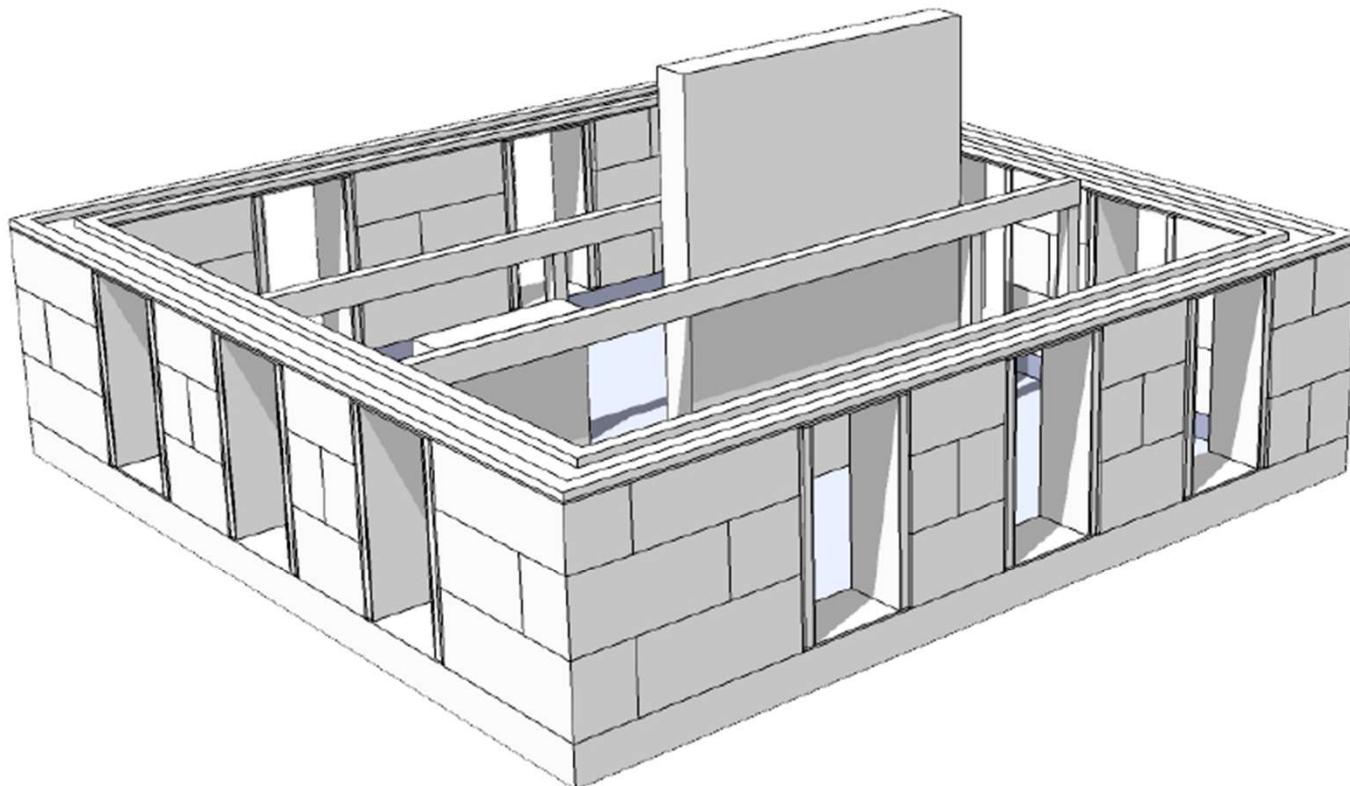
Load-bearing straw bales components



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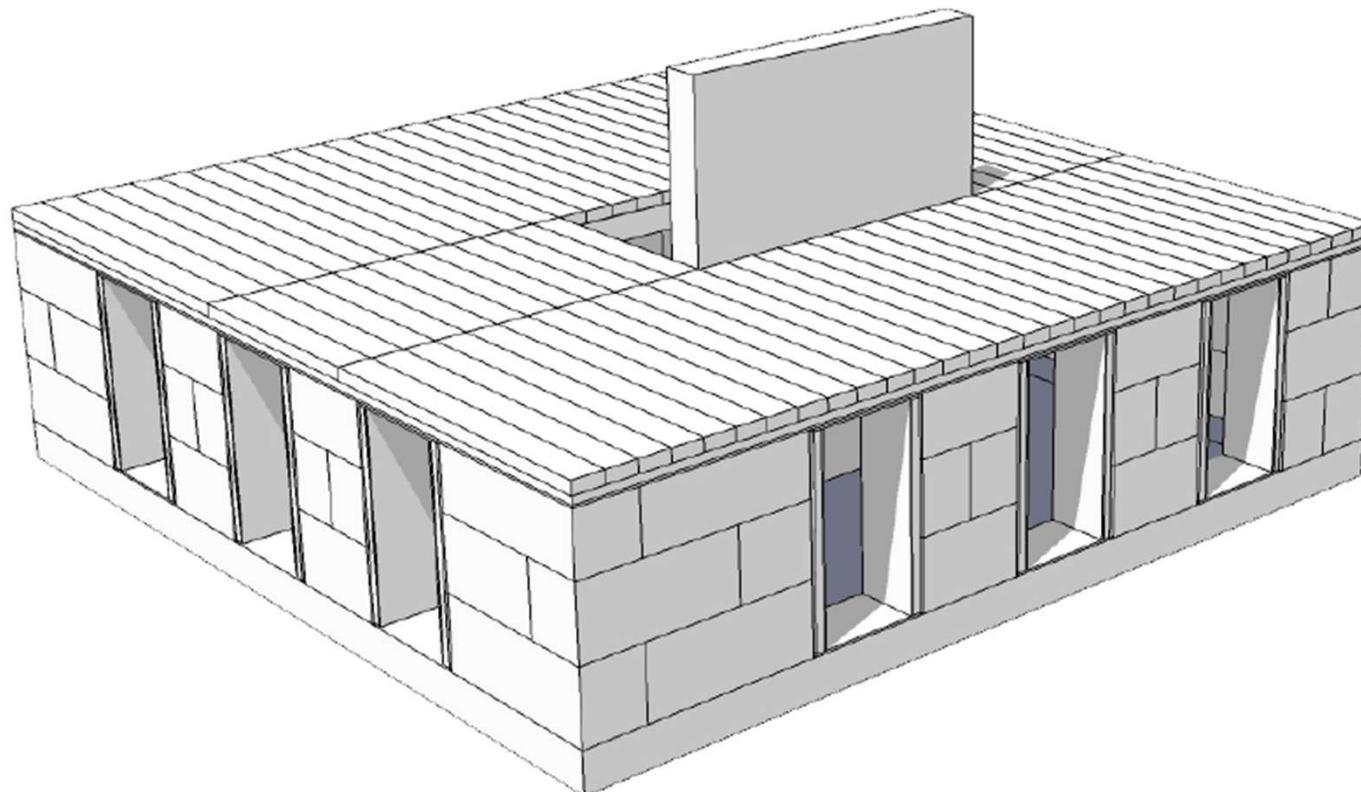
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CArPE / Normal Office

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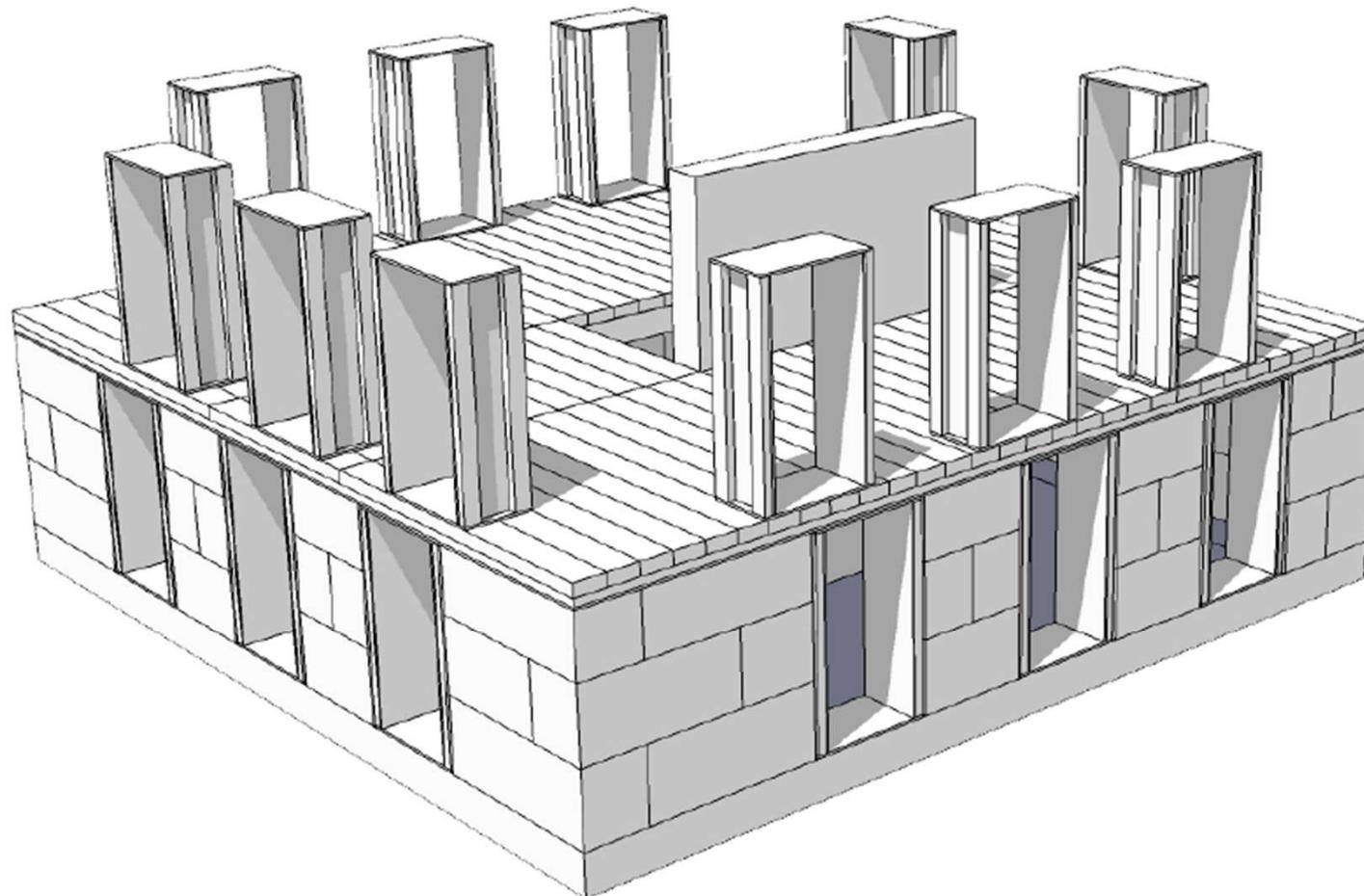
Load-bearing straw bales components



ECO46 / bâtiment démonstrateur en paille porteuse
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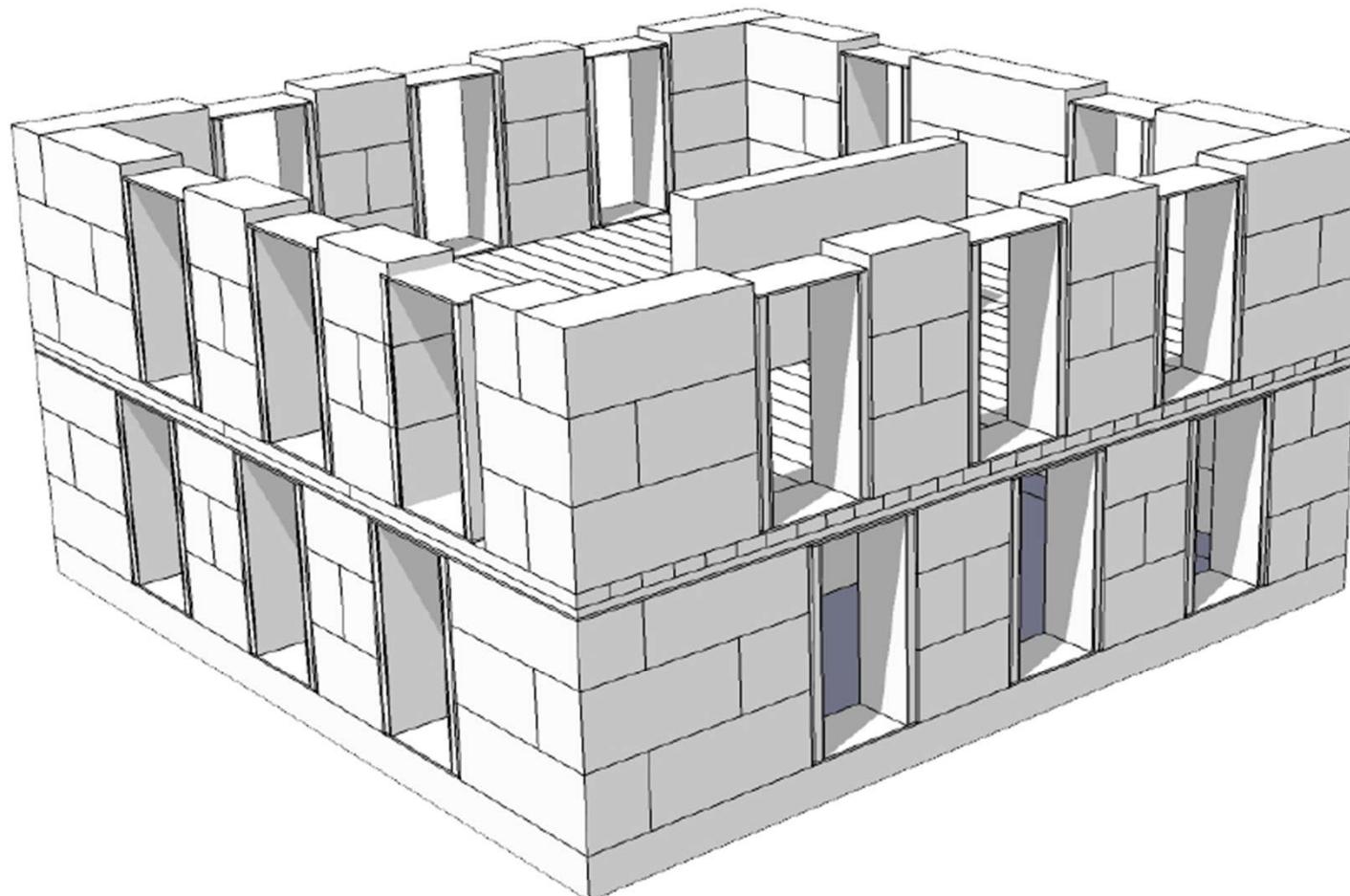
Load-bearing straw bales components



ECO46 / bâtiment démonstrateur en paille porteuse
CArPE / Normal Office

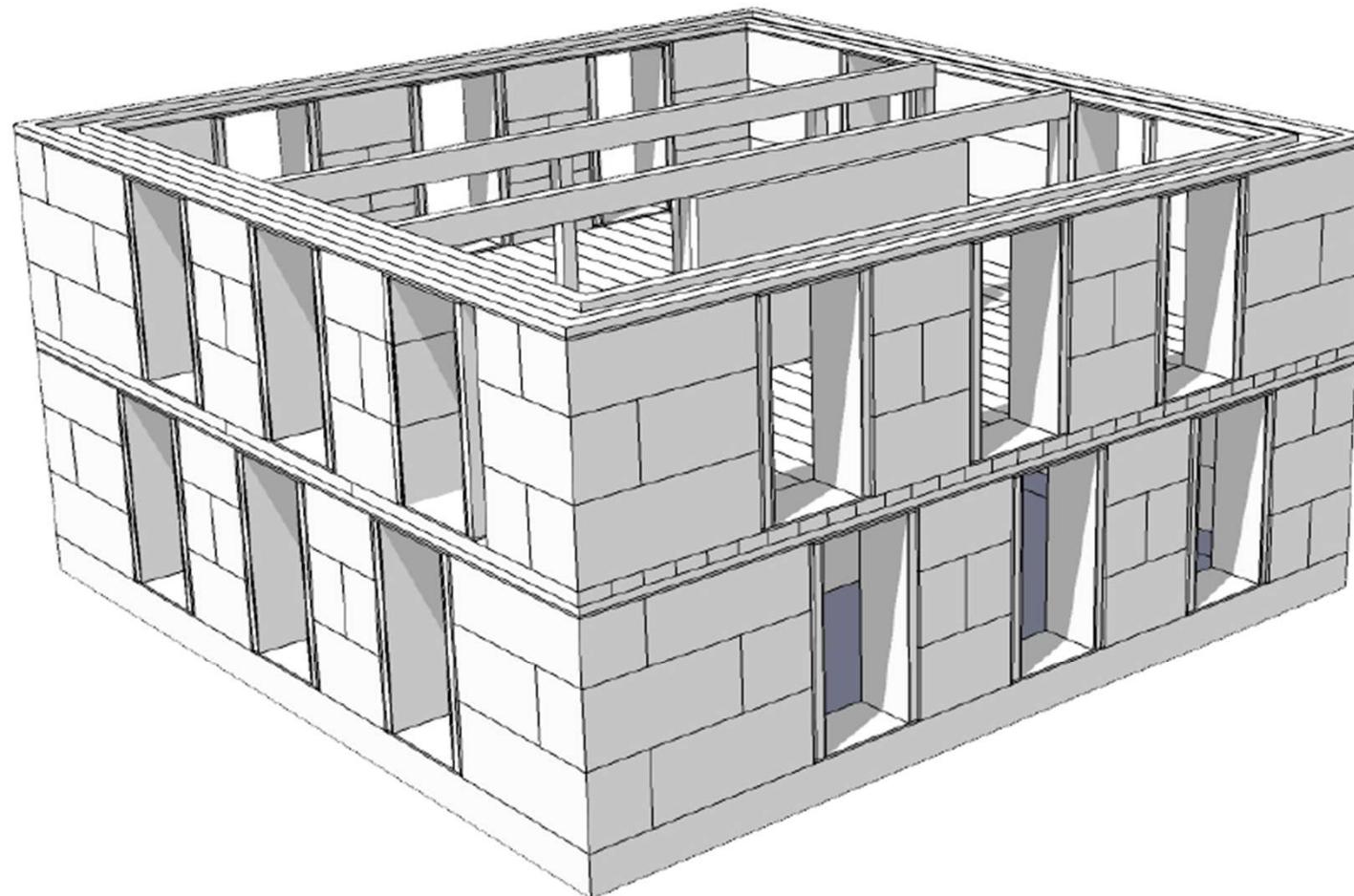
Eléments porteurs en botte de paille

Load-bearing straw bales components



Eléments porteurs en botte de paille

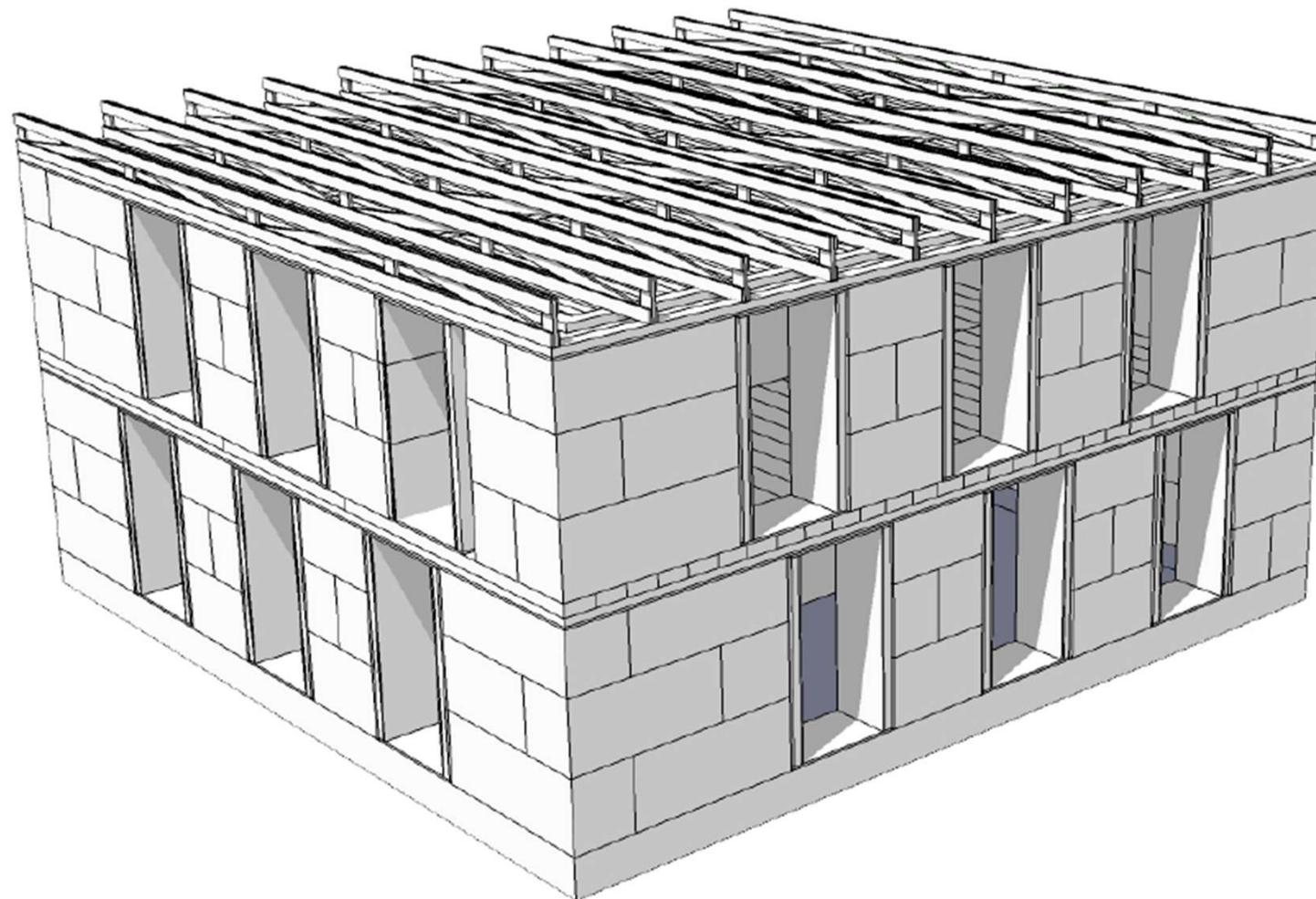
Load-bearing straw bales components



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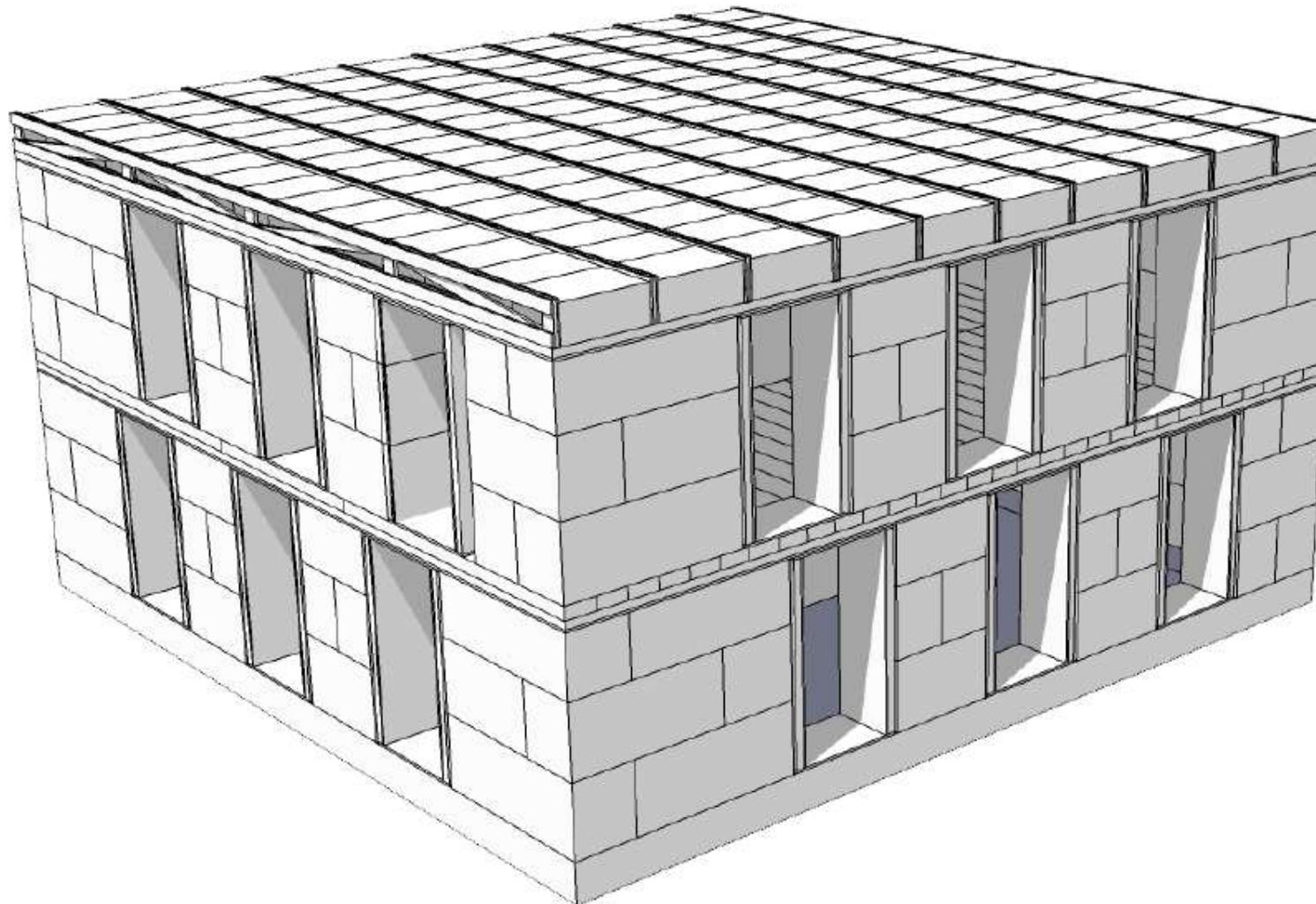
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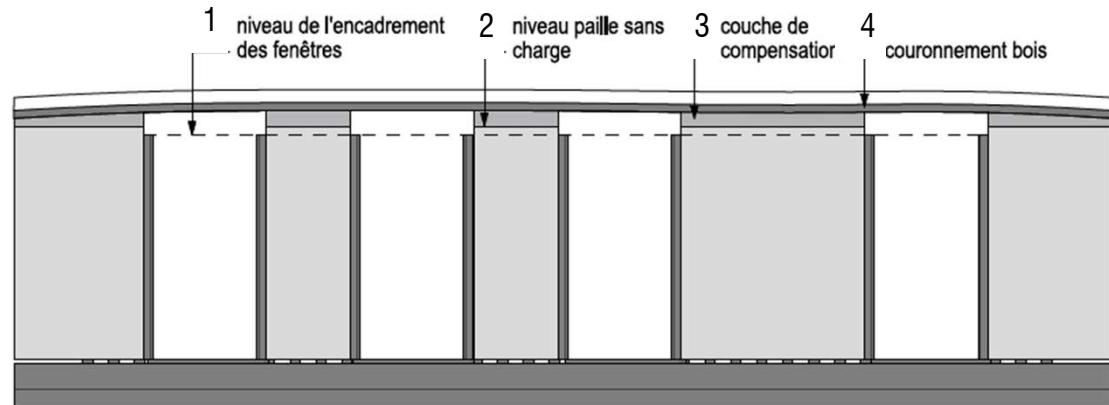


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CArPE / Normal Office

Eléments porteurs en botte de paille

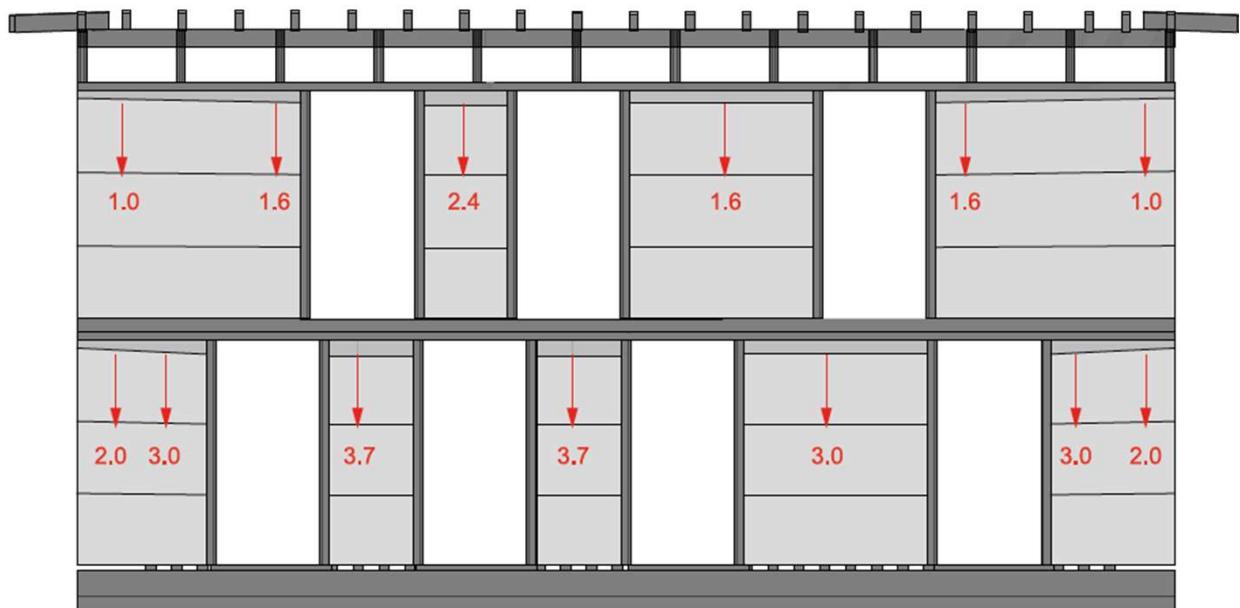
1. window frame level
2. level of straw bales without loads
3. compensation layer
4. Wall beam

Load-bearing straw bales components



Façade sud après la pose de la dalle de l'étage

south facade after the floor slab has been laid



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

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

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



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



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

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





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



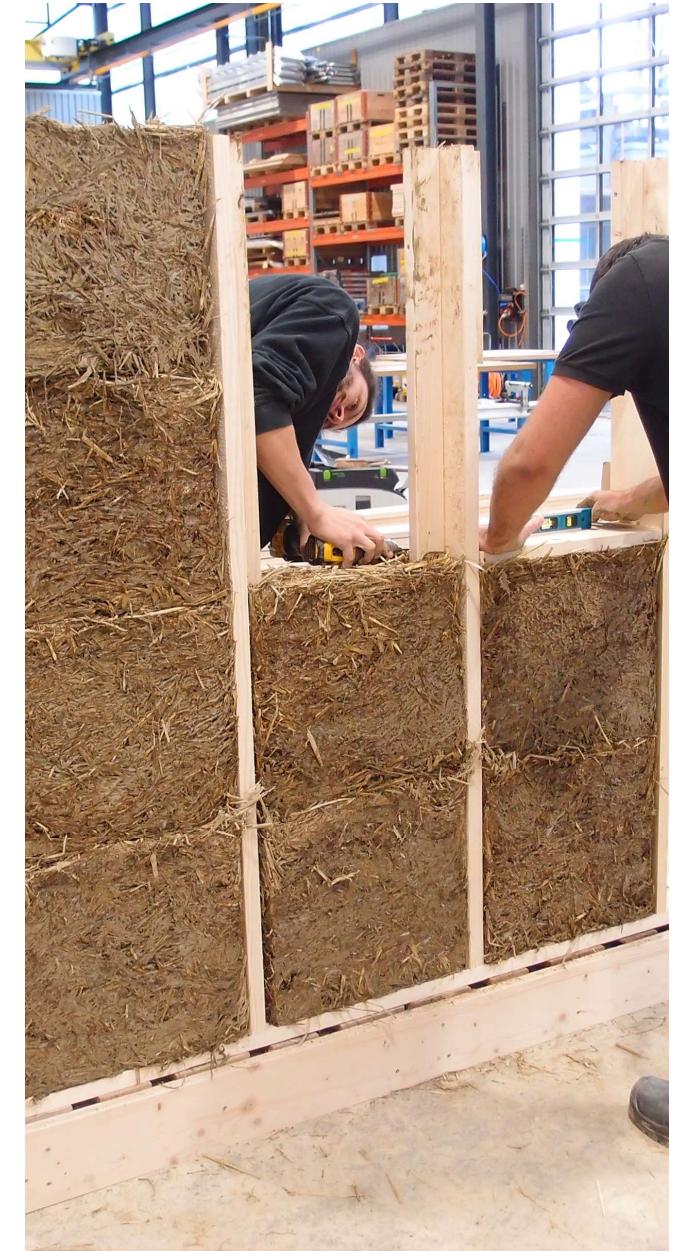
Second œuvre : terre allégée

Finishing work : light earth



Briques/panneaux de terre allégée insérés dans une ossature

Lightweight earth bricks/panels inserted into a framework



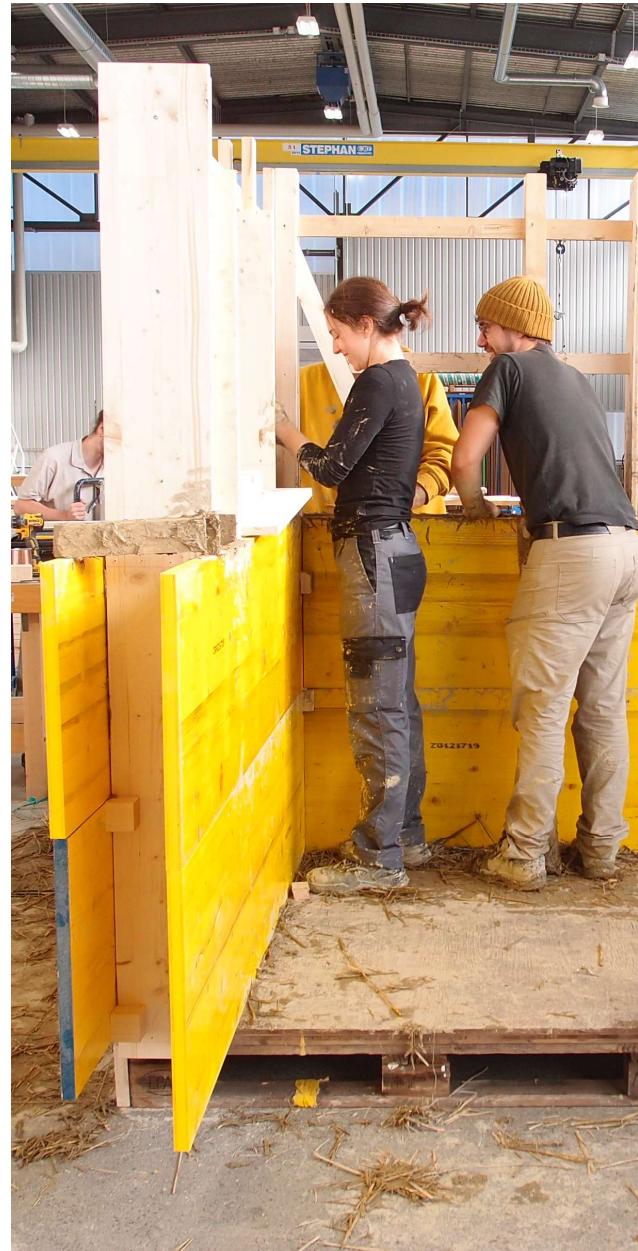
Terre allégée – panneaux préfabriqués

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



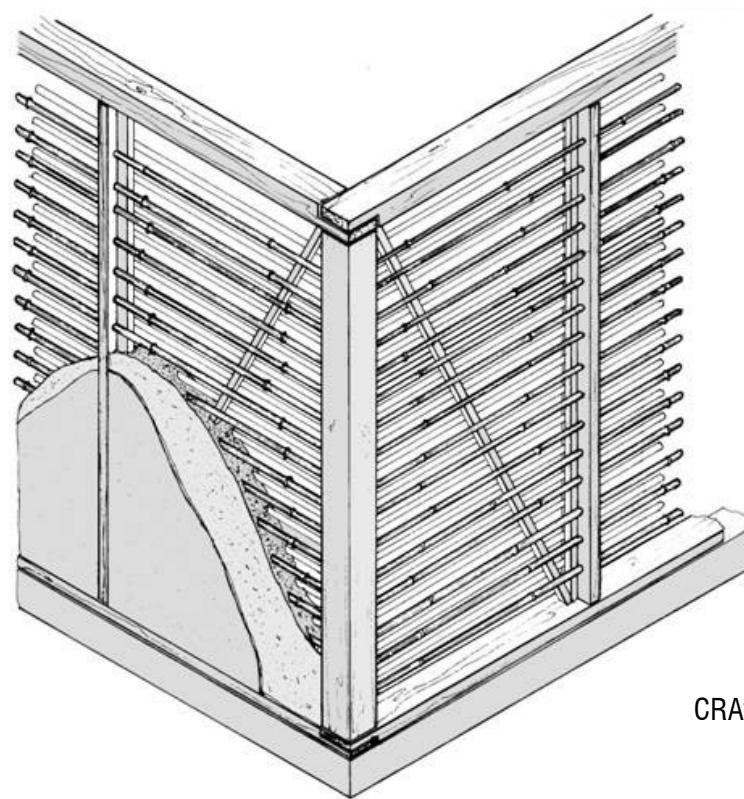
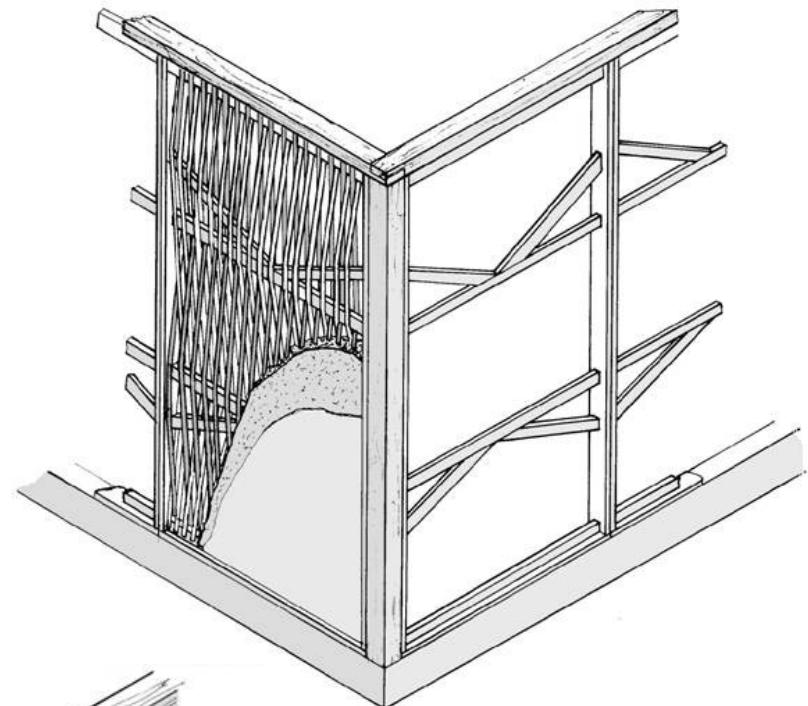
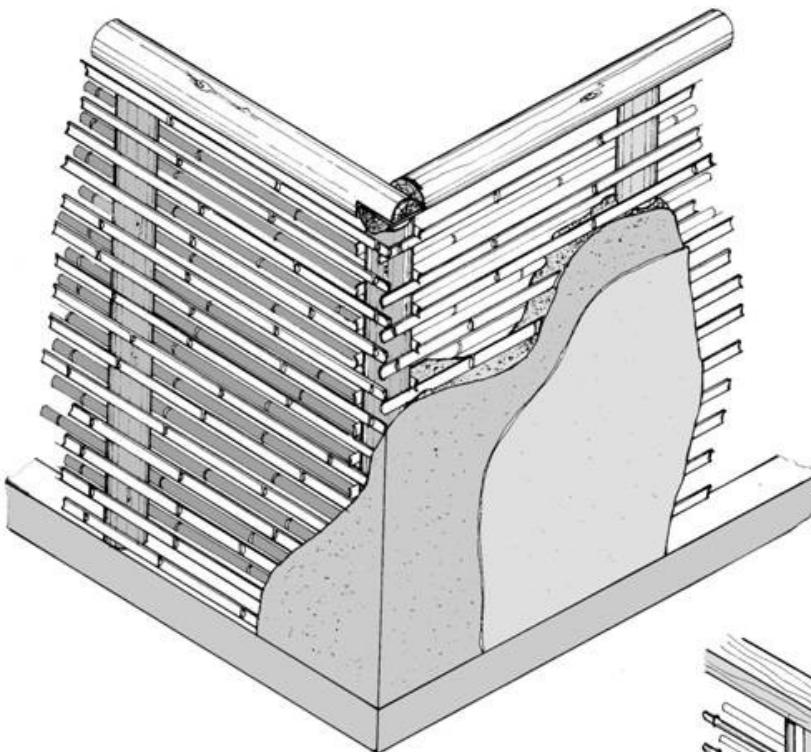
Second œuvre :torchis

Finishing work : wattle and daub



Second œuvre :torchis

Finishing work : wattle and daub



CRAterre

Maison J, 1996, Autriche



Lieu Darmstadt, Autriche

Programme Maison

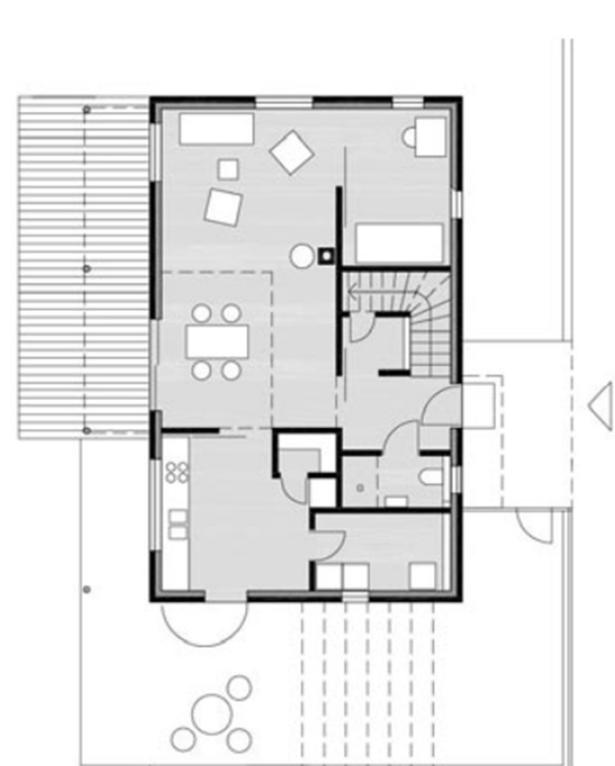
Année 1996

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





“panneaux”
épaisseur 36 mm

