Build a Safe House with
CONFINED MASONRY

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Gujarat State Disaster Management Authority
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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.

**In-plane Walls**

- **Shaking**:
  - **In-plane Compression**
  - **In-plane Tension**

**Out-of-plane Walls**

- **Shaking**:
  - **Out-of-plane Bending**

**Shaking along length direction of masonry wall results in diagonal cracking**

**Shaking along thickness direction of masonry wall can result in collapse**

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.
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.

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.

**Sequence of RC frame construction with URM infill walls**

**A villager rebuilding his house**
with unreinforced masonry

**An RC frame building**
commonly built in cities
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.

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. Thirupugazh, 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.

Dr. Svetlana N. Brzev, British Columbia Institute of Technology, Vancouver, CANADA, readily agreed to review the early manuscript and provided valuable comments for improving the quality of the publication. The authors are grateful to her for this special contribution. Ms. Betsy Ponnachan, III Year B.Tech. (Civil Engineering) Student of MNIT, Jaipur, played a pivotal role in bringing the document to publishable standards by significantly simplifying many graphics presented in this document; this special contribution is gratefully acknowledged. The authors acknowledge with thanks the support offered by various sections of IIT Madras in administering this book writing project. In particular, the authors gratefully acknowledge support offered by Mrs. S. Kavita, Project Assistant, Department of Civil Engineering, and of Mrs. C. Sankari and Mr. Anand Raj of the Structural Engineering Laboratory of the Institute.

The authors remain indebted to their family members for the unconditional support and understanding throughout the 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

How do I prevent this?

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.

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

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Masonry confined thus is resistant to earthquakes.
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.

**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.
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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 m²
- Carpet area: 18.78 m²

Option 2
- Built-up area: 32.03 m²
- Carpet area: 20.18 m²
What are the available options?

**Option 1**
- Built-up area: 24.67 m²
- Carpet area: 18.78 m²

**Option 2**
- Built-up area: 32.03 m²
- Carpet area: 20.18 m²
Option 3
Built-up area: 25.54 m²
Carpet area: 18.60 m²

Option 4
Built-up area: 32.47 m²
Carpet area: 19.21 m²
Option 5
Built-up area: 30.53 m²
Carpet area: 18.92 m²

- Main Room
- Toilet
- Kitchen
- Bath
- Access Road
Option 6
Built-up area: 24.67 m$^2$ each house
Carpet area: 18.78 m$^2$ each house
Option 7
Built-up area: 30.53 m$^2$ each
Carpet area: 18.92 m$^2$ each
Option 1

- **Bath**: 1.2 m x 1.1 m (1.32 m²)
- **Kitchen**: 1.2 m x 2.31 m (2.77 m²)
- **Toilet**: 1.2 m x 0.9 m (1.08 m²)
- **Main Room**: 2.9 m x 4.69 m (14.54 m²)
Option 1

Section A-A

Section B-B
Option 1

Ventilator
with Built-in Steel Grill

X

Elevation

Section X-X

X

Vertical RC Elements

Plan

Roof Slab

Round Steel Bars
(10mm diameter) along vertical and horizontal directions

Lintel Band
Option 1

Pivoted Window
Open Position

Pivoted Window
Closed Position
Option 1

Window Details

12mm thick E Board
Ventilator with MS Grill
Lintel Band
RC Roof Slab
Sill Band
Section W-W

Primary Timber Frame
75 mm x 25 mm
Secondary Timber Frame
50 mm x 25 mm
Window Shutter
12 mm thick E Board

Option 1
Option 1

Lintel Band
75 mm deep over windows

Primary Timber Frame
75 mm x 25 mm

Secondary Timber Frame
50 mm x 25 mm

Window Shutter
12 mm thick E Board

Vertical RC Element around Opening

MS Rods
20 mm diameter

Timber Frame
50 mm x 25 mm

Timber Frame
75 mm x 25 mm

Detail Q
Sectional Plan

Detail R
Sectional Elevation
Option 1

Door Details

Option 1

Detail T

Sectional Plan

Detail V

Sectional Elevation

T.W. member

100 mm x 36mm

MS Angle

65mm x 65mm x 6mm

I.P.S Threshold

38mm x 100 mm

E Board

12mm thick

T.W. member

100 mm x 36mm

MS Angle

65mm x 65mm x 6mm

E Board

12mm thick

T.W. member

100 mm x 36mm

MS Angle

65mm x 65mm x 6mm

E Board

12mm thick

Door Details

RC Roof Slab

Lintel Band

Section S-S
**Option 1**

**Detail T**
Sectional Plan

- **T.W. member**
  - 100 mm x 36mm

- **E Board**
  - 12mm thick

- **I.P.S Threshold**
  - 38mm x 100 mm

**Detail U**
Sectional Elevation

- **T.W. member**
  - 100 mm x 36mm

- **E Board**
  - 12mm thick

- **I.P.S Threshold**
  - 38mm x 100 mm

- **MS Angle**
  - 65mm x 65mm x 6mm

**Detail V**
Sectional Elevation

- **MS Angle**
  - 65mm x 65mm x 6mm

- **E Board**
  - 12mm thick

- **T.W. member**
  - 100 mm x 36mm
Option 1

House with sloping roof

Plan

Ridge Line

Toilet
1.2m x 0.9m

Bath
1.2m x 1.1m

Main Room
2.90m x 4.69m

Kitchen
1.20m x 2.31m

Backfilled earth
Unexcavated Ground

House with sloping roof

Plan

Ridge Line

Toilet
1.2m x 0.9m

Bath
1.2m x 1.1m

Main Room
2.90m x 4.69m

Kitchen
1.20m x 2.31m
Right Elevation

Section C-C

Backfilled earth
Unexcavated Ground

3070 mm
965 mm

Brick Masonry Courses

3070 mm

Plan

Ridge Line

Main Room 2.90m x 4.69m
Kitchen 1.20m x 2.31m
Bath 1.2m x 1.1m
Toilet 1.2m x 0.9m

Option 1
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

Built-up area: 40.14 m²
Carpet area: 31.77 m²
Option 1 Extended

Section D-D
Option 2

Bath
1.20 m x 1.10 m
(1.32 m²)

Kitchen
1.20 m x 2.31 m
(2.77 m²)

Toilet
1.20 m x 0.90 m
(1.08 m²)

Main Room
3.20 m x 4.69 m
(14.54 m²)
Option 2

Front Elevation

Plan

Main Room
3.20m x 4.69m

Toilet
1.20m x 0.90m

Bath
1.20m x 1.10m

Kitchen
1.20m x 2.31m

Brick Masonry
Courses
Option 2

Back Elevation

Right Elevation
Option 2

Section A-A

Section B-B
Option 2

House with sloping roof

Plan

Main Room
3.20m x 4.69m

Ridge Line

Toilet
1.2m x 0.9m

Bath
1.2m x 1.1m

Kitchen
1.20m x 2.31m

450

1000

1225

3750

75

75

925

3000 mm

1085 mm

Section C-C

42
Option 2

Right Side Elevation

Section C-C
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

Built-up area: 43.85 m²
Carpet area:  29.78 m²
Option 2 Extended

Plan

- Main Room
- Kitchen
- Toilet
- Bath
- Access Road
- Additional Room
Option 2 Extended

Overlap of Roof Slab done for extension

Section D-D
Option 3

Bath
1.2 m x 1.1 m
(1.32 m²)

Toilet
1.2 m x 0.9 m
(1.08 m²)

Main Room
3.00 m x 4.76 m
(14.54 m²)

Kitchen
1.10 m x 2.23 m
(2.77 m²)
Option 3

Front Elevation

Plan

Brick Masonry Courses

Main Room
4.76m x 3.00m

Kitchen
2.30m x 1.10m

Toilet
1.2 m x 0.9 m

Bath
1.1 m x 1.2 m

2 (1.32 m)

2 (2.77 m)
Option 3

Front Elevation

Right Elevation
Option 3

Section A-A

Section B-B
Option 3

House with sloping roof

Plan

Main Room
4.76m x 3.00m

Bath
1.1m x 1.2m

Toilet
0.9 m x 1.2 m

Kitchen
2.30m x 1.10m

Ridge Line

Backfilled earth

Unexcavated Ground

52
Option 3

Front Elevation

Section C-C

Brick Masonry Courses

3100 mm
975 mm

Backfilled earth
Unexcavated Ground
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

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.

- Built-up area: 47.94 m²
- Carpet area: 32.20 m²
Plan

- Main Room
- Toilet
- Bath
- Kitchen
- Access Road
- Additional Room
Option 4

Bath
1.2 m x 1.1 m
(1.32 m²)

Toilet
1.2 m x 0.9 m
(1.08 m²)

Main Room
3.00 m x 4.69 m
(14.54 m²)

Kitchen
1.10 m x 2.23 m
(2.77 m²)
Option 4

Front Elevation

Plan

Main Room
4.69m x 3.00m

Kitchen
1.10m x 2.23m

Bath
1.2m x 1.1m

Toilet
1.2m x 0.9m
Option 4

Left Elevation
Option 4

House with sloping roof

Plan

Toilet
1.2m x 0.9m

Kitchen
1.10m x 2.23m

Main Room
4.69m x 3.00m

Bath
1.2m x 1.1m

Ridge Line

C

Section C-C
3400 mm
1300 mm

Front Elevation
Option 4

Front Elevation

Section C-C

3400 mm

1300 mm

Backfilled earth

Unexcavated Ground
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

Built-up area: 40.38 m²
Carpet area: 26.69 m²
Option 4 Extended

Section D-D
Option 5

Bath
1.2 m x 1.1 m
(1.32 m²)

Toilet
1.2 m x 0.9 m
(1.08 m²)

Kitchen
1.20 m x 3.00 m
(2.77 m²)

Main Room
4.20 m x 3.00 m
(14.54 m²)
Option 5

Right Elevation

Left Elevation of Toilet
Option 5

Section A-A

Section B-B
Option 5

House with sloping roof

Plan

- **Main Room**: 4.20m x 3.00m
- **Kitchen**: 1.20 x 3.00m
- **Bath**: 1.10 x 1.20m
- **Toilet**: 0.90 x 1.20m

Ridge Line
Option 5

Front Elevation

Section C-C

Backfilled earth

Unexcavated Ground
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

Built-up area: 40.22 m²
Carpet area: 30.86 m²

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

Plan

- Main Room
- Toilet
- Bath
- Kitchen
- Access Road
- Additional Room
Option 5 Extended

Section D-D
Basics of Construction
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.
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).

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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).

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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 $230 \text{mm} \times 115 \text{mm} \times 75 \text{mm}$.

**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 $230 \text{ mm} \times 115 \text{ mm} \times 75 \text{ mm}$.

**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 $300 \text{ mm} \times 150 \text{ mm} \times 100 \text{ mm}$.

**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 $230 \text{ mm} \times 115 \text{ mm} \times 75 \text{ mm}$.
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.

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

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  - 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 \( \times \) 115mm \( \times \) 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 \( \times \) 115 mm \( \times \) 75 mm.

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  - 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 \( \times \) 150 mm \( \times \) 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 \( \times \) 115 mm \( \times \) 75 mm.
What materials are required to build my floor?

- Earth Fill
- Sand Fill
- Plain Concrete
- Flooring

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?

- Earth Fill
- Sand Fill
- Plain Concrete Flooring

What materials are required to build my roof?

- Flat Roof
- Reinforced Concrete
- Sloping Roof
- Metal Sheet roofing supported on steel angles
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?

- **Concrete for roof slab**
  - Cement: 1 Box
  - Clean Sand: 1 1/2 Boxes
  - Aggregate: 3 Boxes
  - Water: 22 Litres

- **Concrete for RC vertical element and bands**
  - Cement: 1 Box
  - Clean Sand: 2 Boxes
  - Aggregate: 4 Boxes
  - Water: 22 Litres

- **Concrete for foundation mat and flooring**
  - Cement: 1 Box
  - Clean Sand: 3 Boxes
  - Aggregate: 6 Boxes
  - Water: 22 Litres
How do I make confined masonry walls?

Build walls in Flemish Bond

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1 Box</td>
</tr>
<tr>
<td>Clean Sand</td>
<td>4 Boxes</td>
</tr>
<tr>
<td>Water</td>
<td>20 Litres</td>
</tr>
</tbody>
</table>

Provide 10mm thick cement mortar joints between brick courses.
Build walls in Flemish Bond

Do not build walls in English Bond

Course 1, 3, 5, ...
Course 2, 4, 6, ...

How do I make confined masonry walls?

Clean Sand
4 Boxes

Cement
1 Box

Water
20 Litres

Mortar for masonry

Provide 10mm thick cement mortar joints between brick courses

10 mm thick cement mortar joint
Build a maximum of 1.2 m of masonry wall segments in a day.
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.
Vertical and Horizontal confining elements around all openings prevent early cracking at wall corners.

Lintel, Sill and Plinth bands pass through 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.
Vertical RC elements and horizontal RC bands hold masonry wall segments together (like a strap holding a package).

Masonry wall segments confined on all sides with RC elements.

RC elements prevent masonry form collapsing.

Earthquake ground movement.
How do I make horizontal RC bands?

- **Sill and Lintel Bands**
  - Two 10 mm longitudinal bars
  - 6 mm diameter ties @ 200mm c/c
  - 75 mm height
  - 230 mm width

- **Plinth Band**
  - Four 10 mm diameter longitudinal bars
  - 6 mm diameter ties @ 200mm c/c
  - 150 mm height
  - 230 mm width
How do I make vertical RC elements?

- **10 mm diameter Longitudinal HYSD bars**
- **6 mm diameter ties bars @ 200mm c/c**

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

**Straight length is given of hook ends beyond bend**

**How do I make horizontal RC bands?**

- **Sill and Lintel Bands**
- **Plinth Band**

- **Two 10 mm longitudinal Bars**
- **Four 10mm diameter longitudinal bars**

- 60
- 60
- 230
- 230
- 115
- 115
- 230
- 230
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

Window opening

Sill Band
Construction of Confined Masonry House - Option 1
Construction of a Confined Masonry House entails 3 major phases, namely:

- **Foundation and Plinth**
- **Superstructure**
- **Roof**

In this section, the 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:

How do I build my Confined Masonry House?
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 900 mm 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.
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.
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.
Foundation and Plinth

Step 5
Pour concrete (1:2:4 mix of cement, sand and aggregate) in gaps between brick masonry and steel reinforcement bars.

Step 6
Place the next four masonry courses with cement mortar (1:4 mix of cement and sand) above the earlier brick masonry wall.
**Foundation and Plinth**

**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.

**Step 8**
Place the next four masonry courses with cement mortar (1:4 mix of cement and sand)
Foundation and Plinth

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.
**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

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

- **Cement**: 36 bags
- **Sand**: 36.8 m
- **Aggregates**: 3.20 mm (Nominal) : 3.1 m
- **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 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 m³

**Aggregates**
- 20 mm (Nominal) : 3.1 m³

**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
Walls

**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.
**Walls**

**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.
Walls

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

**Cement**
- 30 bags

**Sand**
- 2.5 m³

**Aggregates**
- 20 mm (Nominal) : 1.5 m³

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

- **Cement**: 30 bags
- **Sand**: 3
- **Aggregates**: 3
  - 20 mm (Nominal): 1.5 m
- **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

**Confined Masonry Walls**
Longitudinal reinforcement grid placed at bottom of slab with 25 mm clear cover

**Bottom Layer of Reinforcing Steel**
Along Y-direction: below
Along X-direction: above

**Top Layer of Reinforcing Steel**
Along X-direction: below
Along Y-direction: above

**Extra bars for**
(1) Kitchen and Toilet area, and
(2) Cantilever part of Roof Slab

**10 mm diameter HYS bars @ 200 mm centers**
(Along Y-direction: below)
**10 mm diameter HYS bars @ 240 mm centers**
(Along X-direction: above)

**Place reinforcement cage of RC roof slab**

**Step 24**

10 mm diameter HYS bars on 4th side

6 mm diameter MS bars on 3 sides

10 mm diameter HYS bars on 3 sides

**Roof**

1100

2000

230

450

1100

2000

230

450
Reinforcement at Slab Corner Edge

Section A-A

Top Steel grid

Bottom Steel grid
Step 25
Pour concrete (1:1 ½ 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.
For the construction of Roof, the materials required are:

**Cement**
- 26 bags

**Sand**
- 1.1 m³

**Aggregates**
- 20 mm (Nominal) : 2.1 m³

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

**Burnt Clay Bricks**
- None
For the construction of Roof, the materials required are:

- Cement: 26 bags
- Sand: 3.1 m
- Aggregates:
  - 20 mm (Nominal): 2.1 m
- Steel:
  - High Strength Steel: 500 m of 10 mm diameter bars
  - Mild Steel: 60 m of 6 mm diameter bars
- Burnt Clay Bricks: None
How do I build my house with a sloping roof

Section S-S

Ridge Beam
Two ISA 65 x 65 x 6 Steel Angles back to back

Purlin
ISA 65 x 65 x 6 Steel Angle

Wall Runner
ISA 65 x 65 x 6 Steel Angle

Rafters
Two ISA 65 x 65 x 6 Steel Angles
Roof

Corrugated Metal Roofing Sheets (1 m x 3 m)

Ridge Beam
Wall Runner
Rafters
Purlin
RC Gable Band

Metal Ridge Flashing
For the construction of the entire house, the materials required are:

- **Cement**: 92 bags
- **Sand**: 10.4 m
- **Aggregates**: 6.7 m of 20 mm (Nominal) aggregates
- **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

**Steel Channel Section** screwed to wall runner and purlin

**Purlin**

**Wall Runner**

**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 m³

**Aggregates**
- 20 mm (Nominal) : 6.7 m³

**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