Straw dwelling construction

CONSTRUCTION GUIDE

Dwelling TYPE A001 -DESIGNED FOR MEDITERRANEAN CLIMATE
Services (plumbing, electricity, water) provided by local government

version 1.0
4 November 2021

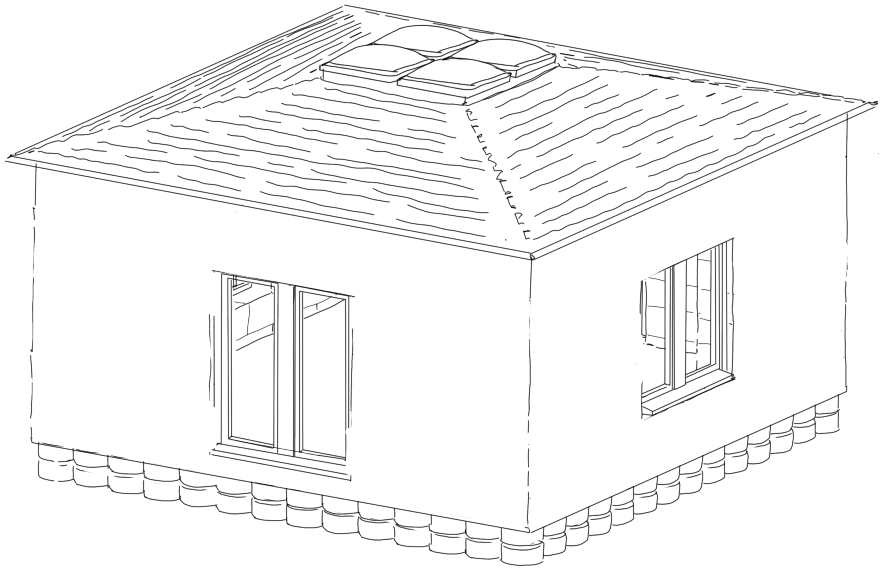
This book is a manual on how to build the dwelling type A001, designed for the Mediterranean climate.

The best results will be achieved when working together. Gain knowledge and understanding by talking to others who have previously constructed the same dwelling, or have a background in construction.

Be sure to engage in conversations with local carpenters and refugee city management.

This dwelling is not difficult to build, however, team work is key.

Thoughts on improvements or changes in design, are more than welcome! Write them down and let the supervisor know.



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1. PREPARATION

2. CONSTRUCTION

3. FINISHING

4. APPENDIX

Read me

IMPORTANT INFORMATION

Keep the straw at all times dry. During storage **as well as** during construction!

Consult local weather reports.

Construction time is between approx. two and five weeks.

This dwelling type (A001) is suited for the Mediterranean climate.

Services (plumbing, electricity, water) provided by local government or NGO's.

This dwelling type is specifically designed with Lesvos, Greece, as a location in mind. Materiality (with the exception of the straw and plaster) like roof tiles subject to change when changing locations.

Construction drawings can be found in appendix A.

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0.0.0

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1

PREPARATION

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IMPORTANT INFORMATION

For the creation of dwelling type A001, the amounts for the building materials are given.

Half of straw bales are needed. To acquire these, you will need to half and re-tie the straw bales yourself *(see 1.3.x)*

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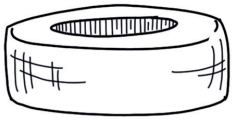
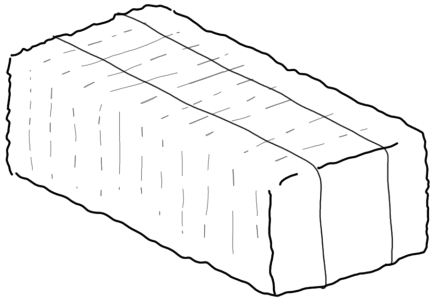
1.1.0

1.1.1

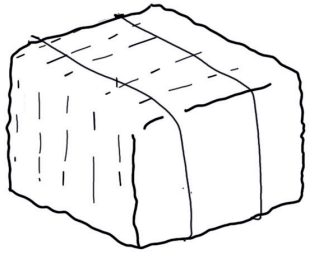
Total required amount of car tires and straw bale



x104



x384

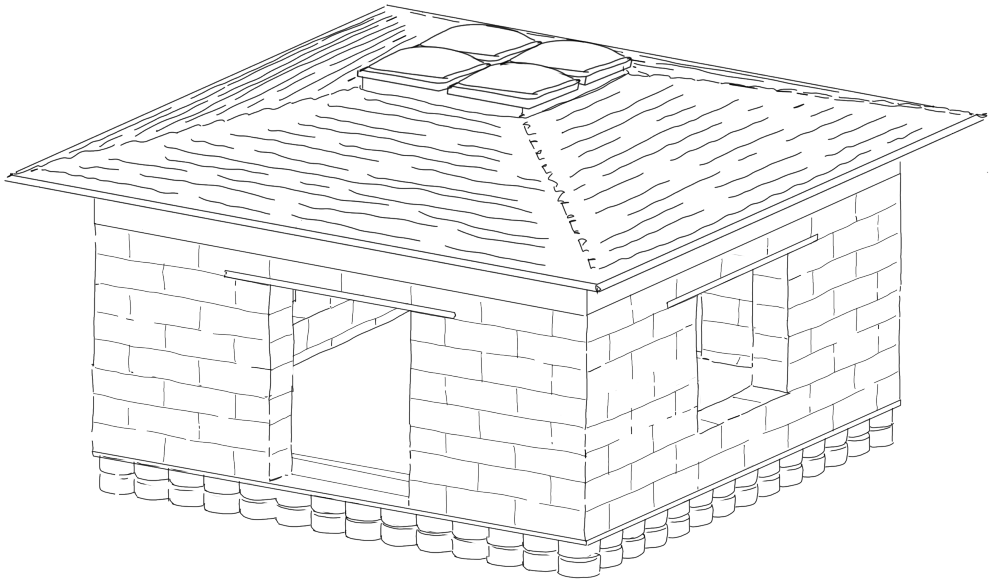


x24

1.1.2

Final bare-bone construction

6 t/ha straw yield = 1.3 ha field



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1. PREPARATION

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IMPORTANT INFORMATION

This chapter explains the steps necessary in order to make sure that the straw bales meet requirements to be used for construction.

For safety reasons, **do not skip any of these steps.**

Before using the straw bales, the quality of **each** bale needs to be assessed. The quality check consists of sensory tests (visual, haptic, and smell), as well as practical checks of the weight and dimensions.

If weight or density (110 kg/m^3) is insufficient, a low-tech solution for re-compressing the straw bales is given.

1.2.0

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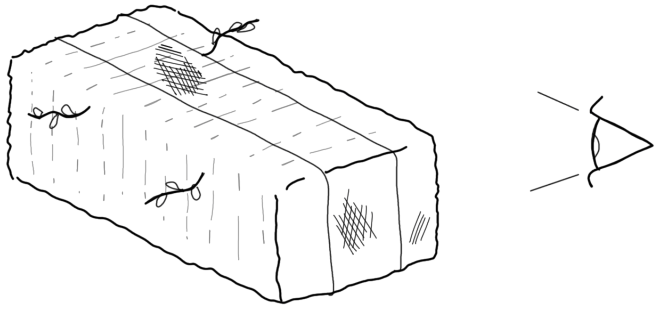
1.2.1

Visual inspection

Check for dark spots and for weeds.
If present, discard straw bale.



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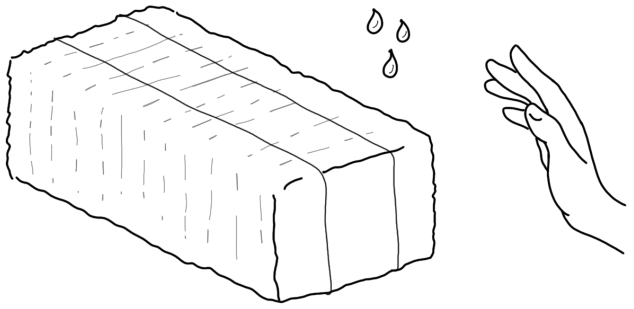
1.2.2

Haptic inspection

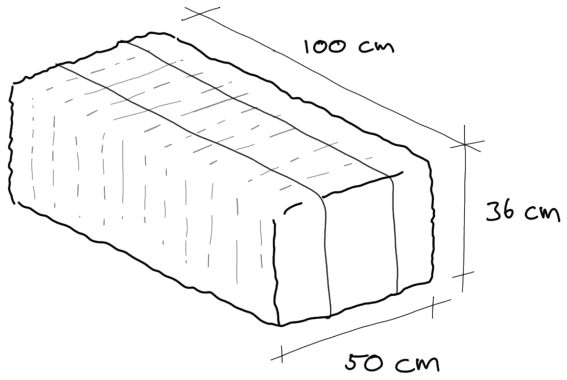
Feel for any wet spots. If wet, lay out in sun to dry.
If there is a mouldy smell, discard straw bale.



1.2.3

Measuring the straw bale

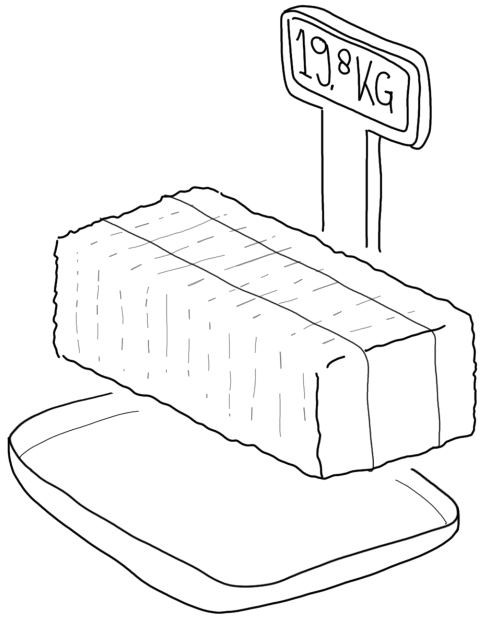
Measure the straw bale. If sizes differ more that 1,5 cm,
add straw, re-compress *(see 1.2.5)* and retie
(see pages 110-111, appendix D, 4.D.1 on which knot to use).



1.2.4

Weighing the straw bale

Weigh the straw bale: it needs to be 19,8 kg. If the difference is
more than 1kg (5%), add straw and re-compress *(see 1.2.5).*



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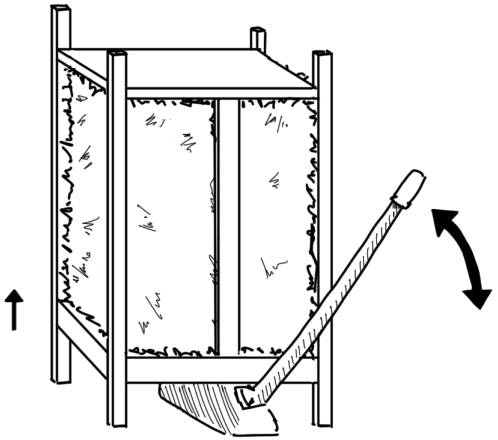
1.2.5

Compressing the straw bale

If re-compression is needed, put the straw bale in a jig as shown below, use a car jack to compress the straw bale.



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Retying and how to tie the straw bale using the Miller's knot.

For information on how to restring a straw bale and which knot to use: please refer to pages 110-111, appendix D, 4.D.1.

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IMPORTANT INFORMATION

This chapter explains how to half straw bales.

For this dwelling type, 24 halves of a straw bale are needed. Follow these steps to successfully half a straw bale.

For instructions on which knot to use, see pages 110-111, appendix D, 4.D.1.

After halving, you **must** weigh and measure the straw bale again, to ensure sufficient compression.

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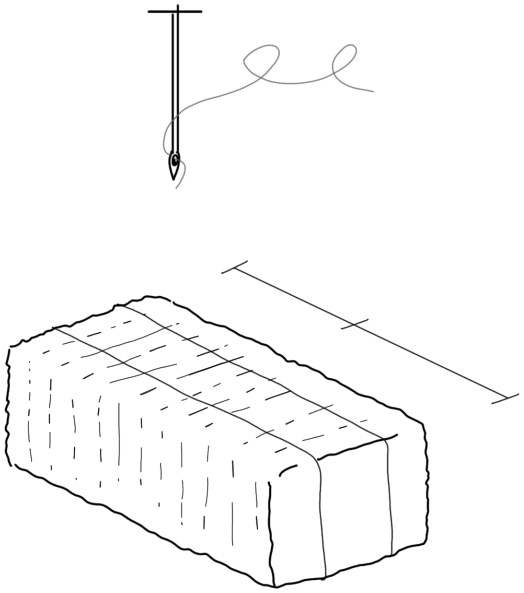
1.3.0

1.3.1

Halving the straw bales

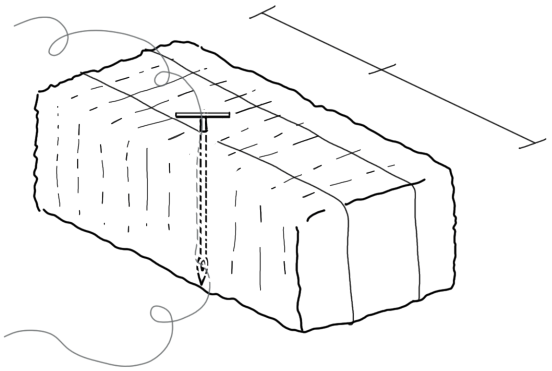
Pull thread through the baling needle.



1.3.2

Halving the straw bales

Push the needle at the half way point through the straw bale, as shown below.



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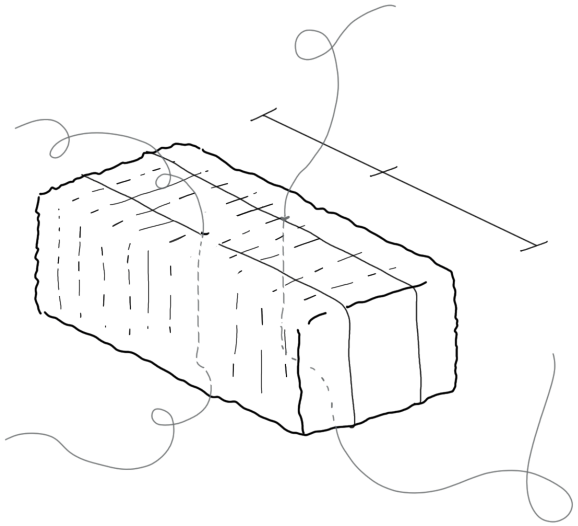
1.3.3

Halving the straw bales

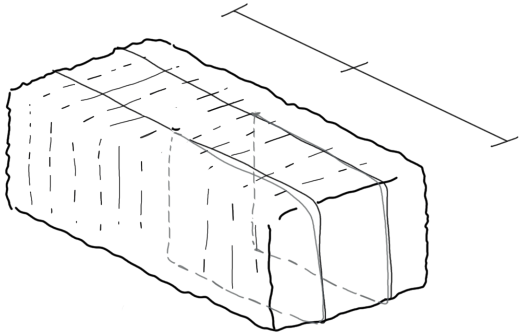
Do the same for the second string.



1.3.4

Halving the straw bales

Tie the strings together using a Miller's knot (see pages 110-111, appendix D, 4.D.1)



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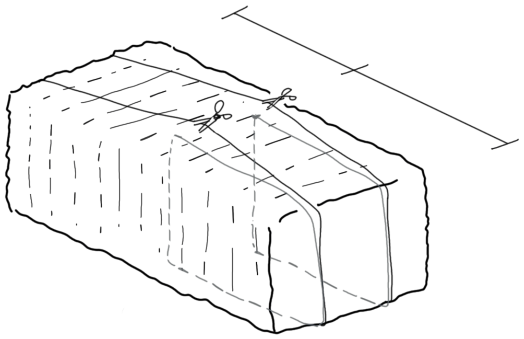
1.3.5

Halving the straw bales

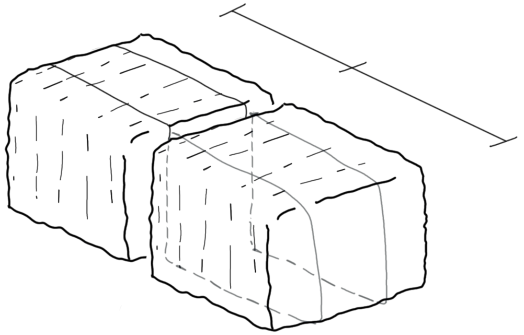
Cut the original strings.
Tie those strings as well using a Miller's knot.



1.3.6

Halving the straw bales

Now you have two re-stringed half straw bales.



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CONSTRUCTION

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IMPORTANT INFORMATION

This chapter explains how to construct the foundation and the floor.

If the construction of a standard concrete foundation is not possible, a DYI alternative which is cheap and sturdy and sustainable is presented. This requires 104 car tires.

It is important to make sure the base on which the straw bales are put is level and as wide as the straw bales themselves.

The build up of the floor should not be changed. Do not forget the moisture barriers.

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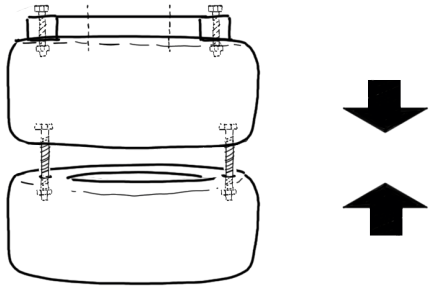
2.1.0

2.1.1

Preparing the tires

Stack two car tires on top of each other, drill a hole and connect them with nuts and bolts as shown below.

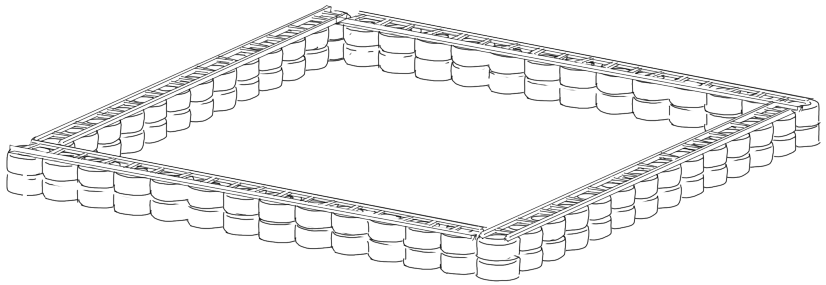
The radius should be a maximum of 251 mm and should have a height of 205mm.



2.1.2

Arranging the tires

Arrange the tires in the way as seen below. Add a wooden structure on top to ensure a level base for the straw bales.



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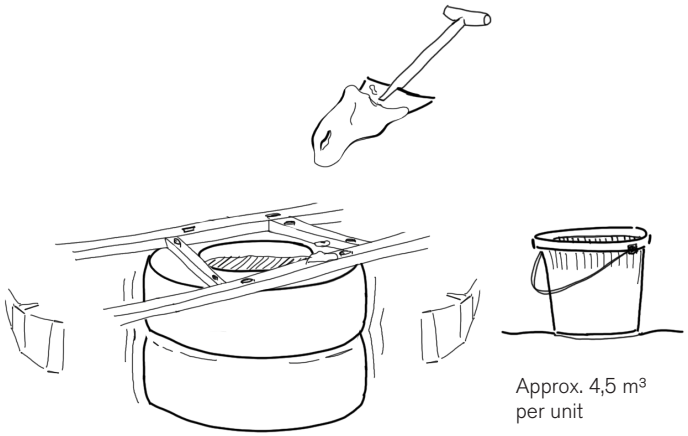
2.1.3

Add concrete

Fill the tires with the concrete.
Be sure to shake the tires to let air escape.



Approx. 4,5 m³
per unit

2.1.4

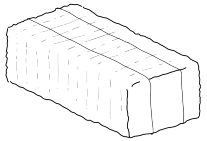
Floor build-up

Build up the floor as shown below. Pay special attention to the moisture barrier between the ground and the palettes.

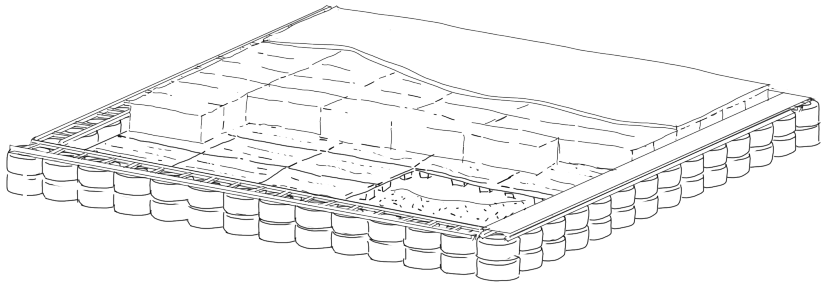
The floor needs to be higher than the base for the wall as shown below.

See page 90, appendix A, 4.A.1 for detail on floor built-up and dimensions.

Materials needed:
- Moisture barrier
- Palettes
- Straw
- OSB board



x72



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2.2.0

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IMPORTANT INFORMATION
This chapter explains how to construct the walls.

The walls need to be stacked in a **running bond.** The images portray the position, courses and amount of the straw bales **correctly,** therefore you can reference them when stacking the straw bales.

Since the building is symmetrical, the backside is the same as the front.

Do **not** add the window- and door frames yet!

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2.2.0

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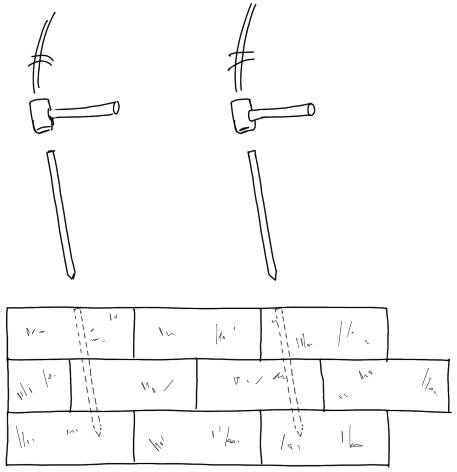
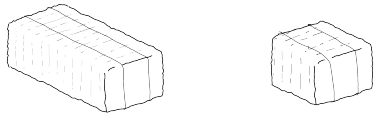
2.2.1

Stacking the straw bales to create the exterior walls

Drive a wooden **stick** (do **not** use any other material for this) through 2,5 straw bales for extra stability.

See page 97, appendix A, 4.A.8 for floorplan.





x220

X24

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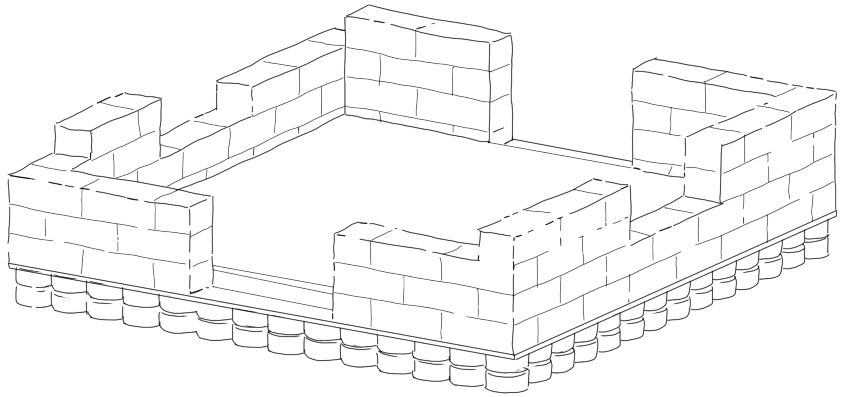
2.2.1

Stacking the straw bales to create the exterior walls

Stack the straw bales in a running bond in the exact way as shown below.



2.2.2

Stack the bales, add ring beam on top of wall

Build up the walls.
Do **not** yet add the door frames and window frame.

See page 91, appendix A, 4.A.2 for roof edge details.

In case you need two of these dwellings connected to form one building, see appendix B for instructions on how to do that.

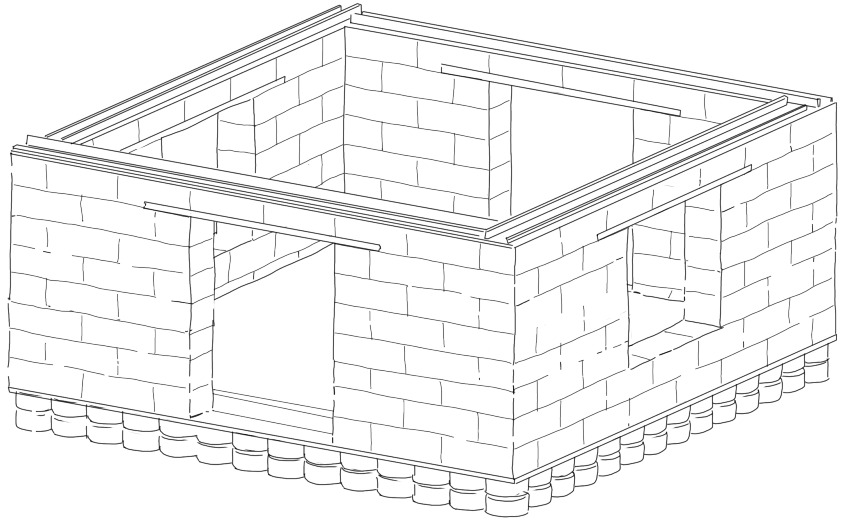
2.2.2

Stack the bales, add ring beam on top of wall

Stack the walls eight straw bales high.
Leave openings for the doors and windows.
Add the ring beam on top as per detail on page 91, appendix A, 4.A.2 for roof edge details.

The detail ensures equal roof load distribution on the wall.

Add lintels above the openings for the doors and windows.



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2. CONSTRUCTION

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IMPORTANT INFORMATION

This chapter explains the construction of the roof and skylight.

The roof, the windows, and the doors will be constructed under guidance of local carpenters. This is a point of collaboration between refugee (builder) and host-community.

The requirement for craftsmen for this part of the construction stems from the need for a construction that can stay permanently. Quality roofing and installation of the skylight is needed to ensure durability and comfortable indoor climate.

Add the windows and doors **after** the wall has settled through the roof load.

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2.3.0

2.3.1

Building the roof

The roof structure follows a standard construction method using wood.

Construction under supervision and guidance of craftsmen/carpenters.

Important to note; the rafters must be under the isolation (straw bales).

Add roof tiles.

See page 91, appendix A, 4.A.2 for roof edge details.

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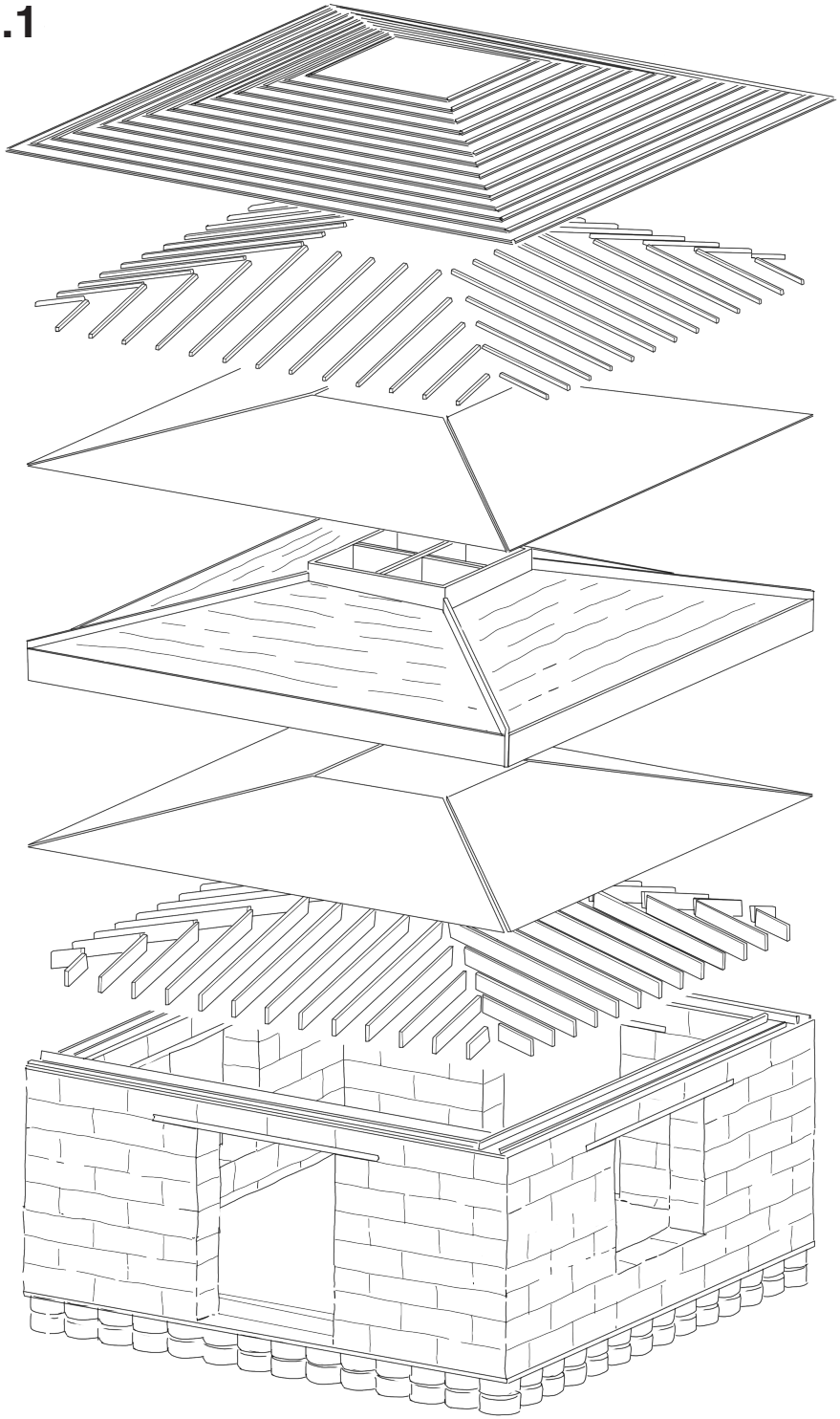
2.3.1



2.3.2

Finished roof construction

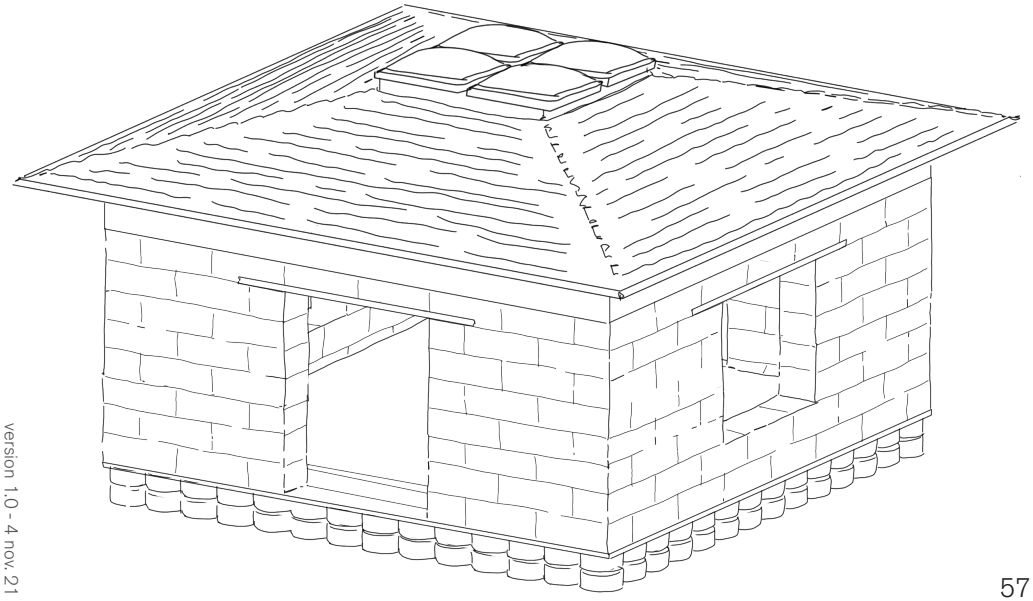
All four skylights should be openable from the interior.

At this stage the walls and roof, including skylight, are finished.

See page 91, appendix A, 4.A.2 for roof edge detail.

See page 92, appendix A, 4.A.3 for skylight detail.

2.3.2



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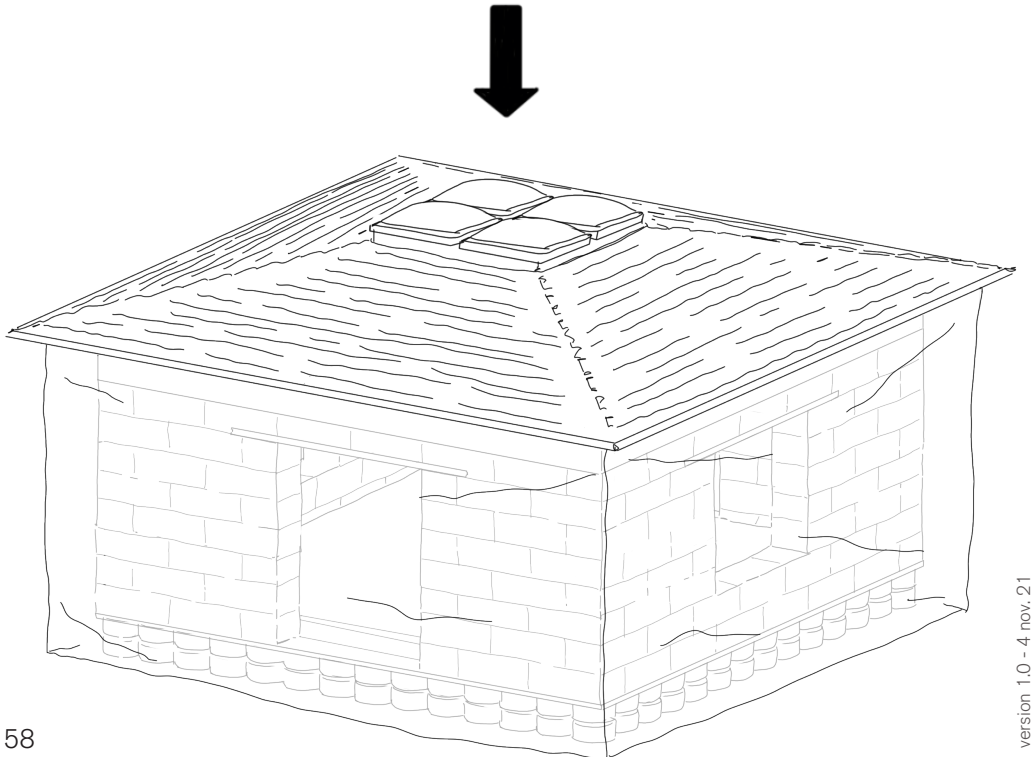
2.3.3

Settling of the straw bales through roof load compression

Add a tarp around the outside perimeter of the roof
to keep the straw dry.

The load of the roof will compress and settle the straw bales,
effectively shrinking the wall.

Measure the height of the wall each day for a minimum of
one week, or until no further shrinkage of the wall is observed.



2.3.4

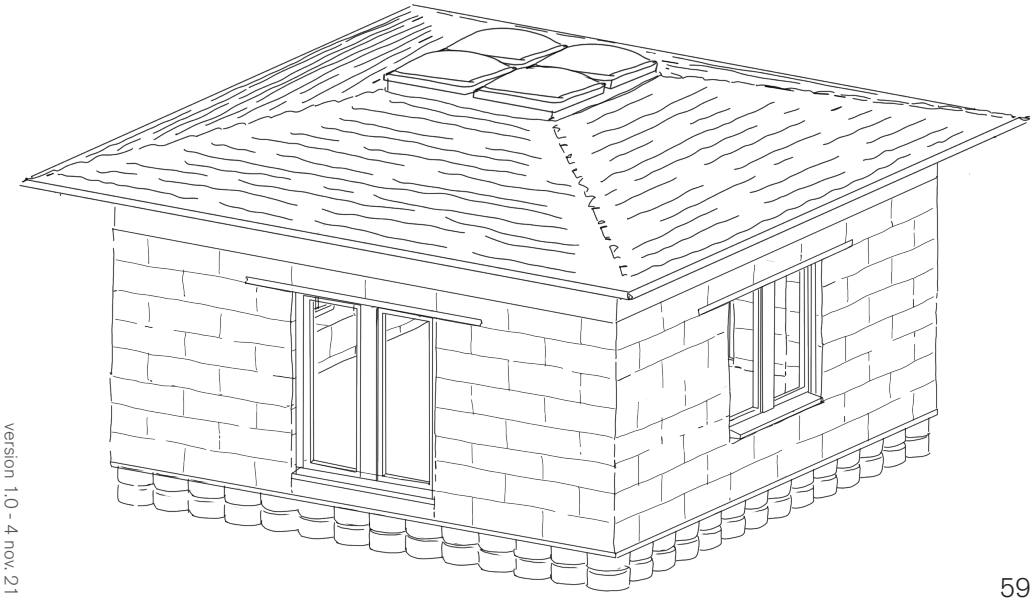
Adding the doors and windows

After walls have settled, add the windows and doors.

Construction under supervision and guidance of
craftsmen/carpenters.

See page 93, appendix A, 4.A.4 for horizontal door detail.
See page 90, appendix A, 4.A.1 for vertical door detail.

See page 94, appendix A, 4.A.5 for vertical window detail.
See page 95, appendix A, 4.A.6 for horizontal window detail.



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3

FINISHING

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IMPORTANT INFORMATION

This chapter explains the mixing and application of the exterior waterproof layer (called render) that needs to be applied on top of the straw bales.

For the mixing of the plaster a **starting recipe** and tips and tricks are given to create a water-proof and stable plaster mix. Note that the content of soil differs per region. This means that the amount of each ingredient needed will vary per location.

Therefore, **testing is crucial** to create a quality mix.

The exterior render needs something for water-proofing. In this case a recipe for lime is given since this is a tested and trusted recipe. However, if lime is not available, other options are available.

If waterproof render is not an option, weather boarding can also be installed, and fastened to the roof and base structure, which is on top of the car tires.

3.1.0

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3.1.1

Testing the clay content of the soil

For quality plaster you will need soil with roughly 80% sand and 20% clay and silts.

Figure out the clay content of the soil in the following way.

- Fill a glass jar with 50% soil and 50% water
- Close the lid and shake the jar as hard as you can
- Let the contents settle for about at least three days
- Measure each layer (see image on the right)
- Determine the percentages of each layer

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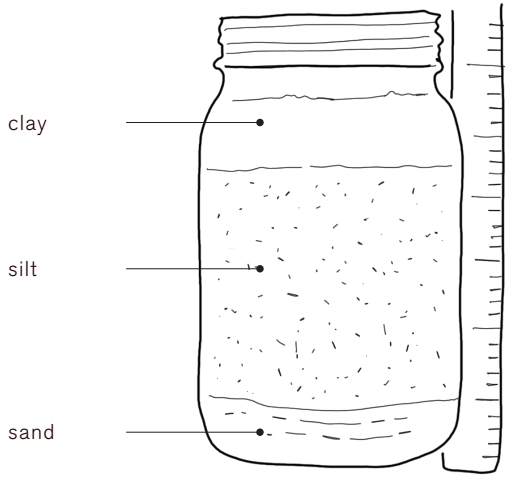
3.1.1

Testing the clay content of the soil



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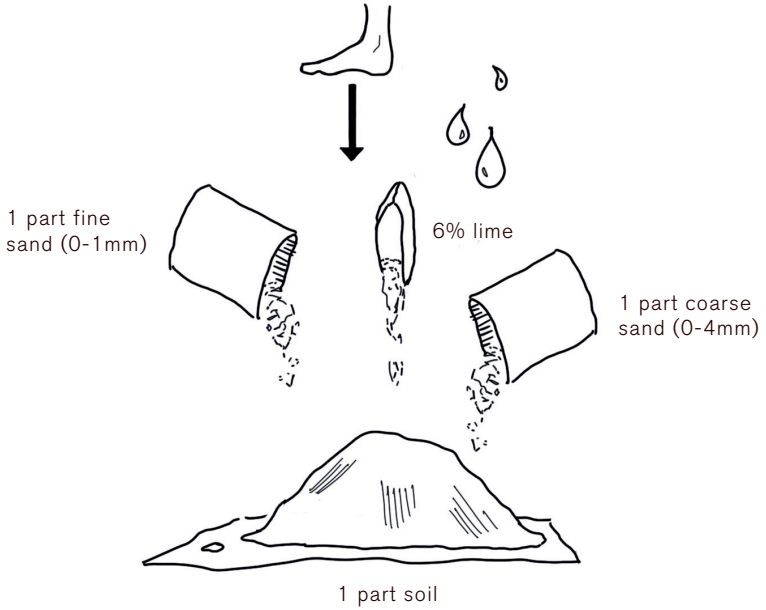
3.1.2

Mixing the plaster

With the clay contents determined, mix the soil according to the recipe below.

The amount of water needed varies again per region and type of soil, therefore the test on the next page is crucial.

Mix with feet until a homogeneous mix is created.

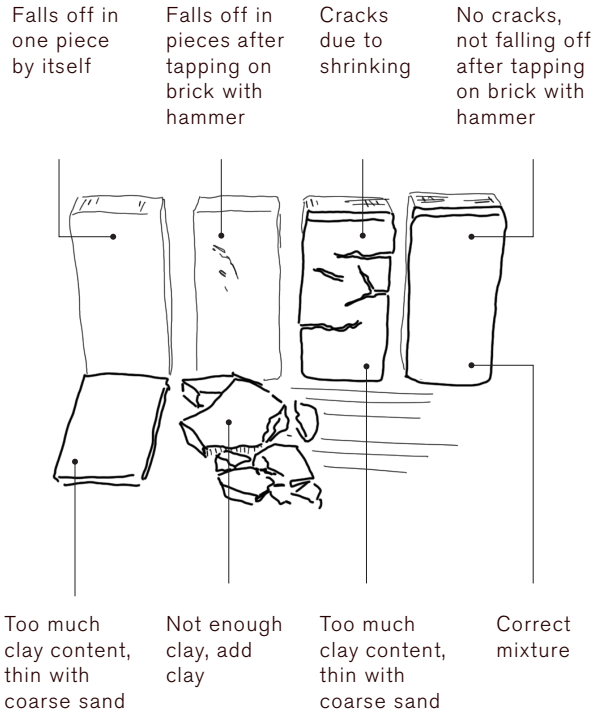


3.1.3

Testing the plaster mix

To test the quality of the quality of the plaster do the following.

Apply a 2 cm thick layer of plaster to a brick
Let it dry for 2 to 4 days
Observe what has happened to the applied layer as shown below, and take action as stated below the image:



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3.1.4

Applying the plaster

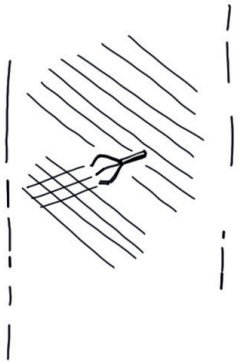
Add the plaster on the exterior walls.

You will need to add 3 layers, with a combined minimum thickness of 3cm up to 15cm.

Each successive coat should have a little more and than the previous one to avoid any cracks

It is advisable to spray on the first coat. If not possible, rubbing the first coat very thoroughly in all the nooks and cracks of the straw bales is also sufficient.

Between coats, it is strongly advised to roughen up the surface and create a strong bond between the plaster layers.



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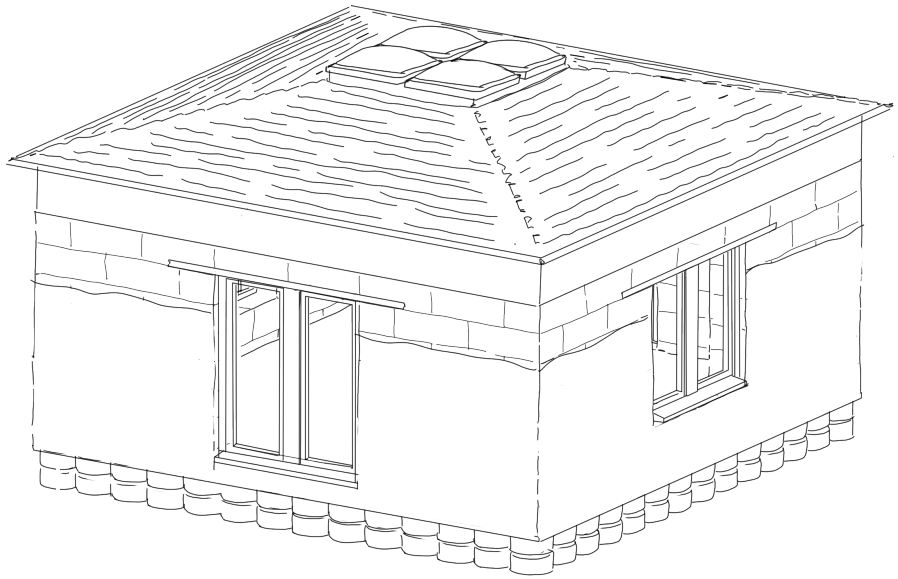
3.1.4

Applying the plaster

Start at the bottom and work your way up homogeneously along all sides of the wall as shown below.



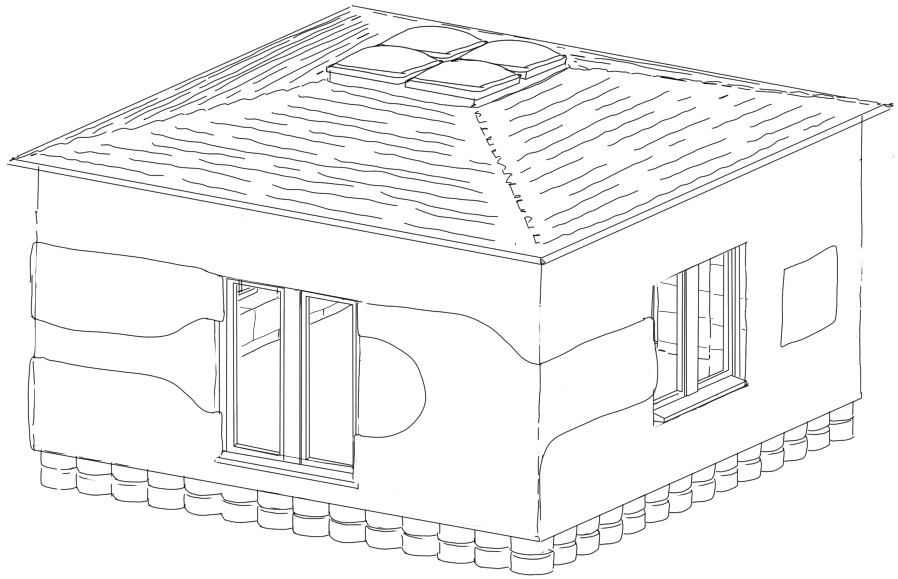
3.1.5

Personalization of the facade

It is possible to add pigments to the plaster and play with the thickness of the render in order to create forms and shapes into the wall.

This allows for the creation of a personalized facade.

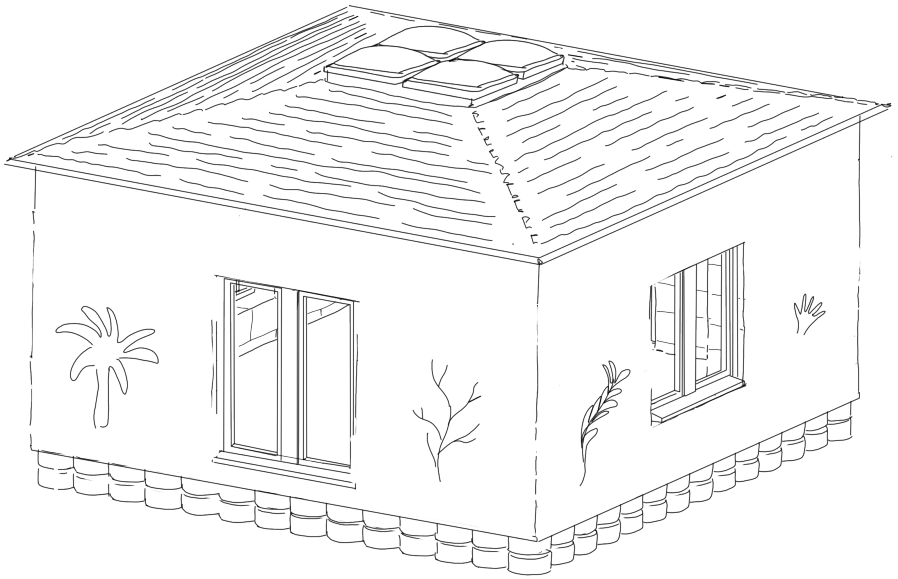
Keep in mind, the minimum thickness of all the layers combined needs to be 3cm.



3.1.5

Personalization of the facade

Start at the bottom and work your way up homogeneously along all sides of the wall as shown below.



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3. FINISHING

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IMPORTANT INFORMATION

This chapter explains the mixing and application of the layer (render) that needs to go on top of the straw bales for the interior walls.

The process is the **same as for the exterior walls.**

The only difference is the following: the interior render does not need to be waterproof, it is possible to omit the lime in the mixture for the render.

Since the process is the same, refer to chapter 3.1.x for all the steps necessary.

3.2.0

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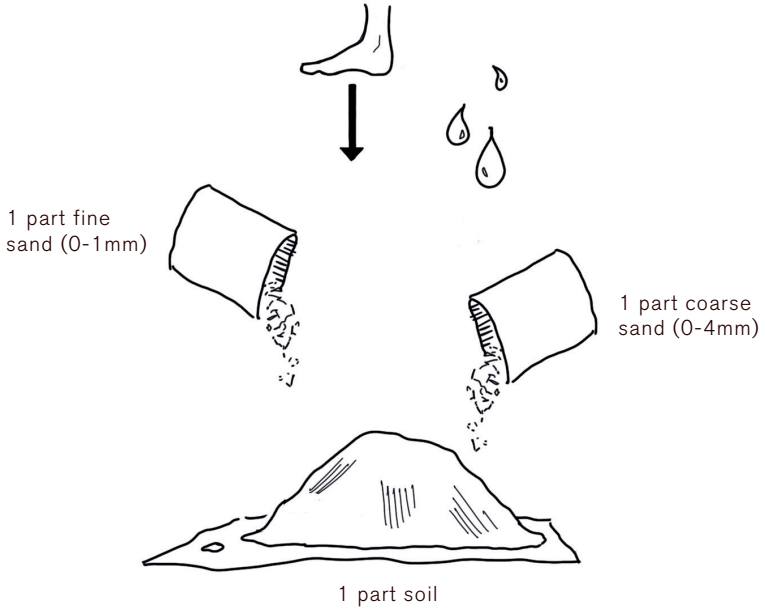
3.2.1

Creating the interior render

Go through all the same steps as shown in the previous chapter, 3.1.X about the exterior render.

Omit the lime in the recipe for the render.



3.2.2

Interior render for wet rooms

In wet rooms (bathroom, near kitchen) the plaster should be treated with silicon resin if possible.

If this is not possible, the same waterproof render that has been used for the exterior can be used for the wet rooms.

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3. FINISHING

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IMPORTANT INFORMATION

This chapter explains the process of creating interior walls.

The interior walls are created with unfired earth bricks (meaning, mud dried in the sun without fire).

The bricks fulfil an **essential role** in regulating the indoor climate. Therefore, if it is not possible to use unfired earth bricks, do use another material with sufficient **thermal mass** (meaning, it can store, absorb and release heat).

The interior walls can be placed in any way desired. They are easily installed, and can be moved just as easy, allowing for flexibility in creating the amount and sizes of rooms **according to the wishes of the occupant.** They are attached to the rafters and the OSB floor board.

The recipe for thee mixture of the bricks can best be perfected through trial and error, since it is dependable on the type of soil available.

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3.3.0

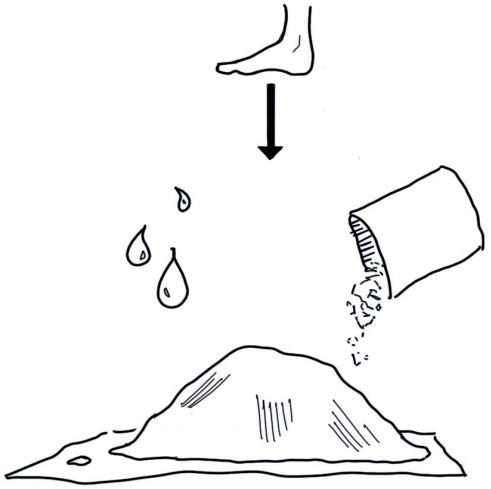
3.3.1

Creating the mud for unfired earth bricks

Add water to sand and soil.

The amounts of these ingredients vary depending on the available soil. The right recipe is found through trial and error.

If you find the bricks are not sturdy enough, start off with varying the amount of sand.



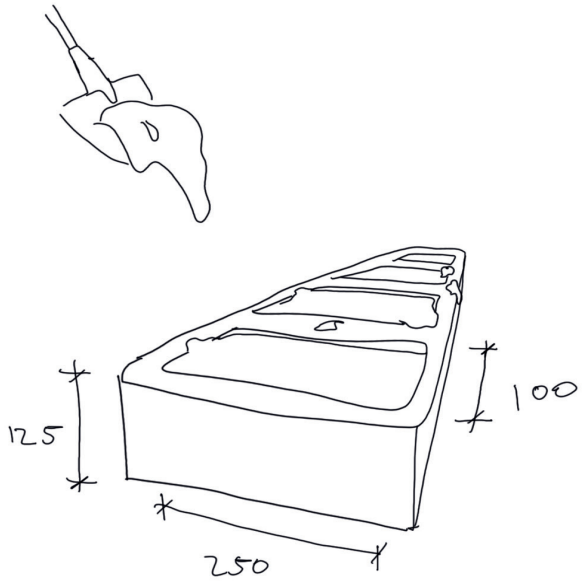
3.3.2

Creating unfired earth bricks

Put the mud mixture into moulds made of wood with dimensions as shown below.

Let the bricks dry for five days. If cracks appear, take them out of the direct sunlight.

After five days take them out of the moulds and let them dry for at least two more days



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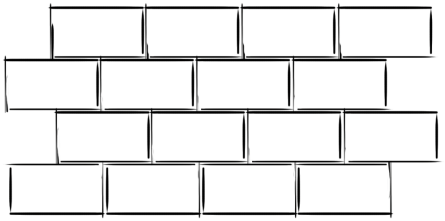
3.3.3

Creating the interior walls

The interior walls are created by laying the bricks in a running bond as shown below.

The bricks can then be attached to the rafters and the OSB floor board in any way possible. Some ideas for this are given on the right hand side.

If more sound insulation is required, you can add locally available noise absorbing material between the bricks and the construction material holding the wall in place.



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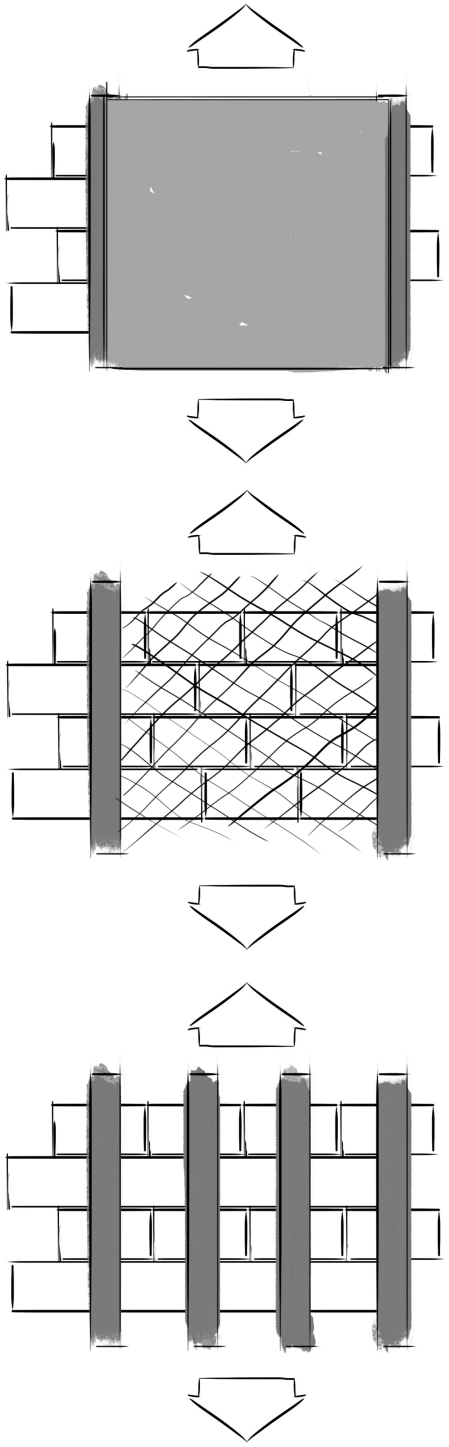
3.3.3



3.3.4

Possible arrangements for the interior walls

Possible arrangements for the interior walls are shown on the right hand side.

These walls can be placed according to your own needs and preferences.

The examples shown on the right are not exhaustive. They are meant to help you get started.

It is advisable to consider that a bed of 1 x 2 m needs to fit into the room.

Be sure to **consult appendix C** to understand the climate design of this dwelling unit, and therefore understand the consequences of the placements of the wall for the indoor climate.

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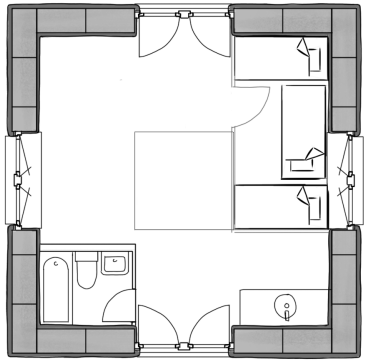
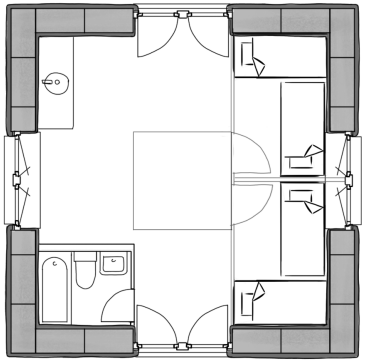
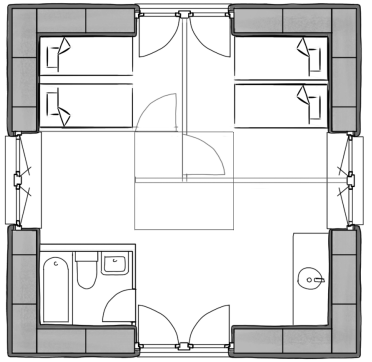
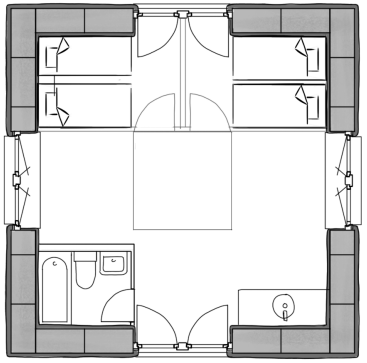
3.3.4

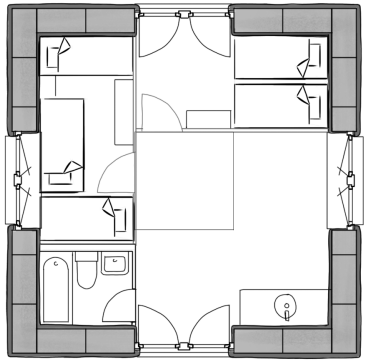
Examples for interior wall placement











NOTES

4

APPENDIX

A. Construction drawings
B. Attaching two dwellings
C. Climate design
D. Miller's knot

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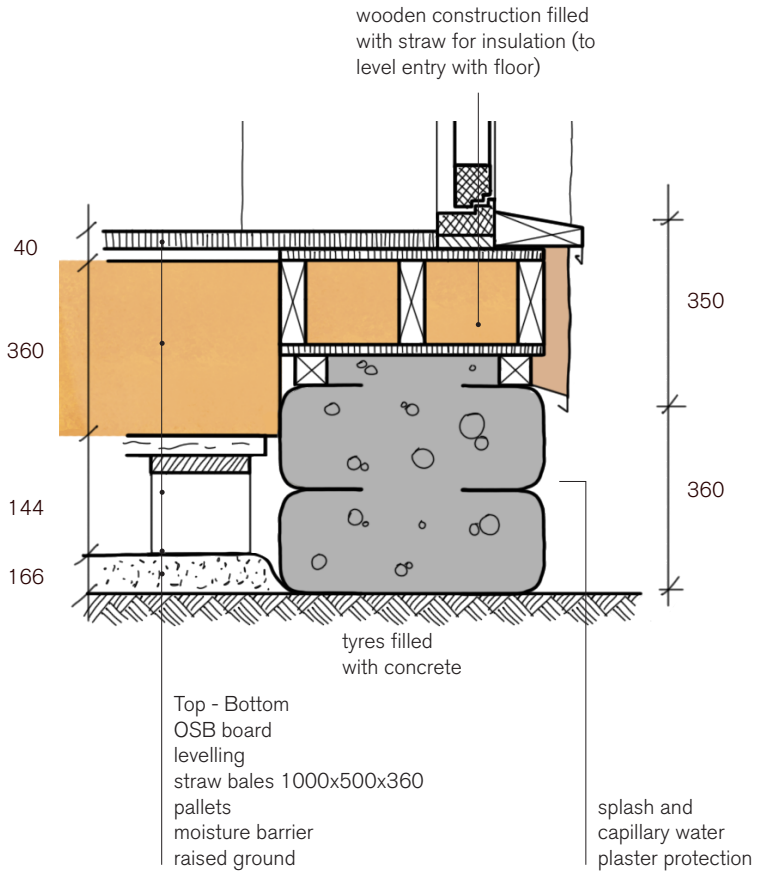
4.A.1

Floor and foundation/door detail horizontal1:15



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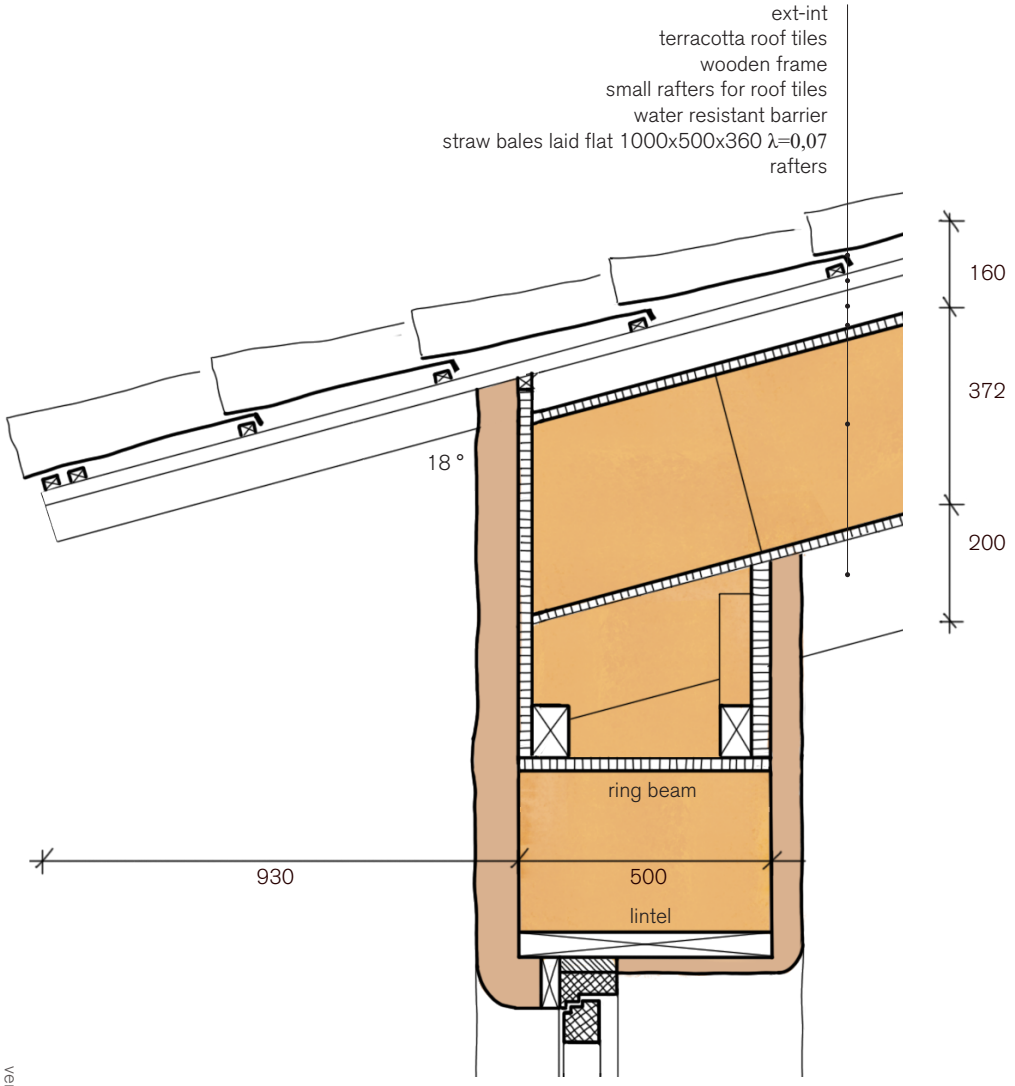
4.A.2

Roof edge detail horizontal 1:15



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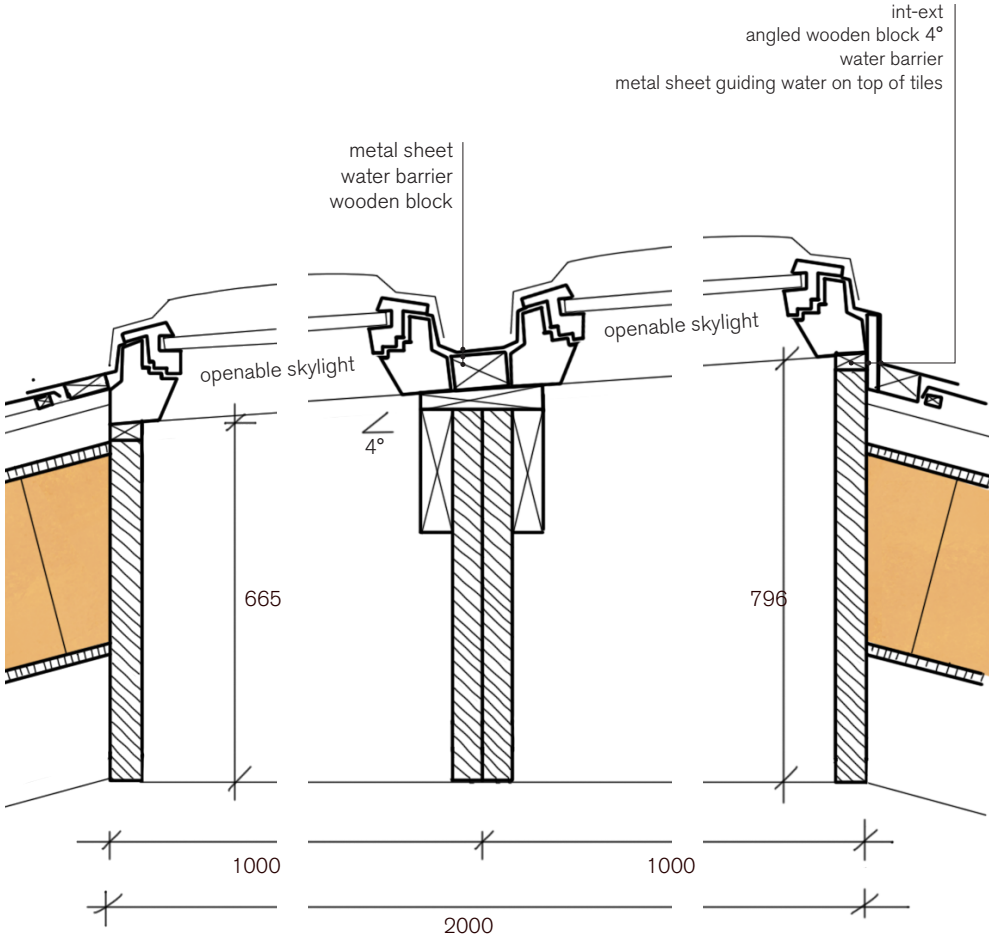
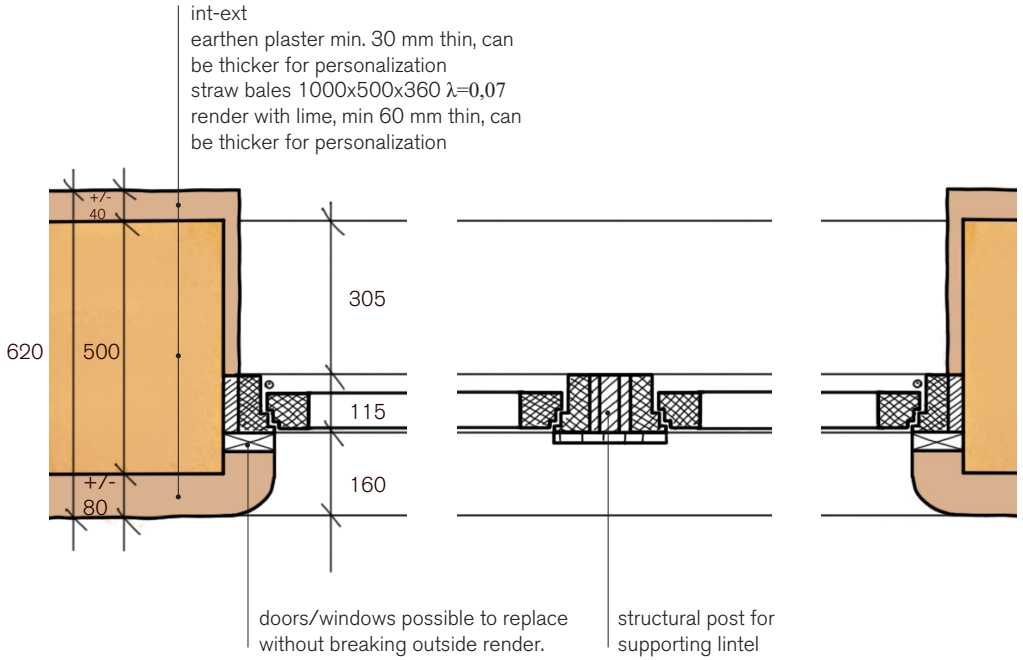
4.A.3

Skylight detail horizontal 1:15 (must be openable)



4.A.4

Door detail vertical 1:15



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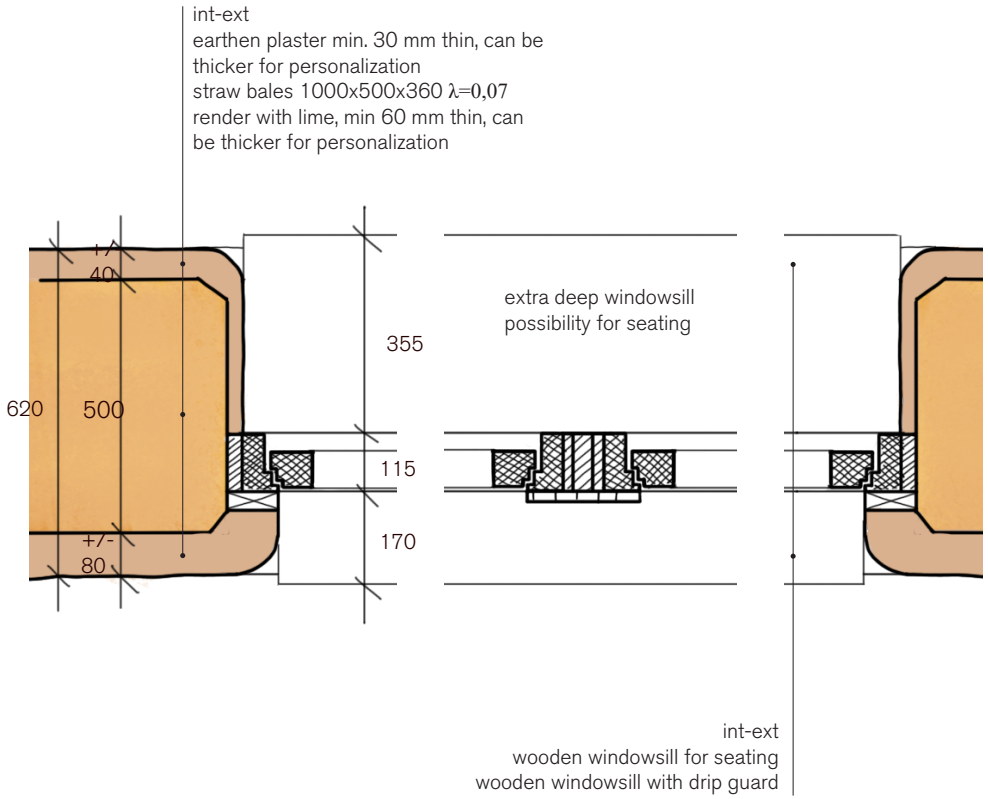
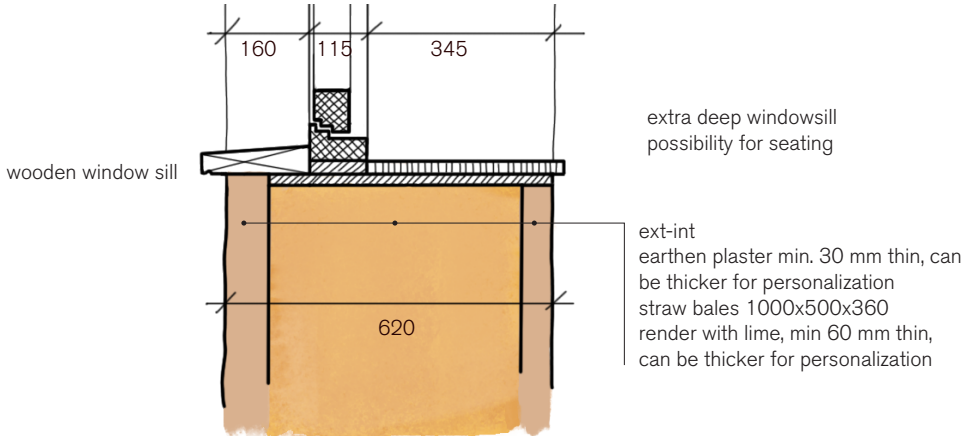
4.A.5

Window detail vertical 1:15



4.A.6

Window detail horizontal 1:15



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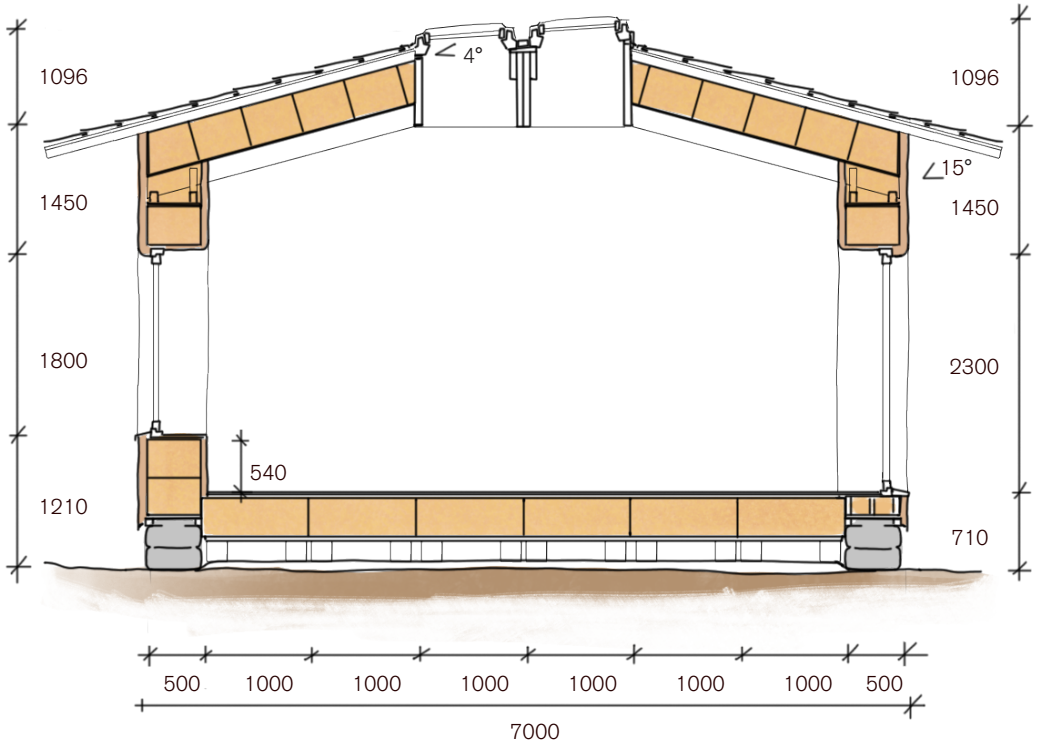
4.A.7

Section 1:70

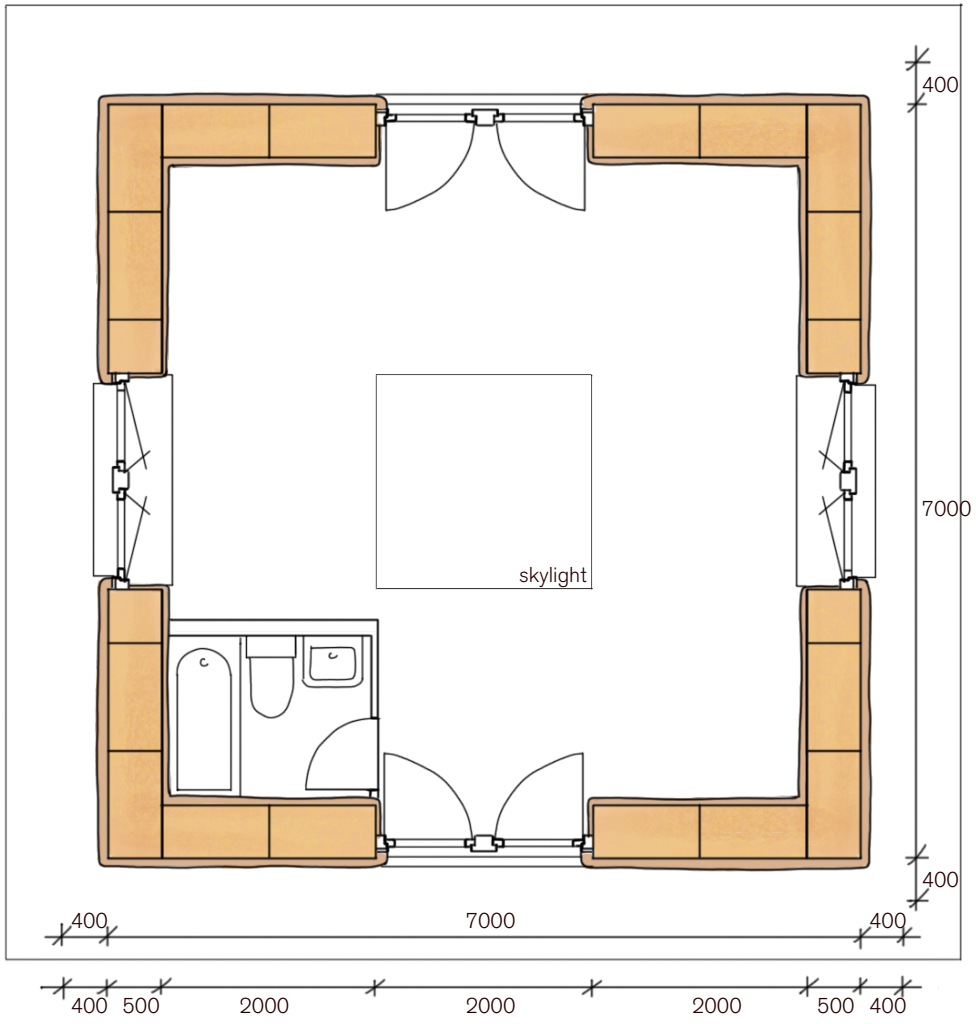
!! note: this section makes a 90 degree turn !!

!! In reality, windows and doors are on opposite side of each other !!



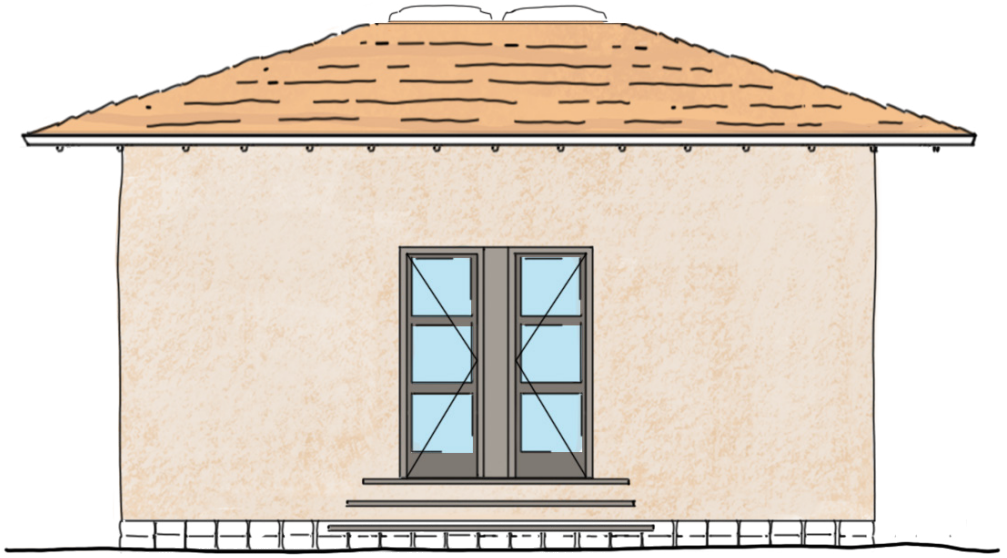
4.A.8

Floorplan without interior walls 1:70



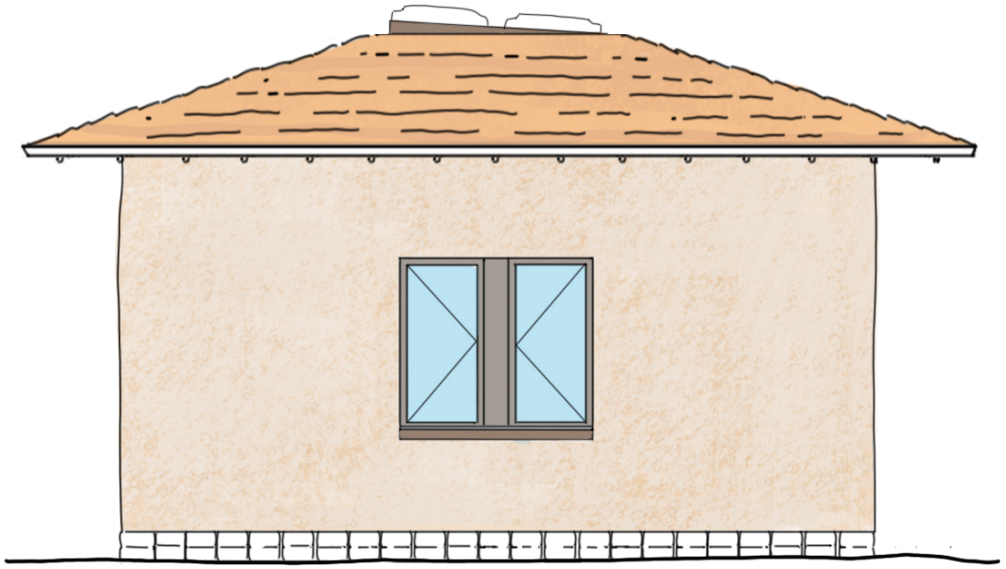
4.A.9

Facades on opposite sides door 1:70



4.A.10

Facades on opposite sides window 1:70



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4.B.1

Creating a larger dwelling by merging two units

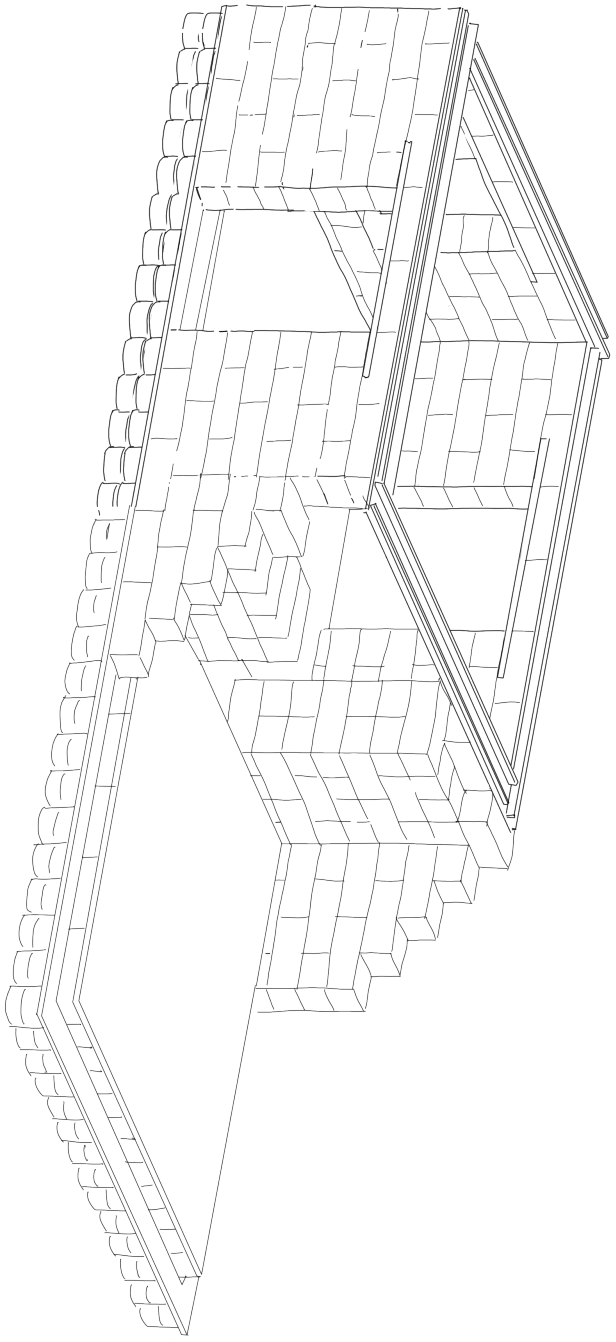
Creating a larger dwelling is possible by combining two of the A001 types as shown on the right.

As a result you will have a wall that is one metre thick.

The roof load of the each unit needs to rest on its own walls to ensure equal distribution of the roof loads onto the walls.

Make sure that there is no seam between straw bales going from the bottom to the top.

4.B.1



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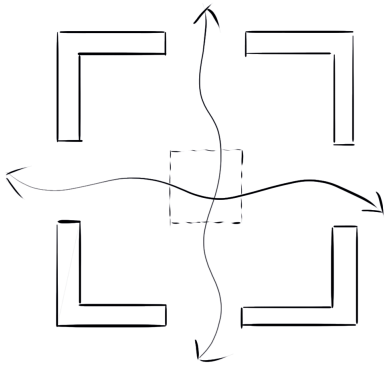
4.C.1

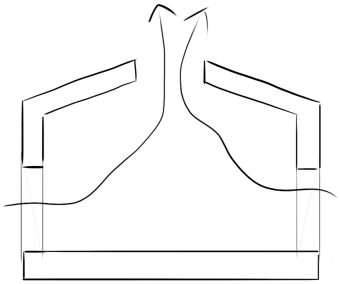
Cross ventilation, openable skylight and night purge

The cooling of this dwelling relies on cross ventilation and letting the heat escape through the openable skylights.

Since the skylights are openable, cooling can also happen through cross ventilation from window or door to skylight.

During heat waves or hot days, night purge is recommended, allowing the unfired earth bricks to cool down more rapidly due to draft. In this way, the bricks can take up more heat during the day, making for a more comfortable indoor climate.





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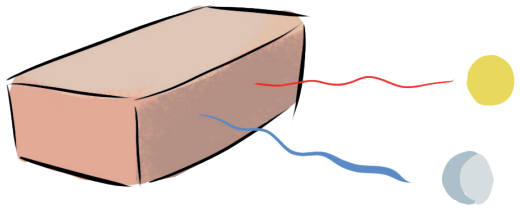
4.C.2

Thermal mass

Having interior walls with thermal mass is of great essence. The bricks (or other material with a lot of thermal mass) can absorb heat an release them later. This makes for a more stable and comfortable indoor climate.

During consecutive hot days it is of essence that you let the bricks cool through night purging the dwelling.



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4. APPENDIX

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4.D.1

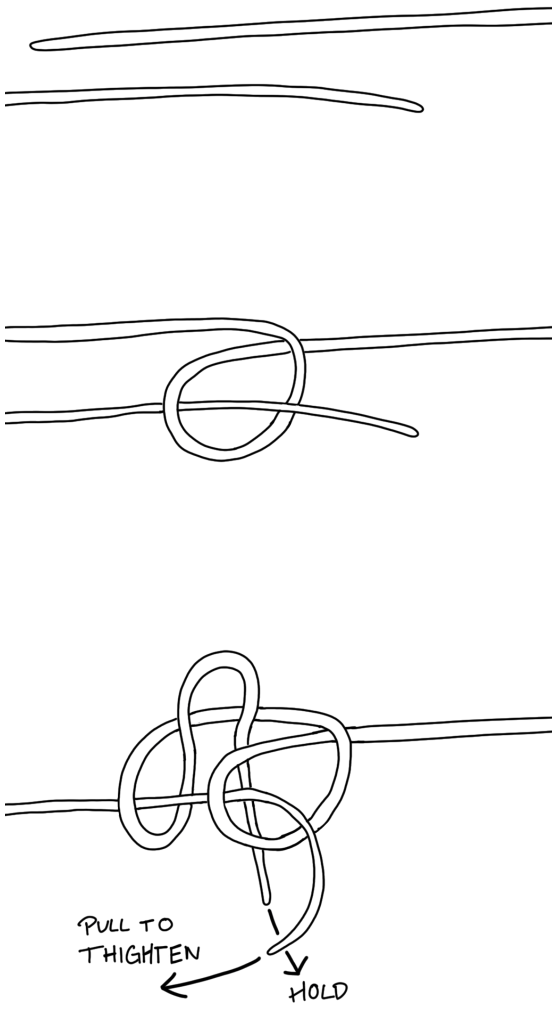
Tying a Miller's knot

In order to re-string and tie a straw bale (half or whole), it is recommended to use a Miller's knot, using non biological semi elastic cord.

This knot allows for the string to be taught enough around the bale for it to not lose any of its density.

4.D.1

Tying a Miller's knot



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