DESIGN CATALOGUE FOR
RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Volume I

October, 2015 (Aswin, 2072)
DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Volume I

Government of Nepal
Ministry of Urban Development
Department of Urban Development and Building Construction
Babarmahal, Kathmandu
It gives me an immense pleasure on the occasion of the publication of Design catalogue for the reconstruction of Earthquake resistant houses. The impact of the 25th April, 2015 and 12th May 2015 earthquakes in Nepal were enormous, both in terms of loss of lives and properties. More than 8000 people lost their lives and 22,000 number of people were injured. More than 6,400 Government buildings were damaged. More than 960 health buildings and 8500 schools as well as 600,000 private homes were fully damaged. In addition, more than 285,000 private homes were partially damaged.

The objective of this document is to provide rural households with clear guidance regarding earthquake resistant construction techniques and to support them to have house designs in compliance with the National Building Code of Nepal. I expect that the design catalogue supports rural households to apply for, and secure the building permit through various types of design models and flexible designs. I hope that the information provided in the Design Catalogue will be a strong basis for rural households to start the construction of their houses.

My sincere thanks to the respected Secretary, Mr. Arjun kumar Karki, Joint Secretaries, Mr. Shambhu K.C. and Mr. Padma Kumar Mainalee of Ministry of Urban Development for their valuable suggestions. I am very much thankful to Mr. Ravi Shah, Deputy Director General and Mr. Nilam Kumar Dangol, Senior Divisional Engineer and all the staffs of Housing Division for their continuous involvement during the preparation of this document. My thanks also goes to all of the personnel and agencies involved in the preparation of the Design Catalogue for Reconstruction of Earthquake Resistant Houses for their hard work and concerted efforts on the preparation of this important document.
Preface

I would like to congratulate all involved in the development of the Design Catalogue for Reconstruction of Earthquake Resistant Houses, which has been produced by the Department of Urban Development and Building Construction (DUDBC) to support rural households in the reconstruction of their houses.

The impact of the April 25th 2015 and May 12th 2015 earthquakes in Nepal had a significant impact in affected areas, in particular in relation to housing which suffered severe damage and left thousands of families living in temporary shelters. The primary objective of the housing reconstruction programme is to ensure that earthquake affected households are enabled to reconstruct houses that are safe, adequate, and affordable.

The housing prototype and flexible design provided in the Design Catalogue for Reconstruction of Earthquake Resistant Houses provide a variety of options in terms of cost, size, layout, and typology. It is not mandatory for households to select a design from this catalogue, and they are free to prepare house designs outside of the catalogue but these designs must comply with the National Building Code. The house designs have been prepared in such a way as to ensure that vernacular architecture and building practices can be maintained with the addition earthquake resistant construction practices to ensure that households are able to ‘Build Back Better’.

I would like to congratulate all the personnel of this department, and all those who have been involved directly or indirectly in the preparation of this catalogue, for their valuable contributions to the preparation of this catalogue.

Rabi Shah
Deputy Director General, DUDBC
# Table of Contents

- Foreword .......................... I
- Preface ............................ II
- Background ........................ 1
- Introduction ........................ 2
- List of Model houses .............. 3
- Site Plan ........................... 4
- Model houses
  - Stone masonry in cement mortar .......................... 5
    Minimum Requirements, One-story, Two-storey, Technical details, Flexible design
  - Brick masonry in cement mortar ........................... 70
    Minimum Requirements, One-story, Two-storey, Technical details, Flexible design
  - Stone masonry in mud mortar ................................ 128
    Minimum Requirements, One-story, Technical details, Flexible design
  - Brick masonry in mud mortar ................................ 145
    Minimum Requirements, One-story, Technical details, Flexible design
Background

The April 25th 2015 and May 12th 2015 earthquakes in Nepal caused widespread damage to housing in the affected districts, as well as loss of life of almost 9,000 people. The Government of Nepal figures indicate that 602,257 houses were fully damaged, and 285,099 houses were partially damaged.

The Government of Nepal Post Disaster Needs Assessment (PDNA) set out principles for housing and human settlements recovery and reconstruction as follows:

1. Encourage the participation of communities by empowering them to take control of reconstruction of their houses and ensuring facilitation of Owner Driven Reconstruction.
2. A comprehensive view of housing reconstruction should include holistic habitat development, with basic services and community infrastructure. The principle of build back better (BBB) should translate into a concept of safer settlements.
3. Reconstruction should be seen as a vehicle to build long-term community resilience by reducing vulnerabilities and strengthening community capacities to mitigate future disasters through improved construction practices for the majority of the building stock in the country.
4. Strengthen the local economy through reconstruction and processes that work to the benefit of the poor and marginalised sections who are mostly in the informal sector. Reconstruction should provide an opportunity for the poor to upgrade their living conditions.
5. Ensure sustainable and environment-friendly reconstruction processes, taking note of climate change, natural resource management and scientific risk assessments.
6. Ensure that rehabilitation is equitable and inclusive.
Introduction

The Design Catalogue for Reconstruction of Rural Housing has been developed to support rural households to commence the reconstruction of their homes from a solid basis, by providing prototype and flexible house designs which can be adopted, and adapted, in all earthquake affected communities. The designs provided in the catalogue cover four broad categories of building materials and typology:

- Stone and mud mortar masonry
- Brick and mud mortar masonry
- Stone and cement mortar masonry
- Brick and cement mortar masonry

The designs provided in this catalogue have all been prepared in compliance with the revised National Building Code of Nepal and are approved by the Department of Urban Development and Building Construction (DUDBC).

For each design included in the catalogue the following information is provided:
- 3D view of the design
- Floor plan
- Elevations
- Section
- Technical Details

The number of manpower days for skilled and unskilled labour, as well as the quantity of materials required for the construction of the design is also provided and is broken down in terms of requirements to construct up to plinth level, up to ring beam level, and for the construction of the roof.

Designs included in the Design Catalogue for Reconstruction of Rural Housing can be selected and used as is, the prototype designs, or can be adapted based on the parameters as defined in the National Building Code of Nepal, the flexible designs. Once a design has been selected this can be used by the household as part of the building permit application process. The Design Catalogue for Reconstruction of Rural Housing can also provide guidance in terms of budgeting, and estimating the quantity of material required and as a general guide for basic earthquake resistant construction techniques.
## List of Model Houses

<table>
<thead>
<tr>
<th>Structural Type</th>
<th>No. of Floor</th>
<th>Model No.</th>
<th>Designed by</th>
<th>Page</th>
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<tbody>
<tr>
<td><strong>Stone masonry in cement mortar, P5-</strong> SMCM</td>
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<td>JICA</td>
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<td>DUDBC</td>
<td>33</td>
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<td>37</td>
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<tr>
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<td>2+ATTIC</td>
<td>SMC-2.5</td>
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<td>SMC-2.6</td>
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<tr>
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<tr>
<td>Flexible design</td>
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<td></td>
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<td><strong>Brick masonry in cement mortar P71-</strong> BMCM</td>
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<td>BMC-2.1</td>
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<td>DUDBC</td>
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<td>BMC-2.3</td>
<td>DUDBC</td>
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<td><strong>Stone masonry in mud mortar, P129-</strong> SMMM</td>
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<td><strong>Brick masonry in mud mortar, P147-</strong> BMMM</td>
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</table>
STONE MASONRY IN CEMENT MORTAR (SMC)
This section of the Design Catalogue for Reconstruction of Earthquake Resistant houses refers to stone masonry construction using cement mortar. Designs for both one-storey and two-storey houses are included in this category of the catalogue. A flexible design is also included which can be adapted as per the households’ requirements within the parameters as set out in the National Building Code of Nepal 202.

The house designs are based on the use of reinforced concrete bands. The technical specifications for the material required in the construction of the house designs included under this category can be found in the ‘Minimum Requirements’ at the beginning of this section.

The key technical details related to this category are included at the end of this section and should be referred to when constructing any of the designs presented under this category.
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Requirements</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Selection</td>
<td>A building shall not be constructed if site is:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Geological fault or Raptured Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Areas Susceptible to Landslide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Steep Slope &gt; 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Filled Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ River Bank and Water-logged Area</td>
</tr>
<tr>
<td>2</td>
<td>Shape of House</td>
<td>No. of story Two storey+ attic, load bearing masonry buildings constructed in cement mortar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ The span of wall shall not more than 4.5 meters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size of room The area of individual floor panel not more than 13.5 square metres</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ The height of wall should not be more than 3.0 meters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.</td>
</tr>
<tr>
<td>3</td>
<td>Foundation</td>
<td>General The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depth The depth of footing should not be less than 800mm for one story, 900mm for two storey.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings.</td>
</tr>
<tr>
<td>4</td>
<td>Plinth</td>
<td>General Provide a reinforced concrete band at plinth level, as shown in detail drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height Minimum height of Plinth band is 150mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width Minimum thickness of plinth band width should be equal to wall thickness. 350mm for Stone masonry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement Main reinforcement should be 4-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.</td>
</tr>
<tr>
<td>5</td>
<td>Walls</td>
<td>General Masonry should not be laid staggered or straggled in order to avoid continuous vertical joints. At corners or wall junctions, through vertical joints should be avoided by properly laying the masonry. It should be interlocked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Joints Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Through Stone Through-stone of a length equal to the full wall thickness should be used in every 600 mm lift at not more than 1.2 m apart horizontally.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width The minimum width of wall is 350mm for one-storey and two-storey.</td>
</tr>
<tr>
<td>Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202)</td>
<td>Page 2</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openings</td>
<td>✔</td>
<td>Openings are to be located away from inside corners by a clear distance should not be less than 600 mm.</td>
</tr>
<tr>
<td>Total length</td>
<td>✔</td>
<td>The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.</td>
</tr>
<tr>
<td>Distance</td>
<td>✔</td>
<td>The horizontal distance between two openings is to be not less than 600 mm.</td>
</tr>
<tr>
<td>Lintel level</td>
<td>✔</td>
<td>Keep lintel level same for doors and windows.</td>
</tr>
<tr>
<td><strong>Vertical Reinforcement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>✔</td>
<td>Place vertical steel bars in the wall at all corners, junctions of walls and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them during the masonry construction.</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>✔</td>
<td>The vertical reinforcing bar for masonry is given in detail drawings. 12 mm dia is minimum requirements for masonry houses.</td>
</tr>
<tr>
<td><strong>Horizontal Band</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sill band</td>
<td>✔</td>
<td>A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.</td>
</tr>
<tr>
<td>Lintel band</td>
<td>✔</td>
<td>A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.</td>
</tr>
<tr>
<td>Stitch</td>
<td>✔</td>
<td>This band shall be provided where dowel-bars are required at all corners, junctions of walls. The minimum height is 75mm.</td>
</tr>
<tr>
<td>Roof band</td>
<td>✔</td>
<td>Roof band shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75mm.</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>✔</td>
<td>Main reinforcement should be 4 or 2-12 dia. bars. Use 6 mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.</td>
</tr>
<tr>
<td><strong>Light roof</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use light roof comprising wooden or steel truss covered with CGI sheets.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td><strong>Connection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All members of the timber truss or joints should be properly connected as shown in detail drawings.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td><strong>Cross-tie</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trusses should be properly cross-tied with wooden braces as shown in detail drawings.</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td><strong>Timber</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well seasoned hard wood without knots should be used for roofing, timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects</td>
<td>✔</td>
<td></td>
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<tr>
<td><strong>Mortar</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement sand mortar should not be leaner than 1:4 (1 part cement and 4 parts sand) for masonry and 1:6 for plaster</td>
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<tr>
<td><strong>Concrete</strong></td>
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</tr>
<tr>
<td>The concrete mix for seismic bands should not be leaner than 1:1.5:3 (1 part cement, 1.5 parts sand and 3 parts aggregate)</td>
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<tr>
<td><strong>Reinforcement</strong></td>
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<tr>
<td>High Strength Deformed Bars – Fe415: High strength deformed bars with fy = 415 N/</td>
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</table>
STONE MASONRY IN CEMENT MORTAR, ONE-STOREY

SMC-1.1
Model SMC-1.1 is a one-storey house which can accommodate 3-5 people. It consists of two rooms with dimensions of 2650 x 4300, and a verandah with dimensions of 1500 x 6350. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness.

The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

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**Nepal Housing Reconstruction Programme**

**MODEL SMC-1.1**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**SCALE:** None

**DESIGNED BY:** JICA

**DATE:** SMC-1.1

1/4

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**MAN POWER**

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<th>CEMENT</th>
<th>SAND</th>
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<th>WOOD</th>
<th>CGI SHEET</th>
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<td>Bags</td>
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<td>4.71</td>
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**MATERIALS**

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<td>Bags</td>
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<td>SUPERSTRUCTURE</td>
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<td>ROOFING</td>
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<td>1.43</td>
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<td>9</td>
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**MODEL SMC-1.1**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**SCALE:** None

**DESIGNED BY:** JICA

**DATE:** SMC-1.1

1/4

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**Nepal Housing Reconstruction Programme**

**MODEL SMC-1.1**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**SCALE:** None

**DESIGNED BY:** JICA

**DATE:** SMC-1.1

1/4
Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

GROUND FLOOR PLAN
FLOOR AREA: 31.75sqm

ROOM1
2650 x 4300

ROOM2
2650 x 4300

VERANDA
1500 x 6350

See Technical Detail 3
See Technical Detail 5
Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

- FRONT ELEVATION
- SIDE ELEVATION
- SIDE ELEVATION
- BACK ELEVATION

- ROOF CGI SHEETS
- TIMBER FRAME
- GABLE: WOODEN BOARD

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-1.1
DRAWING TITLE: ELEVATION

SCALE: None
DATE: SMC-1.1
DESIGNED BY: JICA
STONE MASONRY IN CEMENT MORTAR, ONE-STOREY

SMC-1.2
Model SMC-1.2 is a one-storey house which can accommodate 1-3 people. It consists of one room with dimensions of 2650 x 4300, and a verandah with dimensions of 2850 x 4500. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness.

The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
**Model SMC-1.2: STONE MASONRY IN CEMENT MORTAR**

**ONE-STOREY**

---

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**Nepal Housing Reconstruction Programme**

**MODEL SMC-1.2**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**TYPE OF HOUSE:**

**SCALE:** None

**DATE:**

**DESIGNED BY:** JICA

**SMC-1.2 1/4**
Model SMC-1.2: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

DRAWING TITLE: MODEL SMC-1.2

FLOOR AREA: 15.88sqm

ROOM1
2650 x 4300

VERANDA
2850 x 4500

GROUND FLOOR PLAN

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-1.2

SCALE: 1:50

DESIGNED BY: JICA
Model SMC-1.2: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

FRONT ELEVATION

SIDE ELEVATION

BACK ELEVATION

SIDE ELEVATION

GABLE: WOODEN BOARD

ROOF CGI SHEETS
TIMBER FRAME

GABLE: WOODEN BOARD

Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-1.2
DRAWING TITLE: ELEVATION

SCALE: None
DATE: SMC-1.2
DESIGNED BY: JICA

19
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.1
Model SMC-2.1 is a two-storey house which can accommodate more than 4 people. It consists of four rooms with dimensions of 2650 x 4300, and a verandah with dimensions of 1500 x 6350. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness. The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
### Model SMC-2.1: STONE MASONRY IN CEMENT MORTAR

**TWO-STOREY**

![Image of a two-storey stone masonry house](image)

#### MANPOWER

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**Nepal Housing Reconstruction Programme**

**TYPE OF HOUSE:** MODEL SMC-2.1

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**SCALE:** None

**DATE:** SMC-2.1

**DESIGNED BY:** JICA
Model SMC-2.1: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

GROUND FLOOR PLAN

AREA: 31.75sqm

TOTAL AREA: 63.5sqm

ROOM1
2650 x 4300

ROOM2
2650 x 4300

VERANDA
1500 x 6350

FIRST FLOOR PLAN

AREA: 31.75sqm

ROOM3
2650 x 4300

ROOM4
2650 x 4300

See Technical Detail 3

See Technical Detail 5

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.1

DRAWING TITLE: PLAN

SCALE: None

DATE: SMC-2.1

DESIGNED BY: JICA

2/4
Model SMC-2.1: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

Front Elevation

Back Elevation

Side Elevation

Model SMC-2.1

FROM ELEVATION TO SIDE ELEVATION

GABLE: WOODEN BOARD

ROOF CGI SHEETS TIMBER FRAME

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.1

DRAWING TITLE: ELEVATION

SCALE: None

DATE: SMC-2.1

DESIGNED BY: JICA

3/4
Model SMC-2.1: STONE MASONRY IN CEMENT MORTAR

Room 1:
- Roof Beam: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 4no., 6mm
- Vertical reinforcement: 12mm, 1no.
- Sill Band: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 2no., 6mm
- Plinth Band: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 2no., 6mm
- Wall: Stone masonry in cement mortar
- Foundation: Stone masonry in cement mortar
- Floor: Wooden

Room 3:
- Roof Beam: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 4no., 6mm
- Vertical reinforcement: 12mm, 1no.
- Sill Band: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 2no., 6mm
- Plinth Band: RCC, Concrete 1:1.5:3
- Reinforcement: 12mm, 2no., 6mm
- Wall: Stone masonry in cement mortar
- Foundation: Stone masonry in cement mortar
- Roof angle: 22°
- CGI Sheet: 26 gauge (0.55mm) on Wooden frame
- Parin: 75mm/27mm/450mm
- Riini: 100mm/50mm

SECTION A-A:

Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.1
DRAWING TITLE: SECTION
SCALE: 1:50
DATE:

DESIGNED BY: JICA

SMC-2.1
4/4
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.2
Model SMC- 2.2 is a two storey building which can accommodate 3-7 people. It consists of three rooms and a verandah in the ground floor. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along wooden rafters and purlins. All designs have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcements, corner reinforcement, and T-junctions to improve diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house. The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
### CONSTRUCTION MATERIAL AND MANPOWER

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<th>LEVEL</th>
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Model SMC-2.2: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

- **DATE**: 
- **SCALE**: NONE
- **DESIGNED BY**: DUDBC
- **TYPE OF HOUSE**: MODEL SMC-2.2
- **DRAWING TITLE**: PERSPECTIVE AND ESTIMATION

---
Model SMC-2.2: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

GROUND FLOOR PLAN
AREA: 47.40 SQ.M.

FIRST FLOOR PLAN
AREA: 47.40 SQ.M.

TOTAL AREA: 94.8 sqm
Model SMC-2.2: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY MODEL SMC-2.2: STONE MASONRY IN CEMENT MORTAR

SECTION A-A

DETAIL

FIRST FLOOR

VERANDA

PLINTH LEVEL

VERANDA

DETAIL

GR. LEV.

SECTION

DATE: SCALE: DESIGNED BY:

Nepal Housing Reconstruction Programme

MODEL SMC-2.2

DRAWING TITLE: SECTION

SMC-2.2

SCALE: 1:50

DATE: 4/4

DUBDC
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.3
Model SMC-2.3 is a two-storey building which can accommodate 8-10 people. It consists of two rooms with dimension of 3225 x 3150 and a verandah 7800 x 1210. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafters and purlins. All designs have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcements, corner reinforcement, and T-junctions to improve diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house. The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
## Model SMC-2.3: STONE MASONRY IN CEMENT MORTAR

### TWO-STOREY

![Perspective Diagram](image)

#### CONSTRUCTION MATERIAL AND MANPOWER

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<th>MATERIALS</th>
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<td>Ground &amp; First floor</td>
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### Nepal Housing Reconstruction Programme

**Type of House:** MODEL SMC-2.3

**Drawing Title:** PERSPECTIVE AND ESTIMATION

**Designed By:** DUDBC

**Scale:** NONE

**Date:** SMC-2.3

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- **Up to Plinth Level:**
  - Skilled: 61
  - Unskilled: 220
  - Stone: 33
  - Cement: 95
  - Sand: 17
  - Aggregate: 9
  - Wood: 0
  - Rod: 305
  - CGI Sheet: 0
  - GI Sheet: 0

- **Ground & First floor:**
  - Skilled: 162
  - Unskilled: 357
  - Stone: 53
  - Cement: 216
  - Sand: 32
  - Aggregate: 17
  - Wood: 1.02
  - Rod: 1487
  - CGI Sheet: 0
  - GI Sheet: 0

- **Roofing Work:**
  - Skilled: 41
  - Unskilled: 15
  - Stone: 0
  - Cement: 0
  - Sand: 0
  - Aggregate: 0
  - Wood: 1.91
  - Rod: 0
  - CGI Sheet: 4.50
  - GI Sheet: 11

- **Total:**
  - Skilled: 263
  - Unskilled: 592
  - Stone: 86
  - Cement: 311
  - Sand: 48
  - Aggregate: 26
  - Wood: 2.94
  - Rod: 1792
  - CGI Sheet: 4.50
  - GI Sheet: 11
Model SMC-2.3: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

GROUND FLOOR PLAN
AREA: 43.30 SQ.M.

FIRST FLOOR PLAN
AREA: 32.60 SQ.M.

TOTAL AREA: 75.9sqm

Nepal Housing
Reconstruction Programme

MODEL SMC-2.3

TYPE OF HOUSE: MODEL SMC-2.3
DRAWING TITLE: PLAN

SCALE: None
DATE: SMC-2.3
DESIGNED BY: DUDBC

36
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY
Model SMC-2.4 is a two storey house which can accommodate 8-10 people. On both floors there are two rooms with dimensions 3225x3150 and a covered verandah with dimensions 7300X1250 in the first floor. The design focuses on earthquake resistant construction using locally available construction materials. Similarly, stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafters and purlins. All designs have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcements, corner reinforcement, and T-junctions to improve diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house. The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
# Model SMC-2.4: STONE MASONRY IN CEMENT MORTAR

## Two-Storey Model SMC-2.4

### Perspective and Estimation

#### Level: Up to Plinth Level
- Skilled Manpower: 50
- Unskilled Manpower: 184
- Stone: 1038
- Cement: 73
- Sand: 15
- Aggregate: 4
- Wood: 0
- CGI Sheet: 0
- GI Sheet: 0
- Rod (Steel): 207

#### Level: Superstructure
- Skilled Manpower: 190
- Unskilled Manpower: 381
- Stone: 2745
- Cement: 180
- Sand: 34
- Aggregate: 4
- Wood: 3.16
- CGI Sheet: 0
- GI Sheet: 0
- Rod (Steel): 496

#### Level: Roofing
- Skilled Manpower: 46
- Unskilled Manpower: 0
- Stone: 0
- Cement: 0
- Sand: 0
- Aggregate: 2.19
- Wood: 4.36
- CGI Sheet: 11
- GI Sheet: 11
- Rod (Steel): 0

#### Total
- Skilled Manpower: 286
- Unskilled Manpower: 565
- Stone: 3783
- Cement: 253
- Sand: 49
- Aggregate: 8
- Wood: 5.37
- CGI Sheet: 4.36
- GI Sheet: 11
- Rod (Steel): 703

---

**Nepal Housing Reconstruction Programme**

**Type of House:** MODEL SMC-2.4

**Drawing Title:** PERSPECTIVE AND ESTIMATION

**Scale:** NONE

**Date:**

**Designed by:** DUBDC

**Sheet:** 1/4
Model SMC-2.4: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY

TOTAL AREA: 86.6sqm

Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.4

DRAWING TITLE: PLAN

SCALE: None

DATE: SMC-2.4

DESIGNED BY: DUBDC

2/4
Model SMC-2.4: STONE MASONRY IN CEMENT MORTAR

- FRONT ELEVATION
- RIGHT SIDE ELEVATION
- BACK ELEVATION
- LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme

<table>
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<tr>
<th>TYPE OF HOUSE:</th>
<th>MODEL SMC-2.4</th>
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SCALE: None
DATE: SMC-2.4
DESIGNED BY: DUDBC
Model SMC-2.4: STONE MASONRY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme 1:50 SECTION DUDBC

SMC-2.4 TWO-STOREY

MODEL SMC-2.4

SECTION AT A-A-A
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.5
Model SMC-2.5 is a two and a half storey house, which includes an attic. On both floors there are three rooms with dimensions of 2700 X 2700 and a covered verandah with dimensions 6550X1100. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along wooden rafters and purlins. All designs have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcements, corner reinforcement, and T-junctions to improve diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house. The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
### Model SMC-2.5: STONE MASONRY IN CEMENT MORTAR

#### TWO-STOREY+ATTIC

![House Model](Model_SMC-2.5.png)

#### CONSTRUCTION MATERIALS AND MANPOWER

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**Nepal Housing Reconstruction Programme**

**MODEL SMC-2.5**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**DESIGNED BY:** DUDBC

**DATE:** SMC-2.5

**SCALE:** NONE
Model SMC-2.5: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+ATTIC

TOTAL AREA: 107.36sqm

Model SMC-2.5: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+ATTIC

TOTAL AREA: 107.36sqm

MODEL SMC-2.5

PLAN

SMC-2.5

2/4
Model SMC-2.5: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+ATTIC

DATE: SCALE: DRAWING TITLE: Designed by:
Nepal Housing Reconstruction Programme SMC-2.5

MODEL SMC-2.5 SECTION

SCALE: 1:50

SMC-2.5

4/4

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.5

DRAWING TITLE: SECTION

DESIGNED BY: DUDBC
STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.6
Model SMC-2.6 is a two and a half storey building constructed in stone masonry with a RCC flat slab. Covering a plinth area of 48.90 Sq. M., the model consists of kitchen with dimensions of 3300 X 2700, living room with dimensions of 3300 X 2700 and a veranda with dimensions 3300 x 2100 in the ground floor. Similarly, on the first floor it consists of two bedroom with dimensions 3300 X 2700 along with verandah dimensions 3300 x 2100. All designs have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcements.
CONSTRUCTION MATERIALS AND MANPOWER

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<th>MANPOWER</th>
<th>MATERIALS</th>
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Nepal Housing Reconstruction Programme

Model SMC-2.6: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+TERRACE

TYPE OF HOUSE: MODEL SMC-2.6

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

SCALE: None

DATE: SMC-2.6

DESIGNED BY: DUDBC
Model SMC-2.6: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+TERRACE

TOTAL AREA: 97.8sqm
Model SMC-2.6: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY+TERRACE

SECTION AT A-A

GROUND LEVEL

VERANDA

PLINTH LEVEL

FIRST FLOOR

TERRACE

DETAIL

DETAIL

BACKGROUND

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.6

DRAWING TITLE: SECTION

SCALE: None

DATE: SMC-2.6

DESIGNED BY: DUDBC
STONE MASONRY IN CEMENT MORTAR (SMC)

Technical Details
10 KEY MESSAGES

1. Get technical advice before you start.
2. Band your walls together.
3. Tie your house together with tiestones.
4. Build your house with good materials.
5. Tie your gables up.
6. Tie your roof down.
7. Tie your floors to your walls.
8. Build a strong shape.
9. Have a safe site and a safe exit.
10. Build on strong foundations.
Technology for Earthquake Resistant Building Construction (Stone in Cement Mortar)

- **Foundation:** Stone masonry in cement mortar 1:4
- **Wall:** Stone masonry in cement mortar 1:4
- **Vertical reinforcement:** reinforcement 12 mm rebar
- **Roof Band:** RCC: Concrete 1:1.5:3
  - Reinforcement main bar 12 mm^4, Foop6 mm @ 150 mm
- **Lintel Band:** RCC: Concrete 1:1.5:3
  - Reinforcement main bar 12 mm^4, Foop6 mm @ 150 mm
- **Sill Band:** RCC: Concrete 1:1.5:3
  - Reinforcement main bar 12 mm^2, Foop6 mm @ 150 mm
- **Plinth Band:** RCC: Concrete 1:1.5:3
  - Reinforcement main bar 12 mm^4, Foop6 mm @ 150 mm

Nepal Housing Reconstruction Programme

**Model SMC**

**Drawing Title:** TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)

**Scale:** None

**Date:** SMC

**Designed by:** JICA
STONE MASONRY IN CEMENT MORTAR

Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)
STONE MASONRY IN CEMENT MORTAR

Cross section of RC bands for two bars and four bars

Requirement of bar for RC bands

<table>
<thead>
<tr>
<th>Band/Beam</th>
<th>RC Band Minimum Thickness</th>
<th>Min. No. Of. Bars</th>
<th>Min. Diameter of Bars (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plinth</td>
<td>150 mm</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Still</td>
<td>75 mm</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Lintel</td>
<td>75mm</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Roof</td>
<td>75mm</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Dowel (Stitch)</td>
<td>75mm</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Source: NBC202

RCC BAND AT CORNER and T-Junction

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL SMC

DRAWING TITLE: TECHNICAL DETAIL 3 (Reinforcing bar arrangement)

SCALE: None

DATE: SMC

DESIGNED BY:
STONE MASONRY IN CEMENT MORTAR

For one-storey building (in soft soil) or
For two-storey building (in medium soil) (Stone in cement mortar)

Base width of footing

<table>
<thead>
<tr>
<th>Masonry Type</th>
<th>No. Of Story</th>
<th>Minimum base width (mm) of wall footing for soil type:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Soft</td>
</tr>
<tr>
<td>Brick</td>
<td>Two</td>
<td>900</td>
</tr>
<tr>
<td></td>
<td>One</td>
<td>650</td>
</tr>
<tr>
<td>Stone</td>
<td>Two</td>
<td></td>
</tr>
<tr>
<td></td>
<td>One</td>
<td>800</td>
</tr>
</tbody>
</table>

Classification of Foundation Soil and Safe Bearing Capacity

<table>
<thead>
<tr>
<th>Foundation Soil Classification</th>
<th>Types of Foundation Materials</th>
<th>Presumed Safe Bearing Capacity, KN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>Rocks in different state of weathering, boulder bed, gravel, sandy gravel and sand-gravel mixture, dense or loose coarse to medium sand offering high resistance to penetration when excavated by tools; stiff to medium clay which is readily indented with a thumb nail.</td>
<td>&gt;=200</td>
</tr>
<tr>
<td>Medium</td>
<td>Find sand and silt (dry lumps easily pulverised by the finger); moist clay and sand-clay mixture which can be indented with strong thumb pressure.</td>
<td>&lt;200 and &gt;=150</td>
</tr>
<tr>
<td>Soft</td>
<td>Fine sand, loose and dry; soft clay indented with moderate thumb pressure.</td>
<td>&lt;150 and &gt;=100</td>
</tr>
<tr>
<td>Weak</td>
<td>Very soft clay which can be penetrated several centimeters with the thumb, wet clays.</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

*Source: NBC202
Window Section

- 75x125mm Wooden Lintel Band
- 75x100mm Wooden Window Frame
- 100x125mm Sill Band

Door Section

- 75x125mm Wooden Lintel Band
- Wooden Frame

First Floor Detail

- FLOOR FINISH
- 75MM MUD FILLING
- 45x126MM WOODEN PLANK
- 75x125MM WOODEN JOIST @450MM/c

Type 1

- FIRST FLOOR LEVEL
- 75x100MM WALL PLATE
- 75x125MM WALL LINTEL BAND

Type 2

- 100MM R.C.C SLAB

*Source: NBC202
STONE MASONRY IN CEMENT MORTAR

Top (Plan) View
- CGI Sheet
- Ridge Cover
- Rafters (H180xW60)
- Ridge (H240xW180)
- Purlin (H75xW75)

Side View
- Ridge (H240xW120)
- Post (H90xW90)
- Fascia (H270xW20)
- Base (H90xW90)

Isometric View
- CG1 Sheet
- Ridge Cover
- Rafters (H180xW60)

DRAWING TITLE: TECHNICAL DETAIL 7 (Roofing)
TYPE OF HOUSE: MODEL SMC
DATE: SMC
SCALE: None
DESIGNED BY: SMC
Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)

Earthquake Resistant Elements in Building

Typical Ground/First Floor Plan

Foundation Detail

Detail of Rafter Joint at Ridge

Corner Strengthening Band

First Floor Detail

RCC Band at Corner and T-Junction

Flexible design

Window Section

Door Section

Detail of Rafter Joint with Wall Plate

Flexible design
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Detail Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Selection</td>
<td>A building shall not be constructed if site is:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Geological fault or Raptured Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Areas Susceptible to Landslide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Steep Slope &gt; 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Filled Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ River Bank and Water-logged Area</td>
</tr>
<tr>
<td>2</td>
<td>Shape of House</td>
<td>No. of story: Two storey+ attic, load bearing masonry buildings constructed in cement mortar</td>
</tr>
<tr>
<td></td>
<td>Span of wall</td>
<td>✔ The span of wall shall not be more than 4.5 meters</td>
</tr>
<tr>
<td></td>
<td>Size of room</td>
<td>✔ The area of individual floor panel not more than 13.5 square metres</td>
</tr>
<tr>
<td></td>
<td>Height of wall</td>
<td>✔ The height of wall should not be more than 3.0 meters</td>
</tr>
<tr>
<td></td>
<td>Proportion</td>
<td>✔ The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.</td>
</tr>
<tr>
<td>3</td>
<td>Foundation</td>
<td>General: The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depth: The depth of footing should not be less than 800mm for one story, 900mm for two story.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width: The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings.</td>
</tr>
<tr>
<td>4</td>
<td>Plinth</td>
<td>General: Provide a reinforced concrete band at plinth level, as shown in detail drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height: Minimum height of Plinth band is 150mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width: Minimum thickness of plinth band width should be equal to wall thickness. 350mm for Stone masonry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement: Main reinforcement should be 4-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.</td>
</tr>
<tr>
<td>5</td>
<td>Walls</td>
<td>General: Masonry should not be laid staggered or straggled in order to avoid continuous vertical joints. At corners or wall junctions, through vertical joints should be avoided by properly laying the masonry. It should be interlocked.</td>
</tr>
<tr>
<td></td>
<td>Joints</td>
<td>✔ Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).</td>
</tr>
<tr>
<td></td>
<td>Through Stone</td>
<td>✔ Through stone of a length equal to the full wall thickness should be used in every 600 mm lift at not more than 1.2 m apart horizontally.</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>✔ The minimum width of wall is 350mm for one-storey and two-storey.</td>
</tr>
<tr>
<td>6</td>
<td>Openings</td>
<td>Location: Openings are to be located away from inside corners by a clear distance should not be less than 600 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total length: The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance: The horizontal distance between two openings is to be not less than 600 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel level: Keep lintel level same for doors and windows.</td>
</tr>
<tr>
<td>7</td>
<td>Vertical Reinforcement</td>
<td>Location: The vertical reinforcing bar for masonry is given in detail drawings. 12mm dia is minimum requirements for masonry houses.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement: Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sill band: A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel band: A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stitch: This band shall be provided where dowel-bars are required at all corners, junctions of walls. The minimum height is 75mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof band: Roof band shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement: Main reinforcement should be 4or 2-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.</td>
</tr>
<tr>
<td>8</td>
<td>Horizontal Band</td>
<td>Light roof: Use light roof comprising wooden or steel truss covered with CGI sheets.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connection: All members of the timber trusses or joints should be properly connected as shown in detail drawings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cross-tie: Trusses should be properly cross-tied with wooden braces as shown in detail drawings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timber: Well seasoned hard wood without knots should be used for roofing, timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects</td>
</tr>
<tr>
<td>9</td>
<td>Roof</td>
<td>Mortar: Cement sand mortar should not be leaner than 1:4 (1 part cement and 4 parts sand) for masonry and 1.6 for plaster.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete: The concrete mix for seismic bands should not be leaner than 1:1.5:3:1 (1 part cement, 1.5 parts sand and 3 parts aggregate)</td>
</tr>
</tbody>
</table>
|     |                                 | Reinforcement: High Strength Deformed Bars – Fe415: High strength deformed bars with fy = 415 N/
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
BRICK MASONRY IN CEMENT MORTAR (BMC)
This section of the Design Catalogue for Reconstruction of Earthquake Resistant houses refers to brick masonry construction using cement mortar. Designs for both one-storey and two-storey houses are included in this category of the catalogue. A flexible design is also included which can be adapted as per the households’ requirements within the parameters as set out in the National Building Code of Nepal 202.

The house designs are based on the use of reinforced concrete bands. The technical specifications for the material required in the construction of the house designs included under this category can be found in the ‘Minimum Requirements’ at the beginning of this section. The key technical details related to this category are included at the end of this section and should be referred to when constructing any of the designs presented under this category.
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>A building shall not be constructed if site is:</th>
</tr>
</thead>
</table>
| 1   | Site Selection | ✔ Geological fault or Raptured Area  
✔ Areas Susceptible to Landslide  
✔ Steep Slope > 20%  
✔ Filled Area  
✔ River Bank and Water-logged Area |
| 2   | Shape of House | No. of story ✔ Two storey+ attic, load bearing masonry buildings constructed in cement mortar  
Span of wall ✔ The span of wall shall not more than 4.5 meters  
Size of room ✔ The area of individual floor panel not more than 13.5 square metres  
Height of wall ✔ The height of wall should not be more than 3.0 meters  
Proportion ✔ The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width. |
| 3   | Foundation | General ✔ The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.  
Depth ✔ The depth of footing should not be less than 800mm for one story, 900mm for two storey.  
Width ✔ The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings. |
| 4   | Plinth | General ✔ Provide a reinforced concrete band at plinth level, as shown in detail drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.  
Height ✔ Minimum height of Plinth band is 150mm.  
Width ✔ Minimum thickness of plinth band width should be equal to wall thickness. 230mm for brick masonry.  
Reinforcement ✔ Main reinforcement should be 4-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete. |
| 5   | Walls | General ✔ Masonry should not be laid staggered or straggled in order to avoid continuous vertical joints. At corners or wall junctions, through vertical joints should be avoided by properly laying the masonry. It should be interlocked.  
Joints ✔ Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).  
Width ✔ The minimum width of wall is 230mm for one-storey and 350mm for two-storey of ground floor. |
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Location</th>
<th>Total length</th>
<th>Distance</th>
<th>Reinforcement</th>
<th>Horizontal Band Stitch</th>
<th>Roof Band</th>
<th>Sill Band</th>
<th>Lintel Band</th>
<th>Reinforcement</th>
<th>Light roof</th>
<th>Cross-tie</th>
<th>Timber</th>
<th>Mortar</th>
<th>Concrete</th>
<th>Reinforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Openings</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Vertical</td>
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</tr>
<tr>
<td>8</td>
<td>Reinforcement</td>
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<td></td>
</tr>
<tr>
<td>9</td>
<td>Roof</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>10</td>
<td>Materials</td>
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</tr>
</tbody>
</table>

- Openings are to be located away from inside corners by a clear distance that should not be less than 600 mm.
- The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.
- Keep lintel level same for doors and windows and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them during the masonry construction.
- The horizontal reinforcing bar for masonry is given in detail drawings.
- The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.
- The horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:
  - Sill band
  - Lintel band
  - Roof band
  - Stitch
- Reinforcement should be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75 mm.
- Roof band shall be provided at 150 mm. Hook length should be 500 mm. Bars shall have a clear cover of 25 mm concrete.
- All members of the timber truss or joints should be properly connected as shown in detail drawings.
- The light roof comprising wooden or light truss covered with CGI sheets.
- Cement and mortar should not be leaner than 1:1.5:3 (1 part cement, 1.5 parts sand and 3 parts aggregate) for the concrete mix for seismic bands should not be leaner than 1:1.5:3 (1 part cement, 1.5 parts sand and 3 parts aggregate).
- Main reinforcement should be 4 or 2-12 dia. bars. Use 6 mm diameter bars. Use 6 mm diameter bars. Use 6 mm diameter bars.
- Use 6 mm diameter bars. Use 6 mm diameter bars. Use 6 mm diameter bars.
- Well seasoned hard wood without knots should be used for roofing. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.
- Use light roof comprising wooden or steel trusses covered with CGI sheets.
BRICK MASONRY IN CEMENT MORTAR, ONE-STOREY

BMC-1.1
Model BMC-1.1 a one-storey housing which can accommodate 3-5 people. It consists of two rooms with dimensions of 2830 x 4500, and a verandah with dimensions of 1500 x 6350. The design focuses on earthquake resistant construction using locally available construction materials. Similarly, brick masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness.

The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skilled</td>
<td>Unskilled</td>
</tr>
<tr>
<td></td>
<td>Md</td>
<td>Md</td>
</tr>
<tr>
<td>Up to Plinth Level</td>
<td>45</td>
<td>104</td>
</tr>
<tr>
<td>SUPERSTRUCTURE</td>
<td>67</td>
<td>59</td>
</tr>
<tr>
<td>ROOFING</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>TOTAL</td>
<td>129</td>
<td>183</td>
</tr>
</tbody>
</table>

Nepal Housing Reconstruction Programme

MODEL BMC-1.1

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

TYPE OF HOUSE: ONE-STOREY

SCALE: None

DATE: BMC-1.1

DESIGNED BY: JICA
Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR

GROUND FLOOR PLAN
FLOOR AREA: 31.75sqm

ROOM1
2830 x 4500

ROOM2
2830 x 4500

VERANDA
1500 x 6350

See Technical Detail 2
See Technical Detail 2
See Technical Detail 3

DATE: SCALE: DESIGNED BY:
BMC-1.1

Nepal Housing Reconstruction Programme
ONE-STOREY

DRAWING TITLE: MODEL BMC-1.1
PLAN

JICA

SCALE: 1:50

2/4
Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR

TYPE OF HOUSE: MODEL BMC-1.1
DRAWING TITLE: ELAVATION

SCALE: None
DATE: BMC-1.1
DESIGNED BY: JICA

Nepal Housing
Reconstruction Programme
BRICK MASONRY IN CEMENT MORTAR, ONE-STOREY

BMC-1.2
Model BMC-1.2 is a one-storey house which can accommodate 1-3 people. It consists of one room with dimensions of 2830 x 4500, and a verandah with dimensions of 3090 x 4960. The design focuses on earthquake resistant construction using locally available construction materials. Similarly brick masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. This includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness.

The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
Model BMC-1.2: BRICK MASONRY IN CEMENT MORTAR

**LEVEL** | **MAN POWER** | **MATERIALS**
--- | --- | ---
 | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
--- | --- | --- | --- | --- | --- | --- | --- | --- | ---
Up to Plinth Level | Md | Md | Nos | Bags | cu.m. | cu.m. | cu.m. | Bundel | Kg |
| 29.28 | 68.05 | 8419.00 | 48.00 | 7.01 | 3.56 | 0.00 | 0.00 | 87.30 |
SUPERSTRUCTURE | 39.80 | 38.10 | 5384.40 | 31.23 | 3.00 | 1.62 | 0.46 | 0.00 | 164.92 |
ROOFING | 10.02 | 11.34 | 0.00 | 0.00 | 0.00 | 0.00 | 1.48 | 3.69 | 0.00 |
TOTAL | 79.09 | 117.49 | 13803.40 | 79.23 | 10.01 | 5.18 | 1.94 | 3.69 | 252.22

**Nepal Housing Reconstruction Programme**

**MODEL BMC-1.2**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**SCALE:** None

**DATE:**

**DESIGNED BY:** JICA

**BMC-1.2**

1/4
BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

BMC-2.1
Model BMC-2.1 is a two-storey house which can accommodate more than 4 people. It consists of four rooms with dimensions of 2650 x 4260 for ground floor and 2830 x 4500 for first floor, and a verandah with dimensions of 1500 x 6350. The design focuses on earthquake resistant construction using locally available construction materials. Similarly, brick masonry in cement mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafter and purlin. All design have been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions to improve diaphragm effectiveness. The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
**Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR**

**DATE:** SCALE: DESIGNER: 

**Nepal Housing Reconstruction Programme**

**MODEL BMC-2.1**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skilled Md</td>
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<td>Up to Plinth Level</td>
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<td>17.32</td>
<td>19.53</td>
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<td>282.24</td>
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Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY

GROUND FLOOR PLAN
AREA: 31.75sqm

ROOM1
2650 x 4300

ROOM2
2650 x 4260

VERANDA
1500 x 6350

FIRST FLOOR PLAN
AREA: 31.75sqm

ROOM3
2830 x 4500

ROOM4
2830 x 4500

TOTAL AREA: 63.5sqm

See Technical Detail 2

See Technical Detail 2

See Technical Detail 3

Nepal Housing Reconstruction Programme
Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: TYPE OF HOUSE: DESIGNED BY: MODEL BMC-2.1 1:100 ELEVATION

Nepal Housing Reconstruction Programme

TWO-STOREY

MODEL BMC-2.1

ELEVATION

JICA
Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

Roof: RCC Concrete 1:1:5:3
Reinforcement: bar 12mm², 4mm

Sill Band: RCC Concrete 1:1:5:3
Reinforcement: bar 12mm², 4mm

Lintel Band: RCC Concrete 1:1:5:3
Reinforcement: bar 12mm², 4mm

Vertical reinforcement: bar 12mm

Foundation: Stone masonry in cement mortar or brick masonry in cement mortar

Wall: Brick masonry in cement mortar

See Technical Detail 6

ROOM1

ROOM3

VERANDA

SECTION A-A
BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

BMC-2.2
Model BMC-2.2 is a two storey building constructed in brick masonry. Covering a plinth area of 37.35 Sq. M., the model consists of kitchen with dimensions 2925X 2925 and a covered veranda with sizes 5475 x 2050 in the ground floor. Similarly, in the first floor it consists of two bedrooms, one with dimensions 2925x 2925 and the other with dimensions of 5475 x 2050. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions. The design of this model is influenced by the vernacular architecture of the Hilly region of Nepal, with incorporation of Pidi, Pali and slope roofs.
### CONSTRUCTION MATERIALS AND MANPOWER

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
</tr>
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<tbody>
<tr>
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<td>Nos</td>
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<td>Up to Plinth Level</td>
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<td>SUPERSTRUCTURE</td>
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**Model BMC 2.2 BRICK MASONARY IN CEMENT MORTAR**

**DATE:**

**SCALE:** NONE

**TYPE OF HOUSE:** MODEL BMC-2.2

**DESIGNED BY:** DUDBC

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**Nepal Housing Reconstruction Programme**

**DATE:**

**SCALE:** NONE

**TYPE OF HOUSE:** MODEL BMC-2.2

**DESIGNED BY:** DUDBC

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**DATE:**

**CONSTRUCTION MATERIALS AND MANPOWER**

<table>
<thead>
<tr>
<th>LEVEL</th>
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<th>MATERIALS</th>
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<tr>
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<td></td>
<td>Brick</td>
<td>CEMENT</td>
</tr>
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<td></td>
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<td>113</td>
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<tr>
<td>SUPERSTRUCTURE</td>
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<td>ROOFING</td>
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<tr>
<td>TOTAL</td>
<td>280</td>
<td>241</td>
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</tbody>
</table>
Model BMC 2.2 BRICK MASONARY IN CEMENT MORTAR

GROUND FLOOR PLAN
AREA 51.30 SQ.M.

FIRST FLOOR PLAN
AREA 37.35 SQ.M.

TOTAL AREA: 88.65 SQ.M.

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.2
DRAWING TITLE: PLAN

SCALE: None
DATE: DUDBC

BMC-2.2

95
Model BMC-2.2: BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme
MODEL BMC-2.2 1:100 ELEVATION DUDBC

FRONT ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

RIGHT SIDE ELEVATION

Model BMC-2.2: BRICK MASONARY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme
MODEL BMC-2.2 1:100 ELEVATION DUDBC

FRONT ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

RIGHT SIDE ELEVATION

Model BMC-2.2: BRICK MASONARY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme
MODEL BMC-2.2 1:100 ELEVATION DUDBC

FRONT ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

RIGHT SIDE ELEVATION

Model BMC-2.2: BRICK MASONARY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme
MODEL BMC-2.2 1:100 ELEVATION DUDBC

FRONT ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

RIGHT SIDE ELEVATION
Model BMC-2.2: BRICK MASONARY IN CEMENT MORTAR

SECTION AT A-A

TWO-STOREY

DRAWING TITLE: SECTION

TYPE OF HOUSE: MODEL BMC-2.2

SCALE: 1:50

DATE:

BMC-2.2

Nepal Housing Reconstruction Programme

DESIGNED BY: DUDBC
BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

BMC-2.3
Model BMC-2.3 is a two-storey building constructed of brick masonry using cement mortar. Covering a plinth area of 45.35 Sq. M., the model consists of kitchen with dimensions 3100 X 2100, bedroom with dimensions 3100x 3100 and a covered veranda with dimensions 3100x 2100 on the ground floor. Similarly, on the first floor it consists of two bedrooms, one with dimensions 3100 x 2100 and the other with dimensions 3100x 3100, a covered veranda with dimensions of 3100 x 2100 and a living room with dimensions of 3100 x 3100. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal bands, vertical reinforcement, corner reinforcement, and T-junctions.
Model BMC-2.3: BRICK MASONRY IN CEMENT MORTAR

CONSTRUCTION MATERIALS AND MANPOWER

<table>
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<th>LEVEL</th>
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<th>MATERIALS</th>
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</thead>
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Nepal Housing Reconstruction Programme

MODEL BMC-2.3

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

SCALE: NONE

DATE: 

DESIGNED BY: DUDBC

BMC-2.3

1/4
Model BMC-2.3: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY

GROUND FLOOR PLAN
AREA 45.35 SQ.M.

FIRST FLOOR PLAN
AREA 45.35 SQ.M.

TOTAL AREA: 90.7sqm

Nepal Housing
Reconstruction Programme

Model: BMC-2.3

Type of House: MODEL BMC-2.3

Drawing Title: PLAN

Designed by: DUDBC

Scale: None

Date: 2/4

BMC-2.3
Model BMC-2.3: BRICK MASONRY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

ELEVATION

1:100

TWO-STOREY

BMC-2.3

3/4

Nepal Housing Reconstruction Programme

FRONT ELEVATION

RIGHT SIDE ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

TWO-STOREY

Model BMC-2.3 :BRICK MASONRY IN CEMENT MORTAR

DATE: SCALE: DRAWING TITLE: DESIGNED BY:

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

ELEVATION

1:100

TWO-STOREY

BMC-2.3

3/4

Nepal Housing Reconstruction Programme

FRONT ELEVATION

RIGHT SIDE ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION
Model BMC-2.3: BRICK MASONRY IN CEMENT MORTAR

SECTION AT A-A

GROUND LEVEL

FIRST FLOOR

PLINTH LEVEL

DATE: 1/50

SCALE: 1:50

Model BMC-2.3 - TWO-STOREY

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

DRAWING TITLE: SECTION

DESIGNED BY: DUDBC

4/4
Model BMC-2.4 is a two and half storey building constructed of brick masonry with cement mortar. Covering a plinth area of 50.76 Sq. M., the model consists of a shop (with dimensions 3450 x 3000) and two store rooms (one with dimensions 2700 x 3000 and one with dimensions 3450 x 3000) on the ground floor. Similarly, on the first floor it consists of two bedrooms (one with dimensions 2700 x 3000, and one with dimensions 3450x 3000) and a living room (with dimensions 3450x3000). The attic space includes a kitchen, dining and terrace. The façade has been designed so as to comply with the traditional architectural feature of a typical Newari house with a slight variation in its functional characteristics. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal RCC bands and vertical reinforcement.
### Model BMC-2.4: BRICK MASONRY IN CEMENT MORTAR

**TWO-STOREY+ATTIC**

**CONSTRUCTION MATERIALS AND MANPOWER**

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
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<tr>
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<td>TOTAL</td>
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**Nepal Housing Reconstruction Programme**

**MODEL BMC-2.4**

**DRAWING TITLE:** PERSPECTIVE AND ESTIMATION

**DESIGNED BY:** DUDBC
Model BMC-2.4: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY+ATTIC

FRONT ELEVATION

RIGHT SIDE ELEVATION

LEFT SIDE ELEVATION

BACK ELEVATION

DATE: SCALE: DRAWING TITLE: DESIGNED BY:
108 1:100 ELEVATION DUDBC

Nepal Housing Reconstruction Programme

MODEL BMC-2.4

BMC-2.4

3/4
BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

BMC-2.5
Model- BMC 2.5 is a typology for row houses design with each unit covering a plinth area of 41.22 Sq. M. This model represents a simple two-storey building with flat roof, constructed in brick masonry with cement mortar. On the ground floor, it consists of living room with dimensions 3000 X 3725, a kitchen with dimensions 3000 x 3075, a bathroom with dimensions 1200x 2100 and a store with dimensions 1200 x 1525. Similarly it comprises of two bedrooms on the first floor and a terrace space is include in the roof. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal RCC bands and vertical reinforcement.
Table: Construction Materials and Manpower

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
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<th>REINFORCEMENT</th>
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</tr>
<tr>
<td></td>
<td>Md</td>
<td>Md</td>
<td>Nos</td>
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<tr>
<td>Up to Plinth Level</td>
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<td>109</td>
<td>11012</td>
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<tr>
<td>Ground FLOOR</td>
<td>127</td>
<td>146</td>
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<tr>
<td>FIRST FLOOR</td>
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<td>141</td>
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<td>396</td>
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Model BMC 2.5 BRICK MASONARY IN CEMENT MORTAR  
TWO-STOREY+TERRACE
Model BMC 2.5 BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY+TERRACE

DATE: SCALE: TYPE OF HOUSE: DRAWING TITLE: DESIGNED BY:
Nepal Housing Reconstruction Programme None MODEL BMC-2.5 PLAN DUDBC

Nepal Housing
Reconstruction Programme

TWO-STOREY+TERRACE

GROUND FLOOR PLAN
AREA 41.22 SQ.M.

KITCHEN 3000 X 3075
STORE 1200X1525
BATHROOM 1200x2100
LIVING ROOM 3000 X 3725

UP.  5260
DN.

FIRST FLOOR PLAN
AREA 41.52 SQ.M.

BEDROOM 3000 X 3075
BED ROOM 3000x3725

UP.
VERANDA
DN.

ROOF PLAN
AREA 38.00 SQ.M.

LOWER TERRACE
TERRACE
Model BMC 2.5 BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY+TERRACE

FRONT ELEVATION

BACK ELEVATION

RIGHT SIDE ELEVATION

LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.5
DRAWING TITLE: ELEVATION

Scale: None
Date: BMC-2.5

Designed by: DUDBC

Page 114
BRICK MASONRY IN CEMENT MORTAR (BMC)

Technical Details
Well built STONE houses can better withstand earthquakes. Here are 10 TIPS ON HOW TO BUILD BACK SAFER

1. GET TECHNICAL ADVICE BEFORE YOU START
2. BAND YOUR WALLS TOGETHER
3. TIE YOUR HOUSE TOGETHER WITH TIE STONES
4. BUILD YOUR HOUSE WITH GOOD MATERIALS
5. TIE YOUR GABLES UP
6. TIE YOUR ROOF DOWN
7. TIE YOUR FLOORS TO YOUR WALLS
8. BUILD A STRONG SHAPE
9. HAVE A SAFE SITE AND A SAFE EXIT
10. BUILD ON STRONG FOUNDATIONS

Shelter Cluster Nepal
ShelterCluster.org
Coordinating Humanitarian Shelter
Government of Nepal
Ministry of Urban Development
Sustainable Human Development

10 KEY MESSAGES - A VISUAL INDEX
VERSION 2: 09/DEC/2015

117
BRICK MASONRY IN CEMENT MORTAR

Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)
BRICK MASONRY IN CEMENT MORTAR

Cross section of RC bands for two bars and four bars

Requirement of bar for RC bands

<table>
<thead>
<tr>
<th>Band/Beam</th>
<th>RC Band Minimum Thickness</th>
<th>Min. No. Of. Bars</th>
<th>Min. Diameter of Bars (mm)</th>
</tr>
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<tbody>
<tr>
<td>Plinth</td>
<td>150 mm</td>
<td>4</td>
<td>12</td>
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<tr>
<td>Still</td>
<td>75 mm</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Lintel</td>
<td>75mm</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Roof</td>
<td>150mm</td>
<td>2</td>
<td>10 (top)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>12 (bottom)</td>
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<tr>
<td>Dowel (Stitch)</td>
<td>75mm</td>
<td>2</td>
<td>8</td>
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*Source: NBC202*
### Base width of footing

<table>
<thead>
<tr>
<th>Masonry Type</th>
<th>No. Of Story</th>
<th>Minimum base width (mm) of wall footing for soil type:</th>
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</thead>
<tbody>
<tr>
<td>Brick</td>
<td>Two</td>
<td>Soft: 900, Medium: 650, Hard: 550</td>
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<tr>
<td>Stone</td>
<td>Two</td>
<td>Soft: 600, Medium: 600, Hard: 600</td>
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<tr>
<td></td>
<td>One</td>
<td>Soft: 800, Medium: 600, Hard: 600</td>
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</tbody>
</table>

### Classification of Foundation Soil and Safe Bearing Capacity

<table>
<thead>
<tr>
<th>Foundation Soil Classification</th>
<th>Types of Foundation Materials</th>
<th>Presumed Safe Bearing Capacity, KN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard</td>
<td>Rocks in different state of weathering, boulder bed, gravel, sandy gravel and sand-gravel mixture, dense or loose coarse to medium sand offering high resistance to penetration when excavated by tools; stiff to medium clay which is readily indented with a thumb nail.</td>
<td>&gt;=200</td>
</tr>
<tr>
<td>Medium</td>
<td>Find sand and silt (dry lumps easily pulverised by the finger); moist clay and sand-clay mixture which can be indented with strong thumb pressure.</td>
<td>&lt;200 and &gt;=150</td>
</tr>
<tr>
<td>Soft</td>
<td>Fine sand, loose and dry; soft clay indented with moderate thumb pressure.</td>
<td>&lt;150 and &gt;=100</td>
</tr>
<tr>
<td>Weak</td>
<td>Very soft clay which can be penetrated several centimeters with the thumb, wet clays.</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

*Source: NBC202*
BRICK MASONRY IN CEMENT MORTAR

Window Section

Door Section

First Floor Detail

75x125mm Wooden Lintel Band

75x125mm Wooden Window Frame

100x125mm Sill Band

FLOOR FINISH
75MM MUD FILLING
45x125MM WOODEN PLANK
75x125MM WOODEN JOIST @450MM/c

FIRST FLOOR LEVEL
75x100MM WALL PLATE
75x125MM WALL LINTEL BAND

Type 1

Type 2

Source: NBC202
Detail of Rafter Joint with Wall Plate

Detail of Rafter Joint at Ridge

---

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC

DRAWING TITLE: TECHNICAL DETAIL 5 (Roof)

DATE: BMC

SCALE: None

DEIGNED BY:
BRICK MASONRY IN CEMENT MORTAR

DATE: SCALE: TYPE OF HOUSE: DRAWING TITLE: MODEL BMC

Nepal Housing Reconstruction Programme

None

TECHNICAL DETAIL 6 (Roofing)

BMC
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Details</th>
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</thead>
</table>
| 1   | Site Selection | A building shall not be constructed if site is:  
- Geological fault or Raptured Area  
- Areas Susceptible to Landslide  
- Steep Slope > 20%  
- Filled Area  
- River Bank and Water-logged Area |
| 2   | Shape of House | No. of story: Two storey + attic, load bearing masonry buildings constructed in cement mortar.  
- Span of wall shall not be more than 4.5 meters  
- The area of individual floor panel not more than 13.5 square metres  
- The height of wall should not be more than 3.0 meters  
- Proportion: The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width. |
| 3   | Foundation | General: The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.  
- Depth: The depth of footing should not be less than 800mm for one story, 900mm for two storey.  
- Width: The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings. |
| 4   | Plinth | General: Provide a reinforced concrete band at plinth level, as shown in detail drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.  
- Height: Minimum height of Plinth band is 150mm.  
- Width: Minimum thickness of plinth band should be equal to wall thickness. 230mm for brick masonry.  
- Reinforcement: Main reinforcement should be 4-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete. |
| 5   | Walls | General: Masonry should not be laid staggered or straggled in order to avoid continuous vertical joints. At corners or wall junctions, through vertical joints should be avoided by properly laying the masonry. It should be interlocked.  
- Joints: Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).  
- Width: The minimum width of wall is 230mm for one-storey and 350mm for two-storey of ground floor. |
| 6   | Openings | Openings are to be located away from inside corners by a clear distance should not be less than 600 mm.  
- Location: Place vertical steel bars in the wall at all corners, junctions of walls and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them during the masonry construction.  
- Total length: The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.  
- Distance: The horizontal distance between two openings is to be not less than 600 mm.  
- Lintel level: Keep lintel level same for doors and windows.  
- lintel level: A continuous lintel band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.  
- Sill band: This band shall be provided where dowel-bars are required at all corners, junctions of walls. The minimum height is 75mm.  
- Roof band: Roof band shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75mm.  
- Reinforcement: Main reinforcement should be 4 or 2-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete. |
| 7   | Vertical Reinforcement | The vertical reinforcing bar for masonry is given in detail drawings.  
- Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:  
- Sill band: A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.  
- Lintel band: A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.  
- Roof band: Roof band shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75mm.  
- Reinforcement: Main reinforcement should be 4 or 2-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete. |
| 8   | Horizontal Band | The height of wall should not be more than 3.0 meters.  
- Location: The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.  
- Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:  
- Sill band: A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.  
- Lintel band: A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.  
- Roof band: Roof band shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum height is 75mm.  
- Reinforcement: Main reinforcement should be 4 or 2-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete. |
| 9   | Roof | Light roof: Use light roof comprising wooden or steel truss covered with CGI sheets as shown in detail drawings.  
- Connection: All members of the timber truss or joints should be properly connected as shown in detail drawings.  
- Cross-tie: Trusses should be properly cross-tied with wooden braces as shown in detail drawings.  
- Timber: Well seasoned hard wood without knots should be used for roofing. timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects. |
| 10  | Materials | Mortar: Cement sand mortar should not be leaner than 1:4 (1 part cement and 4 parts sand) for masonry and 1:6 for plaster.  
- Concrete: The concrete mix for seismic bands should not be leaner than 1:1.5:3 (1 part cement, 1.5 parts sand and 3 parts aggregate).  
- Reinforcement: High Strength Deformed Bars – Fe415; High strength deformed bars with fy = 415 N/
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
STONE MASONRY IN MUD MORTAR (SMM)
STONE MASONRY IN MUD MORTAR (SMM)

This section of the Design Catalogue for Reconstruction of Earthquake Resistant houses refers to stone masonry construction using cement mortar. Designs for both one-storey houses are included in this category of the catalogue. A flexible design is also included which can be adapted as per the households’ requirements within the parameters as set out in the National Building Code of Nepal 203.

The house designs are based on the use of reinforced concrete bands. The technical specifications for the material required in the construction of the house designs included under this category can be found in the ‘Minimum Requirements’ at the beginning of this section.

The key technical details related to this category are included at the end of this section and should be referred to when constructing any of the designs presented under this category.

Minimum Requirements (MRs)
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Selection</td>
<td>A building shall not be constructed if site is:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Prone to geological fault or raptured area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Susceptible to landslide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Steep slope &gt; 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Filled area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ River bank and water-logged area</td>
</tr>
<tr>
<td>2</td>
<td>Shape of House</td>
<td>No. of storeys: Two storey + attic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion: The house shall be planned square, rectangular. House should not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more than 3 times its width.</td>
</tr>
<tr>
<td>3</td>
<td>Foundation</td>
<td>General: The foundation trench shall be of uniform width. The foundation bed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shall be on the same level throughout the foundation in flat area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depth: The depth of footing should be at least 750mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width: The width of footing should not be less than 750mm and 800mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>respectively for one and two-storeyed houses in medium soil condition. Width</td>
</tr>
<tr>
<td></td>
<td></td>
<td>depends on soil type. Refer to technical drawings.</td>
</tr>
<tr>
<td>4</td>
<td>Plinth</td>
<td>General: The top level of plinth should be at least 300mm above existing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ground level. Recommended plinth height from the ground is 450mm.</td>
</tr>
<tr>
<td>5</td>
<td>Walls</td>
<td>General: Masonry should be laid staggered to avoid formation of continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vertical joint. At corners or wall junctions, continuous vertical joints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>should be avoided by properly laying large stones. The walls should be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interlocked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Joints: Mortar joints should not be more than 20mm and less than 10mm in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>thickness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Though Stone: Spacing of through stone shall not be more than 1200mm in the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>horizontal direction and 600mm in the vertical direction. Seasoned timber,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>precast or cast insitu concrete can be used instead of through stone.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length of wall: Maximum length of unsupported wall shall not exceed 12 times</td>
</tr>
<tr>
<td></td>
<td></td>
<td>its thickness. If unsupported length of wall is more than this, buttress</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shall be provided at an interval not exceeding 12 times wall thickness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wall thickness: The wall thickness should not be less than 350-450mm, 450mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>respectively for one and two-storey houses.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height of wall: The height of wall between floors should not be more than 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>times wall thickness.</td>
</tr>
<tr>
<td>No.</td>
<td>Category</td>
<td>Requirement</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Openings</td>
<td>Openings are to be located away from inside corners by 1/4 of the height of the adjoining opening, but not less than 600 mm.</td>
</tr>
<tr>
<td></td>
<td>Total length of openings</td>
<td>Total length of opening should be less than 0.3 and 0.25 of individual wall length respectively for one and two-storey house.</td>
</tr>
<tr>
<td></td>
<td>Distance between opening</td>
<td>Distance between two openings shall be larger of half the height of shorter opening or 600mm.</td>
</tr>
<tr>
<td></td>
<td>Lintel level</td>
<td>Keep lintel level same for doors and windows</td>
</tr>
<tr>
<td>7</td>
<td>Vertical Reinforcement</td>
<td>Place vertical steel bars in the wall at all corners, wall junctions and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them.</td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td>At corners and junctions vertical reinforcing bar should be 12mm for one storey, and 16 mm in the ground floor and 12mm in the upper storey in case of two storey house. At jambs, the reinforcing bars should be 12mm.</td>
</tr>
<tr>
<td>8</td>
<td>Horizontal Band</td>
<td>Horizontal reinforced concrete bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations. Minimum width of bands should be equal to the wall thickness. Where reinforcing bars have been used, these shall have a clear cover of 25mm. Where reinforced concrete is not available, timber bands and stitches could be used.</td>
</tr>
<tr>
<td></td>
<td>Plinth band</td>
<td>A continuous plinth band shall be provided through all walls at the plinth level. The minimum height is 75mm with 2-12 reinforcing bars for hard soil. In case of soft soil, band should be 150mm high with 4-12 reinforcement. Use 6mm dia. stirrups at 150mm centres.</td>
</tr>
<tr>
<td></td>
<td>Sill band</td>
<td>A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm with 2-10 reinforcing bars. Use 6mm diameter stirrups at 150mm centres.</td>
</tr>
<tr>
<td></td>
<td>Lintel band</td>
<td>A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 75mm with 2-12mm bars. Use 6mm stirrups at 150mm centres. Extra thickening should be provided where openings are more than 1m wide.</td>
</tr>
<tr>
<td></td>
<td>Roof band</td>
<td>Roof band shall be provided at the top of walls, so as to tie the walls at their top and tie the roof to the walls. The minimum height is 75mm with 2-12mm diameter bars. Use 6mm dia. Stirrups at 150mm centres.</td>
</tr>
<tr>
<td></td>
<td>Gable band</td>
<td>Masonry gable wall must have the triangular portion of masonry enclosed in a reinforced concrete band. The minimum height of band is 75mm with 2-12mm bars. Use 6mm dia. Stirrups at 150mm centres. It is recommended to replace gable masonry wall with lightweight materials such as metal sheet or timber.</td>
</tr>
<tr>
<td></td>
<td>Stitch</td>
<td>The stitches shall be provided at all corners, junctions of walls to strengthen connections. The min. height is 75mm with 2-8mm bars. Use 6mm dia. Stirrups at 150mm centres.</td>
</tr>
<tr>
<td>No.</td>
<td>Category</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>9</td>
<td>Light roof</td>
<td>Use light roof comprising of wooden or steel structure covered with light roofing materials. Heavy roofing materials such as slabs or mud should be avoided.</td>
</tr>
<tr>
<td></td>
<td>Connection</td>
<td>All members of the timber truss or joints should be properly connected as shown in technical details.</td>
</tr>
<tr>
<td></td>
<td>Cross-tie</td>
<td>Trusses should be properly cross-tied with wooden braces as shown in technical details.</td>
</tr>
<tr>
<td>10</td>
<td>Timber</td>
<td>Well-seasoned hard wood/local wood without knots should be used for structural purpose. Timber treatment such as use of collars or any other preservative can prevent timber from being decayed and attacked by insects.</td>
</tr>
<tr>
<td></td>
<td>Mortar</td>
<td>Mud should be free from organic material and pebbles, etc.</td>
</tr>
<tr>
<td></td>
<td>Brick</td>
<td>Brick should be class A1 or A2 with compressive strength not less than 3.5 N/mm².</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate).</td>
</tr>
<tr>
<td></td>
<td>Reinforcement</td>
<td>High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/mm² or 550 N/mm² could be used for reinforcements.</td>
</tr>
</tbody>
</table>
STONE MASONRY IN MUD MORTAR, TWO-STOREY

SMM-1.1
Model SMM-1.1 is a single storey building which consists of a bedroom of dimensions 3000x3000, a kitchen of dimensions 3000x2100, a living room of dimensions 3000x3000 and a covered verandah of dimensions 3000x2100. An attic space is also included. The design focuses on earthquake resistant construction using locally available construction materials. Similarly, stone masonry in mud mortar has been used for structural type, where CGI sheet is used for covering the roof along with wooden rafters and purlins. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal bands, vertical reinforcements, corner reinforcement and T-junctions to improve the diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house, The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
### Model SMM-1.1: STONE MASONRY IN MUD MORTAR

#### ONE-STOREY

![Diagram of a one-storey stone masonry house](image)

**CONSTRUCTION MATERIALS AND MANPOWER**

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skilled</td>
<td>Unskilled</td>
</tr>
<tr>
<td></td>
<td>Md</td>
<td>Md</td>
</tr>
<tr>
<td>Up to Plinth Level</td>
<td>52</td>
<td>92</td>
</tr>
<tr>
<td>Ground floor</td>
<td>119</td>
<td>65</td>
</tr>
<tr>
<td>Roofing work</td>
<td>68</td>
<td>40</td>
</tr>
<tr>
<td>TOTAL</td>
<td>238</td>
<td>197</td>
</tr>
</tbody>
</table>

**NOTES**

- **Nepal Housing Reconstruction Programme**
- **MODEL: SMM-1.1**
- **DRAWING TITLE:** PERSPECTIVE AND ESTIMATION
- **DESIGNED BY:** DUDBC
- **DATE:** 1/4

**CONSTRUCTION TECHNIQUES**

- **STONE MASONRY IN MUD MORTAR**
- **ONE-STOREY MODELS**
  - **DIMENSIONS**
  - **CONSTRUCTION MATERIALS AND MANPOWER**
  - **LEVELS:**
    - Up to Plinth Level
    - Ground floor
    - Roofing work
  - **TOTAL MANPOWER:** 238 skilled, 197 unskilled
  - **TOTAL MATERIALS:**
    - Stone: 56 cu.m
    - Mud: 41 cu.m
    - Wood: 7.66 cu.m
    - Slate: 161 sq.m
Model SMM-1.1: STONE MASONRY IN MUD MORTAR

Nepal Housing
Reconstruction Programme

MODEL SMM-1.1

DRAWING TITLE: ELAVATION

TYPE OF HOUSE: None

SCALE: None

DATE: None

DESIGNED BY: DUDBC

SMM-1.1

3/4

FRONT ELEVATION

RIGHT SIDE ELEVATION

BACK ELEVATION

LEFT SIDE ELEVATION
STONE MASONRY IN MUD MORTAR (SMM)

Technical Details
Well built STONE houses can better withstand earthquakes. Here are 10 TIPS ON HOW TO BUILD BACK SAFER

1. GET TECHNICAL ADVICE BEFORE YOU START
2. BAND YOUR WALLS TOGETHER
3. TIE YOUR HOUSE TOGETHER WITH TIESTONES
4. BUILD YOUR HOUSE WITH GOOD MATERIALS
5. TIE YOUR GABLES UP
6. TIE YOUR ROOF DOWN
7. TIE YOUR FLOORS TO YOUR WALLS
8. BUILD A STRONG SHAPE
9. HAVE A SAFE SITE AND A SAFE EXIT
10. BUILD ON STRONG FOUNDATIONS

10 KEY MESSAGES - A VISUAL INDEX
Shelter Cluster Nepal
Coordinating Humanitarian Shelter
Government of Nepal
Ministry of Urban Development
10 KEY MESSAGES - A VISUAL INDEX
VERSION 2: 09/0CT/2015
Technology for Earthquake Resistant Building Construction (One Storey Building, Stone in Mud Mortar)

Earthquake Resistant Elements in Building

Foundation Details of Strip Footing Masonry Foundation and DPC (Where cement and Concrete not available)

Ground Floor Detail

Dove Tail Joint for Wood Connection

Wood for Horizontal and Vertical Band at Corner and T-Junction

Bamboo for Horizontal and Vertical Band

Window Section

Door Section

Detail of Rafter Joint with Wall Plate

Detail of Rafter Joint at Ridge

Flexible design

141
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
### Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203)

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Selection</td>
<td>A building shall not be constructed if site is:</td>
</tr>
<tr>
<td></td>
<td>Prone to geological fault or raptured area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Susceptible to landslide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Steep slope &gt; 20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Filled area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>River bank and water-logged area</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Shape of House</td>
<td>No. of storeys Proportion</td>
</tr>
<tr>
<td></td>
<td>Two storeys, attic</td>
<td>The house shall be planned square, rectangular. House should not more than 3 times its width.</td>
</tr>
<tr>
<td>3</td>
<td>Foundation</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The depth of footing should be at least 750mm.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The width of footing should not be less than 750mm and 800mm respectively for one and two-storeyed houses in medium soil condition. Width depends on soil type. Refer to technical drawings.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Plinth</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Walls</td>
<td>General</td>
</tr>
<tr>
<td></td>
<td>Masonry should be laid staggered to avoid formation of continuous vertical joint. At corners or wall junctions, continuous vertical joints should be avoided by properly laying large stones. The walls should be interlocked.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Joints</td>
<td>Mortar joints should not be more than 20mm and less than 10mm in thickness.</td>
</tr>
<tr>
<td></td>
<td>Though Stone</td>
<td>Spacing of through stone shall not be more than 1200mm in the horizontal direction and 600mm in the vertical direction. Seasoned timber, precast or cast in situ concrete can be used instead of through stone.</td>
</tr>
<tr>
<td></td>
<td>Length of wall</td>
<td>Maximum length of unsupported wall shall not exceed 12 times its thickness. If unsupported length of wall is more than this, buttress shall be provided at an interval not exceeding 12 times wall thickness.</td>
</tr>
<tr>
<td></td>
<td>Wall thickness</td>
<td>The wall thickness should not be less than 350-450mm, 450mm respectively for one and two-storey houses.</td>
</tr>
<tr>
<td></td>
<td>Height of wall</td>
<td>The height of wall between floors should not be more than 8 times wall thickness.</td>
</tr>
<tr>
<td>6</td>
<td>Openings</td>
<td>Location</td>
</tr>
<tr>
<td></td>
<td>Total length of openings</td>
<td>Total length of opening should be less than 0.3 and 0.25 of individual wall length respectively for one and two-storey house.</td>
</tr>
<tr>
<td></td>
<td>Distance between opening</td>
<td>Distance between two openings shall be larger than half the height of shorter opening or 600mm.</td>
</tr>
<tr>
<td></td>
<td>Lintel level</td>
<td>Keep lintel level same for doors and windows.</td>
</tr>
<tr>
<td>7</td>
<td>Vertical Reinforcement</td>
<td>Location</td>
</tr>
<tr>
<td></td>
<td>Horizontal reinforcement</td>
<td>Horizontal reinforced concrete bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations. Minimum width of bands should be equal to the wall thickness. Where reinforcing bars have been used, these shall have a clear cover of 25mm. Where reinforced concrete is not available, timber bands and stitches could be used.</td>
</tr>
<tr>
<td></td>
<td>Plinth band</td>
<td>A continuous plinth band shall be provided through all walls at the plinth level. The minimum height is 75mm with 2-12 reinforcing bars for hard soil. In case of soft soil, band should be 150mm high with 4-12 reinforcement. Use 6mm dia. stirrups at 150mm centres.</td>
</tr>
<tr>
<td></td>
<td>Sill band</td>
<td>A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm with 2-10 reinforcing bars. Use 6mm diameter stirrups at 150mm centres.</td>
</tr>
<tr>
<td>8</td>
<td>Horizontal Band</td>
<td>Location</td>
</tr>
<tr>
<td></td>
<td>Lintel band</td>
<td>A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 75mm with 2-12mm bars. Use 6mm stirrups at 150mm centres. Extra thickening should be provided where openings are more than 1m wide.</td>
</tr>
<tr>
<td></td>
<td>Roof band</td>
<td>Roof band shall be provided at the top of walls, so as to tie the walls at their top and tie the roof to the walls. The minimum height is 75mm with 2-12mm diameter bars. Use 6mm dia. Stirrups at 150mm centres.</td>
</tr>
<tr>
<td></td>
<td>Gable band</td>
<td>Masonry gable wall must have the triangular portion of masonry enclosed in a reinforced concrete band. The minimum height of band is 75mm with 2-12mm bars. Use 6mm dia. Stirrups at 150mm centres. It is recommended to replace gable masonry wall with lightweight materials such as metal sheet or timber.</td>
</tr>
<tr>
<td></td>
<td>Stitch</td>
<td>The stitches shall be provided at all corners, junctions of walls to strengthen connections. The min. height is 75mm with 2-8mm bars. Use 6mm dia. Stirrups at 150mm centres.</td>
</tr>
<tr>
<td>No.</td>
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<td>Requirements</td>
</tr>
<tr>
<td>-----</td>
<td>----------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
| 9   | Roof     | **Light roof** ✔
|     |          | Use light roof comprising of wooden or steel structure covered with light roofing materials. Heavy roofing materials such as stone slabs or mud should be avoided. |
|     |          | **Connection** ✔
|     |          | All members of the timber truss or joints should be properly connected as shown in technical details. |
|     |          | **Cross-tie** ✔
|     |          | Trusses should be properly cross-tied with wooden braces as shown in technical details. |
| 10  | Materials| **Timber** ✔
|     |          | Well seasoned hard wood / local wood without knots should be used for structural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects. |
|     |          | **Mortar** ✔
|     |          | Mud should be free from organic material and pebbles, etc. |
|     |          | **Brick** ✔
|     |          | Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm. |
|     |          | **Concrete** ✔
|     |          | The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate) |
|     |          | **Reinforcement** ✔
|     |          | High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements. |
BRICK MASONRY IN MUD MORTAR (BMM)
This section of the Design Catalogue for Reconstruction of Earthquake Resistant houses refers to brick masonry construction using cement mortar. Designs for both one-storey houses are included in this category of the catalogue. A flexible design is also included which can be adapted as per the households’ requirements within the parameters as set out in the National Building Code of Nepal 203. The house designs are based on the use of reinforced concrete bands. The technical specifications for the material required in the construction of the house designs included under this category can be found in the ‘Minimum Requirements’ at the beginning of this section. The key technical details related to this category are included at the end of this section and should be referred to when constructing any of the designs presented under this category.
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Selection</td>
<td>A house shall not be constructed if site is:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Prone to geological fault or raptured area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Susceptible to landslide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Steep slope &gt; 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ Filled area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✔ River bank and water-logged area</td>
</tr>
<tr>
<td>2</td>
<td>Shape of House</td>
<td>No. of story: Two storey + attic</td>
</tr>
<tr>
<td></td>
<td>Proportion</td>
<td>The house shall be planned square, rectangular. Avoid long and narrow house. The house should not be more than 3 times its</td>
</tr>
<tr>
<td>3</td>
<td>Foundation</td>
<td>General: The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Depth: The depth of footing should be at least 750mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Width: The width of footing should not be less than 650mm and 750mm respectively for one and two-storey houses in medium soil condition. Width depends on soil type. Refer to technical drawings.</td>
</tr>
<tr>
<td>4</td>
<td>Plinth</td>
<td>General: The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm.</td>
</tr>
<tr>
<td>5</td>
<td>Walls</td>
<td>General: Masonry should be laid staggered to avoid formation of continuous vertical joint. At corners or wall junctions, continuous vertical joints should be avoided by properly laying the masonry. The walls should be interlocked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Joints: Mortar joints should not be more than 20mm and less than 10mm in thickness.</td>
</tr>
<tr>
<td></td>
<td>Length of wall</td>
<td>Maximum length of unsupported wall shall not exceed 12 times its thickness. If unsupported length of wall is more than this, buttress shall be provided at an interval not exceeding 12 times wall thickness.</td>
</tr>
<tr>
<td></td>
<td>Wall thickness</td>
<td>The thickness of the wall should not be less than 230mm, 350mm respectively for one-storey and two-storey plus attic house.</td>
</tr>
<tr>
<td></td>
<td>Height of wall</td>
<td>The height of wall between floors should not be more than 12 times wall thickness.</td>
</tr>
<tr>
<td>6</td>
<td>Openings</td>
<td>Location: Openings are to be located away from inside corners by 1/4 of the height of the adjoining opening, but not less than 600 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total length: Total length of opening should be less than 0.3 and 0.25 of individual wall length respectively for one and two-storey house.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance between openings: Distance between two openings shall be larger of half the height of shorter opening or 600mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel level: Keep lintel level same for doors and windows</td>
</tr>
<tr>
<td>No.</td>
<td>Category</td>
<td>Location</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Vertical Reinforcement</td>
<td>Place vertical steel bars in the wall at all corners, wall junctions and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them.</td>
</tr>
<tr>
<td>8</td>
<td>Horizontal Band</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plinth band</td>
<td>Horizontal reinforced concrete bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations. Minimum width of bands should be equal to the wall thickness. Where reinforcing bars have been used, these shall have a clear cover of 25mm concrete. Where reinforced concrete is not available, timber bands and stitches could be used.</td>
</tr>
<tr>
<td></td>
<td>Sill band</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lintel band</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roof band</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gable band</td>
<td>Masonry gable wall must have the triangular portion of masonry enclosed in a reinforced concrete band. The minimum height of band is 75mm with 2-12mm bars. Use 6mm dia. Stirrups at 150mm centres. It is recommended to replace gable masonry wall with light-weight materials such as metal sheet or timber.</td>
</tr>
<tr>
<td></td>
<td>Stitch</td>
<td></td>
</tr>
</tbody>
</table>

The stitches shall be provided at all corners, junctions of walls to strengthen connections. The min. height is 75mm with 2-8mm bars. Use 6mm dia. Stirrups at 150mm centres.
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Roof</td>
<td>Use light roof comprising of wooden or steel structure covered with light roofing materials. Heavy roofing materials such as stone slabs or mud should be avoided.</td>
</tr>
<tr>
<td></td>
<td>Connection</td>
<td>All members of the timber truss or joints should be properly connected as shown in technical details.</td>
</tr>
<tr>
<td></td>
<td>Cross-tie</td>
<td>Trusses should be properly cross-tied with wooden braces as shown in technical details.</td>
</tr>
<tr>
<td>10</td>
<td>Materials</td>
<td>Well seasoned hard wood /local wood without knots should be used for structural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.</td>
</tr>
<tr>
<td></td>
<td>Mortar</td>
<td>Mud should be free from organic material and pebbles, etc.</td>
</tr>
<tr>
<td></td>
<td>Brick</td>
<td>Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm.</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate)</td>
</tr>
<tr>
<td></td>
<td>Reinforcement</td>
<td>High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements.</td>
</tr>
</tbody>
</table>
Model BMM-1.1 is a single storey house which consists of a bedroom of dimensions 3000x300, a kitchen of dimensions 3000x2100, a living room of dimensions 3000x3000 and a covered verandah of dimensions 3000x2100. An attic space is also included. The design focuses on earthquake resistant construction using locally available construction materials. Similarly brick masonry in mud mortar has been used for the structure type, where CGI sheet is used for covering the roof along with wooden rafters and purlins. The model has been based on the revised National Building Code of Nepal (NBC) in order to ensure that earthquake resistant construction measures are included. The includes the provision of horizontal bands, vertical reinforcements, corner reinforcements and T-junctions to improve diaphragm effectiveness. Climatic conditions and social and cultural aspects have also been factored into the design of the house. The design concept and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.
**CONSTRUCTION MATERIAL AND MANPOWER**

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>MAN POWER</th>
<th>MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Skilled Md</td>
<td>Unskilled Md</td>
</tr>
<tr>
<td>Up to Plinth Level</td>
<td>38</td>
<td>57</td>
</tr>
<tr>
<td>Ground Floor</td>
<td>66</td>
<td>46</td>
</tr>
<tr>
<td>ROOFING</td>
<td>35</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>139</td>
<td>115</td>
</tr>
</tbody>
</table>
Model BMM-1.1: BRICK MASONRY IN MUD MORTAR

GROUNDFLOOR PLAN

AREA: 40.55 SQ.M.

BEDIROOM
3000 X 2600

LIVING ROOM
3000 X 2600

KITCHEN
3000X2100

VERANDA
3000X2100

Nepal Housing
Reconstruction Programme

DRAWMING TITLE: PLAN

TYPE OF HOUSE: MODEL BMM-1.1

DESIGNED BY: DUDBC

DATE: BMM1.1

SCALE: 1:50

154
Model BMM-1.1: BRICK MASONRY IN MUD MORTAR

DATE: SCALE: TYPE OF HOUSE:

MODEL BMM-1.1: 1:100

DRAWING TITLE: DESIGNER: DUBDC

ONE-STOREY

Nepal Housing Reconstruction Programme

Model BMM-1.1:

- FRONT ELEVATION
- BACK ELEVATION
- RIGHT SIDE ELEVATION
- LEFT SIDE ELEVATION
Model BMM-1.1: BRICK MASONRY IN MUD MORTAR

SECTION AT A-A

Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMM-1.1
DRAWING TITLE: SECTION

SCALE: 1:50
DATE: BMM-1.1
DESIGNED BY: DUDBC

Nepal
Reconstruction
Programme

DATE: SCALE: TYPE OF HOUSE:
DRAWING TITLE: DESIGNED BY:
Nepal Housing
Reconstruction Programme

MODEL BMM-1.1

SECTION

VERANDA

PLINTH LEV.

DETAIL

DETAIL

DETAIL

GR. LEVEL

SECTION AT A-A

Nepal Husiniing
Reconstruction Programme

MODEL BMM-1.1

SECTION

SCALE: 1:50
DATE: BMM-1.1
DESIGNED BY: DUDBC

DATE: SCALE: TYPE OF HOUSE:
DRAWING TITLE: DESIGNED BY:
Nepal Housing
Reconstruction Programme

MODEL BMM-1.1

SECTION

SCALE: 1:50
DATE: BMM-1.1
DESIGNED BY: DUDBC
BRICK MASONRY IN MUD MORTAR (BMM)

Technical Details
Well built STONE houses can better withstand earthquakes. Here are 10 TIPS ON HOW TO BUILD BACK SAFER

1. GET TECHNICAL ADVICE BEFORE YOU START
2. BAND YOUR WALLS TOGETHER
3. TIE YOUR HOUSE TOGETHER WITH TIESTONES
4. BUILD YOUR HOUSE WITH GOOD MATERIALS
5. TIE YOUR GABLES UP
6. TIE YOUR ROOF DOWN
7. TIE YOUR FLOORS TO YOUR WALLS
8. BUILD A STRONG SHAPE
9. HAVE A SAFE SITE AND A SAFE EXIT
10. BUILD ON STRONG FOUNDATIONS

10 KEY MESSAGES
Technology for Earthquake Resistant Building Construction (One Storey Building, Brick in Mud Mortar)

- Earthquake Resistant Elements in Building
- Building Plan
- Foundation Detail of Strip Footing Masonry Foundation and DPC (Where cement and concrete not available)

- Detail of Rafter Joint at Ridge
- Detail of Rafter Joint with Wall Plate

- Detail Plan

- Wood for Horizontal and Vertical Band at Corner and T-Junction
- Bamboo for Horizontal and Vertical Band

- Door Section
- Window Section
- Detail Plan

- Flexible design

- Dove Tail Joint for Wood Connection

- 75x12.5mm Wooden Lintel Band
- 75x100mm Wooden Window Frame
  100x12.5mm Sill Bars
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.
## Minimum Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203)

### Site Selection
- A house shall not be constructed if site is:
  - Prone to geological fault or raptured area
  - Susceptible to landslide
  - Steep slope > 20%
  - Filled area
  - River bank and water-logged area

### Shape of House
- No. of story ▶
- Proportion ▶
- The house shall be planned square, rectangular. Avoid long and narrow house. The house should not be more than 3 times its width.

### Foundation
- Depth ▶
- The depth of footing shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.
- Width ▶
- The width of footing should not be less than 650mm and 750mm respectively for one and two-storey houses in medium soil condition. Width depends on soil type. Refer to technical drawings.

### Plinth
- General ▶
- The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm.

### Walls
- Length of wall ▶
- Maximum length of unsupported wall shall not exceed 12 times its thickness. If unsupported length of wall is more than this, buttress shall be provided at an interval not exceeding 12 times wall thickness.
- Wall thickness ▶
- Mortar joints should not be more than 20mm and less than 10mm in thickness.
- Height of wall ▶
- The height of wall between floors should not be more than 12 times wall thickness.

### Openings
- Location ▶
- Openings are to be located away from inside corners by 1/4 of the height of the adjoining opening, but not less than 600 mm.
- Total length ▶
- Total length of opening should be less than 0.3 and 0.25 of individual wall length respectively for one and two-storey house.
- Distance between openings ▶
- Distance between two openings shall be larger of half the height of shorter opening or 600mm.
-Lintel level ▶
- Keep lintel level same for doors and windows

### Vertical Reinforcement
- Location ▶
- Place vertical steel bars in the wall at all corners, wall junctions and adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them.

### Plinth Band
- General ▶
- A continuous plinth band shall be provided through all walls at the plinth level. The minimum height is 75mm with 2-12 reinforcing bars for hard soil. In case of soft soil, band should be 150mm high with 4-12 reinforcement. Use 6mm dia. stirrups at 150mm centers.

### Horizontal Band
- Sill band ▶
- A continuous sill band shall be provided through all walls at the bottom level of opening [specially windows]. The minimum height is 75mm with 2-10 reinforcing bars. Use 6mm diameter stirrups at 150mm centres.
- Lintel band ▶
- A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 75mm with 2-12mm bars. Use 6mm stirrups at 150mm centres. Extra thickening should be provided where openings are more than 1m wide.
- Roof band ▶
- Roof band shall be provided at the top of walls, so as to tie the walls at their top and fix the roof to the walls. The minimum height is 75mm with 2-12mm diameter bars. Use 6mm dia. Stirrups at 150mm centres.
- Gable band ▶
- Masonry gable wall must have the triangular portion of masonry enclosed in a reinforced concrete band. The minimum height of band is 75mm with 2-12mm bars. Use 6mm dia. Stirrups at 150mm centres. It is recommended to replace gable masonry wall with light-weight materials such as metal sheet or timber.
- Stitch ▶
- The stitches shall be provided at all corners, junctions of walls to strengthen connections. The min. height is 75mm with 2-8mm bars. Use 6mm dia. Stirrups at 150mm centres.
<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| 9   | Roof     | - Light roof: Use light roof comprising of wooden or steel structure covered with light roofing materials. Heavy roofing materials such as stone slabs or mud should be avoided.  
- Connection: All members of the timber truss or joints should be properly connected as shown in technical details.  
- Cross-tie: Trusses should be properly cross-tied with wooden braces as shown in technical details. |
| 10  | Materials | - Timber: Well seasoned hard wood / local wood without knots should be used for structural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.  
- Mortar: Mud should be free from organic material and pebbles, etc.  
- Brick: Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm.  
- Concrete: The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate)  
- Reinforcement: High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements. |
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