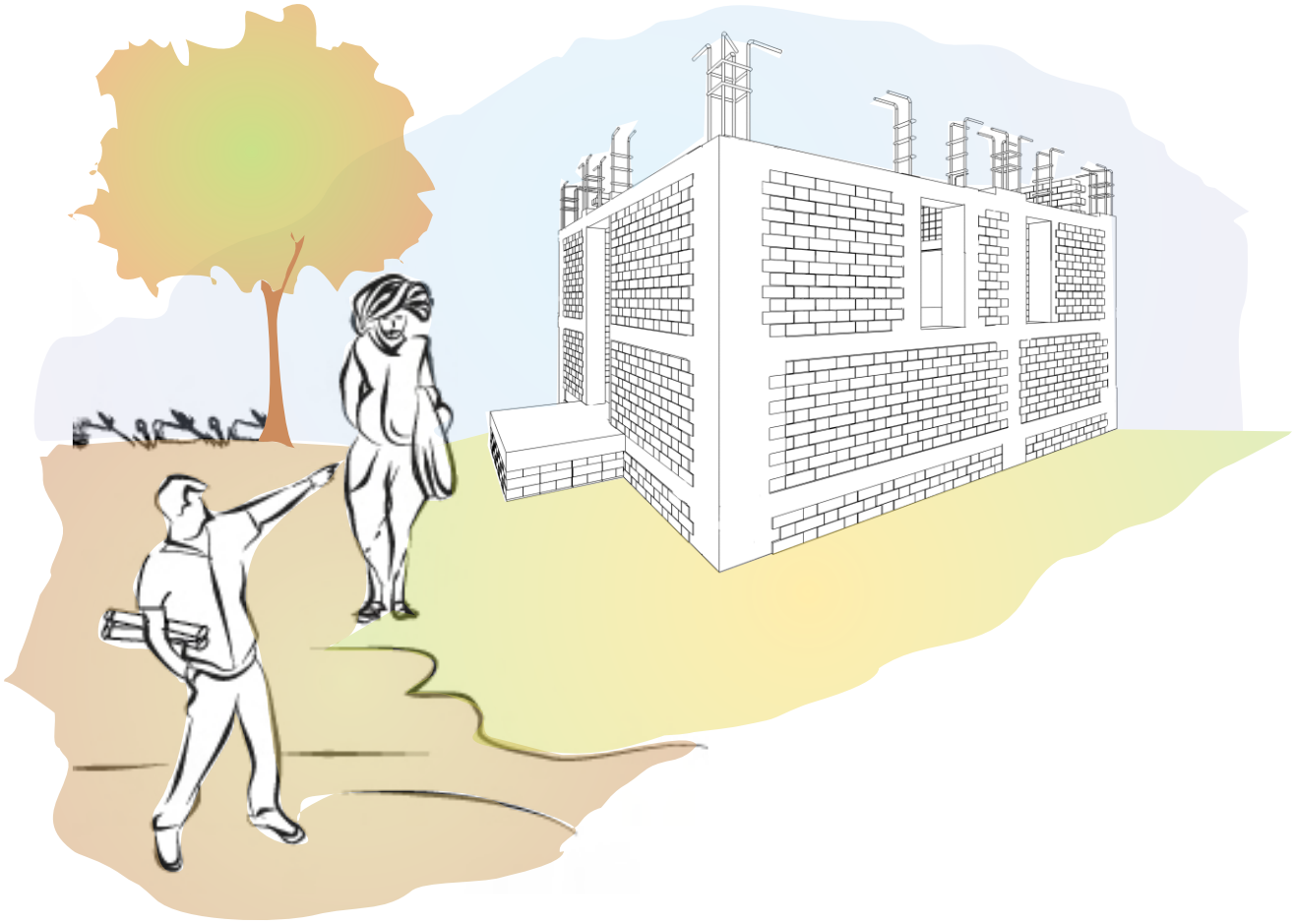
Build a Safe House with
CONFINED MASONRY



Kamu Iyer
Shibani M. Kulkarni
Shantanu Subramaniam

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Gujarat State Disaster Management Authority
Government of Gujarat

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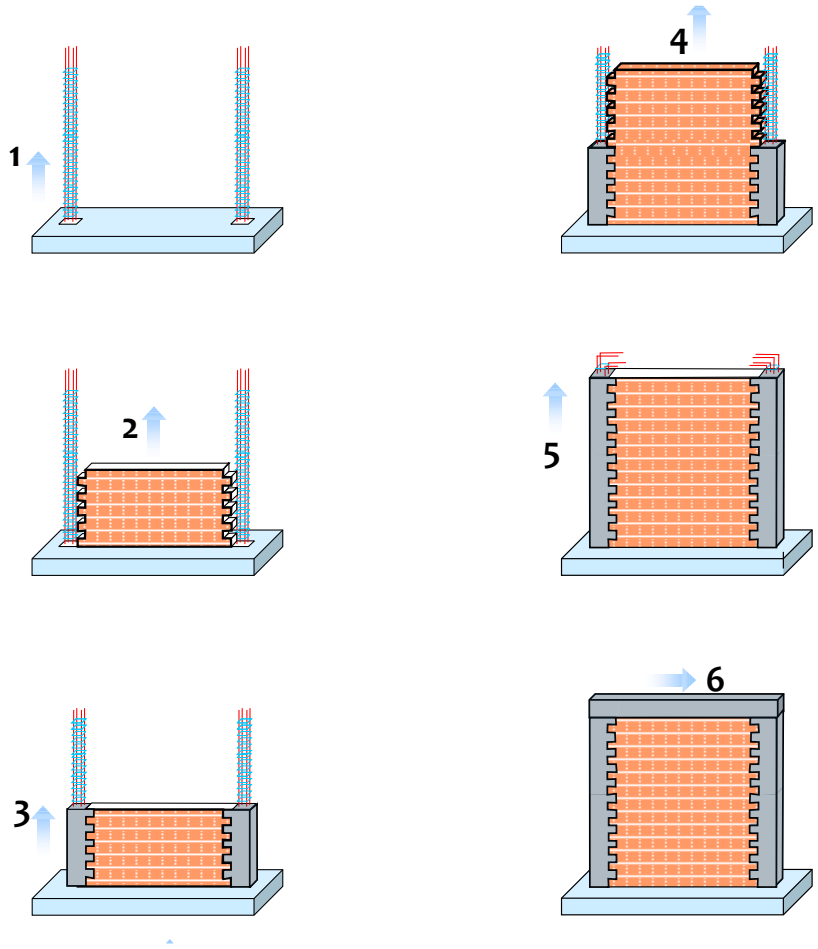

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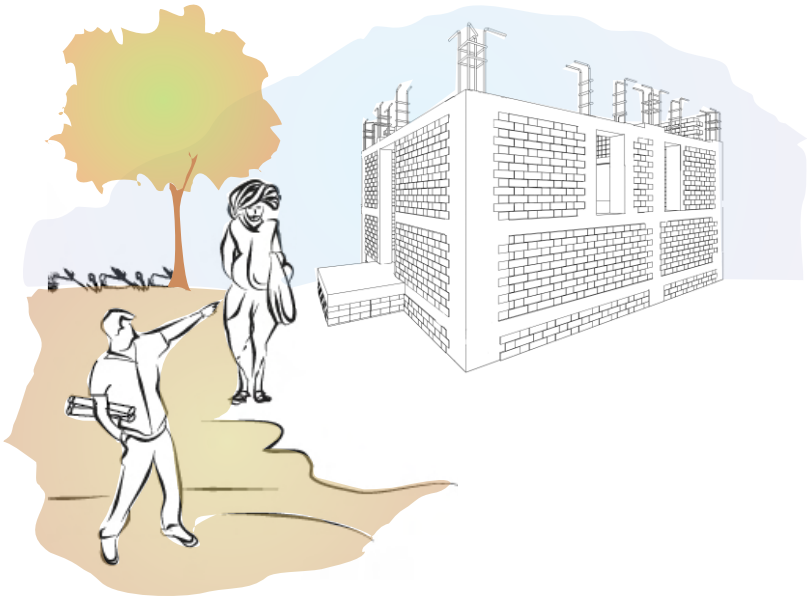


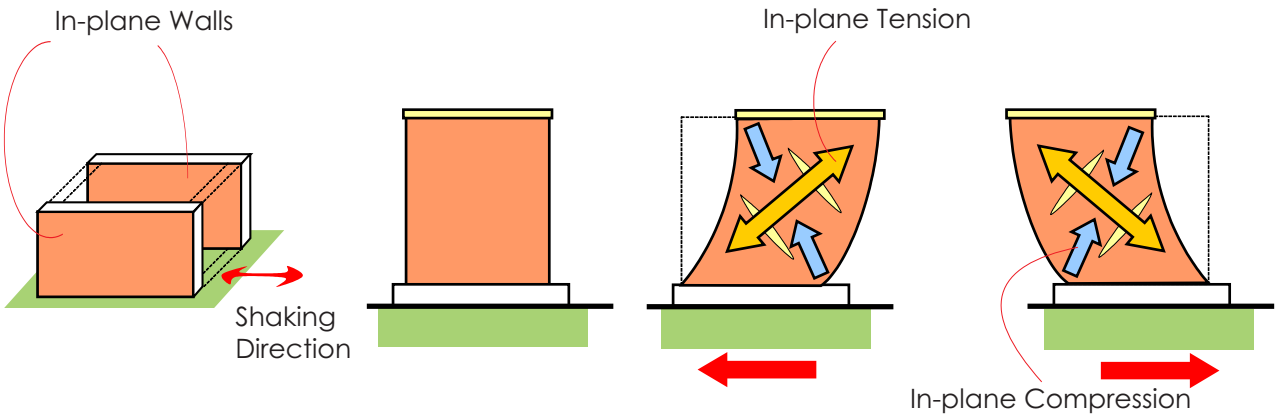
Contents

Preamble

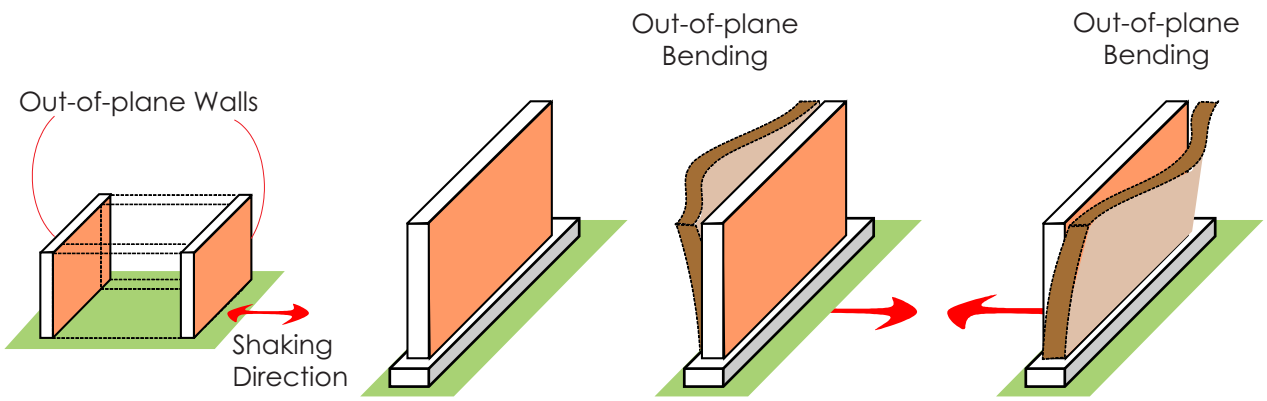
Most houses in rural India are masonry houses. The masonry walls are built with burnt clay brick or natural stone masonry. Many choices are made across India for the roof. For instance, a sloping roof with wood truss and burnt clay tile is adopted in Kachchh region of Gujarat (western state of India), and a flat roof with reinforced concrete (RC) slab in Tehri Region of Uttarakhand (northern state of India). These houses are constructed in the *conventional* manner known to masons. Technically, they are called **Unreinforced Masonry (URM) Houses**; it has plain masonry walls with no steel reinforcement embedded in them to improve their behaviour during earthquakes. Today, of the existing building stock in India, about 45% of houses are made of burnt clay brick and about 10% of natural stone. Thus, over half of India's population lives in URM houses.

A village house
with unreinforced masonry

Unreinforced masonry (URM) walls are pushed sideways during a strong earthquake, along their length and thickness directions. When shaken along their thickness, they collapse. And, when shaken along their length, they develop diagonal cracks along their length and/or separate at wall junctions. When walls collapse, they bring down the roof along with them. This is the main reason for large loss of lives during earthquakes that have occurred in different regions of the country.



Shaking along length direction of masonry wall results in diagonal cracking



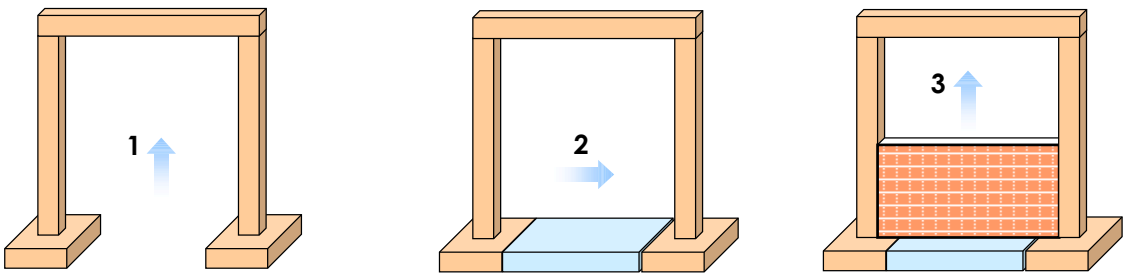
Shaking along thickness direction of masonry wall can result in collapse

Despite houses collapsing in earthquakes, people still continue to reconstruct their houses in the age old method of unreinforced masonry, thereby making their houses vulnerable to future earthquakes.

A villager rebuilding his house
with unreinforced masonry

In cities, RC buildings are constructed first by making the RC frame, and then by infilling the spaces between beams and columns with masonry walls made of burnt clay bricks or cement blocks, and cement mortar. To build a house this way requires high levels of technical skills, which usually are not available in small towns and villages. But, everyone, whether residing in a town or a village, wants a **pucca** house - a house with brick walls and RC roof, just like the buildings in larger towns and cities. This is reason enough to improve earthquake safety measures in these houses.

An RC frame building
commonly built in cities



Sequence of
RC frame construction with URM infill walls

Small, but significant, changes should be made in current method of construction of masonry houses in rural India. This improved method of house construction is called **Confined Masonry Construction**. Loss of life can be reduced considerably in masonry houses during future earthquakes. For this, masonry walls are confined on all four sides with (a) stiffer and stronger vertical elements made in RC, and (b) RC horizontal bands at discrete levels in the masonry walls along the perimeter of all the rooms of the house.

Confined Masonry House
with clay brick walls and RC slab

Books providing technical information on confined masonry construction are exhaustive, but largely offer generic details. They have to be adapted for specific conditions at site. Often, this is difficult for a man building his house. An illustrated manual such as this is required, that follows the requirements of Confined Masonry Construction in an easy-to-follow language, and provides guidance on how to build a confined masonry house with specific functional design. Such a manual will enable the individual house owner or a 'practical technician' to build such a house. Also, the manual will help local authorities to construct houses under any social housing scheme sponsored by the Governments.

This book illustrates the step-by-step construction of a *Confined Masonry House* of a specific design. It provides precautions to be taken and amount of material required to construct the house. Also, alternate specific designs are presented.

Acknowledgements

The authors are grateful to the Gujarat State Disaster Management Authority (GSDMA), Government of Gujarat, Gandhinagar (Gujarat, India), for readily agreeing to support the preparation of this book; the generous financial grant provided by GSDMA towards this effort is gratefully acknowledged. The authors also extend their appreciation to Dr. R. Bannerji, IAS, Chief Executive Officer-GSDMA, Dr. V. Thiruppugazh, IAS, Additional Chief Executive Officer, GSDMA and Mr. S. I. Patel, Additional Chief Executive Officer, GSDMA for their invaluable inputs and guidance during the course of preparing and finalizing this book. Ms. Alpa R. Sheth, Managing Director, Vakil Mehta Sheth Consulting Engineers Private Limited, Mumbai, and Seismic Advisor, GSDMA, Gandhinagar, Gujarat, supported idea of developing this book, and guided us throughout the course of this project from discussing the contents, mid-course feedback on the contents, to getting the book reviewed. The authors sincerely thank Mr.Birju Patel, Deputy Director, GSDMA, Gandhinagar, for providing necessary details of government-driven social housing schemes being undertaken in Gujarat, and for the administrative support from GSDMA .

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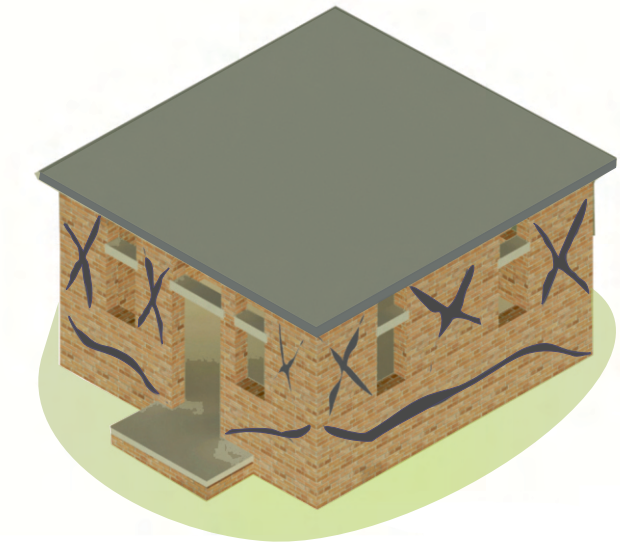
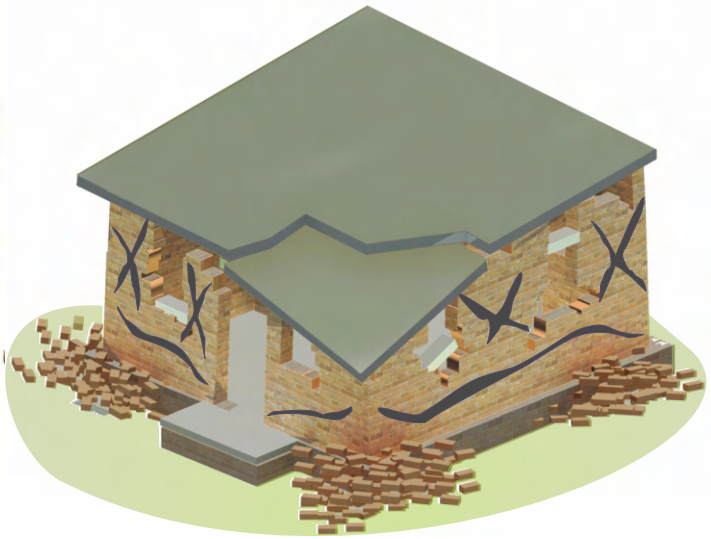
The authors remain indebted to their family members for the unconditional support and understanding throughout the of development of the book… This book is dedicated to all the people of India, who lost their kith and kin in masonry house collapses during past earthquakes in the country…

Confined Masonry

What will happen to my house in an earthquake, If masonry is not confined?



Moderate Shaking
Walls Crack



Severe Shaking
Walls collapse and slab falls

During an earthquake, when the ground shakes moderately, unconfined walls are pushed sideways and therefore develop cracks. When the ground shakes violently, unconfined masonry walls collapse bringing down the roof, either partly or fully.

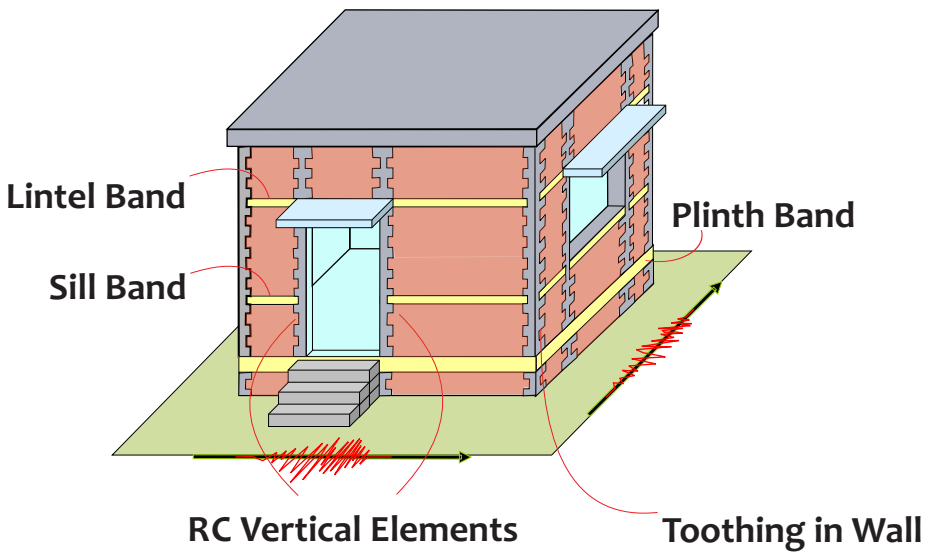
How do I prevent this?

By confining masonry walls of the house. This is achieved by using:
(a) vertical RC elements interlocked with bricks at all wall junctions and door and window openings, and
(b) horizontal RC bands at plinth, sill and lintel levels.

Masonry confined thus is resistant to earthquakes.

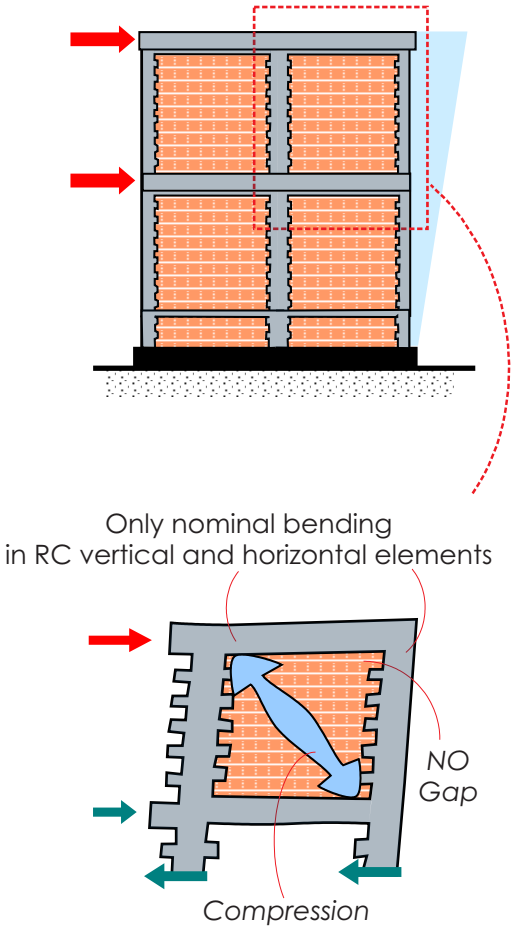
What is Confined Masonry ?

Confined masonry (CM) consists of RC confining vertical and horizontal confining elements that are cast in-situ around URM wall segments built in small heights. Concrete in these RC elements is poured after the walls are made. This in-situ concrete fills all gaps and covers vertical bars protruding out from the foundation. On hardening of concrete, the RC elements hold the masonry wall segments snugly without any gap between them. This snug action is created by the toothing left in the masonry walls at wall corners and junctions, and adjoining door, window and ventilator openings.



Small-sized vertical reinforced concrete (RC) confining elements are cast in-situ at all wall junctions and adjoining all openings. Horizontal RC elements (called bands) are cast in-situ above and below all openings and at floor levels. Normally, Plinth, Sill and Lintel Bands are provided; in buildings with pitched roofs, two more bands are provided, namely the Roof and Gable Bands. Longitudinal reinforcement bars in vertical RC elements are anchored into the plinth masonry at the bottom and roof slab (when roof is flat), or into the roof band (when the roof is pitched) at the top. Longitudinal reinforcement bars in horizontal RC bands run through all walls of the house; sill band alone is discontinued at door openings.

Under earthquake shaking, the loads are carried primarily by the composite system of masonry wall and RC elements through load-bearing action. These RC confining elements are small in size and grip the whole width of the wall at door and window openings and wall junctions. They have sufficient stiffness to resist to dilation of masonry wall that otherwise happens during earthquake shaking. Thus, each wall panel bound by the confining RC elements stays as an integral unit without disintegrating into its constituent materials.



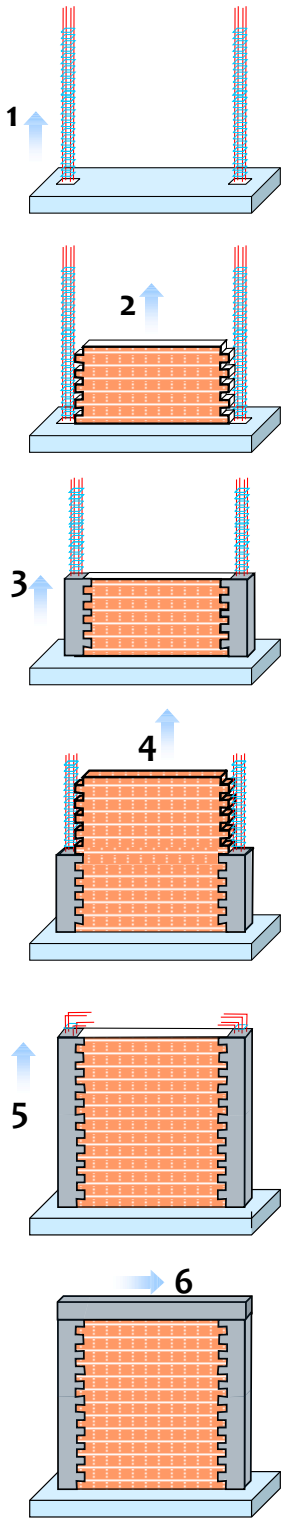
RC elements holds masonry walls snugly
during earthquake shaking

Confined masonry is most suitable and practical method for construction of houses by individual home owners in earthquake areas. The level of engineering required is embedded in empirical rules for planning, design and construction of these houses. Two prominent features of confined masonry construction are:

(1) Use of a regular grid of walls in both directions with RC vertical members at all wall junctions and in straight walls of longer lengths, and RC vertical elements (toothed into the masonry wall segments) and RC horizontal bands (resting on the masonry walls of the whole house). These items together confine the wall segments and prevent them from dilating along the length direction of the wall and from falling out-of-plane along the thickness direction of the wall..

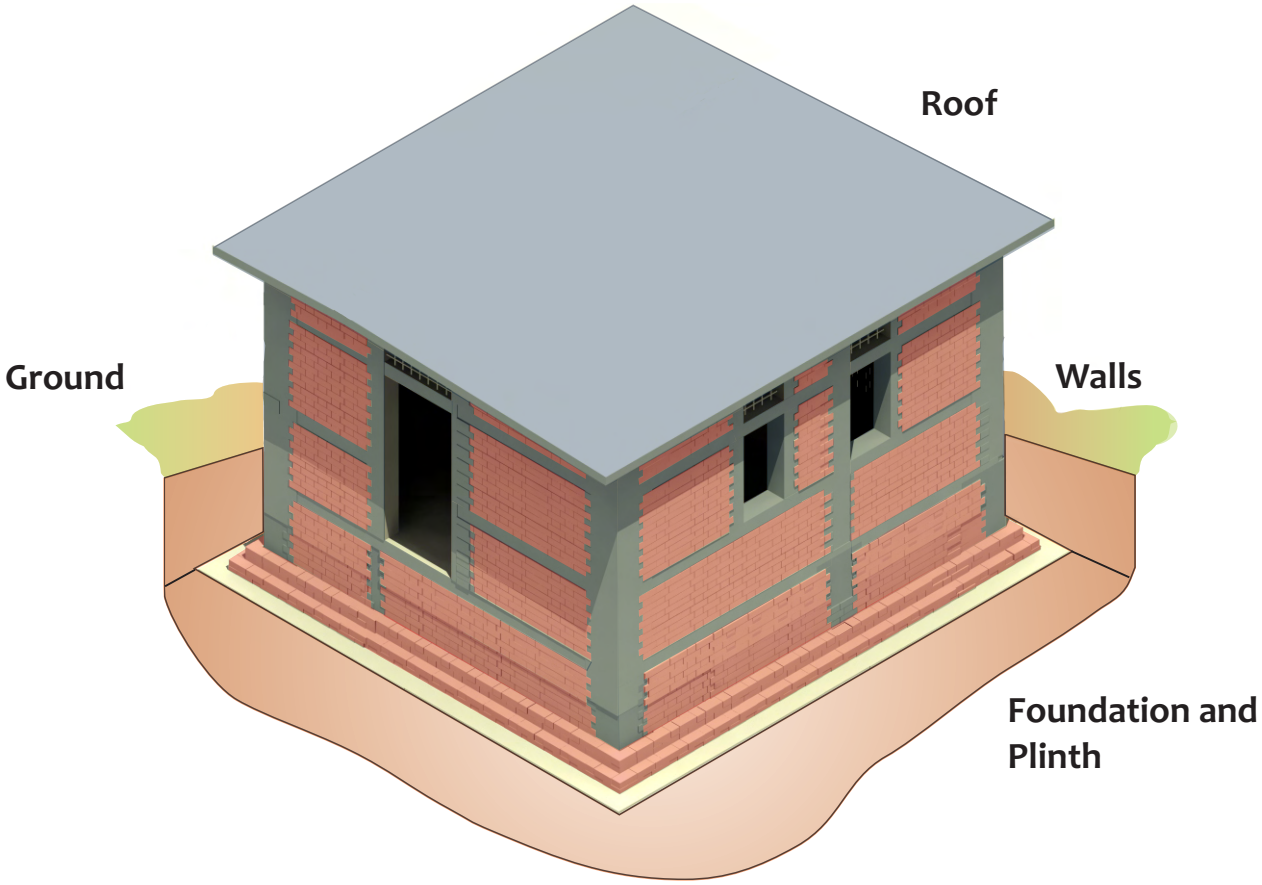
(2) Sequence of first making the masonry walls and then pouring in-situ the RC vertical elements and horizontal bands. This choice of construction sequence is responsible for enhancing the integrity of the masonry units and mortar in Confined Masonry, which in turn makes Confined Masonry Construction superior to regular RC frame buildings with plain masonry walls as infills.

Earthquake performance is good of confined masonry construction. While confined masonry constructions sustained severe damage during past earthquakes, complete *collapse has not been observed* in this typology of construction.



Sequence of
Confined Masonry Construction

What are the main elements of a Confined Masonry House ?



Foundation

All elements of construction from soil level to ground level

Plinth

All elements of construction from ground level to floor level

Wall

Masonry wall, vertical RC elements and horizontal RC bands

Roof

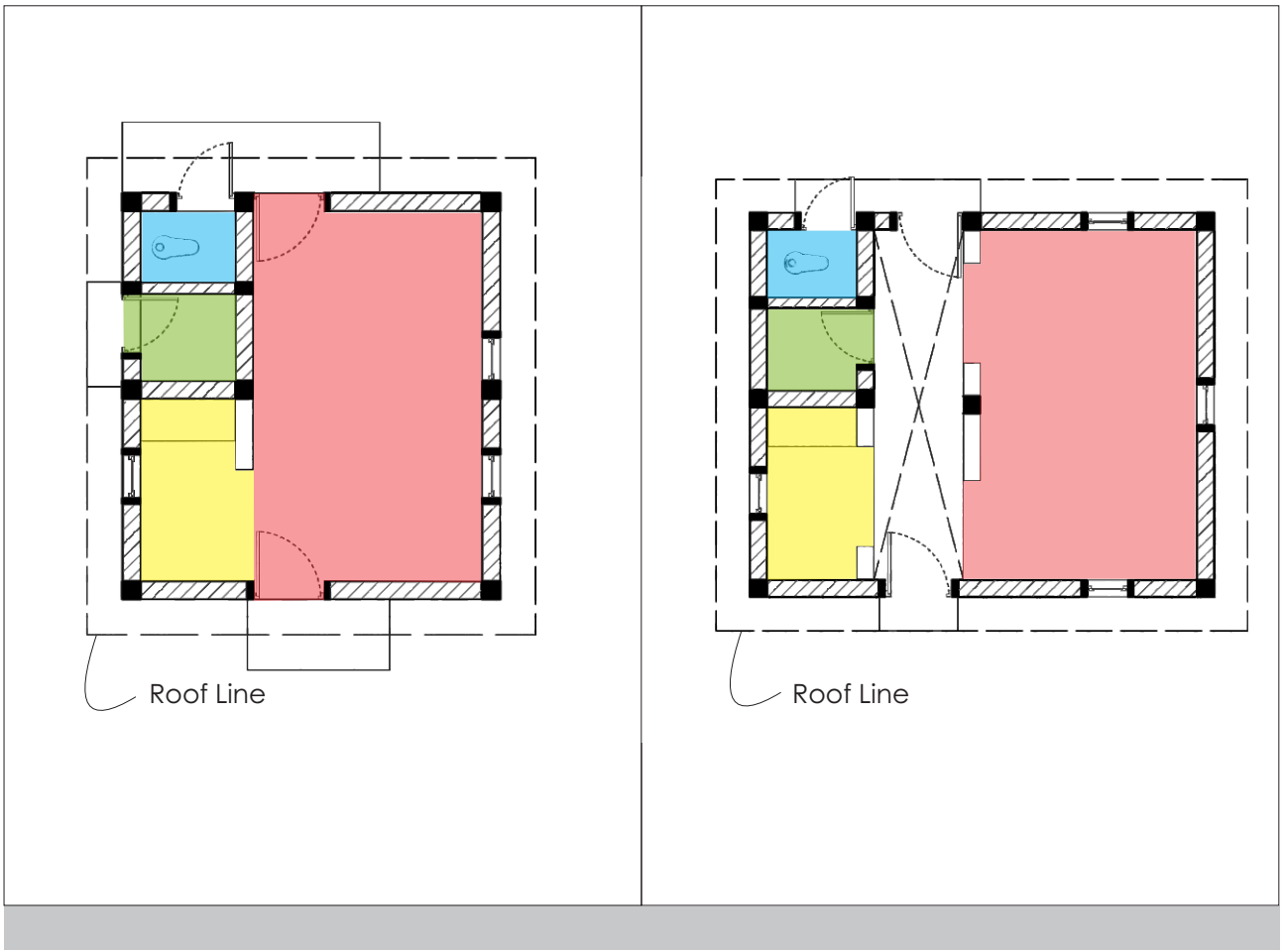
RC slab with all finishes on it in a flat roof, wood/steel truss, clay tiles/sheeting and all finishes on it in a pitched roof

Confining Elements

Vertical RC elements, Horizontal RC bands at plinth, sill and lintel levels in a house with flat roof, and RC eaves and gable bands in a house with pitched roof

Options of Confined Masonry Houses

What are the available options ?



Option 1
Built-up area: 24.67 m^2
Carpet area: 18.78 m^2

Option 2
Built-up area: 32.03 m^2
Carpet area: 20.18 m^2

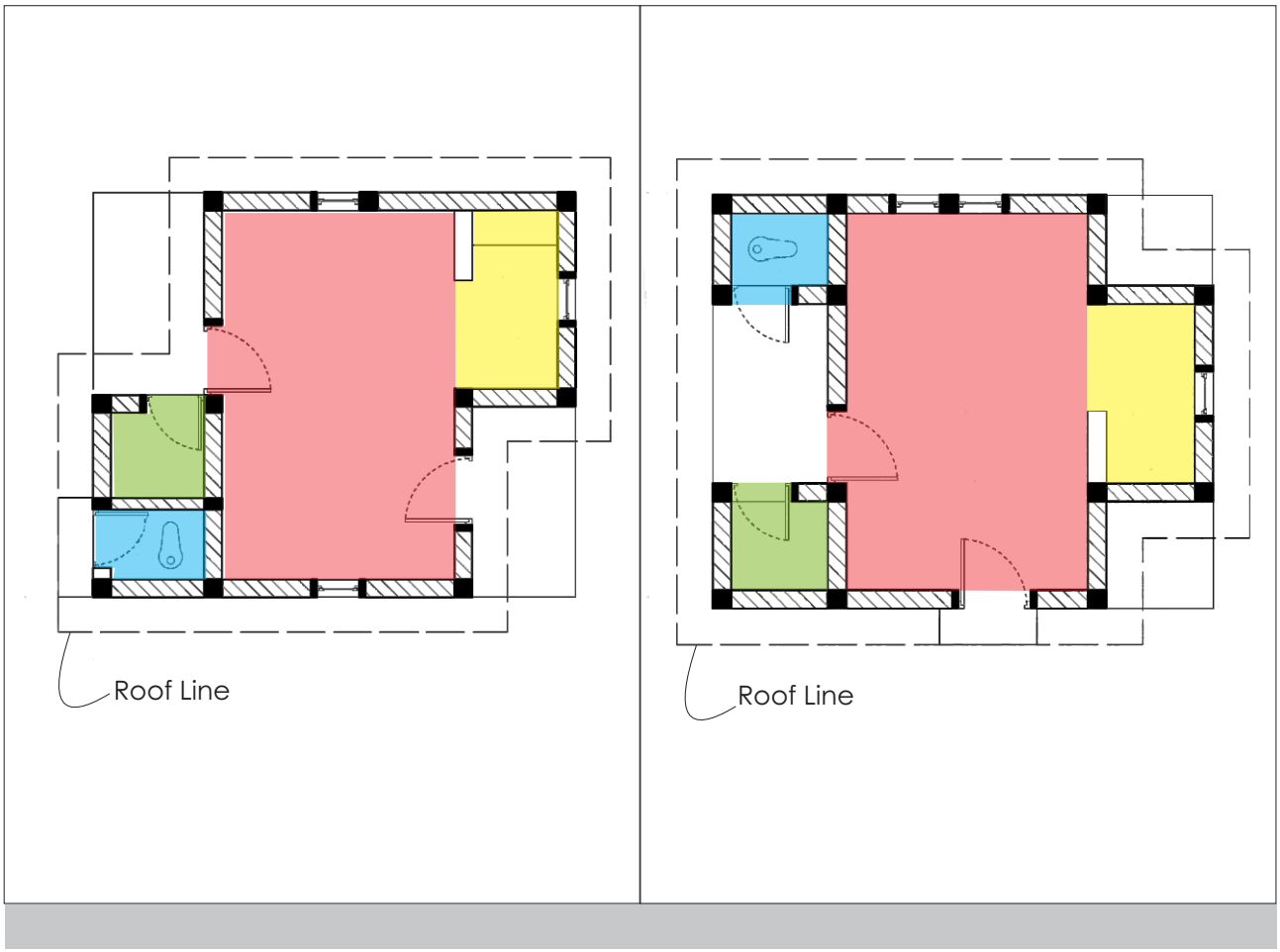
Main Room

Toilet

Bath

Kitchen

Access Road



Option 3

Built-up area: 25.54 m^2
Carpet area: 18.60 m^2

Option 4

Built-up area: 32.47 m^2
Carpet area: 19.21 m^2

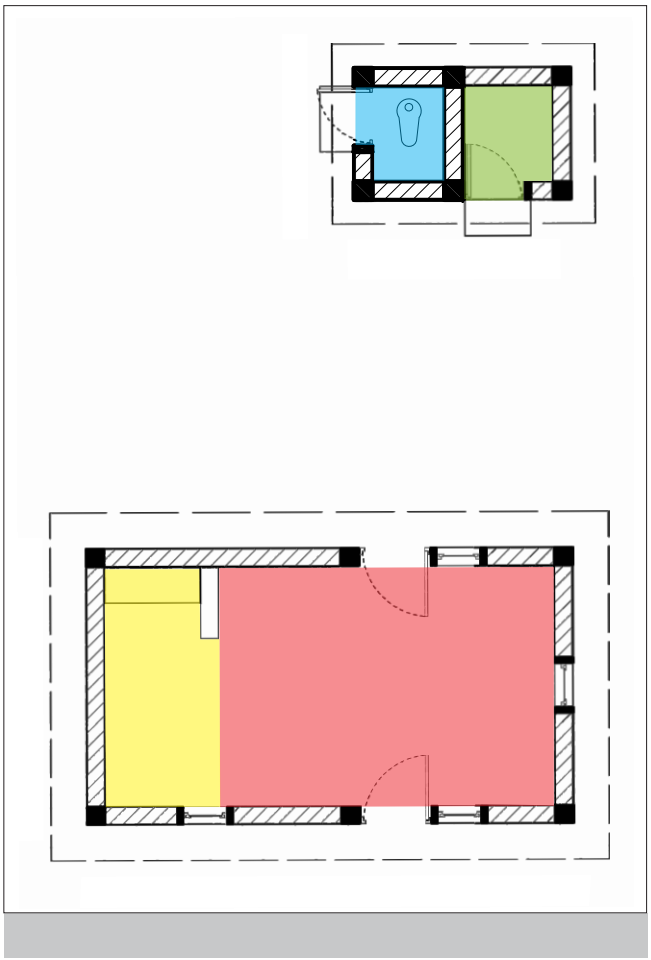
Main Room

Toilet

Bath

Kitchen

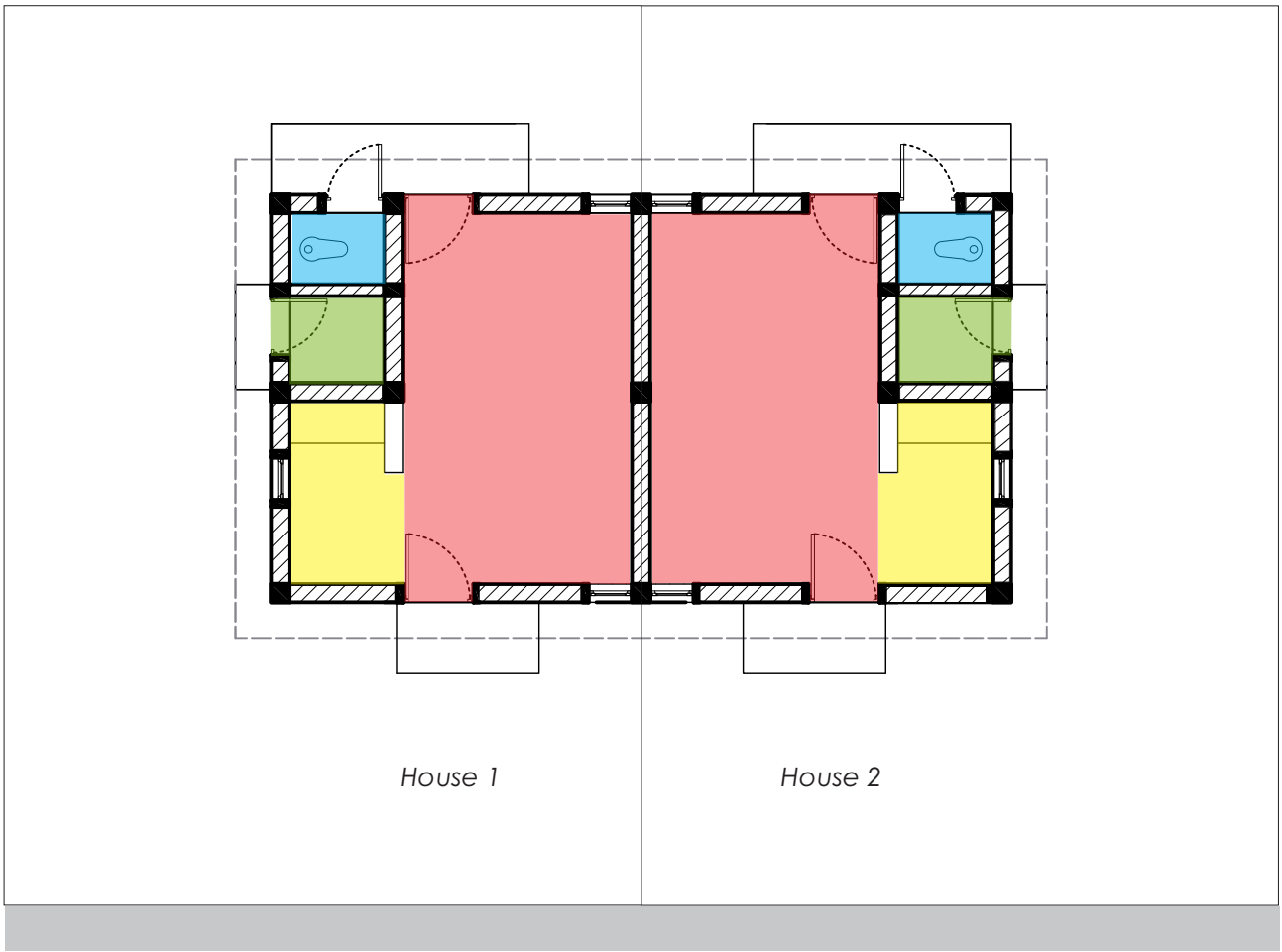
Access Road



Option 5

Built-up area: 30.53 m^2
Carpet area: 18.92 m^2

- Main Room
- Kitchen
- Toilet
- Access Road
- Bath



Option 6

Built-up area: 24.67 m^2 each house
Carpet area: 18.78 m^2 each house

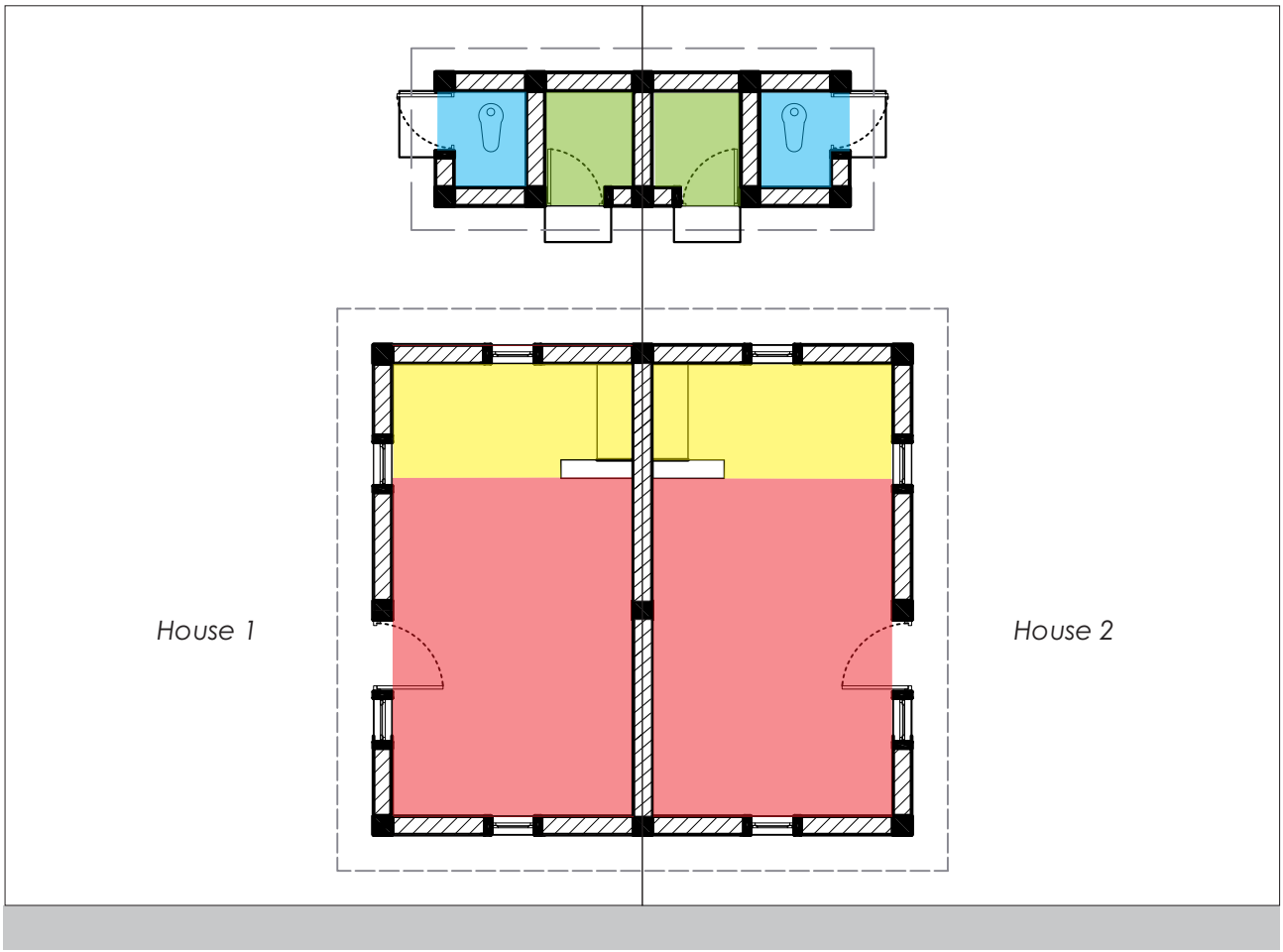
Main Room

Toilet

Bath

Kitchen

Access Road



Option 7

Built-up area: 30.53 m^2 each
Carpet area: 18.92 m^2 each

Main Room

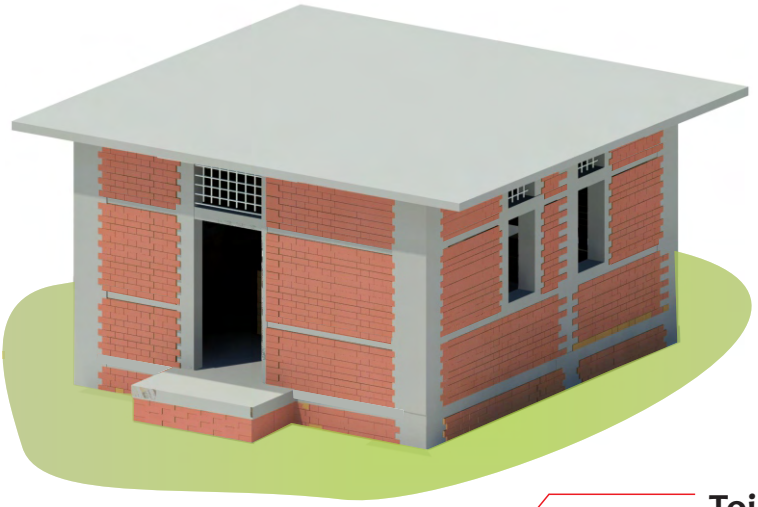
Kitchen

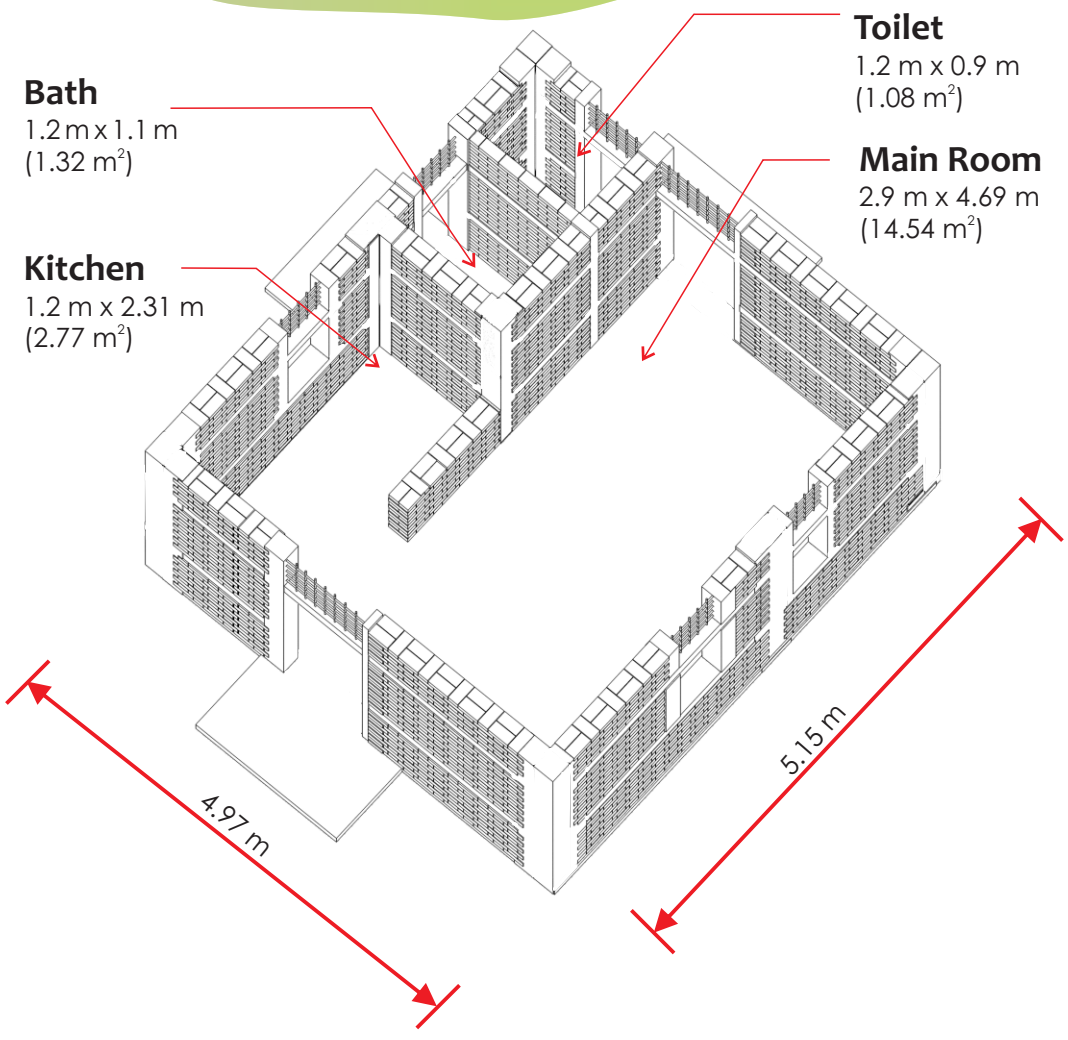
Toilet

Access Road

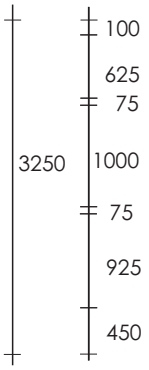
Bath

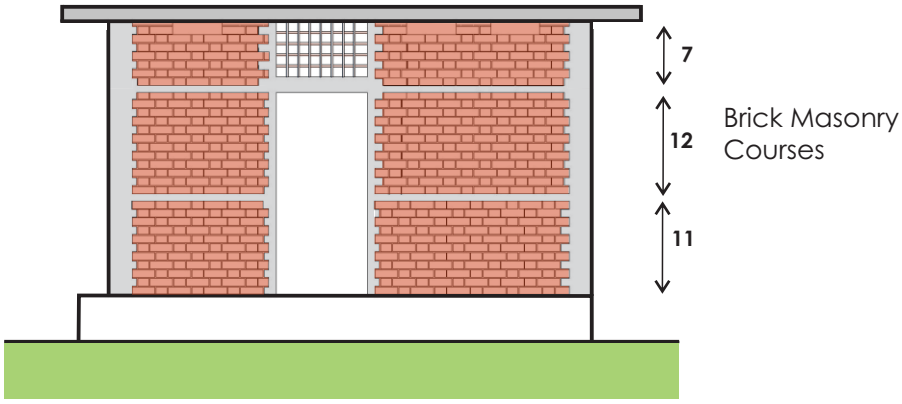
Option 1



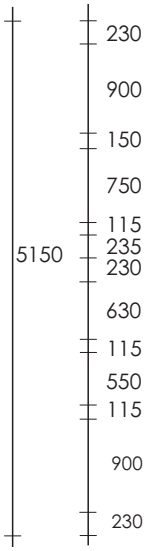

Toilet
1.2 m x 0.9 m
(1.08 m²)
Bath
1.2 m x 1.1 m
(1.32 m²)
Main Room
2.9 m x 4.69 m
(14.54 m²)
Kitchen
1.2 m x 2.31 m
(2.77 m²)
4.97 m
5.15 m

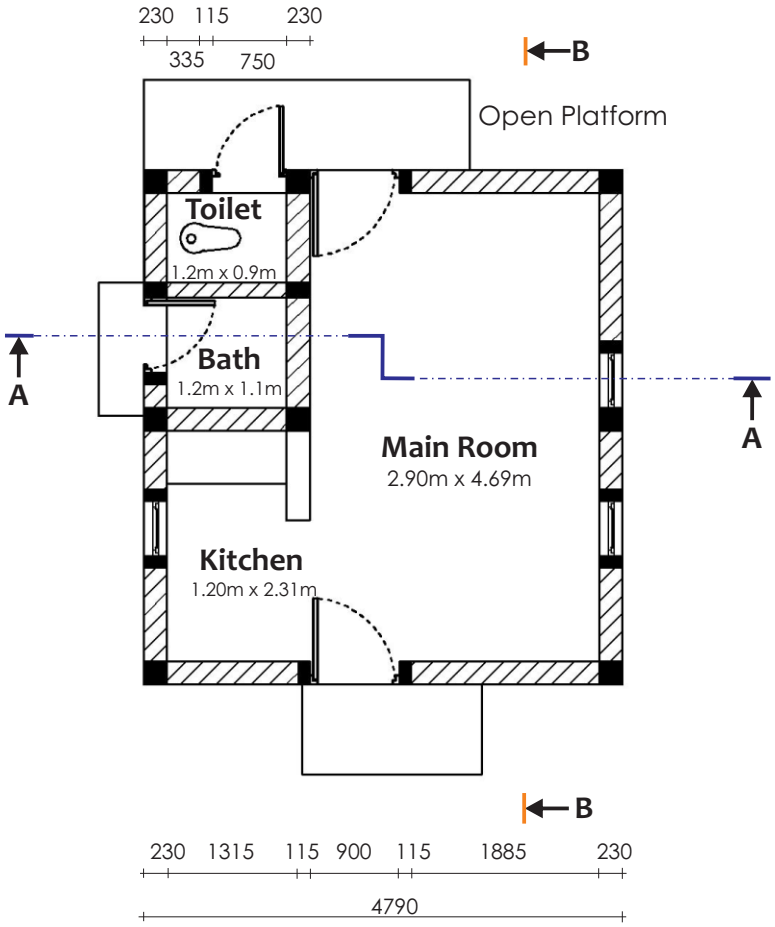
Option 1

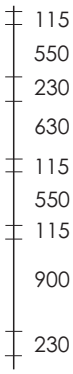




Front Elevation

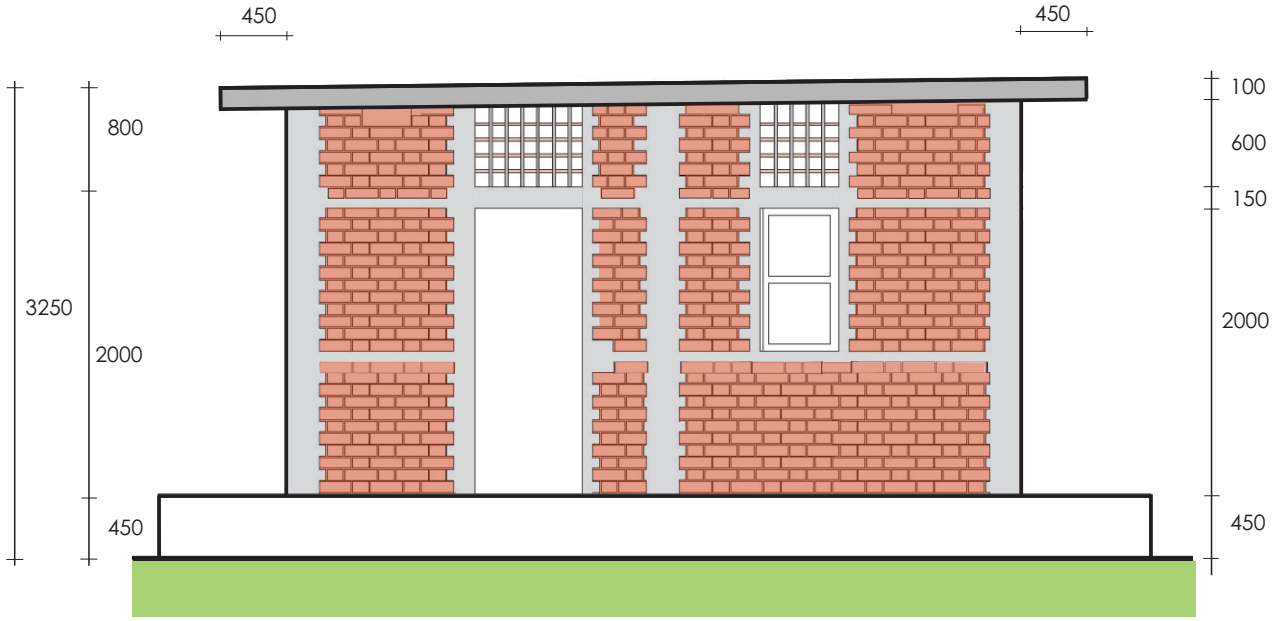






Plan

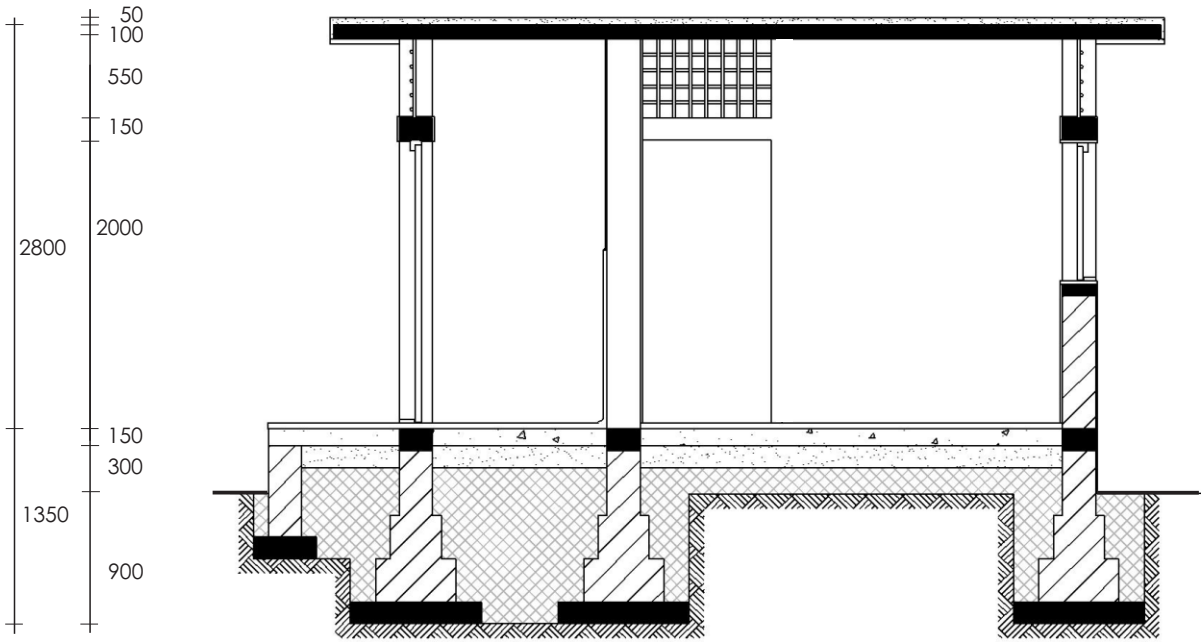
Option 1



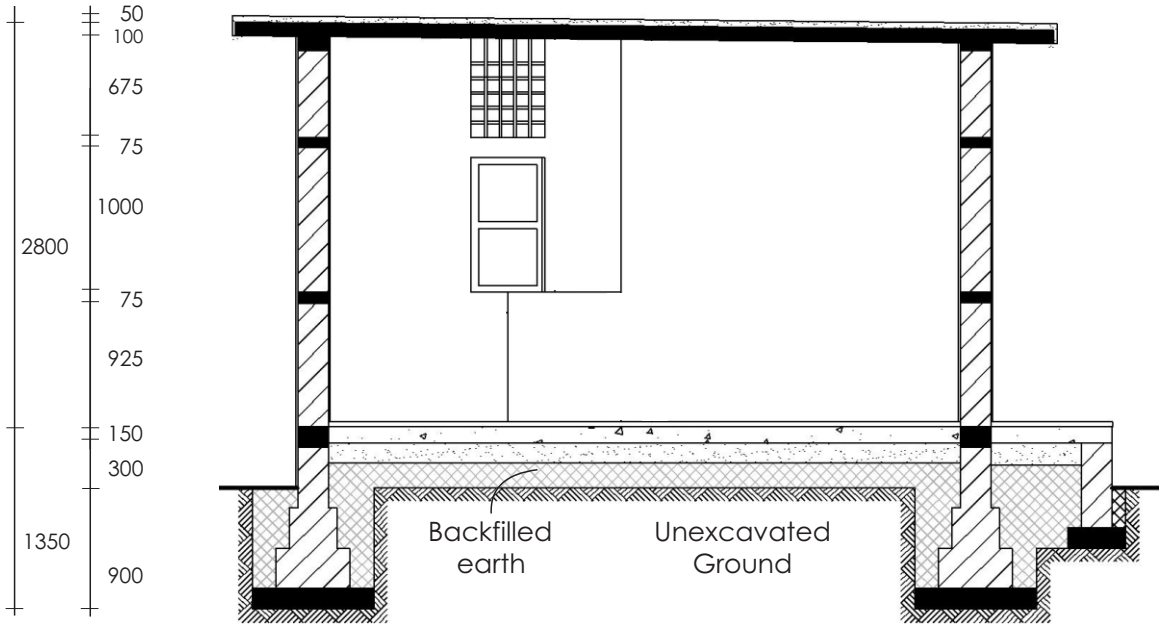
Left Elevation

Right Elevation

Option 1

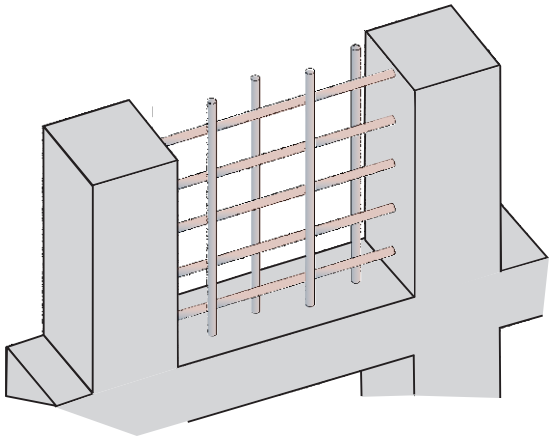


Section A-A

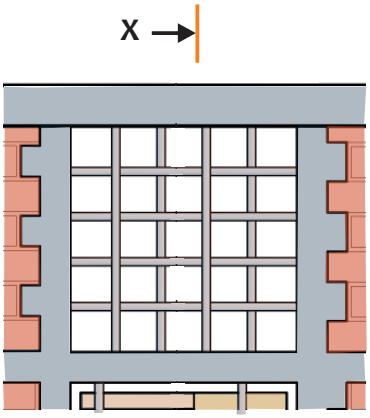


Section B-B

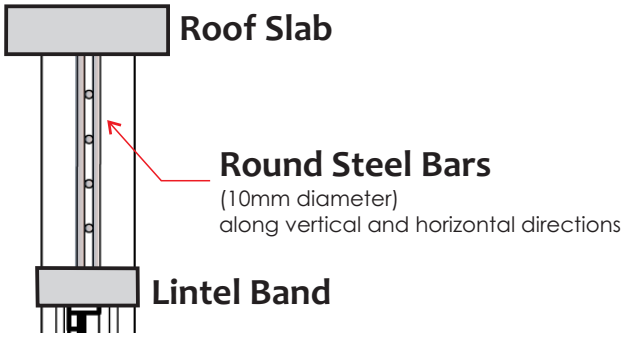
Option 1



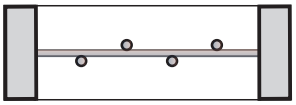
Ventilator
with Built-in Steel Grill



Elevation

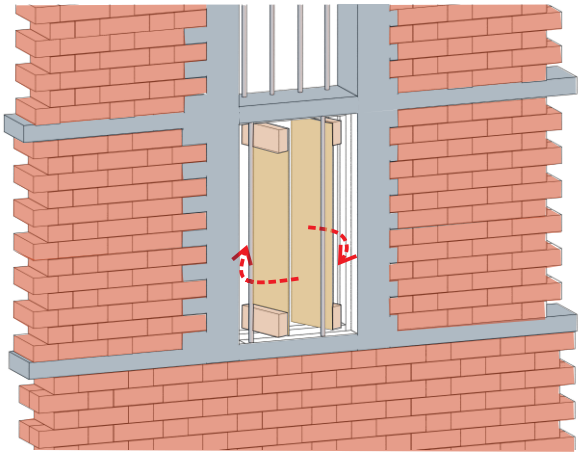


Section X-X

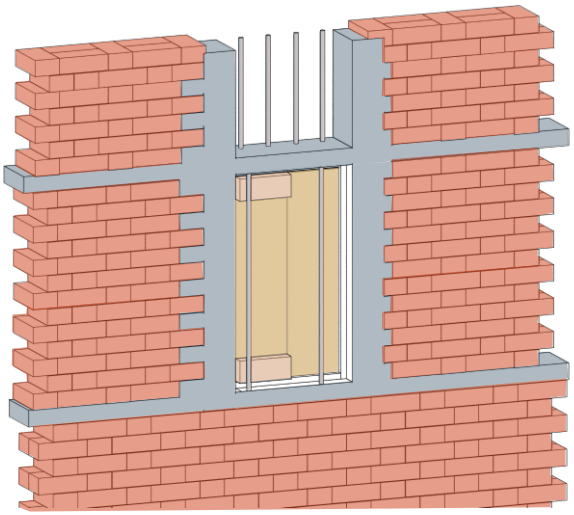


Plan

Option 1

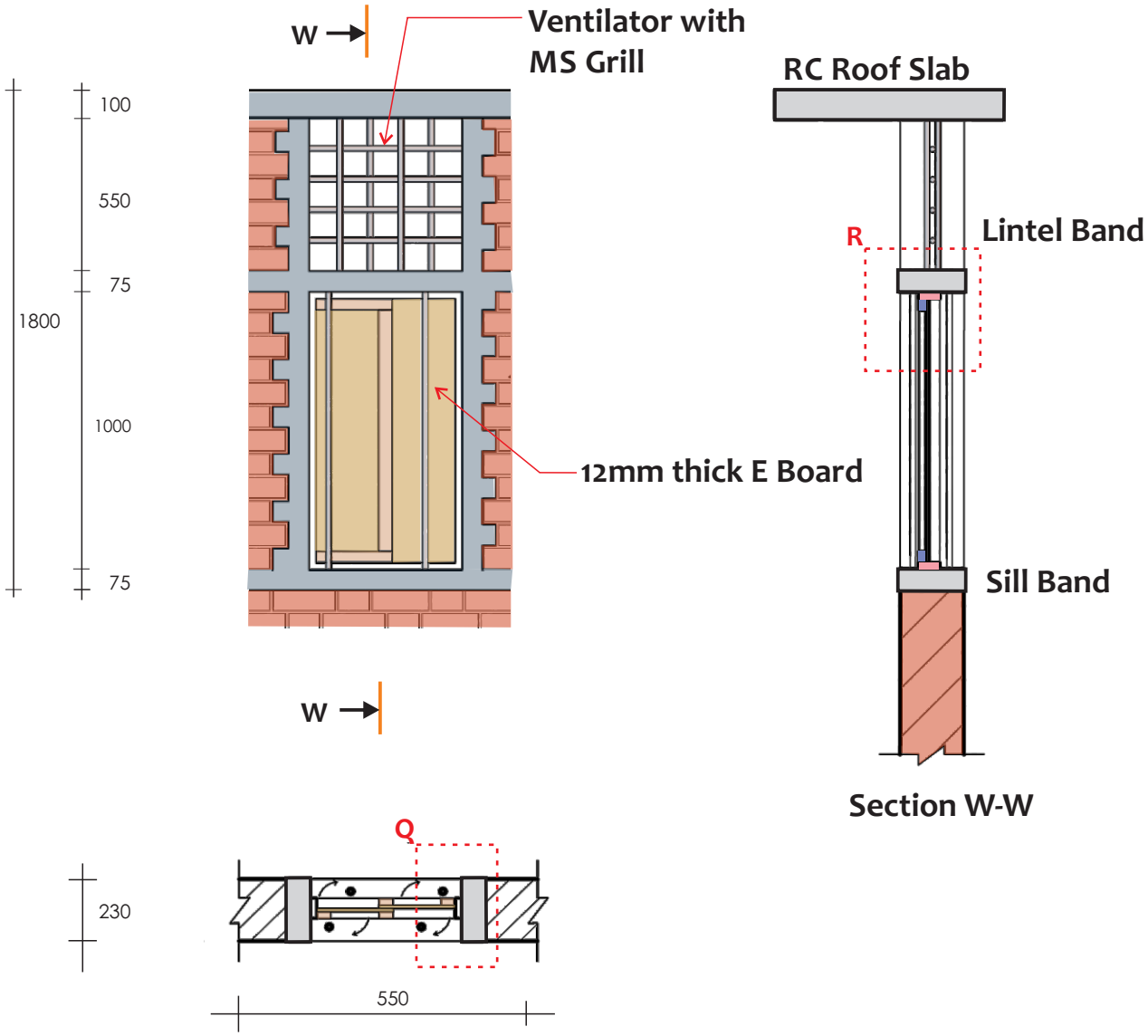


Pivoted Window
Open Position



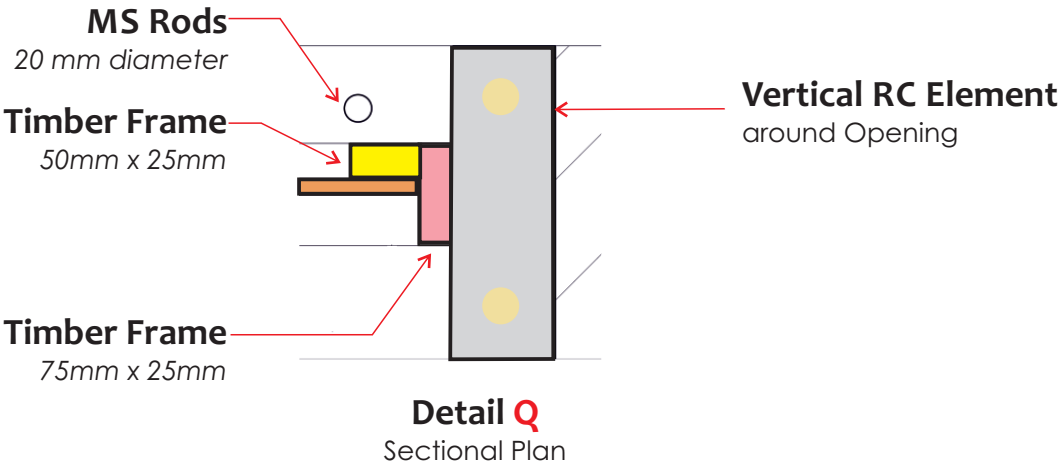
Pivoted Window
Closed Position

Option 1

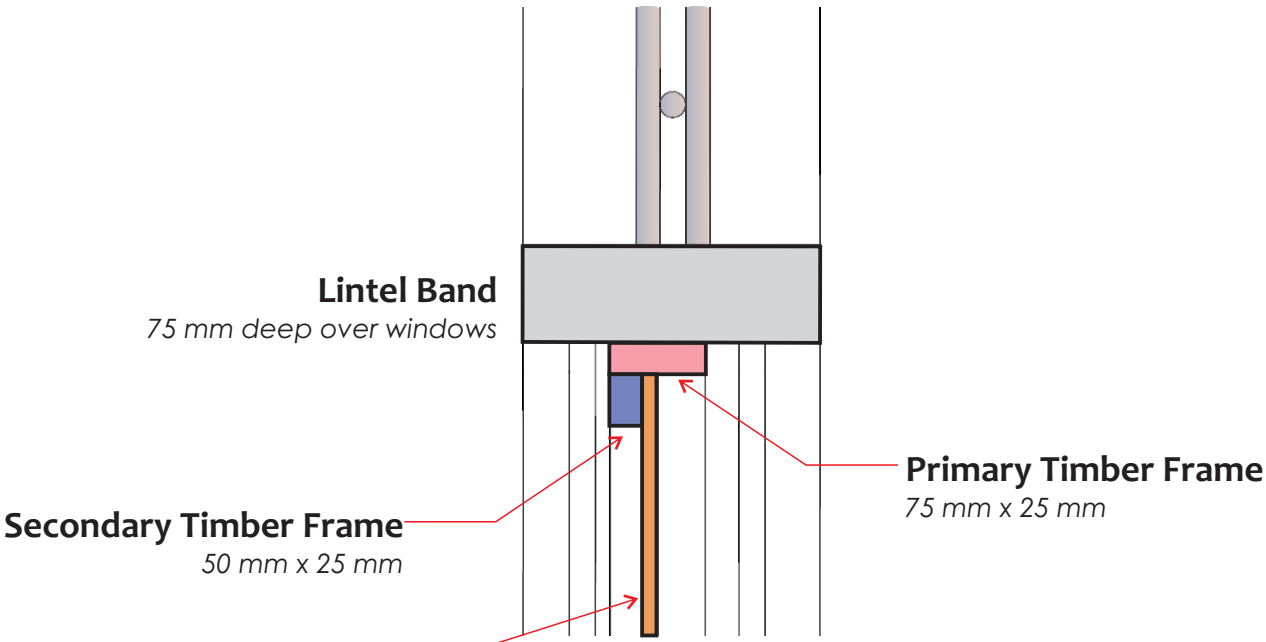


Window Details

Option 1

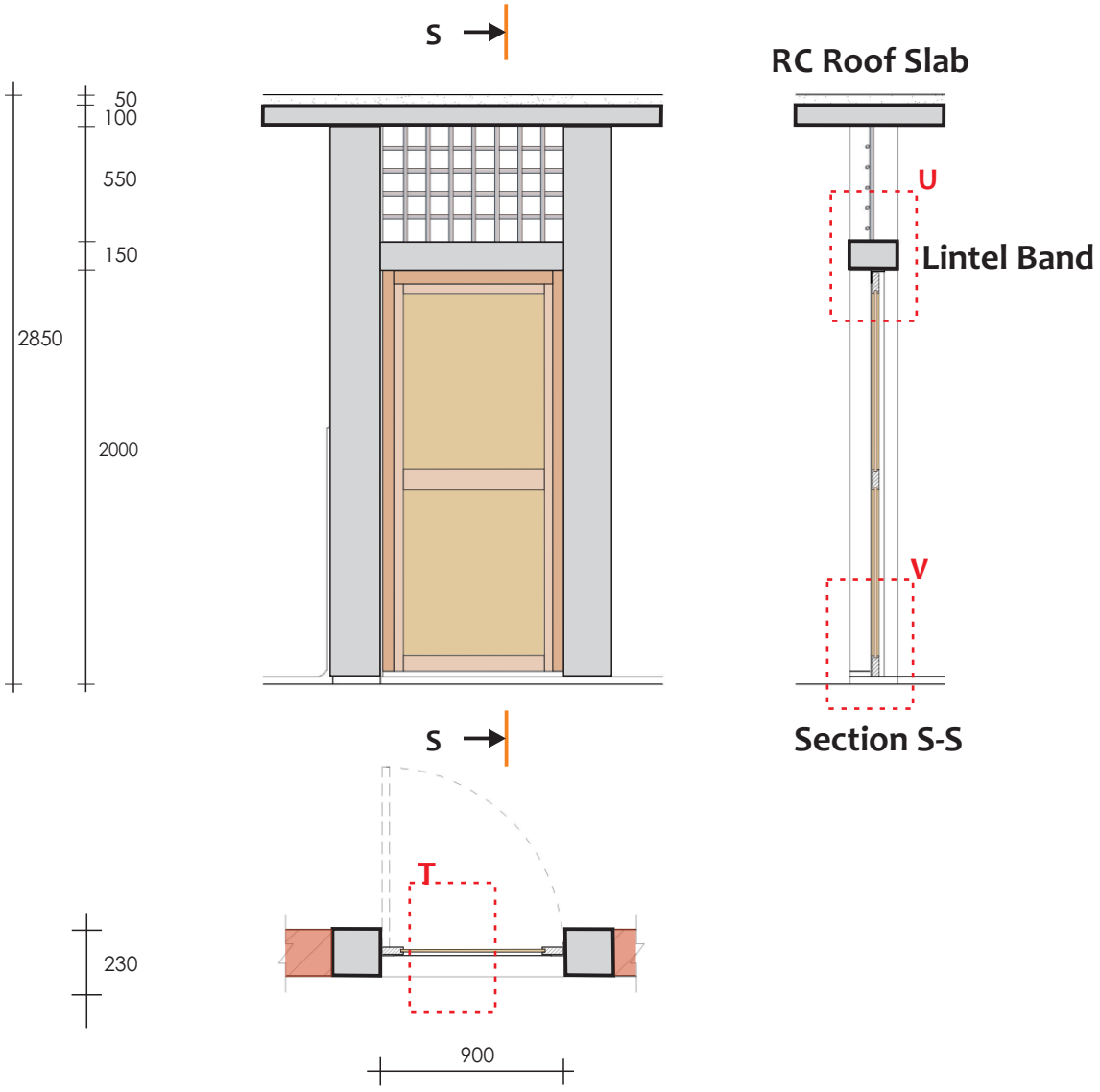


Detail Q
Sectional Plan



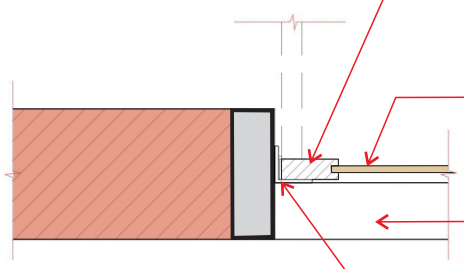
Detail R
Sectional Elevation

Option 1



Door Details

Option 1



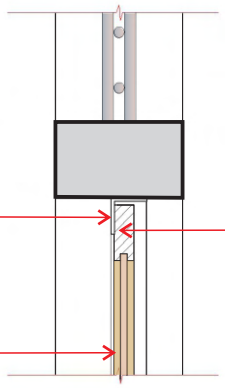
T.W. member
100 mm x 36mm

E Board
12mm thick

I.P.S Threshold
38mm x100 mm

Detail T
Sectional Plan

MS Angle
65mm x 65mm x 6mm

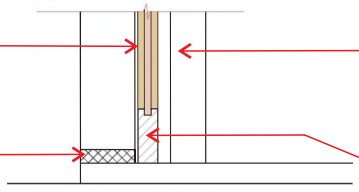


MS Angle
65mm x 65mm x 6mm

E Board
12mm thick

T.W. member
100 mm x 36mm

Detail U
Sectional Elevation



E Board
12mm thick

I.P.S Threshold
38mm x100 mm

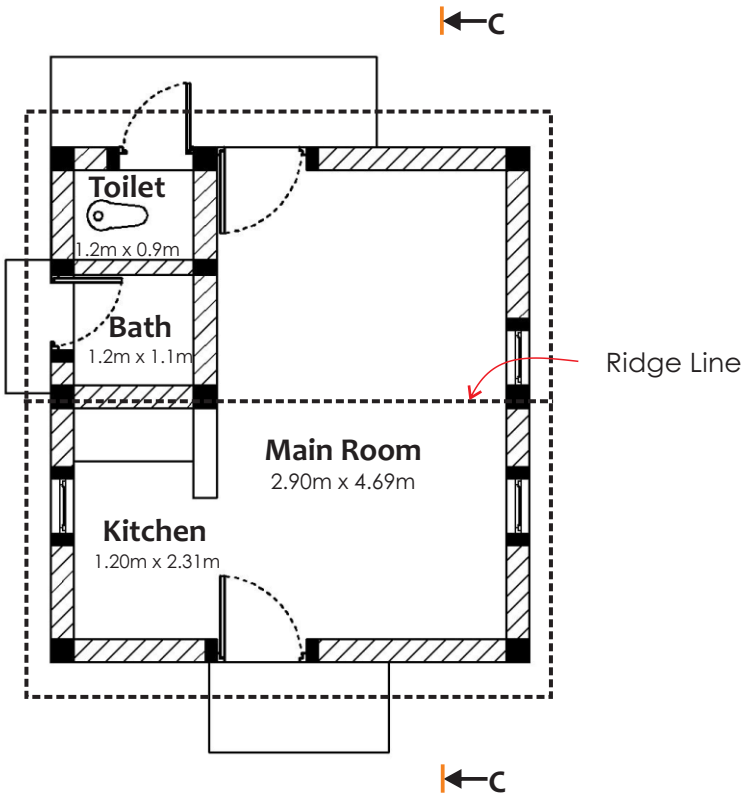
MS Angle
65mm x 65mm x 6mm

T.W. member
100 mm x 36mm

Detail V
Sectional Elevation

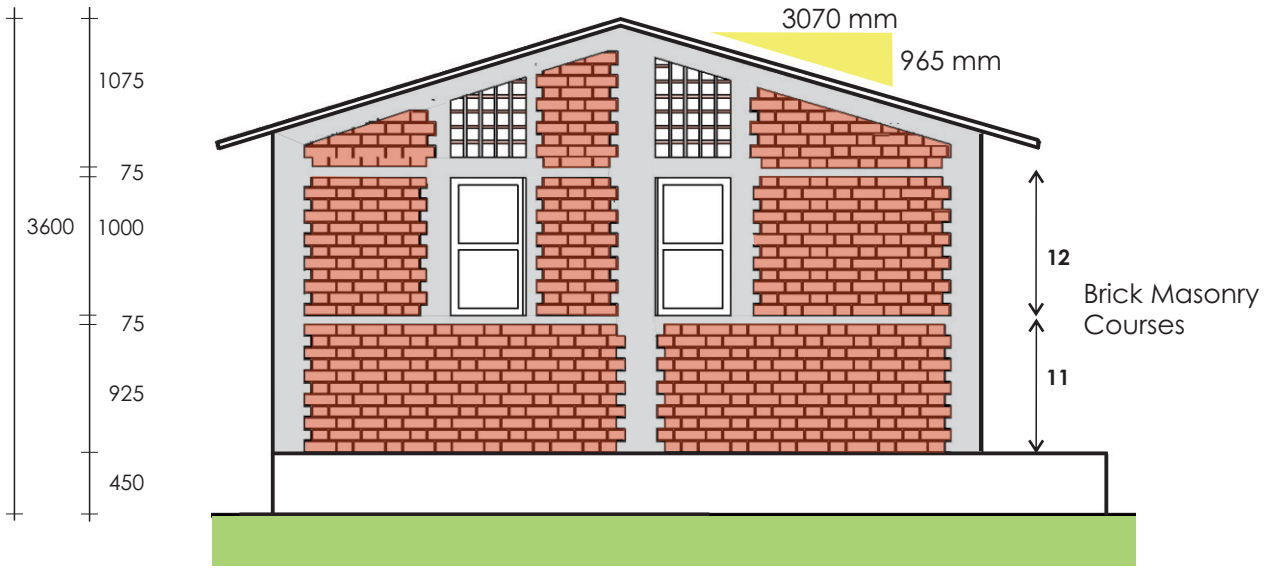
Option 1

House with sloping roof

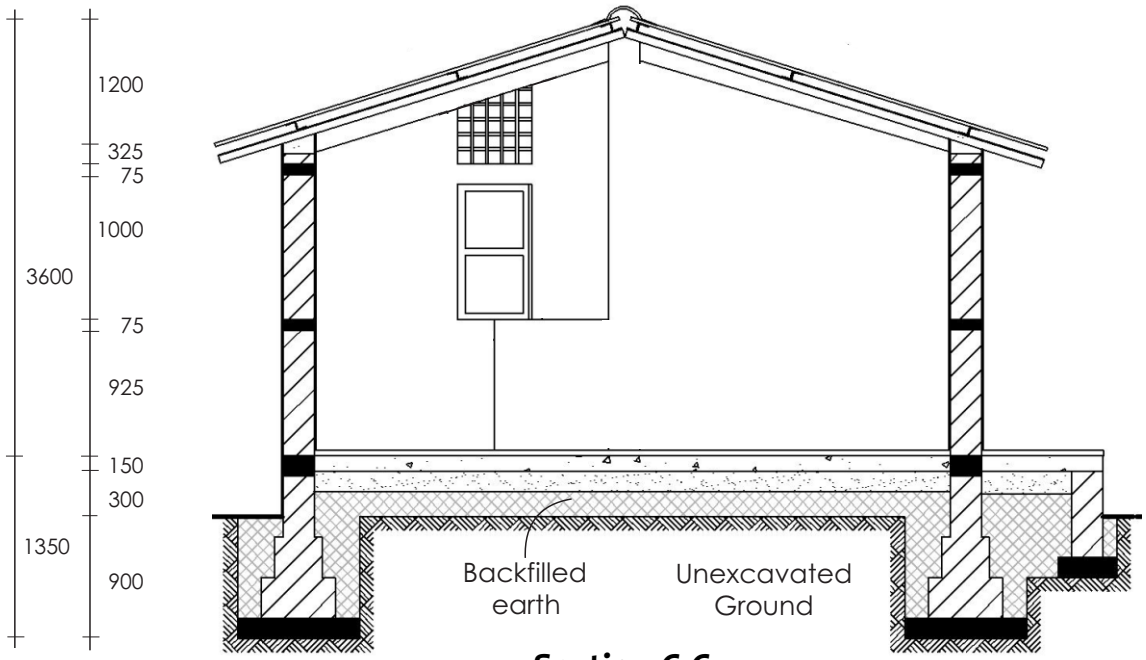


Plan

Option 1



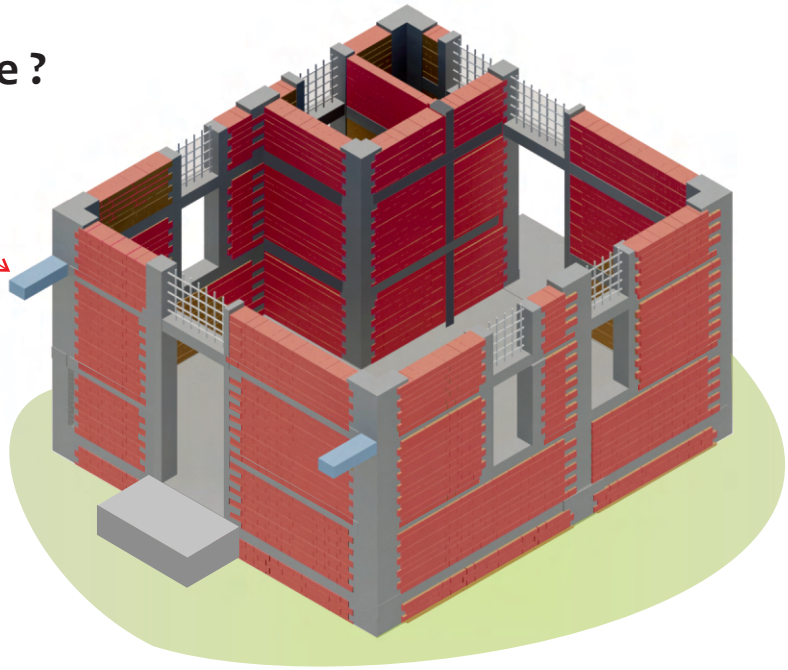
Right Elevation



Section C-C

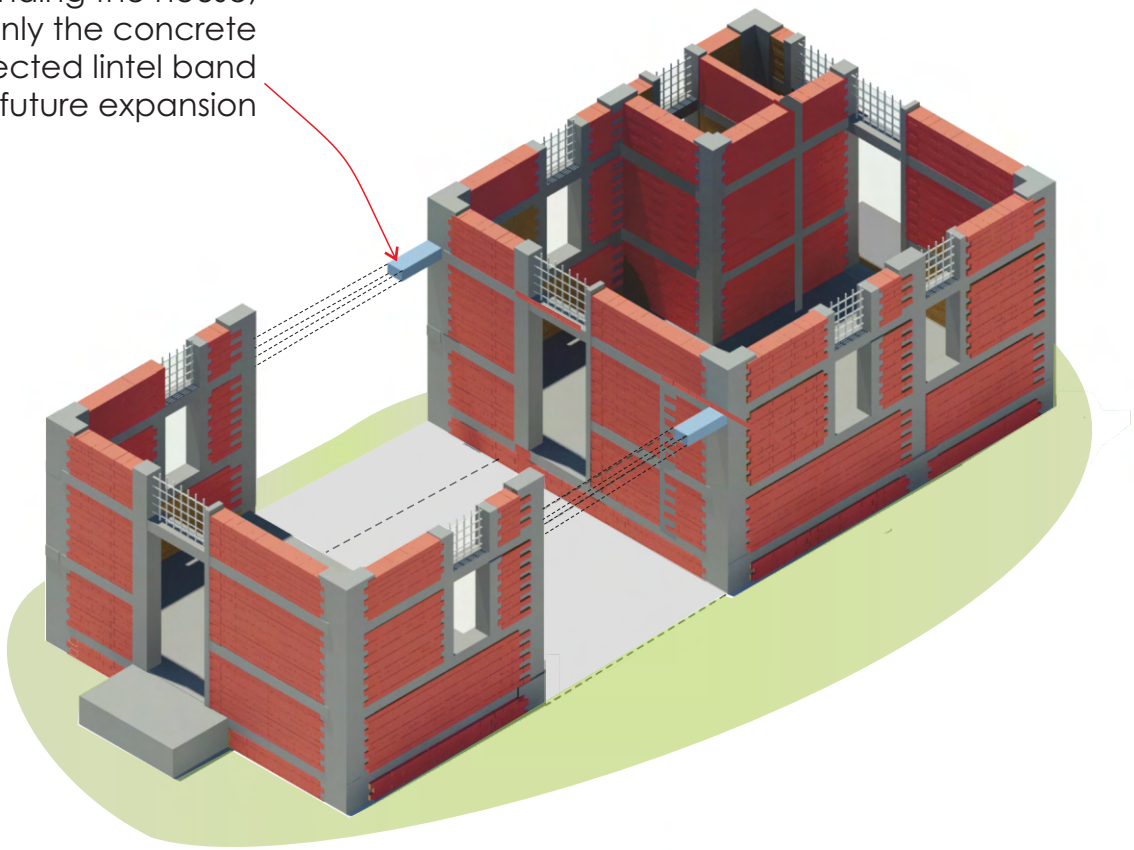
Option 1 Extended

How to extend my house ?

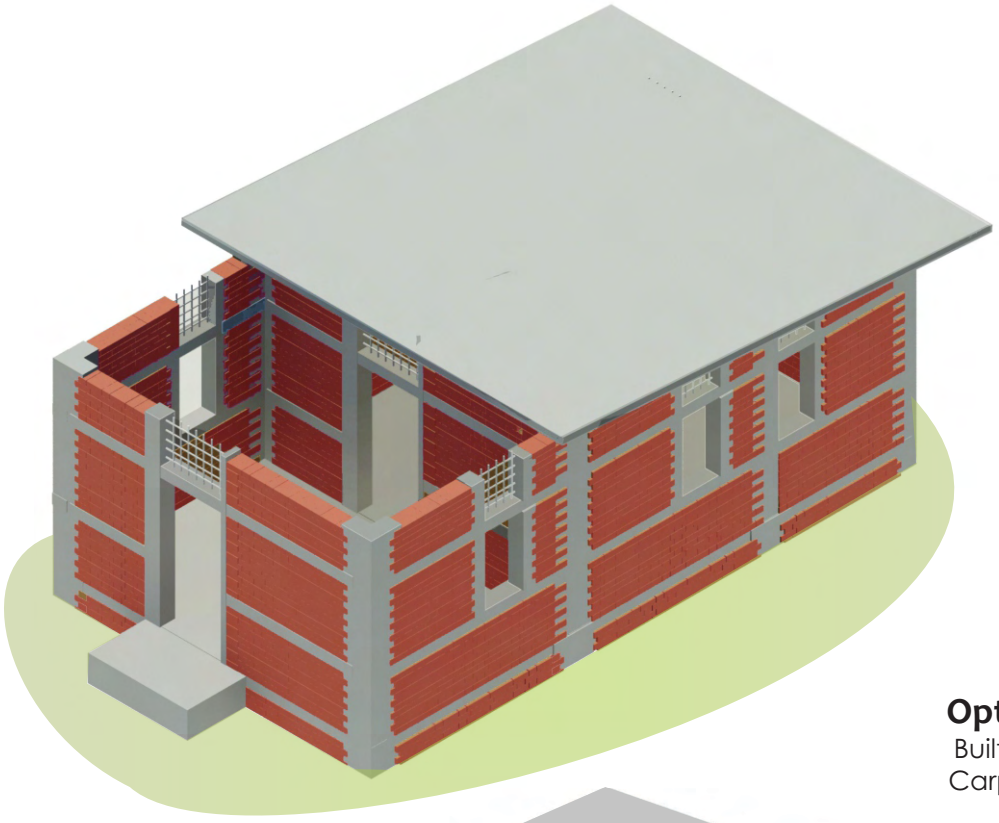


To extend the house, leave a 600mm projection from the Lintel Band in the direction of proposed expansion

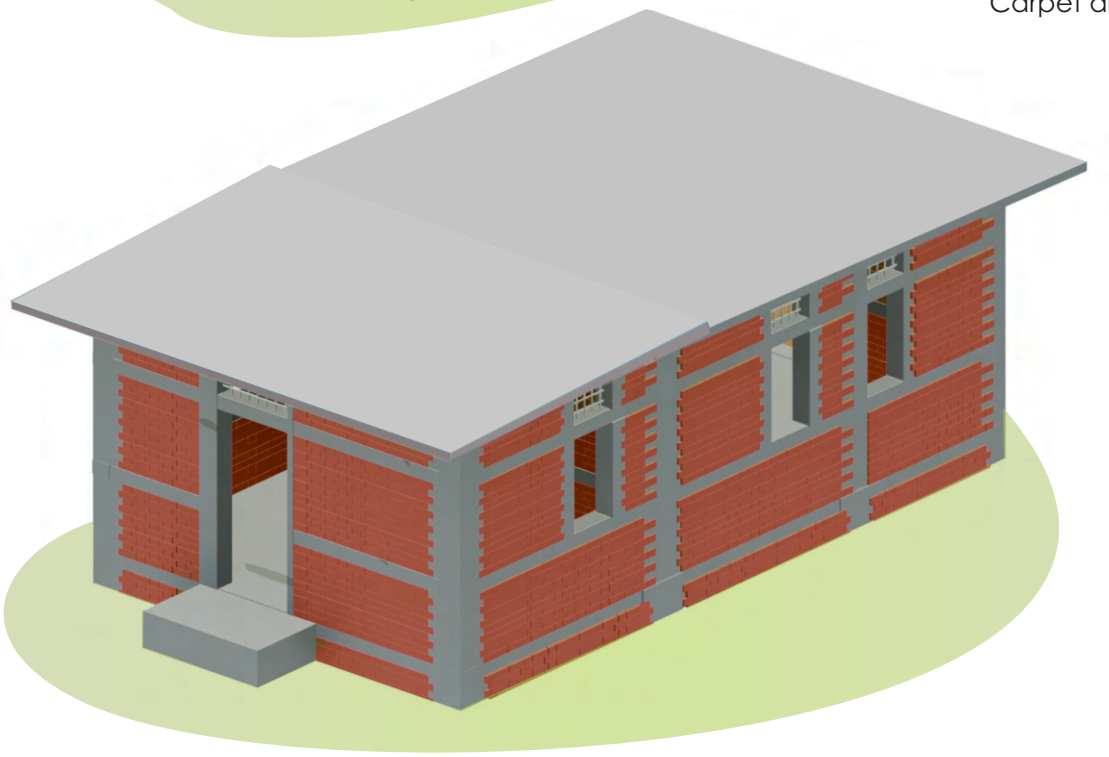
While extending the house, chip only the concrete from the projected lintel band left for future expansion



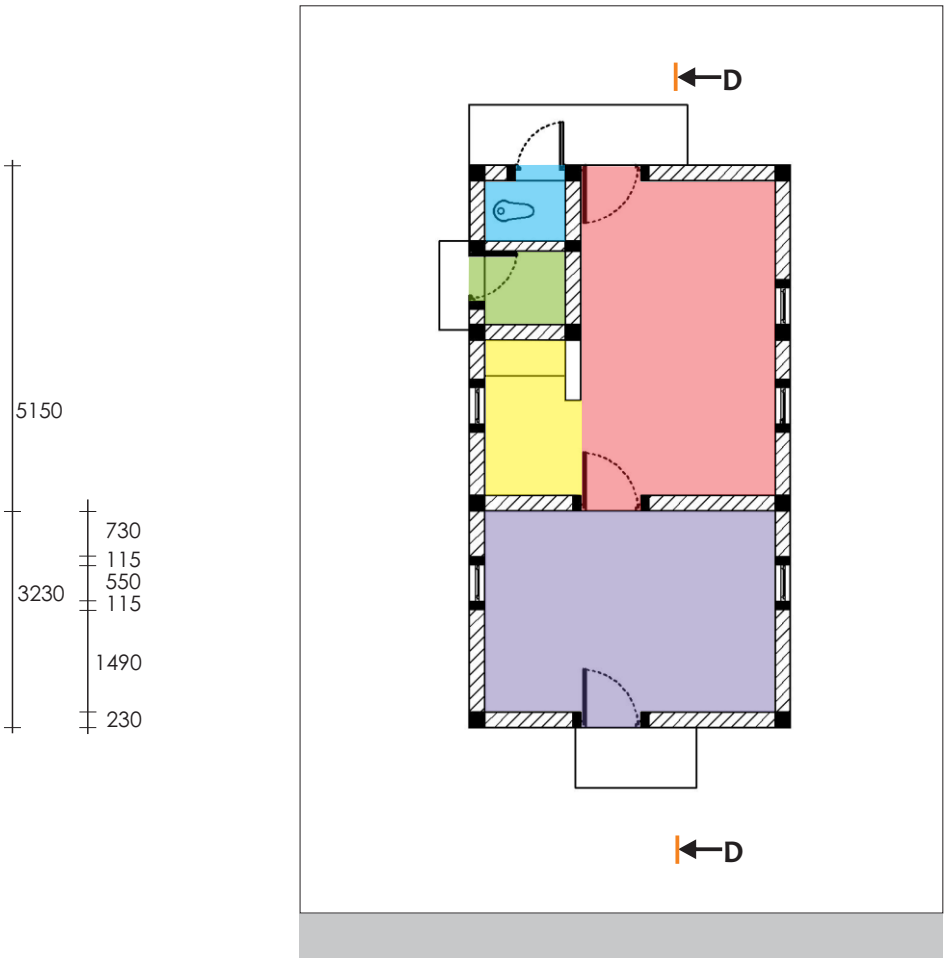
Option 1 Extended



Option 1 Extended
Built-up area: 40.14 m^2
Carpet area: 31.77 m^2



Option 1 Extended



Plan

Main Room

Kitchen

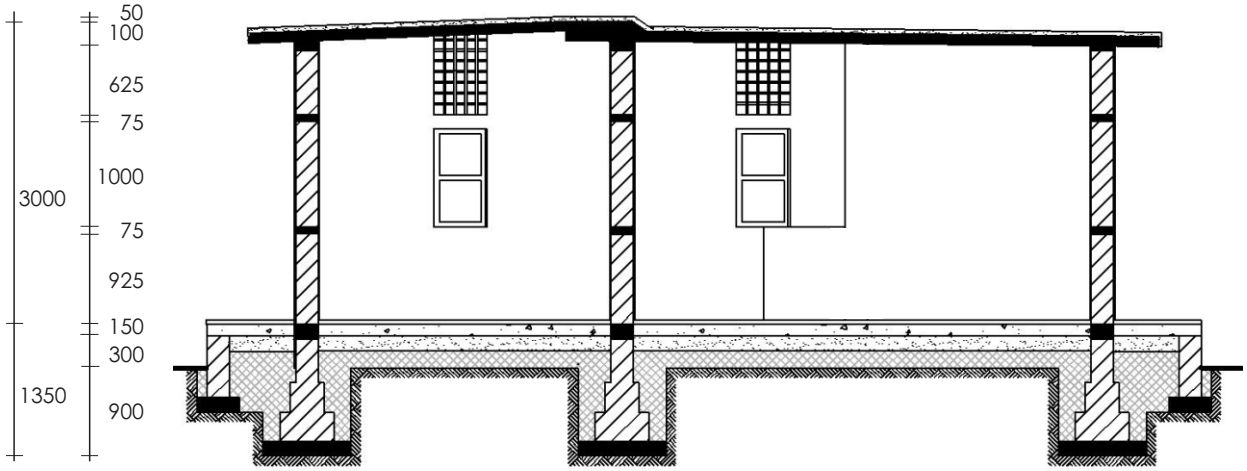
Toilet

Access Road

Bath

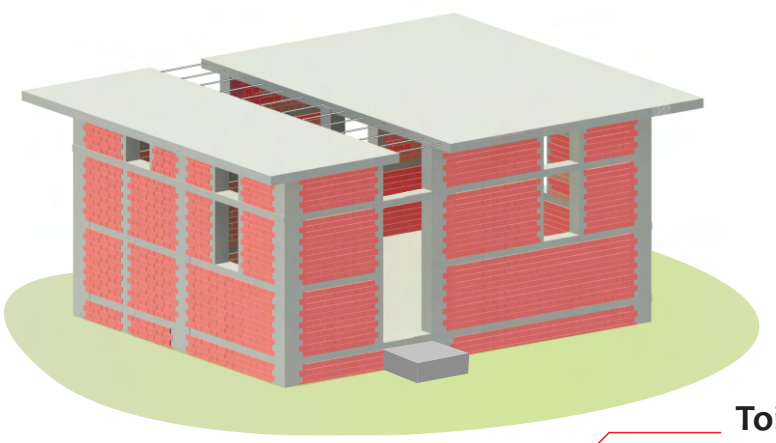
Additional Room

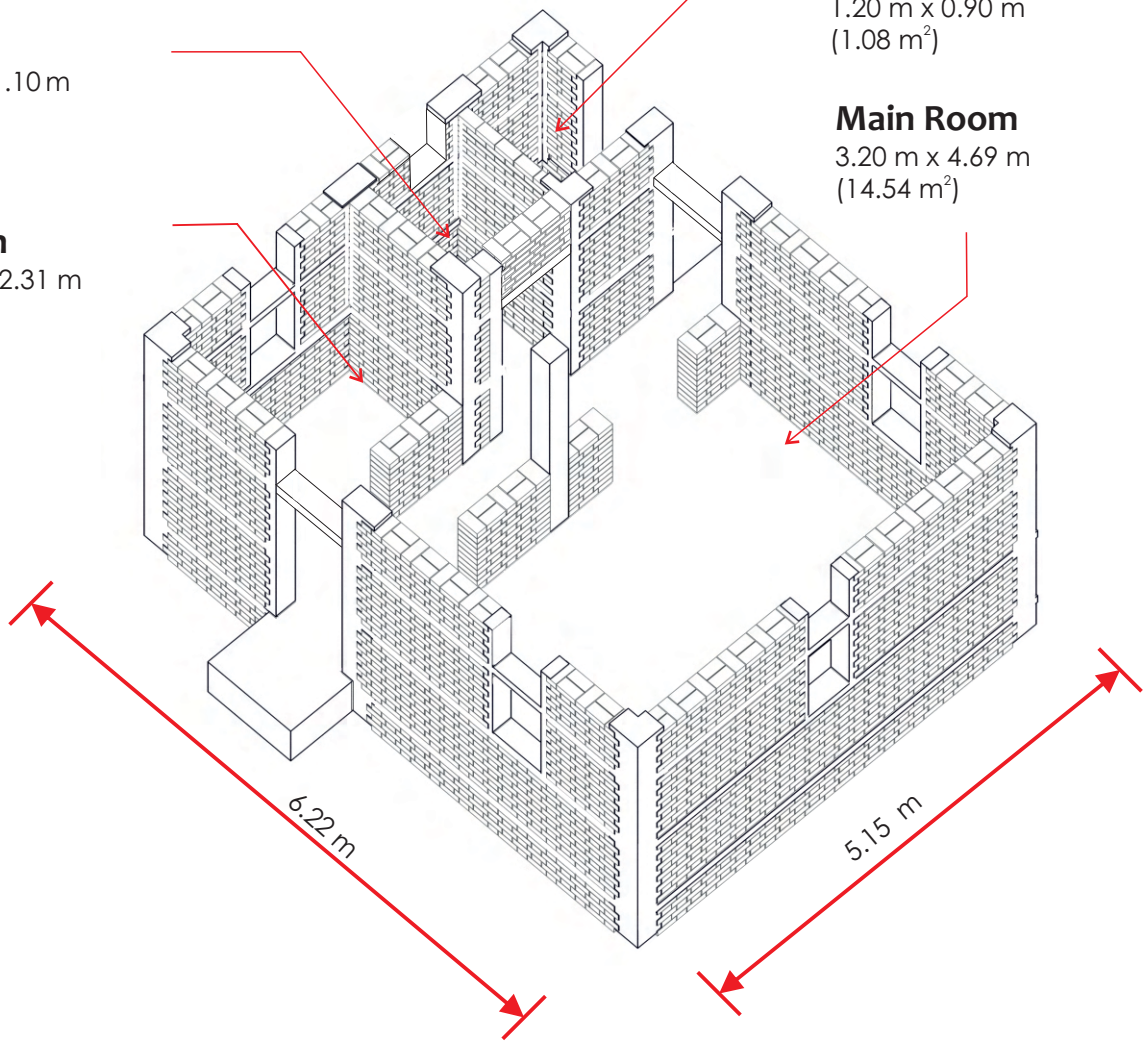
Option 1 Extended



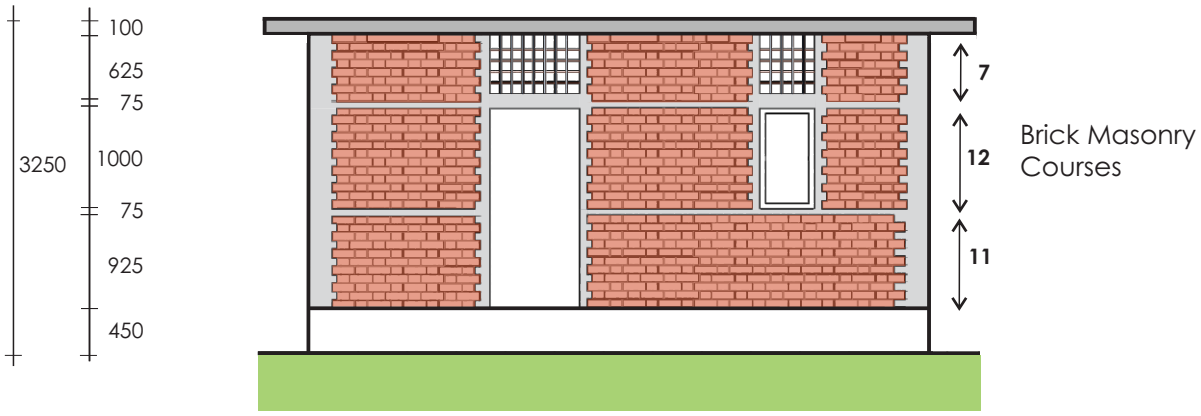
Section D-D

Option 2

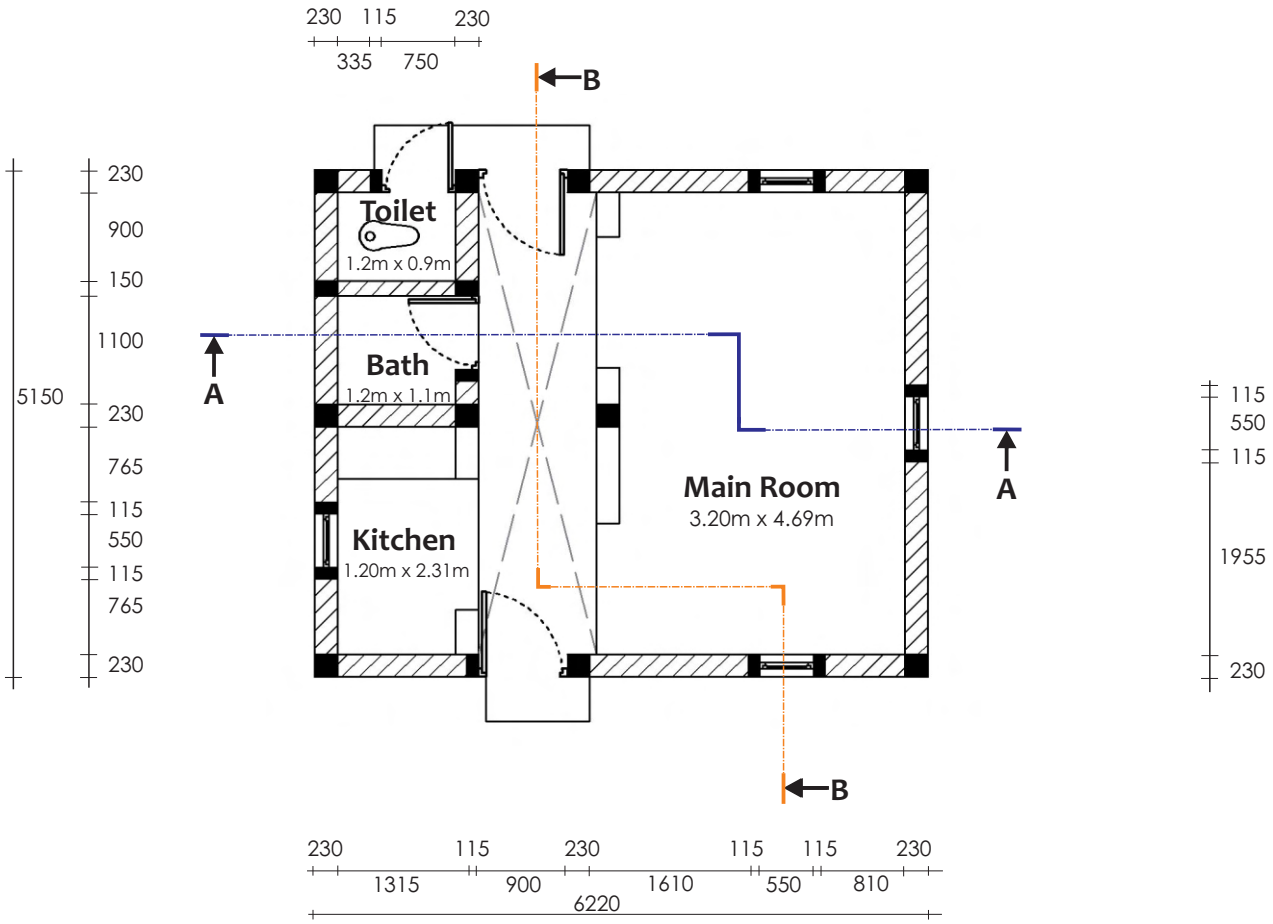



Toilet
1.20 m x 0.90 m
(1.08 m²)
Bath
1.20 m x 1.10 m
(1.32 m²)
Main Room
3.20 m x 4.69 m
(14.54 m²)
Kitchen
1.20 m x 2.31 m
(2.77 m²)
6.22 m
5.15 m

Option 2

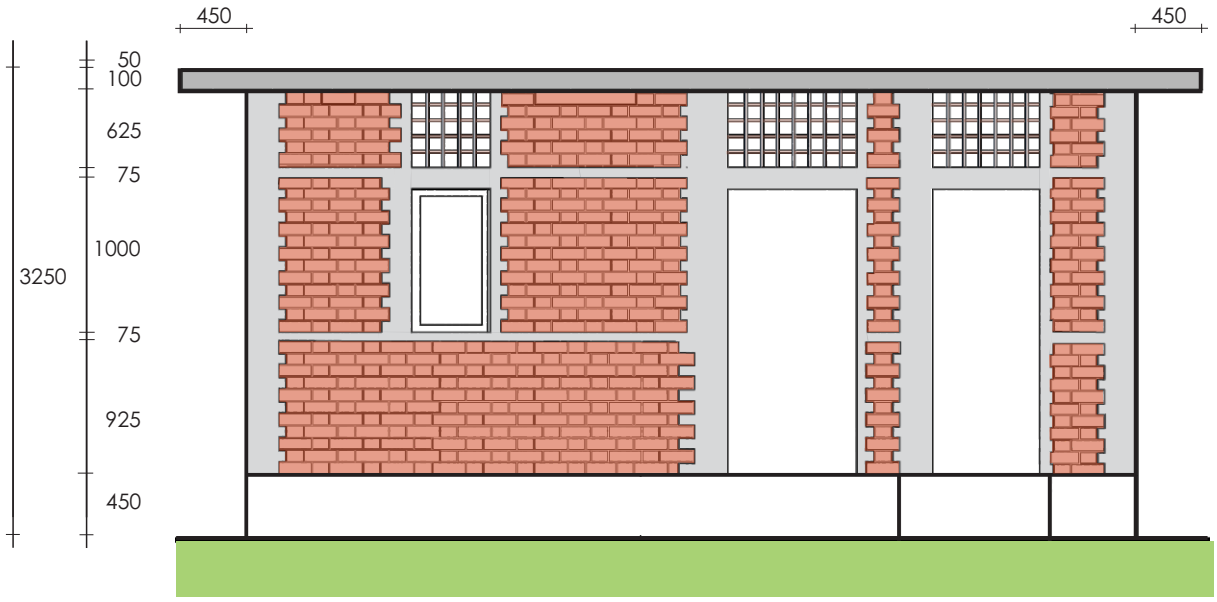


Front Elevation

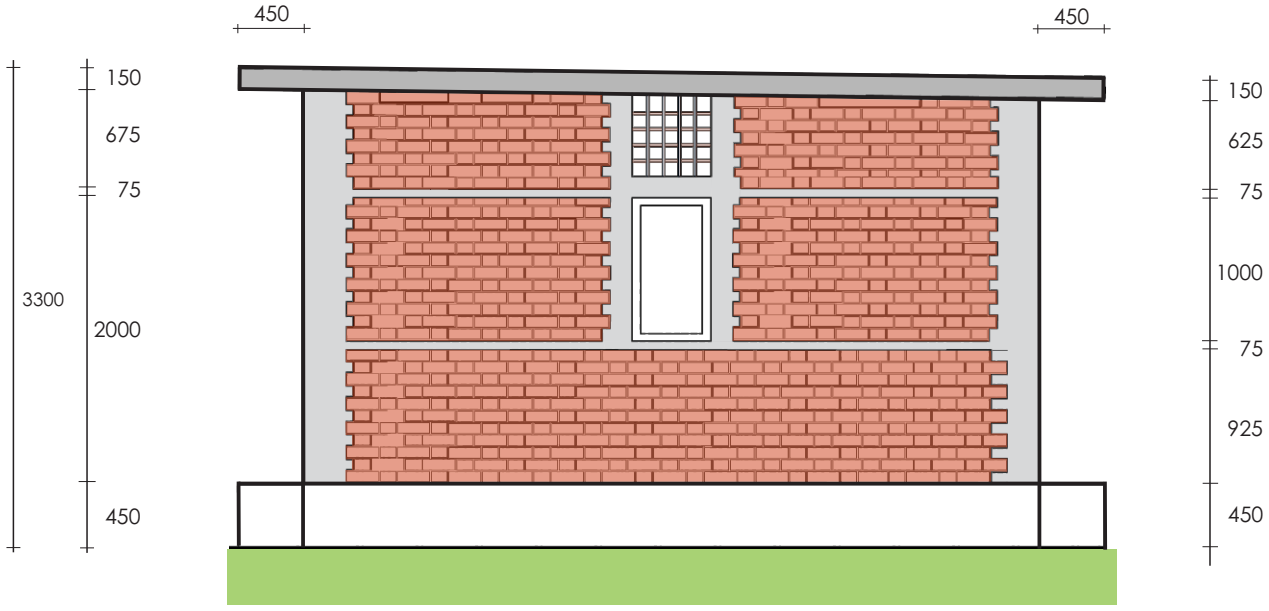


Plan

Option 2

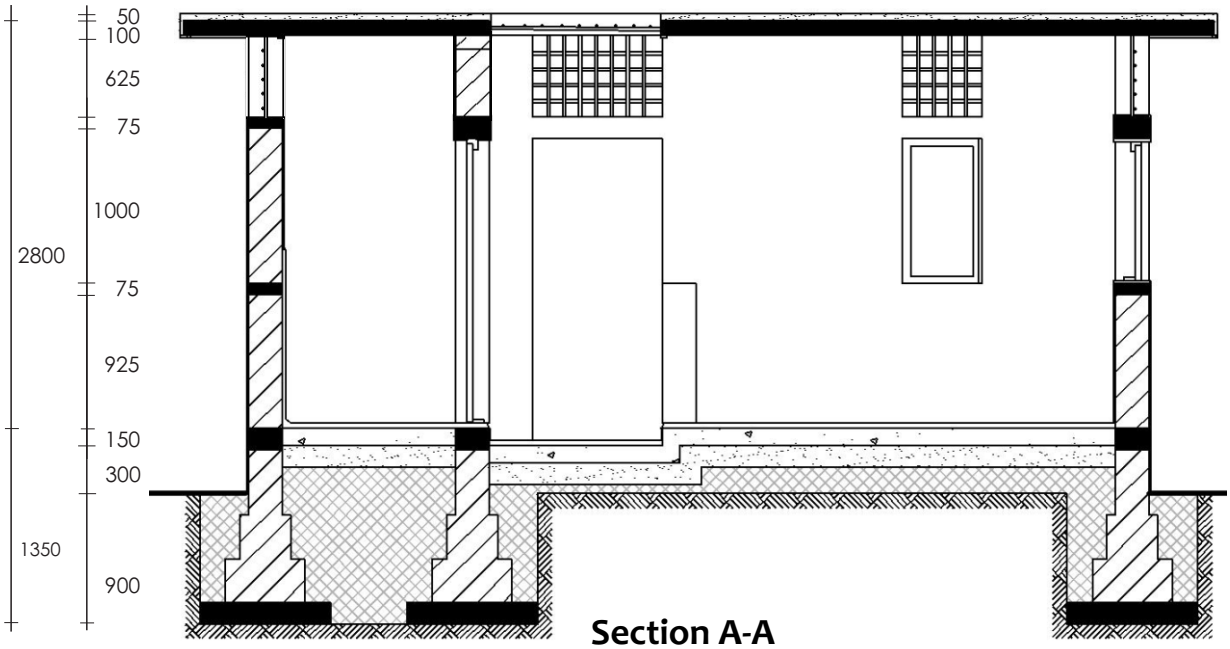


Back Elevation

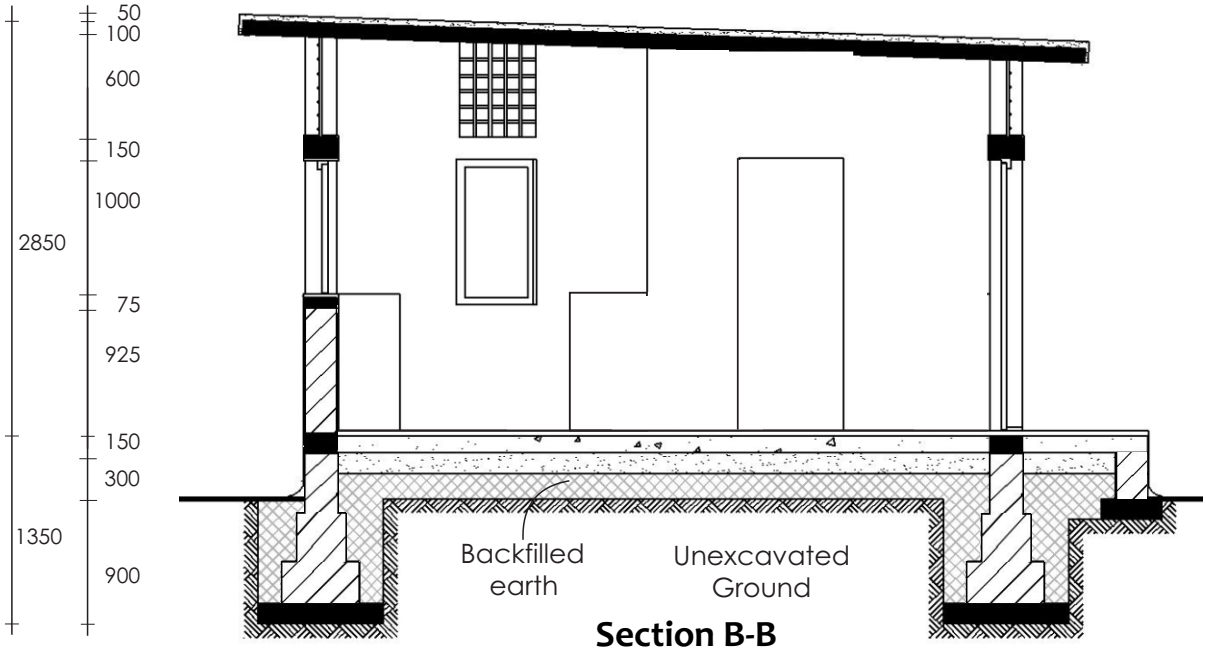


Right Elevation

Option 2



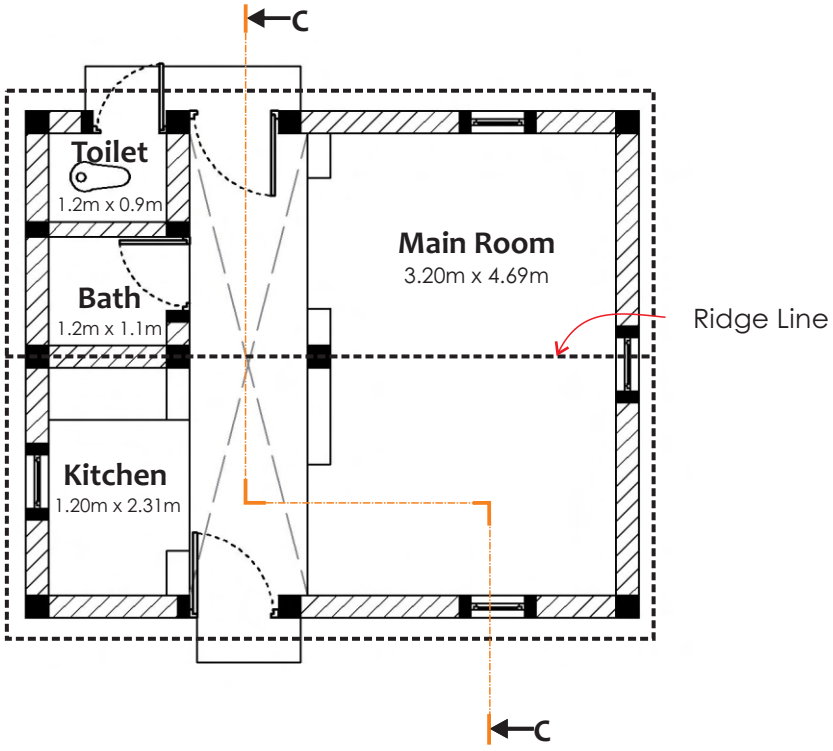
Section A-A



Section B-B

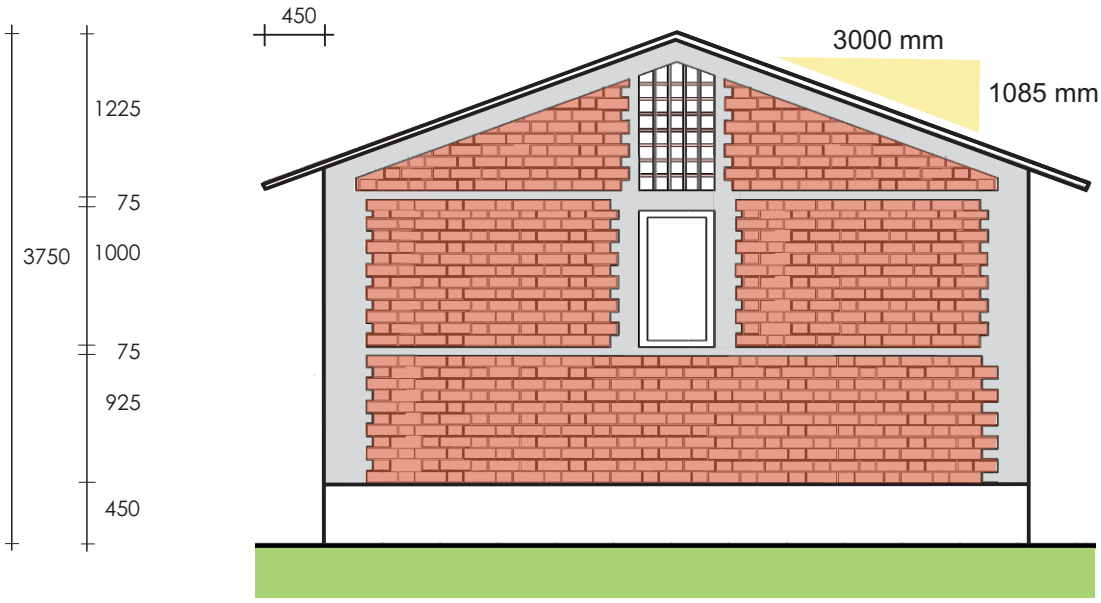
Option 2

House with sloping roof

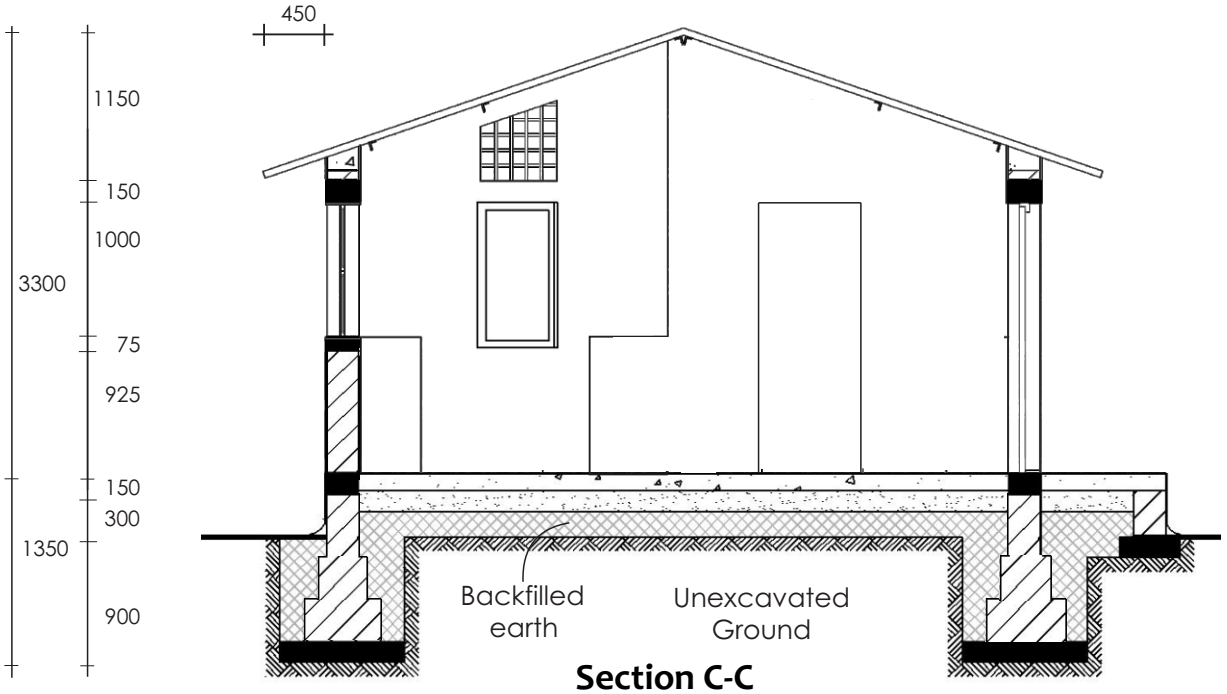


Plan

Option 2



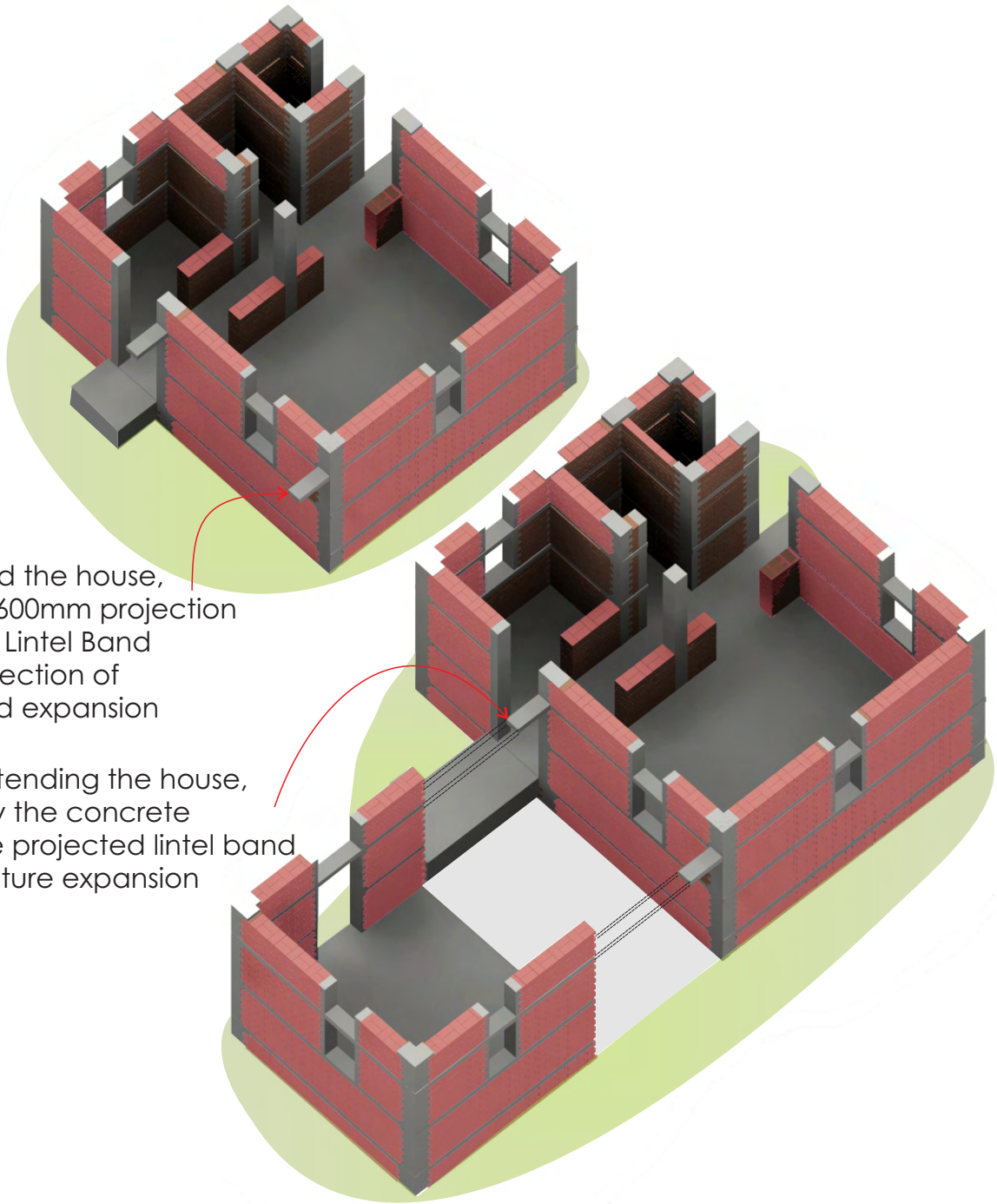
Right Side Elevation



Section C-C

Option 2 Extended

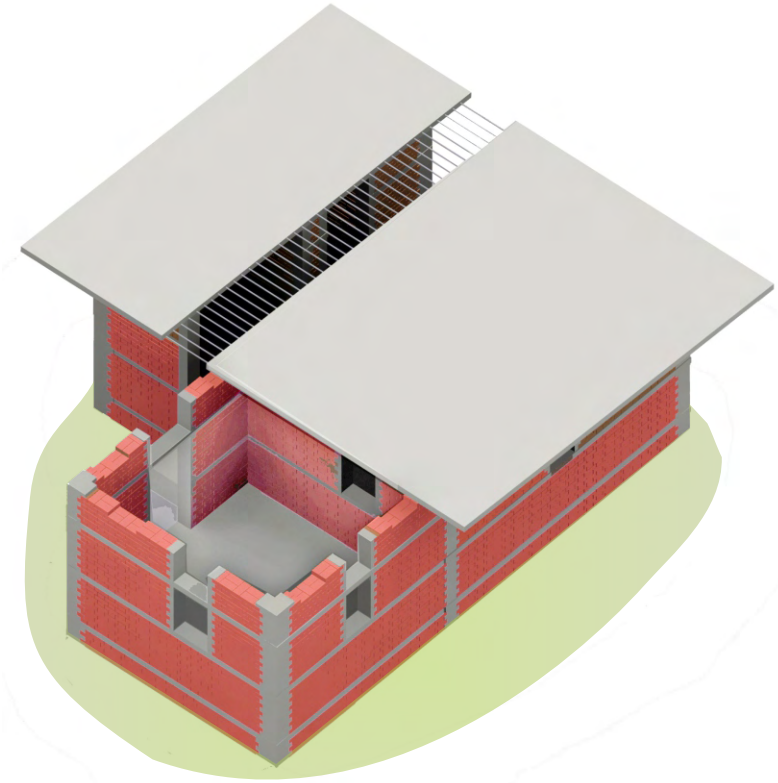
How to extend my house ?



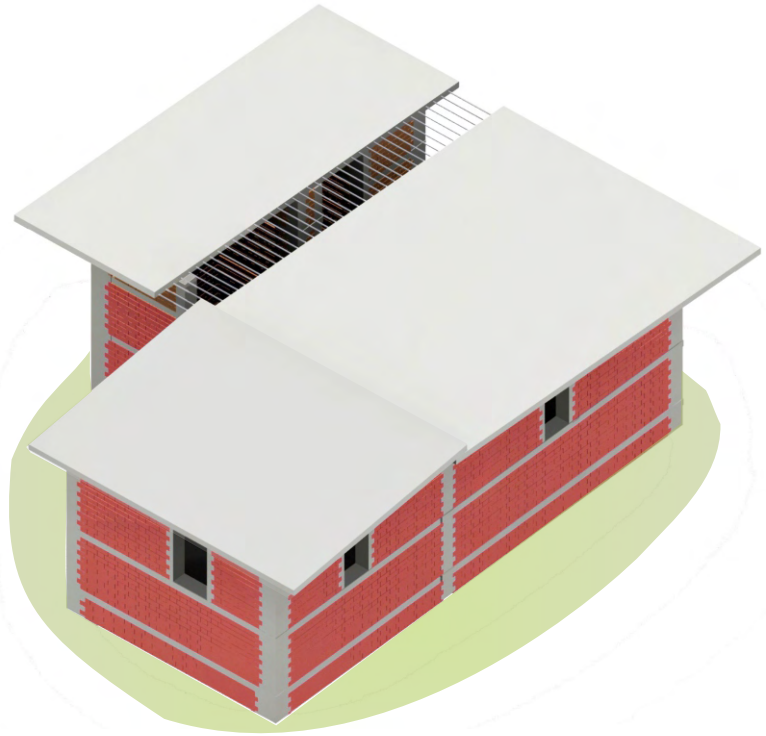
To extend the house, leave a 600mm projection from the Lintel Band in the direction of proposed expansion

While extending the house, chip only the concrete from the projected lintel band left for future expansion

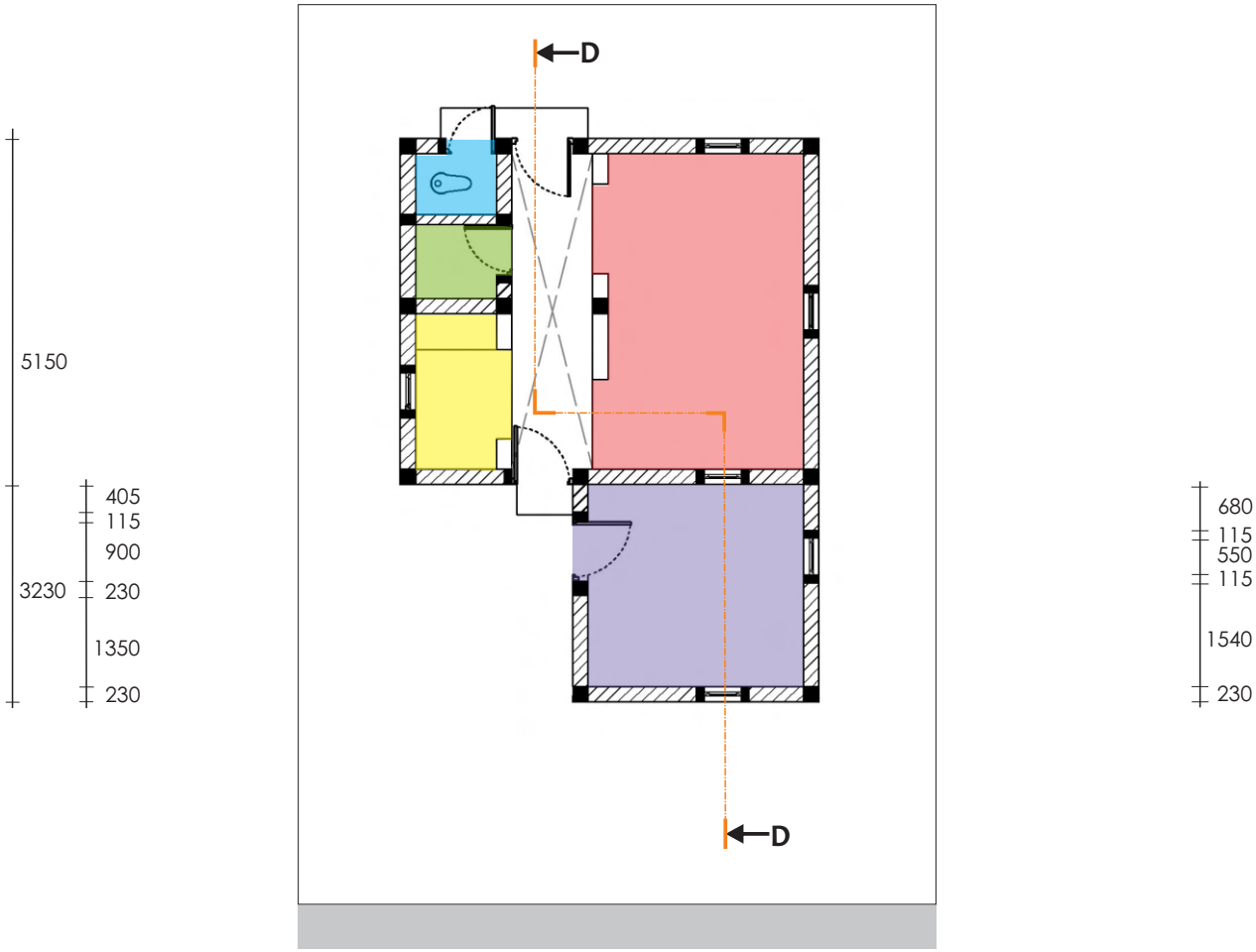
Option 2 Extended



Option 2 Extended
Built-up area: 43.85 m^2
Carpet area: 29.78 m^2



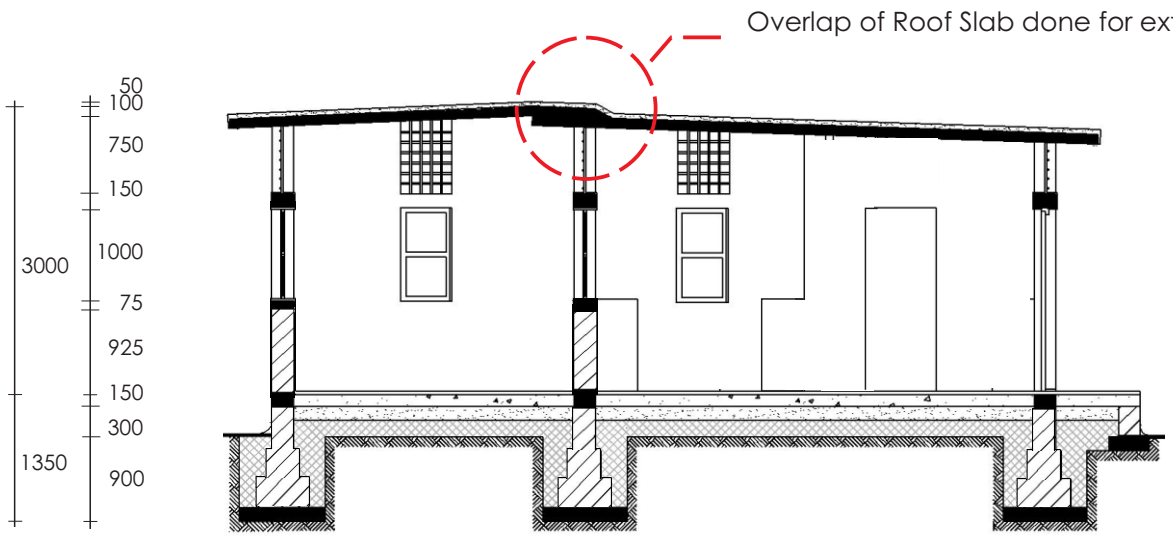
Option 2 Extended



Plan

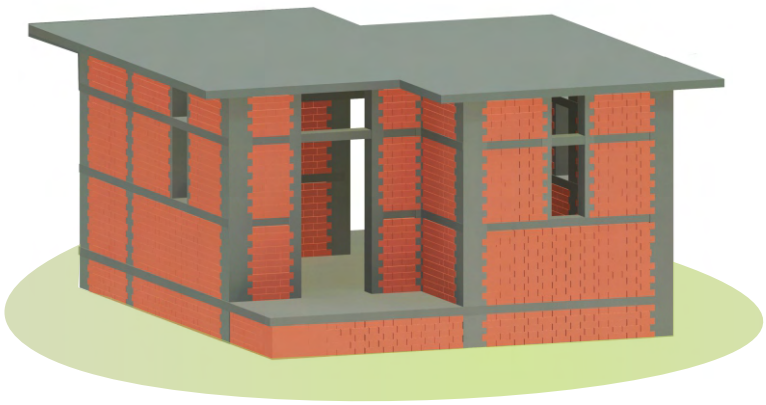
Main Room	Kitchen
Toilet	Access Road
Bath	Additional Room

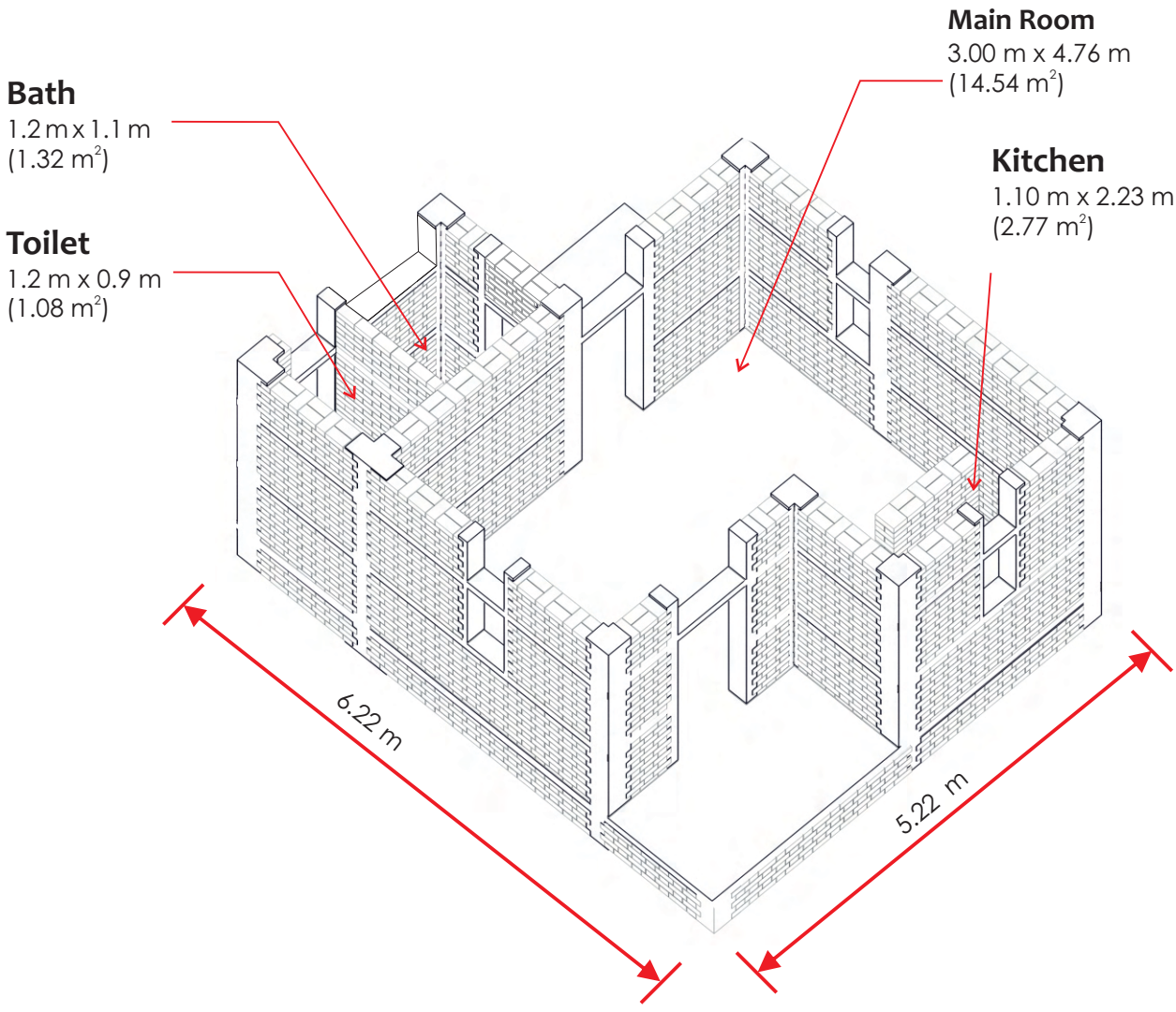
Option 2 Extended



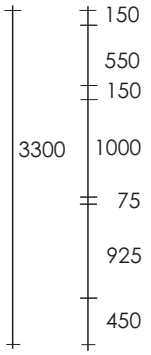
Section D-D

Option 3



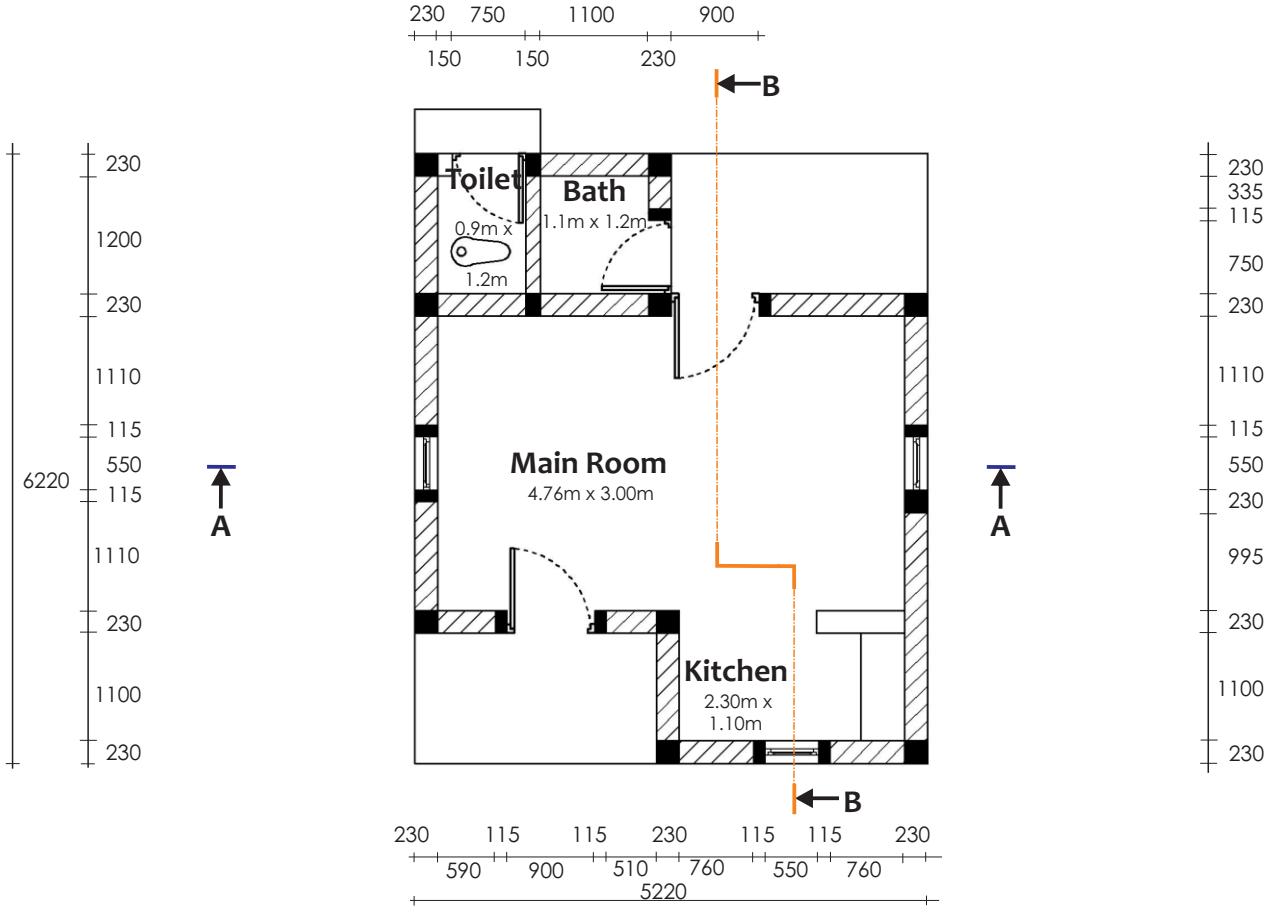

Main Room
3.00 m x 4.76 m
(14.54 m²)
Bath
1.2 m x 1.1 m
(1.32 m²)
Kitchen
1.10 m x 2.23 m
(2.77 m²)
Toilet
1.2 m x 0.9 m
(1.08 m²)
6.22 m
5.22 m

Option 3



Brick Masonry Courses

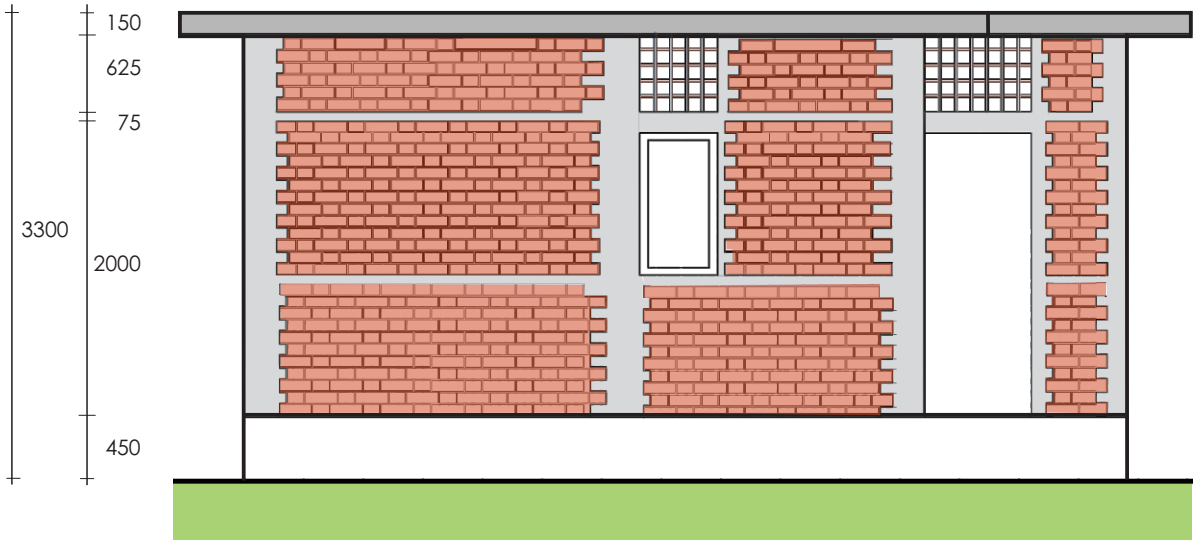
Front Elevation



Plan

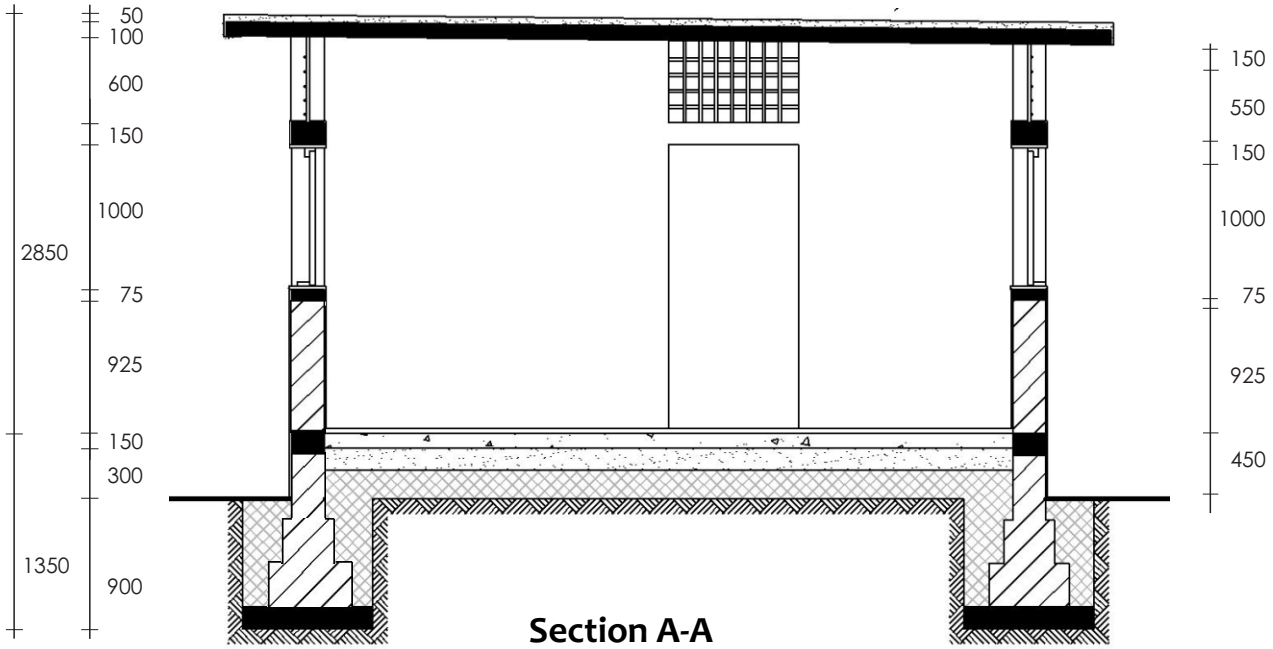
Option 3

Front Elevation

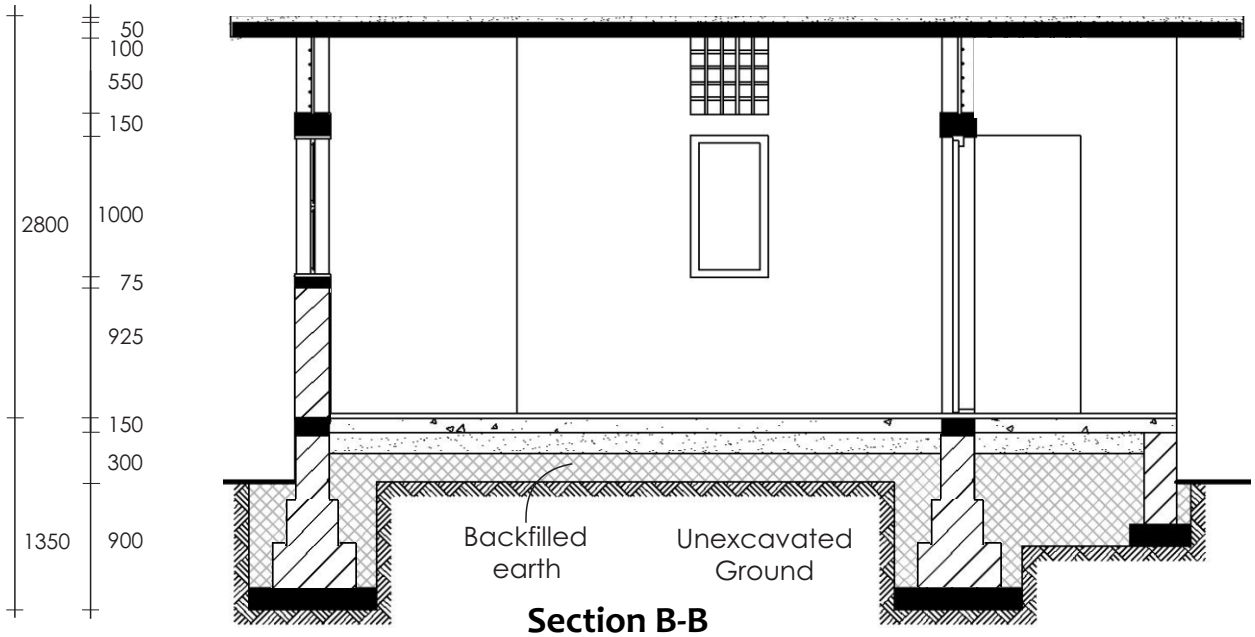


Right Elevation

Option 3

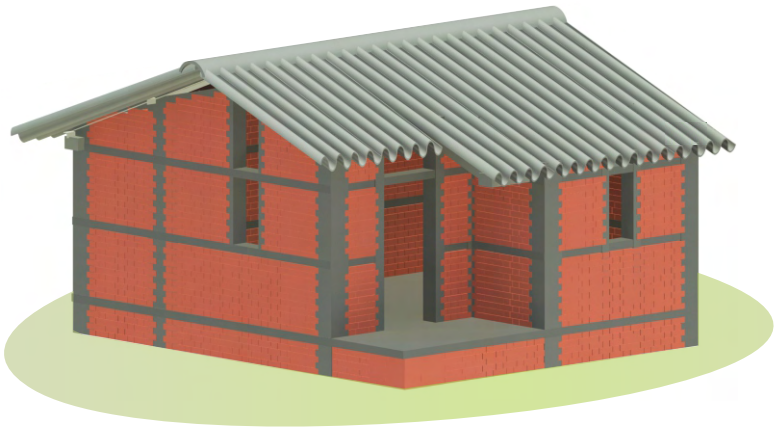


Section A-A

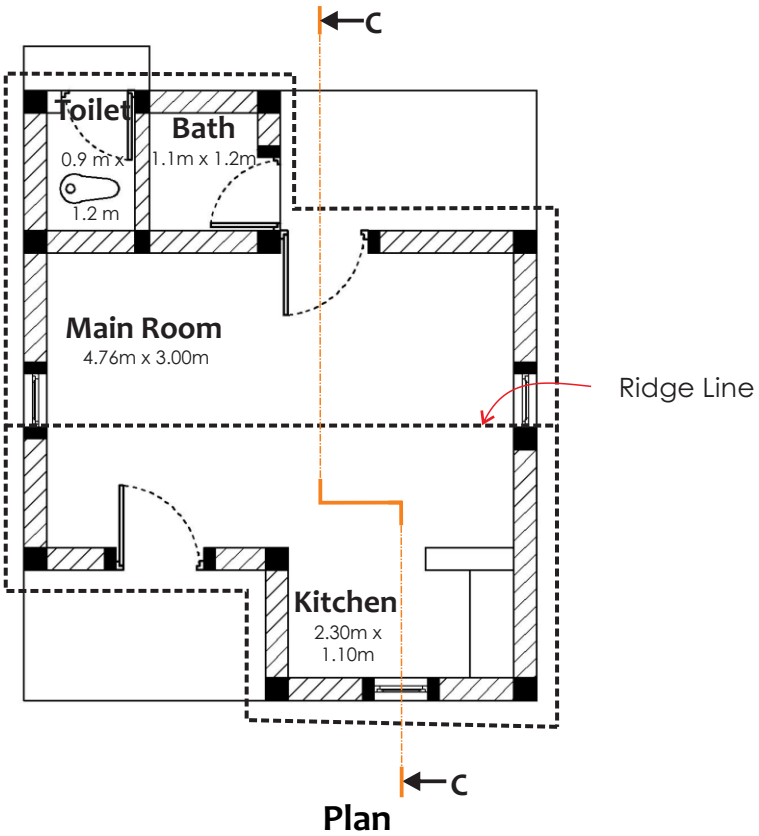


Section B-B

Option 3

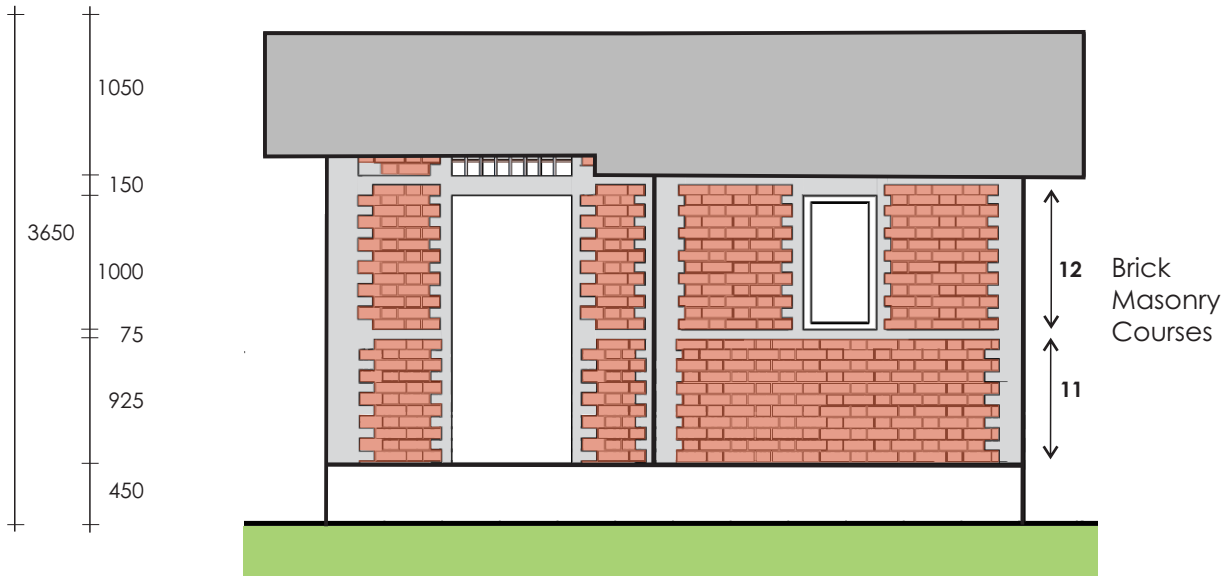


House with sloping roof

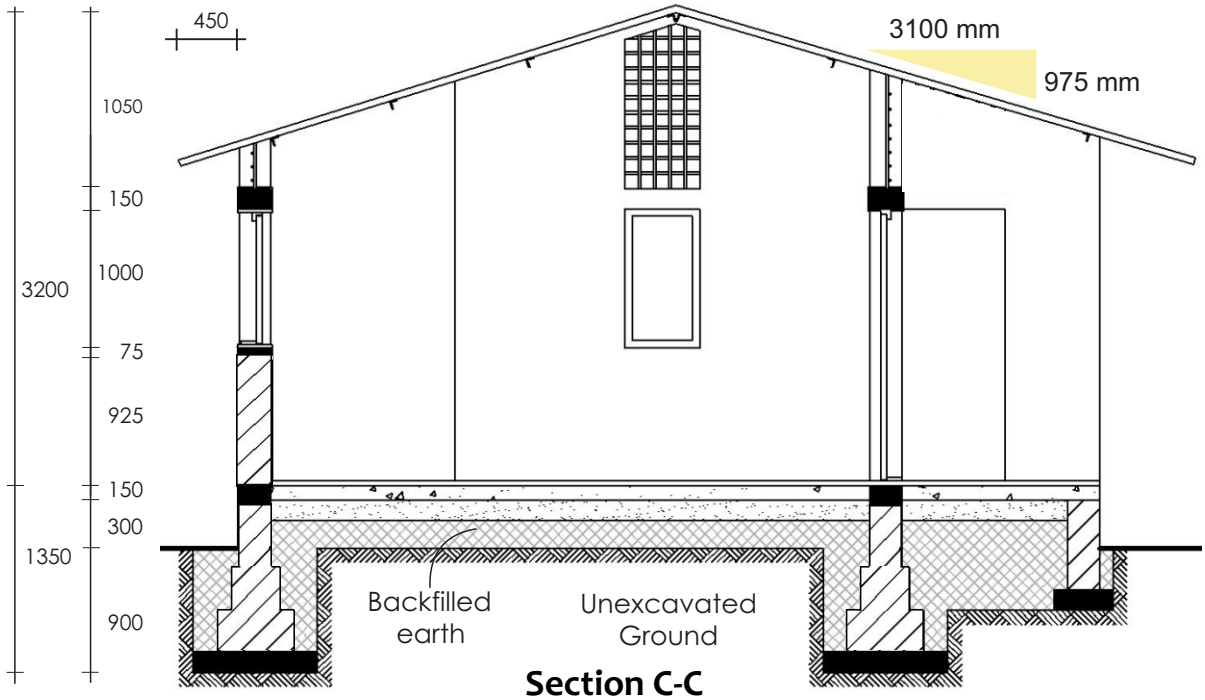


Plan

Option 3



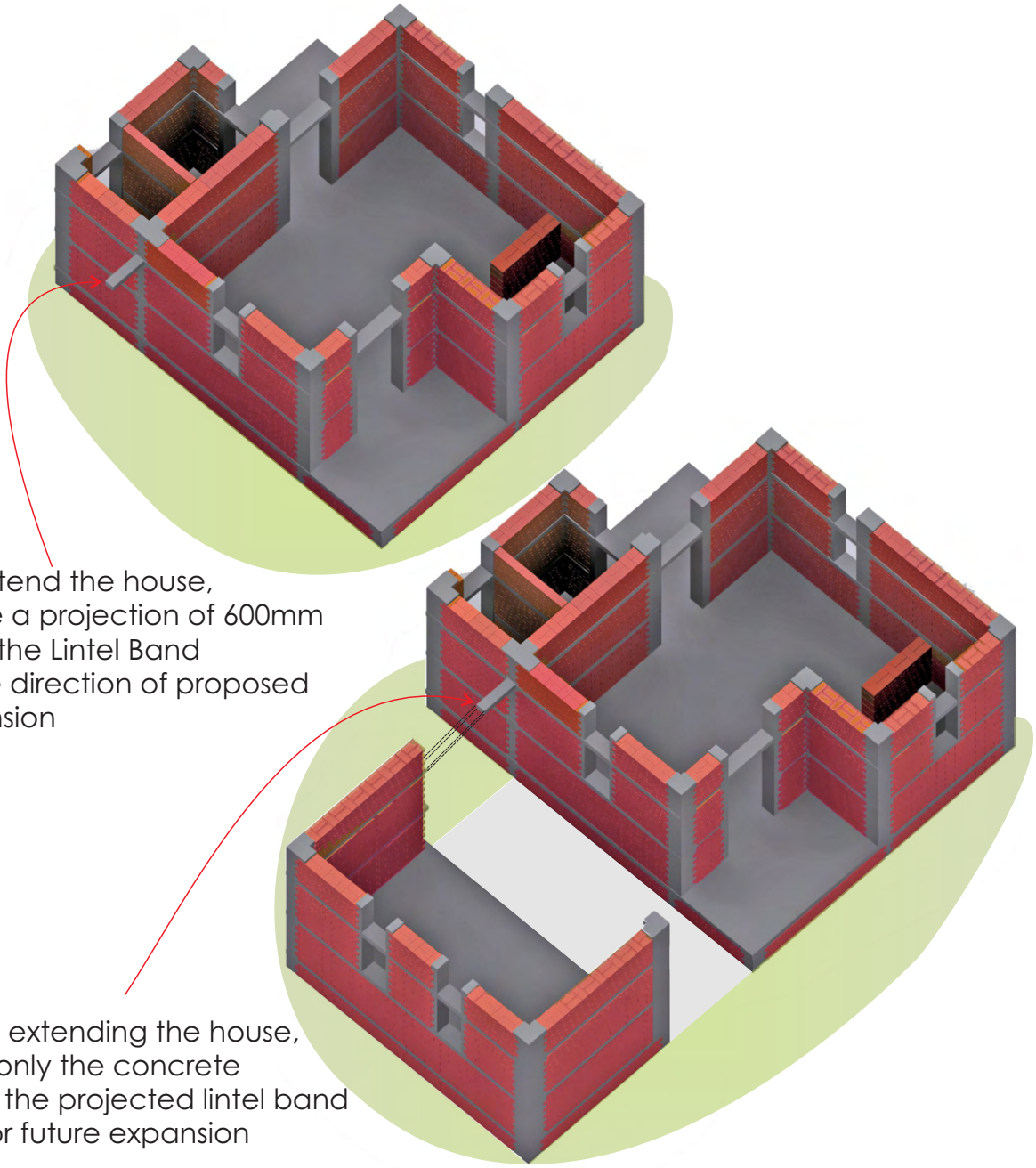
Front Elevation



Section C-C

Option 3 Extended

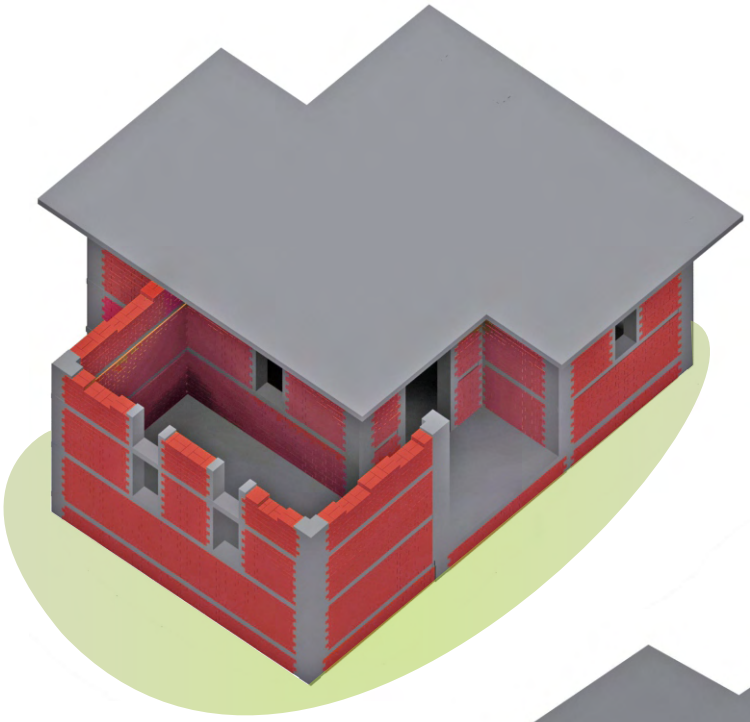
How to extend my house ?



To extend the house,
leave a projection of 600mm
from the Lintel Band
in the direction of proposed
extension

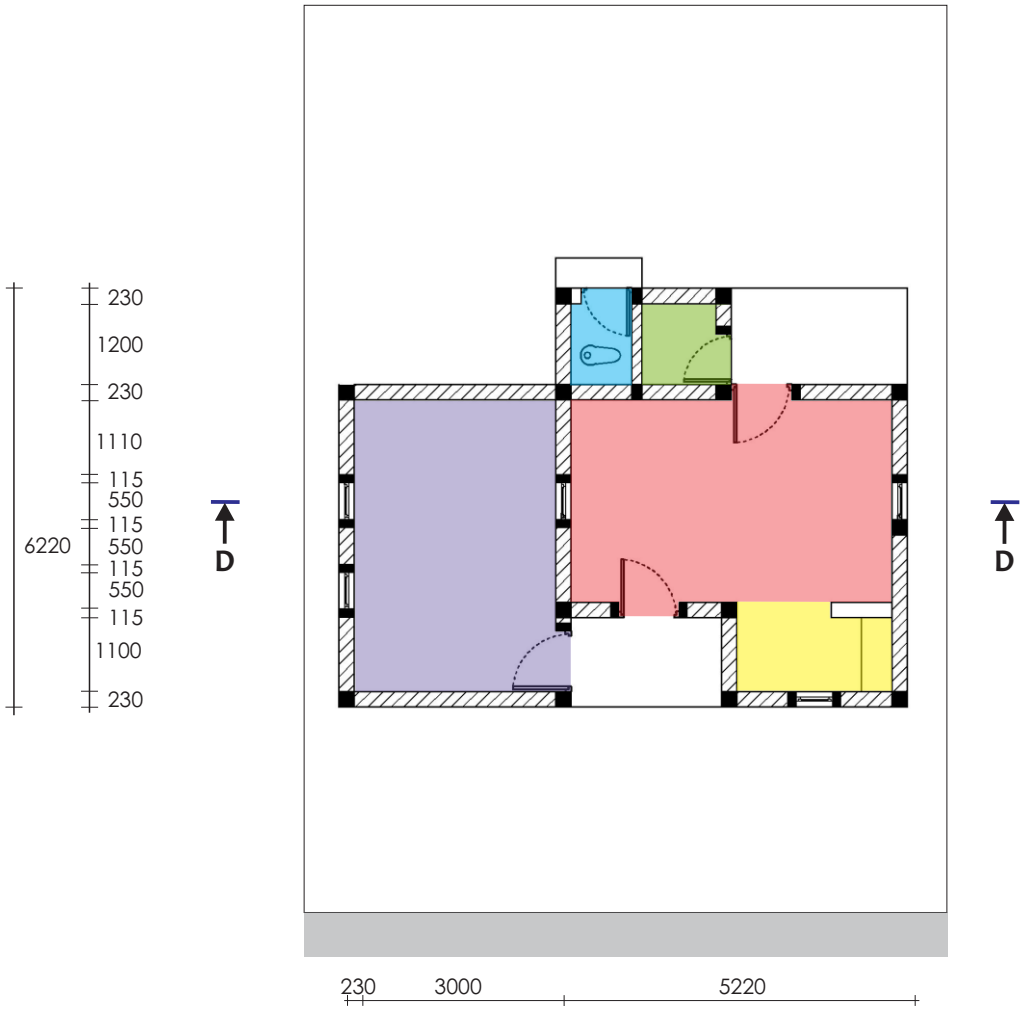
While extending the house,
chip only the concrete
from the projected lintel band
left for future expansion

Option 3 Extended



Option 3 Extended
Built-up area: 47.94 m^2
Carpet area: 32.20 m^2

Option 3 Extended



Plan

Main Room

Kitchen

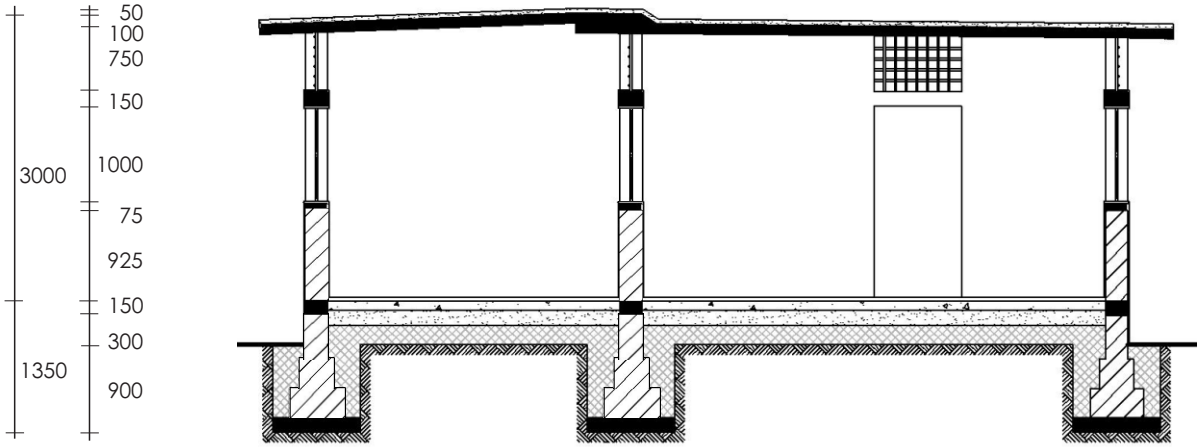
Toilet

Access Road

Bath

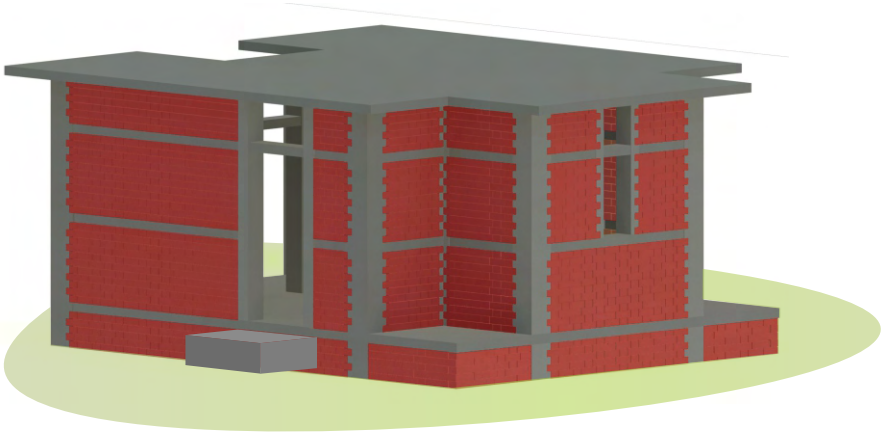
Additional Room

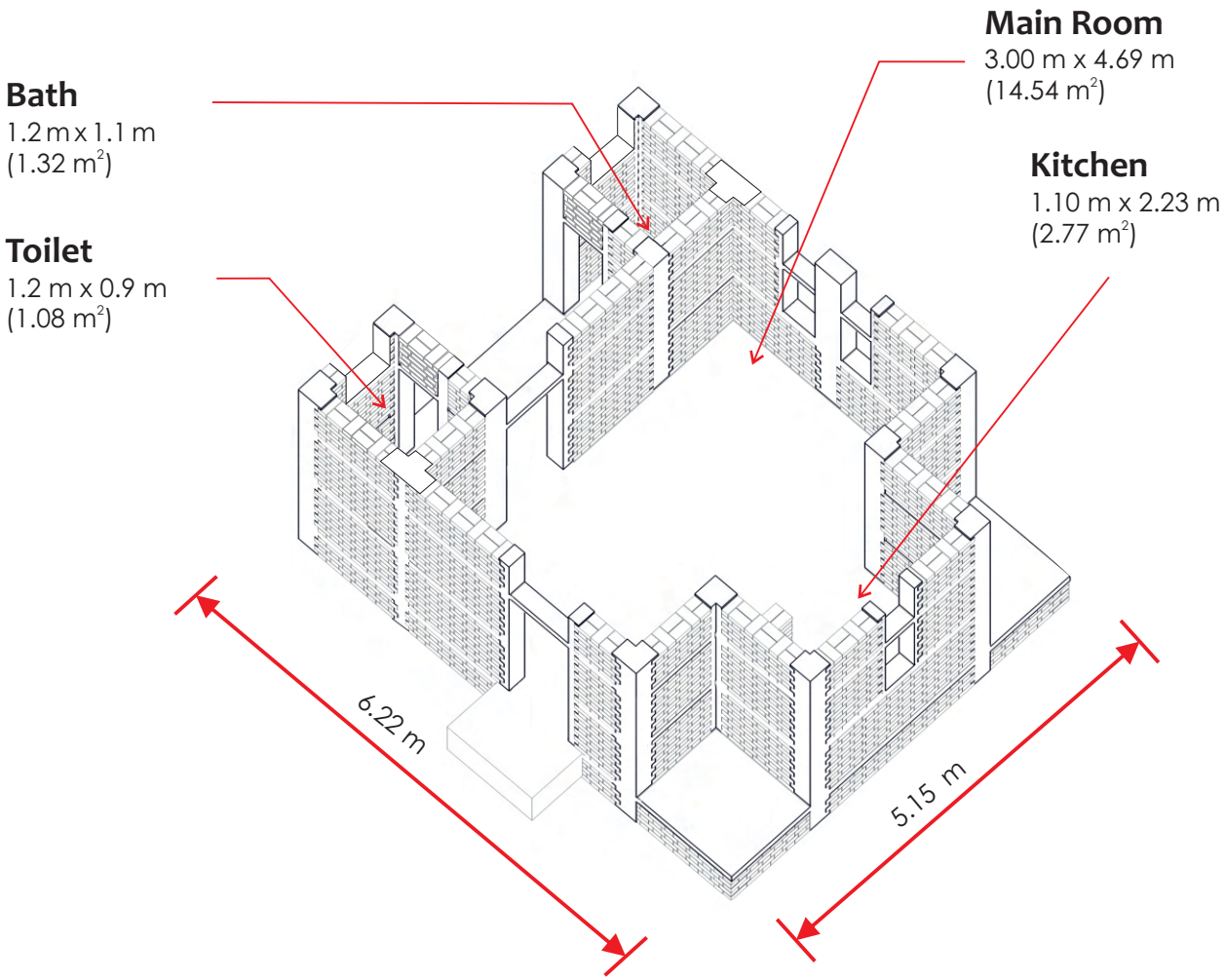
Option 3 Extended



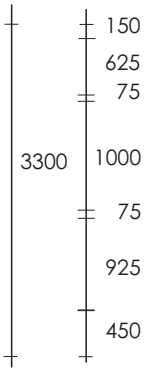
Section D-D

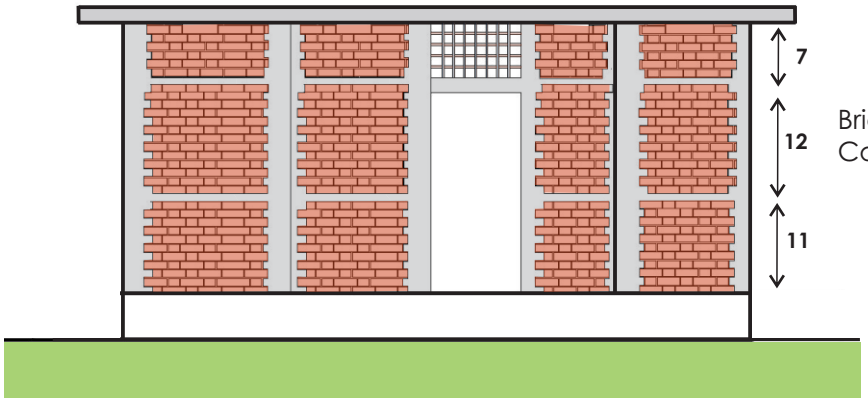
Option 4




Main Room
3.00 m x 4.69 m
(14.54 m²)
Bath
1.2 m x 1.1 m
(1.32 m²)
Kitchen
1.10 m x 2.23 m
(2.77 m²)
Toilet
1.2 m x 0.9 m
(1.08 m²)
6.22 m
5.15 m

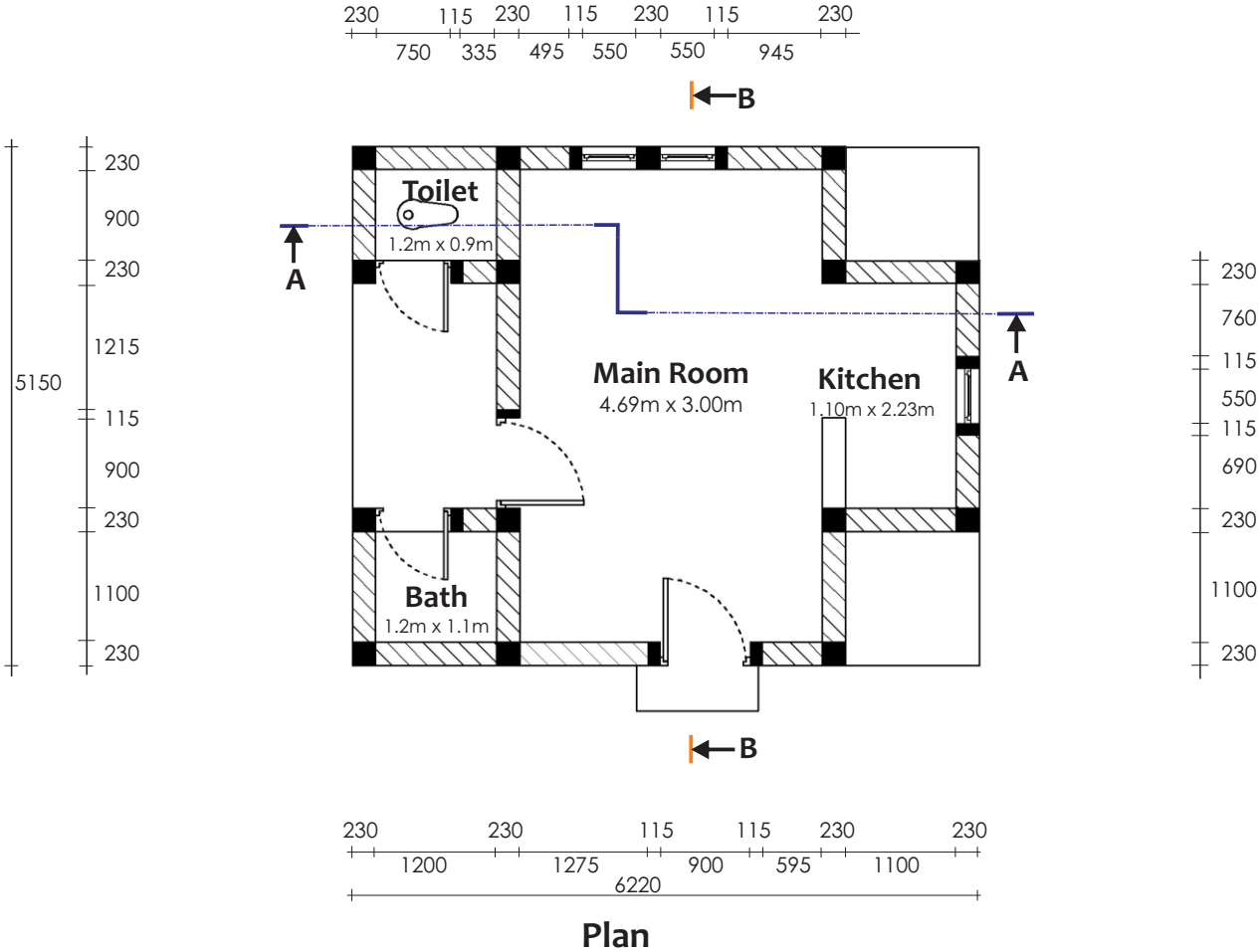
Option 4





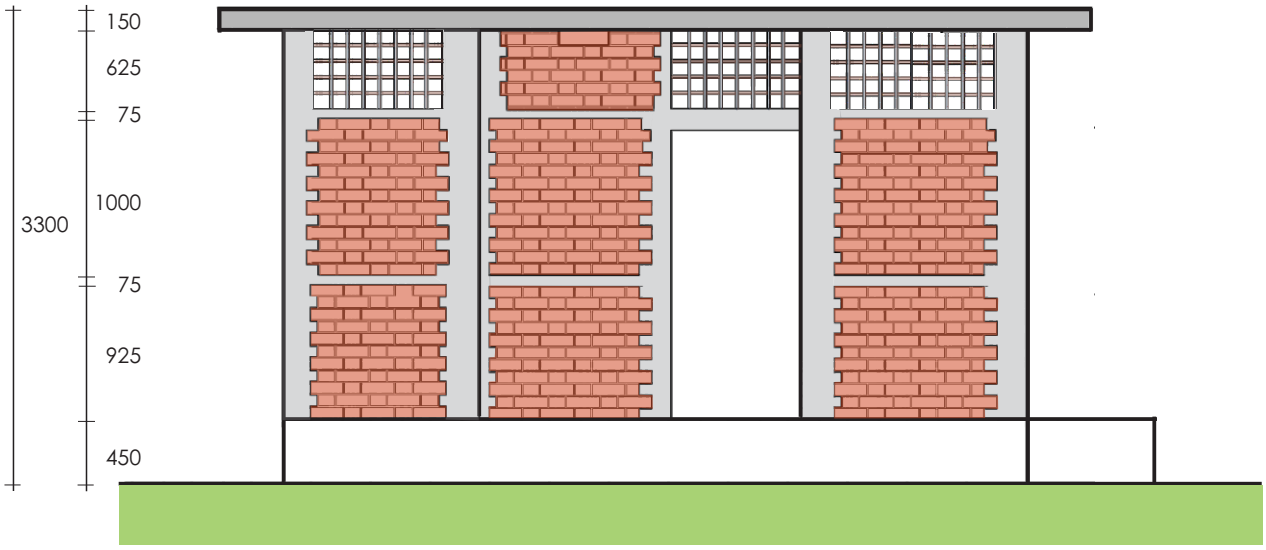
Brick Masonry Courses

Front Elevation



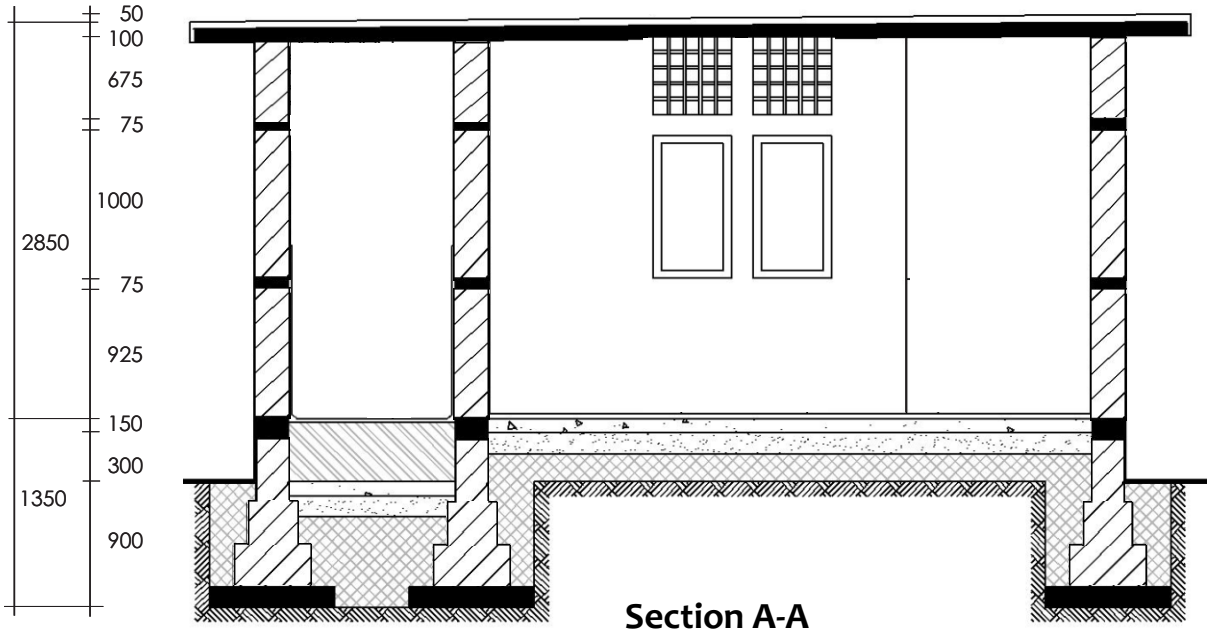
Plan

Option 4

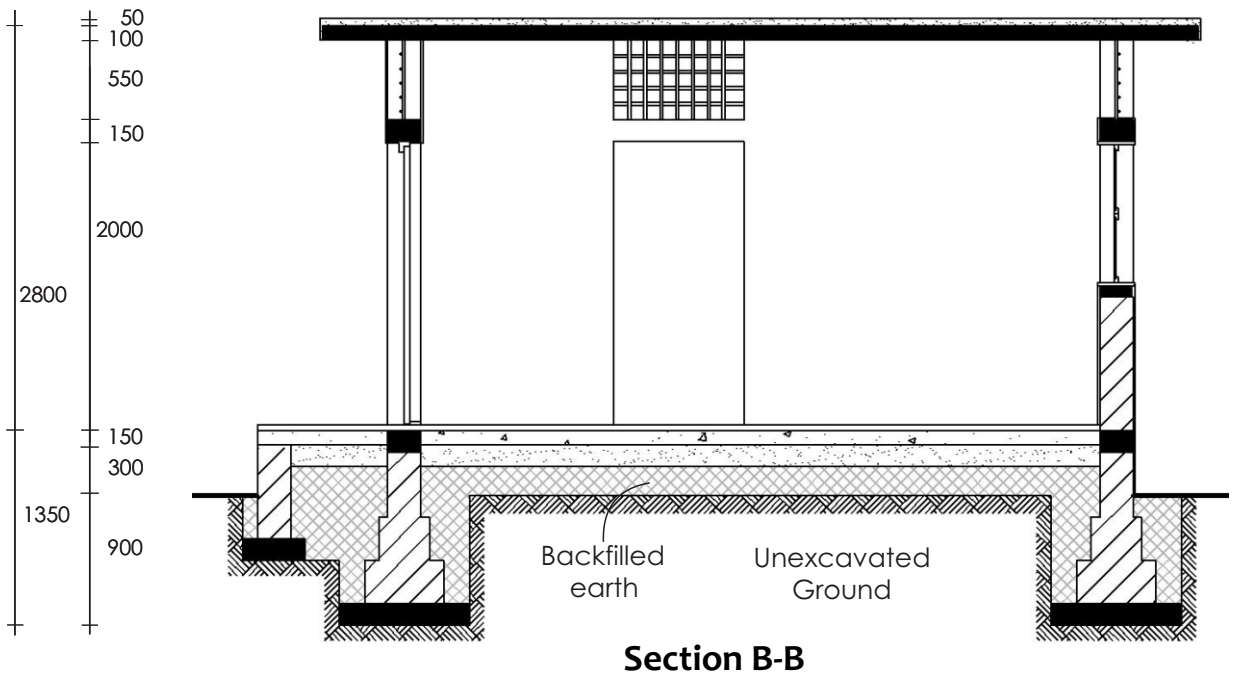


Left Elevation

Option 4

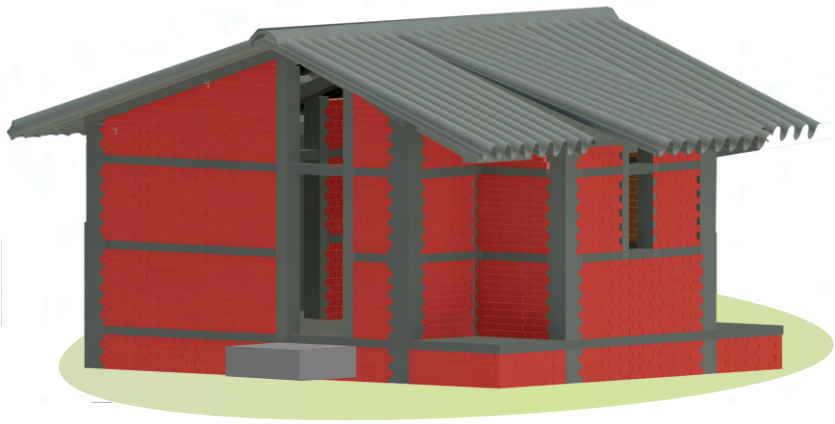


Section A-A

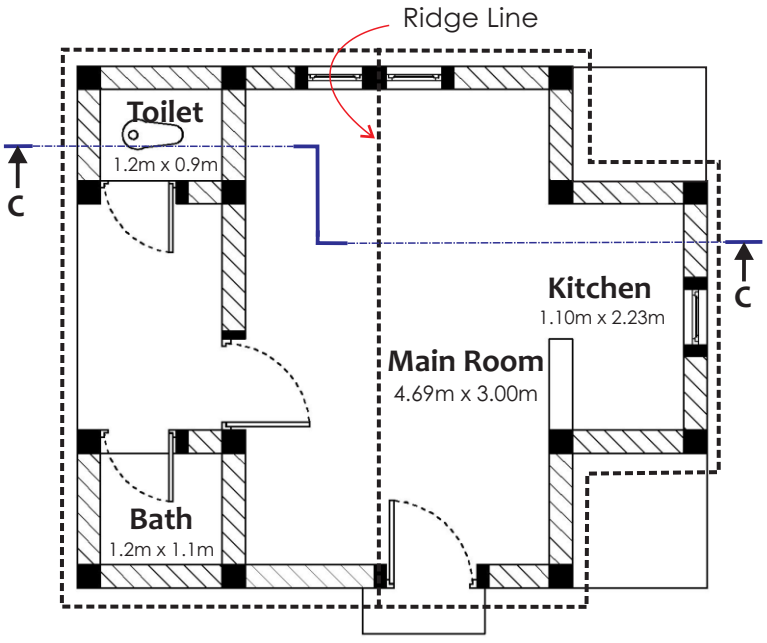


Section B-B

Option 4

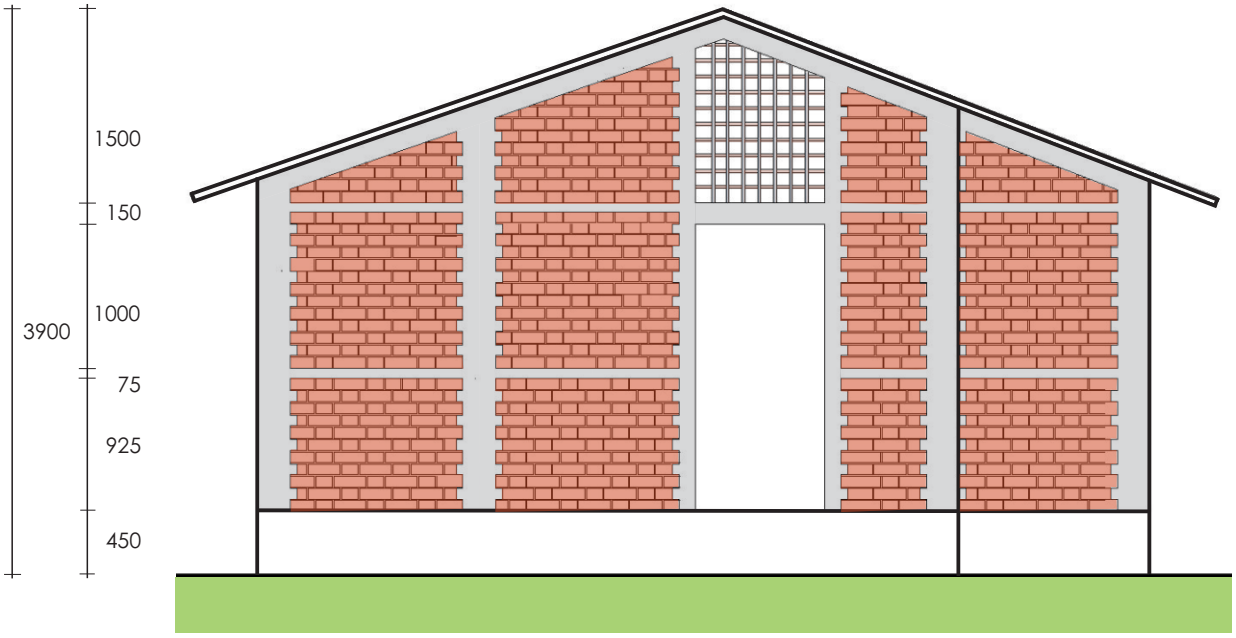


House with sloping roof

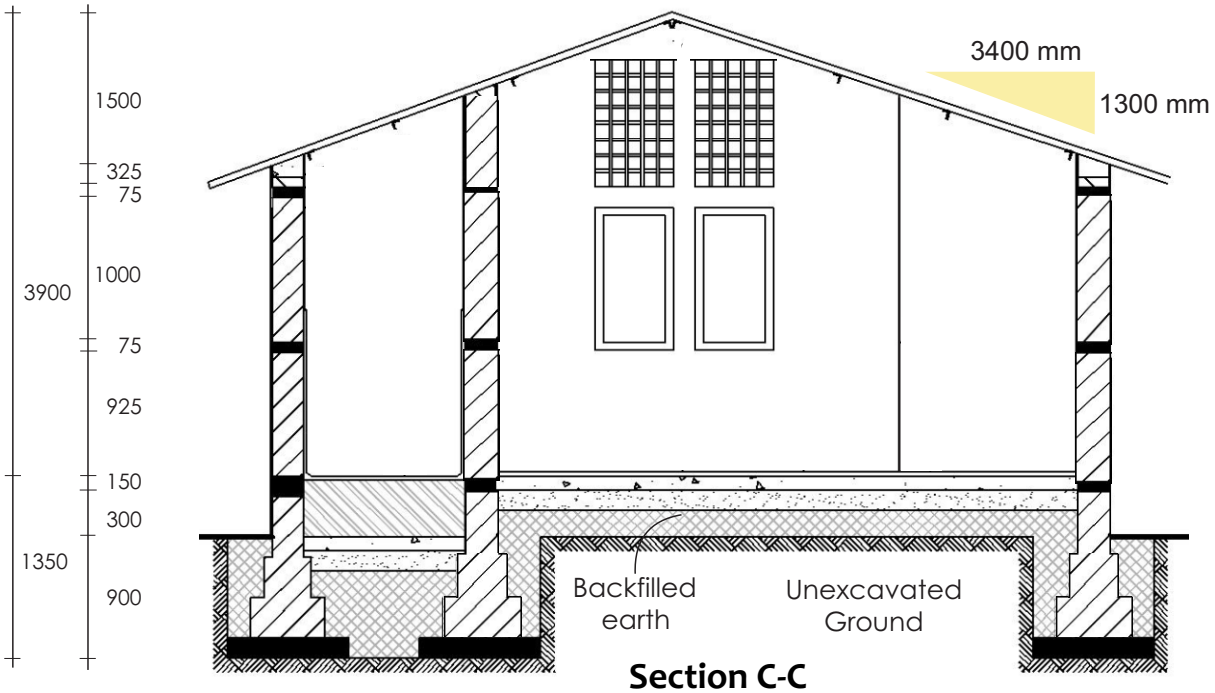


Plan

Option 4



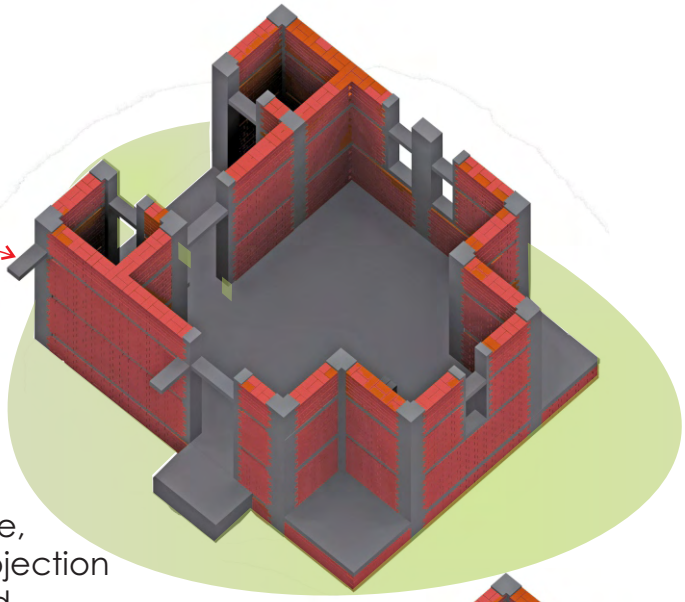
Front Elevation



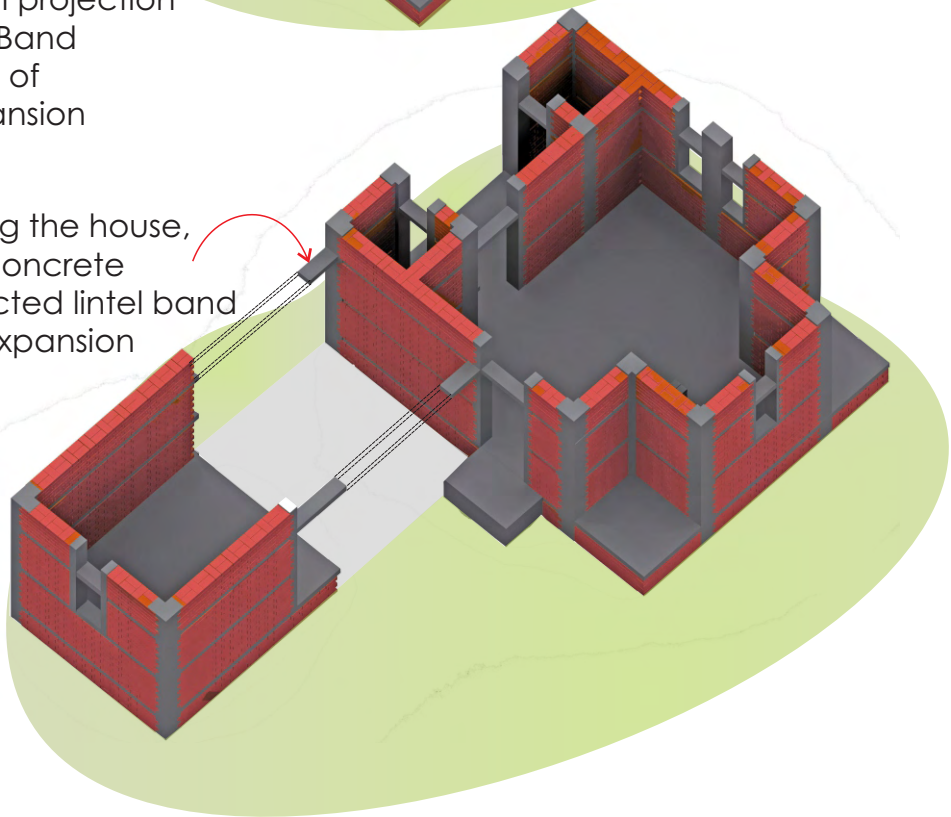
Section C-C

Option 4 Extended

How to extend my house ?

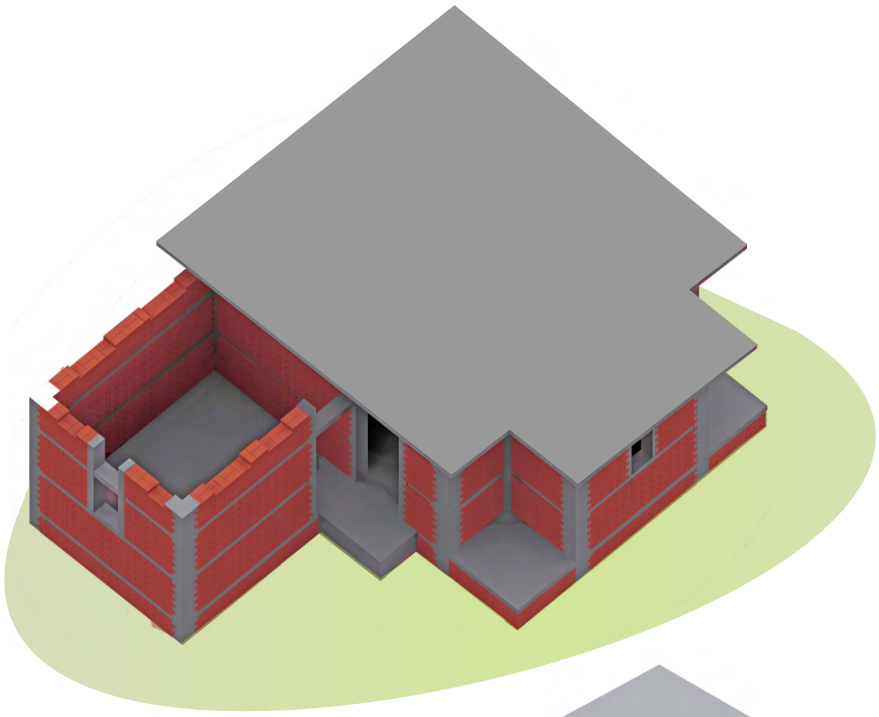


To extend the house,
leave a 600mm projection
from the Lintel Band
in the direction of
proposed expansion



While extending the house,
chip only the concrete
from the projected lintel band
left for future expansion

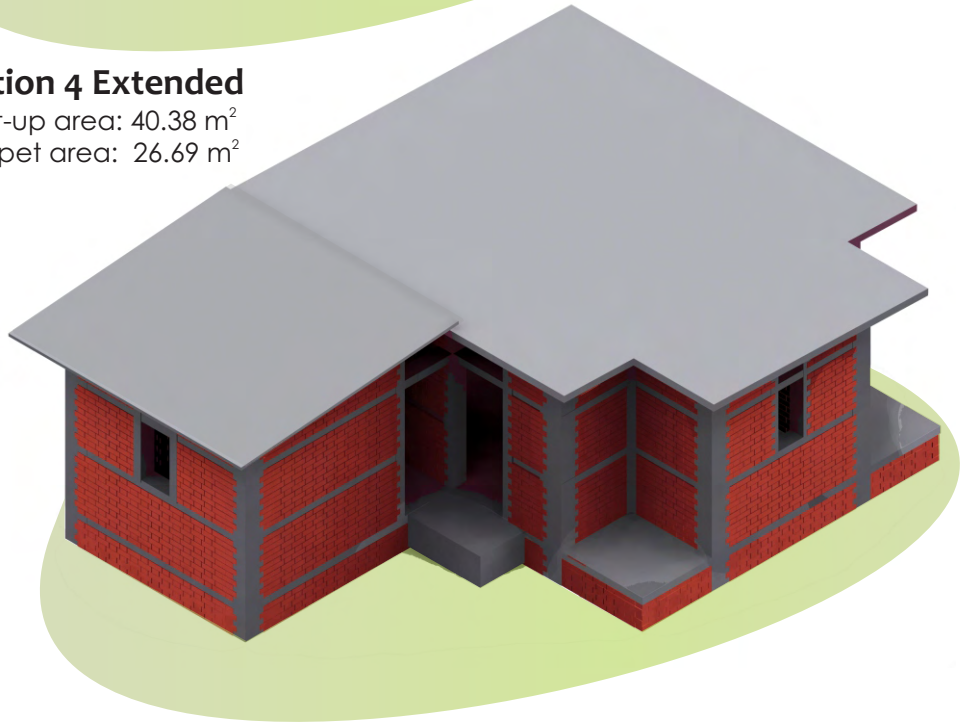
Option 4 Extended



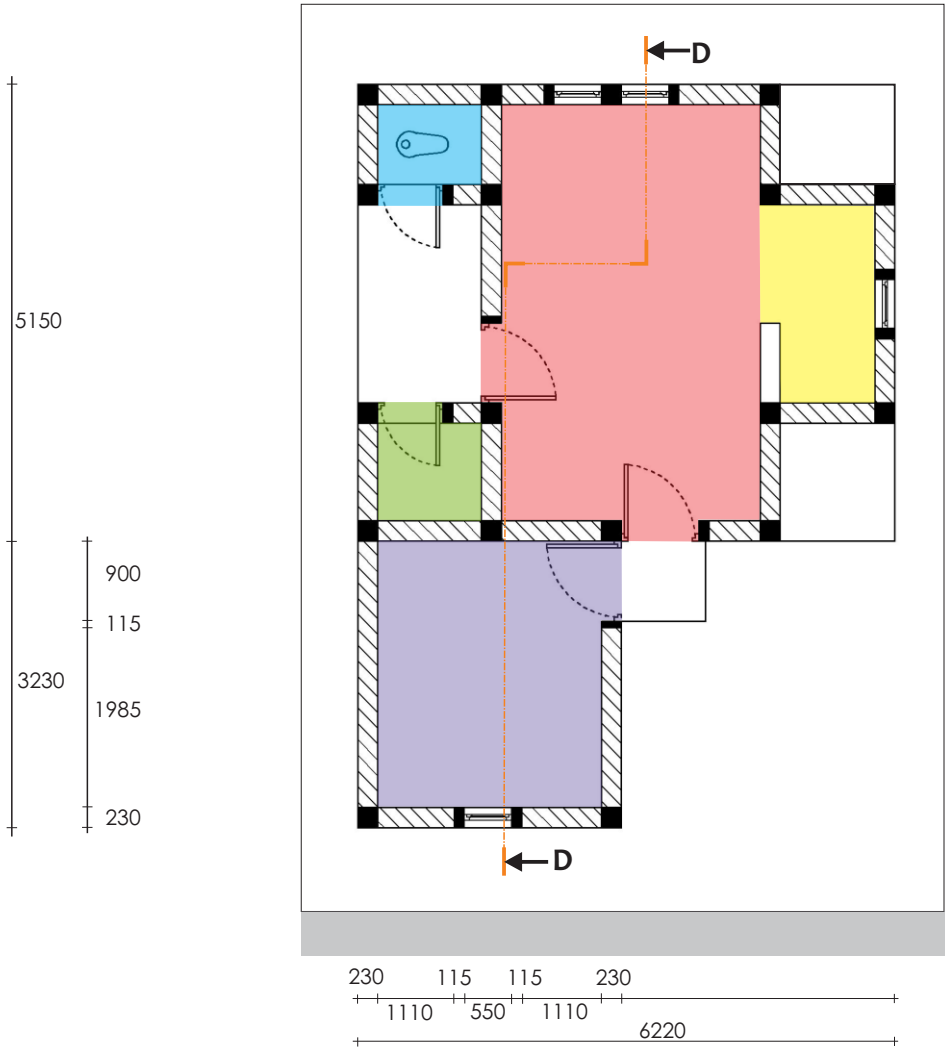
Option 4 Extended

Built-up area: 40.38 m^2

Carpet area: 26.69 m^2



Option 4 Extended



Plan

Main Room

Kitchen

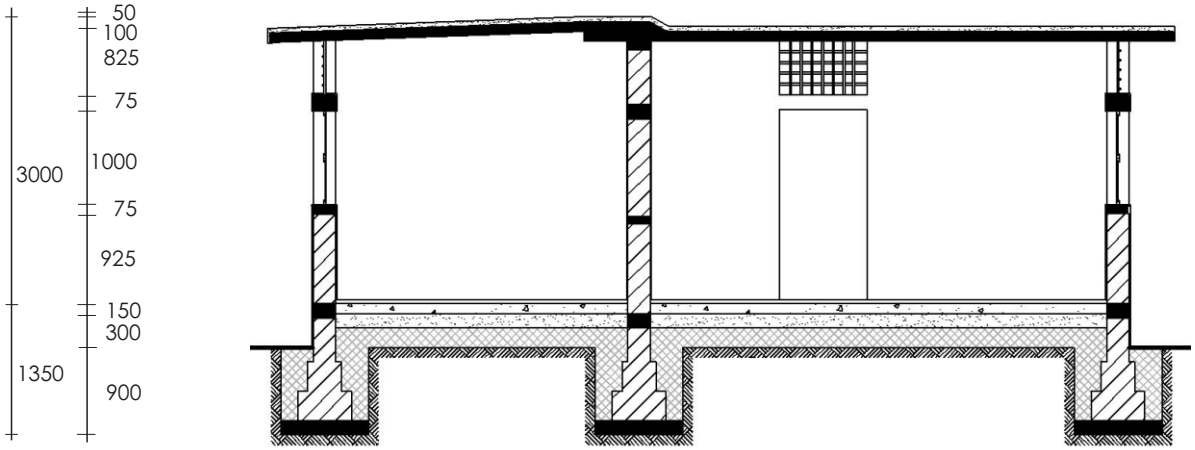
Toilet

Access Road

Bath

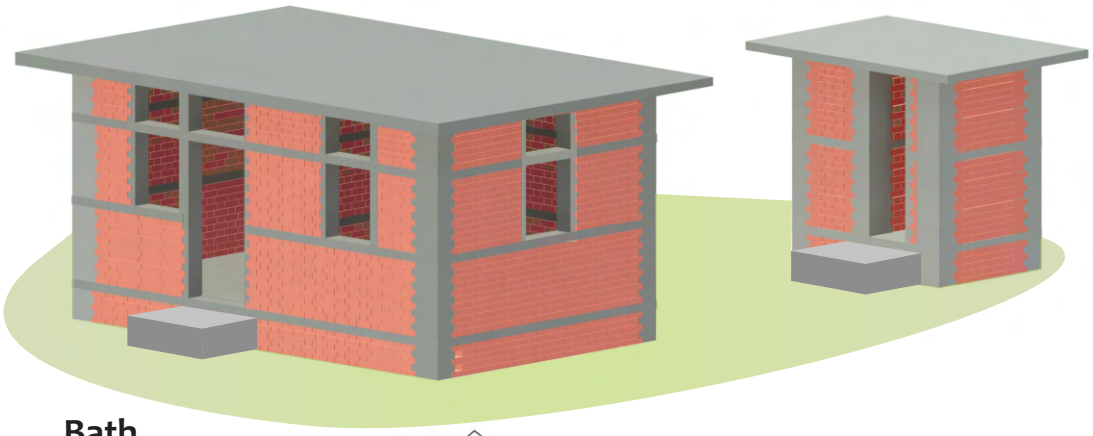
Additional Room

Option 4 Extended



Section D-D

Option 5

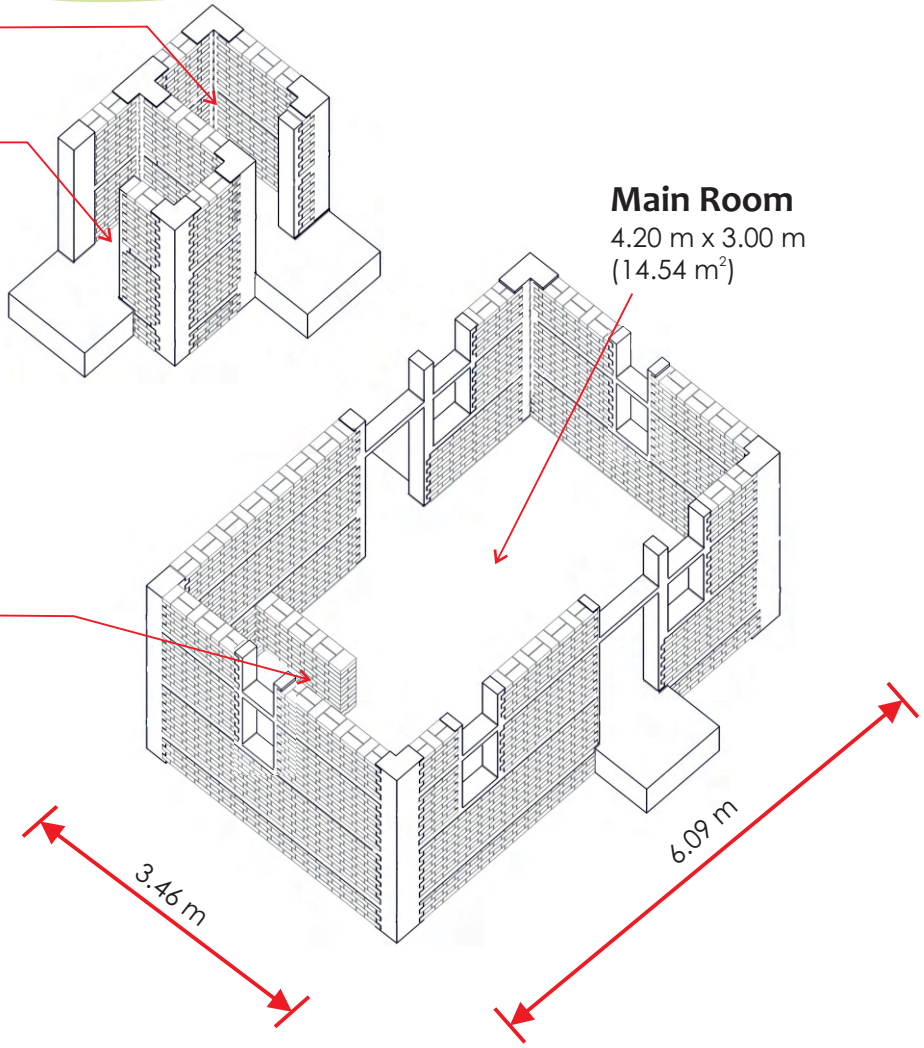


Bath
1.2 m x 1.1 m
(1.32 m^2)

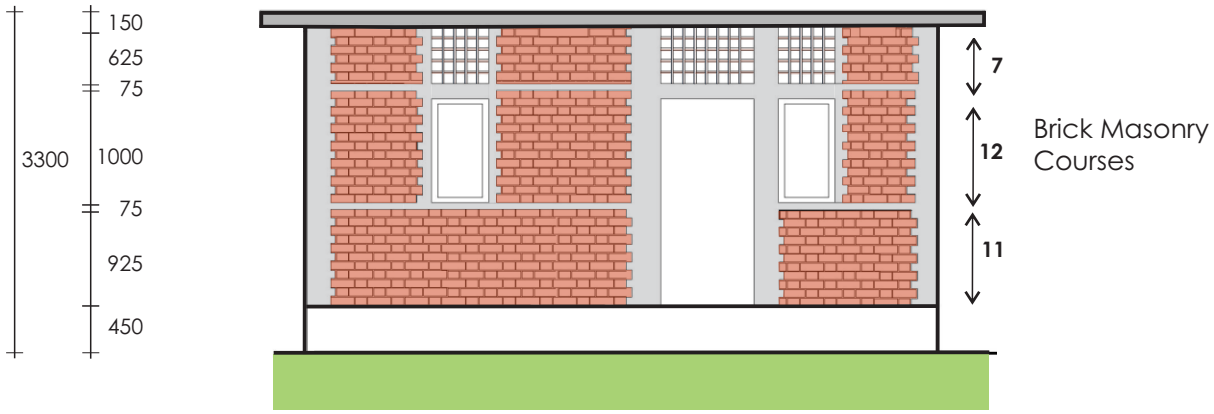
Toilet
1.2 m x 0.9 m
(1.08 m^2)

Main Room
4.20 m x 3.00 m
(14.54 m^2)

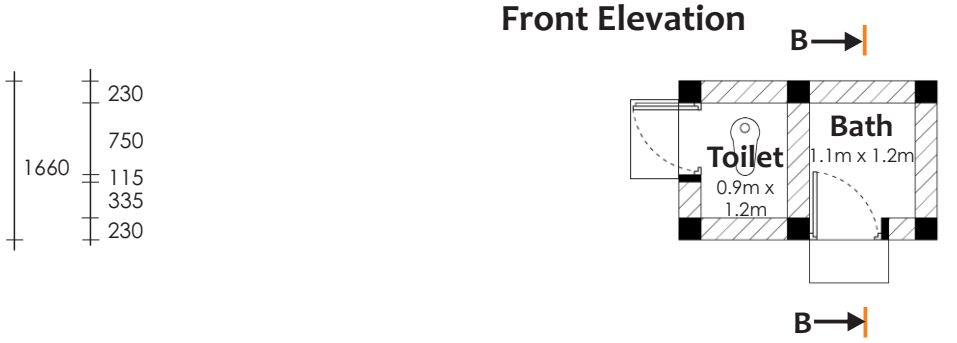
Kitchen
1.20 m x 3.00 m
(2.77 m^2)



Option 5

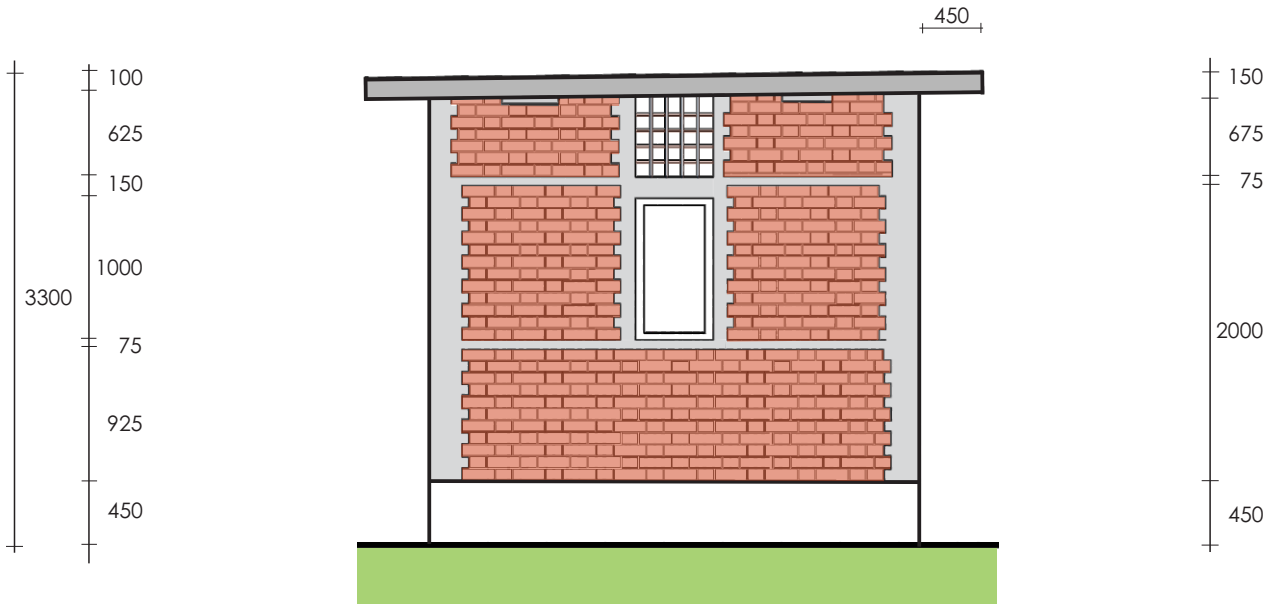


Front Elevation

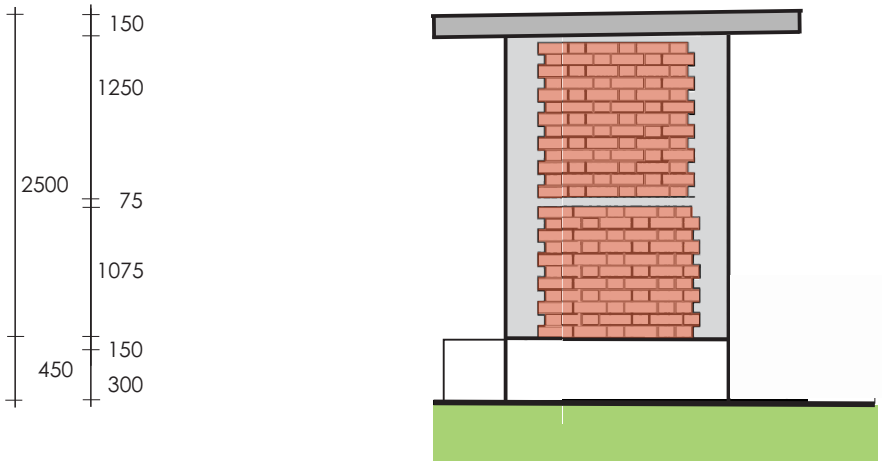


Plan

Option 5

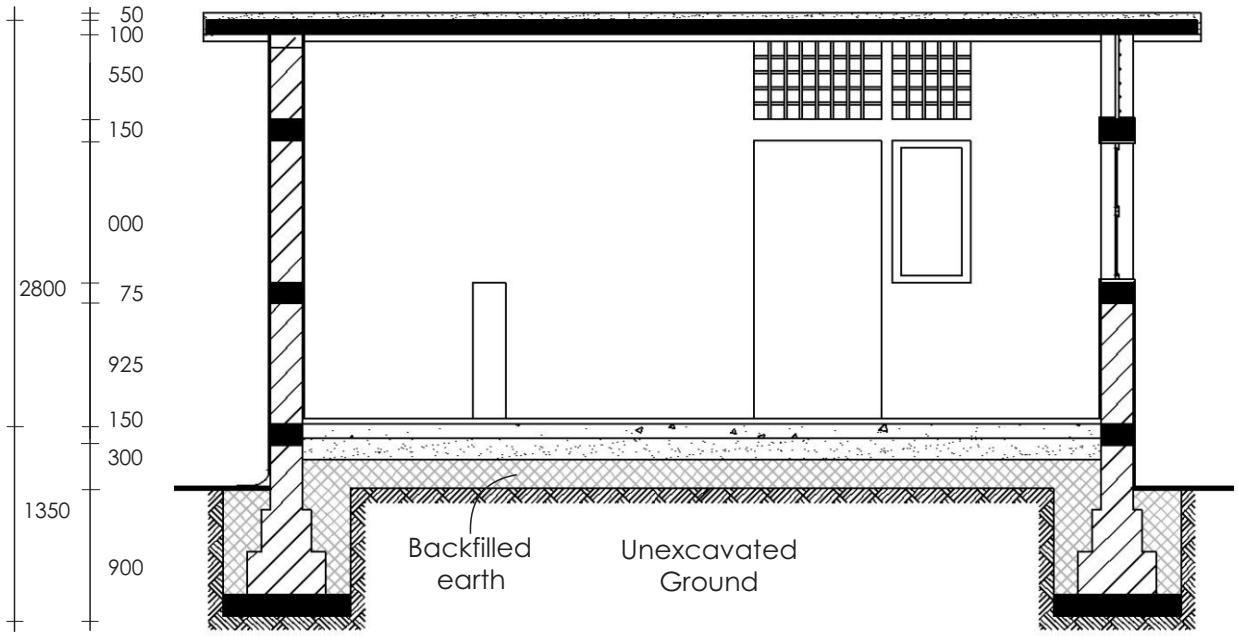


Right Elevation

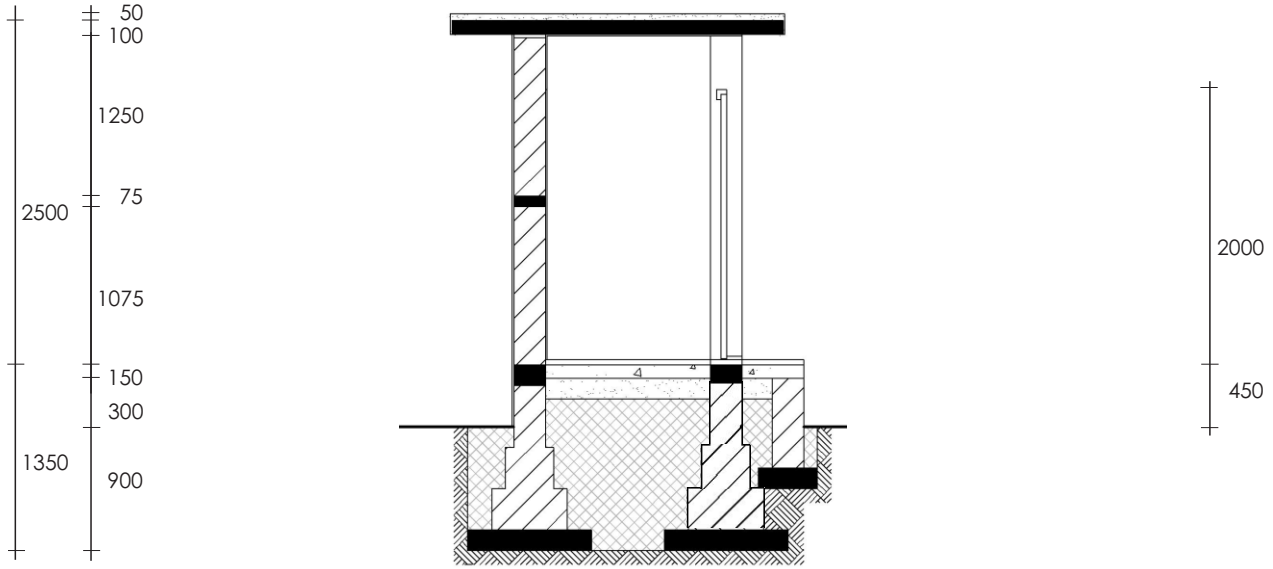


Left Elevation of Toilet

Option 5

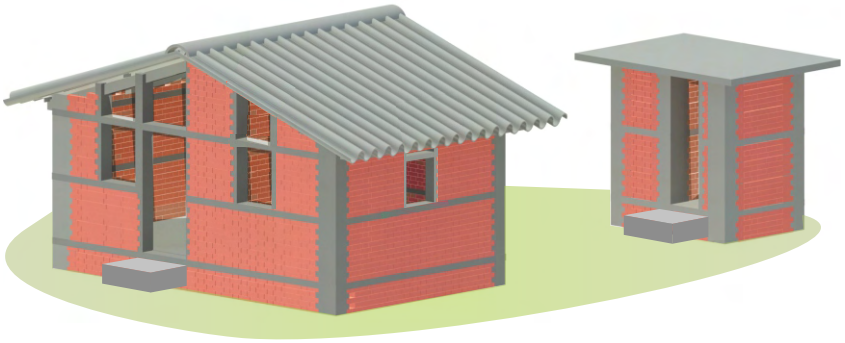


Section A-A

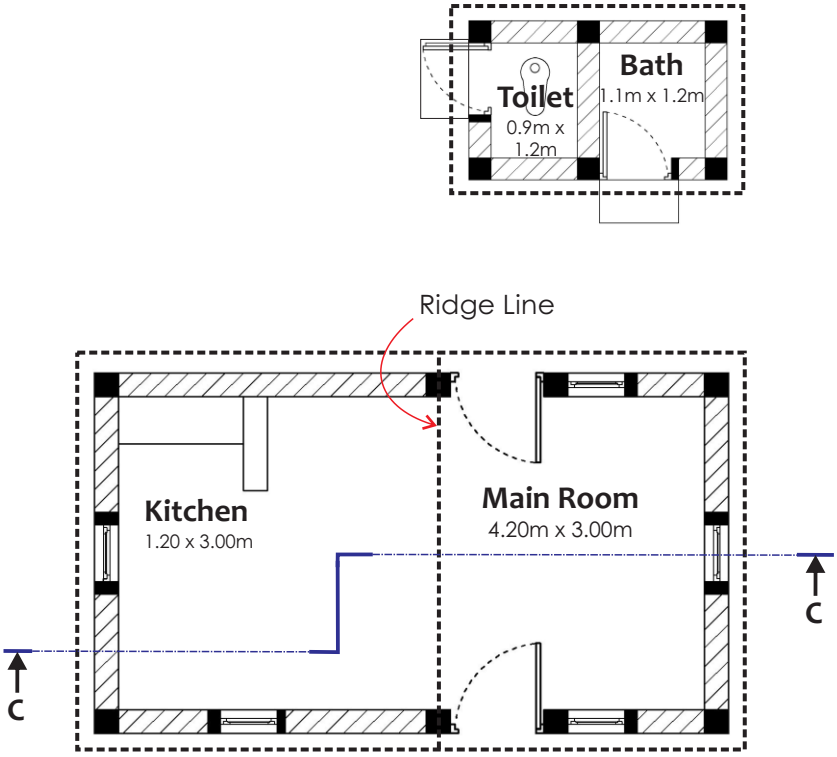


Section B-B

Option 5

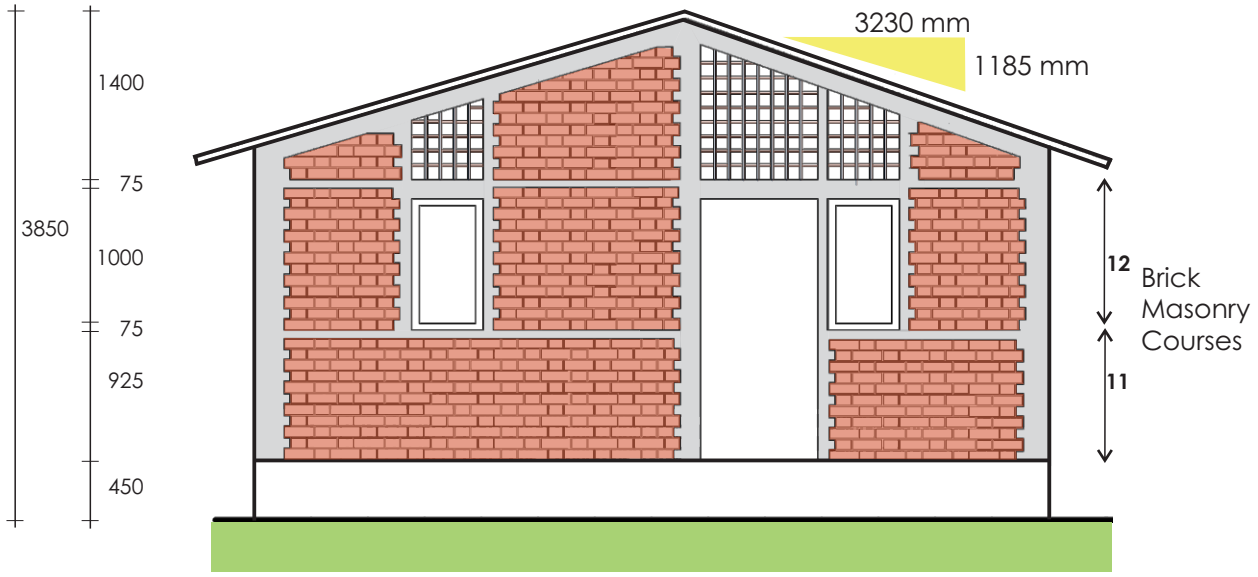


House with sloping roof

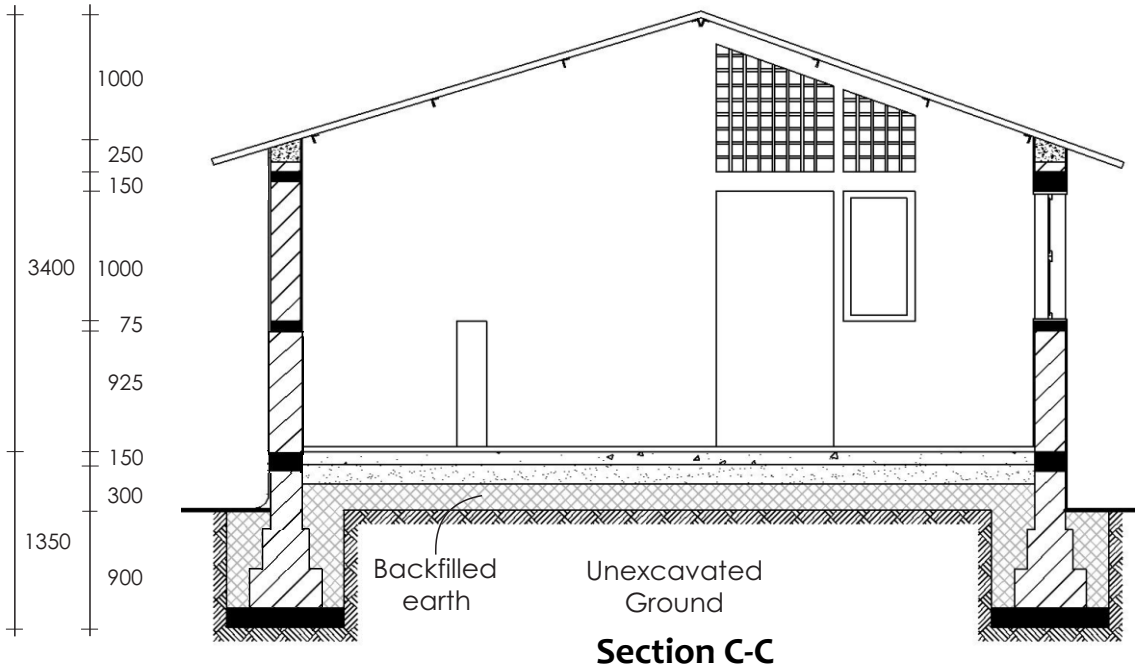


Plan

Option 5



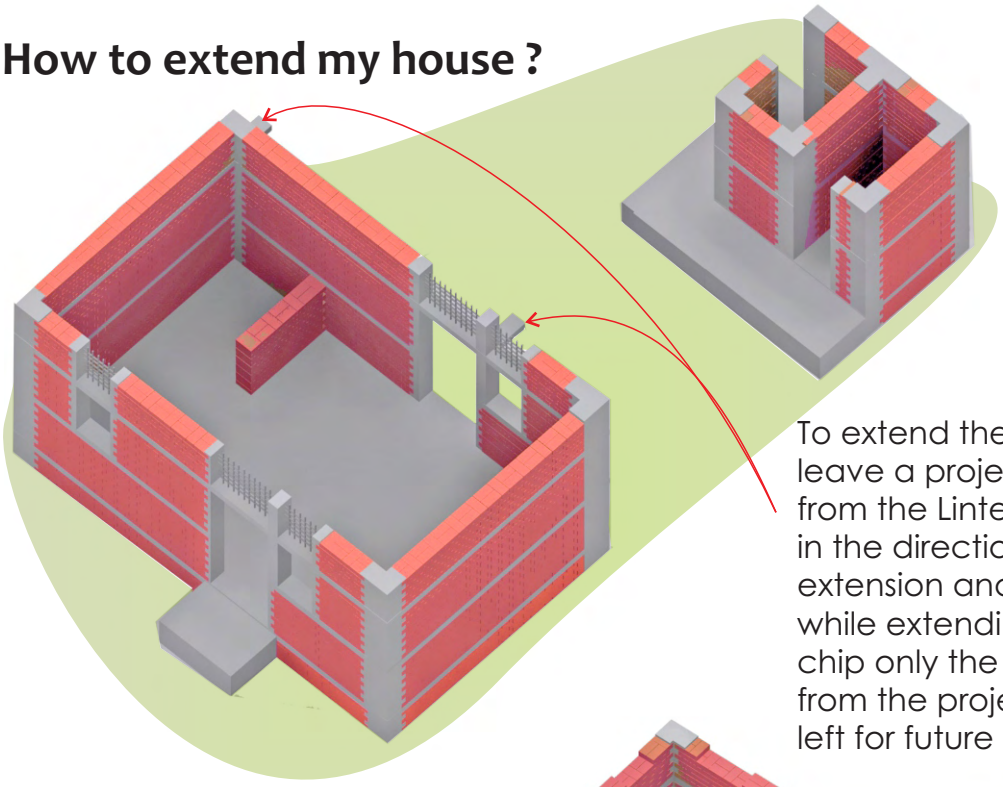
Front Elevation



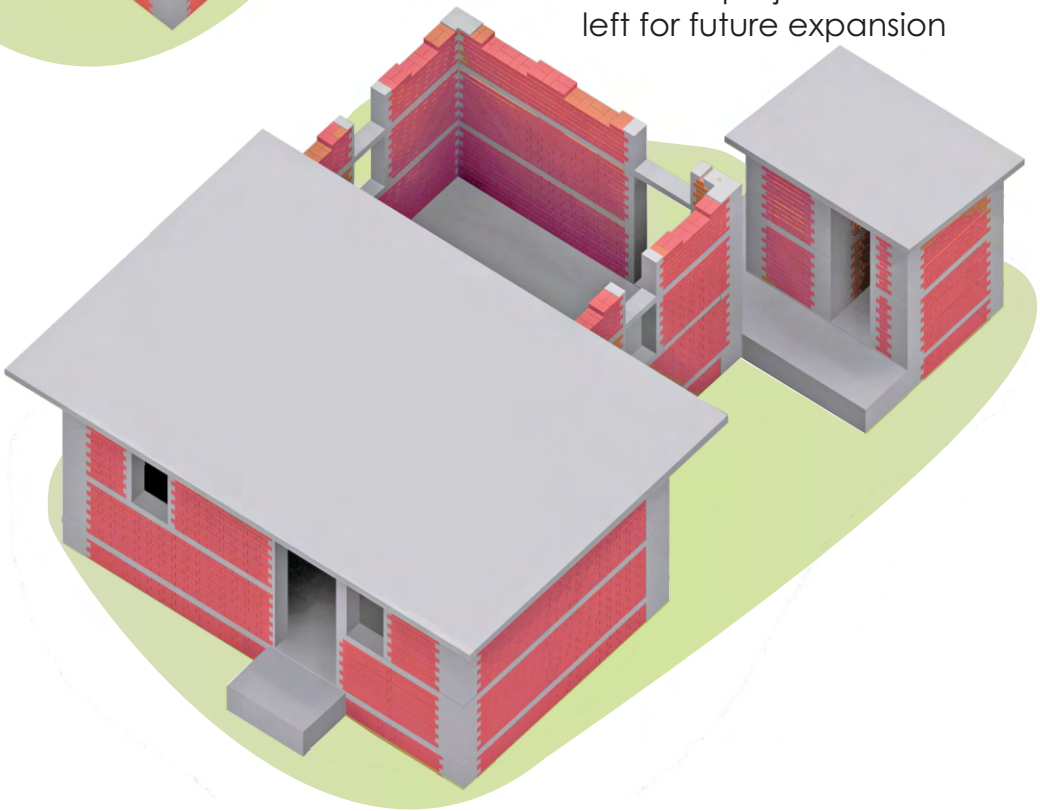
Section C-C

Option 5 Extended

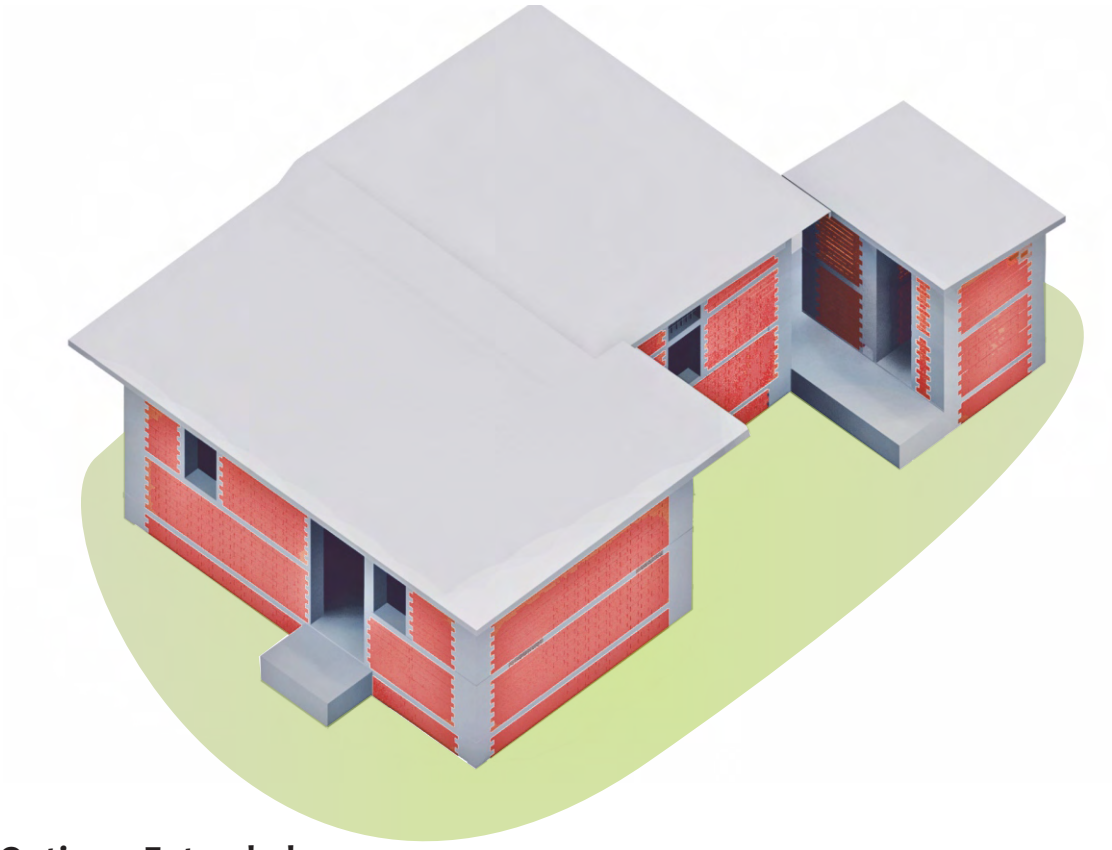
How to extend my house ?



To extend the house,
leave a projection of 600mm
from the Lintel Band
in the direction of proposed
extension and
while extending the house,
chip only the concrete
from the projected lintel band
left for future expansion



Option 5 Extended

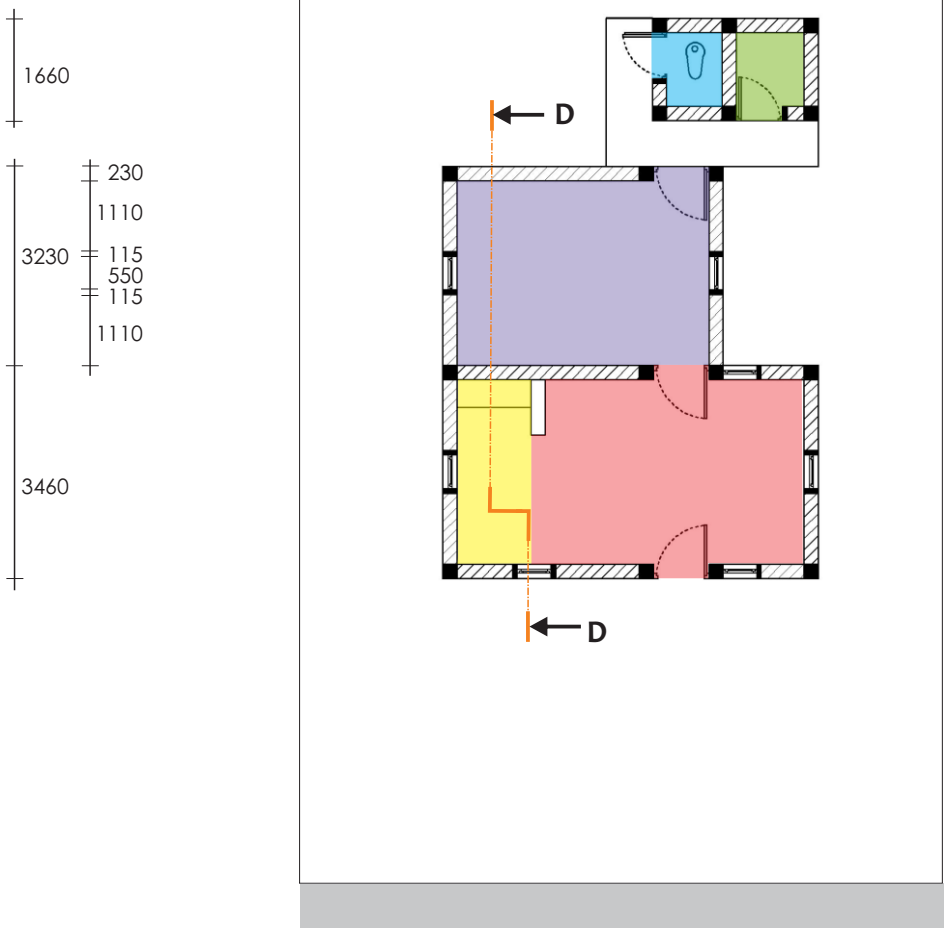


Option 5 Extended

Built-up area: 40.22 m^2

Carpet area: 30.86 m^2

Option 5 Extended



Plan

Main Room

Kitchen

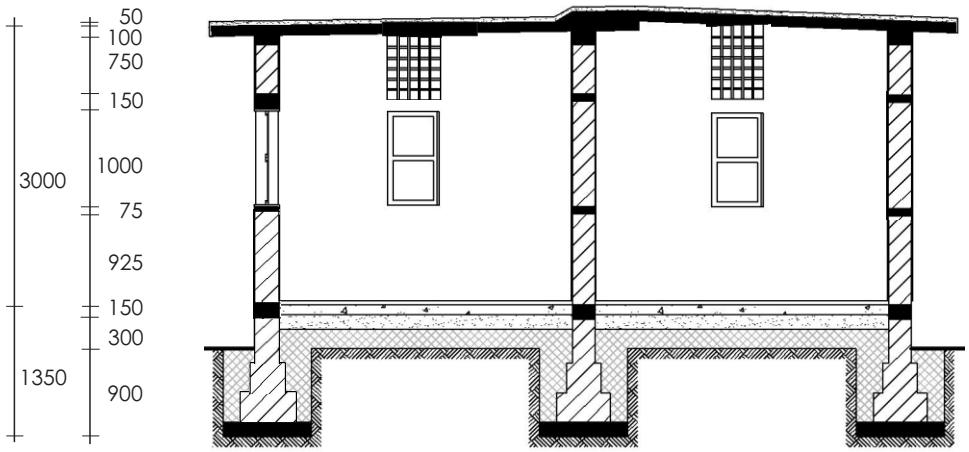
Toilet

Access Road

Bath

Additional Room

Option 5 Extended



Section D-D

Basics of Construction

What basic materials are required to build my house ?

Cement

Grade 33 cement is required in foundation and plinth (in plain concrete mat, and flooring), walls (in mortar, RC bands and RC vertical elements) and roof (reinforced concrete).

Sand

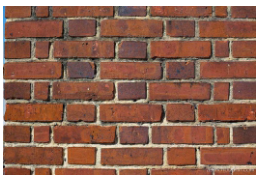
Well graded clean river sand is required in foundation and plinth (in plain concrete mat, plinth fill, and flooring), walls (in mortar, RC bands and RC vertical elements) and roof (reinforced concrete).

Aggregate

Well graded 20mm down stone aggregate is required in foundation and plinth (in plain concrete mat, and flooring), walls (in RC bands and RC vertical elements) and roof (reinforced concrete).

Steel

Steel reinforcing bars of two types are required, namely high yield strength ribbed bars of 10mm diameter and mild steel smooth bars of 6mm diameter. It is required in walls (in RC bands and RC vertical elements) and roof (reinforced concrete).



Masonry Units

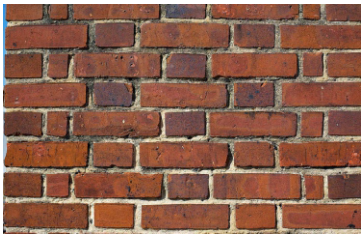
Masonry units can be burnt clay bricks, natural stone (that is dressed), fly ash bricks or cement blocks. It is required in foundation and plinth (in masonry) and walls (in masonry).

Water

Clean potable water is required for all components of the house, namely foundation and plinth, walls and roof.

Which masonry units can I use ?

Masonry walls/foundation using cement mortar can be built with following materials:



Burnt Clay Bricks

Class B or better bunt clay bricks with compressive strength of at least 7-10 MPa. The size of the bricks considered are the standard brick available in India, namely of size 230mm × 115mm × 75mm.

Fly Ash Bricks

Fly Ash bricks from nearby Thermal Power Plants with compressive strength of at least 7-10 MPa. The size of these units should be similar to that of the burnt clay bricks, namely 230 mm × 115 mm × 75 mm.

Sandstone Blocks

Naturally available sandstone units can be used. Usually, it is relatively light and easy to shape by hand using a steel edge. The compressive strength of such units should be at least 7-10 MPa. The size of such hand-shaped units shall not exceed 300 mm × 150 mm × 100 mm.

Cement Blocks

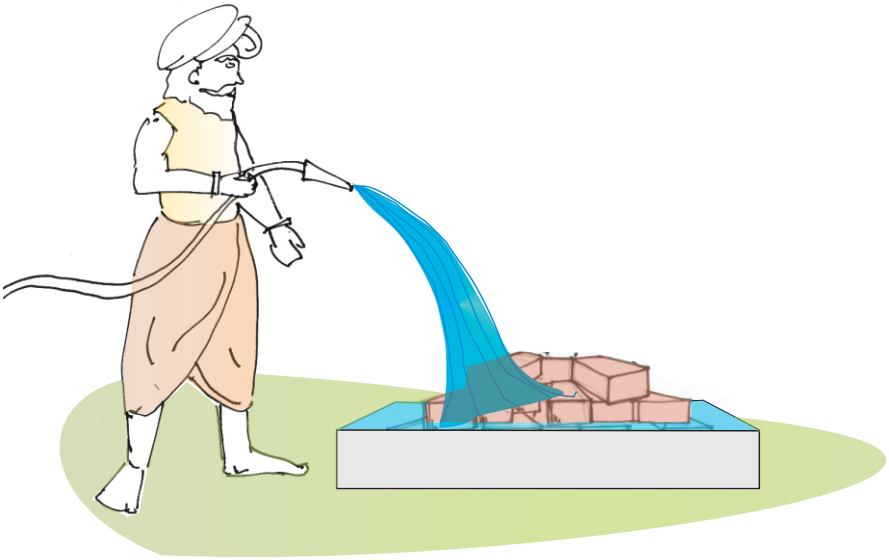
Machine-made cement blocks with 12.5 mm and down aggregated (in 1:3:6 mix of cement, sand and aggregate) can be used. These units should be properly cured to result in a compressive strength of such units of at least 7-10 MPa. The size of such hand-shaped units shall be similar to that of the burnt clay bricks, namely 230 mm × 115 mm × 75 mm.

Should masonry units be watered before I use ?

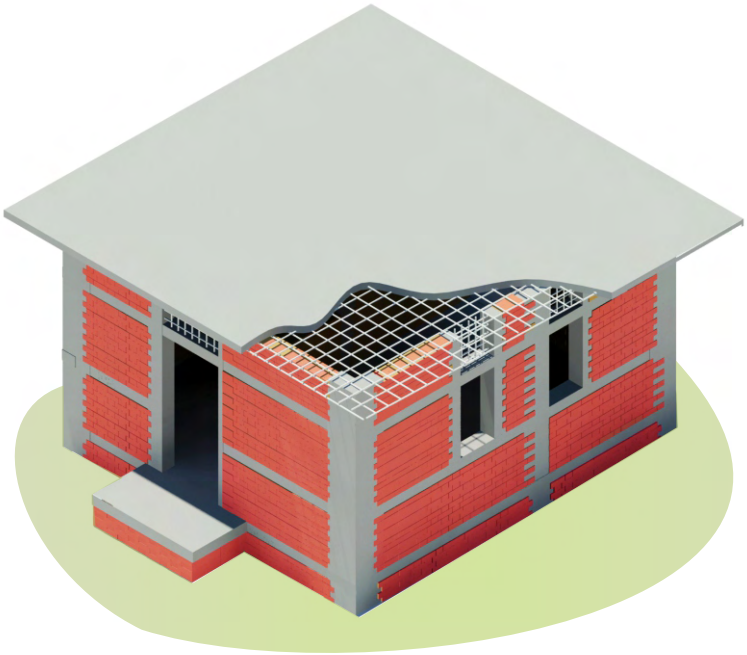
Natural stone with no or little porosity (like granite) need not be soaked before use, but should be cleaned. But, the burnt clay bricks, fly ash bricks, cement blocks and sandstone blocks are porous, and hence should be watered for about 4 hours before laying. This can be done by

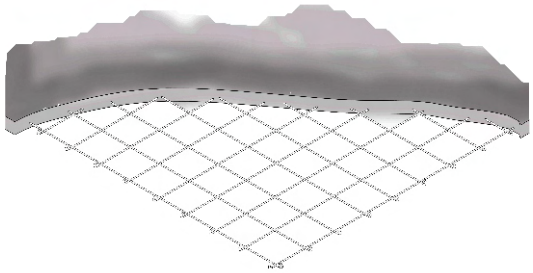
(a) Submerging them in a tub, or

(b) Watering them regularly with a hose to keep them wet all through.

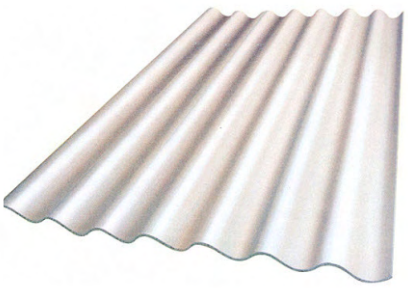


What materials are required to build my roof ?



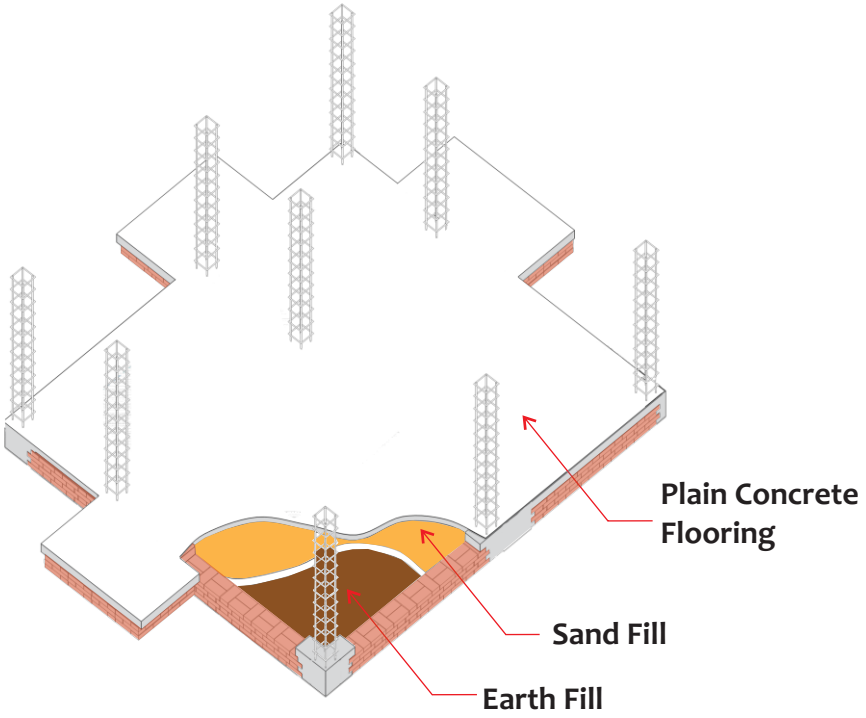


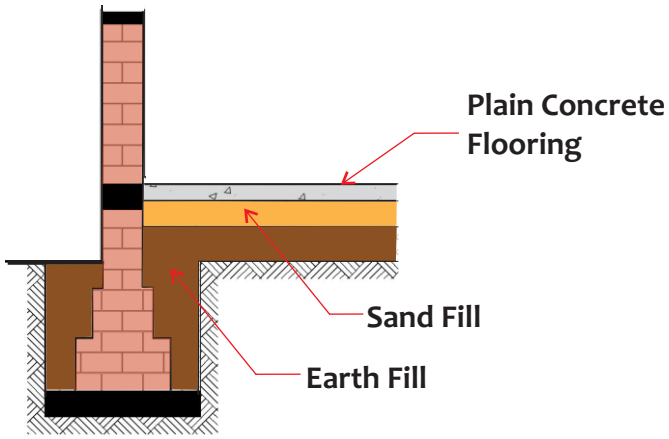
Flat Roof
Reinforced Concrete



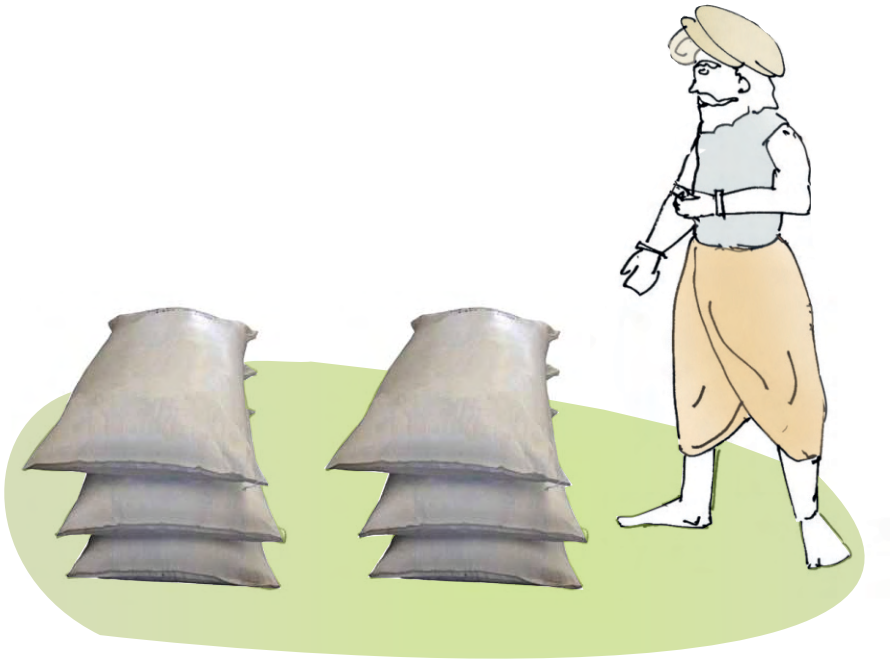
Sloping Roof
Metal Sheet roofing
supported on steel angles

What materials are required to build my floor ?

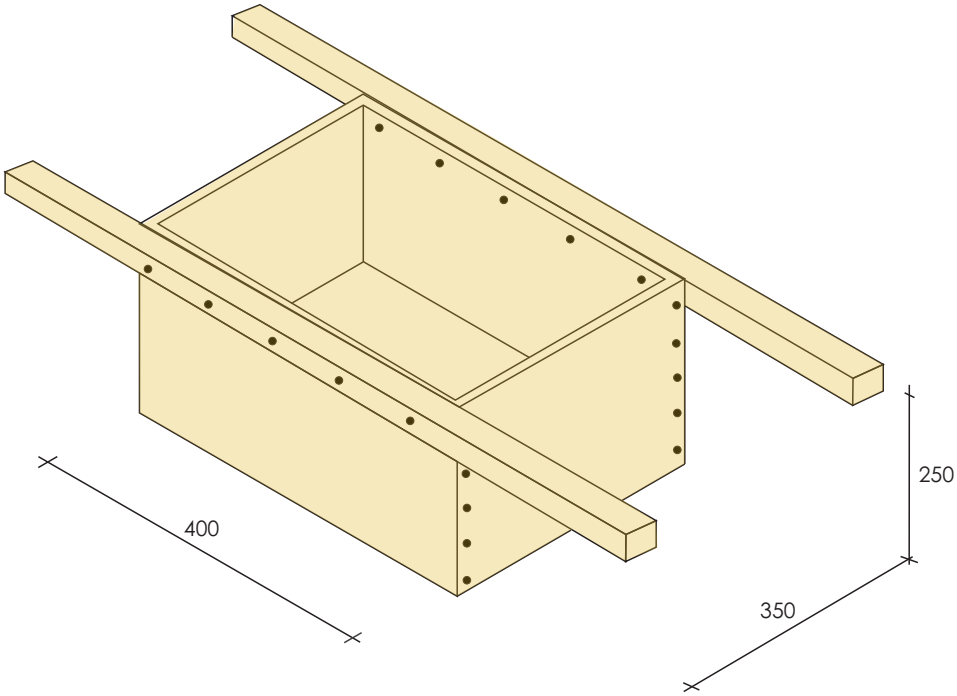




How do I measure materials for construction?

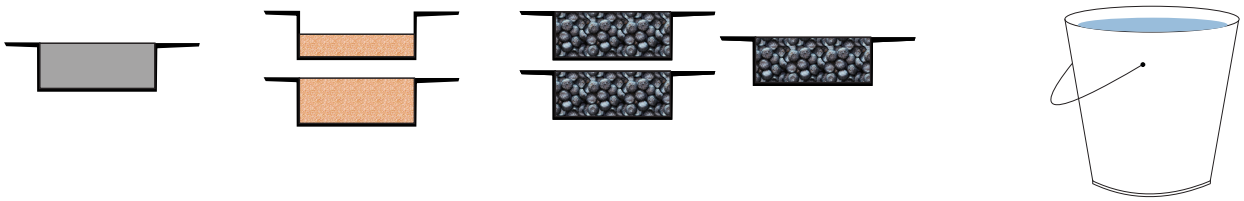


Each cement bag has 50 kg of cement



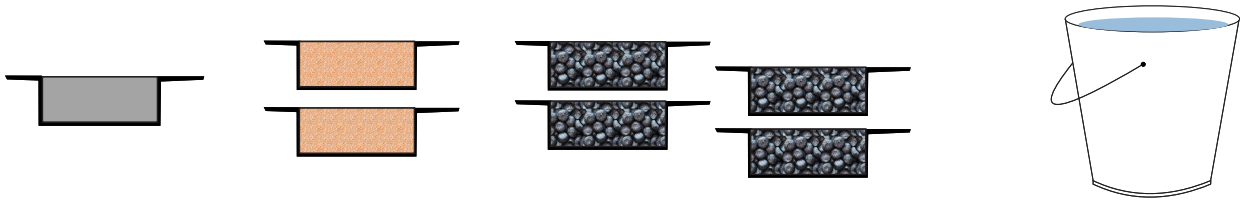
Inner dimensions of the box made of local wood for measuring sand and aggregates

What proportions of materials do I need?



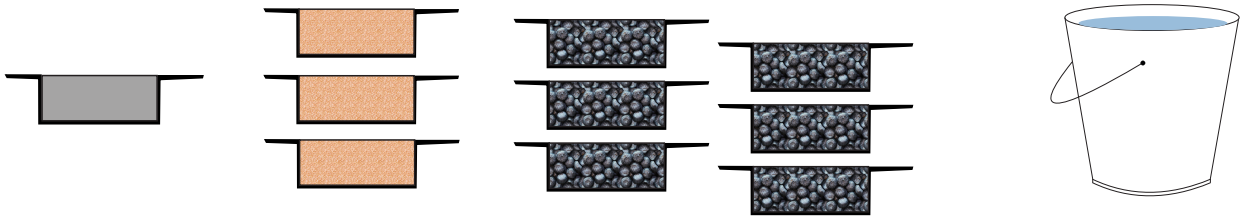
Cement	Clean Sand	Aggregate	Water
1 Box	1 ½ Boxes	3 Boxes	22 Litres

Concrete for roof slab



Cement	Clean Sand	Aggregate	Water
1 Box	2 Boxes	4 Boxes	22 Litres

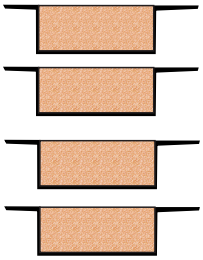
Concrete for RC vertical element and bands



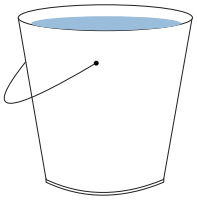
Cement	Clean Sand	Aggregate	Water
1 Box	3 Boxes	6 Boxes	22 Litres

Concrete for foundation mat and flooring

Cement
1 Box



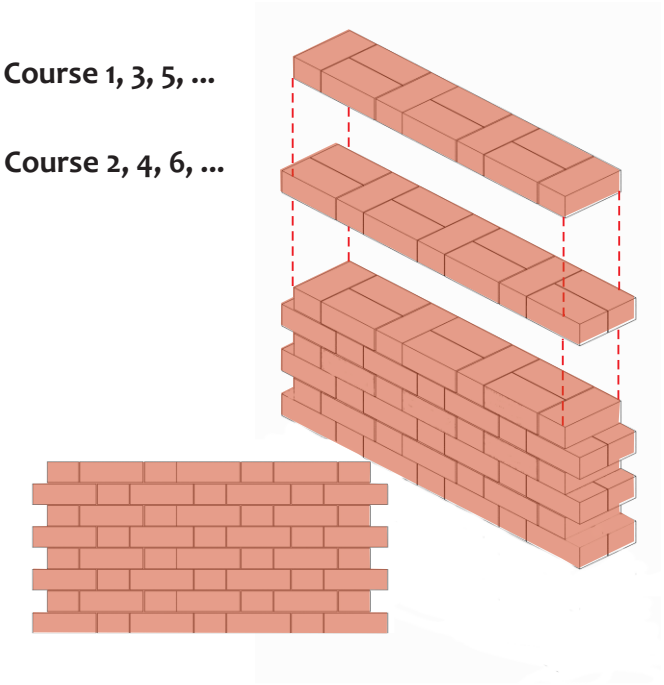
Clean Sand
4 Boxes



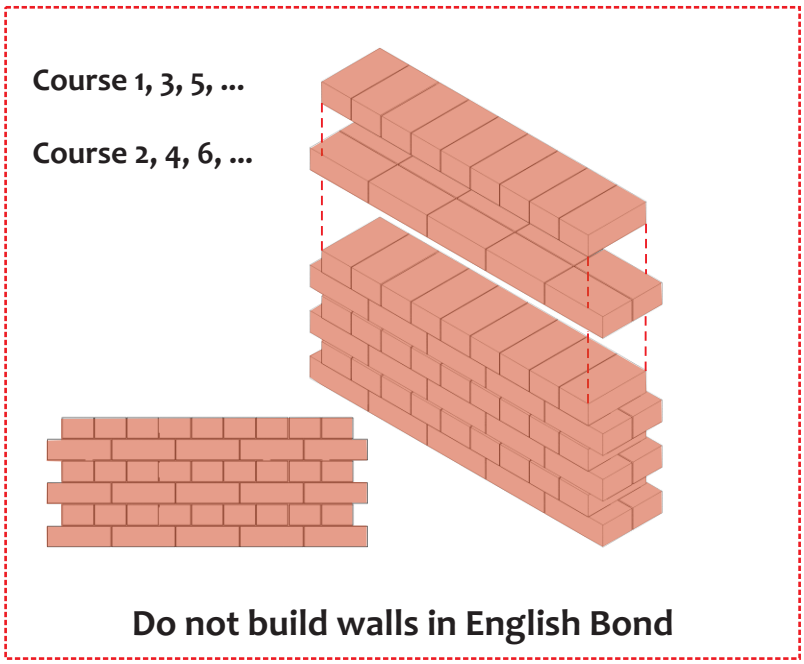
Water
20 Litres

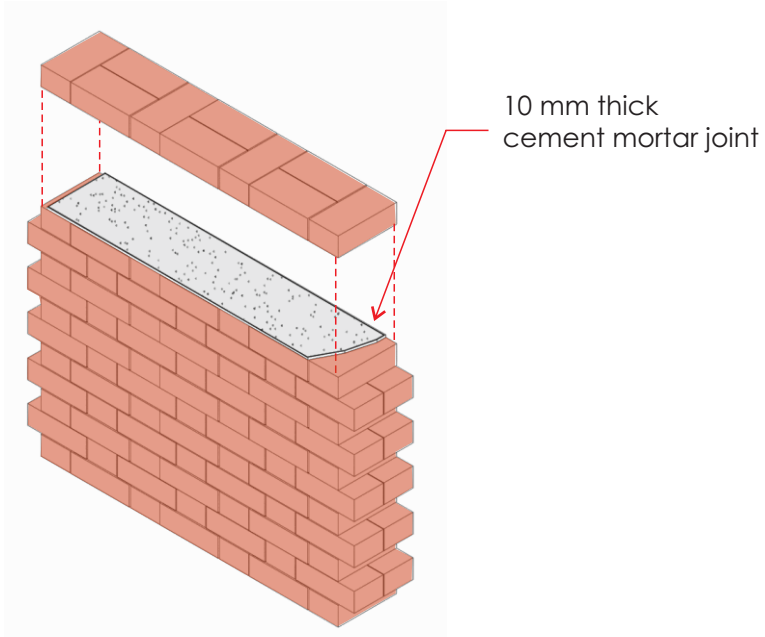
Mortar for masonry

How do I make confined masonry walls ?

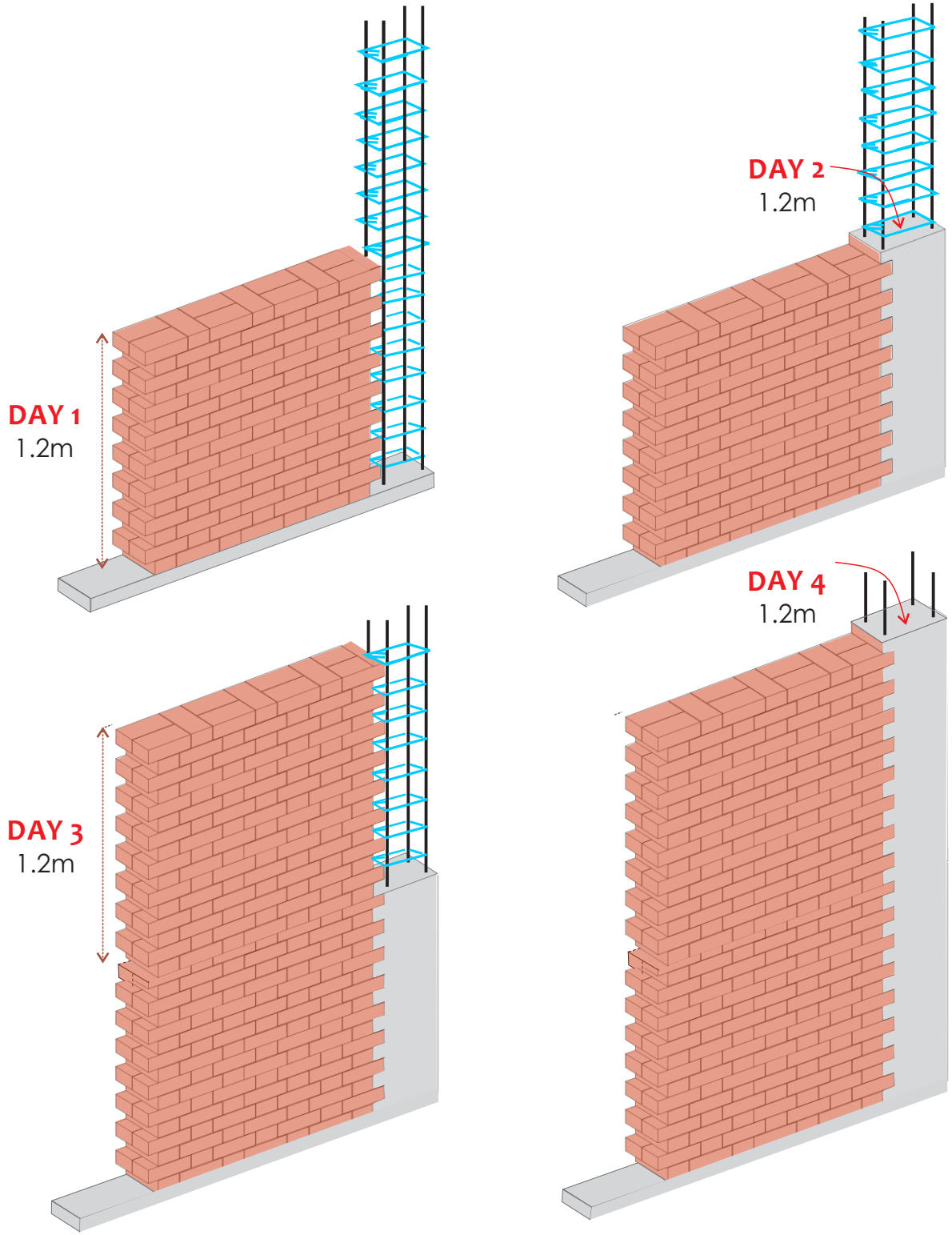


Build walls in Flemish Bond

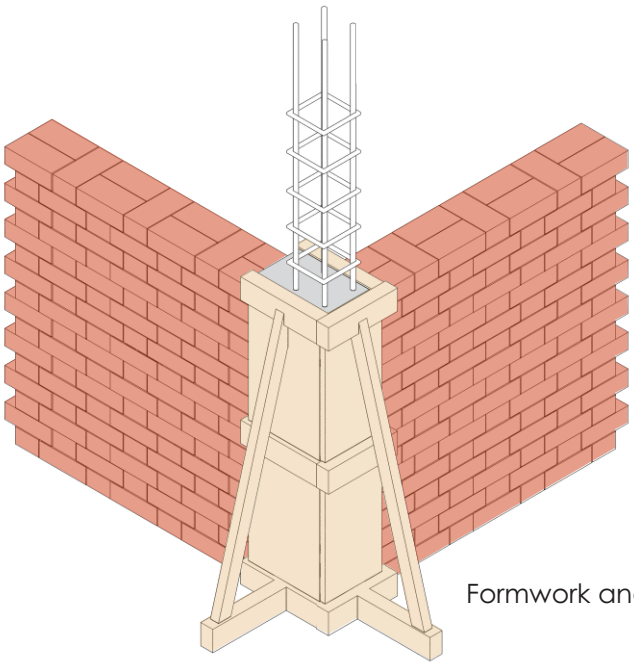




Provide 10mm thick cement mortar joints between brick courses

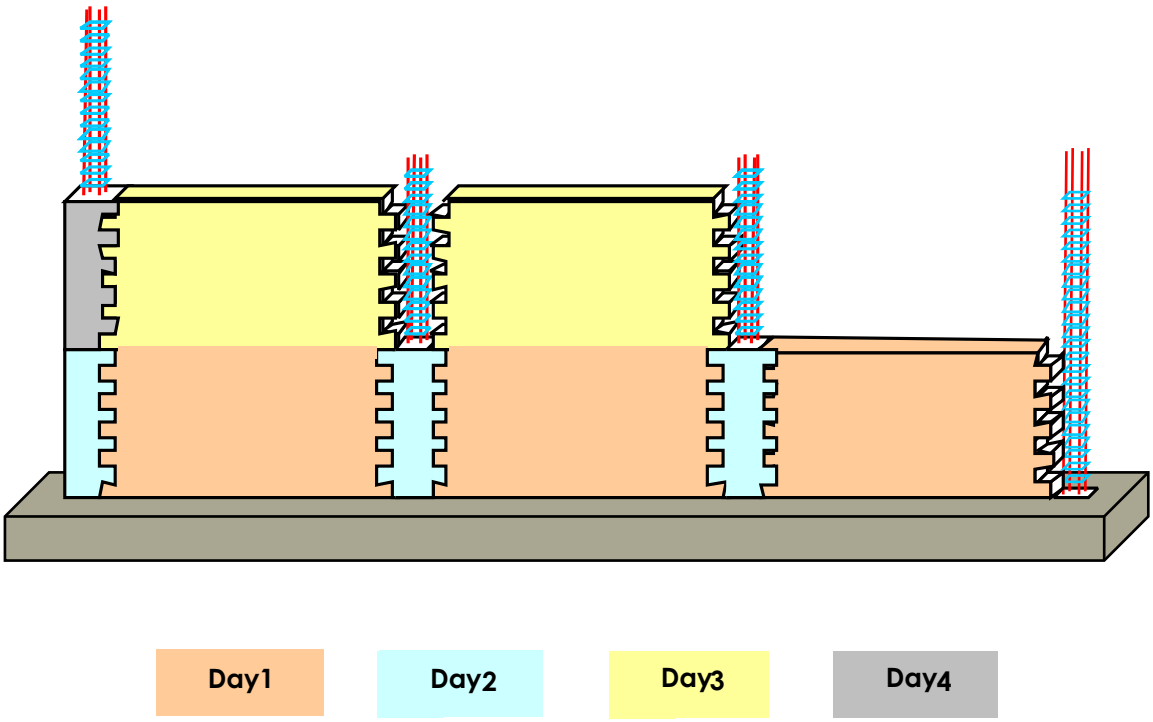


Build a maximum of 1.2 m of masonry wall segments in a day

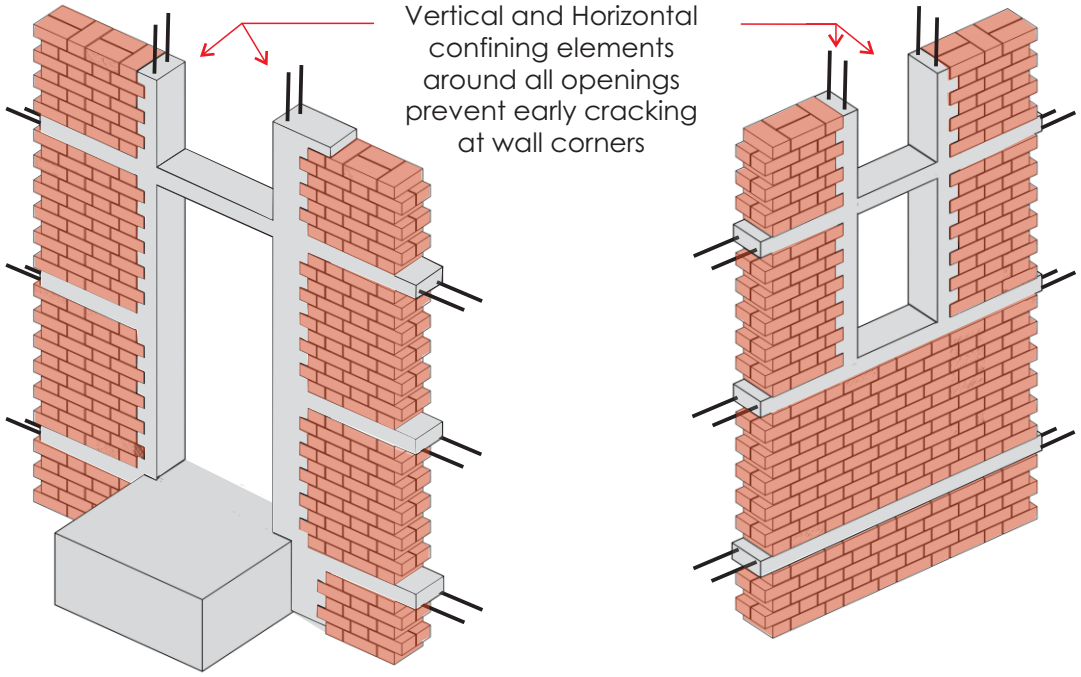


Formwork and supports

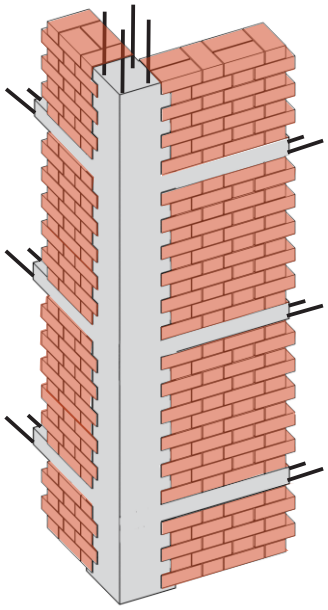
Provide vertical formwork with supports for pouring concrete of RC vertical elements at brick masonry wall junctions



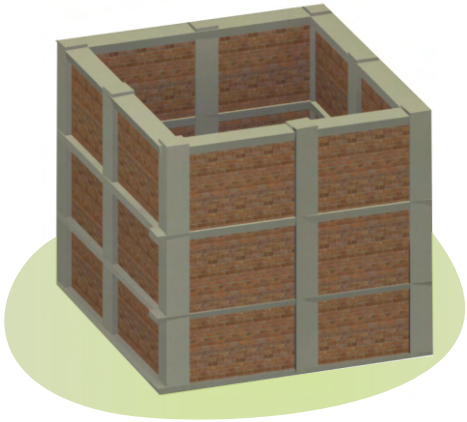
Build the walls leaving slots for RC elements



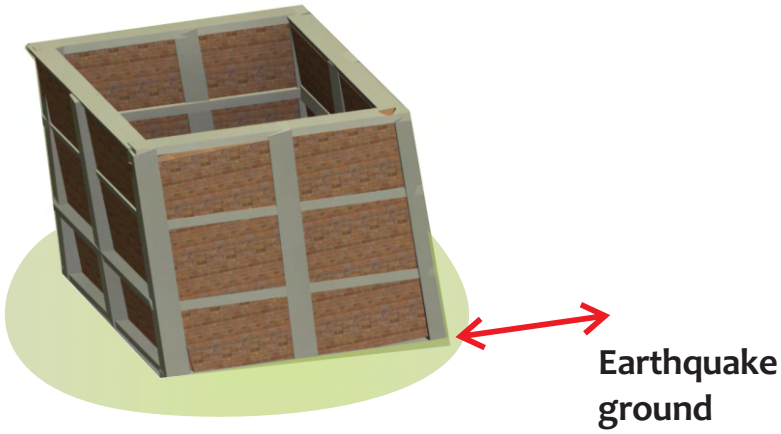
Lintel, Sill and Plinth bands pass though the vertical RC elements
RC bands and elements support the brick masonry at openings



Vertical RC elements keep brick masonry segments in place at the corners



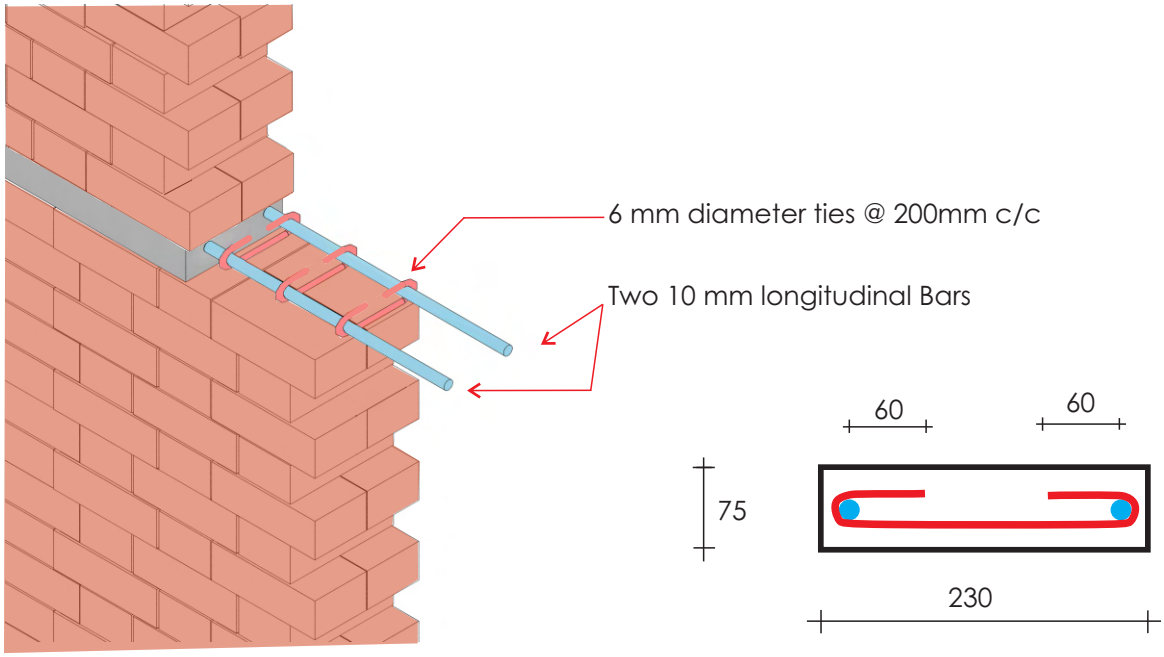
Masonry wall segments
confined on all sides with RC elements



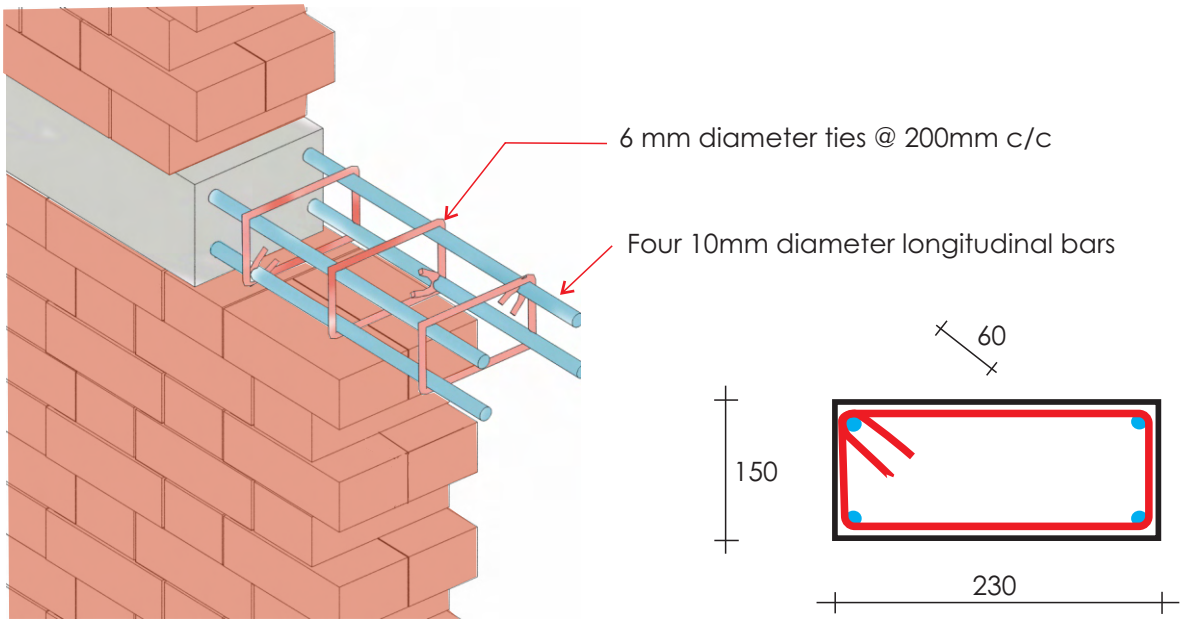
RC elements
prevent masonry form collapsing

Vertical RC elements and horizontal RC bands hold masonry wall segments together (like a strap holding a package)

How do I make horizontal RC bands ?

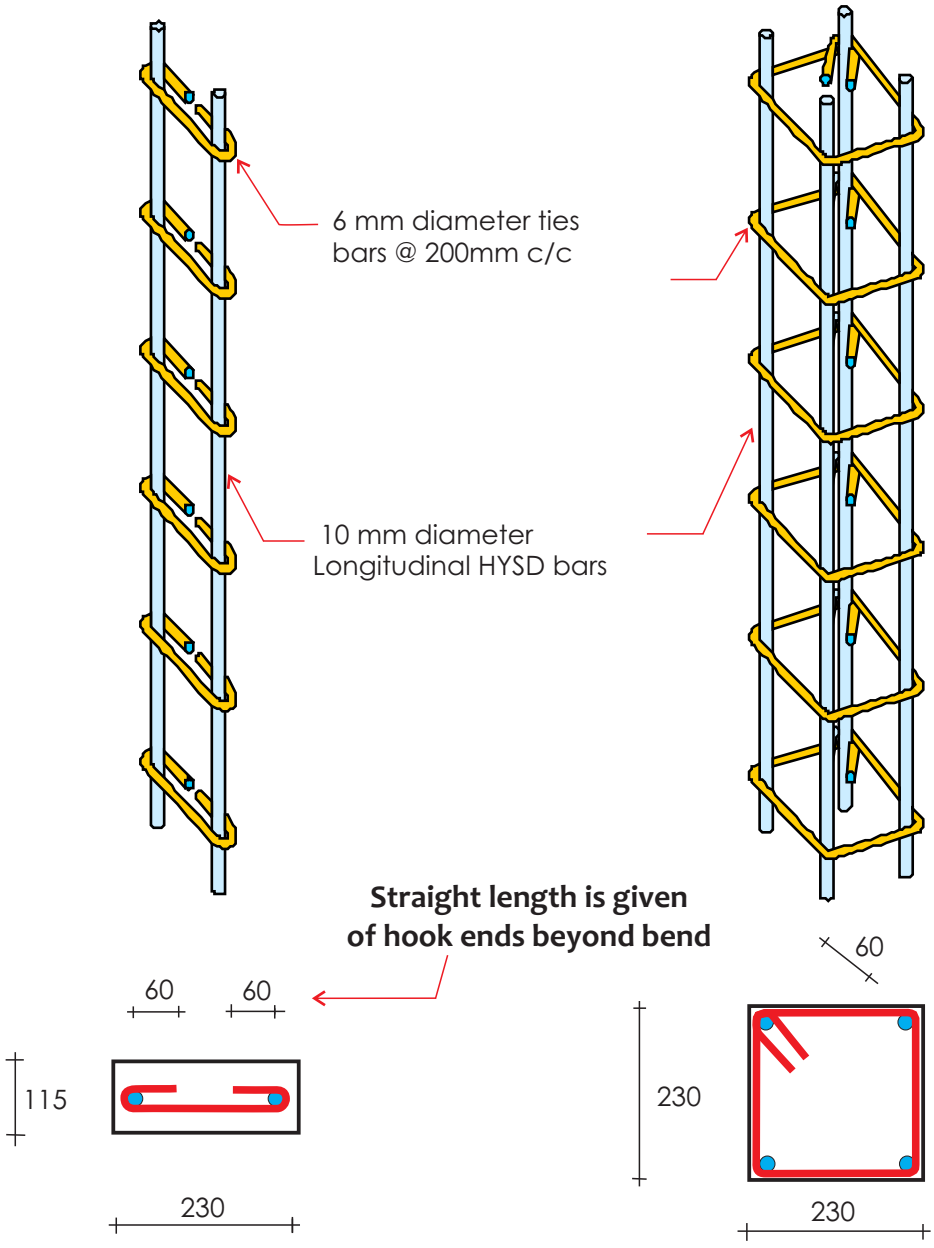


Sill and Lintel Bands



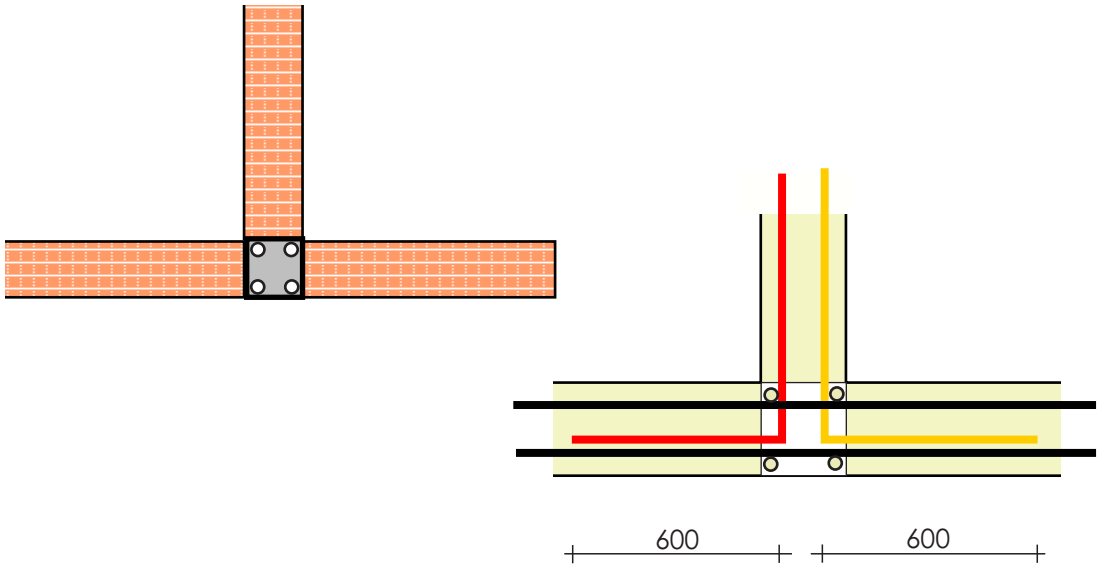
Plinth Band

How do I make vertical RC elements ?



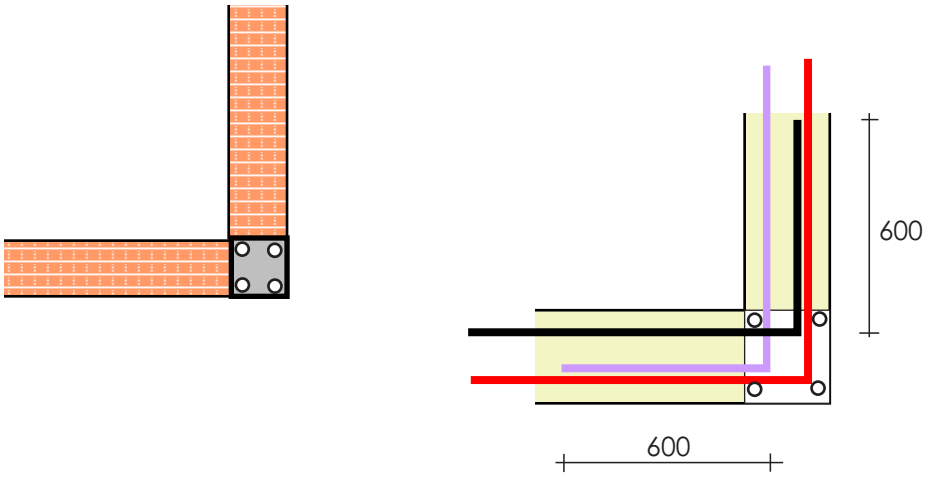
Reinforcement in Vertical RC confining members around door openings (230mm X 115mm)

How do I pass longitudinal bars of horizontal RC bands through vertical RC elements ?



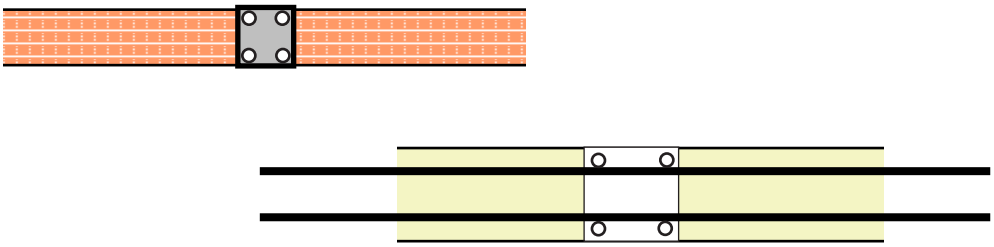
T-Junction of Walls

Reinforcement bars will be at two levels, one above the other



L-Junction of Walls

Reinforcement will be at two levels, one above the other

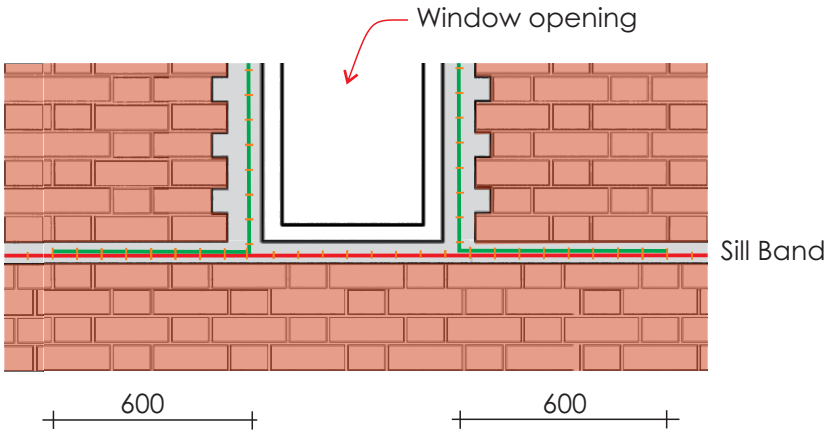


Straight Walls

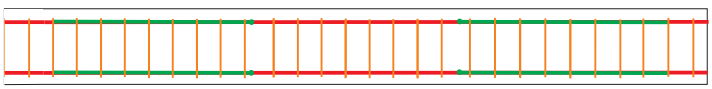
Reinforcement bars will be at one level

Reinforcement detail at junction of RC element and RC sill band

Elevation



Plan



Construction of Confined Masonry House - Option 1

How do I build my Confined Masonry House ?

Step-wise Procedure

Construction of a Confined Masonry House entails 3 major phases, namely

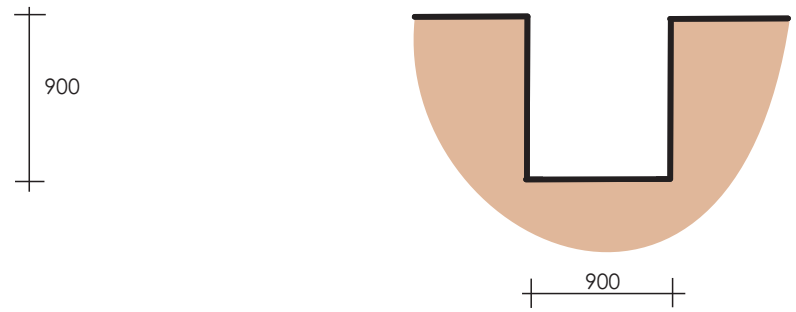
Foundation and Plinth

Superstructure

Roof

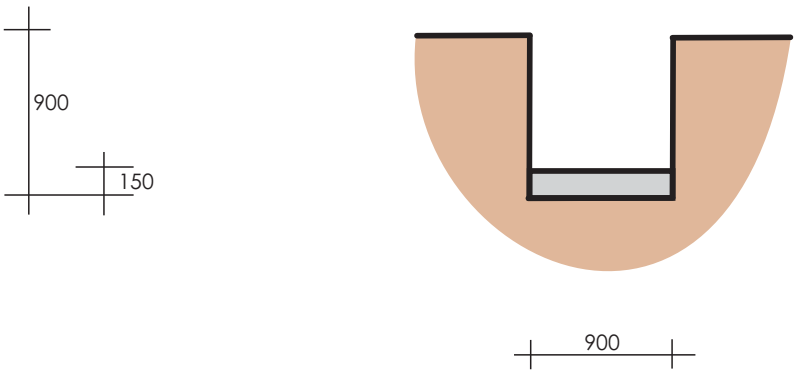
In this section, sequence of construction is elaborated pictorially in a step-wise procedure to recall all salient steps in the making of a Confined Masonry House. The following colour code is adopted for the above three phases of construction:

Foundation and Plinth



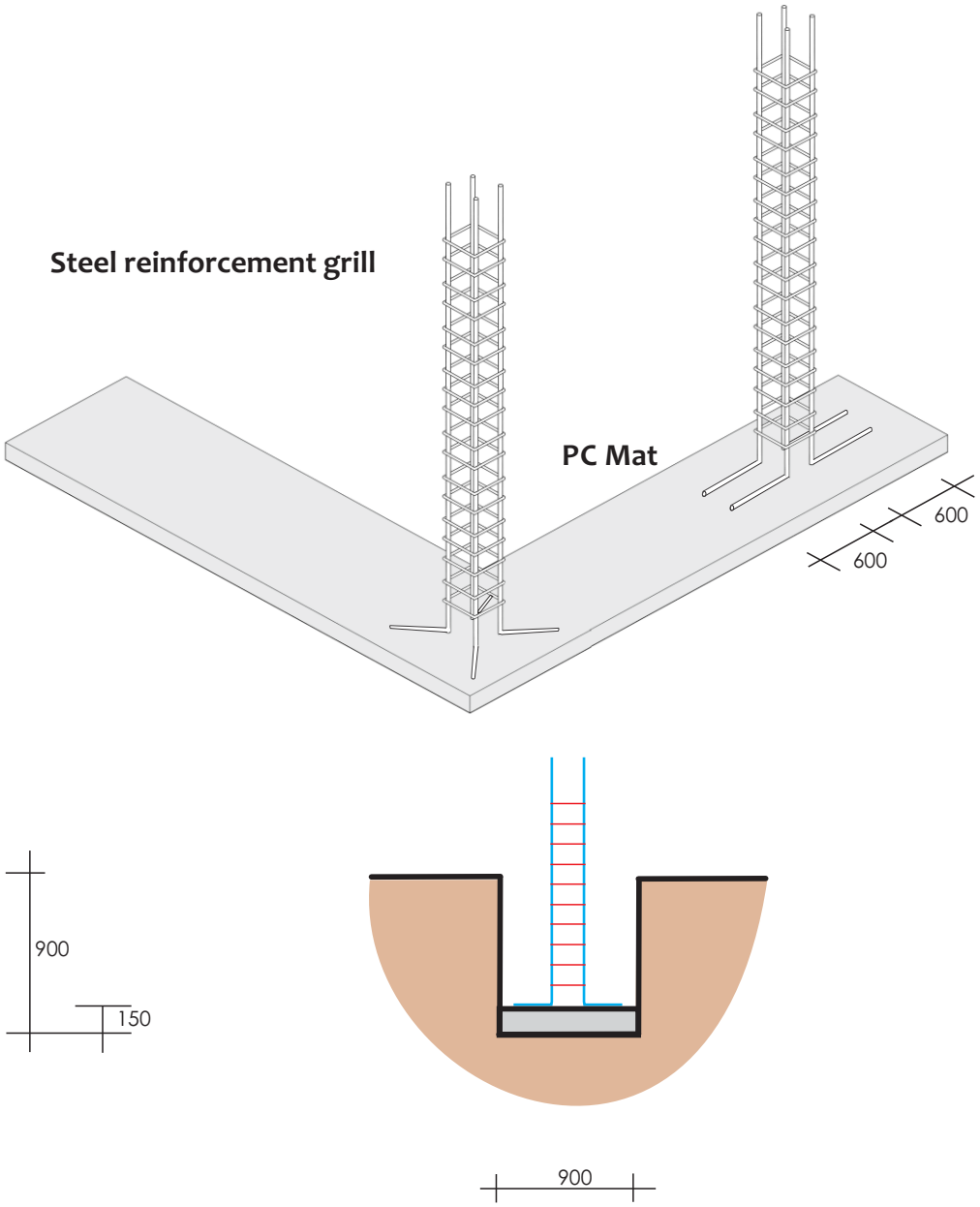
Step 1

Dig a pit 900 mm wide and 900mm deep along the wall line of the house.



Step 2

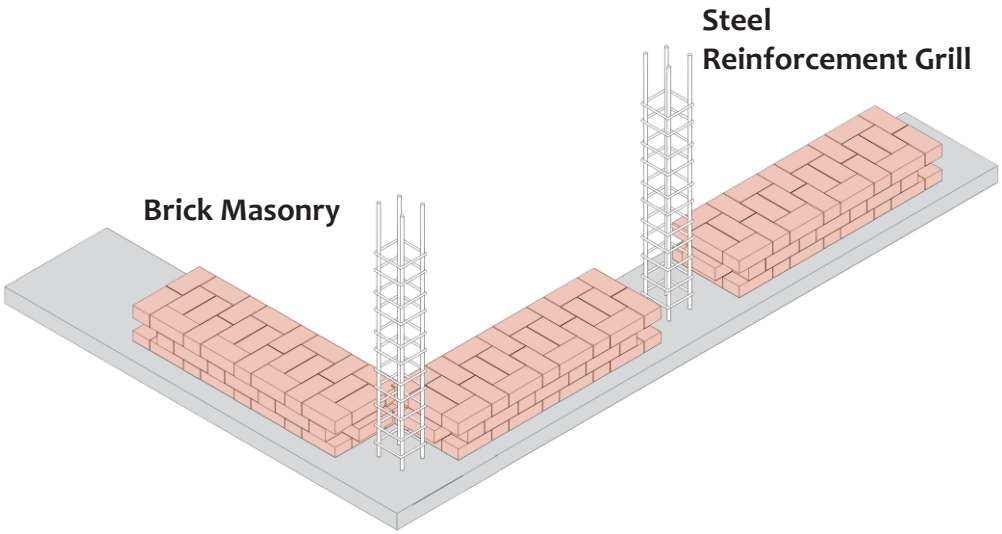
Pour in this pit plain cement concrete (1:3:6 mix of cement, sand and aggregate) of 150 mm thickness

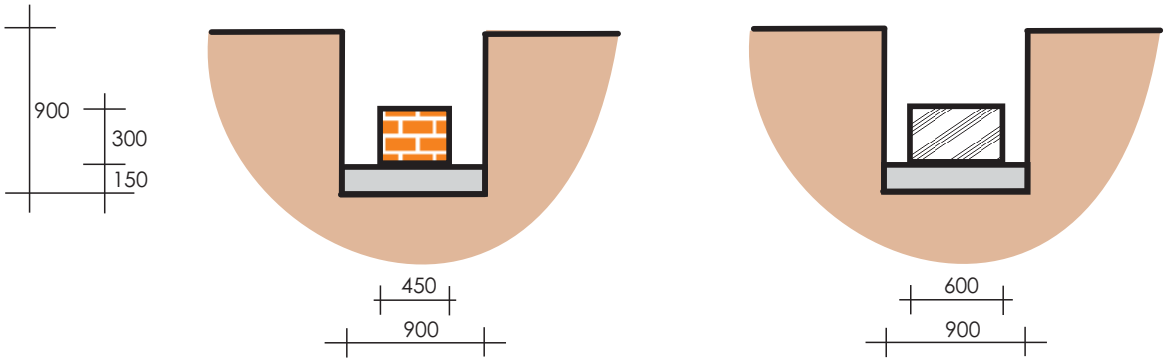


Step 3

Prepare reinforcement grill of RC vertical elements. Use steel reinforcement bars of full height till the roof level, up to which RC vertical elements are required. Provide lateral supports to hold these reinforcement grills during construction.

Foundation and Plinth



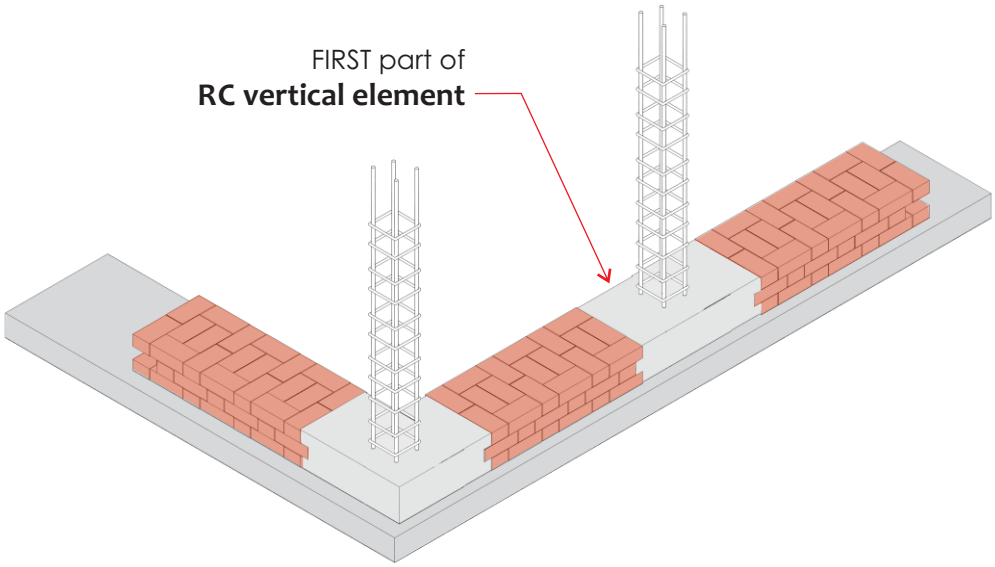


Brick Masonry

Stone Masonry

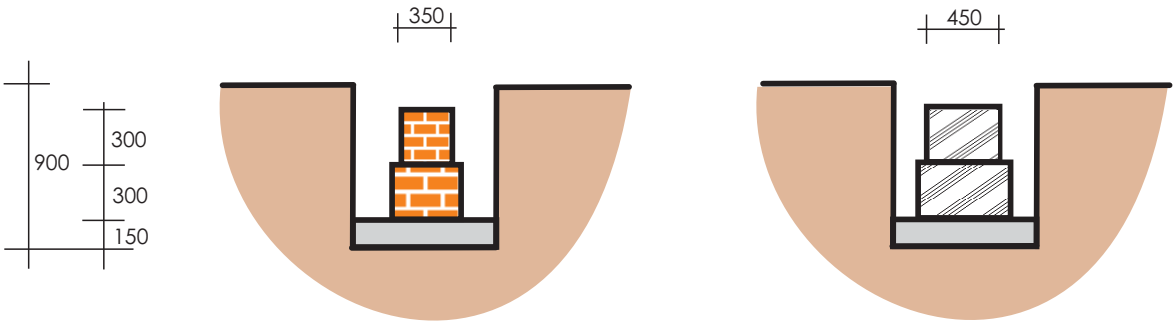
Step 4

Lay the first three masonry courses with cement mortar (1:4 mix of cement and sand) over the plain concrete mat leaving gaps near steel reinforcement provided for RC vertical elements.



Step 5

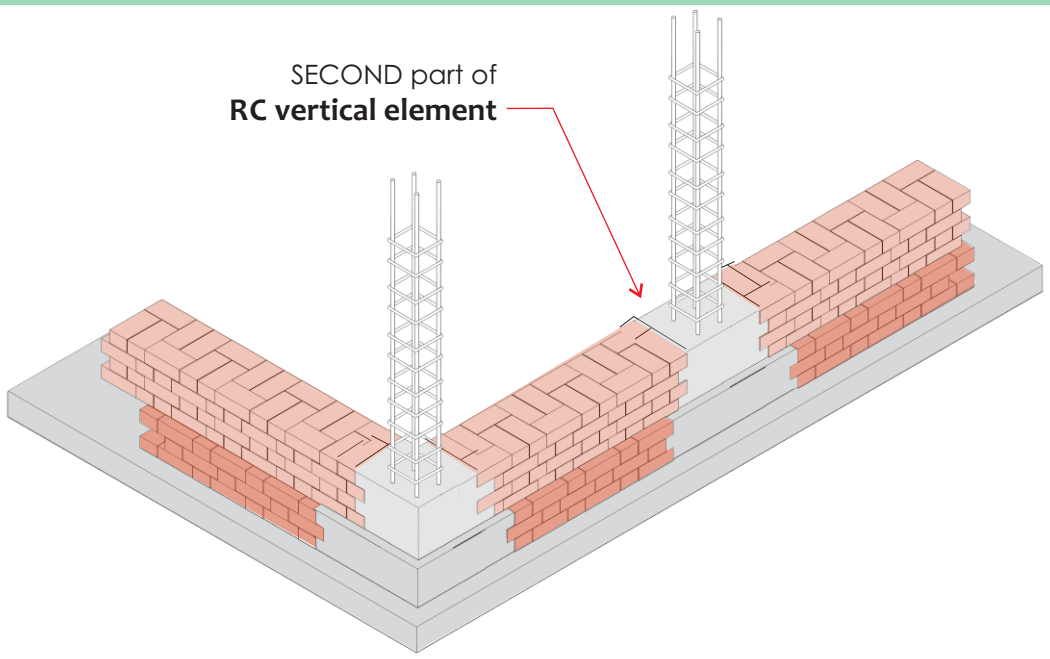
Pour concrete (1:2:4 mix of cement, sand and aggregate) in gaps between brick masonry and steel reinforcement bars.



Brick Masonry **Stone Masonry**

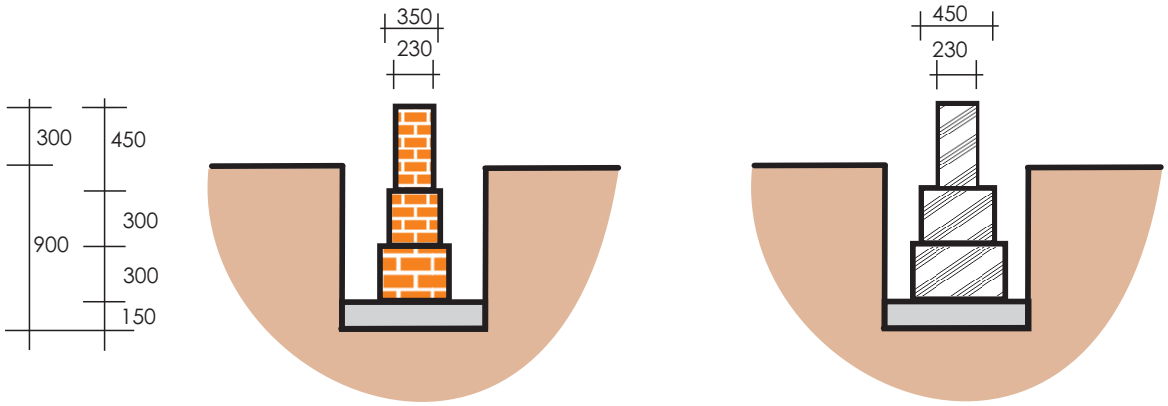
Step 6

Place the next four masonry courses with cement mortar (1:4 mix of cement and sand) above the earlier brick masonry wall



Step 7

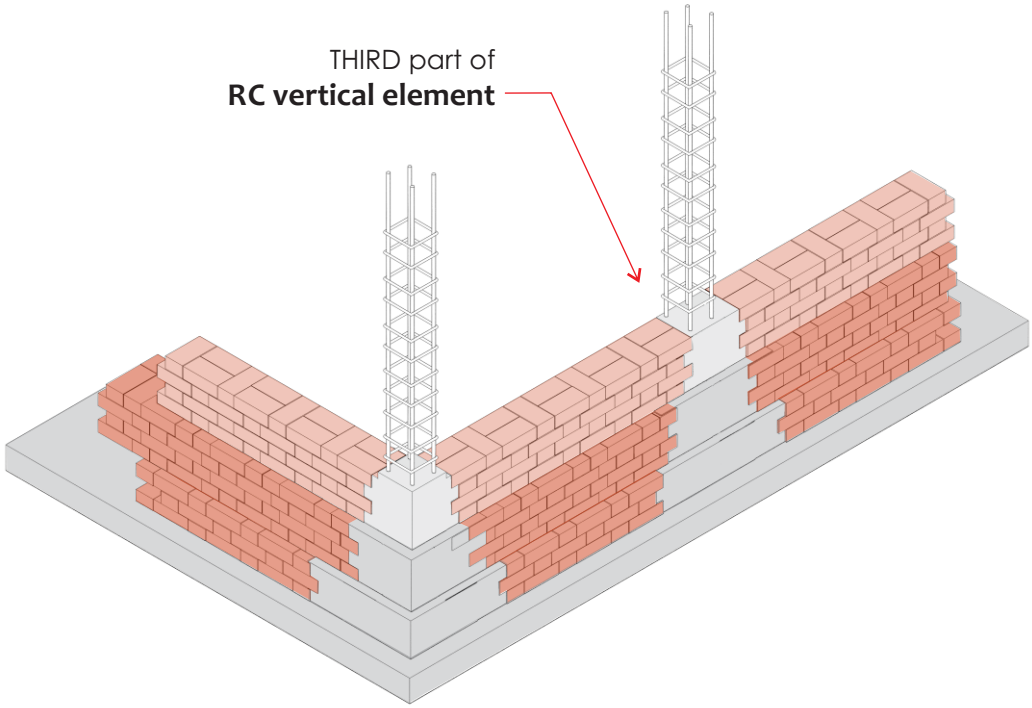
Pour concrete (1:2:4 mix of cement, sand and aggregate) around steel reinforcement grill up to the top level of masonry course made so far.



Brick Masonry **Stone Masonry**

Step 8

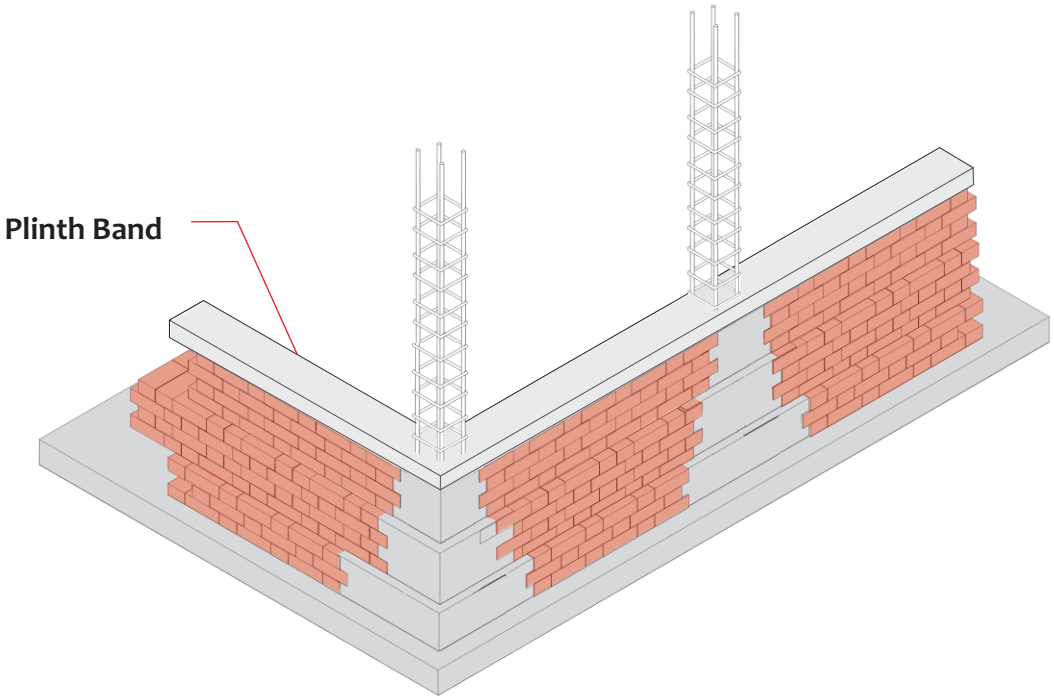
Place the next four masonry courses with cement mortar (1:4 mix of cement and sand)

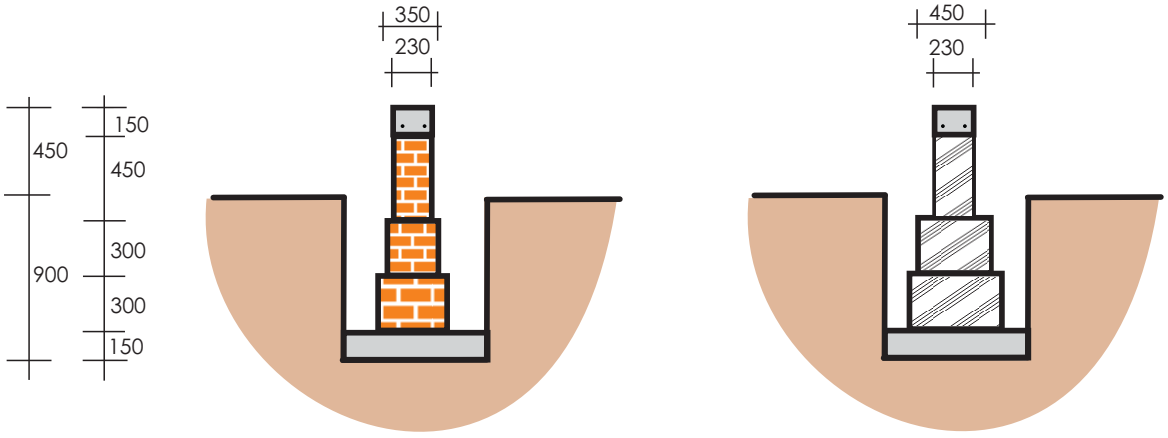


Step 9

Pour concrete (1:2:4 mix of cement, sand and aggregate) around steel reinforcement grill up to the top level of masonry course made so far.

Foundation and Plinth



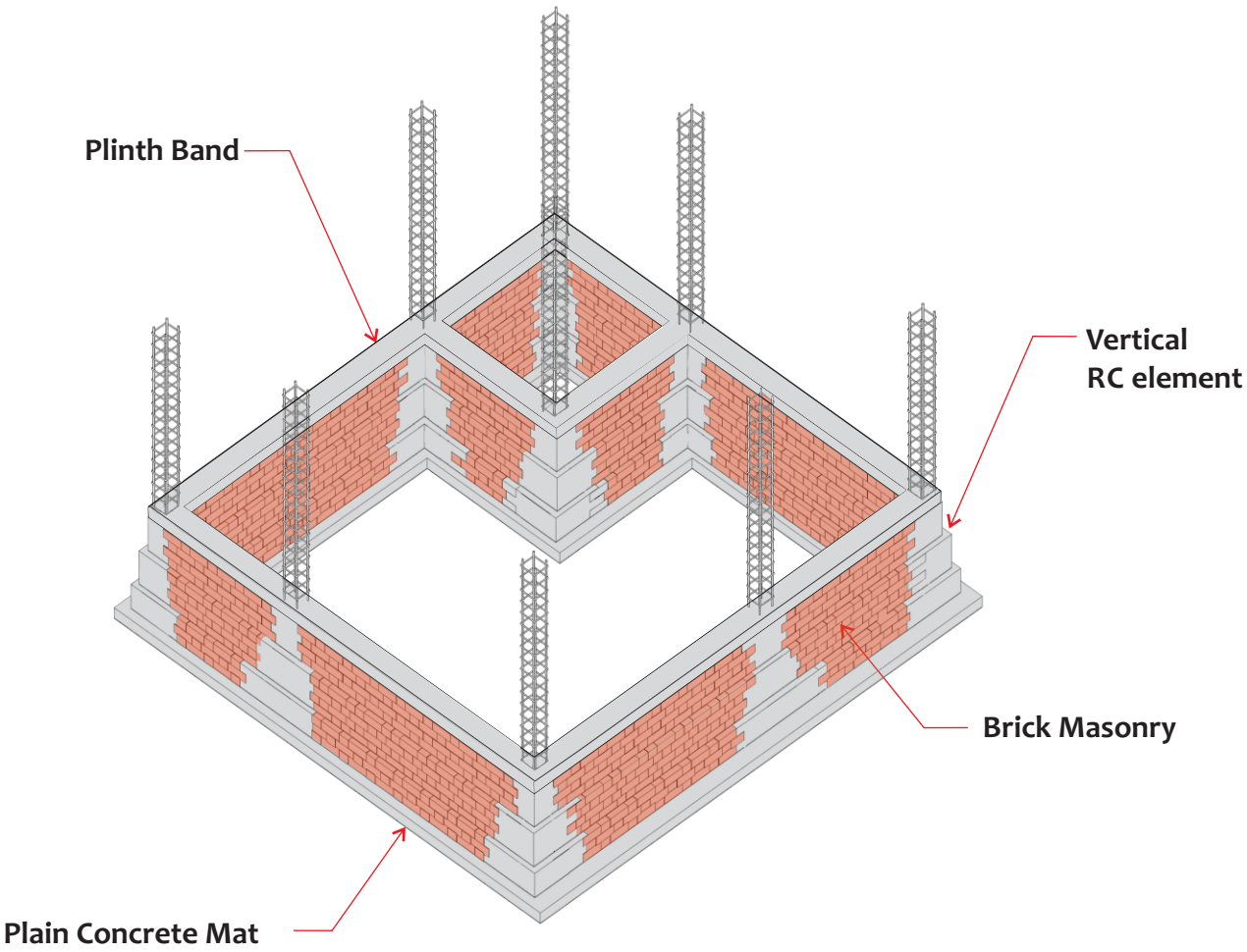


Brick Masonry **Stone Masonry**

Step 10

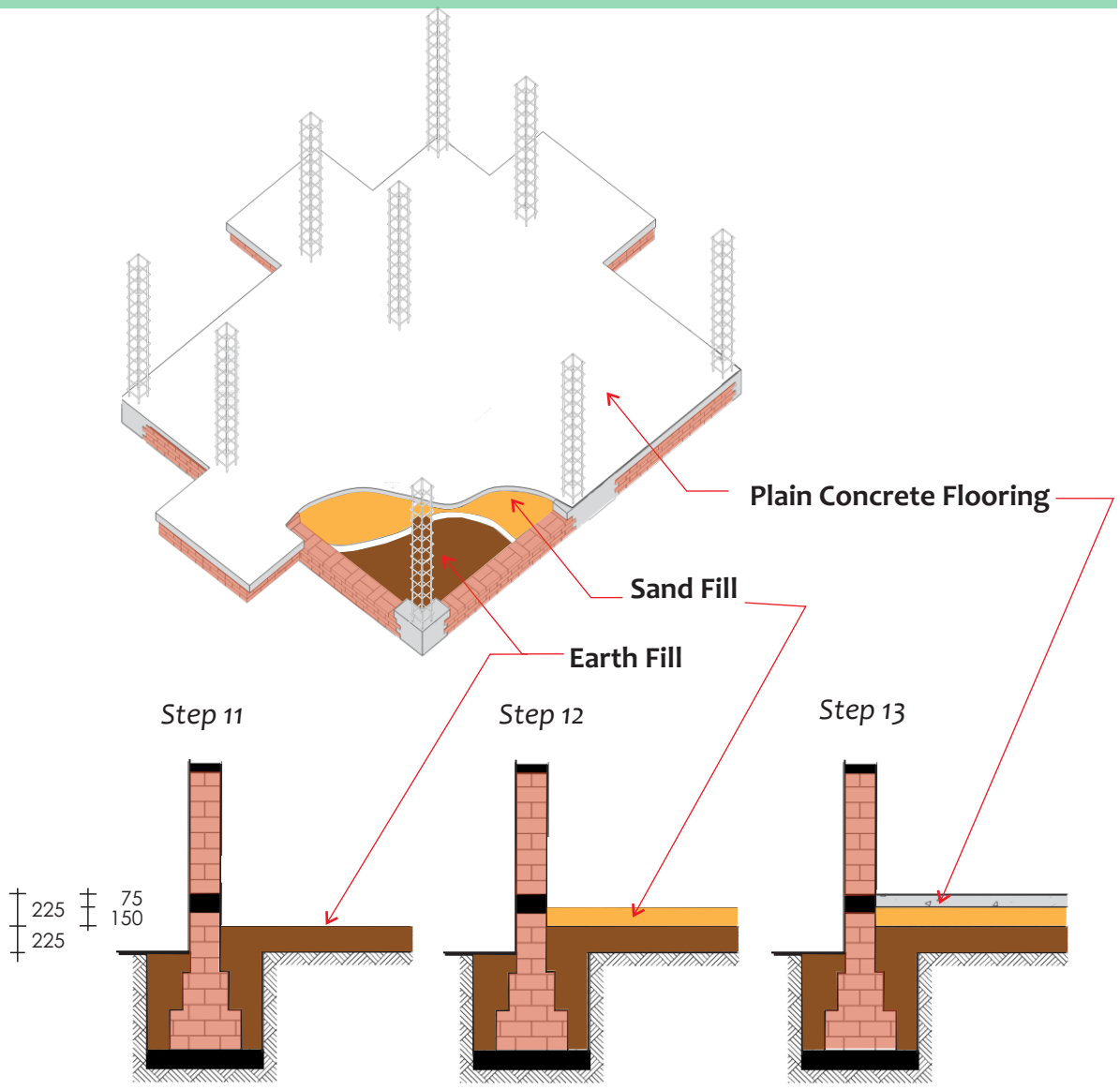
Place steel reinforcement grill for the plinth beam, and pour concrete (1:2:4 mix of cement. sand and aggregates) for plinth band above brick masonry

Foundation and Plinth



View of my Confined Masonry House
after Step 10

Foundation and Plinth



Step 11

Fill the plinth with earth up to 225 mm above native ground level.

Step 12

Top the earth fill with 150mm thick sand bed.

Step 13

Place the plain concrete (1:3:6 mix of cement, sand and aggregate) over the layer of sand.

Foundation and Plinth

For the construction of Foundation and Plinth, the materials required are:

Cement

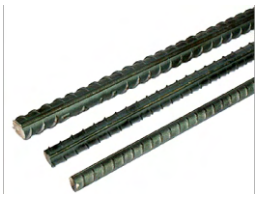
36 bags

Sand

6.8 m^3

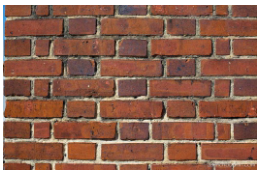
Aggregates

20 mm (Nominal) : 3.1 m^3



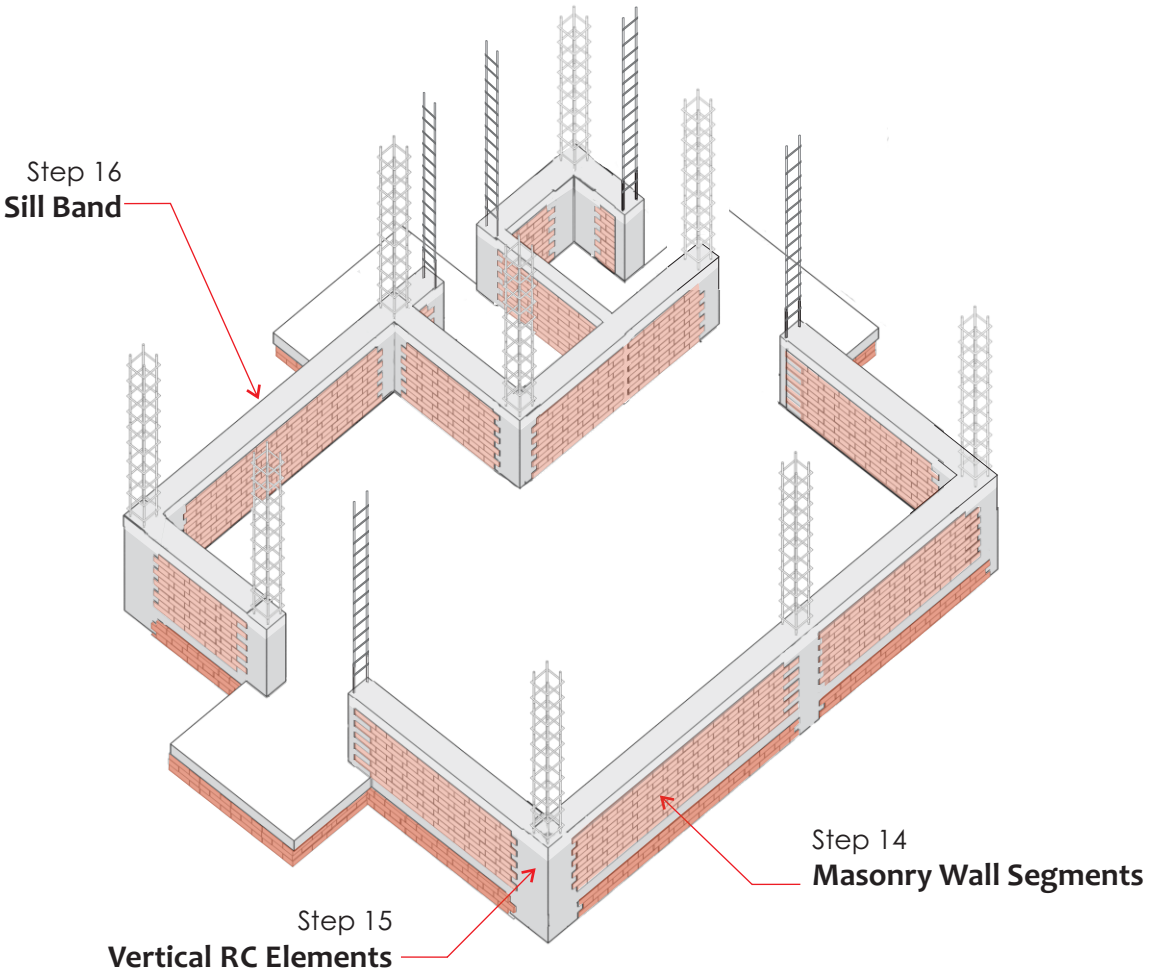
Steel

High Strength Steel : 180 m of **10** mm diameter bars
Mild Steel : 190 m of **6** mm diameter bars



Burnt Clay Bricks

3,600



Step 14

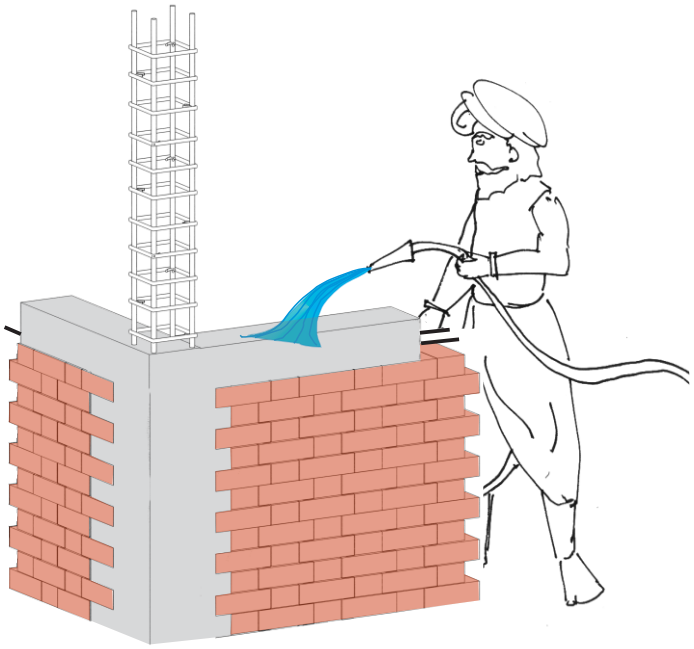
Build masonry wall segments till 75 mm below sill level.

Step 15

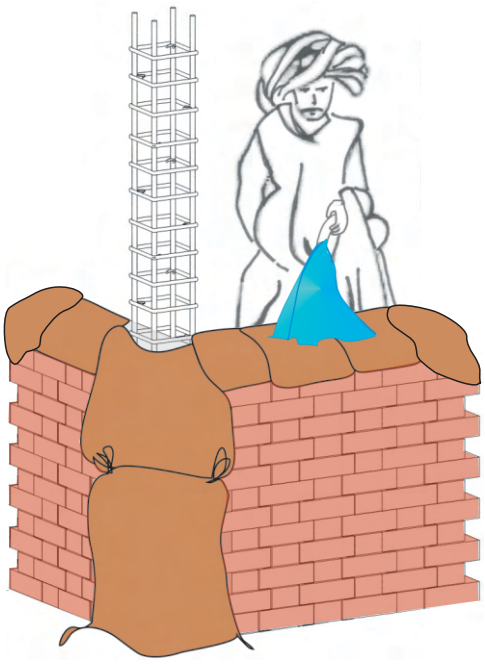
Pour concrete (1:2:4 mix of cement, sand and aggregate) of vertical RC elements around steel reinforcement grill up to the level of top masonry course.

Step 16

Place the steel reinforcement cage and pour concrete (1:2:4 mix of cement, sand and aggregate) for Sill Band.



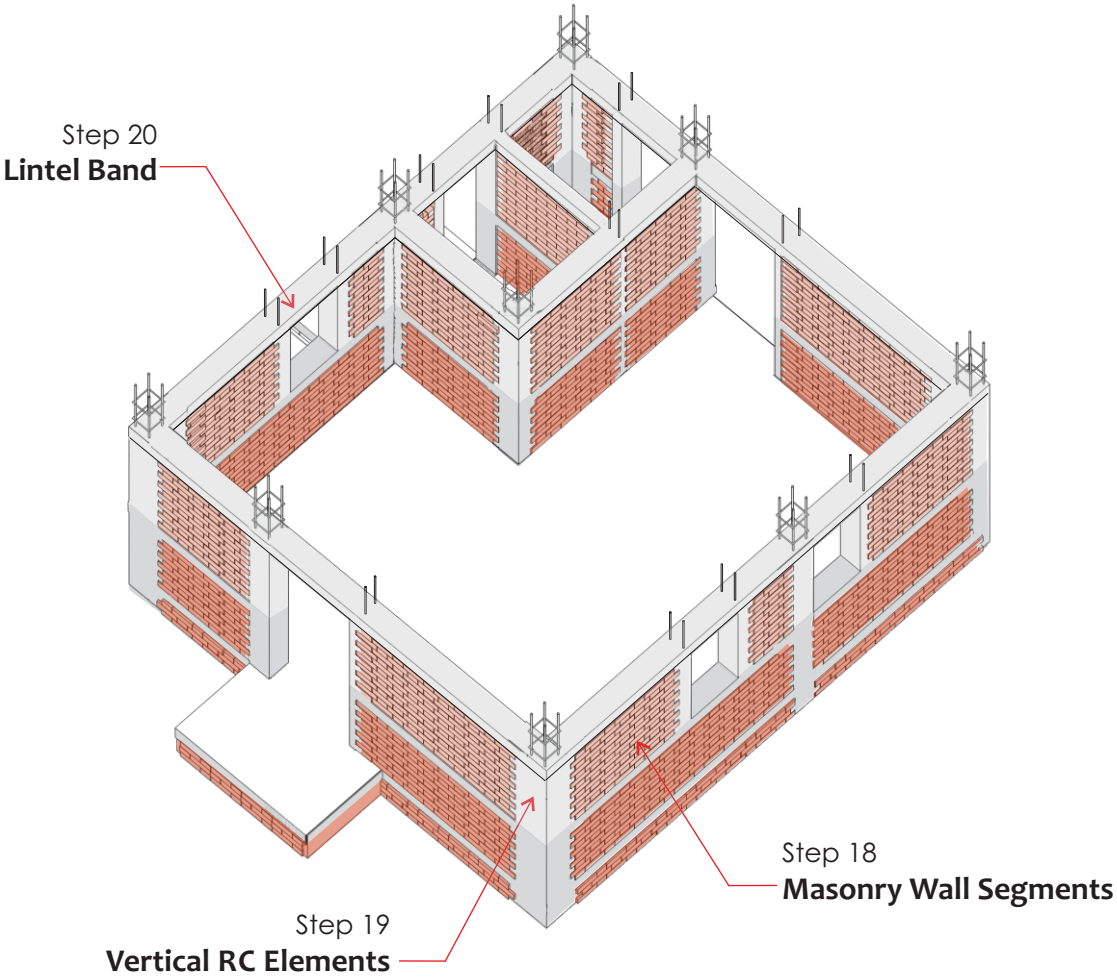
Direct wetting with water hose



Keeping the jute sheets moist

Step 17

Cure the vertical RC elements and horizontal RC bands for at least 7 days. Two options are available, namely (a) wetting the RC elements with direct water jet every hour, and (b) cover the RC elements with jute sheets and keeping the jute sheets moist throughout.



Step 18

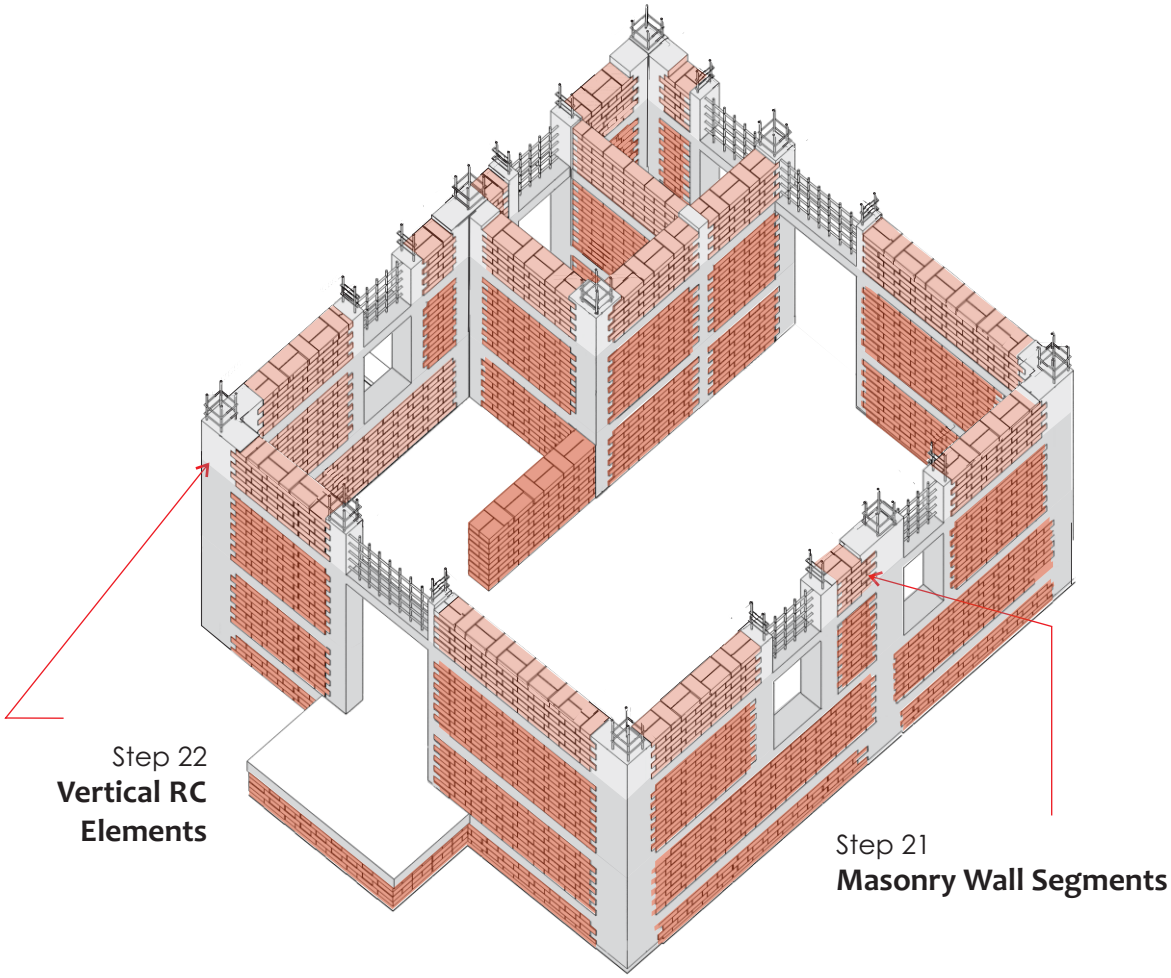
Build masonry wall segments till 75 mm below lintel level.

Step 19

Pour concrete (1:2:4 mix of cement, sand and aggregate) of vertical RC elements around steel reinforcement grill up to the level of top masonry course.

Step 20

Place the steel reinforcement cage and pour concrete (1:2:4 mix of cement, sand and aggregate) for Lintel Band.

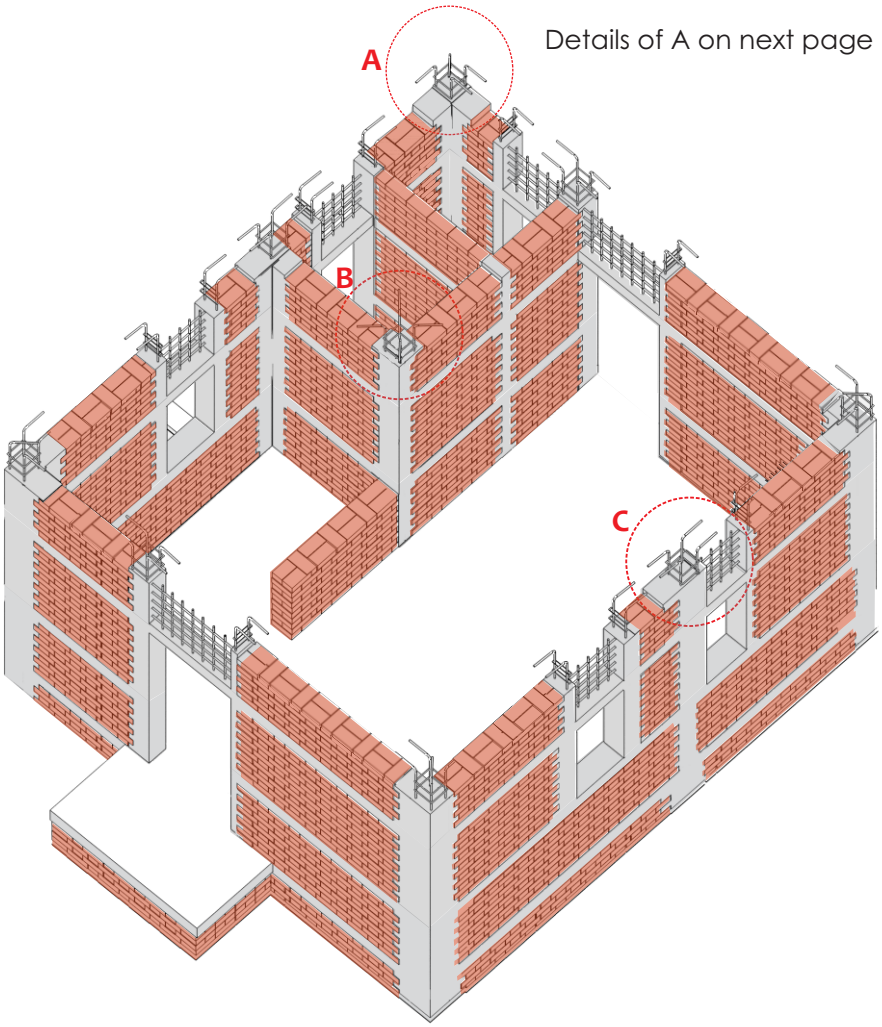


Step 21

Build masonry wall segments with cement mortar (1: 4 mix of cement and sand) till the soffit of the roof slab

Step 22

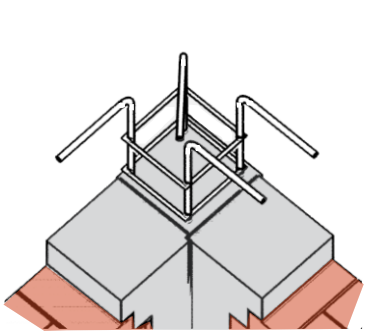
Pour concrete (1:2:4 mix of cement, sand and aggregate) around steel reinforcement cage of vertical RC elements up to the level of top masonry course.

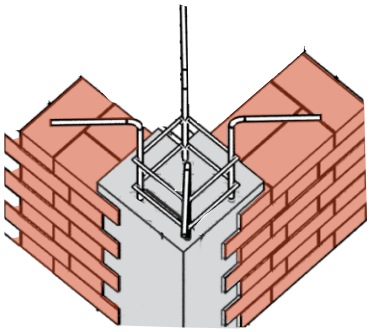


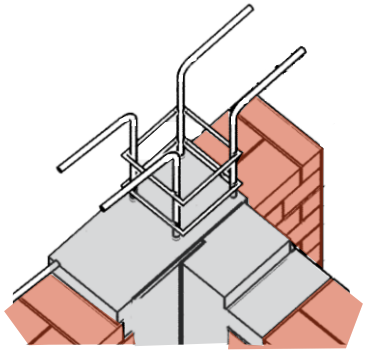
Step 23

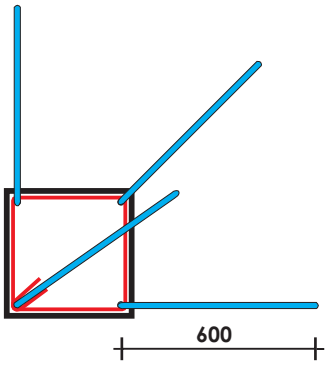
Bend longitudinal bars of vertical RC elements at the ends into the roof slab

How do I bend reinforcement bars into roof slab?

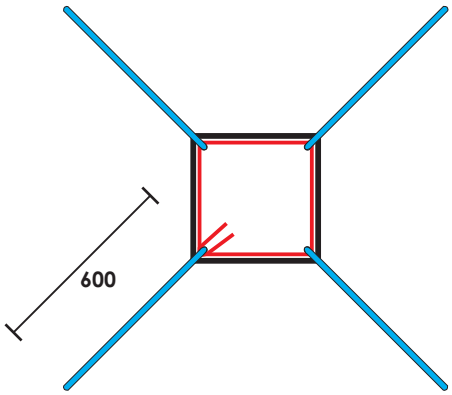




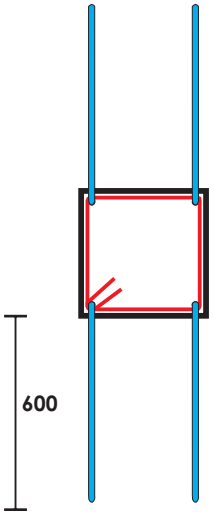




Wall Corner
Detail **A**



Inside Wall
Detail **B**



Wall Edge
Detail **C**

Walls

For the construction of Superstructure till Roof Level, the materials required are:

Cement

30 bags

Sand

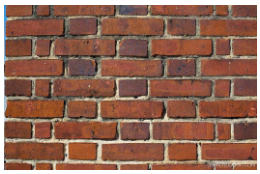
2.5 m^3

Aggregates

20 mm (Nominal) : 1.5 m^3

Steel

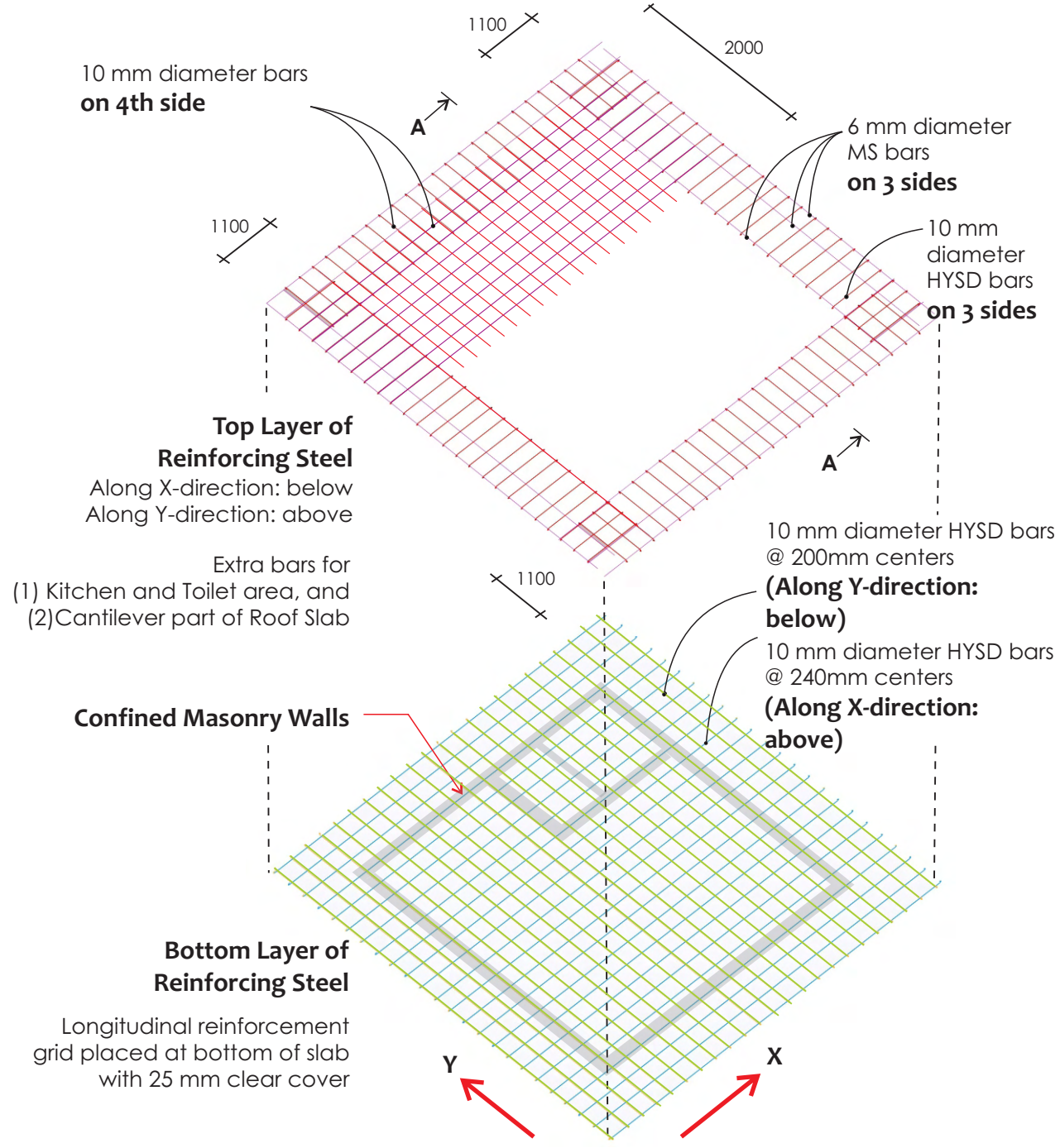
High Strength Steel : 260 m of **10** mm diameter bars
Mild Steel : 230 m of **6** mm diameter bars



Burnt Clay Bricks

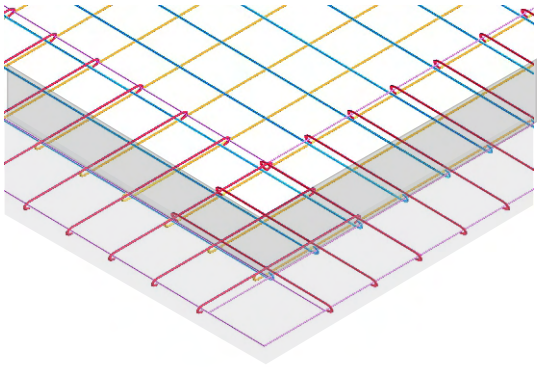
4,200

How do I Build my house with a Flat roof

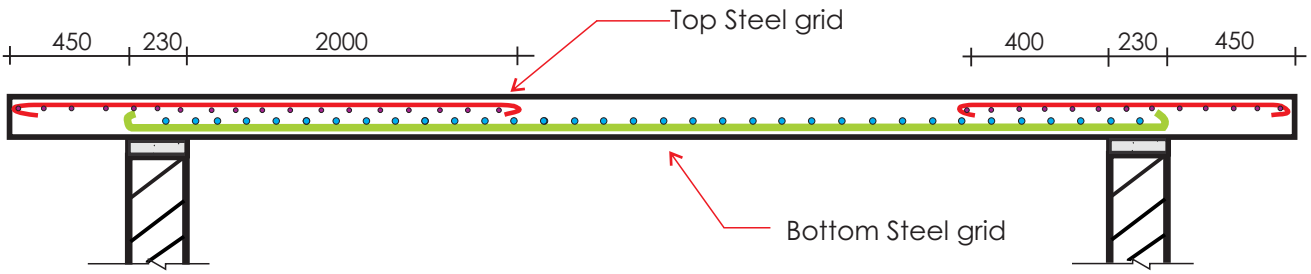


Step 24

Place reinforcement cage of RC roof slab

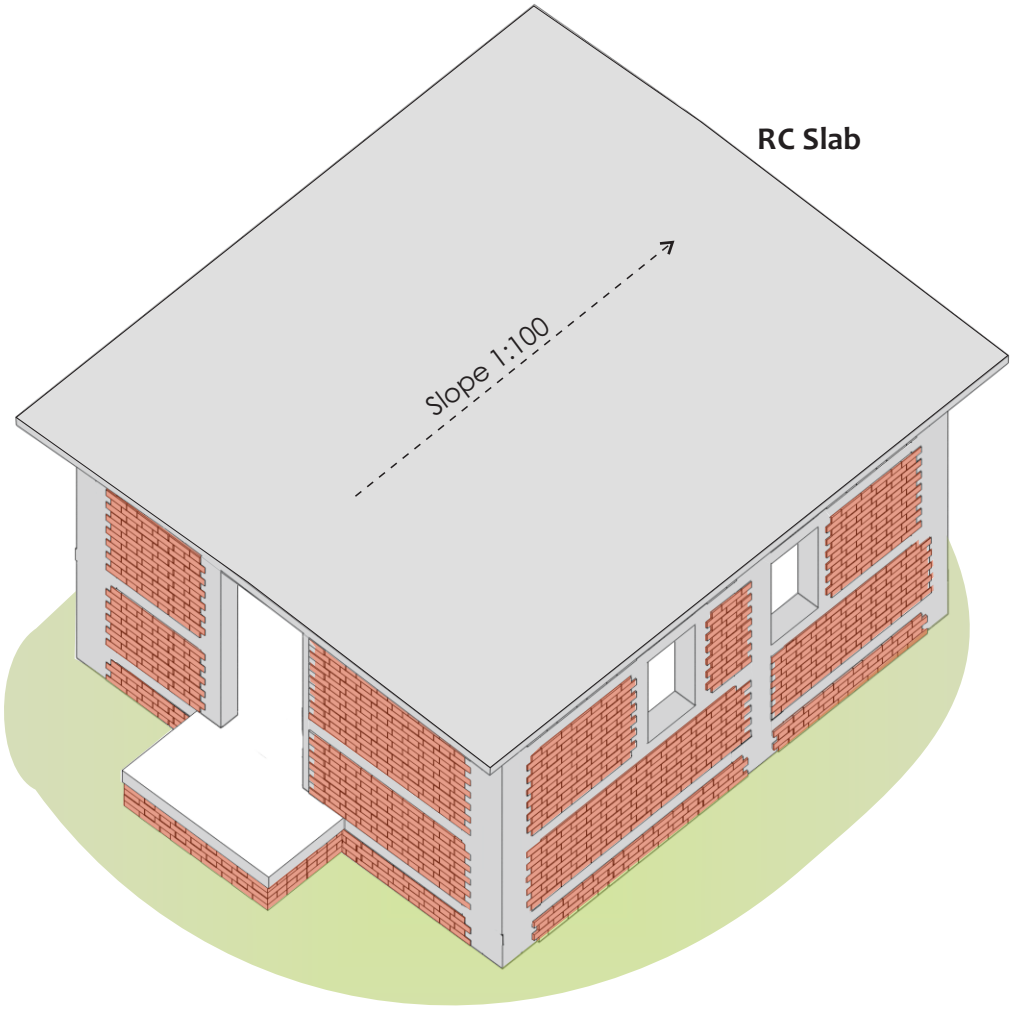


Reinforcement at Slab Corner Edge



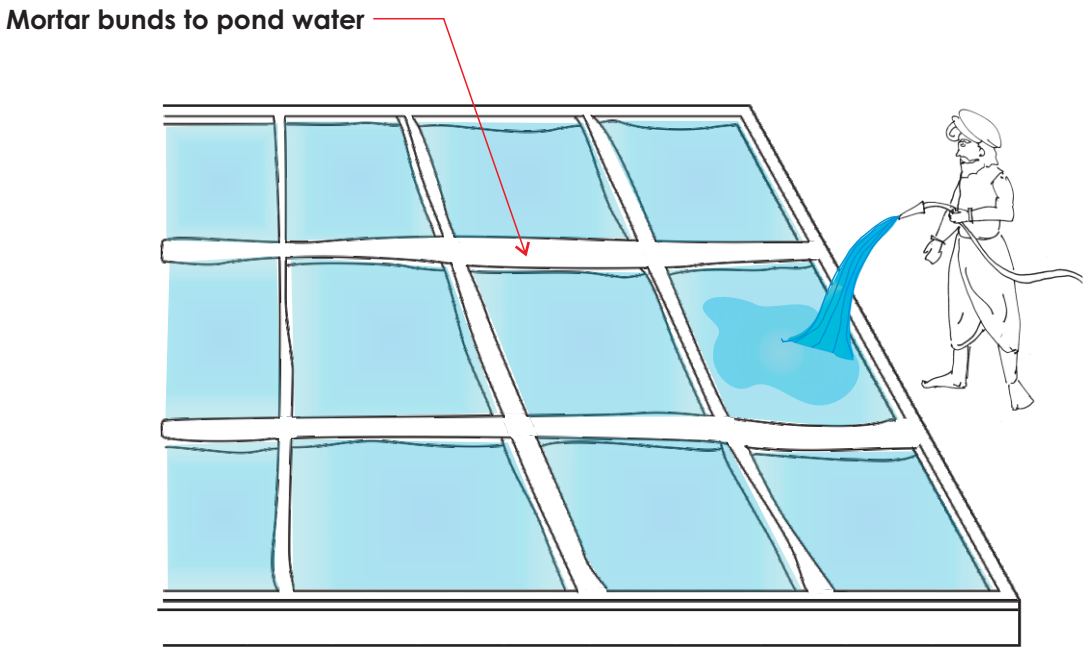
Section A-A

Roof



Step 25

Pour concrete (1:1 ½3 mix of cement, sand and aggregates) of RC flat roof. Finish top surface with a gentle slope of 1:100 to drain rain water to the back side of the house.



Step 26

Cure concrete in flat roof slab after a day of casting. To hold the water, make small bunds of 25mm height to break the large slab into smaller ponds; use 1:8 cement-sand mortar for making these bunds. Water the slab for 28 days.

Roof

For the construction of Roof, the materials required are:

Cement

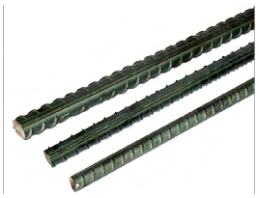
26 bags

Sand

1.1 m^3

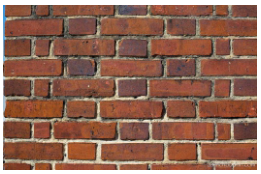
Aggregates

20 mm (Nominal) : 2.1 m^3



Steel

High Strength Steel : 500 m of **10** mm diameter bars
Mild Steel : 60 m of **6** mm diameter bars

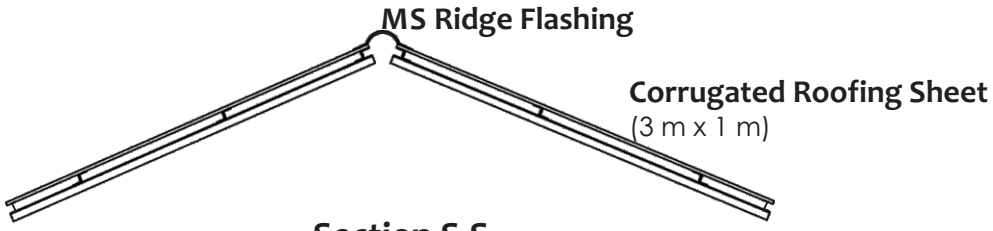


Burnt Clay Bricks

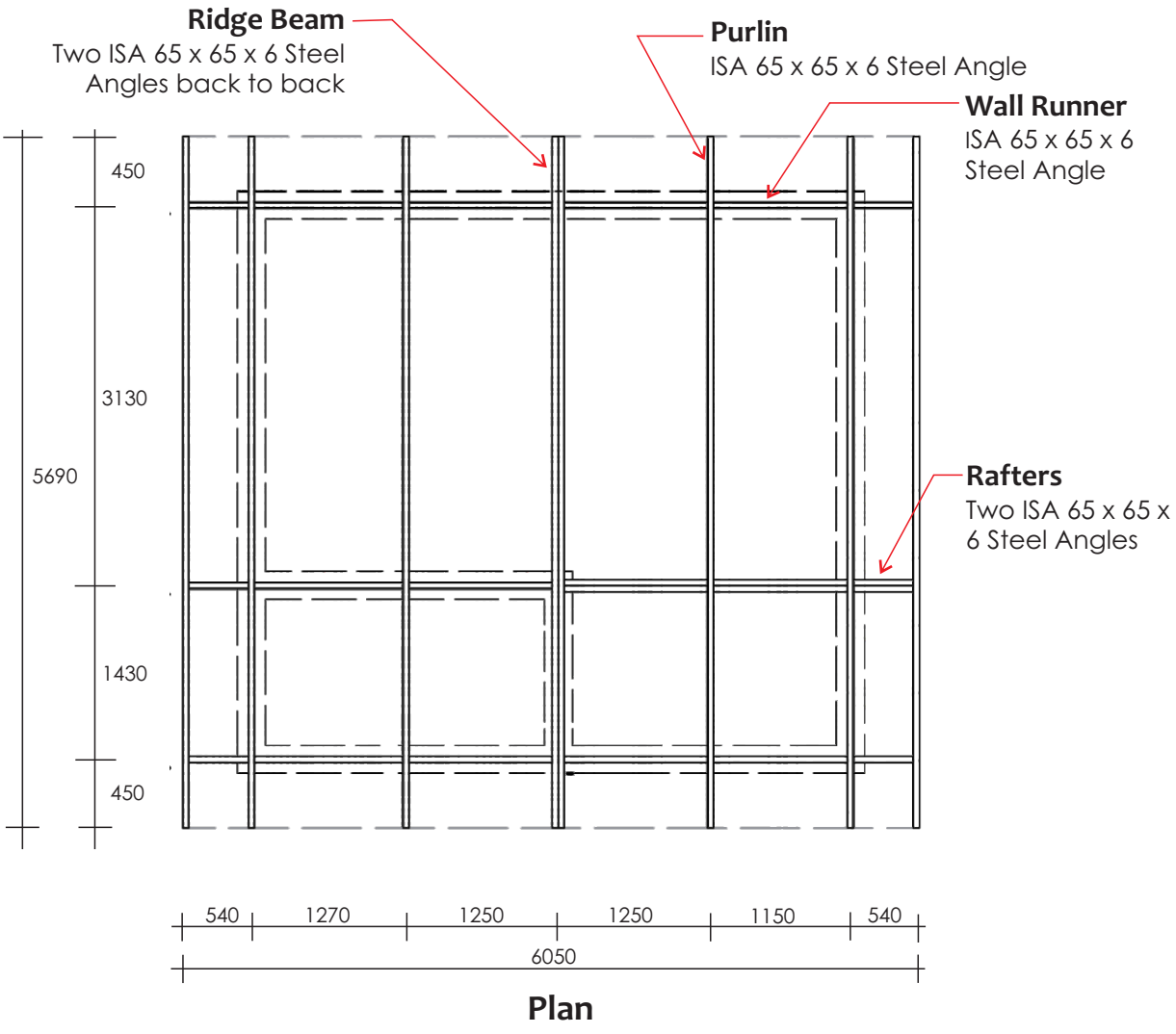
None

Roof

How do I build my house with a sloping roof

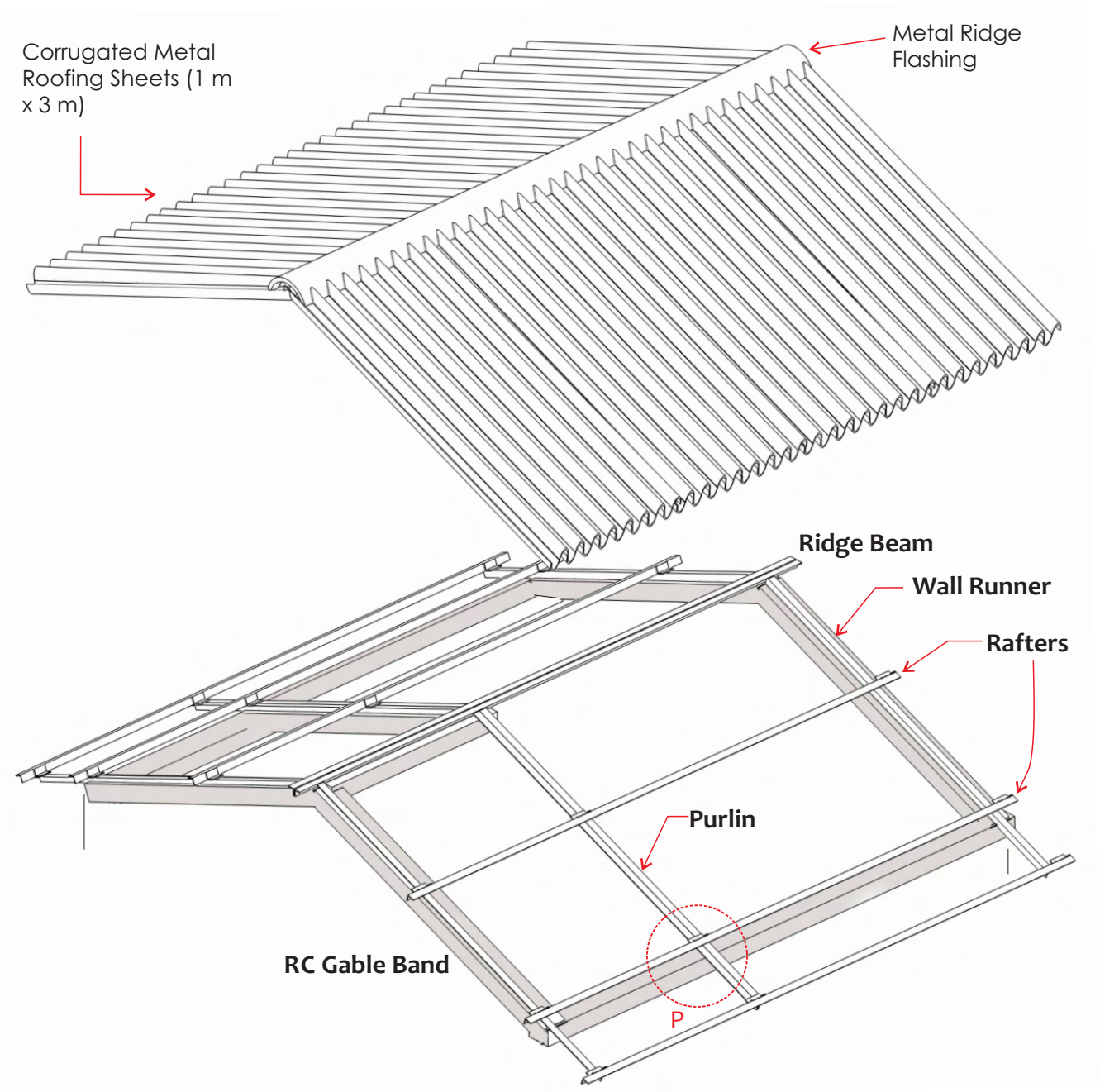


Section S-S

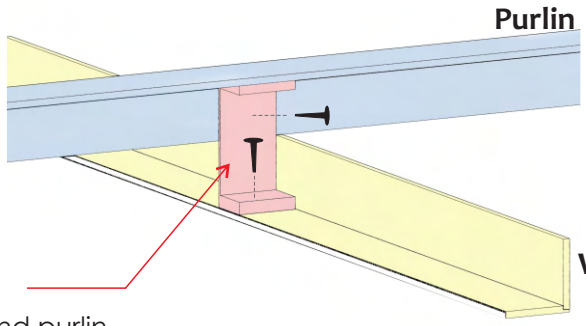


Plan

Roof



Perspective View



Steel Channel Section
screwed to wall runner and purlin

Detail at P

Material required to build the complete house

For the construction of entire house, the materials required are:

Cement

92 bags

Sand

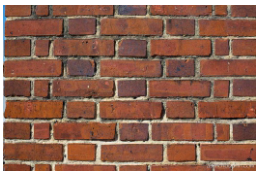
10.4 m^3

Aggregates

20 mm (Nominal) : 6.7 m^3

Steel

High Strength Steel : 940 m of **10** mm diameter bars
Mild Steel : 480 m of **6** mm diameter bars

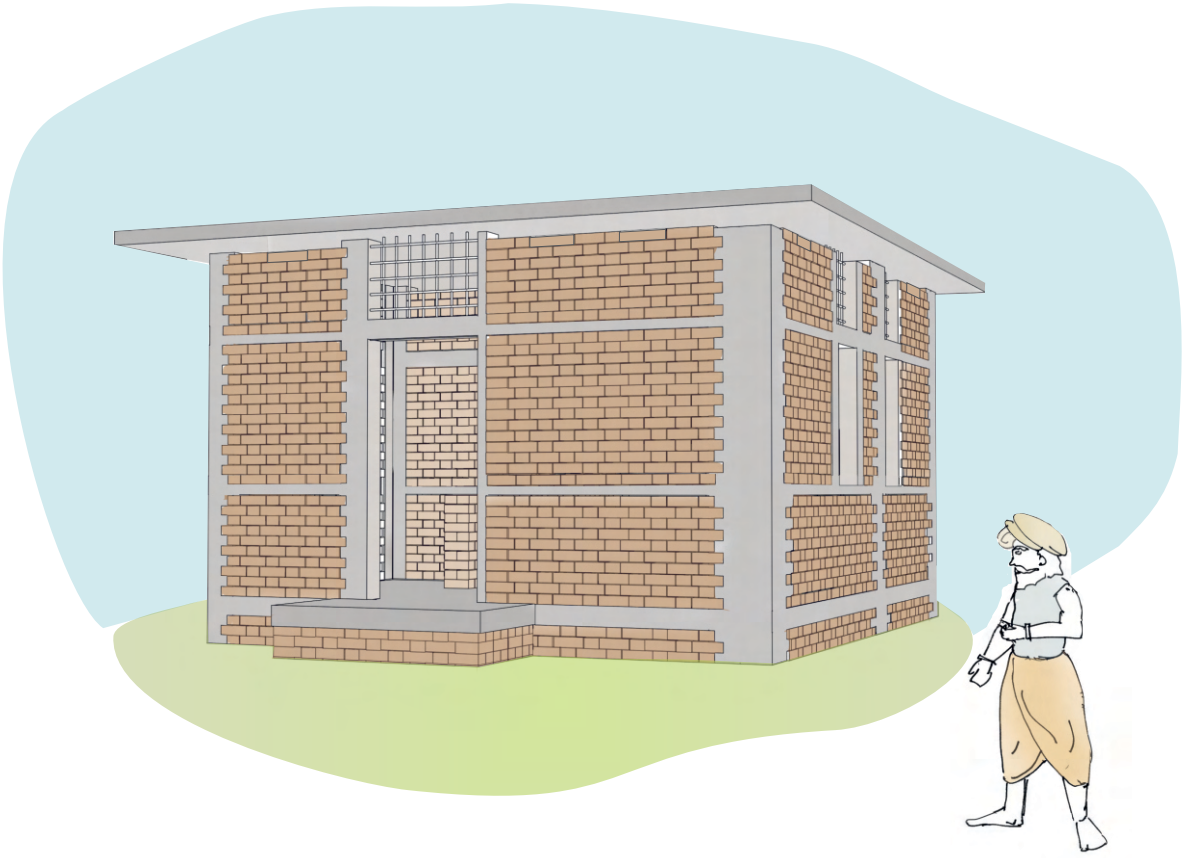


Burnt Clay Bricks

7800

Water

~1,630 liters for mortar and concrete
Extra for curing



Confined Masonry House

Burnt clay brick masonry walls
RC vertical elements and horizontal bands
RC flat roof
: Walls first, RC elements next

Gujarat State Disaster Management Authority
Government of Gujarat
GSDMA