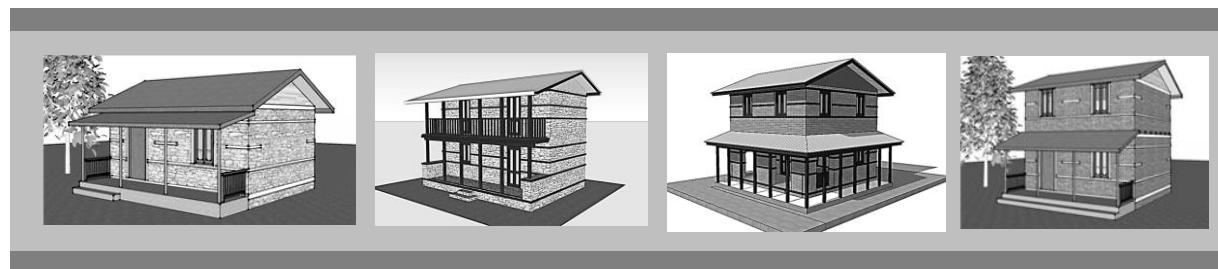


DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Volume I



October, 2015 (Aswin, 2072)



**Nepal Housing
Reconstruction Programme**

**Government of Nepal
Ministry of Urban Development
Department of Urban Development and Building Construction
Babarmahal, Kathmandu**

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Department of Urban Development and Building Construction

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Volume I

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Babarmahal, Kathmandu



Foreword



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.

Ramesh Prasad Singh
Director General, DUDBC

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

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| 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

housing model **Volume I**

| Structural Type | No. of Floor | Model No. | Designed by | Page |
|---|--------------|-------------------|-------------|------|
| Stone masonry in cement mortar, P5- SMC | 1 | SMC-1.1 | JICA | 9 |
| | 1 | SMC-1.2 | JICA | 15 |
| | 2 | SMC-2.1 | JICA | 21 |
| | 2 | SMC-2.2 | DUDBC | 27 |
| | 2 | SMC-2.3 | DUDBC | 33 |
| | 2 | SMC-2.4 | DUDBC | 39 |
| | 2+ATTIC | SMC-2.5 | DUDBC | 45 |
| | 2+TERRACE | SMC-2.6 | DUDBC | 51 |
| | | Technical details | | 57 |
| | | Flexible design | | 67 |
| Brick masonry in cement mortar P71- BMC | 1 | BMC-1.1 | JICA | 74 |
| | 1 | BMC-1.2 | JICA | 80 |
| | 2 | BMC-2.1 | JICA | 86 |
| | 2 | BMC-2.2 | DUDBC | 92 |
| | 2 | BMC-2.3 | DUDBC | 98 |
| | 2+ATTIC | BMC-2.4 | DUDBC | 104 |
| | 2+TERRACE | BMC-2.5 | DUDBC | 110 |
| | | Technical details | | 116 |
| | | Flexible design | | 125 |
| Stone masonry in mud mortar, P129- SMM | 1 | SMM-1.1 | DUDBC | 135 |
| | | Technical details | | 141 |
| | | Flexible design | | 143 |
| Brick masonry in mud mortar, P147- BMM | 1 | BMM-1.1 | DUDBC | 153 |
| | | Technical details | | 159 |
| | | Flexible design | | 161 |

Site Plan



STONE MASONRY IN CEMENT MORTAR (SMC)

SMC

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.

Minimum Requirements(MRs)

| Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) | | | Page1 |
|--|----------------|---|---|
| No. | Category | | |
| 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 | 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. |
| | | General | The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area. |
| 3 | Foundation | 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. |
| | | 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. |
| 4 | Plinth | Height | Minimum height of Plinth band is 150mm. |
| | | Width | Minimum thickness of plinth band width should be equal to wall thickness. 350mm for Stone 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. |
| | | 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. |
| 5 | Walls | Joints | Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand). |
| | | 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. |
| | | Width | The minimum width of wall is 350mm for one-storey and two-storey. |
| | | | |

| Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) | | | | Page2 |
|--|------------------------|---|---|--|
| 6 | Openings | Location | ✓ | Openings are to be located away from inside corners by a clear distance should not be less than 600 mm. |
| | | 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. |
| 7 | Vertical Reinforcement | 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. |
| | | Reinforcement | ✓ | The vertical reinforcing bar for masonry is given in detail drawings. 12 mm dia is minimum requirements for masonry houses. |
| 8 | Horizontal Band | 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. |
| | | Stitch | ✓ | 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 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. |
| 9 | Roof | Light roof | ✓ | Use light roof comprising wooden or steel truss covered with CGI sheets. |
| | | 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 $f_y = 415 \text{ N/}$ |

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.

SMC-1.1



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|-----------------|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | cu.m. | Bags | Cu.m. | Cu.m. | Cu.m. | Bundel | Kg |
| Up to Plinth Level | 57 | 212 | 21 | 82 | 13 | 6 | 0 | 0 | 146 |
| SUPERSTRUCTURE | 75 | 129 | 13 | 59 | 8 | 3 | 0.79 | 0 | 314 |
| ROOFING | 17 | 20 | 0 | 0 | 0 | 0 | 1.43 | 4.71 | 0 |
| TOTAL | 149 | 361 | 34 | 141 | 21 | 9 | 2.22 | 4.71 | 460 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-1.1

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

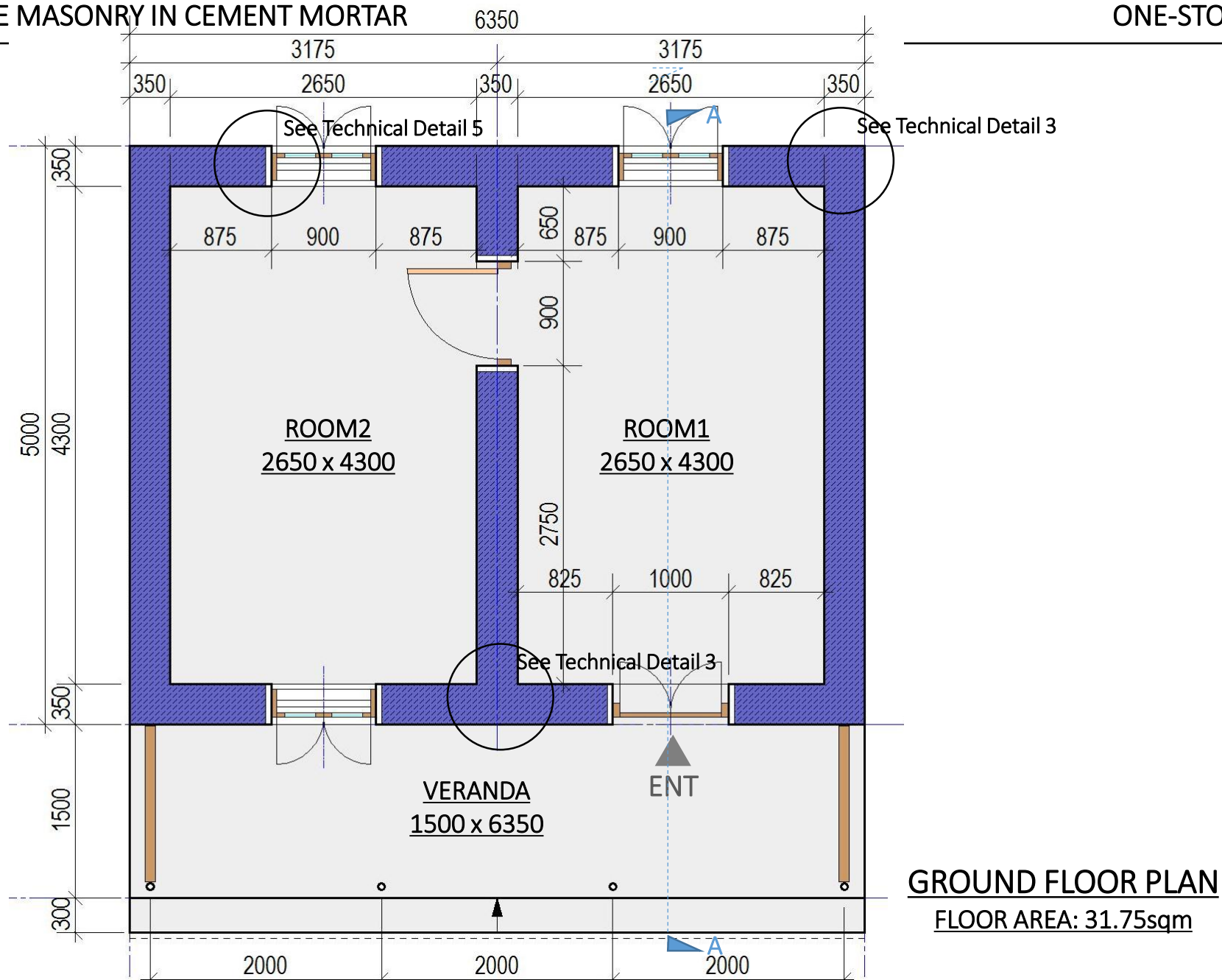
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DATE:

DESIGNED BY: JICA

SMC-1.1

1/4



Nepal Housing
Reconstruction Programme

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

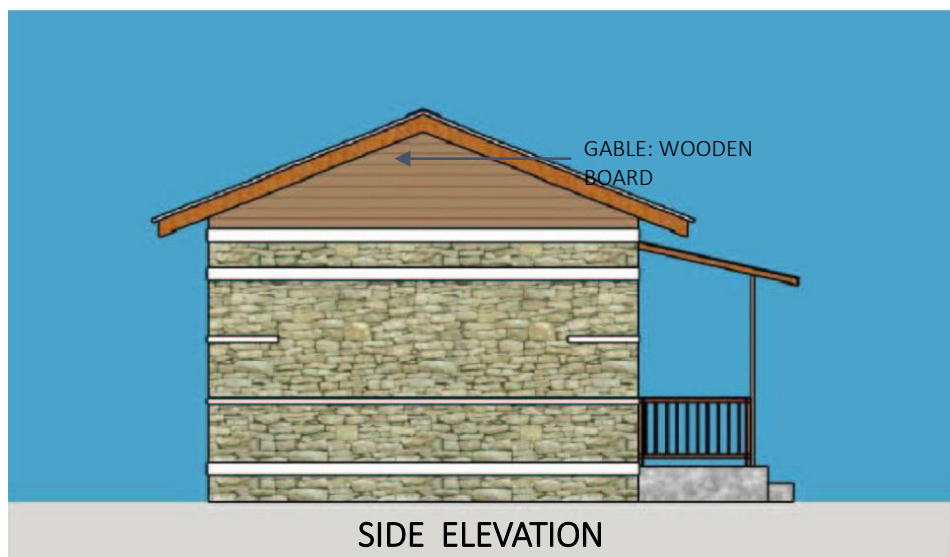
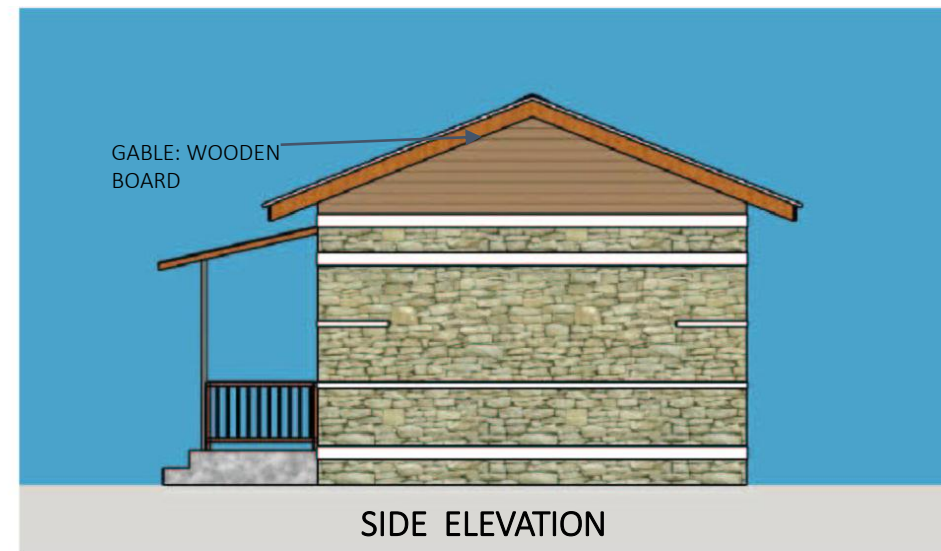
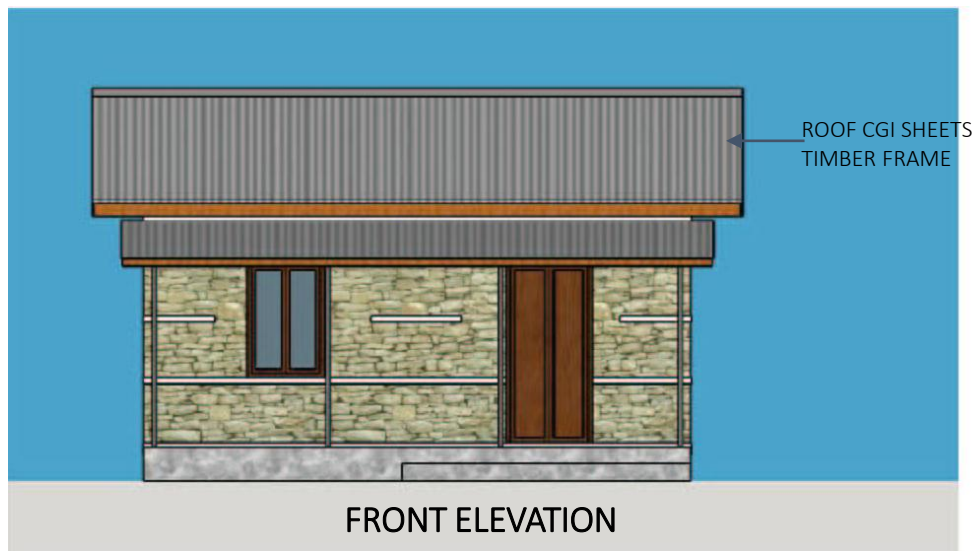
SCALE: 1:50

DATE:

DESIGNED BY: JICA

SMC-1.1

2/4





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.

SMC-1.2



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|-----------------|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | cu.m. | Bags | Cu.m. | Cu.m. | Cu.m. | Bundel | Kg |
| Up to Plinth Level | 40 | 144 | 15 | 47 | 9 | 3 | 0 | 0 | 87 |
| SUPERSTRUCTURE | 49 | 97 | 10 | 45 | 6 | 2 | 0.46 | 0 | 165 |
| ROOFING | 8 | 11 | 0 | 0 | 0 | 0 | 1.48 | 3.69 | 0 |
| TOTAL | 97 | 252 | 25 | 92 | 14 | 6 | 1.94 | 3.69 | 252 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC-1.2

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

None

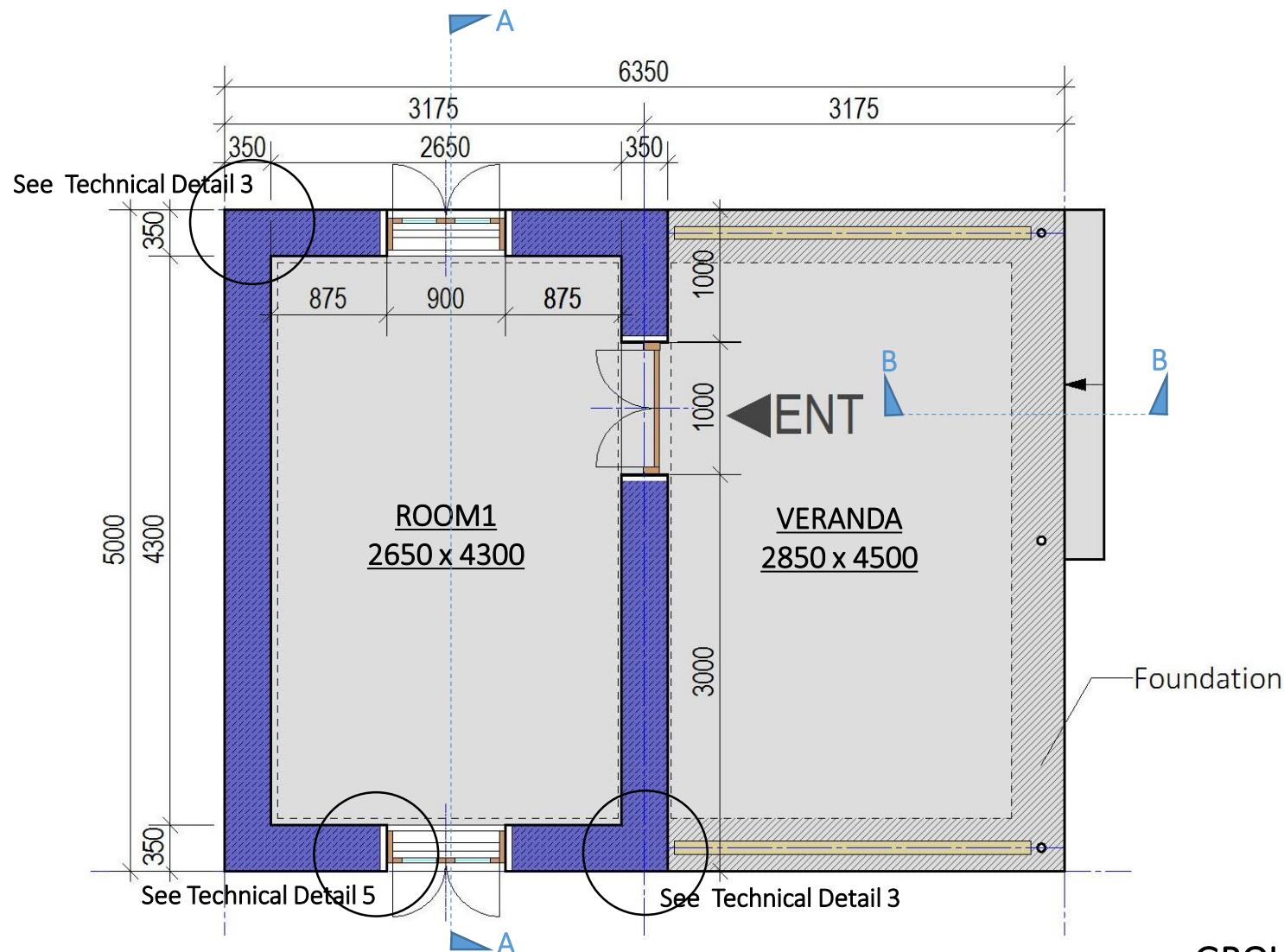
DATE:

DESIGNED BY:

JICA

SMC-1.2

1/4

**GROUND FLOOR PLAN**

FLOOR AREA: 15.88sqm



Nepal Housing
Reconstruction Programme

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

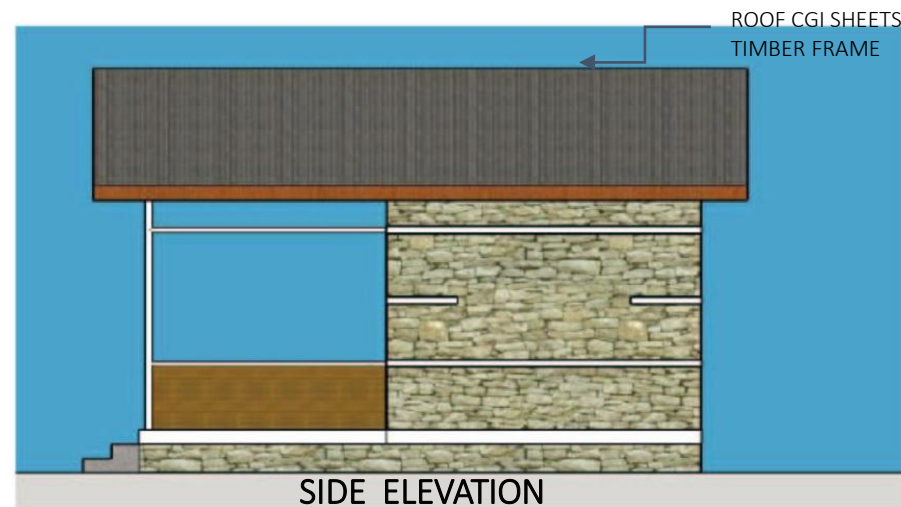
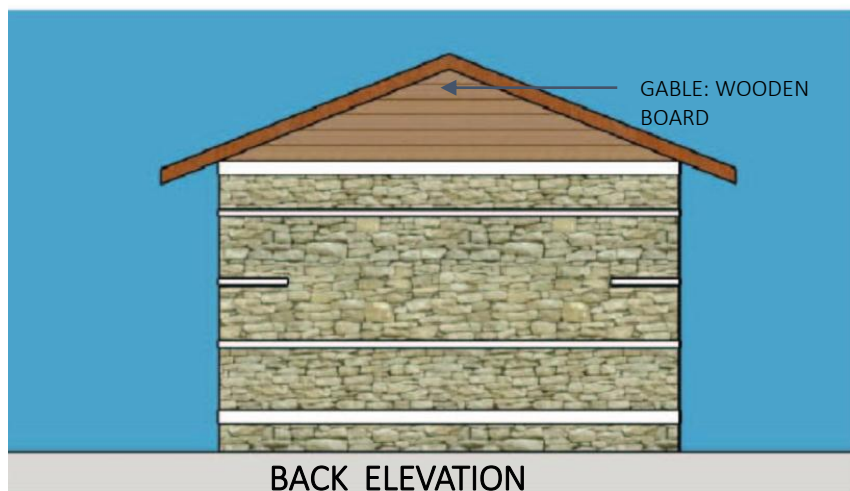
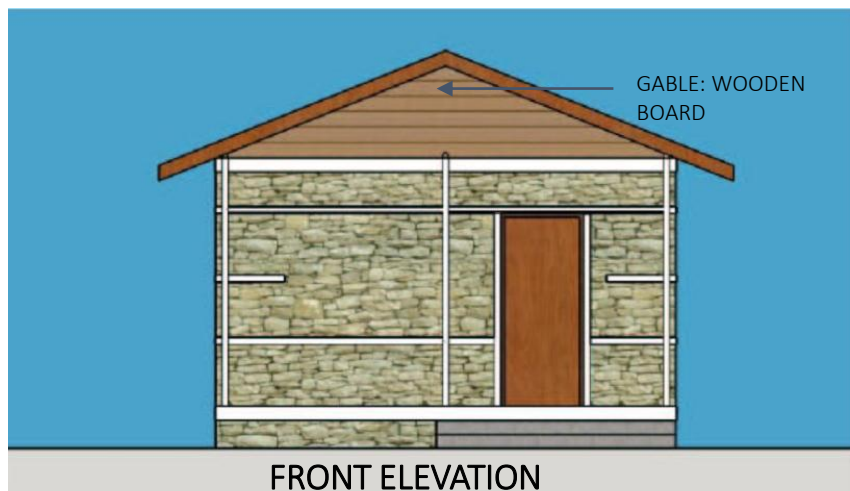
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DATE:

DESIGNED BY: JICA

SMC-1.2

2/4



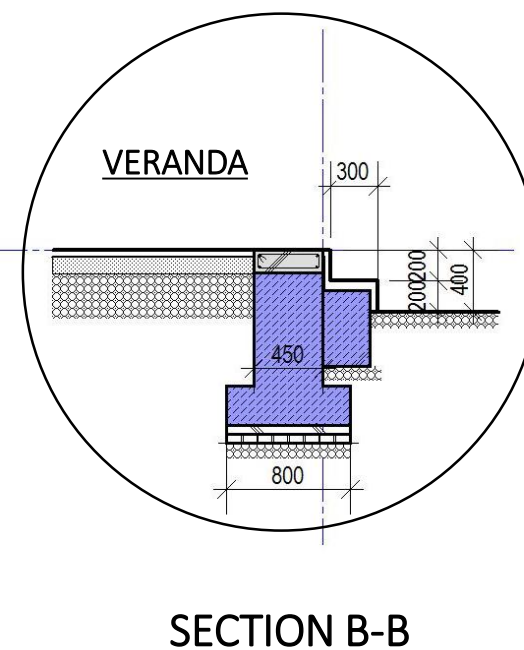
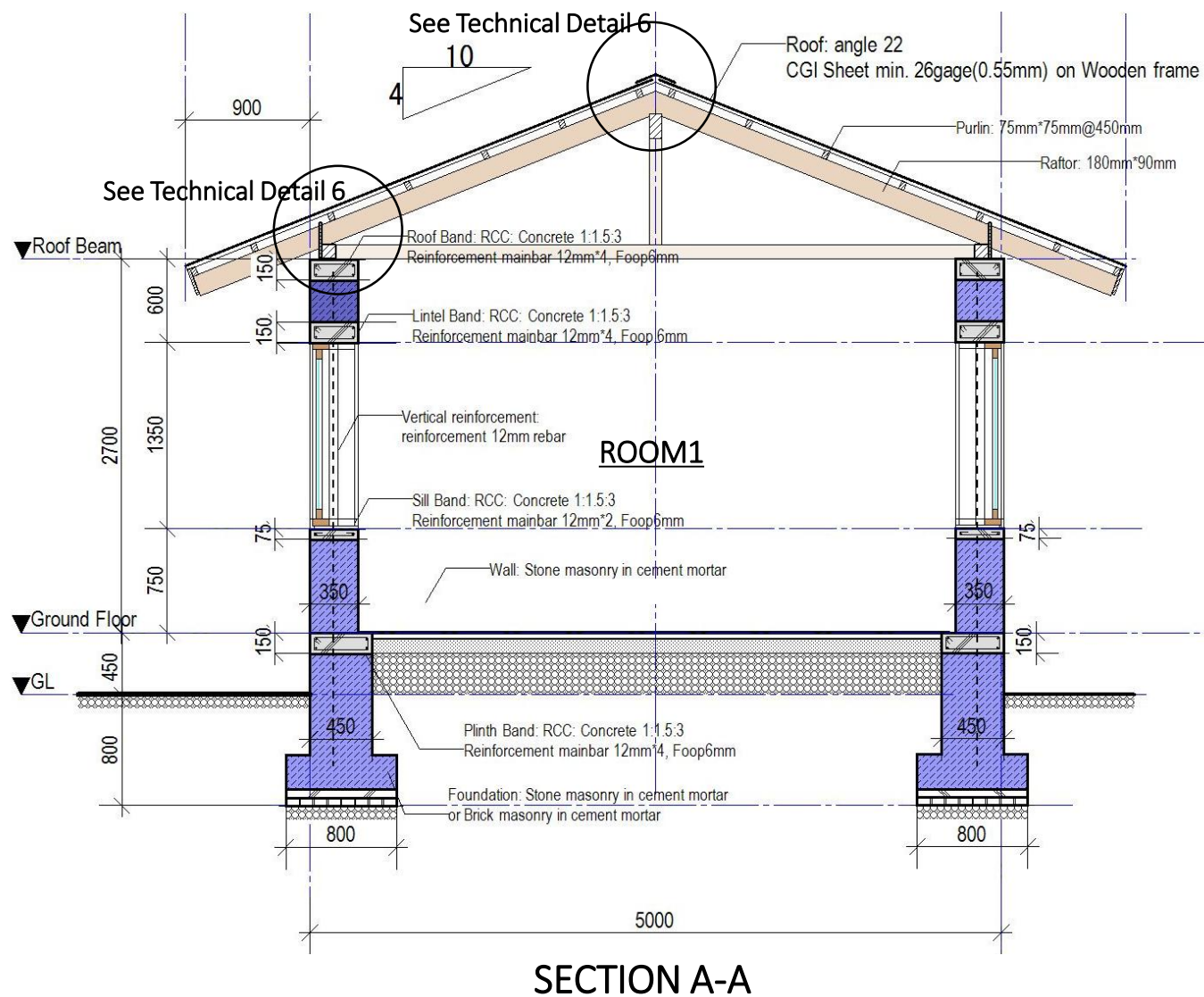
Nepal Housing
Reconstruction Programme

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

SCALE: None
DESIGNED BY: JICA

DATE:

SMC-1.2
3/4



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: JICA

SMC-1.2

4/4

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.

SMC-2.1



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|-----------------|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | cu.m. | Bags | Cu.m. | Cu.m. | Cu.m. | Bundel | Kg |
| Up to Plinth Level | 86 | 317 | 17 | 76 | 12 | 6 | 0 | 0 | 146 |
| SUPERSTRUCTURE | 175 | 290 | 31 | 111 | 17 | 4 | 2.95 | 1.02 | 631 |
| ROOFING | 17 | 20 | 0 | 0 | 0 | 0 | 1.48 | 3.69 | 0 |
| TOTAL | 279 | 626 | 48 | 187 | 29 | 10 | 4.43 | 4.71 | 776 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC-2.1

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

None

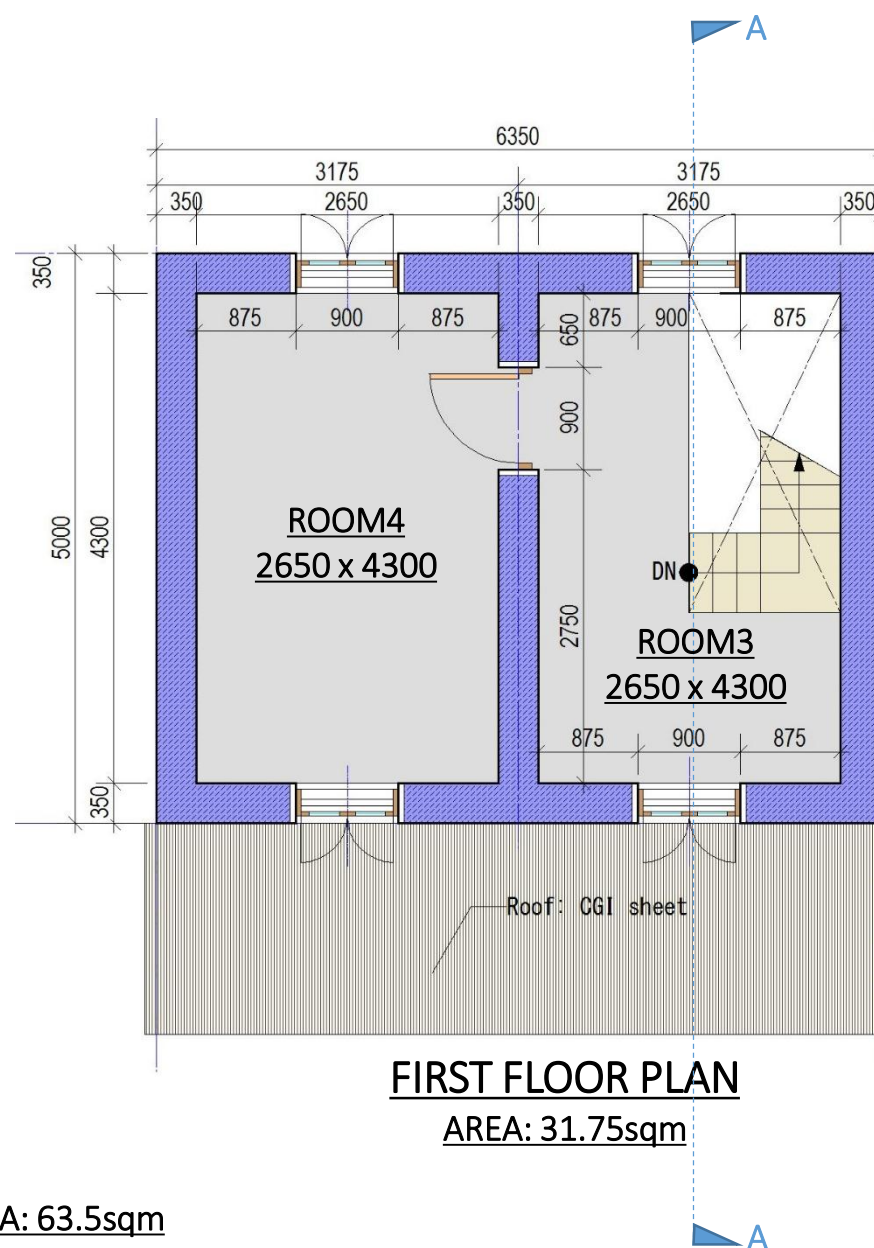
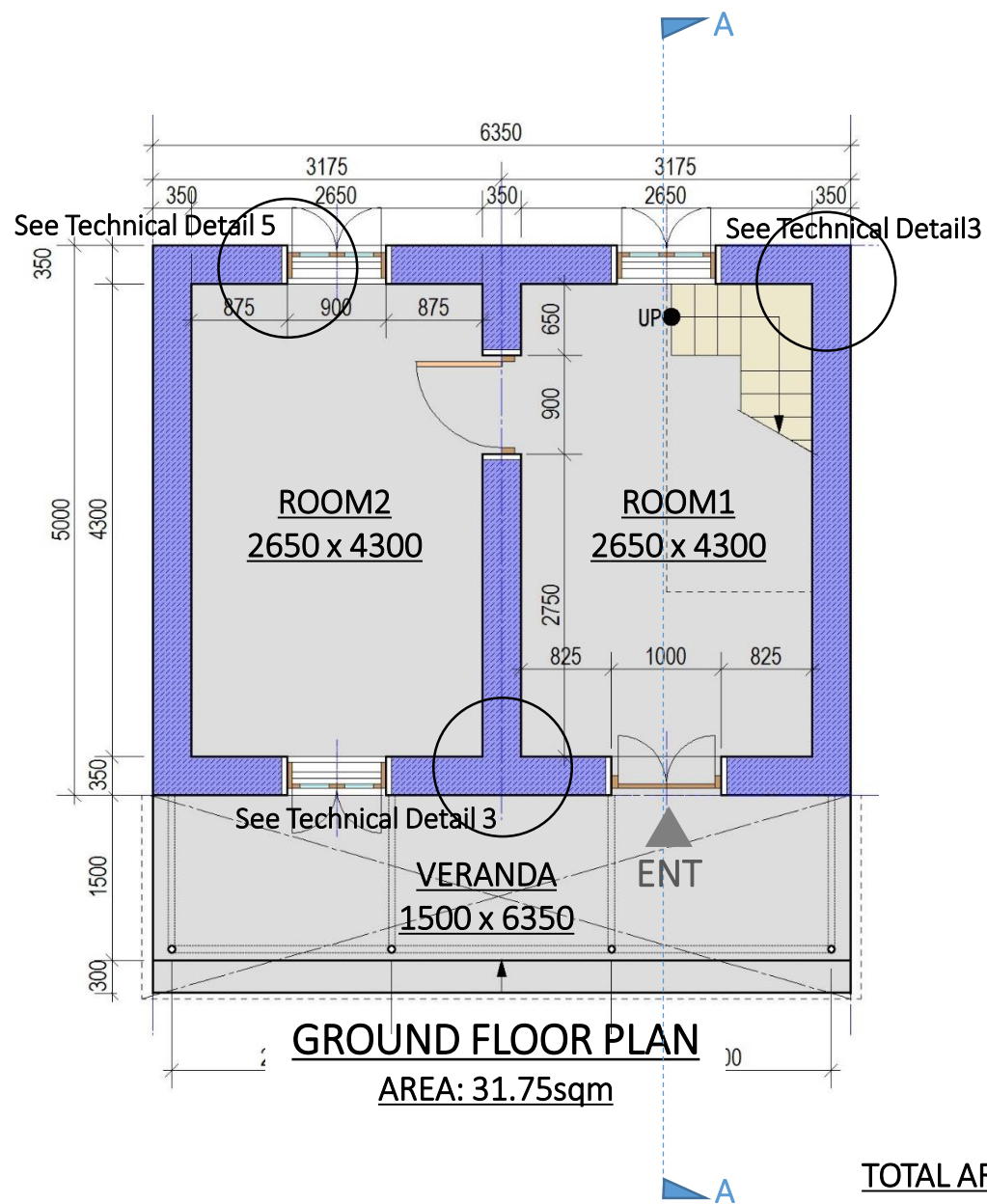
DATE:

DESIGNED BY:

JICA

SMC-2.1

1/4



TOTAL AREA: 63.5sqm



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.1
DRAWING TITLE: PLAN

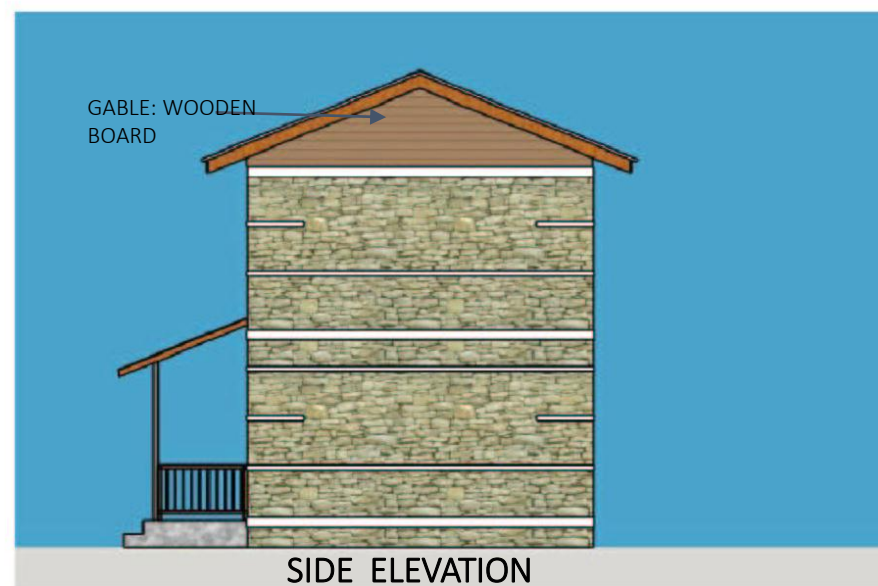
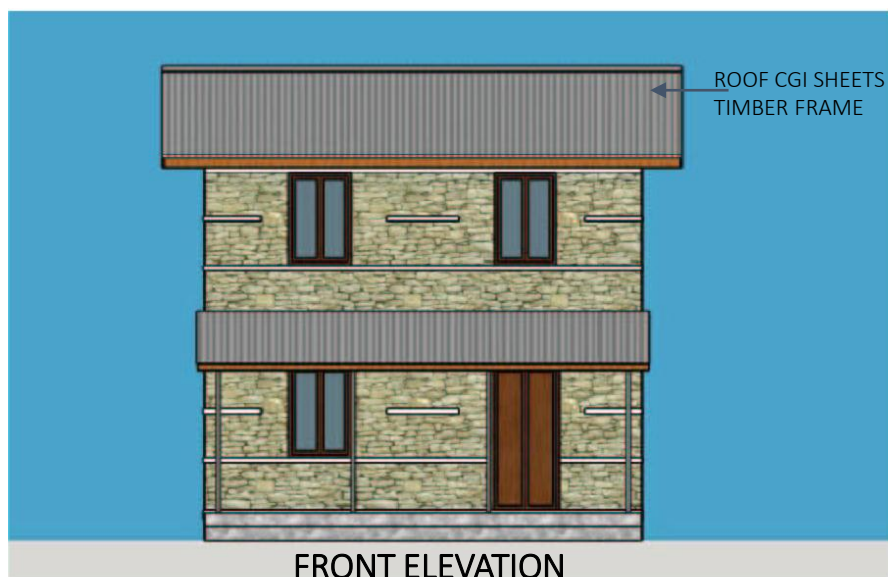
SCALE: None

DATE:

DESIGNED BY: JICA

SMC-2.1

2/4





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.

SMC-2.2



CONSTRUCTION MATERIAL AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|----------------------|----------------|------------------|--------------|---------------|-------------|------------------|------------|-----------|-------------|----------|
| | <u>Skilled</u> | <u>Unskilled</u> | <u>Stone</u> | <u>CEMENT</u> | <u>SAND</u> | <u>AGGREGATE</u> | <u>Rod</u> | CGI SHEET | <u>WOOD</u> | GI SHEET |
| | Md | Md | Cu.m | Bags | Cu.m | Cu.m | kg | Bundel | Cu.m | Rm. |
| Up to Plinth Level | 54 | 198 | 31 | 82 | 19 | 5 | 265 | 0 | 0 | 0 |
| Ground & First floor | 207 | 246 | 41 | 119 | 20 | 5 | 876 | 0 | 3.62 | 0 |
| Roofing work | 43 | 15 | 0 | 0 | 0 | 0 | 0 | 4.69 | 1.96 | 10 |
| TOTAL | 304 | 458 | 72 | 200 | 40 | 10 | 1141 | 4.69 | 5.58 | 10 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.2

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

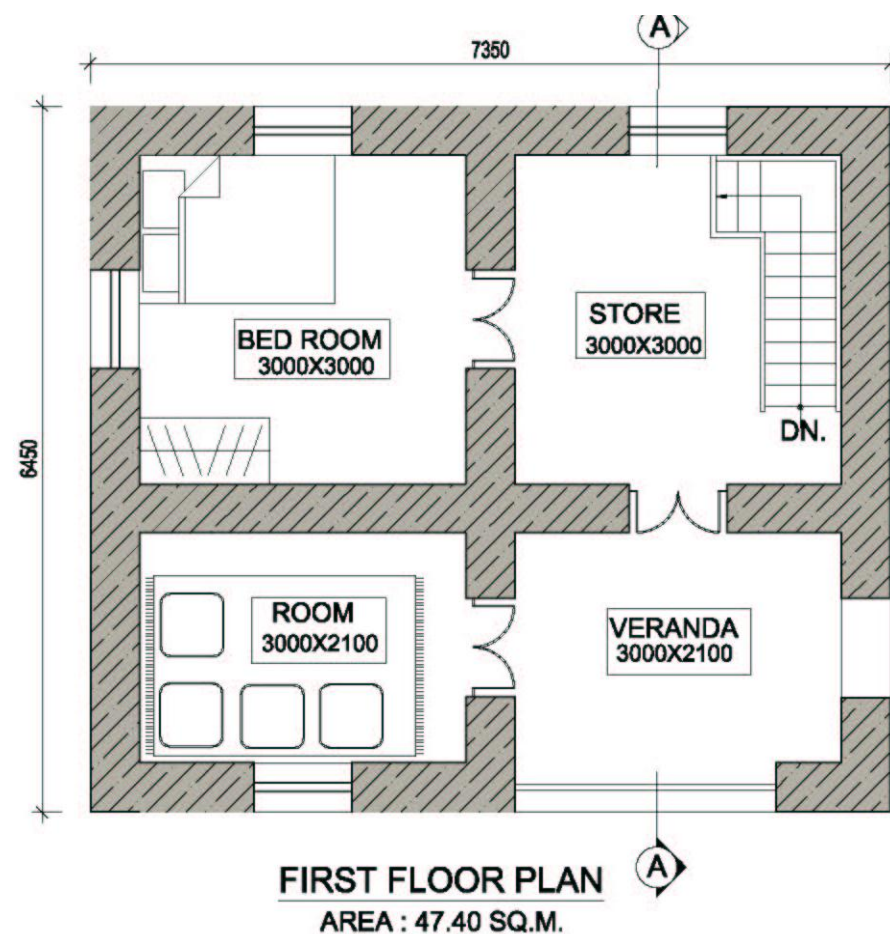
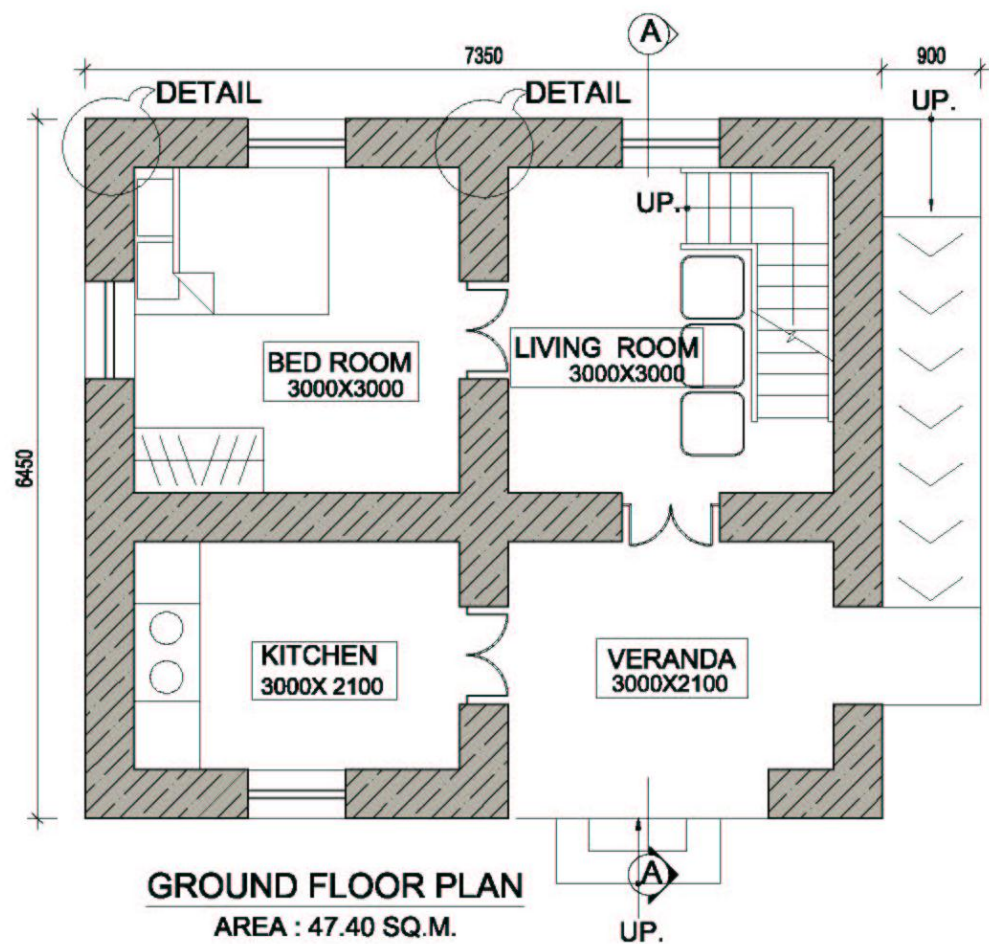
SCALE: NONE

DATE:

DESIGNED BY: DUDBC

SMC-2.2

1/4



TOTAL AREA: 94.8sqm



Nepal Housing
Reconstruction Programme

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

SCALE: None

DATE:

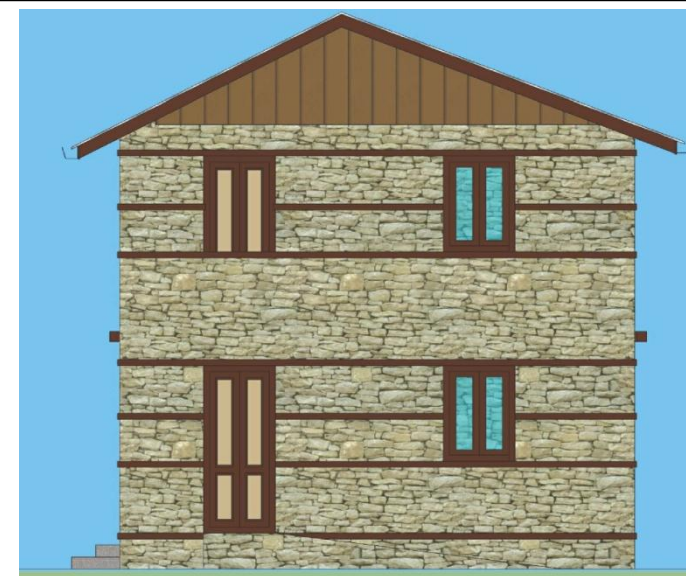
DESIGNED BY: DUDBC

SMC-2.2

2/4



FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.2
DRAWING TITLE: ELEVATION

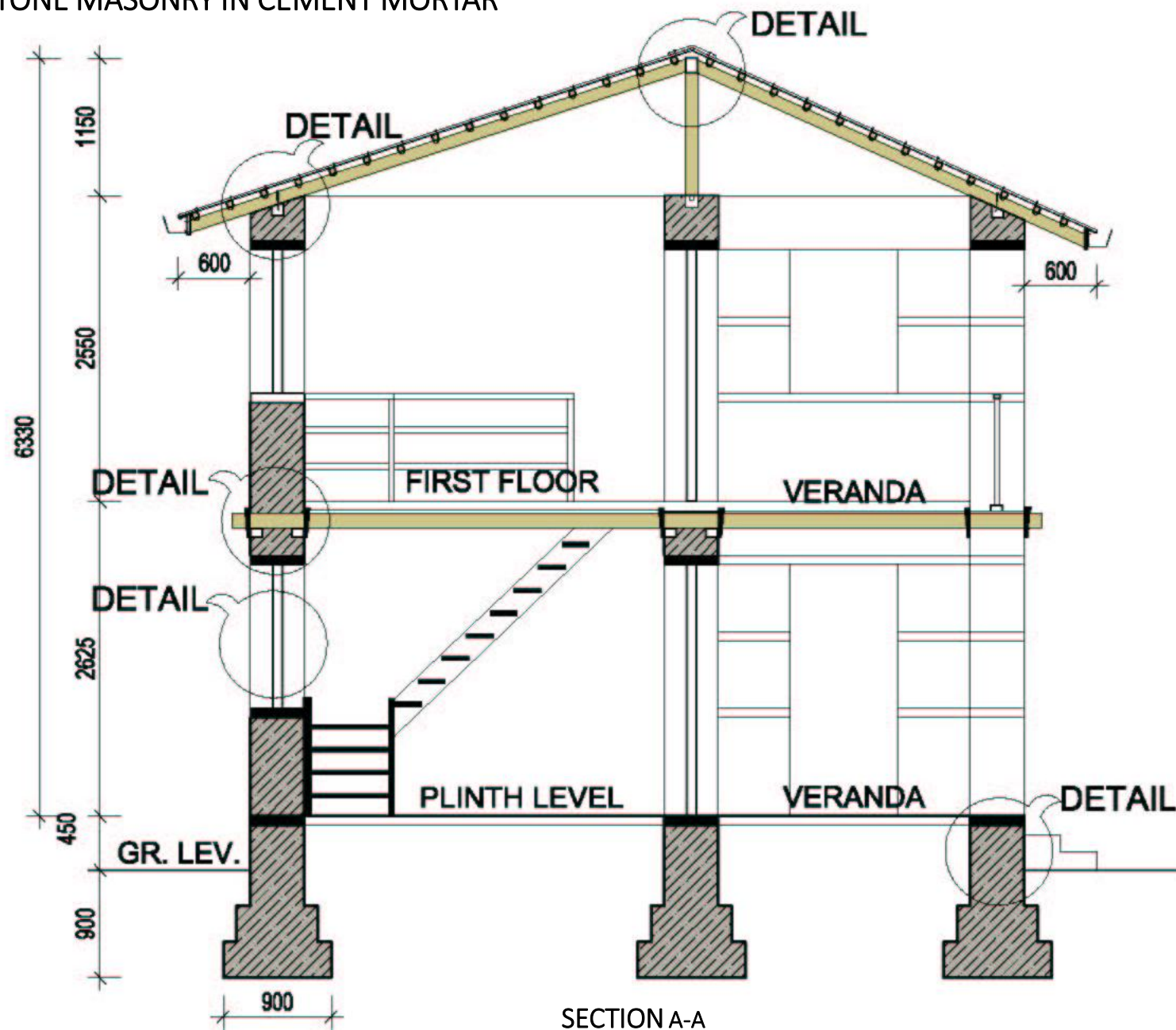
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.2

3/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.2
DRAWING TITLE: SECTION

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

SMC-2.2

4/4

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.

SMC-2.3



CONSTRUCTION MATERIAL AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|----------------------|-----------|-----------|-----------|--------|------|-----------|------|------|-----------|----------|
| | Skilled | Unskilled | STONE | CEMENT | SAND | AGGREGATE | WOOD | ROD | CGI SHEET | GI SHEET |
| | Md | Md | Cu.m | Bags | Cu.m | Cu.m | Cu.m | KG | Bundel | Rm. |
| Up to Plinth Level | 61 | 220 | 33 | 95 | 17 | 9 | 0 | 305 | 0 | 0 |
| Ground & First floor | 162 | 357 | 53 | 216 | 32 | 17 | 1.02 | 1487 | 0 | 0 |
| Roofing work | 41 | 15 | 0 | 0 | 0 | 0 | 1.91 | 0 | 4.50 | 11 |
| TOTAL | 263 | 592 | 86 | 311 | 48 | 26 | 2.94 | 1792 | 4.50 | 11 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.3

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

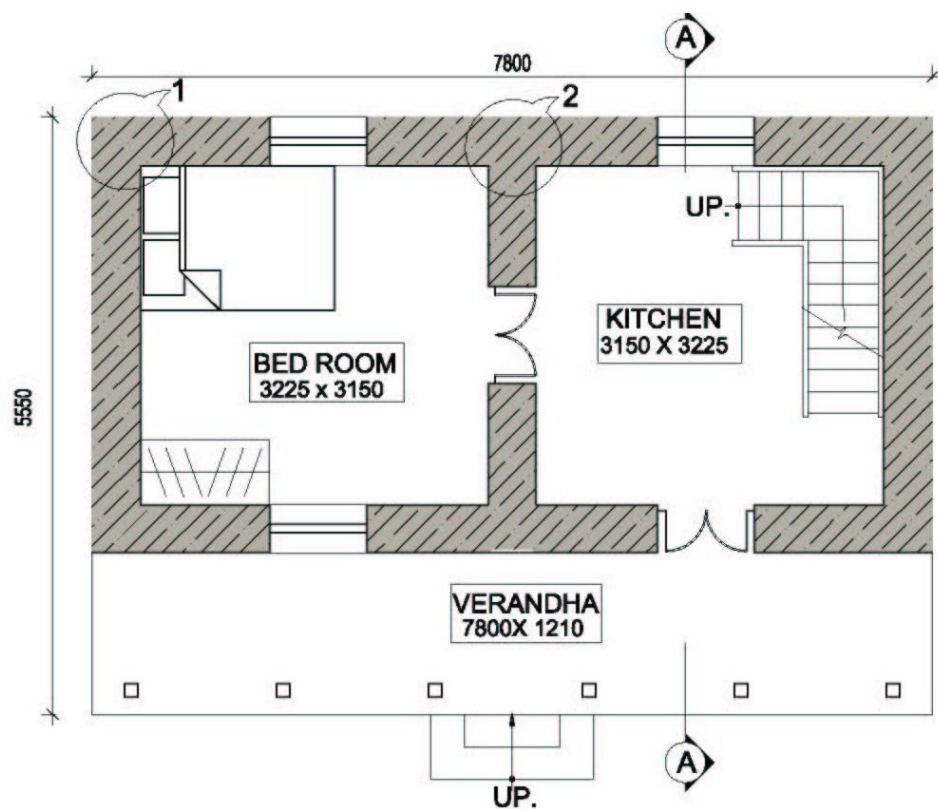
SCALE: NONE

DATE:

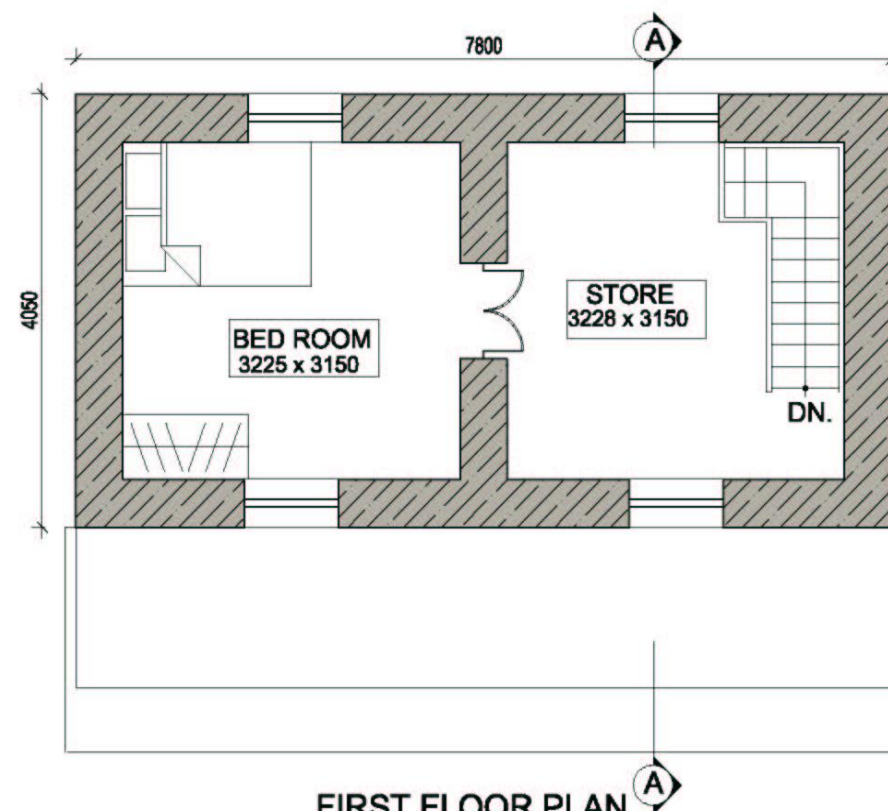
DESIGNED BY: DUDBC

SMC-2.3

1/4



GROUND FLOOR PLAN
AREA : 43.30 SQ.M.



FIRST FLOOR PLAN
AREA : 32.60 SQ.M.

TOTAL AREA: 75.9sqm



Nepal Housing
Reconstruction Programme

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

SCALE: None

DATE:

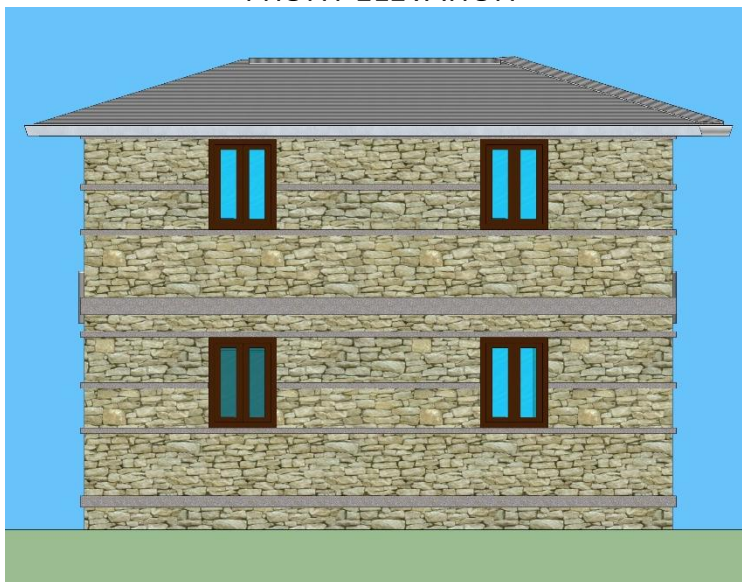
DESIGNED BY: DUDBC

SMC-2.3

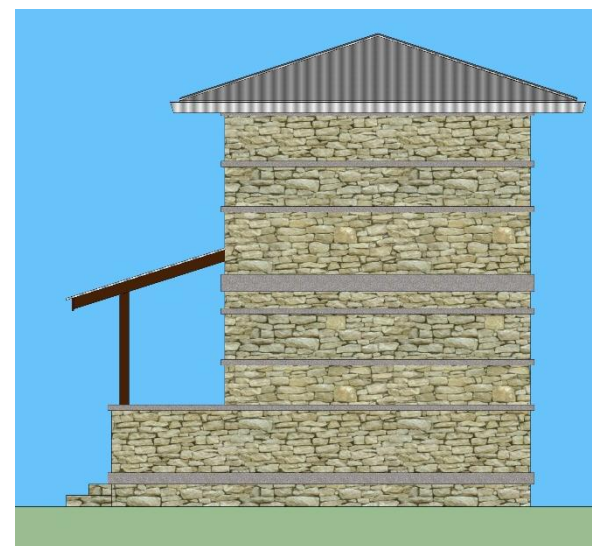
2/4



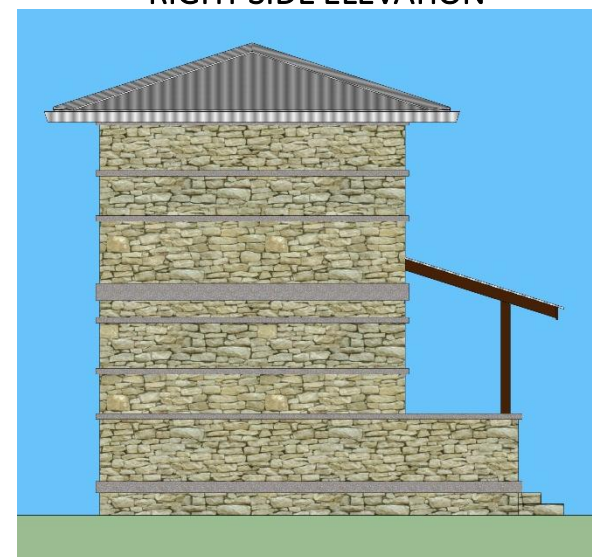
FRONT ELEVATION



BACK ELEVATION



RIGHT SIDE ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

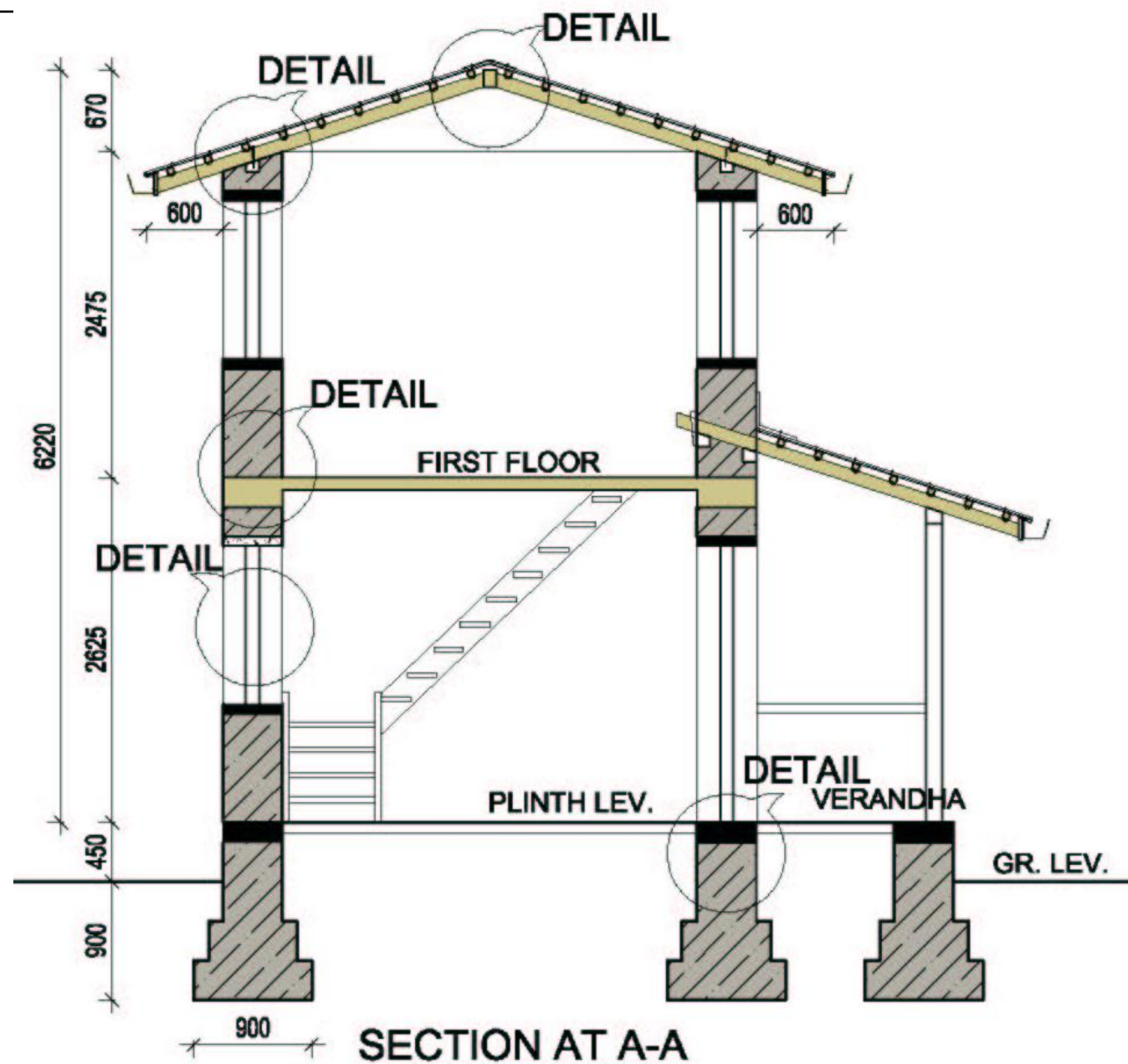
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.3

3/4



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

SMC-2.3

4/4

STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.4

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.

SMC-2.4



CONSTRUCTION MATERIAL AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|--------------------|-----------|-----------|-----------|--------|------|-----------|------|-----------|----------|-------------|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | GI SHEET | Rod (Steel) |
| | Md | Md | Cu.m | Bags | Cu.m | Cu.m | Cu.m | Bundel | Rm. | Kg |
| Up to Plinth Level | 50 | 184 | 1038 | 73 | 15 | 4 | 0 | 0 | 0 | 207 |
| SUPERSTRUCTURE | 190 | 381 | 2745 | 180 | 34 | 4 | 3.16 | 0 | 0 | 496 |
| ROOFING | 46 | 0 | 0 | 0 | 0 | 0 | 2.19 | 4.36 | 11 | 0 |
| TOTAL | 286 | 565 | 3783 | 253 | 49 | 8 | 5.37 | 4.36 | 11 | 703 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.4

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

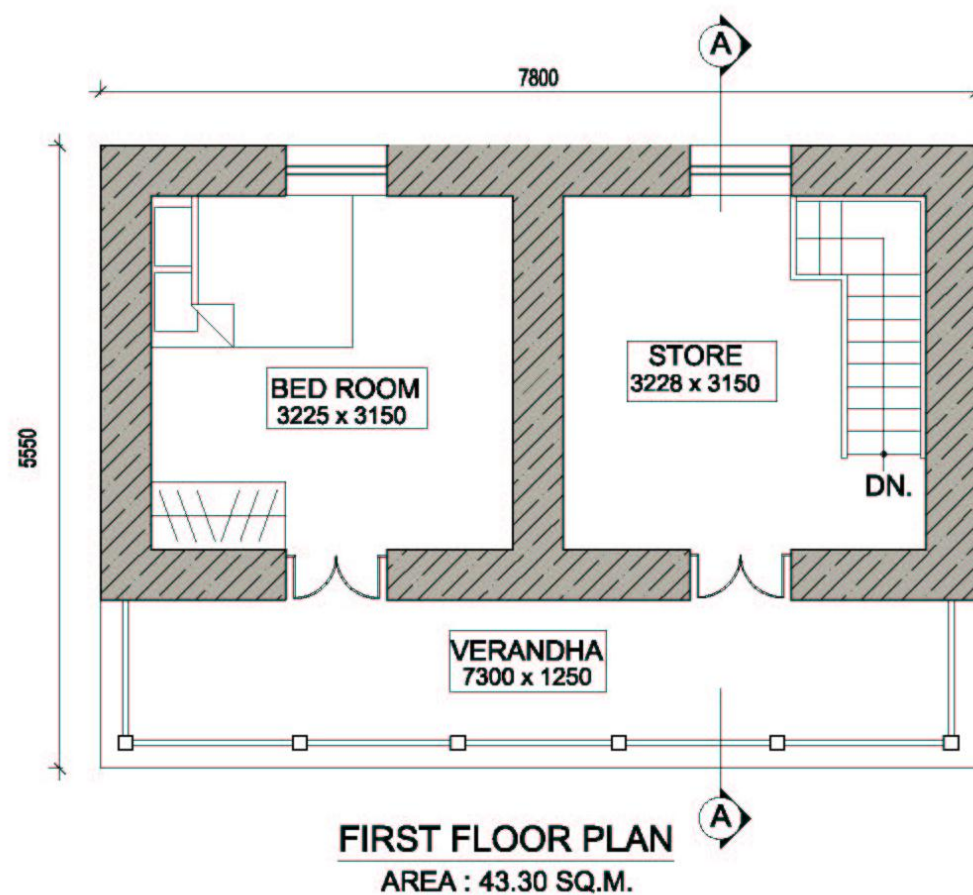
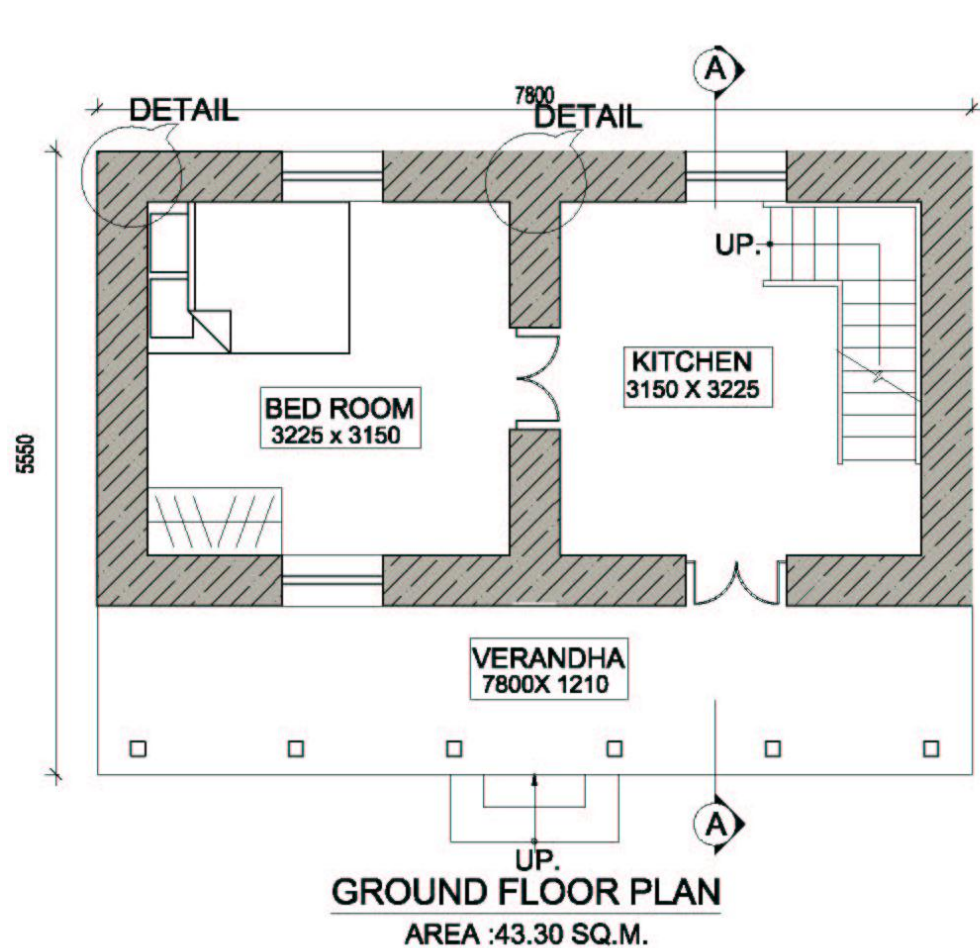
SCALE: NONE

DATE:

DESIGNED BY: DUDBC

SMC-2.4

1/4



TOTAL AREA: 86.6sqm



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.4
DRAWING TITLE: PLAN

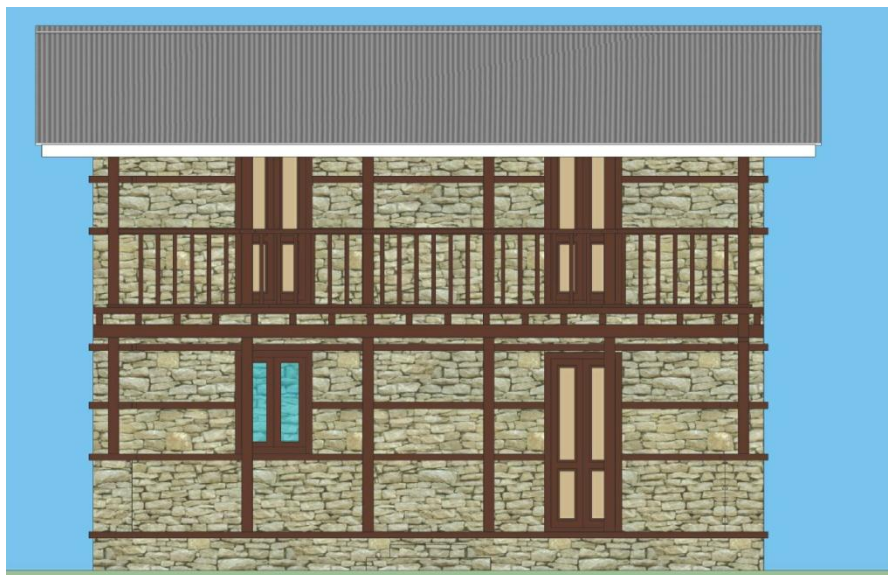
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.4

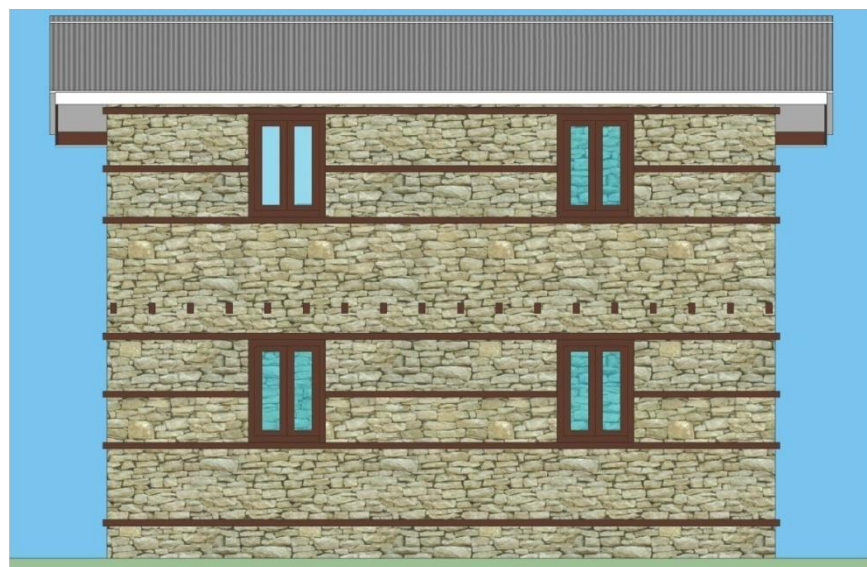
2/4



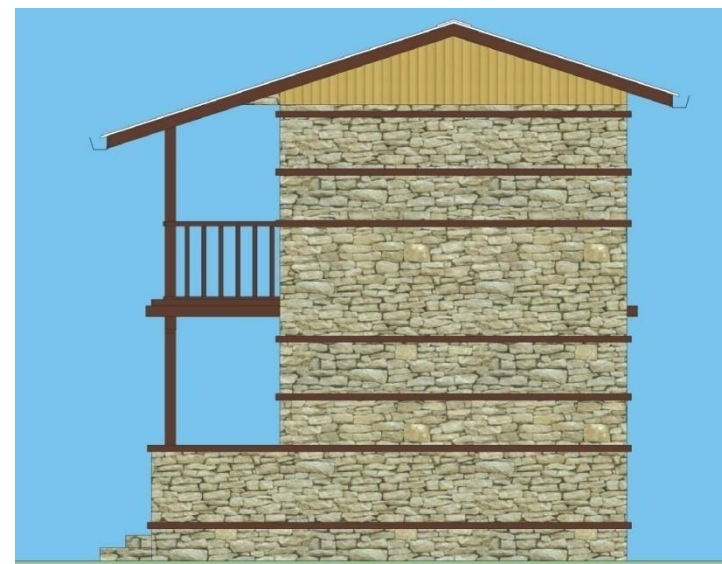
FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.4
DRAWING TITLE: ELEVATION

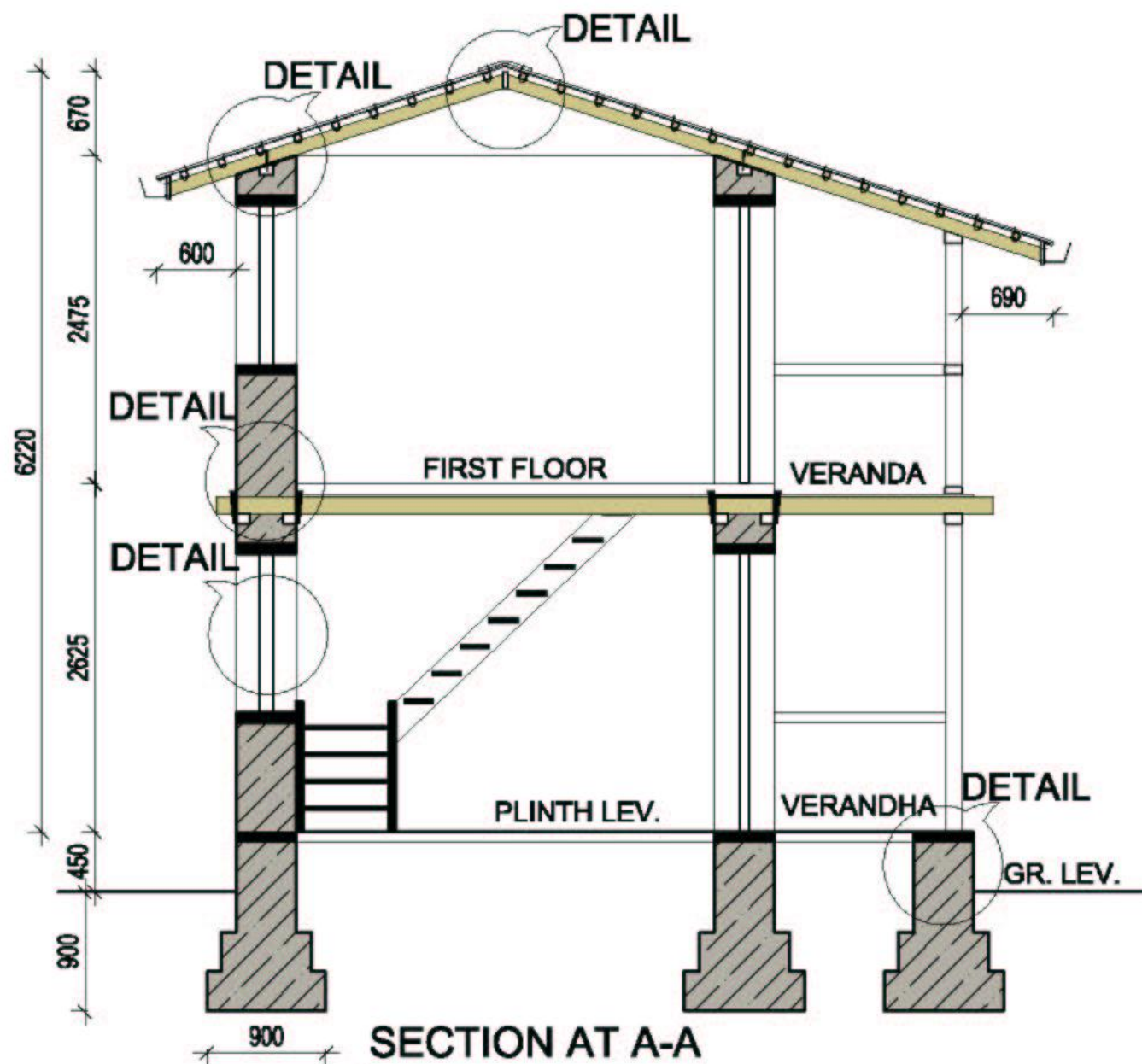
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.4

3/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.4
DRAWING TITLE: SECTION

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

SMC-2.4

4/4

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.

SMC-2.5



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|----------|-----|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | GI SHEET | Rod |
| | Md | Md | Cu.m. | Bags | Cu.m. | Cu.m. | Cu.m. | Bundel | Rm. | Kg |
| Up to Plinth Level | 72 | 261 | 48 | 91 | 18 | 5 | 0.00 | 0.0 | 0 | 282 |
| SUPERSTRUCTURE | 294 | 468 | 90 | 215 | 41 | 6 | 3.97 | 0.0 | 0 | 596 |
| ROOFING | 52 | 17 | 0 | 0 | 0 | 0 | 2.48 | 5.22 | 32 | 0 |
| TOTAL | 418 | 745 | 138 | 306 | 59 | 11 | 6.45 | 5.22 | 32 | 878 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC-2.5

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

NONE

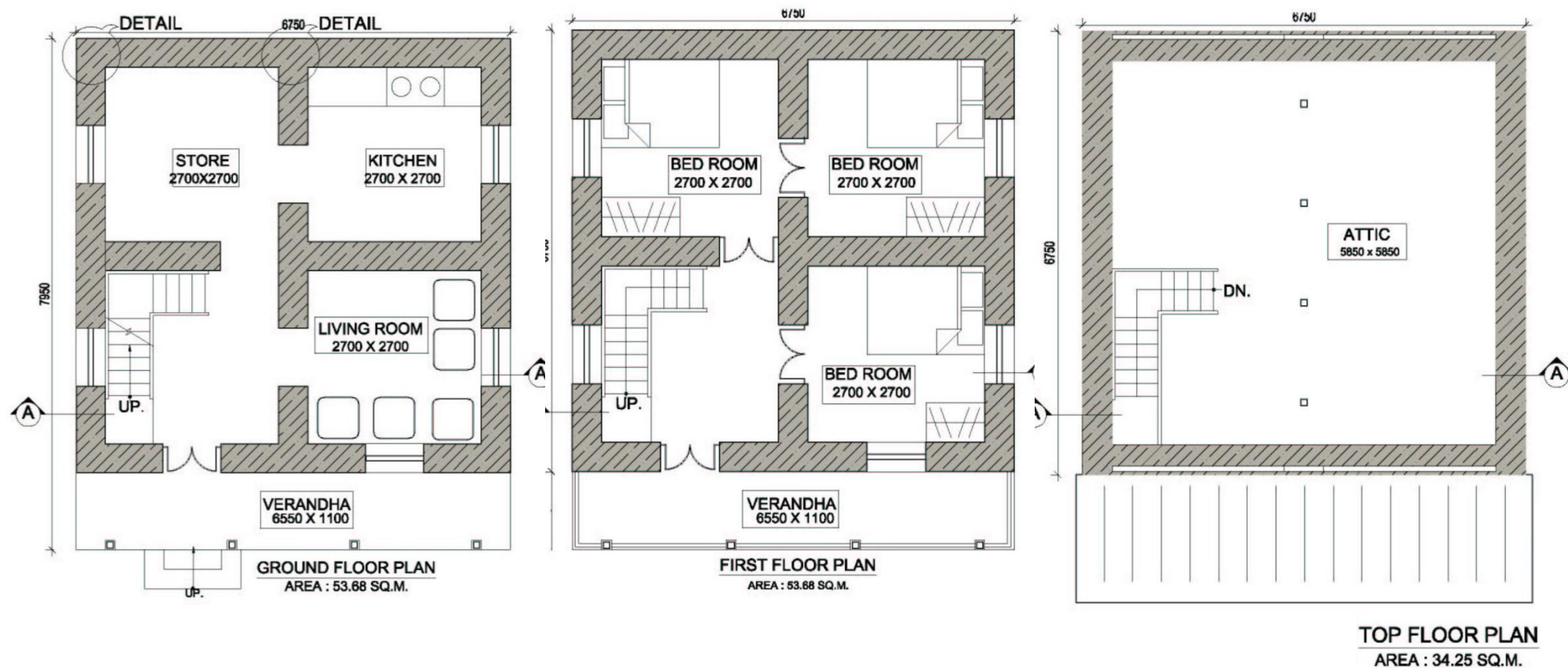
DATE:

DESIGNED BY:

DUDBC

SMC-2.5

1/4



TOTAL AREA: 107.36sqm



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.5
DRAWING TITLE: PLAN

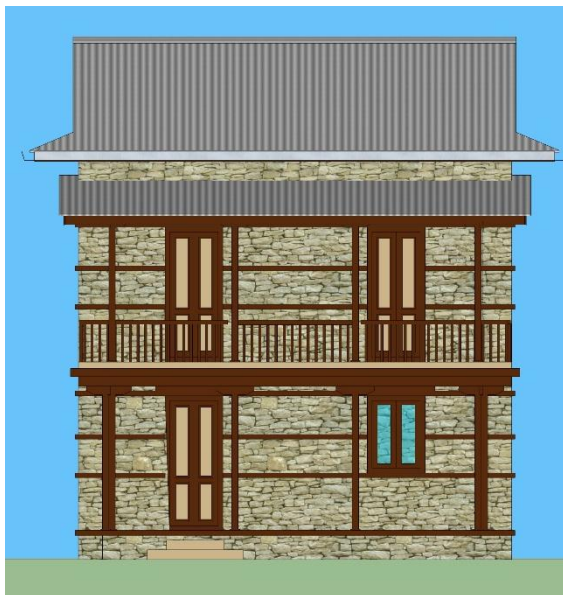
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DATE:

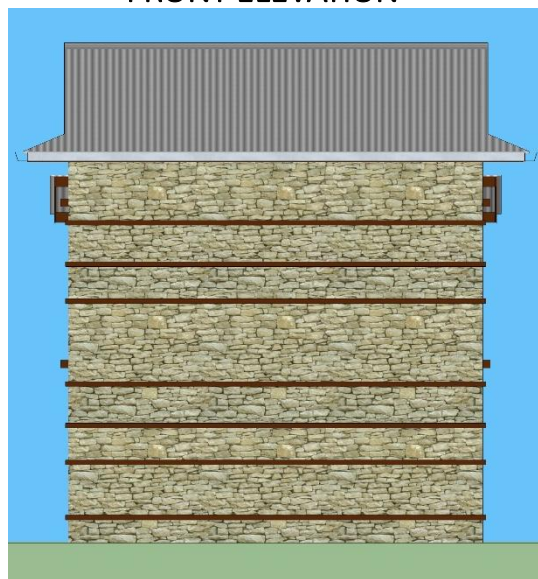
DESIGNED BY: DUDBC

SMC-2.5

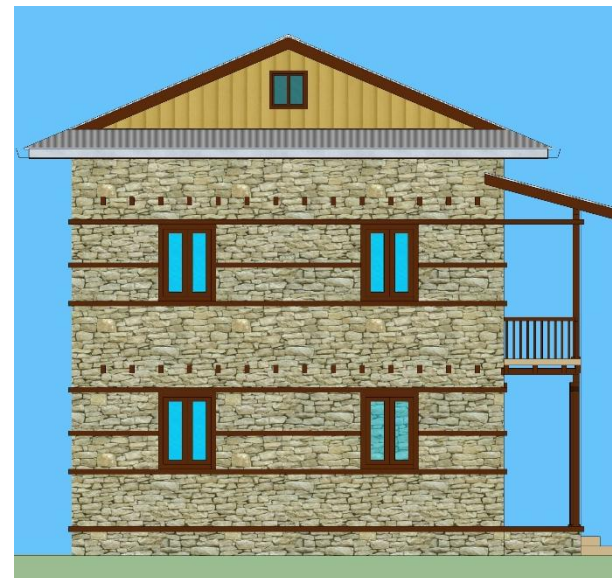
2/4



FRONT ELEVATION



BACK ELEVATION



RIGHT SIDE ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

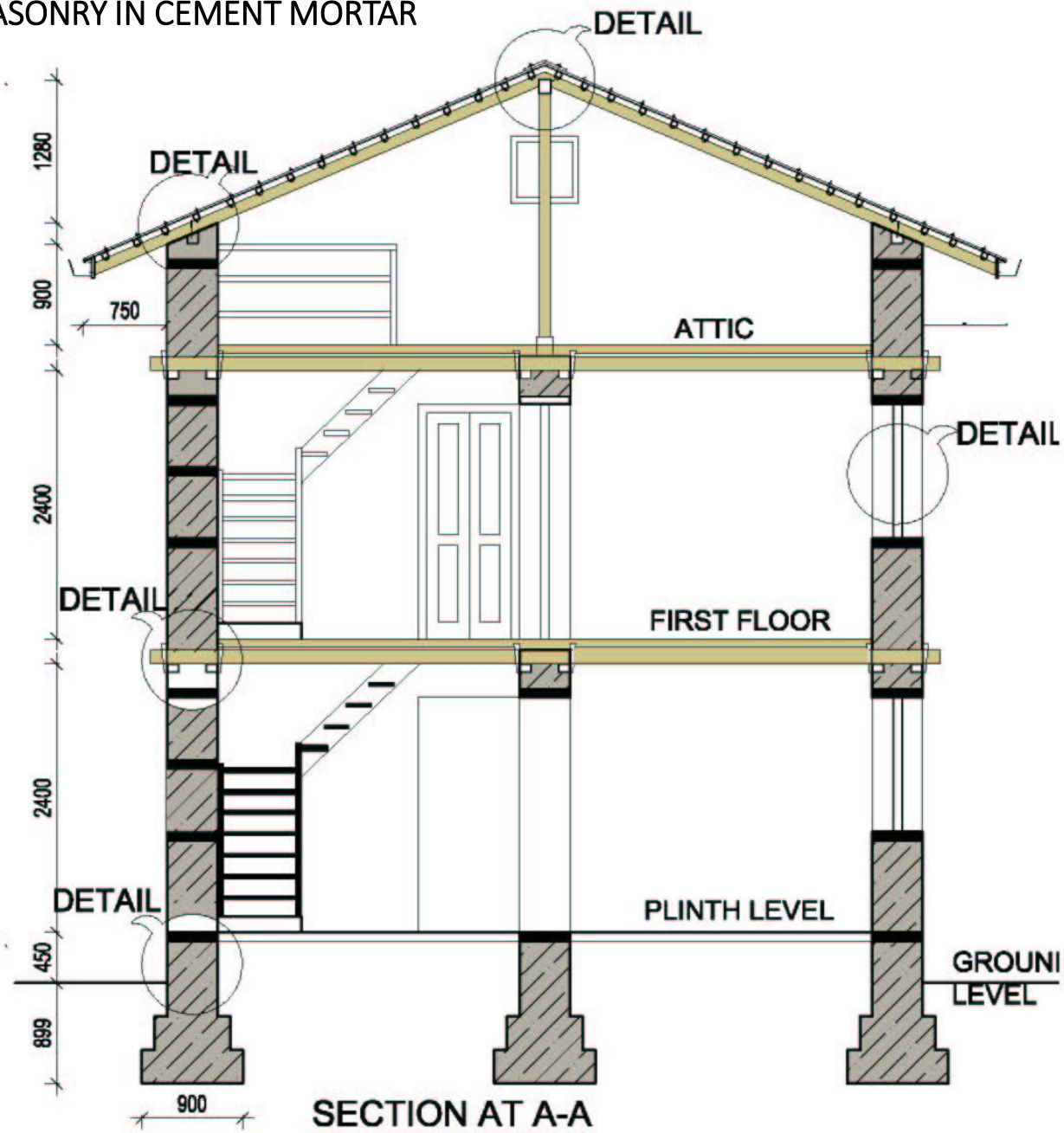
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.5

3/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.5

DRAWING TITLE: SECTION

SCALE: 1:50

DESIGNED BY: DUDBC

DATE:

SMC-2.5

4/4

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.

SMC-2.6



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | |
|-------------------|-----------|-----------|-----------|--------|------|-----------|------|------|
| | Skilled | Unskilled | Stone | CEMENT | SAND | AGGREGATE | WOOD | ROD |
| | Md | Md | Cu.m. | Bags | Cu.m | Cu.m | Cu.m | KG |
| Up to Plinth Band | 65 | 241 | 38 | 103 | 27 | 9 | 0 | 160 |
| Up to Roof Band | 346 | 721 | 93 | 409 | 54 | 22 | 2.09 | 2654 |
| TOTAL | 412 | 962 | 132 | 504 | 81 | 31 | 2.09 | 2814 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.6

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

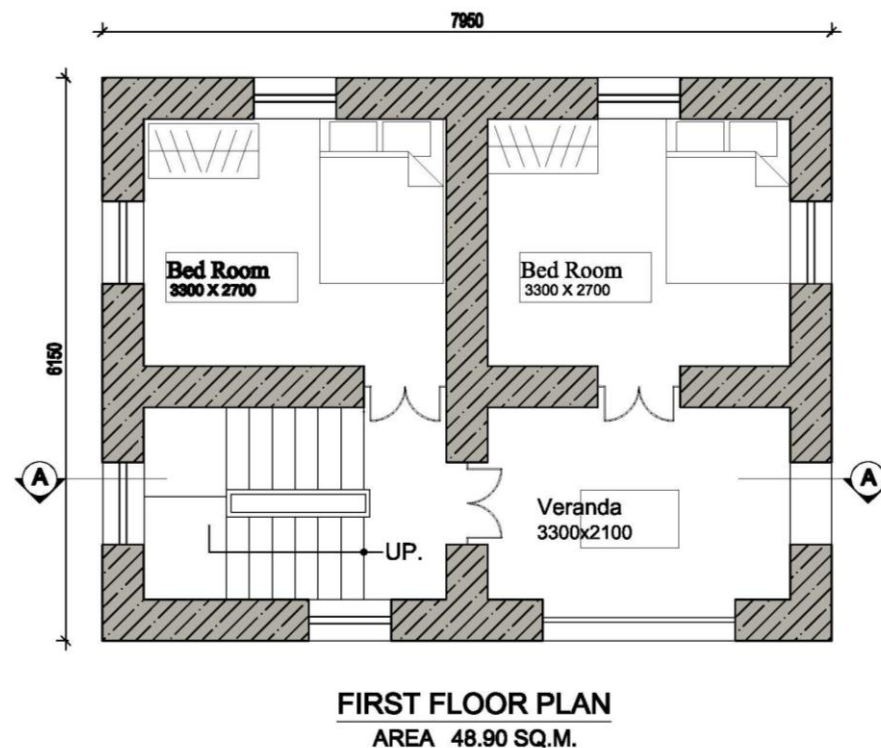
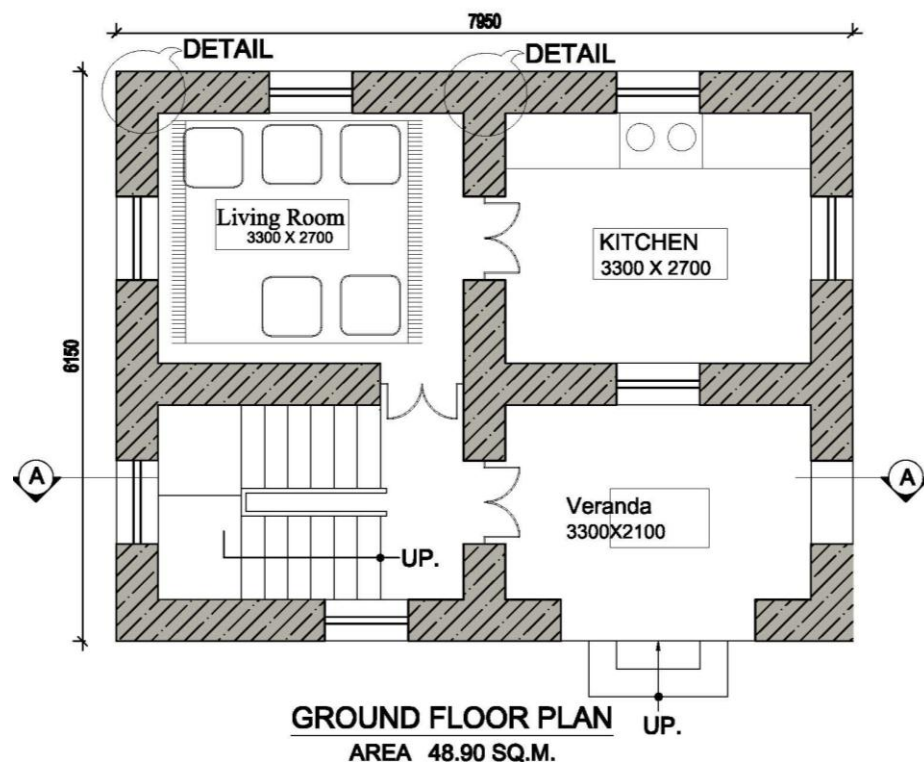
SCALE: None

DATE:

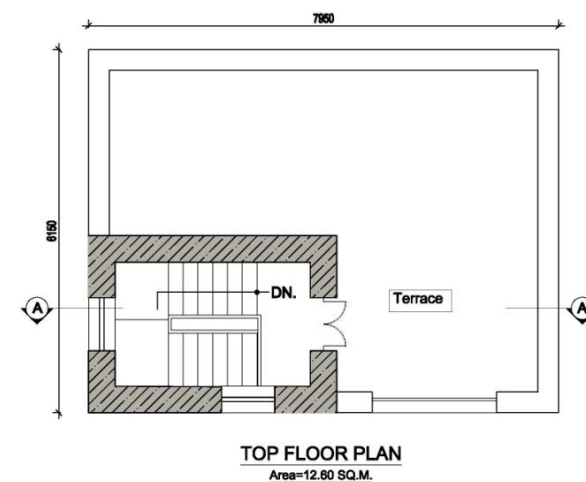
DESIGNED BY: DUDBC

SMC-2.6

1/4



TOTAL AREA: 97.8sqm



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.6
DRAWING TITLE: PLAN

SCALE: None

DATE:

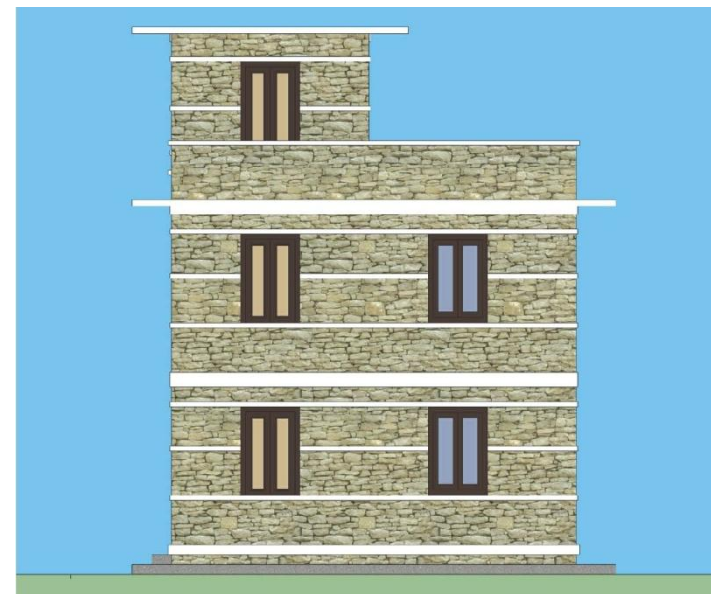
DESIGNED BY: DUDBC

SMC-2.6

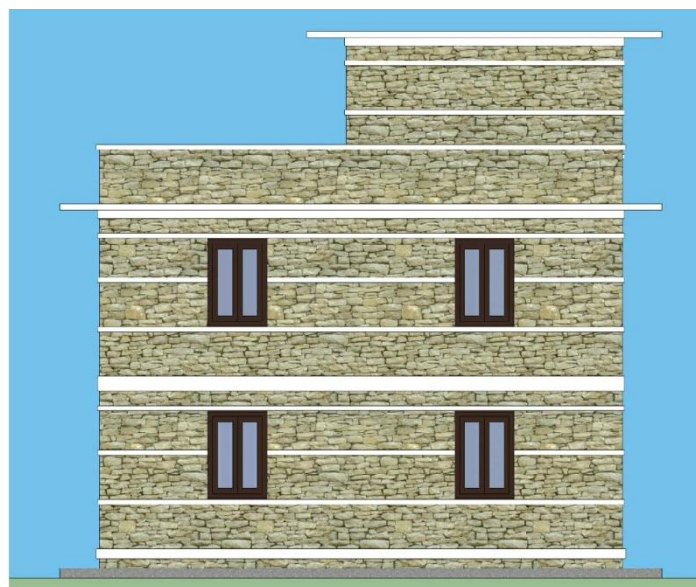
2/4



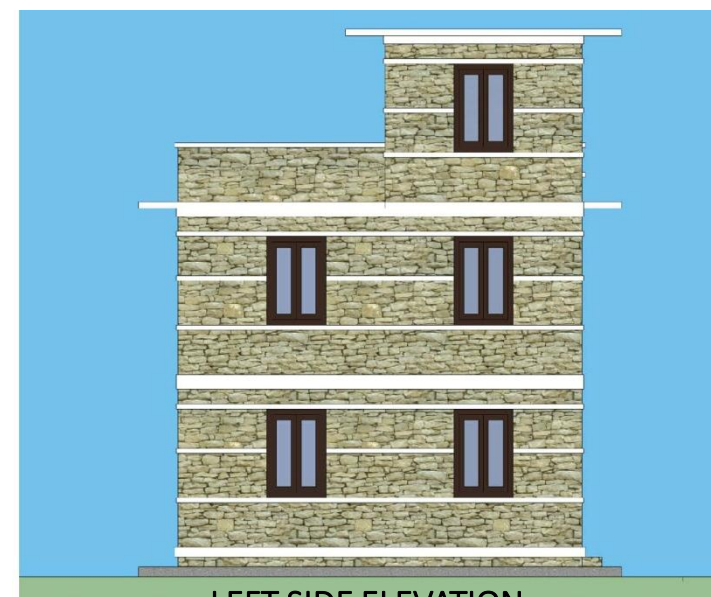
FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.6
DRAWING TITLE: ELEVATION

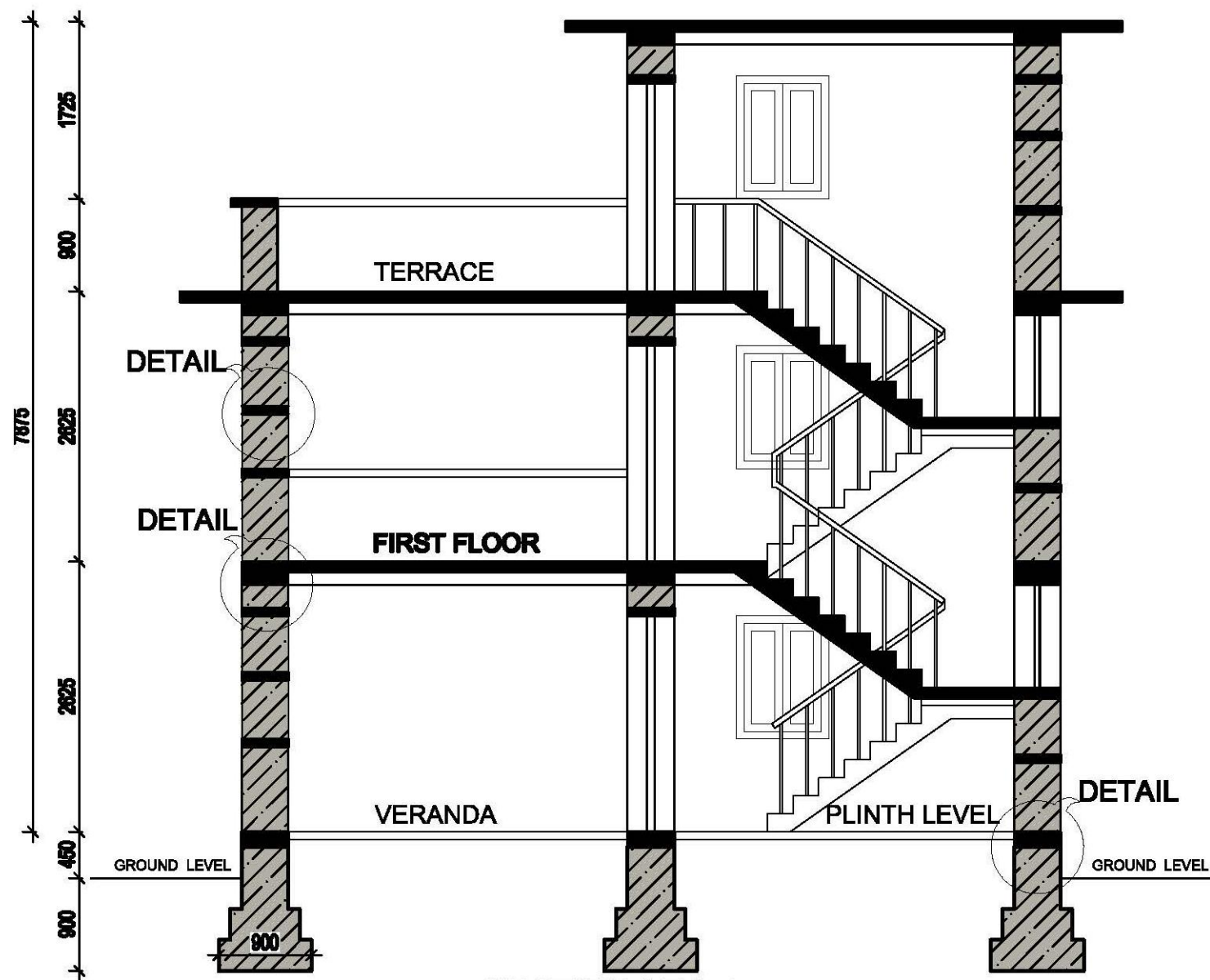
SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.6

3/4



SECTION AT A-A



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC-2.6
DRAWING TITLE: SECTION

SCALE: None

DATE:

DESIGNED BY: DUDBC

SMC-2.6

4/4

STONE MASONRY IN CEMENT MORTAR (SMC)

Technical Details

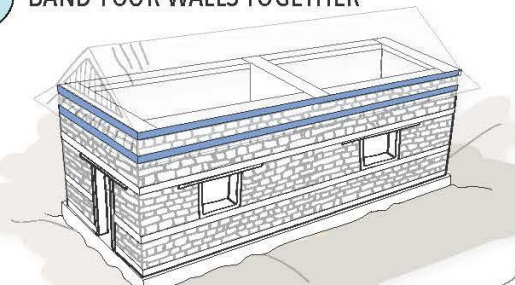


Well built **STONE** houses can better withstand earthquakes. Here are **10 TIPS ON HOW TO BUILD BACK SAFER**

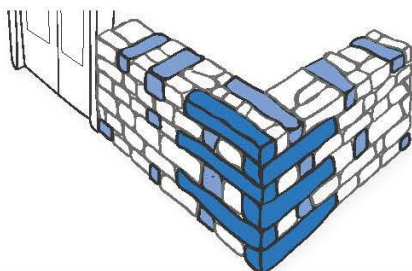
1 GET TECHNICAL ADVICE BEFORE YOU START



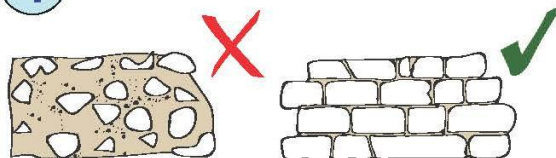
2 BAND YOUR WALLS TOGETHER



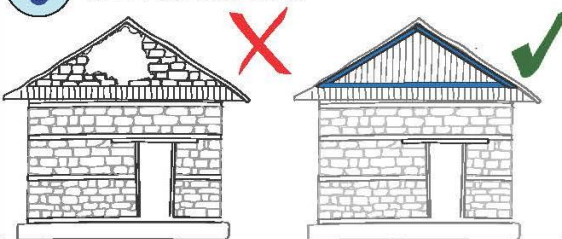
3 TIE YOUR HOUSE TOGETHER WITH TIESTONES



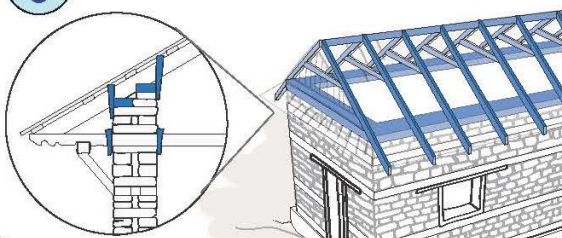
4 BUILD YOUR HOUSE WITH GOOD MATERIALS



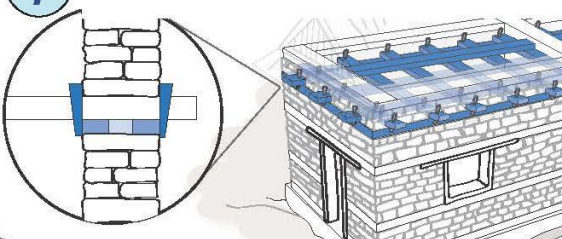
5 TIE YOUR GABLES UP



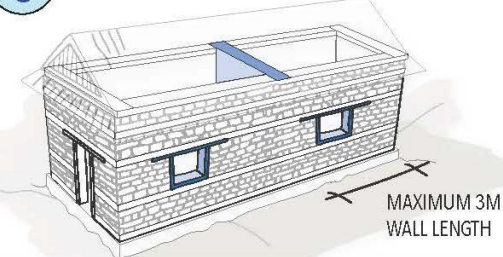
6 TIE YOUR ROOF DOWN



7 TIE YOUR FLOORS TO YOUR WALLS



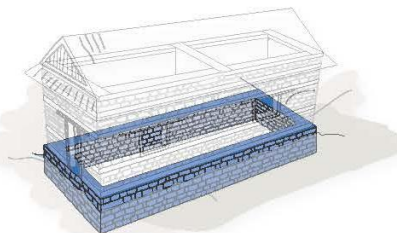
8 BUILD A STRONG SHAPE



9 HAVE A SAFE SITE AND A SAFE EXIT



10 BUILD ON STRONG FOUNDATIONS



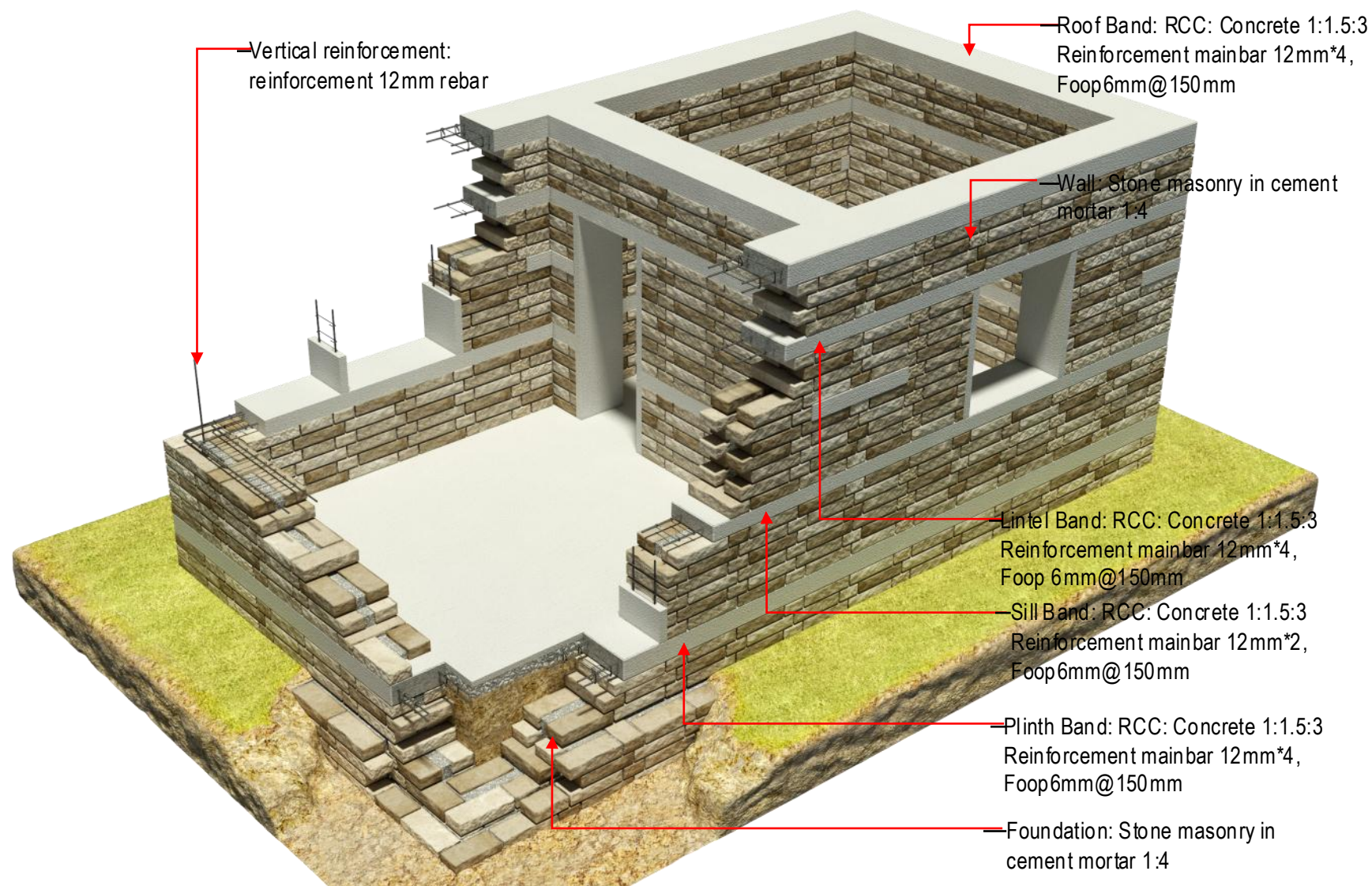
Shelter Cluster Nepal
ShelterCluster.org
Coordinating Humanitarian Shelter

Government of Nepal
Ministry of Urban Development
Department of Urban Development
and Building Construction

**10 KEY MESSAGES -
A VISUAL INDEX**
VERSION 2- 09/OCT/2015

10 KEY MESSAGES

STONE MASONRY IN CEMENT MORTAR



Technology for Earthquake Resistant Building Construction (Stone in Cement Mortar)



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)

SCALE:

None

DATE:

DESIGNED BY: JICA

SMC

STONE MASONRY IN CEMENT MORTAR



Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 2 (SEISMIC ELEMENTS)

SCALE:

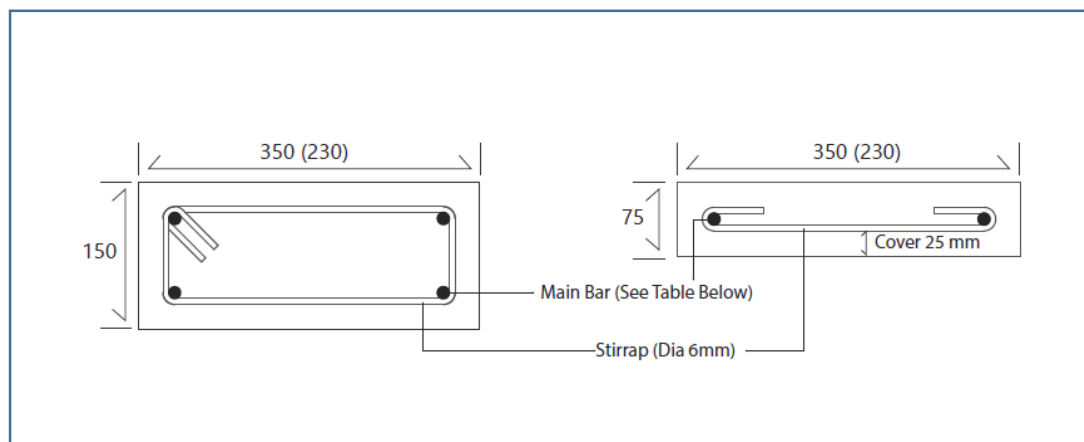
None

DATE:

DESIGNED BY: DUDBC

SMC

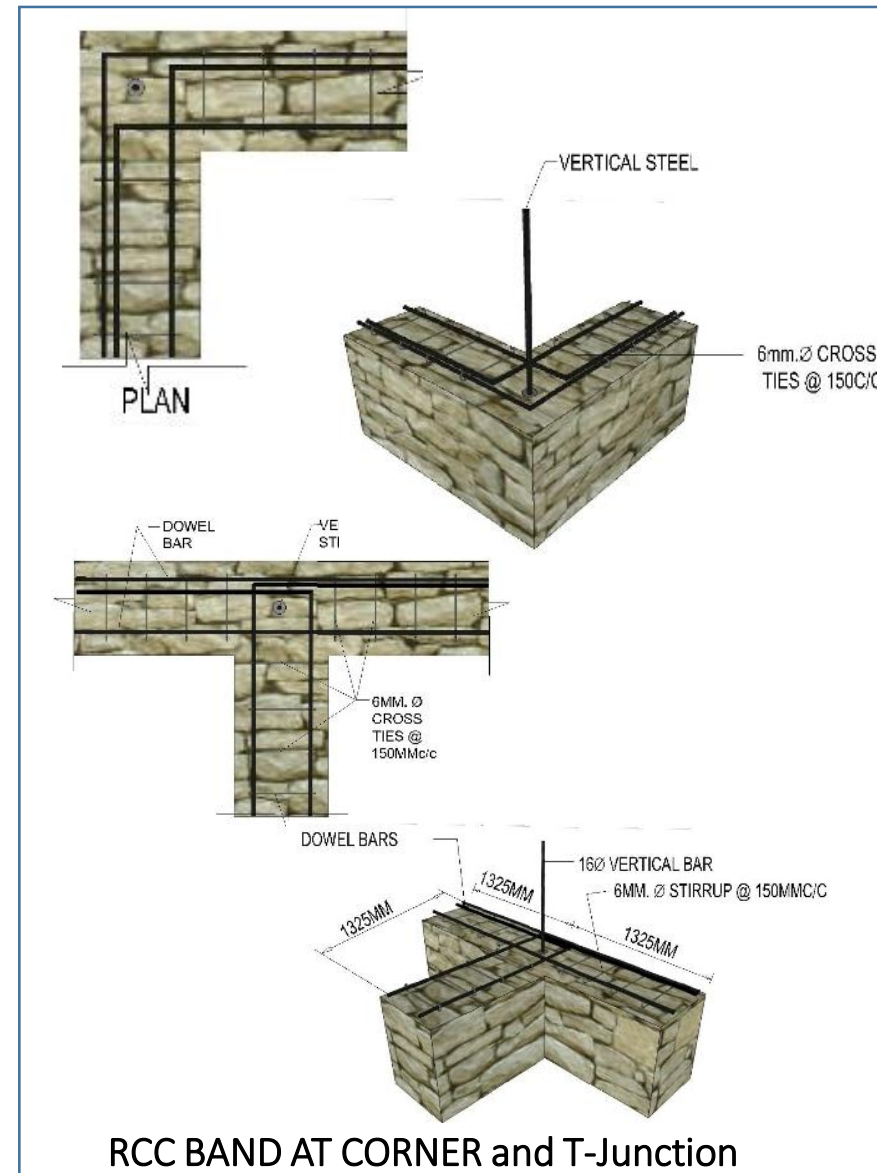
STONE MASONRY IN CEMENT MORTAR



Cross section of RC bands for two bars and four bars

Requirement of bar for RC bands

| Band/Beam | RC Band Minimum Thickness | Min. No. Of. Bars | Min. Diameter of Bars (mm) |
|----------------|---------------------------|-------------------|----------------------------|
| Plinth | 150 mm | 4 | 12 |
| Still | 75 mm | 2 | 10 |
| Lintel | 75mm | 2 | 12 |
| | 150mm | 2 | 10 (top) 12 (bottom) |
| Roof | 75mm | 2 | 12 |
| | 300mm | 4 | 12 |
| Dowel (Stitch) | 75mm | 2 | 8 |



*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 3 (Reinforcing bar arrangement)

SCALE:

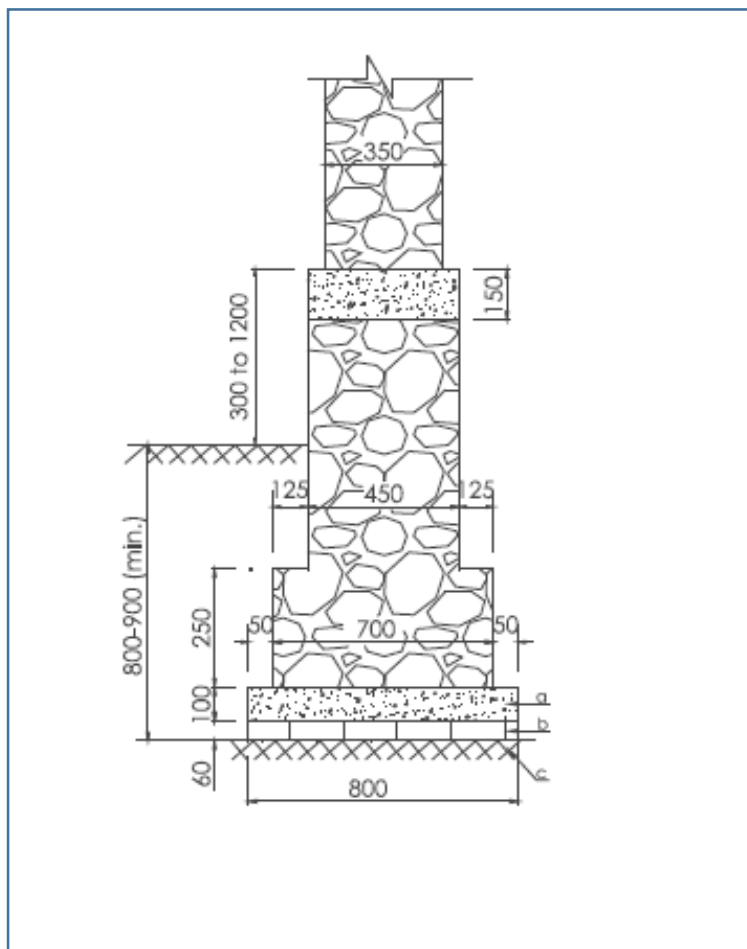
None

DATE:

DESIGNED BY:

SMC

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

| Masonry Type | No. Of Story | Minimum base width (mm) of wall footing for soil type: | | |
|--------------|--------------|--|--------|------|
| | | Soft | Medium | Hard |
| Brick | Two | 900 | 650 | 550 |
| | One | 650 | 550 | 550 |
| Stone | Two | * | 600 | 600 |
| | One | 800 | 600 | 600 |

Classification of Foundation Soil and Safe Bearing Capacity

| Foundation Soil Classification | Types of Foundation Materials | Presumed Safe Bearing Capacity, KN/m ² |
|--------------------------------|---|---|
| Hard | Rocks in different state of wearthing, boulder bed, gravel, sandy gravel and sand-gravel mixture, dense or loose coarse to medium sand offering high resitance to penetration when excavated by tools;stiff to medium clay which is readily indented with a thumb nail. | ≥ 200 |
| Medium | 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. | < 200 and ≥ 150 |
| Soft | Fine sand, loose and dry; soft clay indented with moderate thumb pressure. | < 150 and ≥ 100 |
| Weak | Very soft clay which can be penetrated several centimeters with the thumb, wet clays. | < 100 |

*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 4 (Foundation)

SCALE:

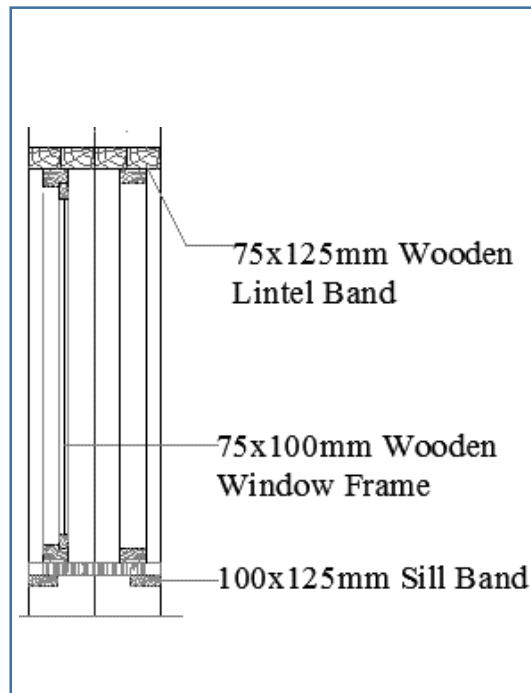
None

DATE:

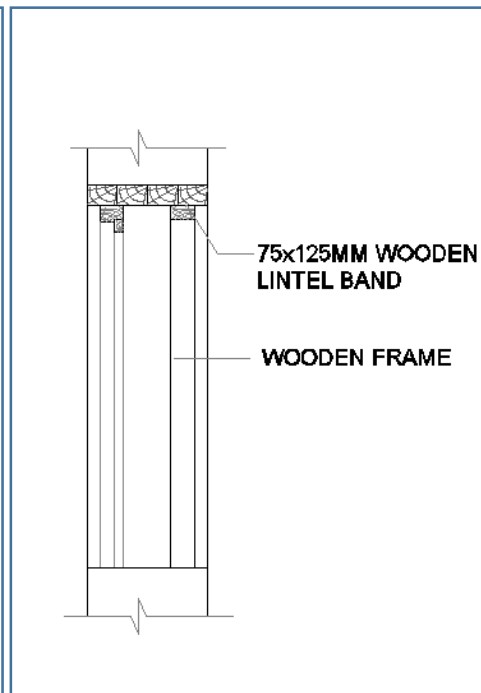
DESIGNED BY:

SMC

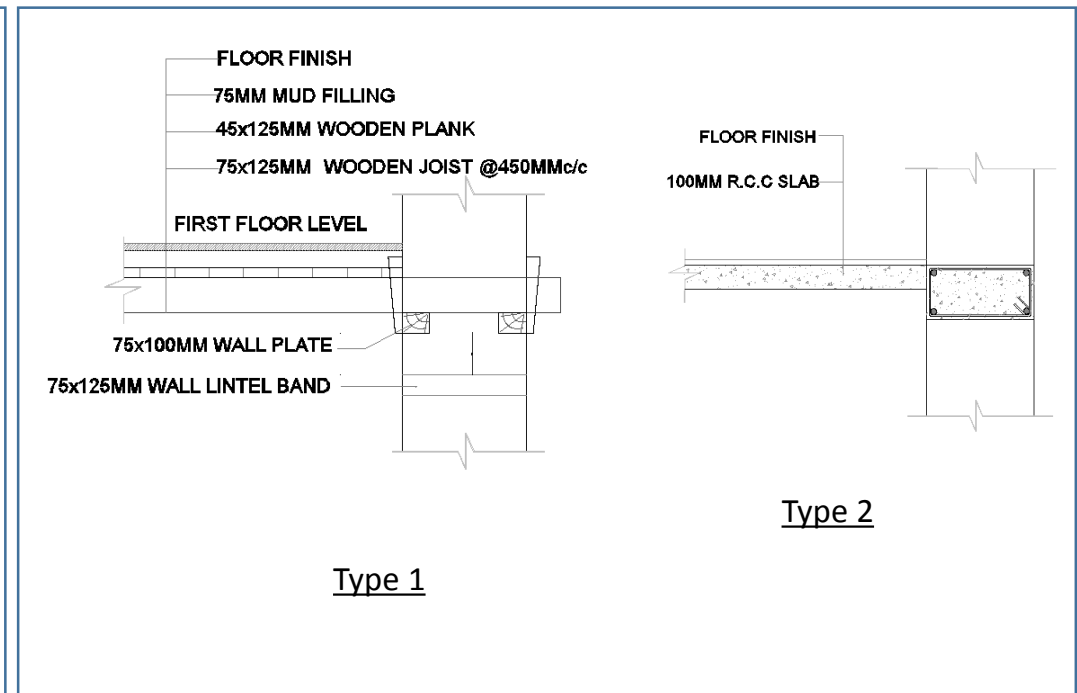
STONE MASONRY IN CEMENT MORTAR



Window Section



Door Section



First Floor Detail

*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC
DRAWING TITLE: TECHNICAL DETAIL 5 (Opening and Floor)

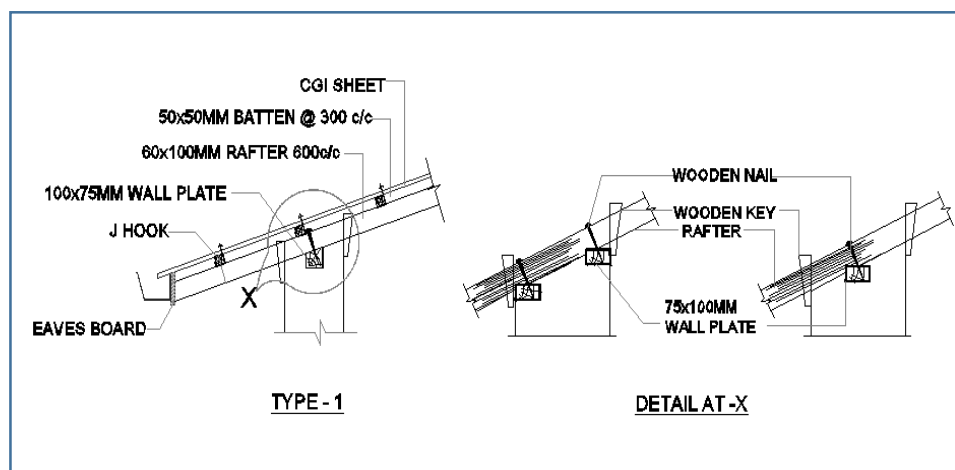
SCALE: None

DATE:

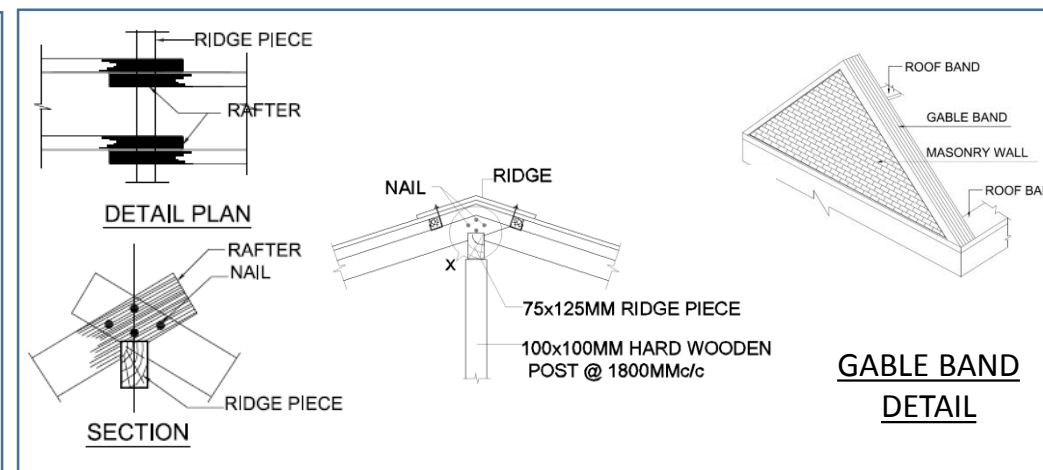
DESIGNED BY:

SMC

STONE MASONRY IN CEMENT MORTAR



Detail of Rafter Joint with Wall Plate



Detail of Rafter Joint at Ridge



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMC
DRAWING TITLE: TECHNICAL DETAIL 6 (Roof)

SCALE: None

DATE:

DESIGNED BY:

SMC

STONE MASONRY IN CEMENT MORTAR

◆ Top (Plan) View



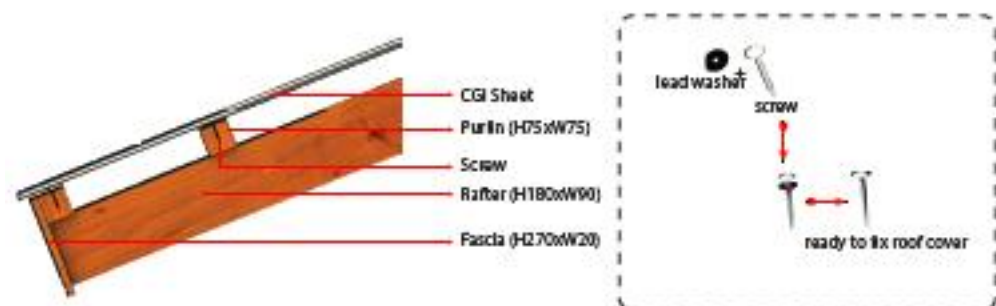
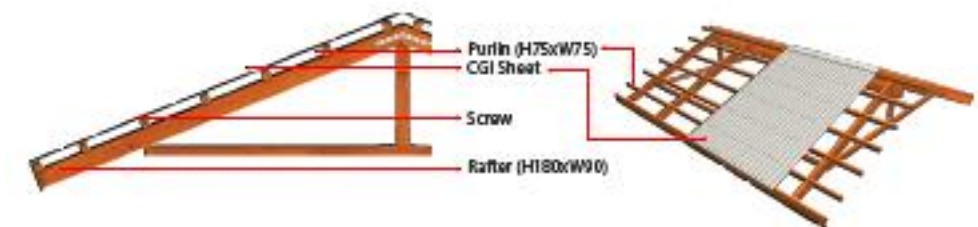
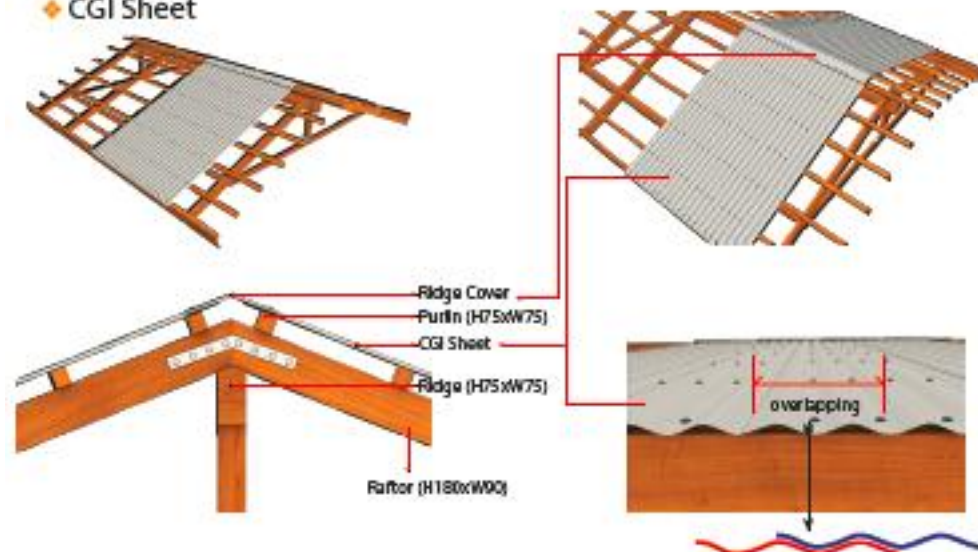
◆ Side View



◆ Isometric View



◆ CGI Sheet



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 7 (Roofing)

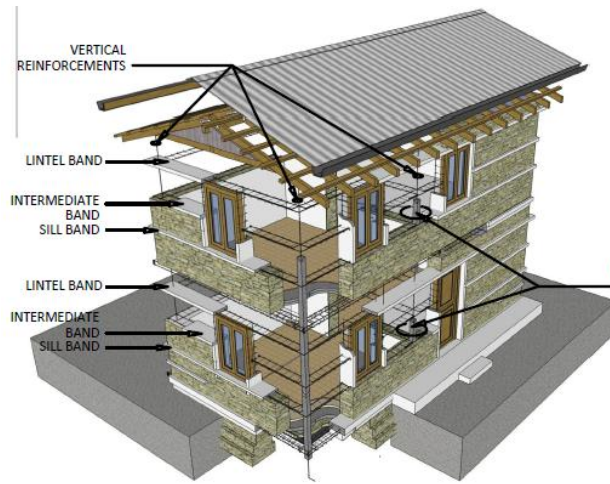
SCALE:

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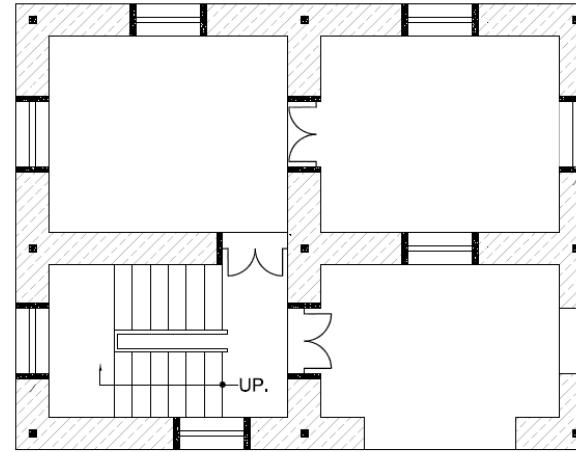
DATE:

DESIGNED BY:

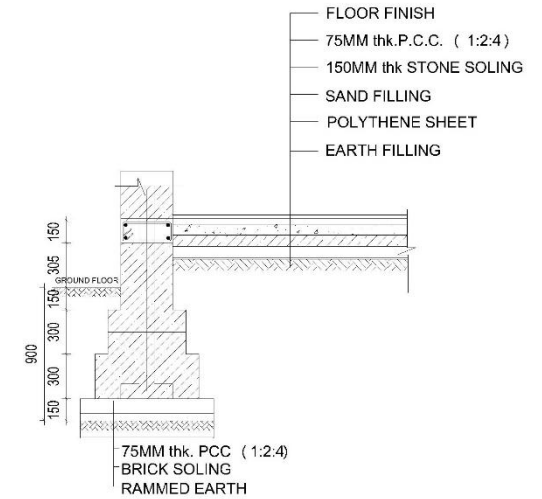
SMC



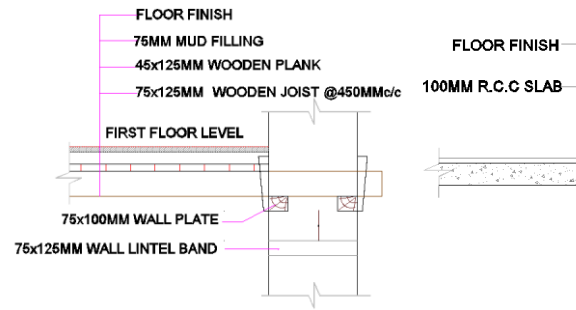
Earthquake Resistant Elements in Building



Typical Ground/ First Floor Plan



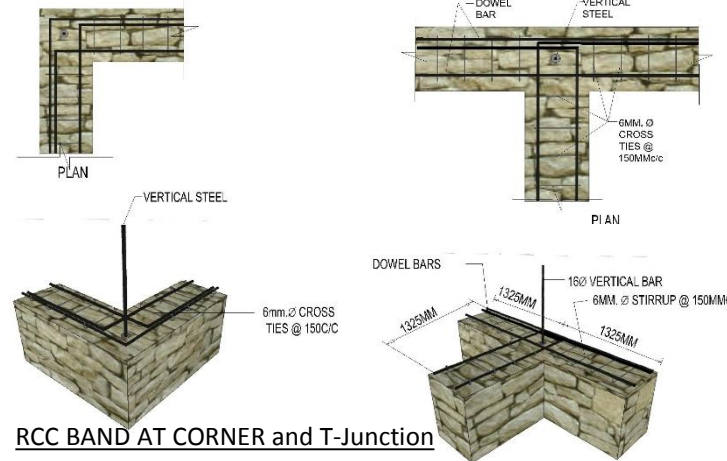
Foundation Detail



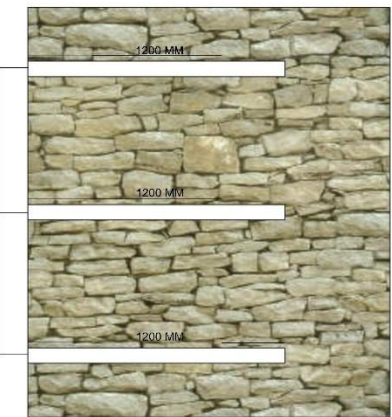
Type 1

Type 2

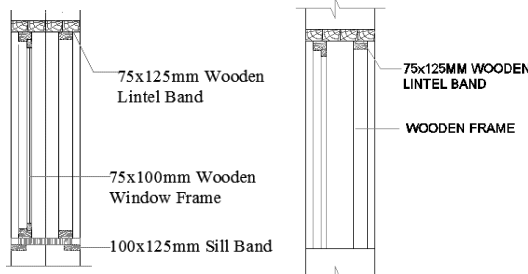
First Floor Detail



RCC BAND AT CORNER and T-Junction

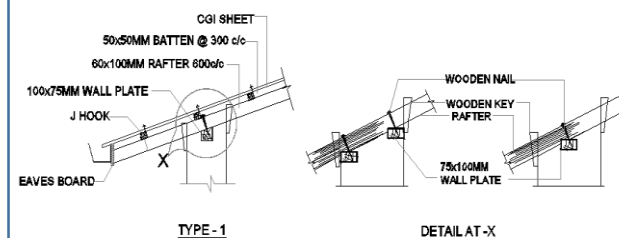


Corner Strengthening Band

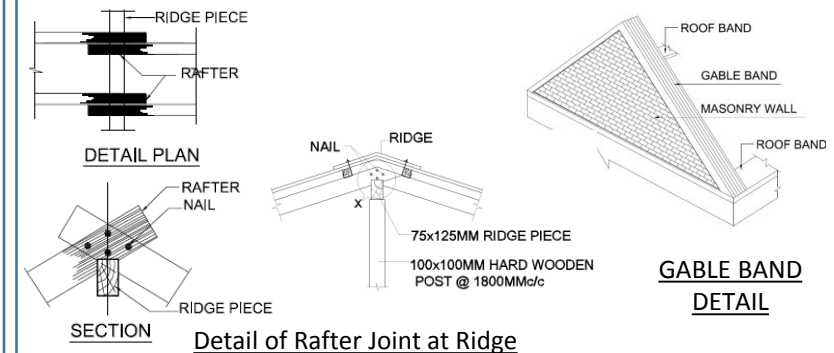


Window Section

Door Section



Detail of Rafter Joint with Wall Plate



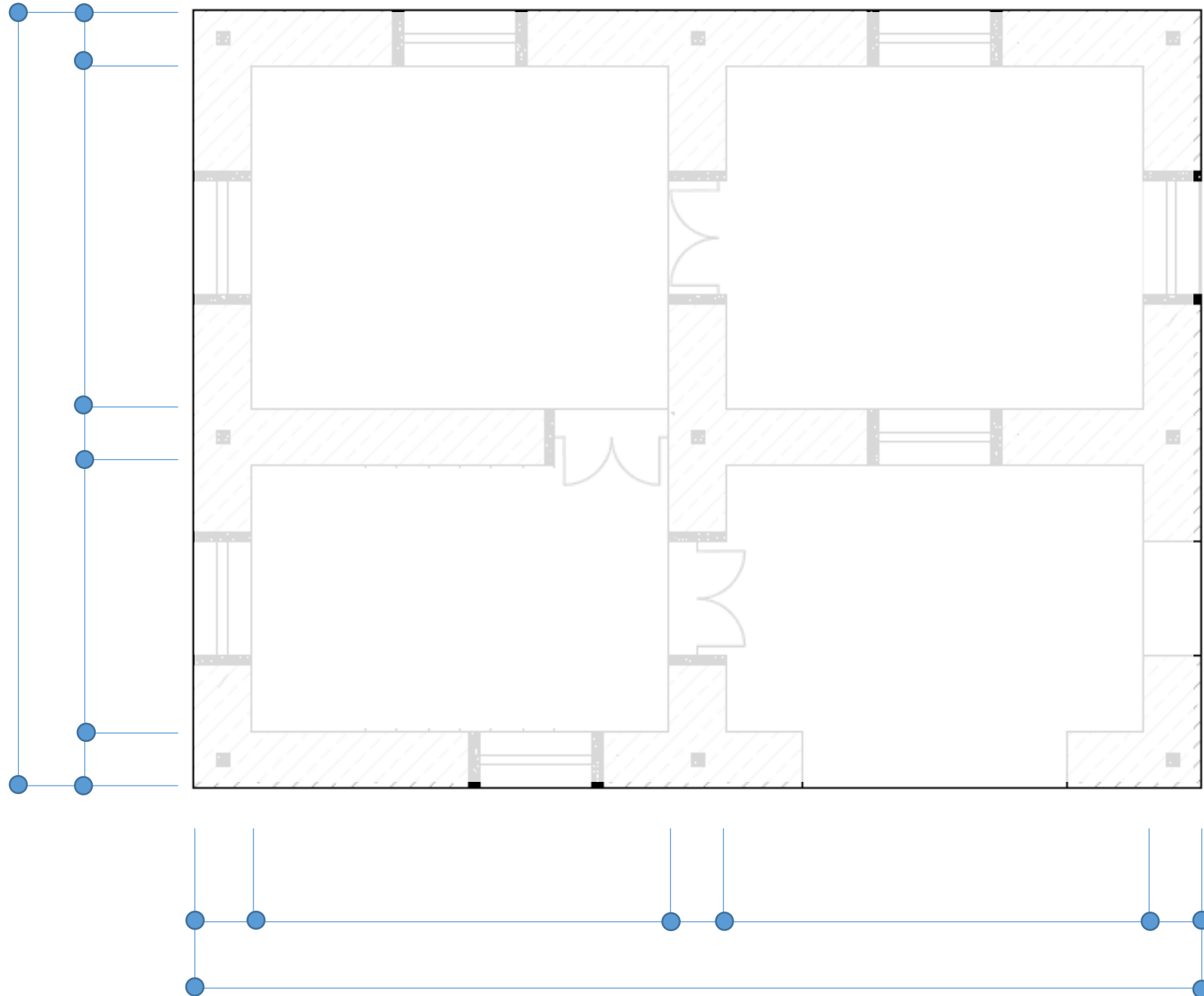
Detail of Rafter Joint at Ridge

GABLE BAND DETAIL

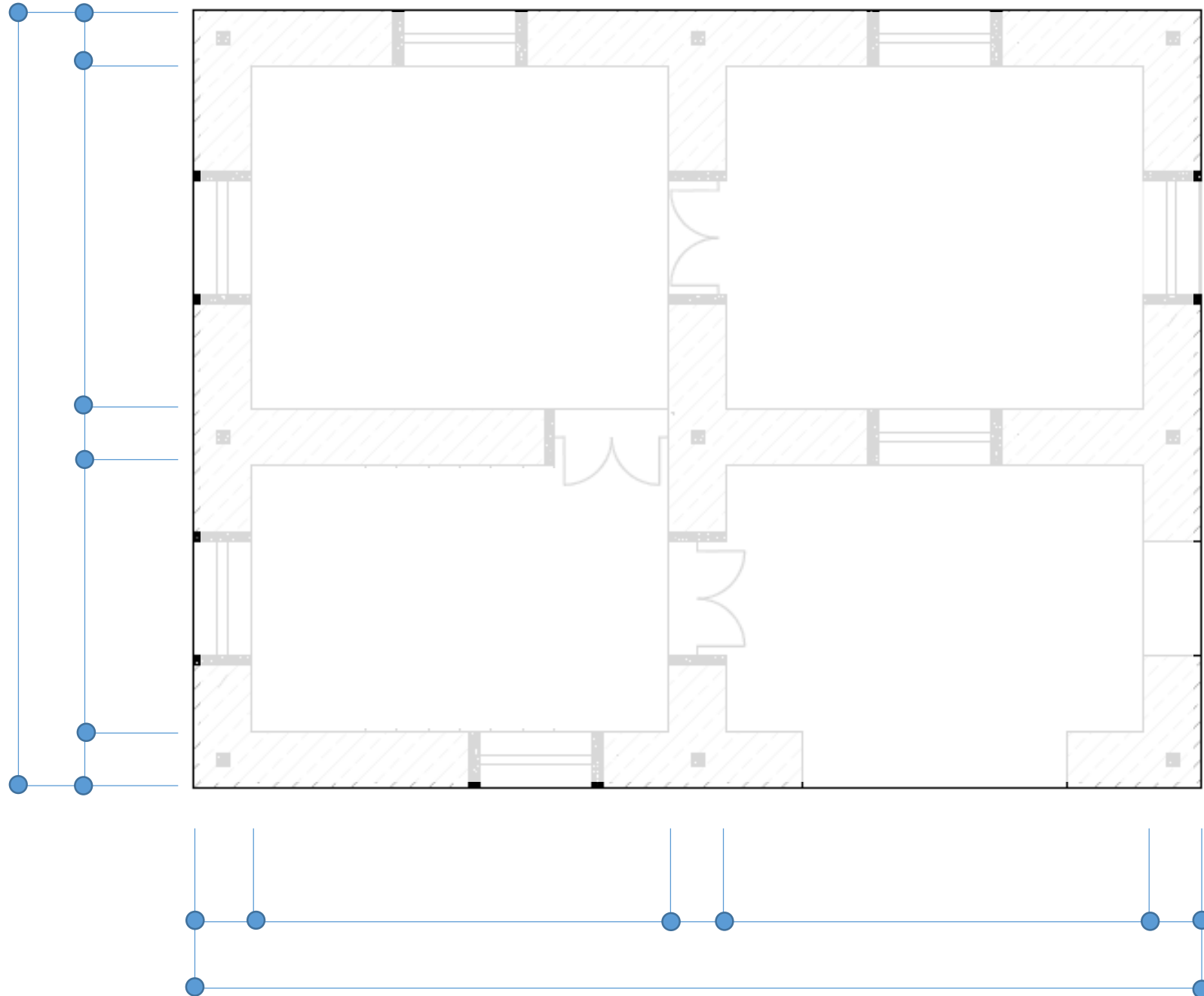
| Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) | | | | Page1 |
|--|----------------|---|-------------------------------------|---|
| No. | Category | | | |
| 1 | Site Selection | A building shall not be constructed if site is: | | |
| | | | ✓ Geological fault or Raptured Area | |
| | | | ✓ Areas Susceptible to Landslide | |
| | | | ✓ Steep Slope > 20% | |
| | | | ✓ Filled Area | |
| 2 | Shape of House | | ✓ River Bank and Water-logged Area | |
| | | 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 |
| 3 | Foundation | Proportion | ✓ | The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width. |
| | | 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. 350mm for Stone masorny. |
| | | 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). |
| | | 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. |
| | | Width | ✓ | The minimum width of wall is 350mm for one-storey and two-storey. |

| Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) | | | | Page2 |
|--|------------------------|---------------|---|--|
| 6 | Openings | Location | ✓ | Openings are to be located away from inside corners by a clear distance should not be less than 600 mm. |
| | | 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. |
| 7 | Vertical Reinforcement | 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. |
| | | Reinforcement | ✓ | The vertical reinforcing bar for masonry is given in detail drawings. 12mm dia is minimum requirements for masonry houses. |
| 8 | Horizontal Band | | | 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. |
| | | Stitch | ✓ | 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. |
| 9 | Roof | 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. |
| | | Light roof | ✓ | Use light roof comprising wooden or steel truss covered with CGI sheets. |
| | | 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. |
| 10 | Materials | 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 |
| | | 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 $f_y = 415 \text{ N/}$ |

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)

BMC

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.

Minimum Requirements (MRs)

| Minimum Requirements (MRs) for Brick Masonry in Cement Mortar (NBC202) | | | | Page1 |
|--|----------------|---|---|---|
| No. | Category | | | |
| | | A building shall not be constructed if site is: | | |
| 1 | Site Selection | | ✓ | Geological fault or Raptured Area |
| | | | ✓ | Areas Susceptible to Landslide |
| | | | ✓ | Steep Slope > 20% |
| | | | ✓ | Filled Area |
| | | | ✓ | River Bank and Water-logged Area |
| | | Two storey+ attic, load bearing masonry buildings , constructed in cement mortar | | |
| 2 | Shape of House | No. of story | ✓ | |
| | | 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 masorny. |
| | | 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. |

| Minimum Requirements (MRs) for Brick Masonry in Cement Mortar (NBC202) | | | Page2 |
|--|------------------------|---------------|---|
| No. | Category | | |
| 6 | Openings | Location | ✓ Openings are to be located away from inside corners by a clear distance should not be less than 600 mm. |
| | | 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. |
| 7 | Vertical Reinforcement | 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. |
| | | Reinforcement | ✓ The vertical reinforcing bar for masonry is given in detail drawings. 12 mm dia is minimum requirements for masonry houses. |
| 8 | Horizontal Band | | 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. |
| | | Stitch | ✓ 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 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. |
| 9 | Roof | Light roof | ✓ Use light roof comprising wooden or steel truss covered with CGI sheets |
| | | 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 $f_y = 415 \text{ N/}$ |

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.

BMC-1.1



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|--------|------|-----------|------|-----------|-----------------|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | Nos | Bags | Cu.m | Cu.m | Cu.m | Bundel | Kg |
| Up to Plinth Level | 45 | 104 | 13115 | 81 | 11 | 7 | 0 | 0 | 146 |
| SUPERSTRUCTURE | 67 | 59 | 8984 | 46 | 5 | 2 | 0.79 | 0 | 314 |
| ROOFING | 17 | 20 | 0 | 0 | 0 | 0 | 1.48 | 4.71 | 0 |
| TOTAL | 129 | 183 | 22099 | 127 | 15 | 9 | 2.27 | 4.71 | 460 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC-1.1

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

None

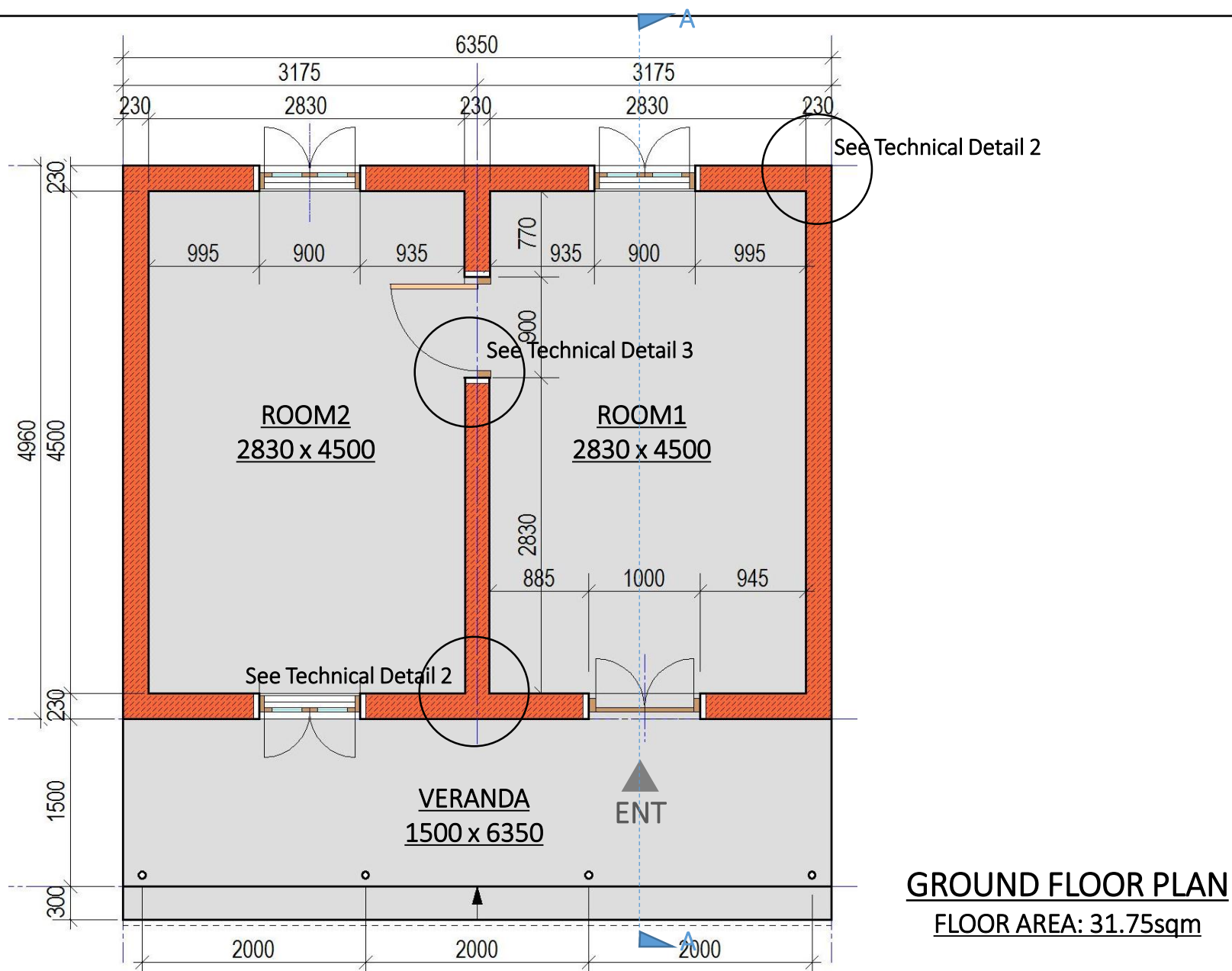
DATE:

DESIGNED BY:

JICA

BMC-1.1

1/4



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: JICA

BMC-1.1

2/4



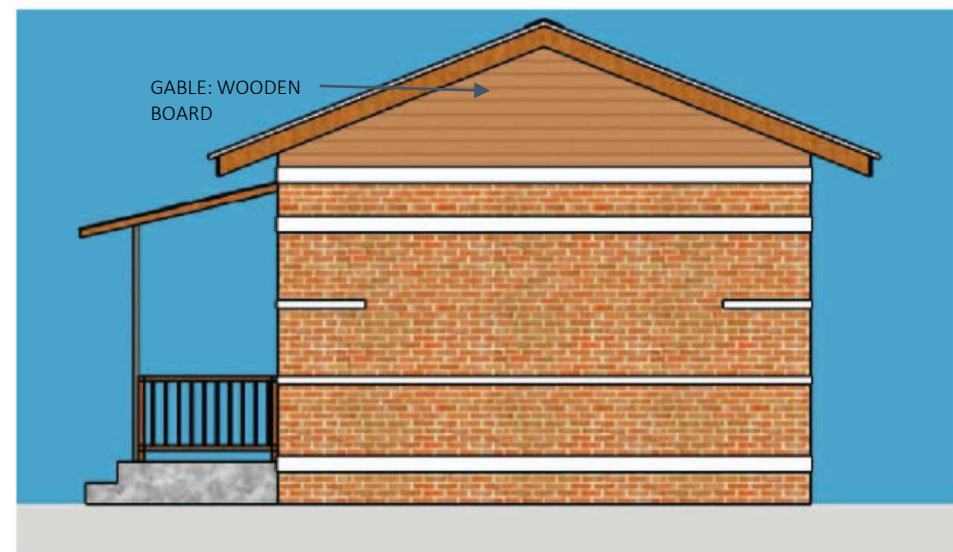
FRONT ELEVATION



BACK ELEVATION



SIDE ELEVATION



SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

SCALE: None
DESIGNED BY: JICA

DATE:

BMC-1.1

3/4



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 has 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.

BMC-1.2



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|-----------------|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | Nos | Bags | cu.m. | cu.m. | cu.m. | Bundel | Kg |
| Up to Plinth Level | 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

TYPE OF HOUSE:

MODEL BMC-1.2

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

None

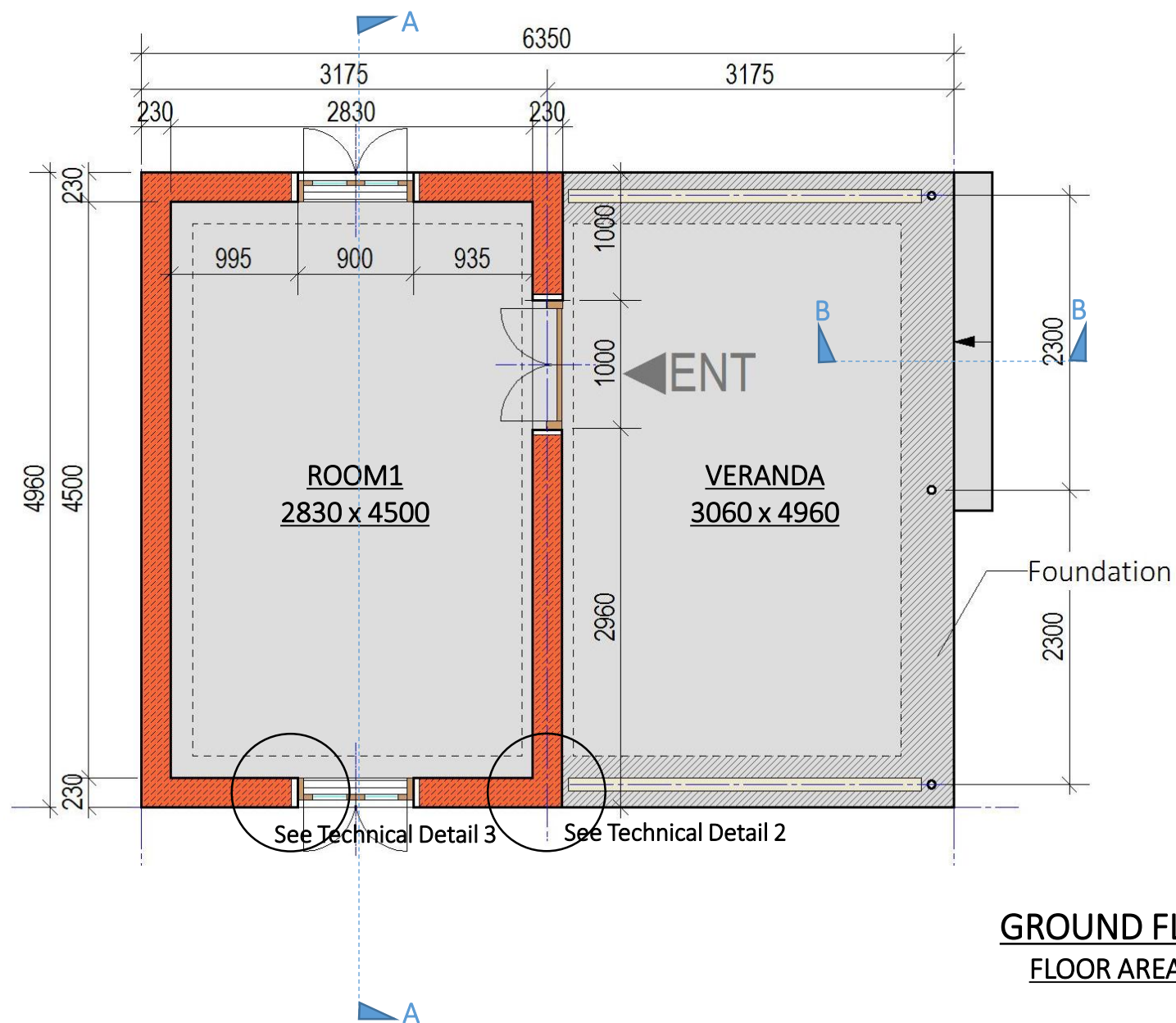
DATE:

DESIGNED BY:

JICA

BMC-1.2

1/4

**GROUND FLOOR PLAN**

FLOOR AREA: 16.31sqm



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-1.2
DRAWING TITLE: PLAN

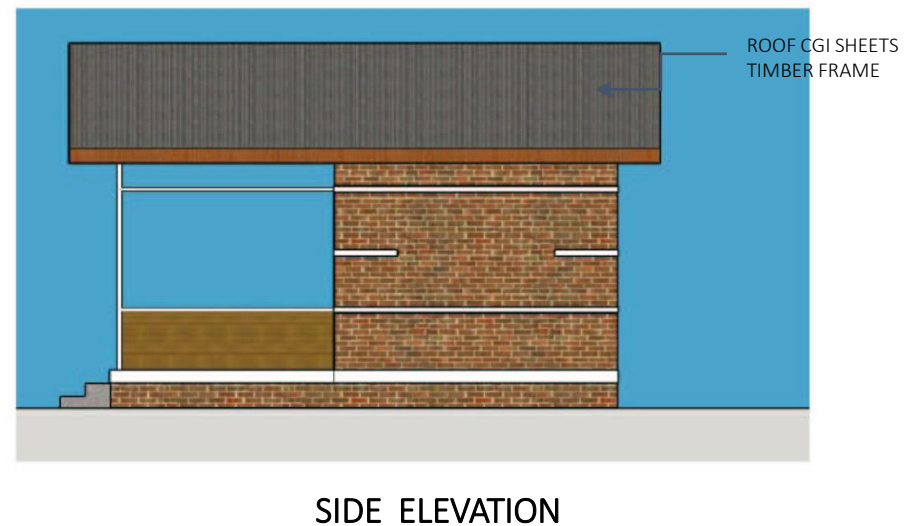
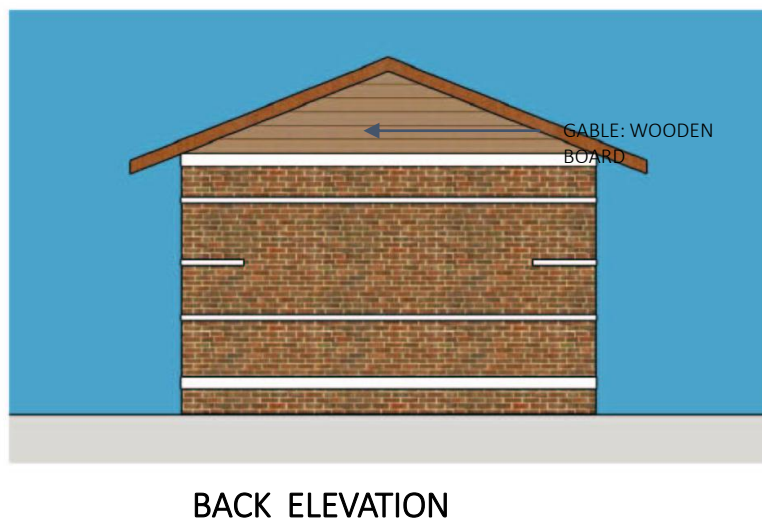
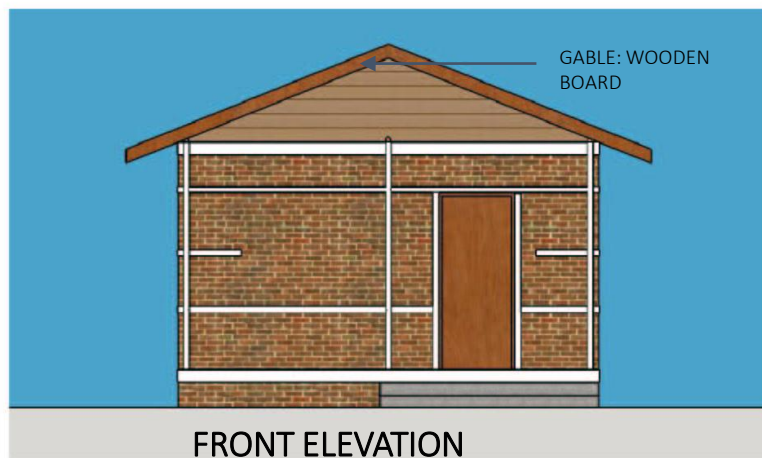
SCALE: 1:50

DATE:

DESIGNED BY: JICA

BMC-1.2

2/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-1.2
DRAWING TITLE: ELAVATION

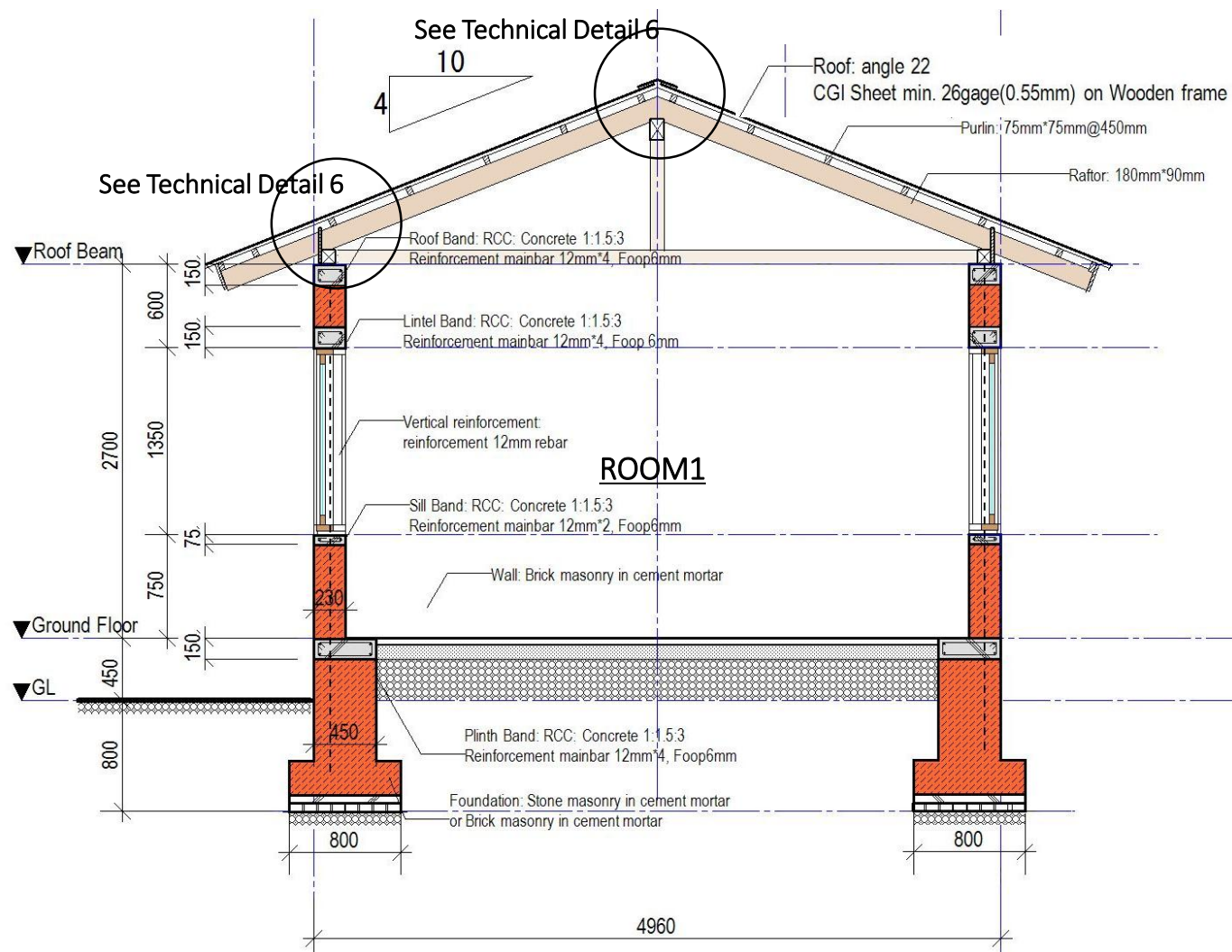
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DATE:

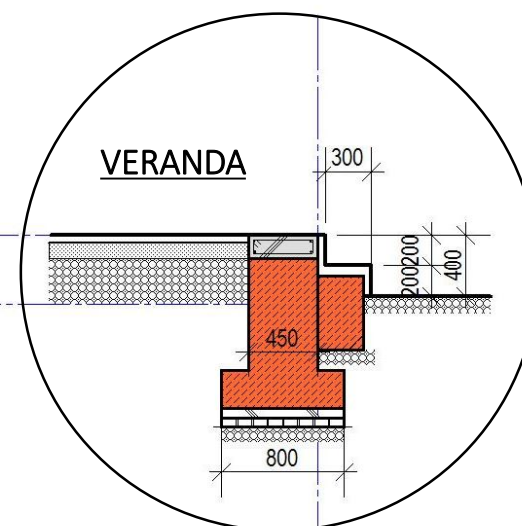
DESIGNED BY: JICA

BMC-1.2

3/4



SECTION A-A



SECTION B-B



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-1.2
DRAWING TITLE: SECTION

SCALE: 1:50

DATE:

DESIGNED BY: JICA

BMC-1.2

4/4

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.

BMC-2.1



| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|---------------|---------------|-----------------|---------------|--------------|--------------|-------------|-------------|-----------------|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | Reinforcing bar |
| | Md | Md | Nos | Bags | cu.m. | cu.m. | cu.m. | Bundel | Kg |
| Up to Plinth Level | 46.93 | 118.50 | 13288.00 | 87.75 | 11.41 | 6.71 | 0.00 | 0.00 | 145.85 |
| SUPERSTRUCTURE | 81.80 | 144.21 | 23648.00 | 109.12 | 11.66 | 4.20 | 2.95 | 1.02 | 630.50 |
| ROOFING | 17.32 | 19.53 | 0.00 | 0.00 | 0.00 | 0.00 | 1.48 | 3.69 | 0.00 |
| TOTAL | 146.05 | 282.24 | 36936.00 | 196.87 | 23.07 | 10.91 | 4.43 | 4.71 | 776.35 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC-2.1

DRAWING TITLE:

PERSPECTIVE AND ESTIMATION

SCALE:

None

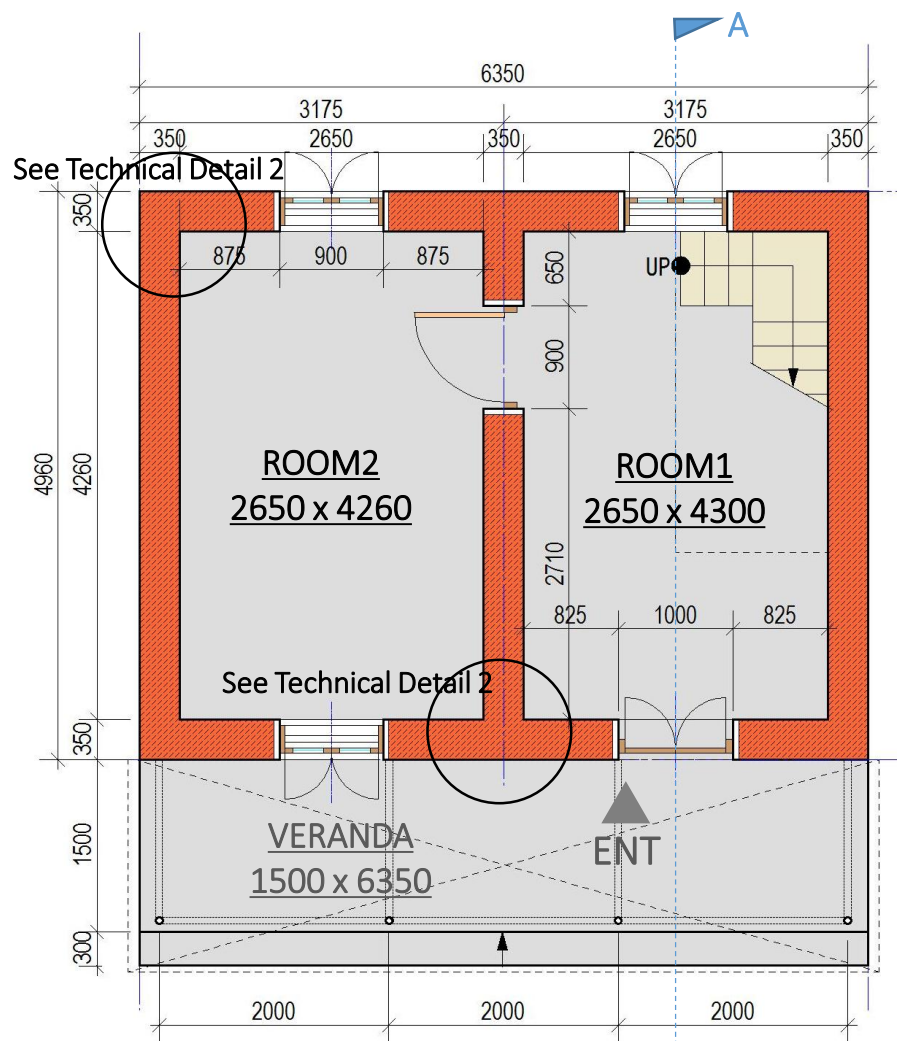
DATE:

DESIGNED BY:

JICA

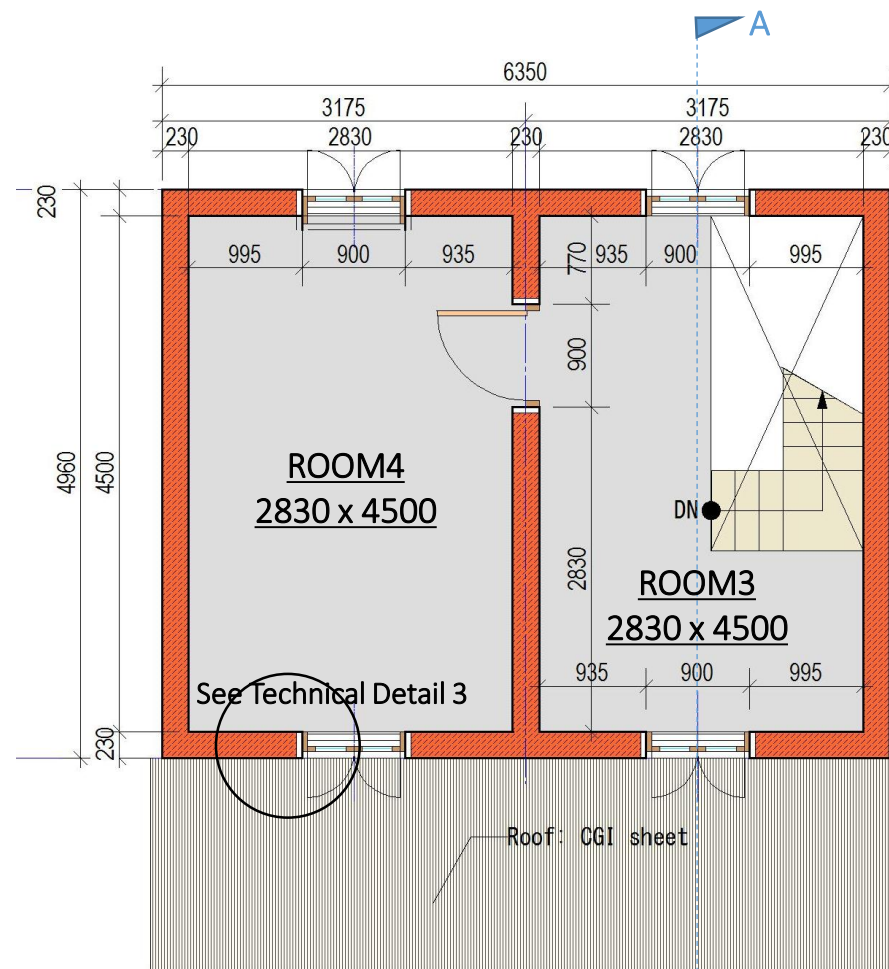
BMC-2.1

1/4



GROUND FLOOR PLAN

AREA: 31.75sqm



FIRST FLOOR PLAN

AREA: 31.75sqm

TOTAL AREA: 63.5sqm



Nepal Housing
Reconstruction Programme

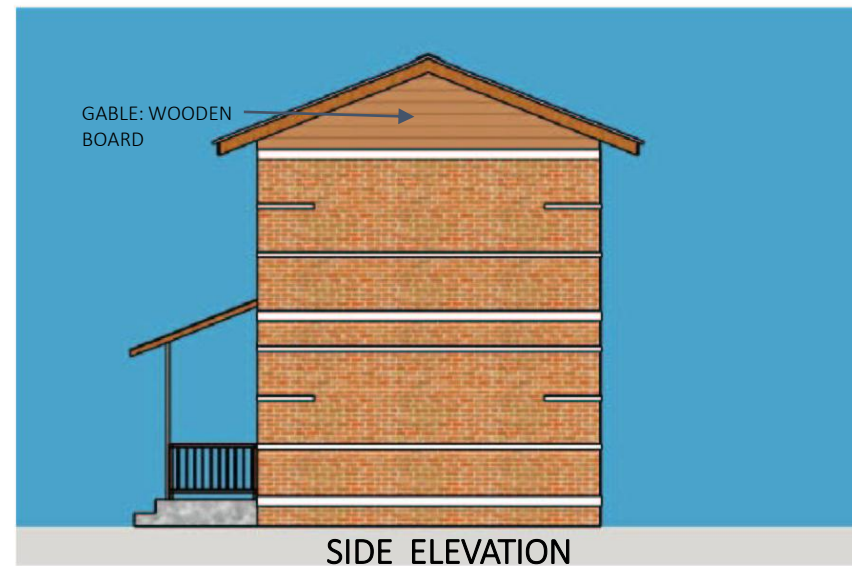
TYPE OF HOUSE: MODEL BMC-2.1
DRAWING TITLE: PLAN

SCALE: None
DESIGNED BY: JICA

DATE:

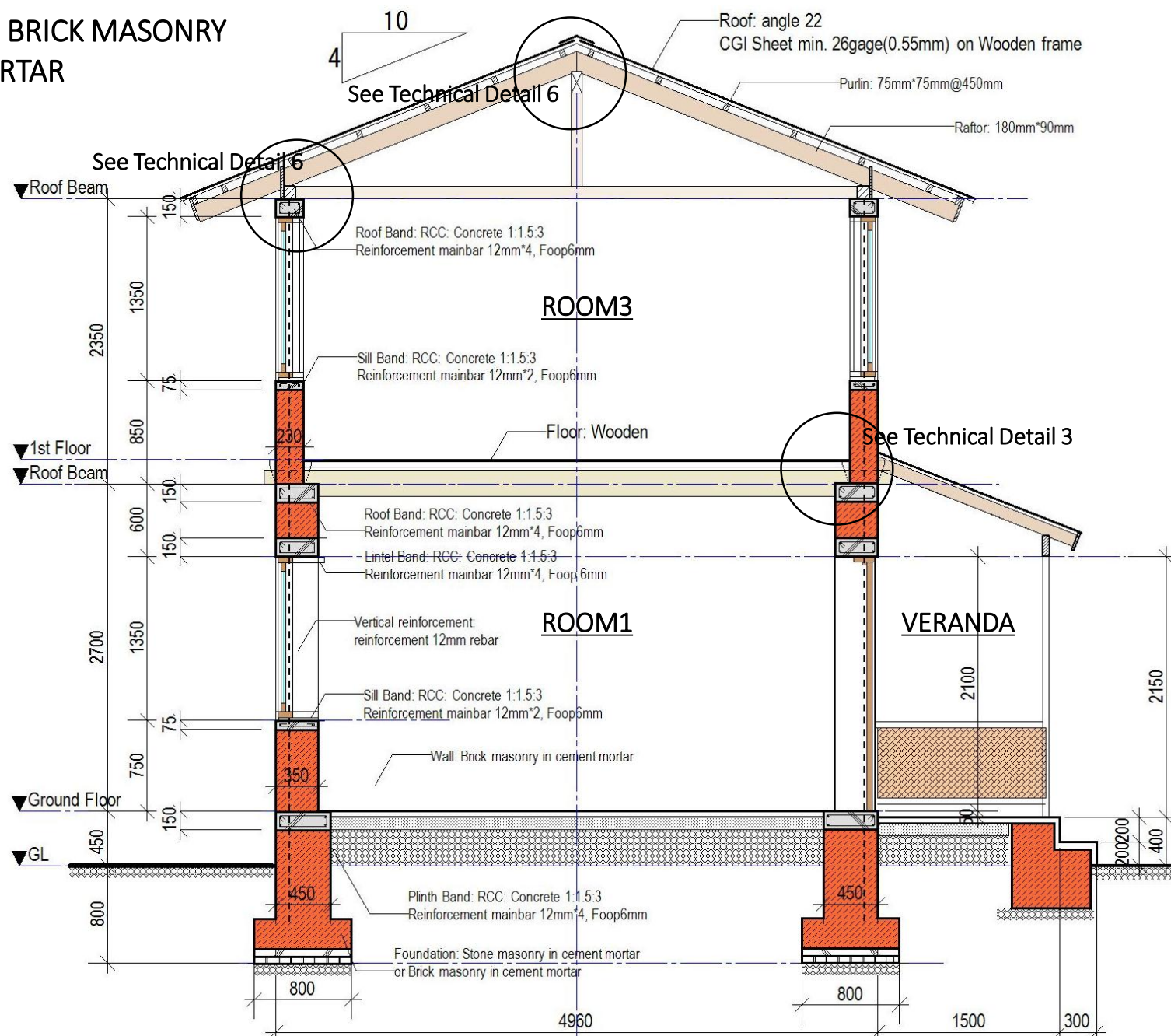
BMC-2.1

2/4



Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: **MODEL BMC-2.1**
DRAWING TITLE: **SECTION**

SCALE: **1:50**

DATE:

DESIGNED BY: **JICA**

BMC-2.1

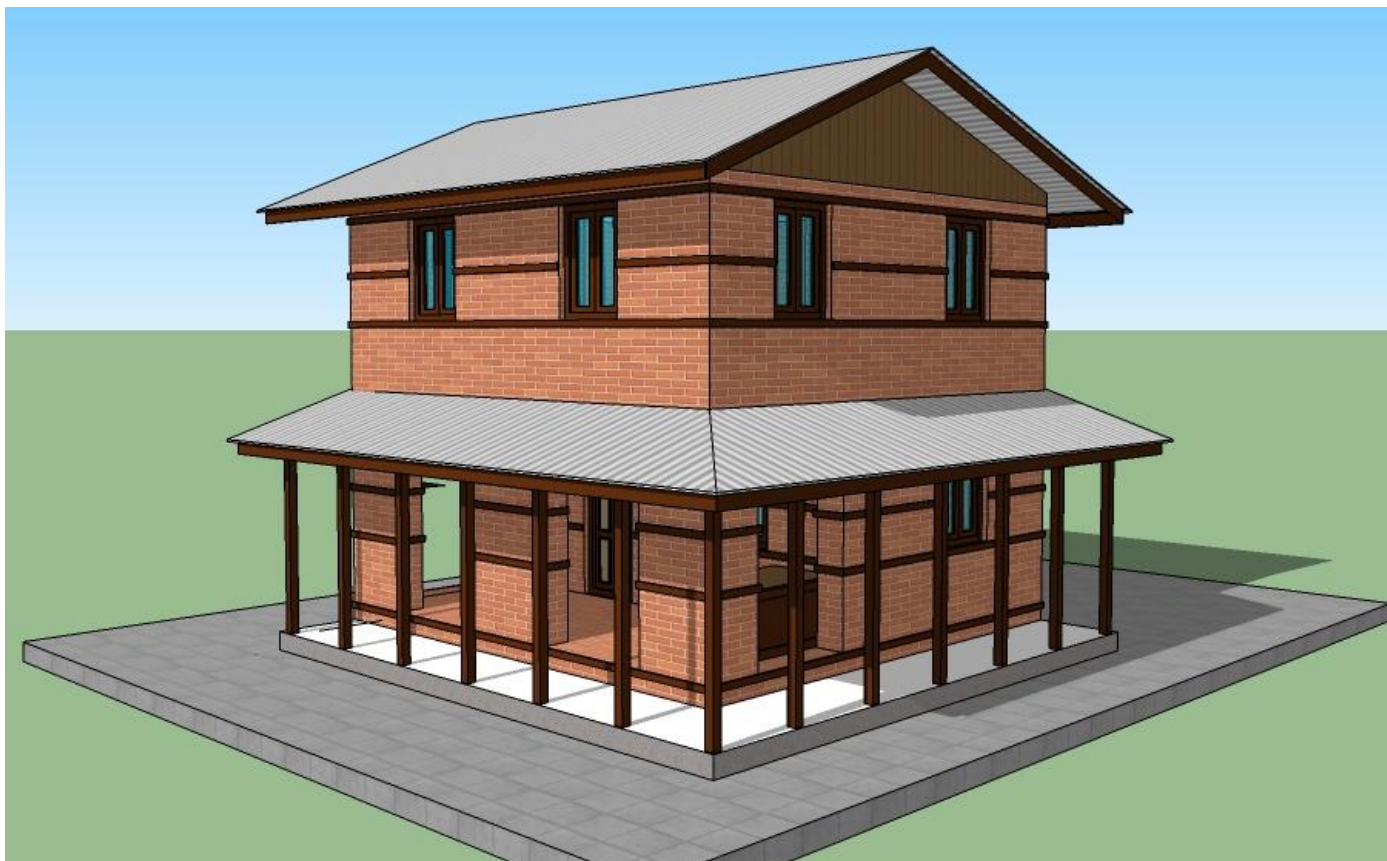
4/4

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

BMC-2.2



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|--------------------|-----------|-----------|-----------|--------|-------|-----------|-------|-----------|----------|-----|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | GI SHEET | Rod |
| | Md | Md | Nos | Bags | Cu.m. | Cu.m. | Cu.m. | Bundel | Rm. | Kg |
| Up to Plinth Level | 52 | 113 | 14296 | 62 | 11 | 3 | 0 | 0 | 0 | 256 |
| SUPERSTRUCTURE | 181 | 110 | 23652 | 121 | 14 | 4 | 3.01 | 0 | 0 | 607 |
| ROOFING | 47 | 18 | 0 | 0 | 0 | 0 | 2.13 | 5.15 | 9 | 0 |
| TOTAL | 280 | 241 | 37948 | 183 | 25 | 7 | 5.14 | 5.15 | 26 | 863 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.2

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

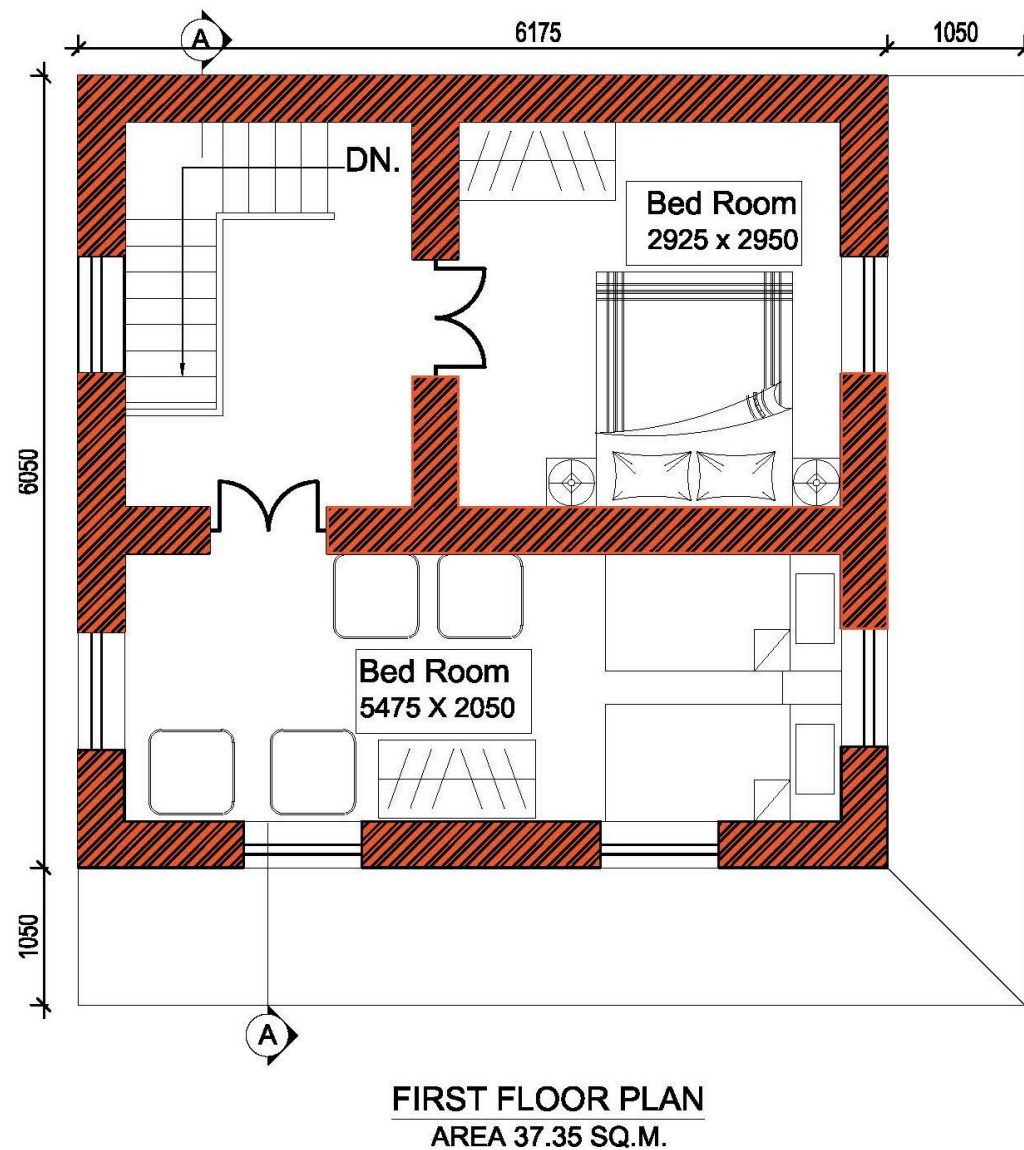
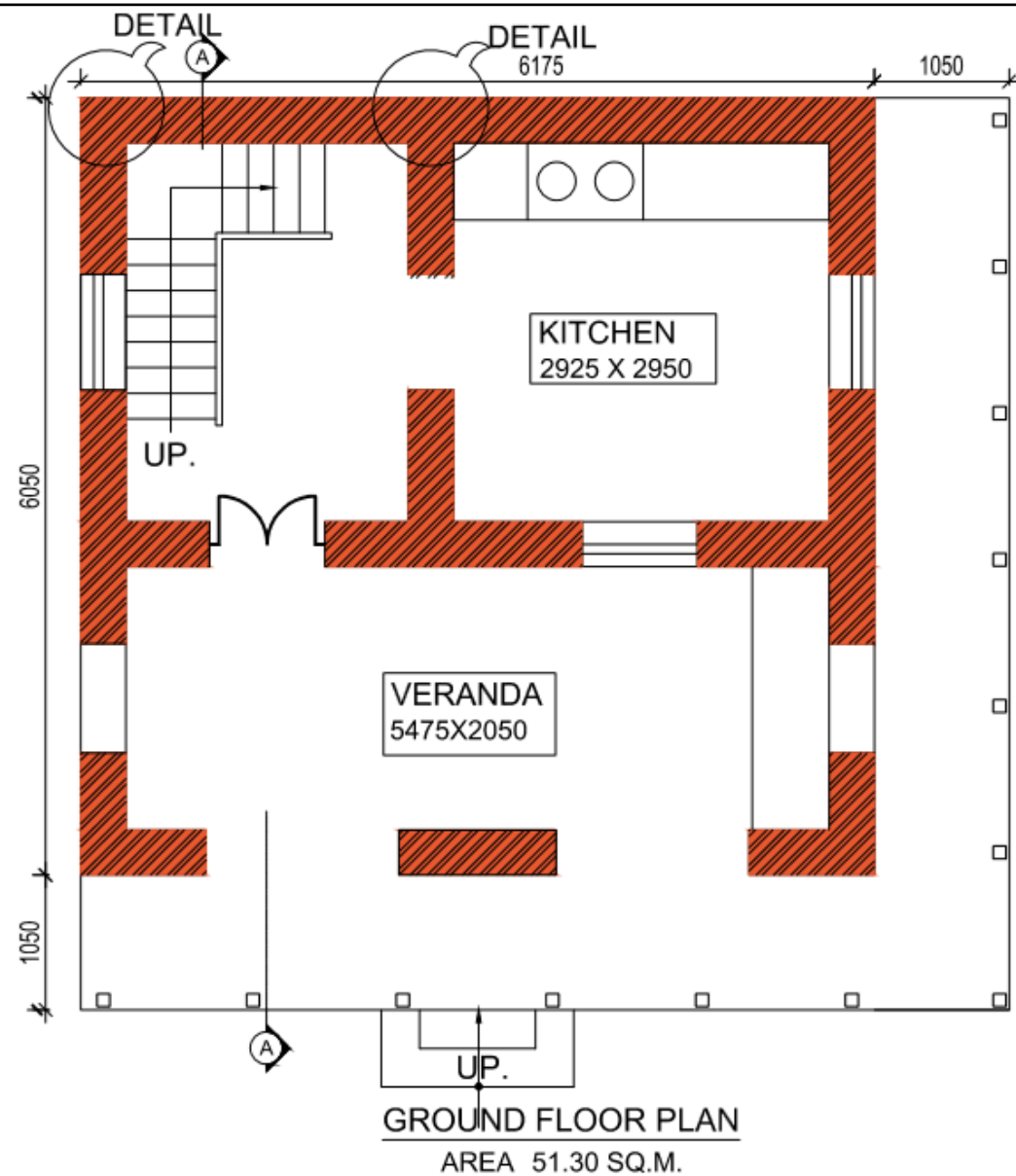
SCALE: NONE

DATE:

DESIGNED BY: DUDBC

BMC-2.2

1/4



TOTAL AREA: 88.65 SQ.M.



Nepal Housing
Reconstruction Programme

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

SCALE: None

DATE:

DESIGNED BY: DUDBC

BMC-2.2

2/4



FRONT ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



RIGHT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

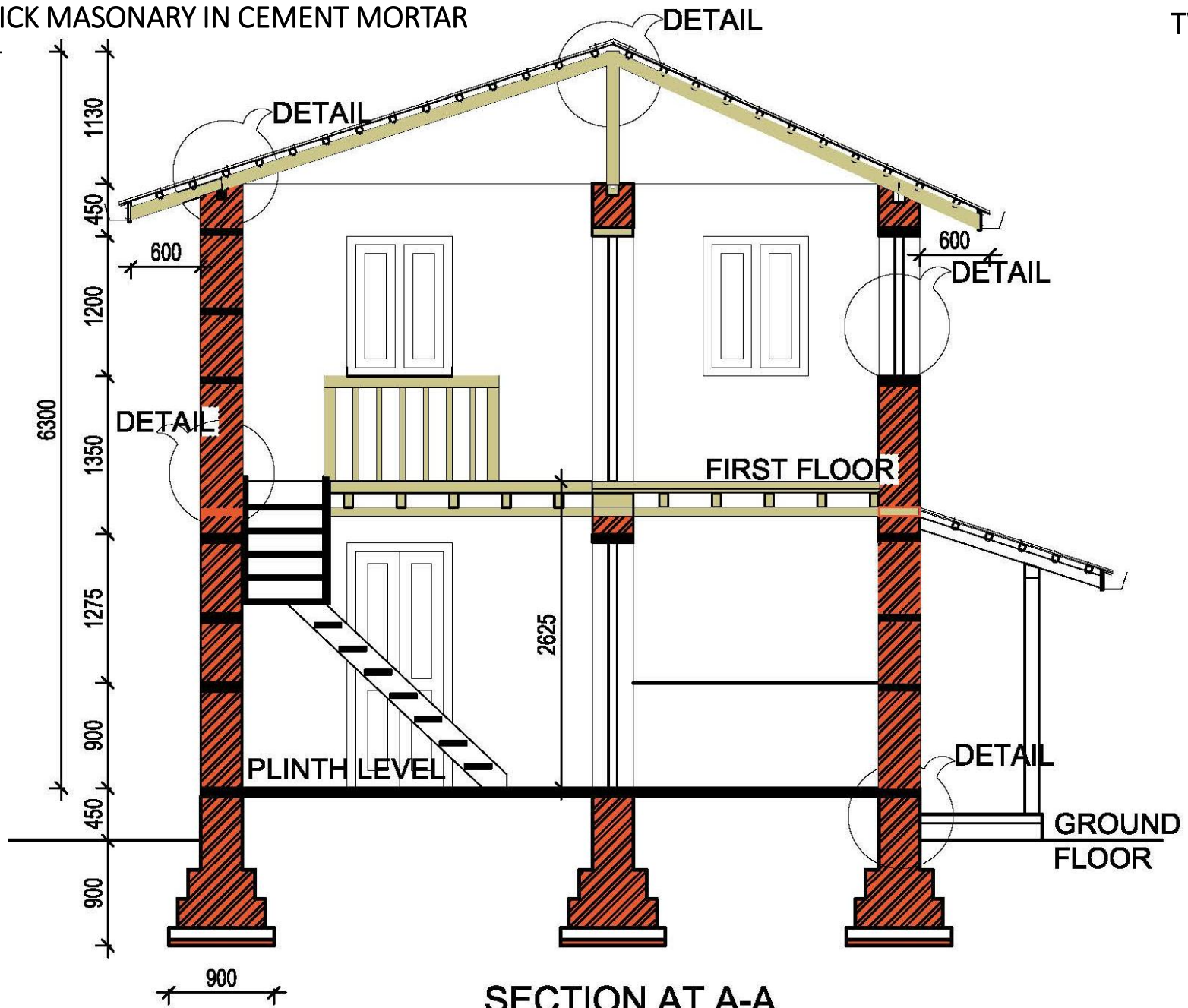
SCALE: 1:100

DATE:

DESIGNED BY: DUDBC

BMC-2.2

3/4



SECTION AT A-A



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMC-2.2

4/4

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.

BMC-2.3



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|--------------------|-----------|-----------|-----------|--------|------|-----------|------|-----------|----------|-----|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | GI SHEET | Rod |
| | Md | Md | Nos | Bags | Cu.m | Cu.m | Cu.m | Bundel | Rm. | Kg |
| Up to Plinth Level | 59 | 132 | 14769 | 82 | 14 | 7 | 2 | 0 | 0 | 242 |
| SUPERSTRUCTURE | 166 | 127 | 23537 | 92 | 12 | 0 | 2 | 0 | 0 | 521 |
| ROOFING | 42 | 14 | 0 | 0 | 0 | 0 | 2 | 4.51 | 9 | 0 |
| TOTAL | 267 | 273 | 38306 | 175 | 27 | 7 | 6 | 4.51 | 9 | 763 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

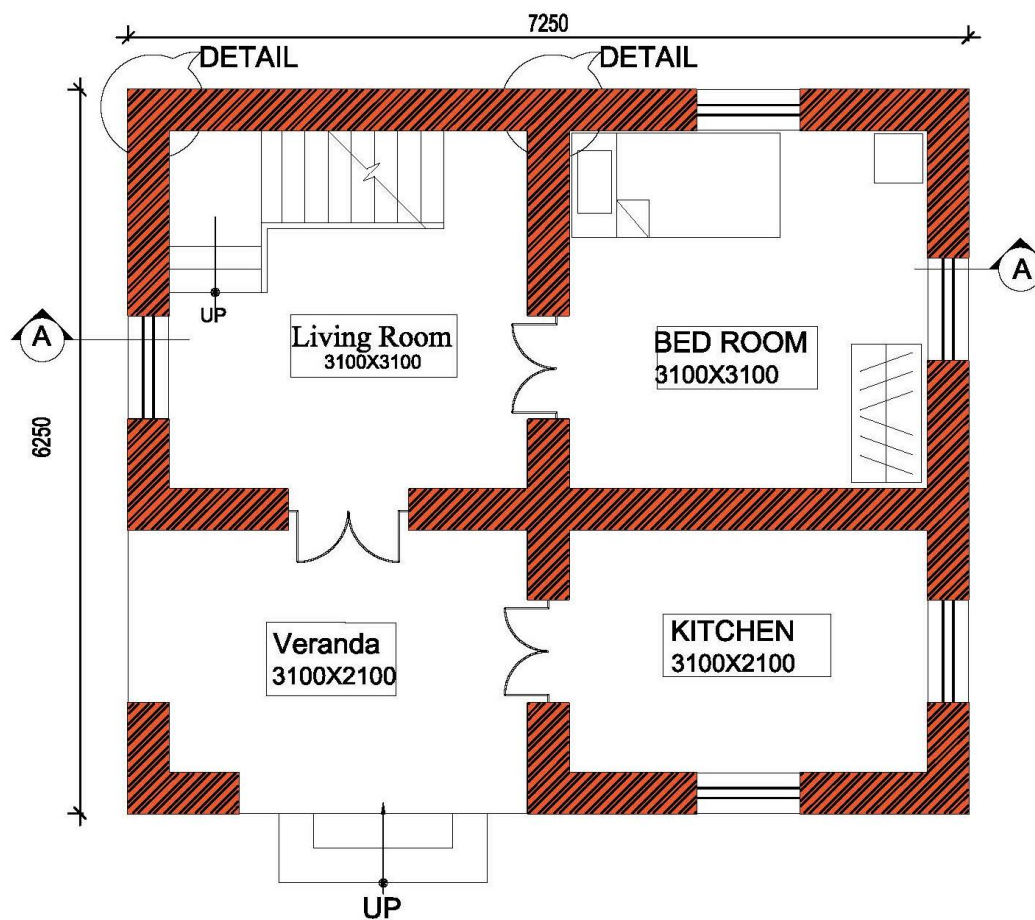
SCALE: NONE

DATE:

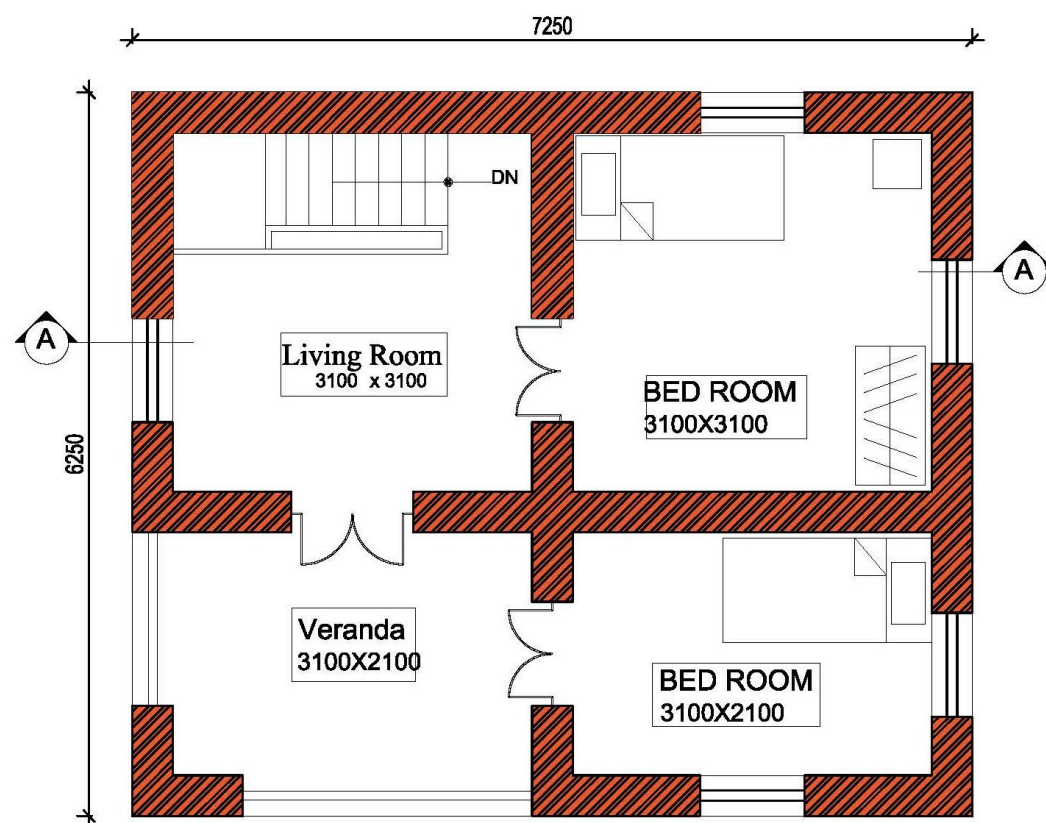
DESIGNED BY: DUDBC

BMC-2.3

1/4



GROUND FLOOR PLAN
AREA 45.35 SQ.M.



FIRST FLOOR PLAN
AREA 45.35 SQ.M.

TOTAL AREA: 90.7sqm



Nepal Housing
Reconstruction Programme

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

SCALE: None

DATE:

DESIGNED BY: DUDBC

BMC-2.3

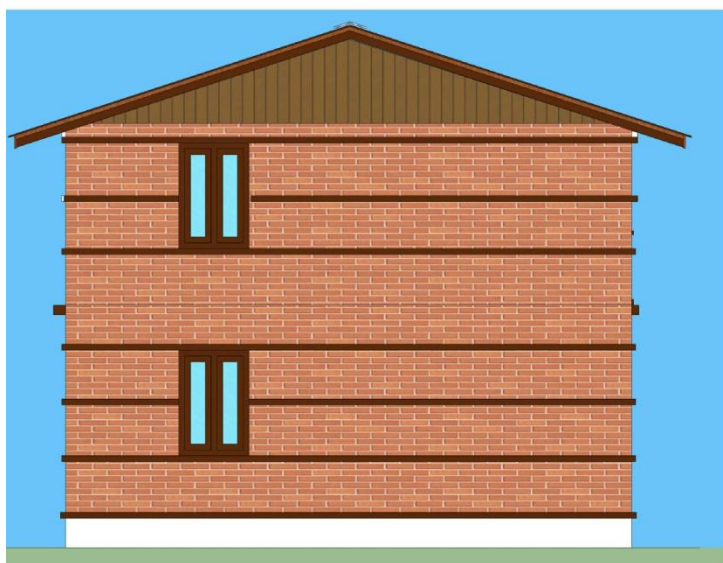
2/4



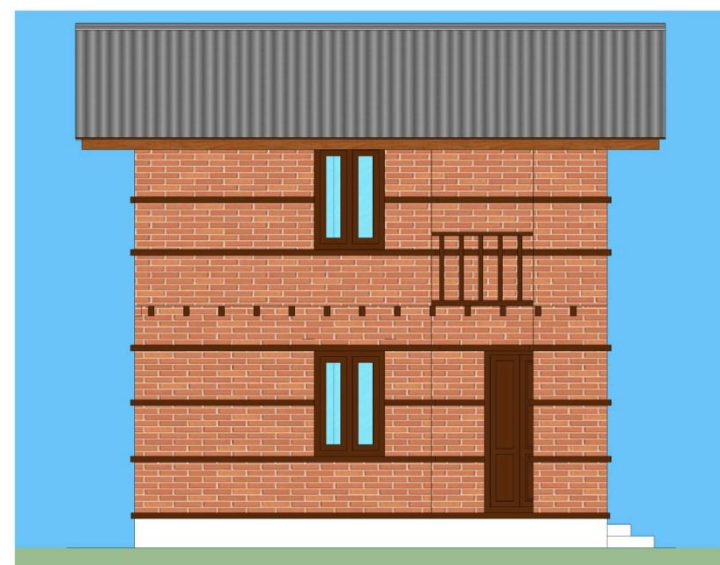
FRONT ELEVATION



RIGHT SIDE ELEVATION



LEFT SIDE ELEVATION



BACK ELEVATION



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

DRAWING TITLE: ELEVATION

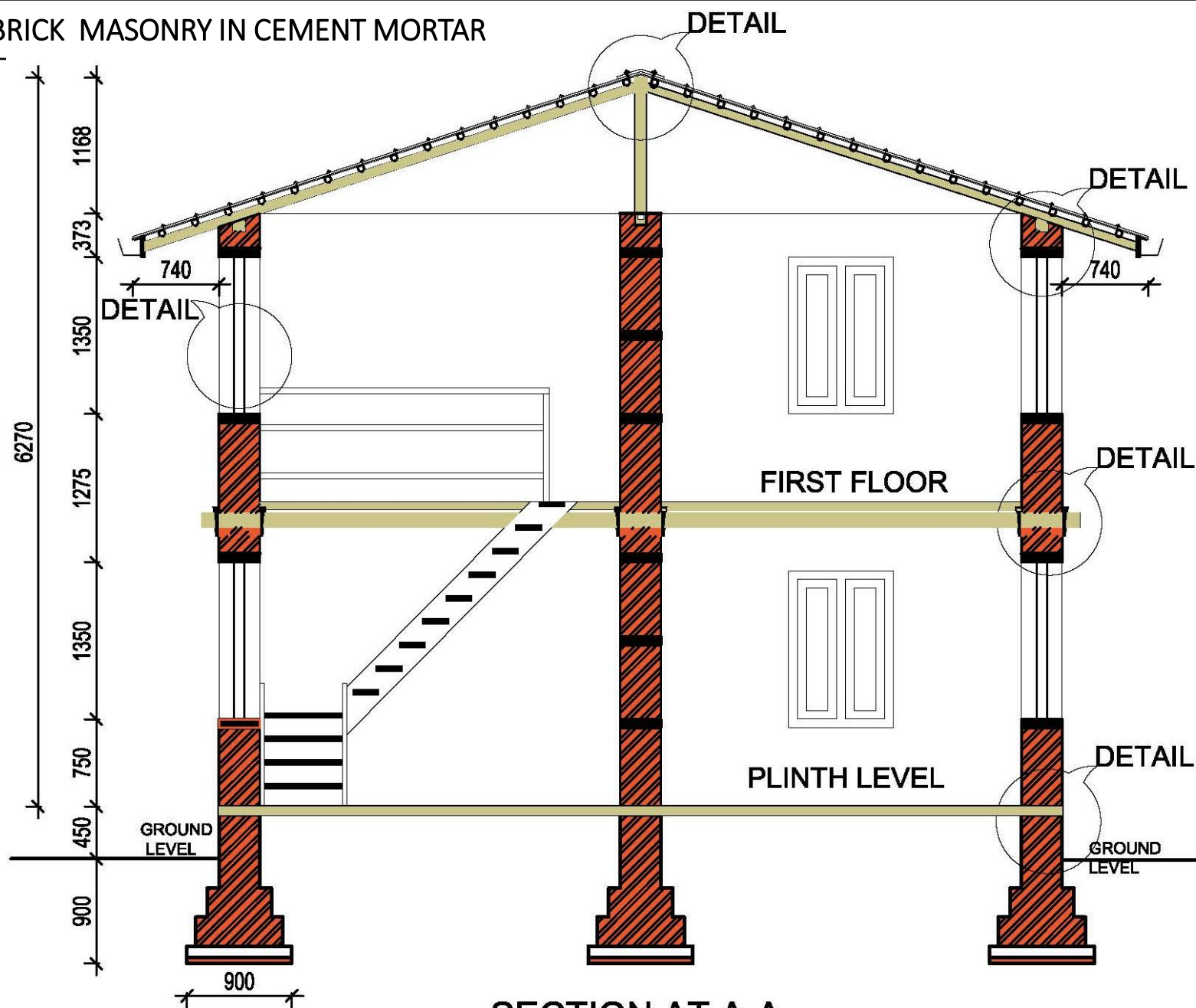
SCALE: 1:100

DATE:

DESIGNED BY: DUDBC

BMC-2.3

3/4



SECTION AT A-A



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3

DRAWING TITLE: SECTION

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMC-2.3

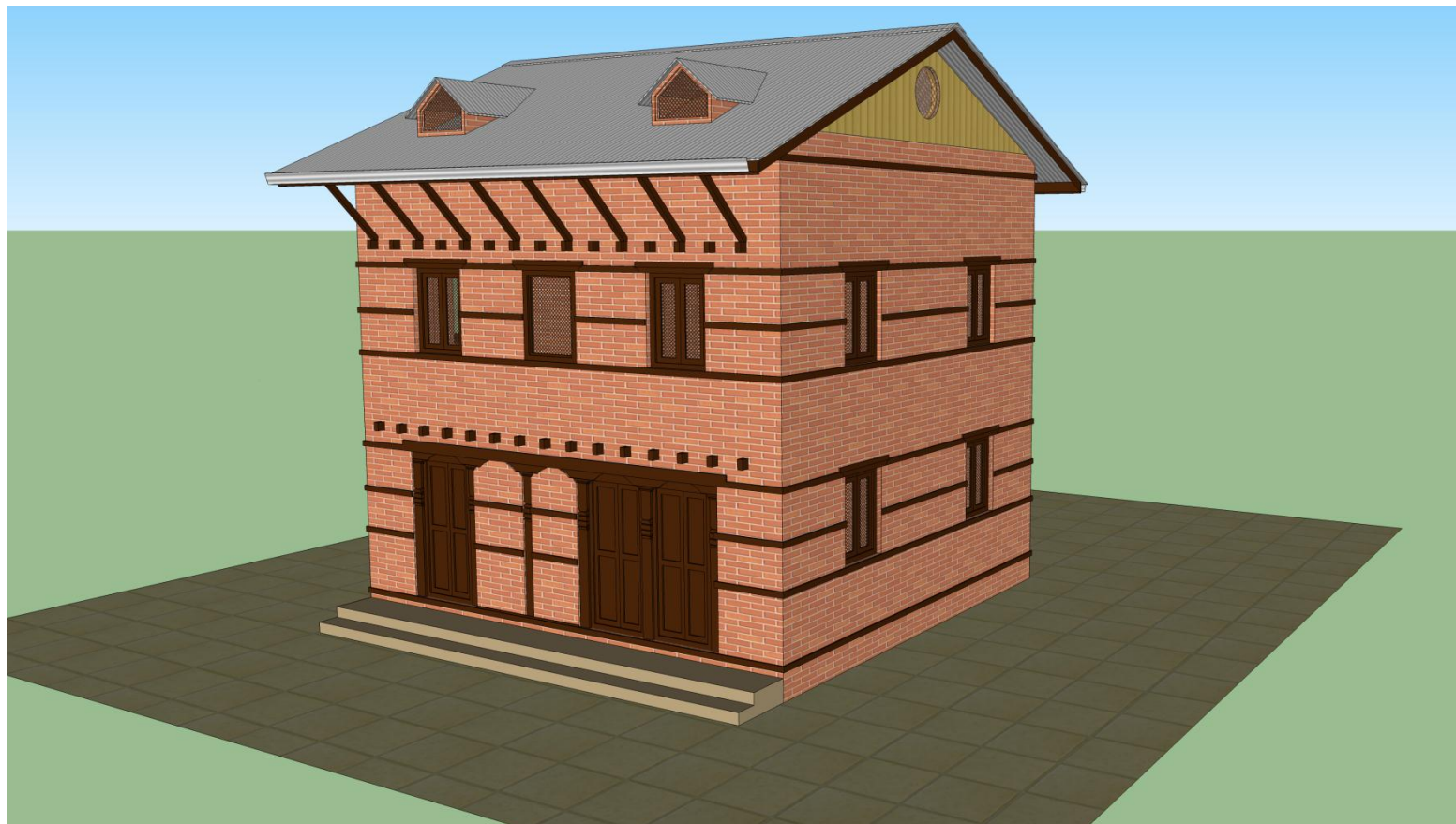
4/4

BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

BMC-2.4

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

BMC-2.4



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | | |
|--------------------|-----------|-----------|-----------|--------|------|-----------|------|-----------|----------|-----|
| | Skilled | Unskilled | Brick | CEMENT | SAND | AGGREGATE | WOOD | CGI SHEET | GI SHEET | Rod |
| | Md | Md | Nos | Bags | Cu.m | Cu.m | Cu.m | Bundel | Rm. | Kg |
| Up to Plinth Level | 48 | 115 | 14446 | 77 | 13 | 6 | 0 | 0 | 0 | 271 |
| SUPERSTRUCTURE | 319 | 216 | 37112 | 176 | 21 | 5 | 5 | 0 | 0 | 557 |
| ROOFING | 41 | 15 | 0 | 0 | 0 | 0 | 2 | 4.97 | 32 | 0 |
| TOTAL | 408 | 345 | 51559 | 252 | 34 | 11 | 7 | 4.97 | 32 | 828 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.4

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

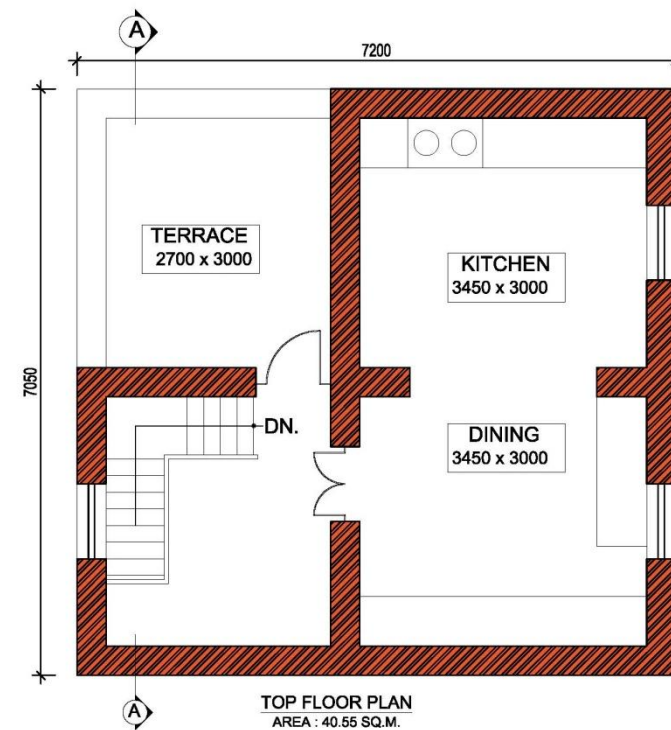
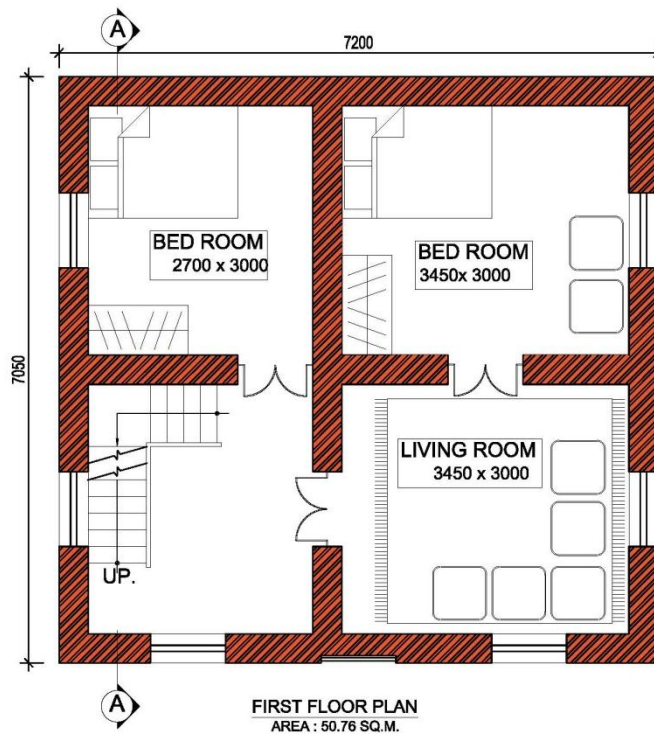
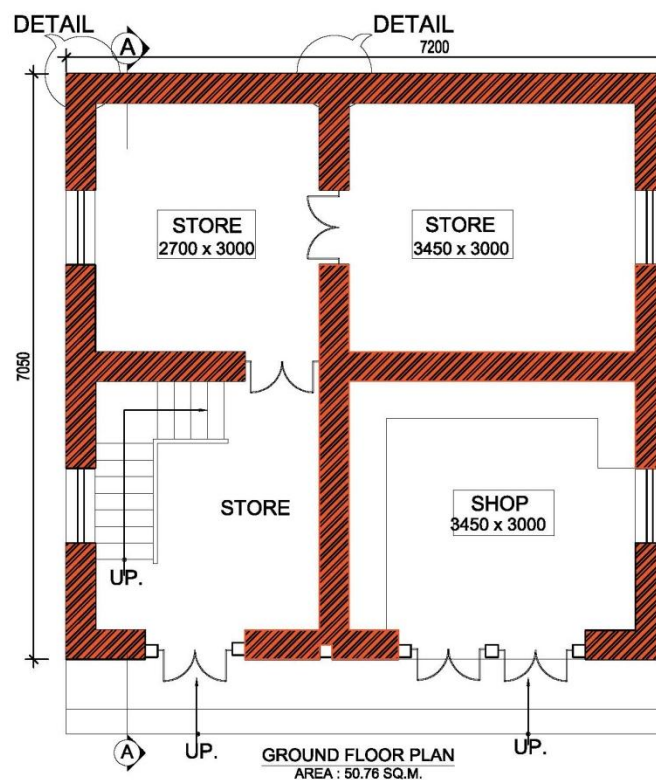
SCALE: NONE

DATE:

DESIGNED BY: DUDBC

BMC-2.4

1/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.4
DRAWING TITLE: FLOOR PLAN

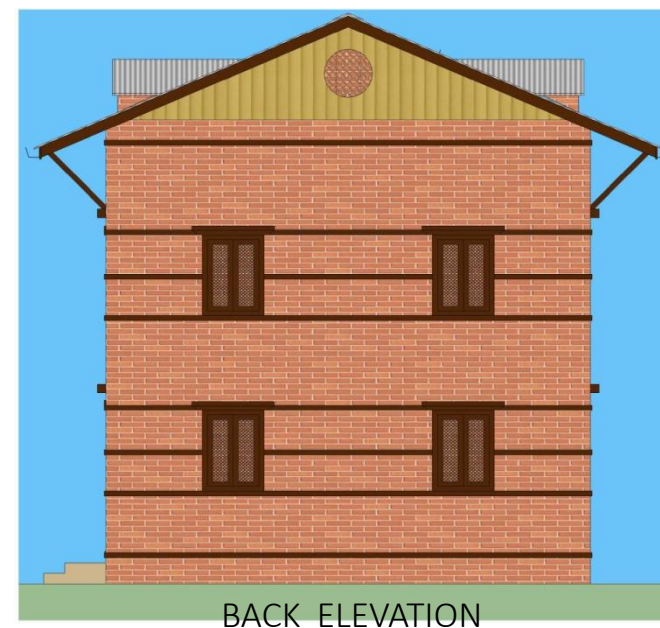
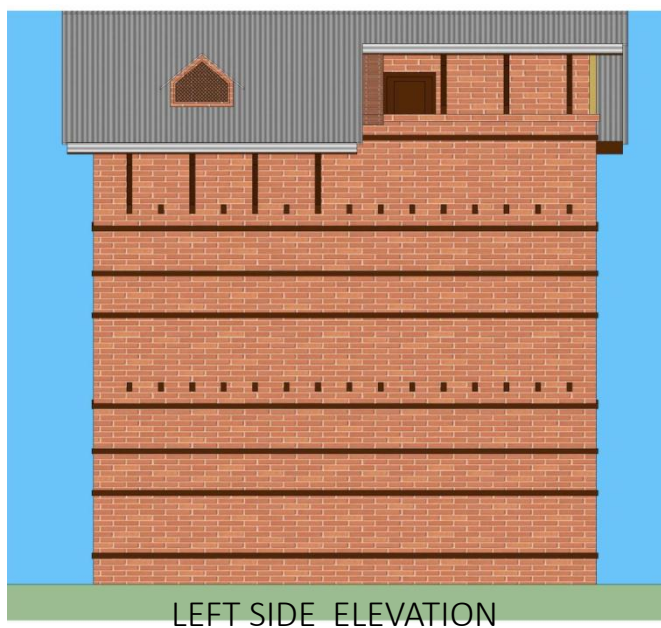
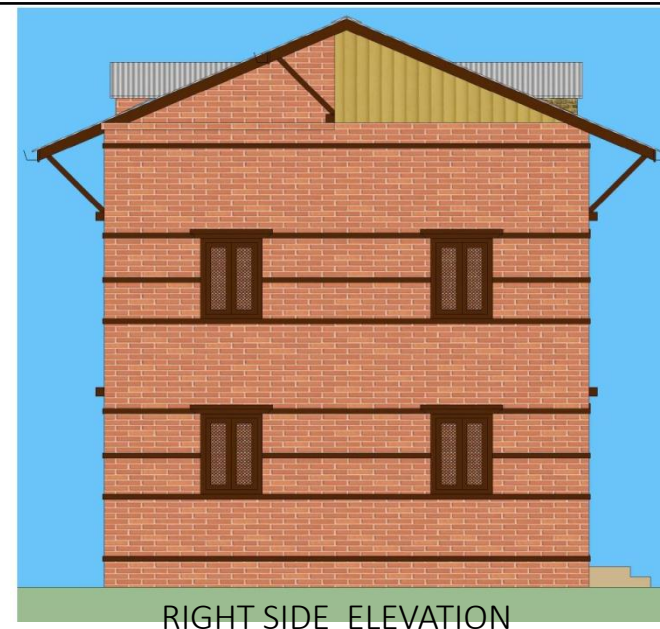
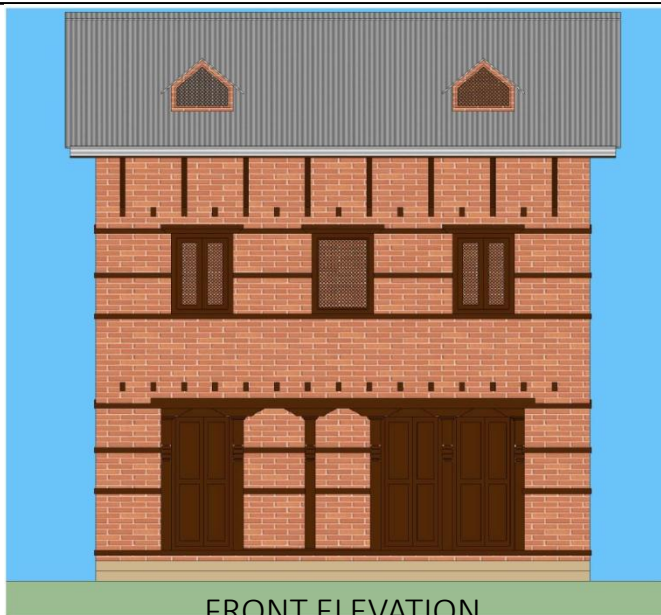
SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMC-2.4

2/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.4

DRAWING TITLE: ELEVATION

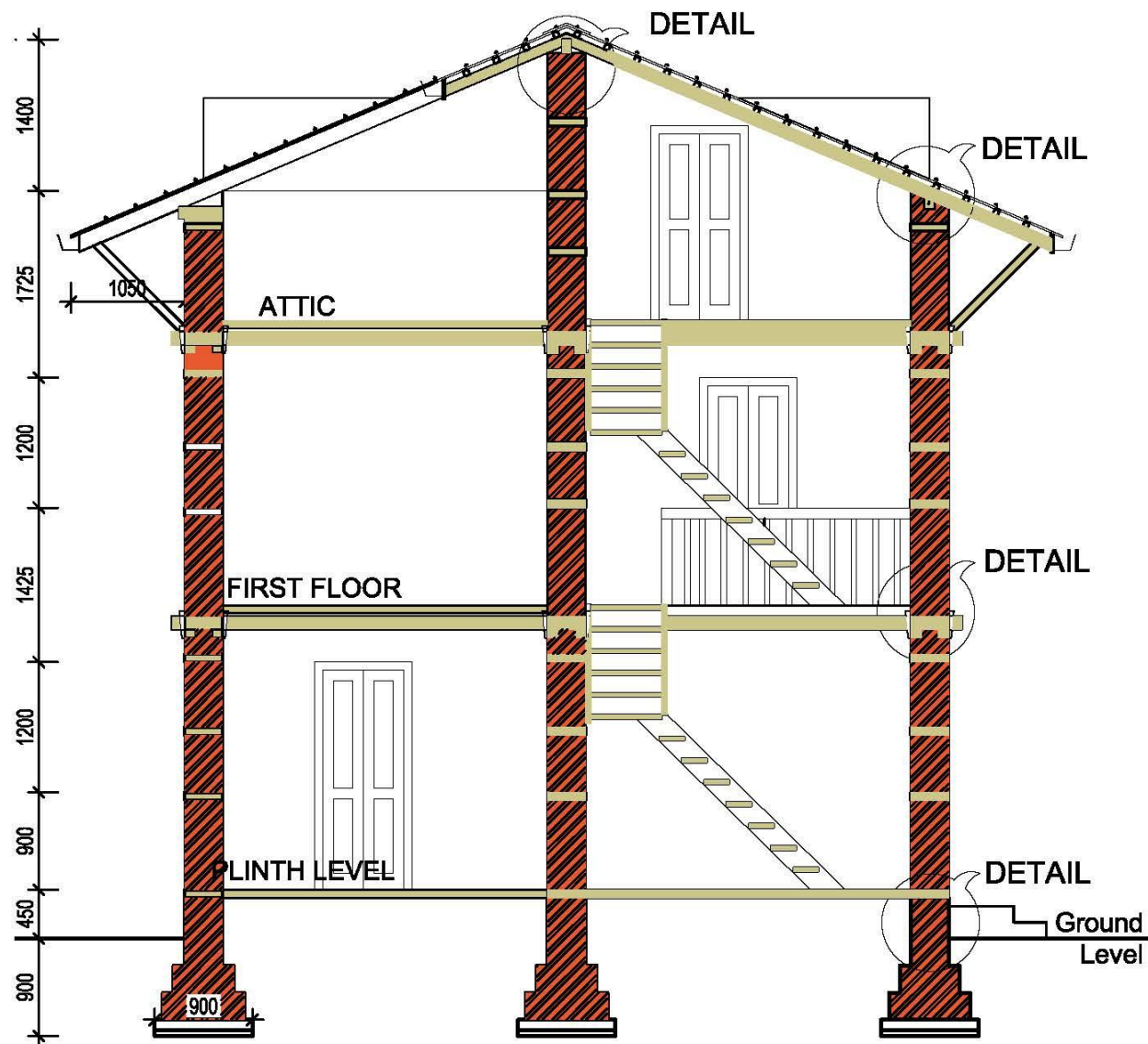
SCALE: 1:100

DATE:

DESIGNED BY: DUDBC

BMC-2.4

3/4



SECTION AT A-A



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.4
DRAWING TITLE: SECTION

SCALE: None

DATE:

DESIGNED BY: DUDBC

BMC-2.4

4/4

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

BMC-2.5



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | | | |
|--------------------|-----------|-----------|-----------|------|--------|------|-----------|------|---------------|
| | Skilled | Unskilled | Brick | MUD | CEMENT | SAND | AGGREGATE | WOOD | REINFORCEMENT |
| | Md | Md | Nos | Cu.m | Bags | Cu.m | Cu.m | Cu.m | BAR |
| Up to Plinth Level | 45 | 109 | 11012 | 1136 | 71 | 11 | 5 | 0 | 101 |
| Ground FLOOR | 127 | 146 | 15561 | 0 | 116 | 13 | 5 | 0.84 | 850 |
| FIRST FLOOR | 124 | 141 | 15156 | 0 | 115 | 13 | 6 | 0.81 | 840 |
| TOTAL | 296 | 396 | 41730 | 1136 | 302 | 37 | 16 | 1.64 | 1791 |



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.5

DRAWING TITLE: PERSPECTIVE AND ESTIMATION

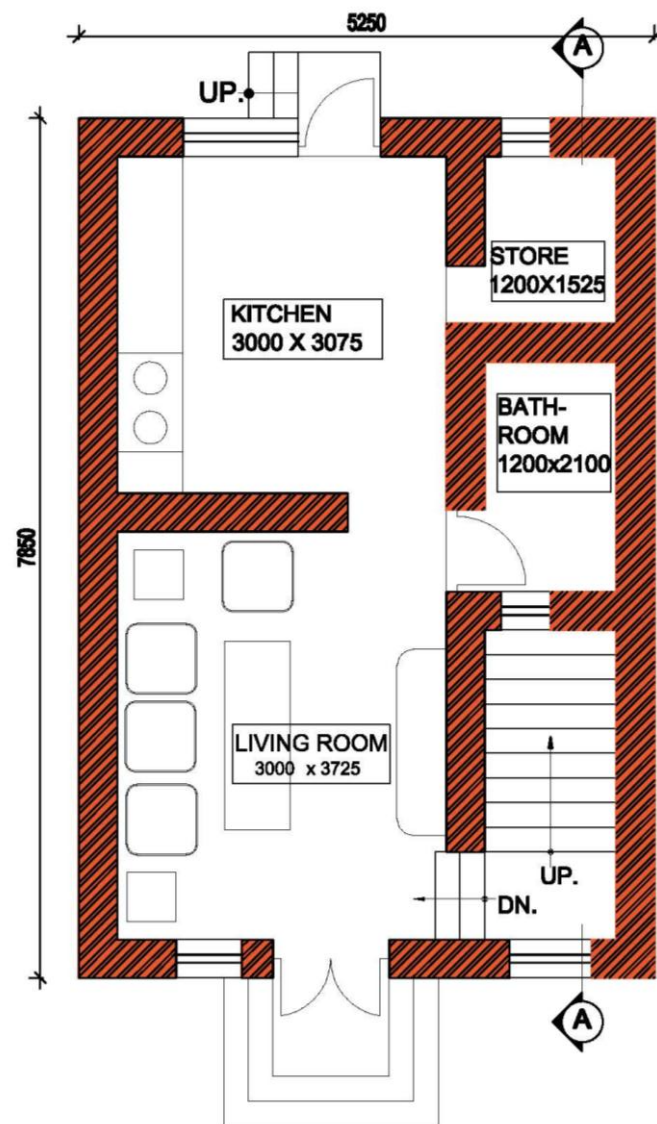
SCALE: None

DATE:

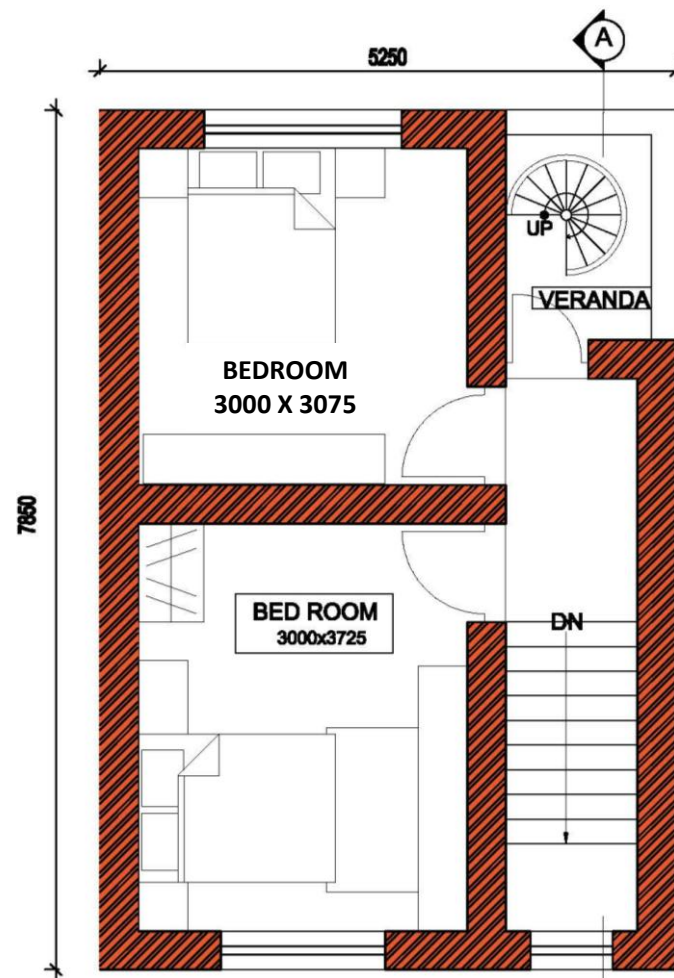
DESIGNED BY: DUDBC

BMC-2.5

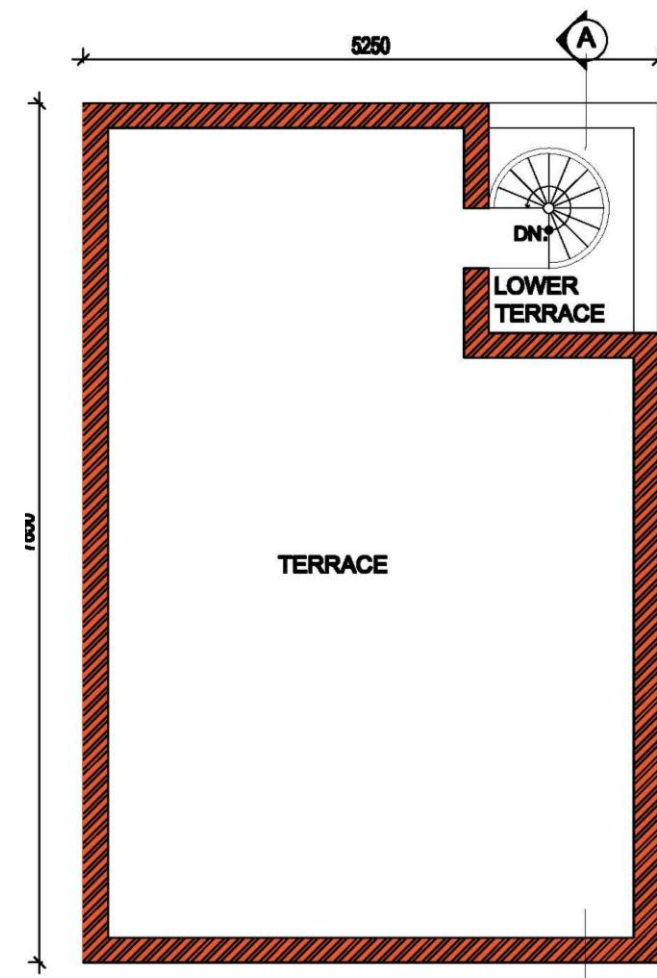
1/4



GROUND FLOOR PLAN
AREA 41.22 SQ.M.



FIRST FLOOR PLAN
AREA 41.52 SQ.M.



ROOF PLAN
AREA 38.00 SQ.M.



Nepal Housing
Reconstruction Programme

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

SCALE: None

DATE:

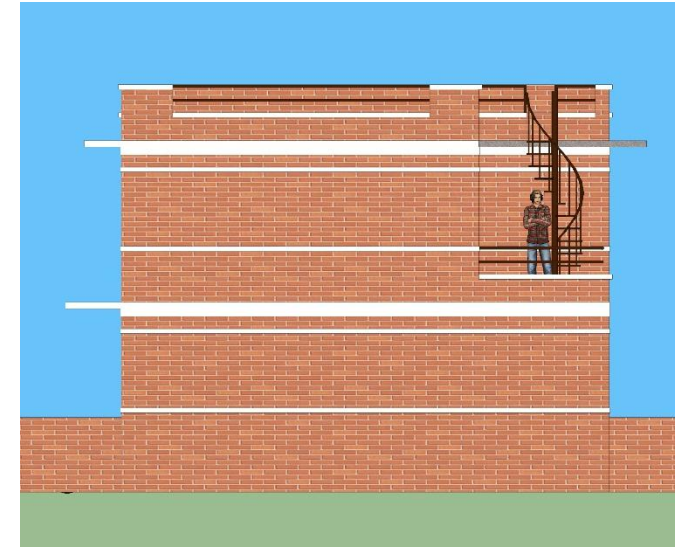
DESIGNED BY: DUDBC

BMC-2.5

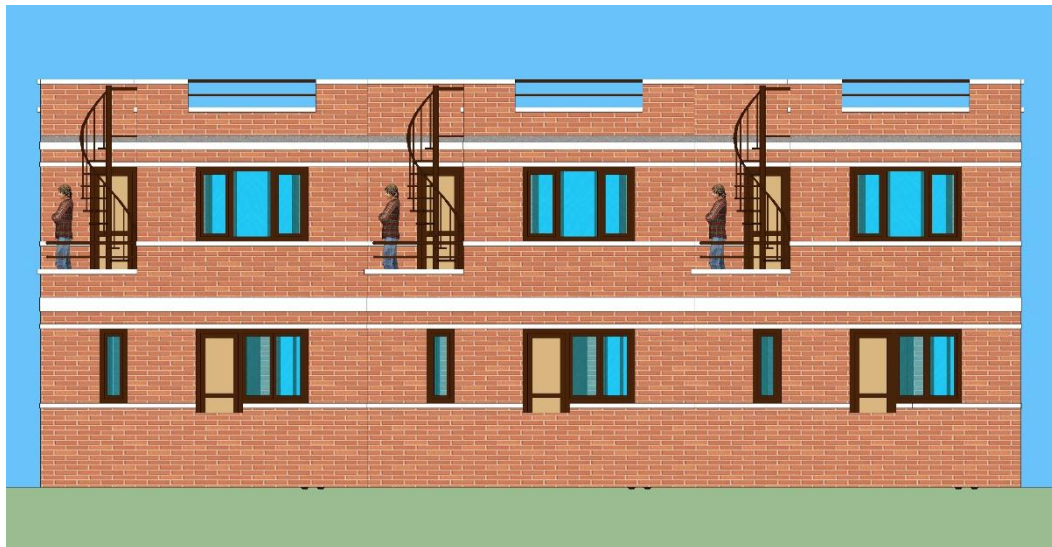
2/4



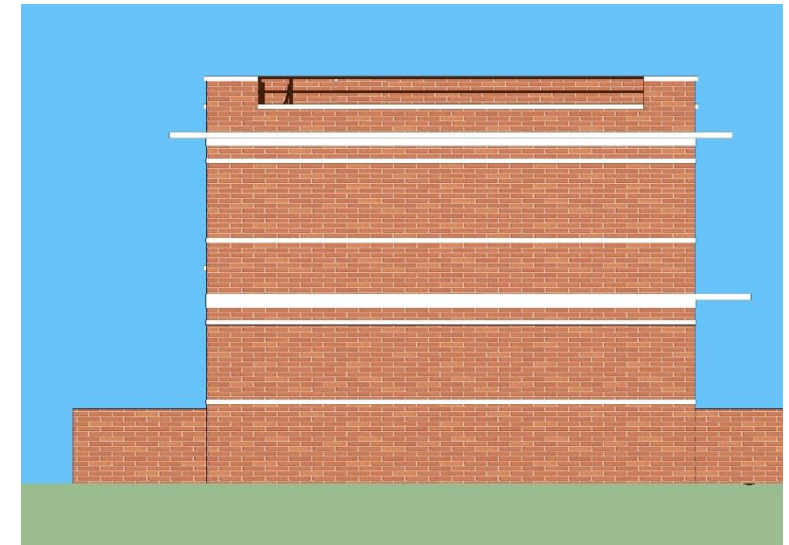
FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

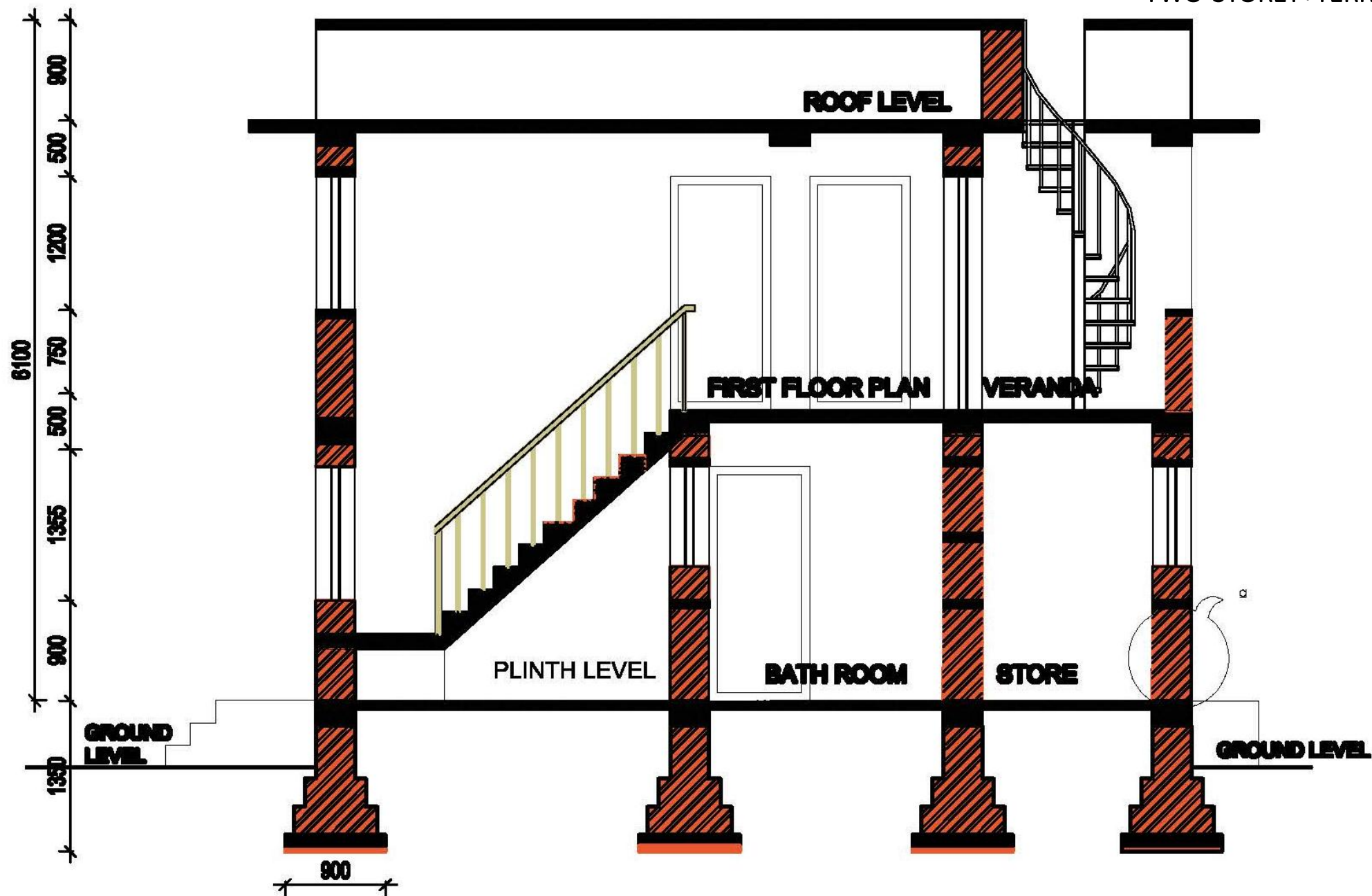
SCALE: None

DATE:

DESIGNED BY: DUDBC

BMC-2.5

3/4



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMC-2.5

4/4

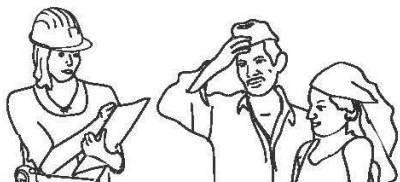
BRICK MASONRY IN CEMENT MORTAR (BMC)

Technical Details

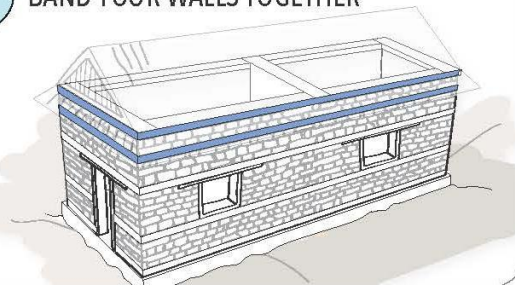


Well built **STONE** houses can better withstand earthquakes. Here are **10 TIPS ON HOW TO BUILD BACK SAFER**

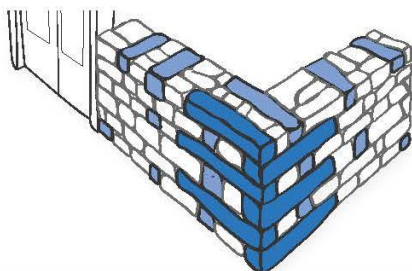
1 GET TECHNICAL ADVICE BEFORE YOU START



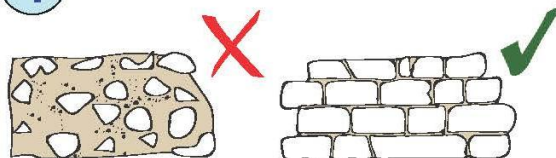
2 BAND YOUR WALLS TOGETHER



3 TIE YOUR HOUSE TOGETHER WITH TIESTONES



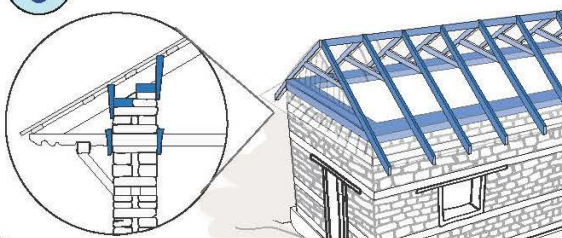
4 BUILD YOUR HOUSE WITH GOOD MATERIALS



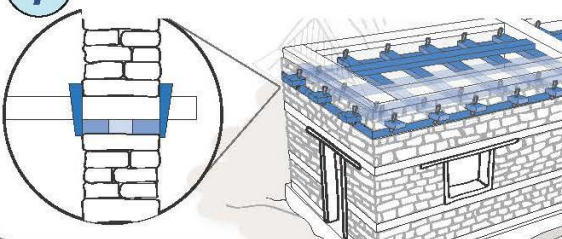
5 TIE YOUR GABLES UP



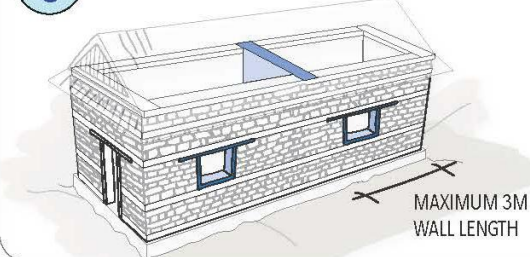
6 TIE YOUR ROOF DOWN



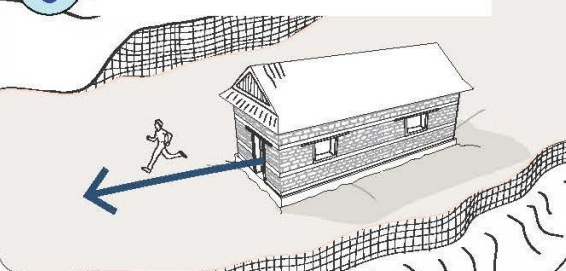
7 TIE YOUR FLOORS TO YOUR WALLS



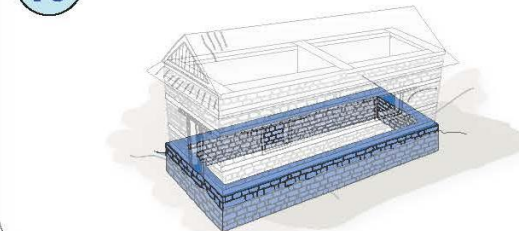
8 BUILD A STRONG SHAPE



9 HAVE A SAFE SITE AND A SAFE EXIT



10 BUILD ON STRONG FOUNDATIONS



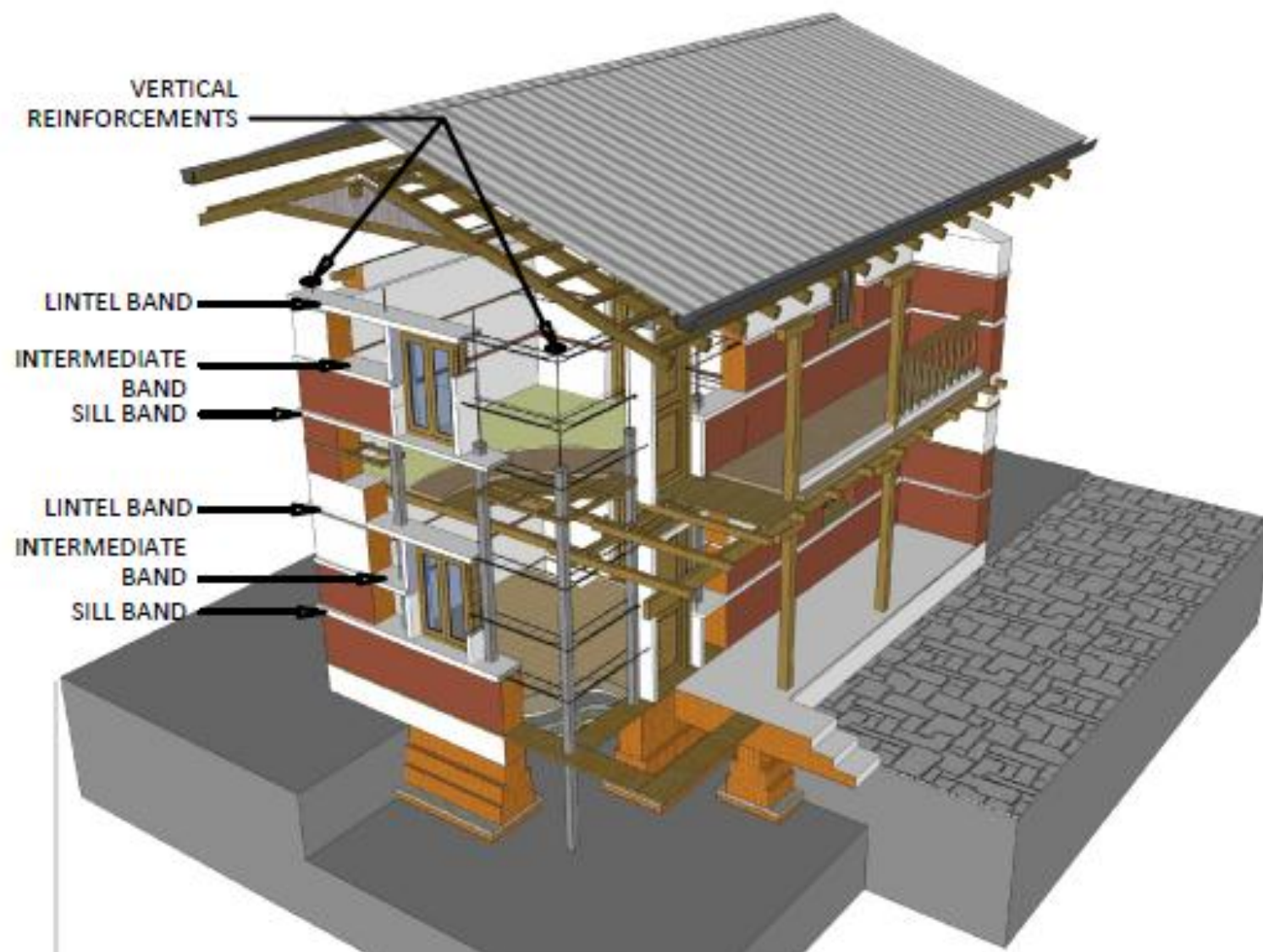
 **Shelter Cluster Nepal**
ShelterCluster.org
Coordinating Humanitarian Shelter

 **Government of Nepal**
Ministry of Urban Development
Department of Urban Development
and Building Construction

**10 KEY MESSAGES -
A VISUAL INDEX**
VERSION 2- 09/OCT/2015

10 KEY MESSAGES

BRICK MASONRY IN CEMENT MORTAR



Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC

DRAWING TITLE:

TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)

SCALE:

None

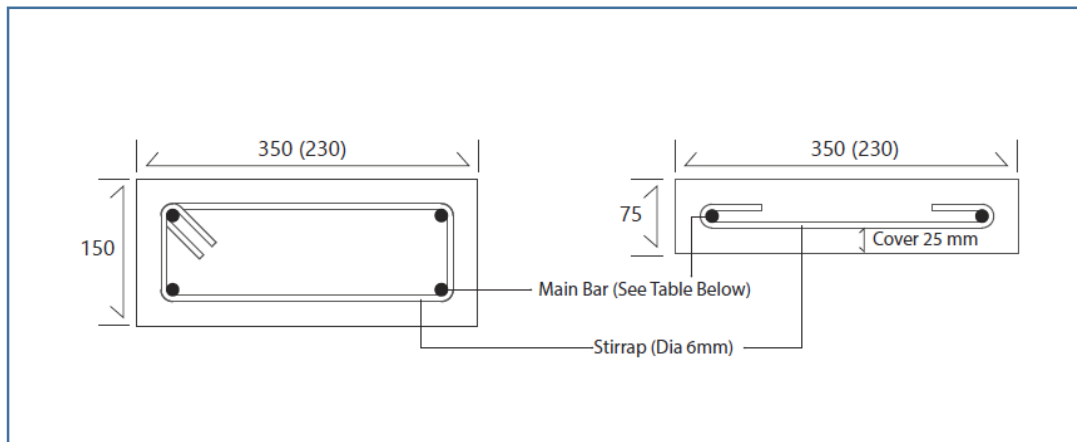
DATE:

DESIGNED BY:

DUDBC

BMC

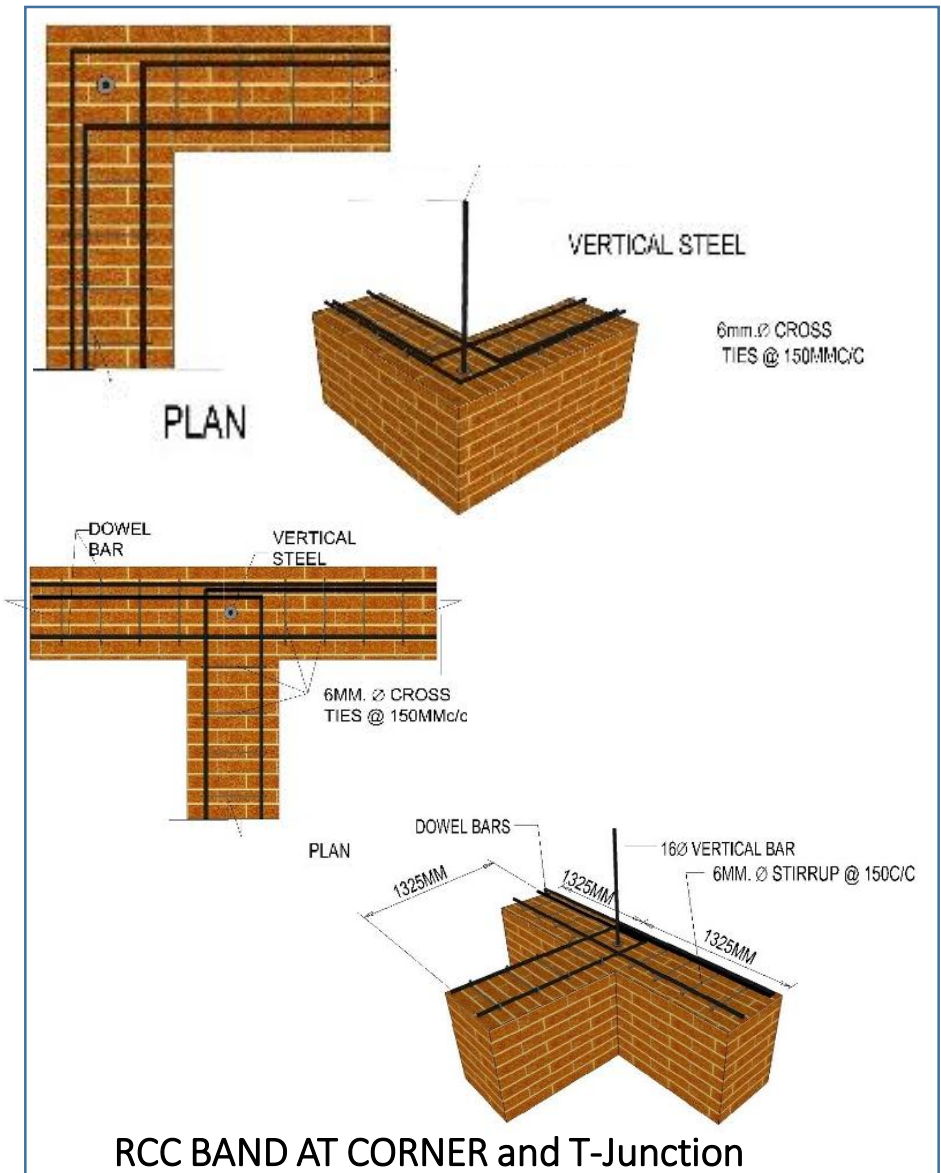
BRICK MASONRY IN CEMENT MORTAR



Cross section of RC bands for two bars and four bars

Requirement of bar for RC bands

| Band/Beam | RC Band Minimum Thickness | Min. No. Of. Bars | Min. Diameter of Bars (mm) |
|----------------|---------------------------|-------------------|----------------------------|
| Plinth | 150 mm | 4 | 12 |
| Still | 75 mm | 2 | 10 |
| Lintel | 75mm | 2 | 12 |
| | 150mm | 2 | 10 (top) 12 (bottom) |
| Roof | 75mm | 2 | 12 |
| | 300mm | 4 | 12 |
| Dowel (Stitch) | 75mm | 2 | 8 |



RCC BAND AT CORNER and T-Junction

*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL SMC

DRAWING TITLE:

TECHNICAL DETAIL 2 (Reinforcing bar arrangement)

SCALE:

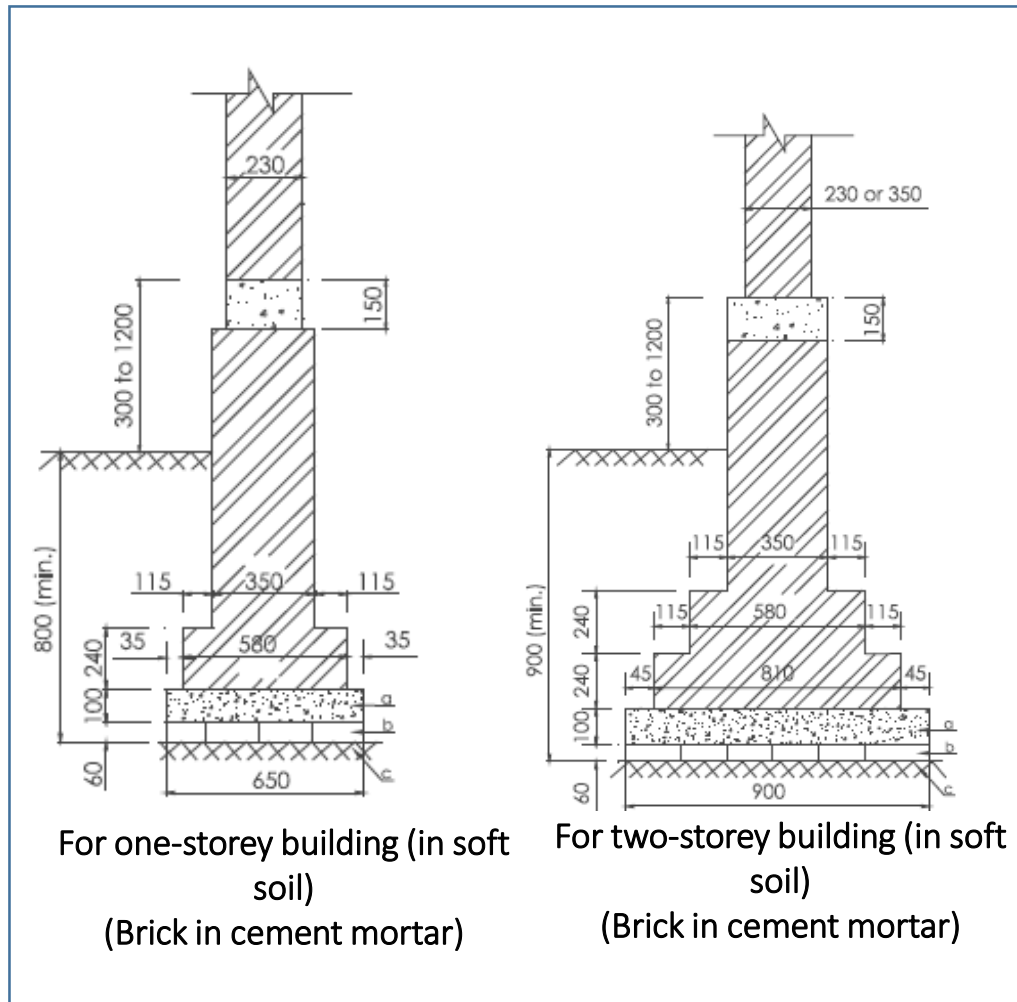
None

DATE:

DESIGNED BY:

SMC

BRICK MASONRY IN CEMENT MORTAR



Base width of footing

| Masonry Type | No. Of Story | Minimum base width (mm) of wall footing for soil type: | | |
|--------------|--------------|--|--------|------|
| | | Soft | Medium | Hard |
| Brick | Two | 900 | 650 | 550 |
| | One | 650 | 550 | 550 |
| Stone | Two | * | 600 | 600 |
| | One | 800 | 600 | 600 |

Classification of Foundation Soil and Safe Bearing Capacity

| Foundation Soil Classification | Types of Foundation Materials | Presumed Safe Bearing Capacity, KN/m ² |
|--------------------------------|---|---|
| Hard | Rocks in different state of wearthing, boulder bed, gravel, sandy gravel and sand-gravel mixture, dense or loose coarse to medium sand offering high resitance to penetration when excavated by tools;stiff to medium clay which is readily indented with a thumb nail. | ≥ 200 |
| Medium | 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. | < 200 and ≥ 150 |
| Soft | Fine sand, loose and dry; soft clay indented with moderate thumb pressure. | < 150 and ≥ 100 |
| Weak | Very soft clay which can be penetrated several centimeters with the thumb, wet clays. | < 100 |

*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC

DRAWING TITLE:

TECHNICAL DETAIL 3 (Foundation)

SCALE:

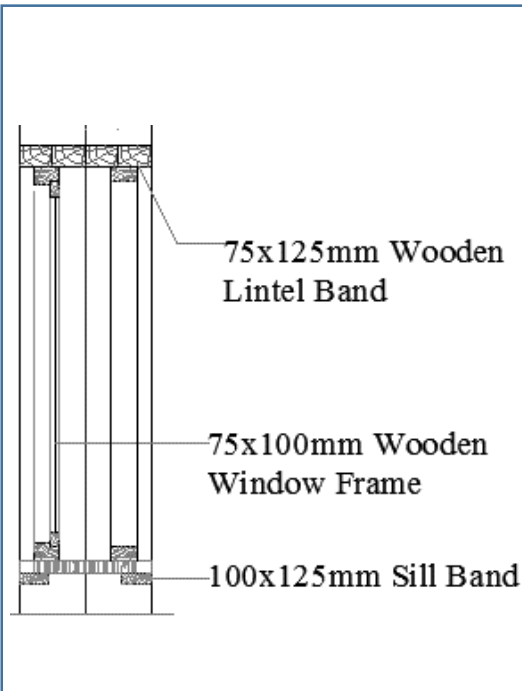
None

DATE:

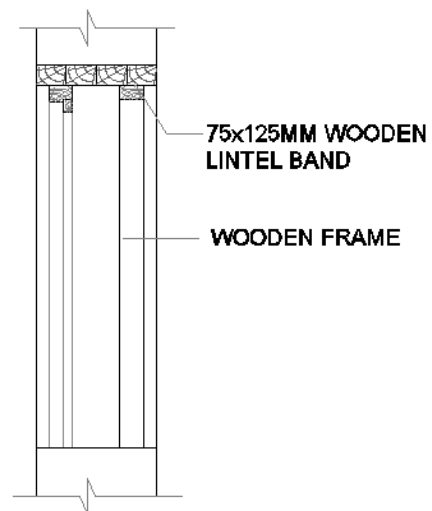
DESIGNED BY:

BMC

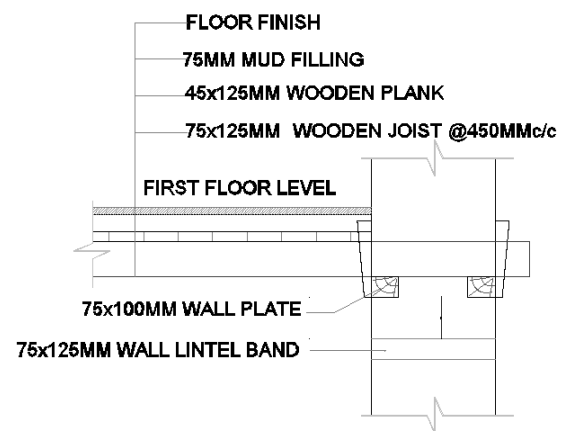
BRICK MASONRY IN CEMENT MORTAR



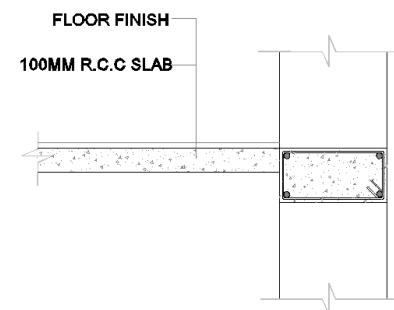
Window Section



Door Section



Type 1



Type 2

First Floor Detail

*Source : NBC202



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC

DRAWING TITLE:

TECHNICAL DETAIL 4 (Opening and Floor)

SCALE:

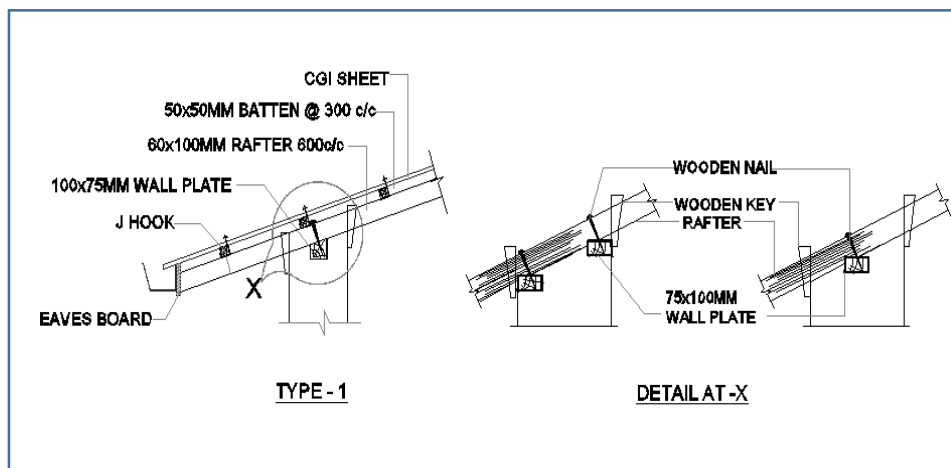
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DATE:

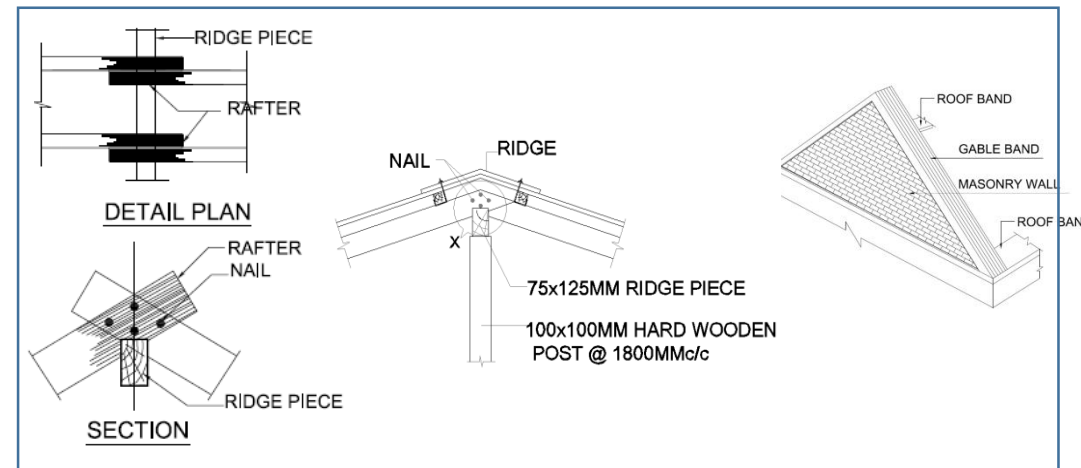
DESIGNED BY:

BMC

BRICK MASONRY IN CEMENT MORTAR



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)

SCALE: None

DATE:

DESIGNED BY:

BMC

BRICK MASONRY IN CEMENT MORTAR

◆ Top (Plan) View



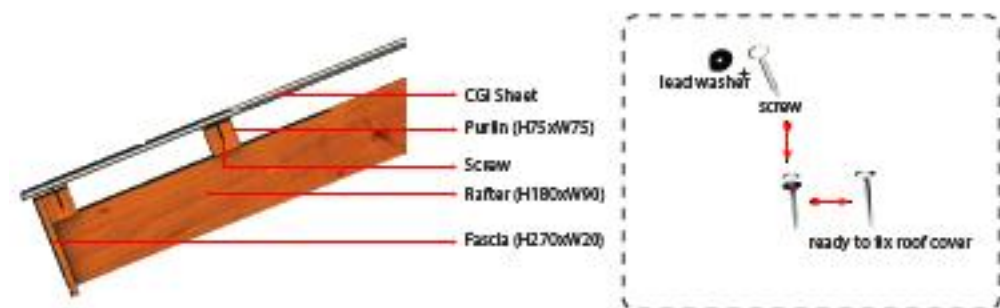
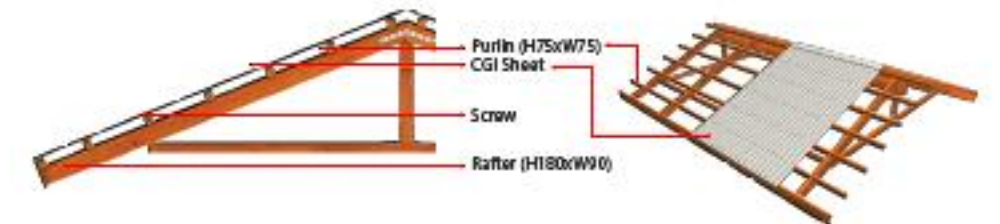
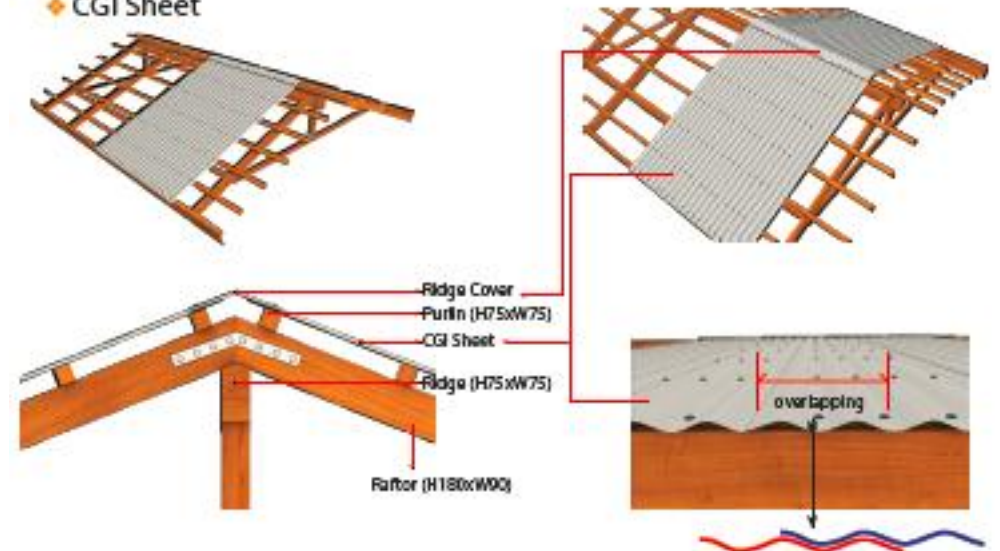
◆ Side View



◆ Isometric View



◆ CGI Sheet



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE:

MODEL BMC

DRAWING TITLE:

TECHNICAL DETAIL 6 (Roofing)

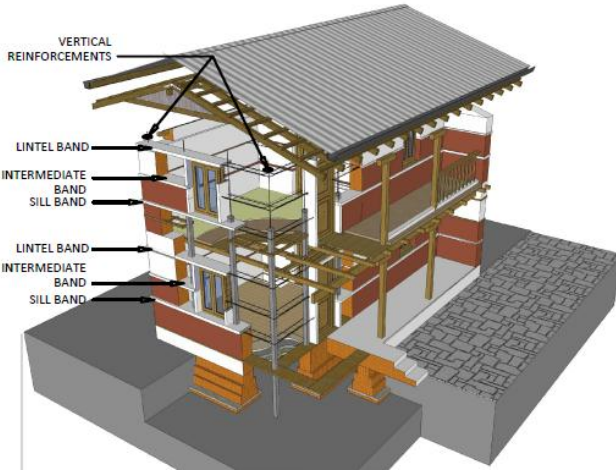
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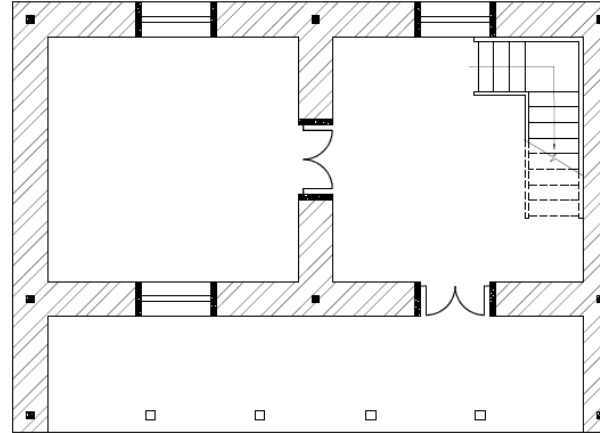
DATE:

DESIGNED BY:

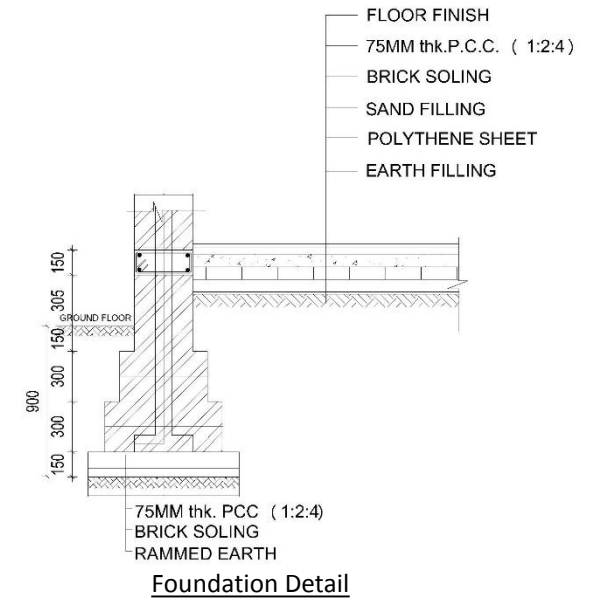
BMC



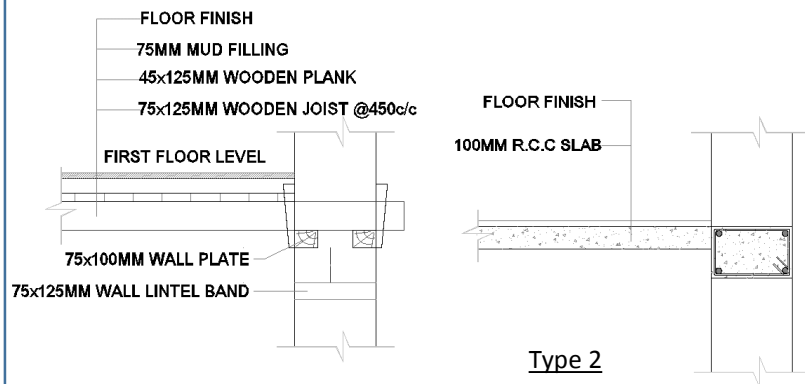
Earthquake Resistant Elements in Building



Typical Ground/ First Floor Plan



Foundation Detail

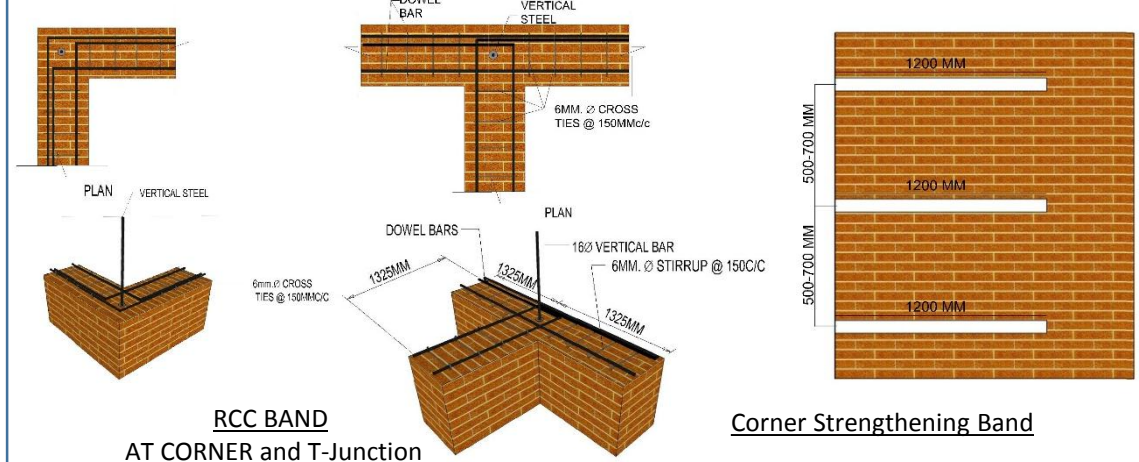


Type 1

Wooden Floor Detail

Type 2

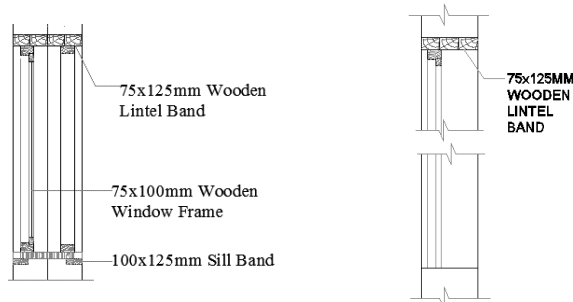
RCC Floor Detail



RCC BAND

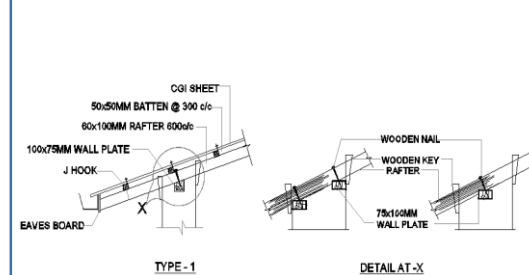
AT CORNER and T-Junction

Corner Strengthening Band

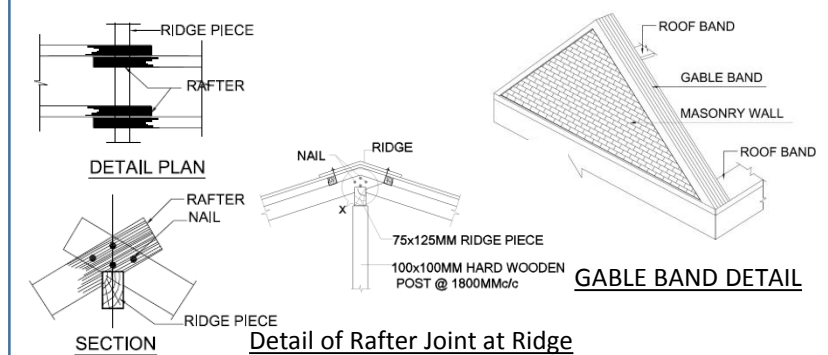


Window Section

Door Section



Detail of Rafter Joint with Wall Plate



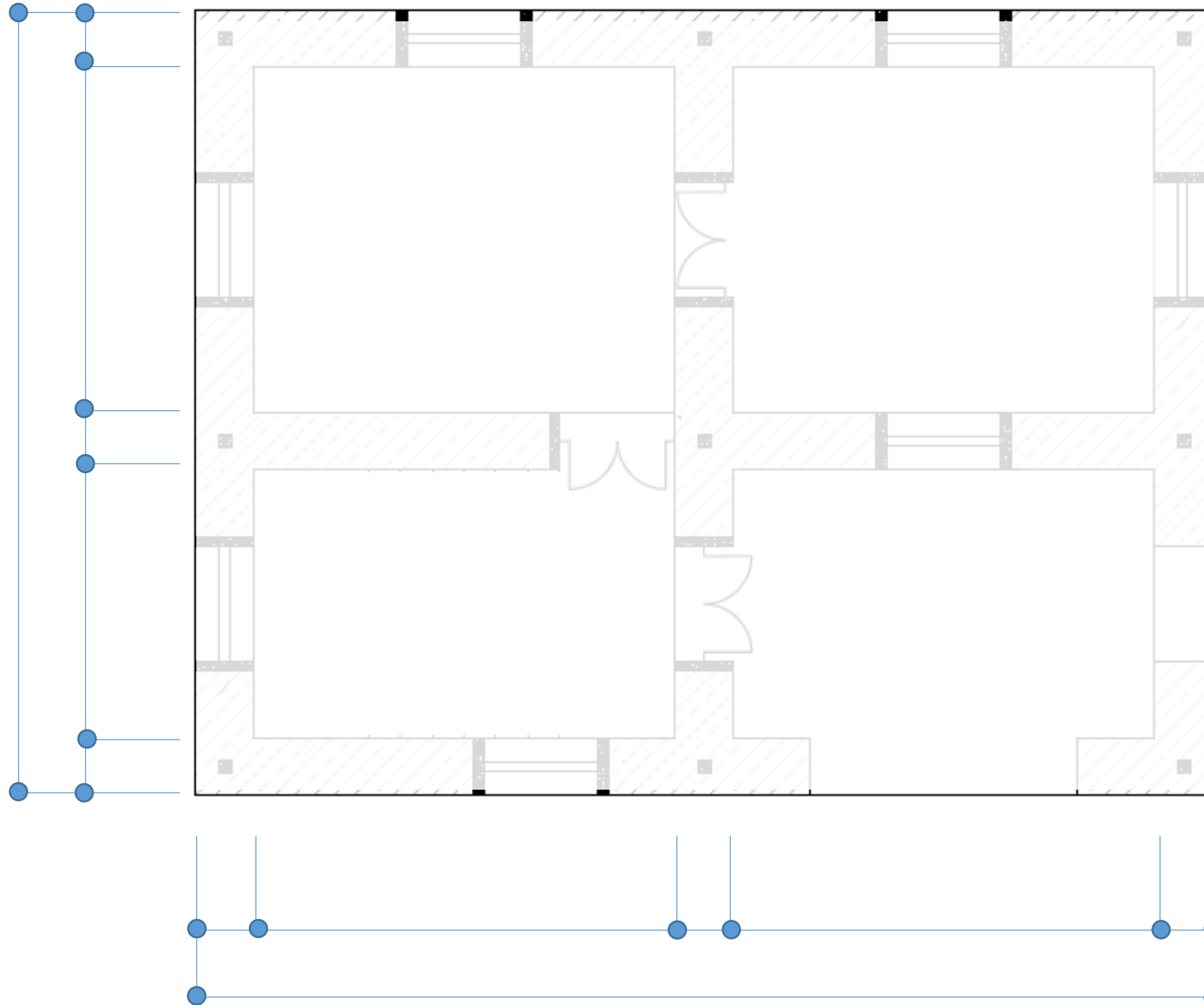
Detail of Rafter Joint at Ridge

GABLE BAND DETAIL

| Minimum Requirements (MRs) for Brick Masonry in Cement Mortar (NBC202) | | | | Page1 |
|--|----------------|---|---|---|
| No. | Category | | | |
| 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 |
| 2 | Shape of House | | ✓ | River Bank and Water-logged Area |
| | | 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 |
| 3 | Foundation | Proportion | ✓ | The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width. |
| | | 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. |

| Minimum Requirements (MRs) for Brick Masonry in Cement Mortar (NBC202) | | | | Page2 |
|--|------------------------|---------------|---|--|
| No. | Category | | | |
| 6 | Openings | Location | ✓ | Openings are to be located away from inside corners by a clear distance should not be less than 600 mm. |
| | | 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. |
| 7 | Vertical Reinforcement | 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. |
| | | Reinforcement | ✓ | The vertical reinforcing bar for masonry is given in detail drawings. 12mm dia is minimum requirements for masonry houses. |
| 8 | Horizontal Band | | | 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. |
| | | Stitch | ✓ | 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. |
| 9 | Roof | 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. |
| | | Light roof | ✓ | Use light roof comprising wooden or steel truss covered with CGI sheets |
| | | 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. |
| 10 | Materials | 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 |
| | | 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 $f_y = 415 \text{ N/}$ |

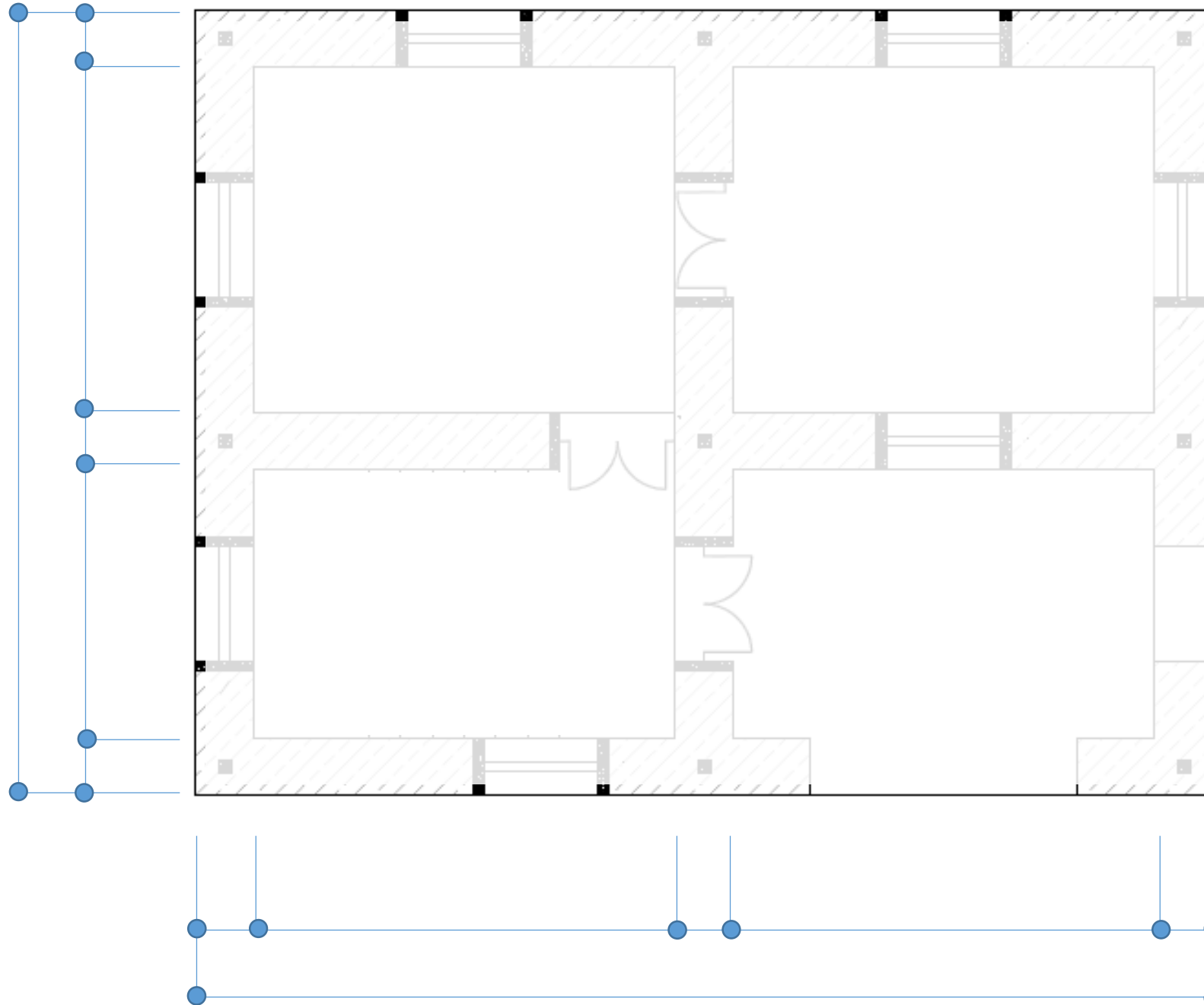
Dimensions may vary as per the requirement and site conditions where as it should be filled by the technicians during construction. And design should follow the Minimum Requirements.



Base drawing for Flexible design

Flexible design

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.



Base drawing for Flexible design

Flexible design

STONE MASONRY IN MUD MORTAR (SMM)

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)

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | | Page1 |
|---|----------------|----------------|---|--|
| No. | Category | | | |
| 1 | Site Selection | | A building shall not be constructed if site is: | |
| | | | ✓ | Prone to geological fault or ruptured area |
| | | | ✓ | Susceptible to landslide |
| | | | ✓ | Steep slope > 20% |
| | | | ✓ | Filled area |
| | | | ✓ | River bank and water-logged area |
| 2 | Shape of House | No. of storeys | ✓ | Two storey+ attic |
| | | Proportion | ✓ | The house shall be planned square, rectangular. House should not more than 3 times 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 be at least 750mm. |
| | | Width | ✓ | 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. |
| 4 | Plinth | General | ✓ | The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm. |
| 5 | Walls | 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 large stones. The walls should be interlocked. |
| | | Joints | ✓ | Mortar joints should not be more than 20mm and less than 10mm in thickness. |
| | | Though Stone | ✓ | 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 insitu concrete can be used instead of through stone. |
| | | 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 | ✓ | The wall thickness should not be less than 350-450mm, 450mm respectively for one and two-storey houses. |
| | | Height of wall | ✓ | The height of wall between floors should not be more than 8 times wall thickness. |
| | | | | |

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | Page2 |
|---|------------------------|--------------------------|--|
| No. | Category | | |
| 6 | 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 of openings | ✓ 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 opening | ✓ 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 |
| 7 | 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. |
| | | Reinforcement | ✓ 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. |
| 8 | Horizontal Band | General | ✓ 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. |
| | | Plinth band | ✓ 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. |
| | | 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 tie 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 lightweight 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. |

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | | Page3 |
|---|-----------|---------------|---|---|
| No. | Category | | | |
| 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 $f_y = 415 \text{ N/sqmm}$ or 550 N/sqmm could be used for reinforcements. |

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.

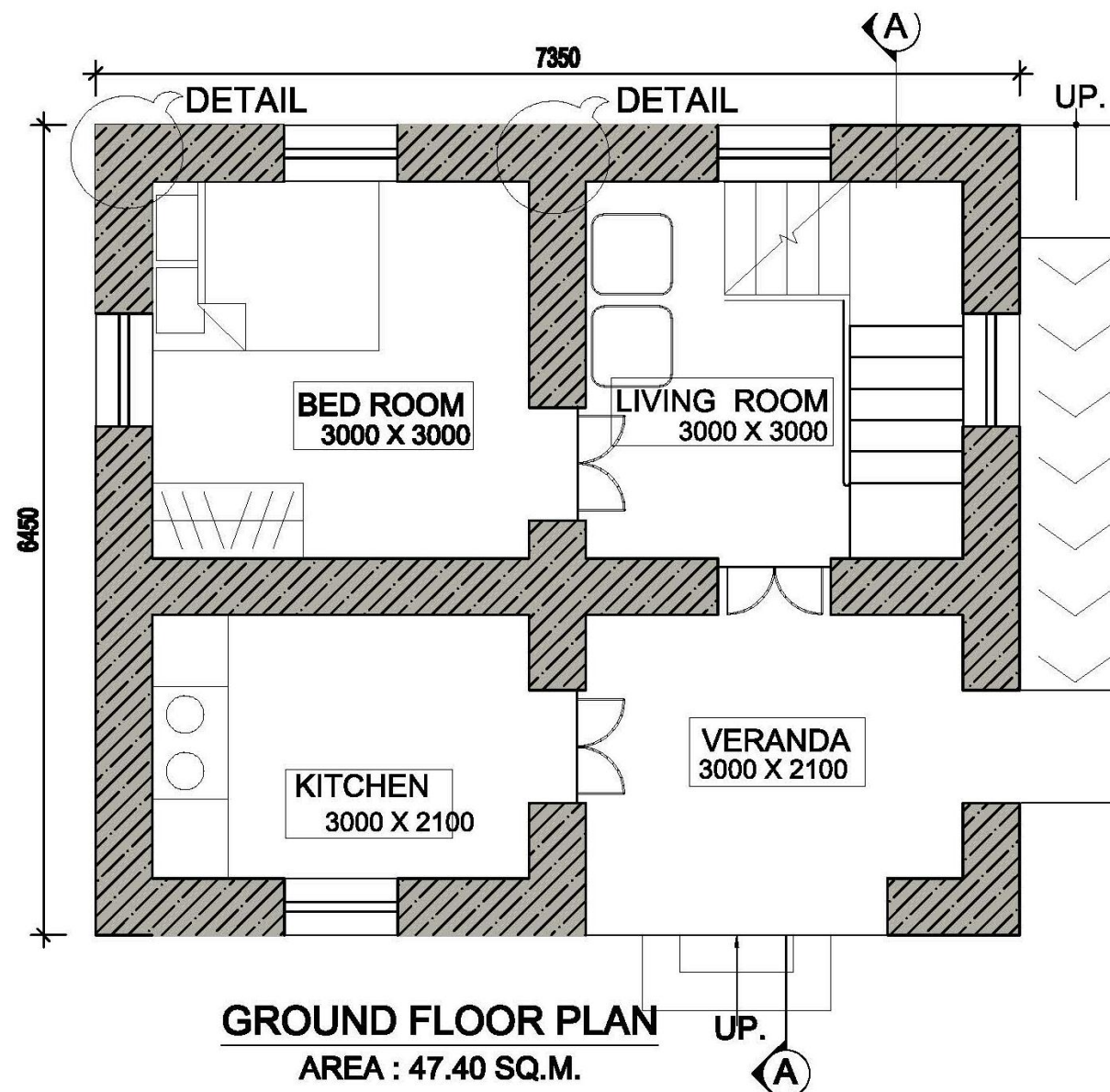
SMM-1.1



CONSTRUCTION MATERIALS AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | |
|--------------------|----------------|------------------|--------------|------------|-------------|-------|
| | <u>Skilled</u> | <u>Unskilled</u> | <u>Stone</u> | <u>MUD</u> | <u>WOOD</u> | SLATE |
| | Md | Md | Cu.m | Cu.m | Cu.m | Sq.m |
| Up to Plinth Level | 52 | 92 | 28 | 30 | 1.54 | 0 |
| Ground floor | 119 | 65 | 27 | 10 | 3.78 | 0 |
| Roofing work | 68 | 40 | 0 | 0 | 2.34 | 161 |
| TOTAL | 238 | 197 | 56 | 41 | 7.66 | 161 |





Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMM-1.1
DRAWING TITLE: PLAN

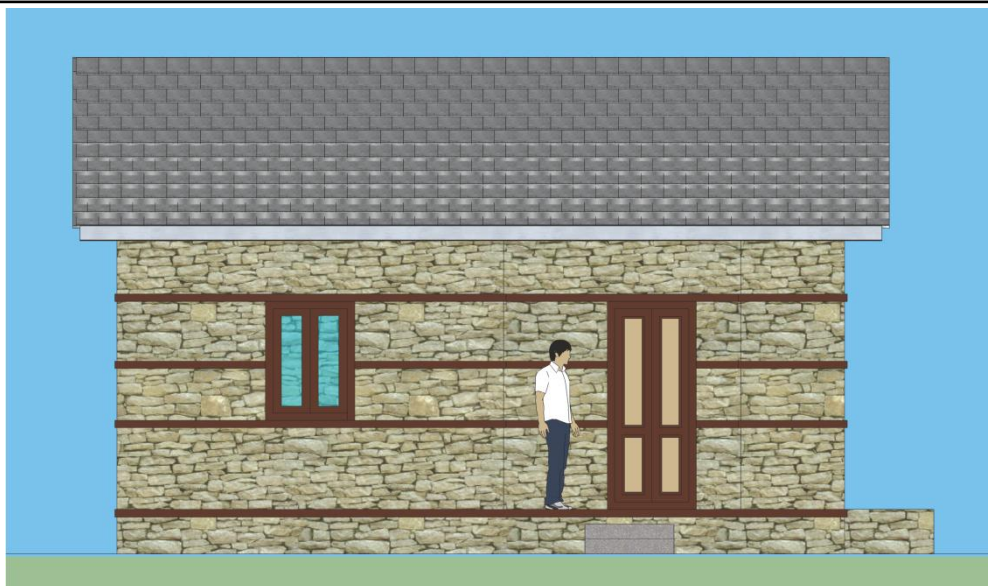
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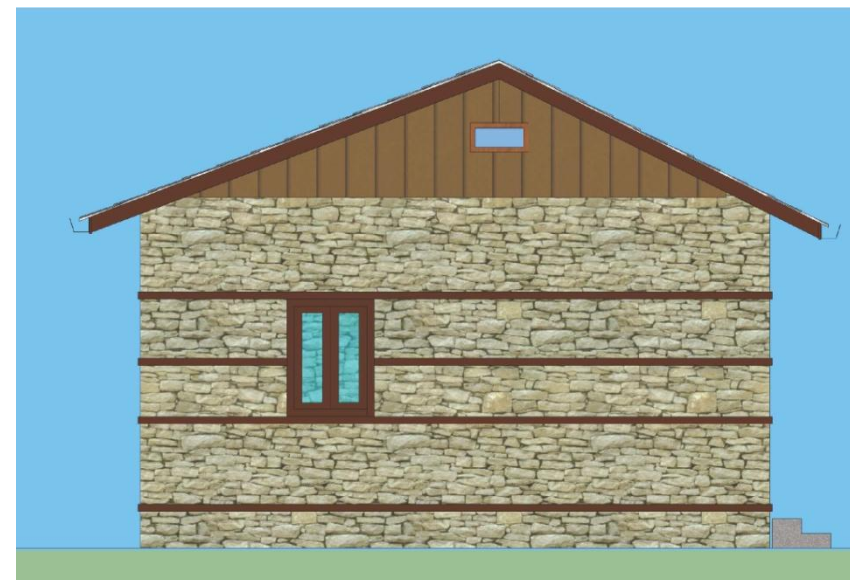
DESIGNED BY: DUDBC

SMM-1.1

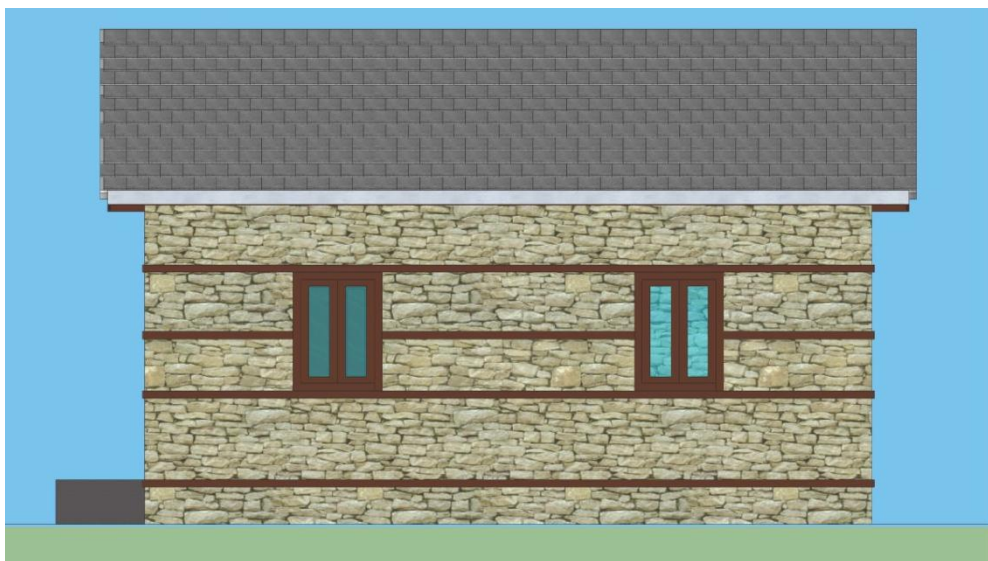
2/4



FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODELSMM-1.1
DRAWING TITLE: ELAVATION

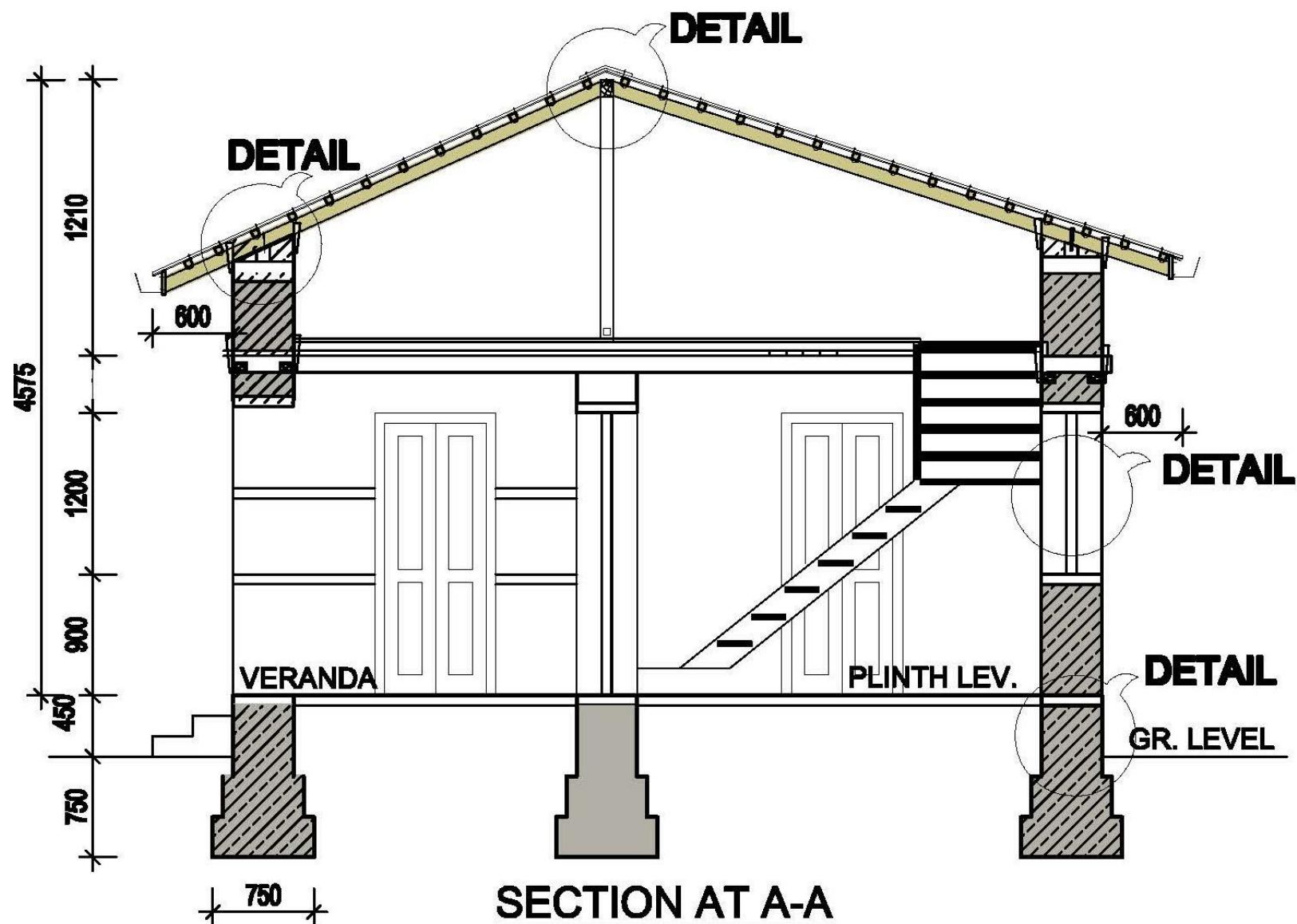
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DATE:

DESIGNED BY: DUDBC

SMM-1.1

3/4



Nepal Housing
Reconstruction Programme

TYPE OF HOUSE: MODEL SMM-1.1

DRAWING TITLE: SECTION

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DATE:

DESIGNED BY: DUDBC

SMM-1.1

4/4

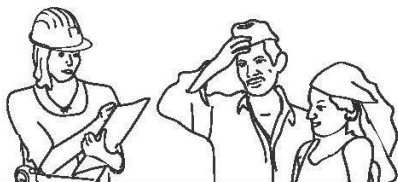
STONE MASONRY IN MUD MORTAR (SMM)

Technical Details

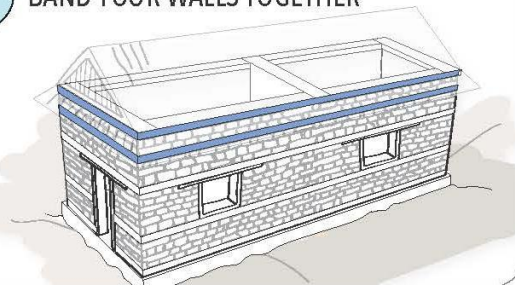


Well built **STONE** houses can better withstand earthquakes. Here are **10 TIPS ON HOW TO BUILD BACK SAFER**

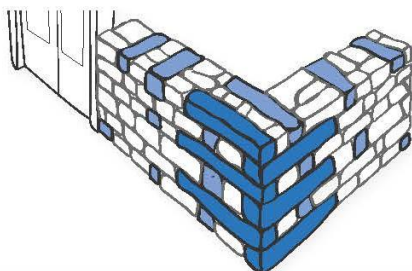
1 GET TECHNICAL ADVICE BEFORE YOU START



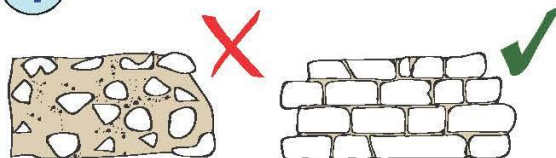
2 BAND YOUR WALLS TOGETHER



3 TIE YOUR HOUSE TOGETHER WITH TIESTONES



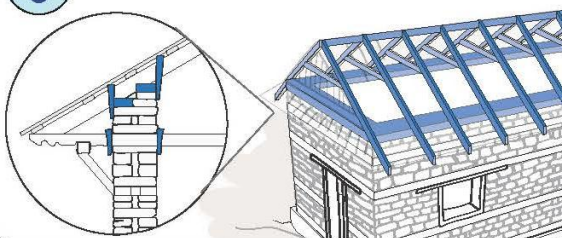
4 BUILD YOUR HOUSE WITH GOOD MATERIALS



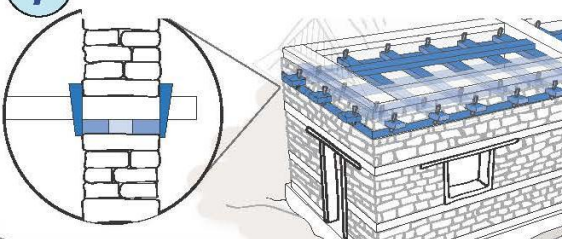
5 TIE YOUR GABLES UP



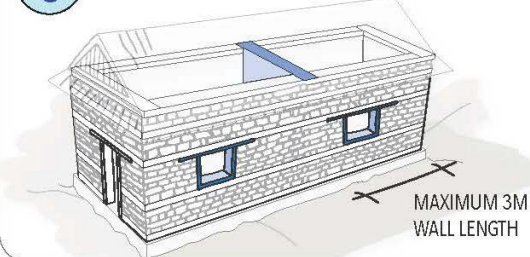
6 TIE YOUR ROOF DOWN



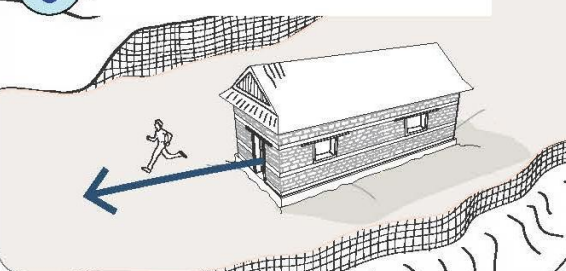
7 TIE YOUR FLOORS TO YOUR WALLS



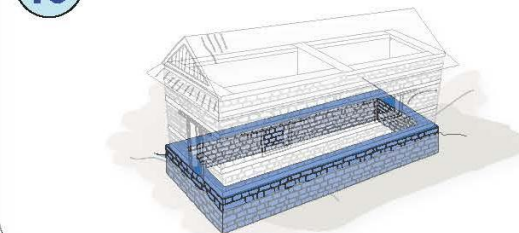
8 BUILD A STRONG SHAPE



9 HAVE A SAFE SITE AND A SAFE EXIT



10 BUILD ON STRONG FOUNDATIONS



Shelter Cluster Nepal
ShelterCluster.org
Coordinating Humanitarian Shelter



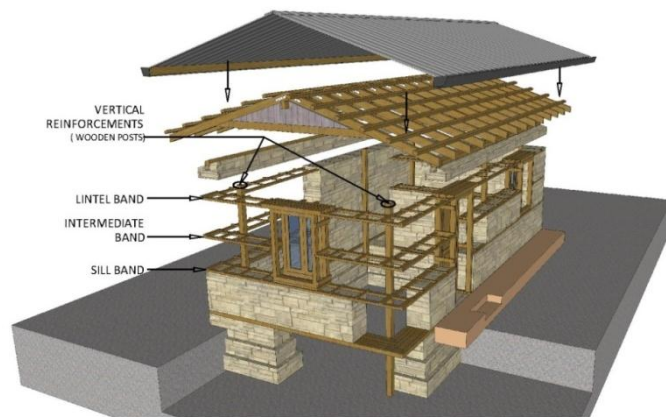
Government of Nepal
Ministry of Urban Development
Department of Urban Development
and Building Construction

**10 KEY MESSAGES -
A VISUAL INDEX**

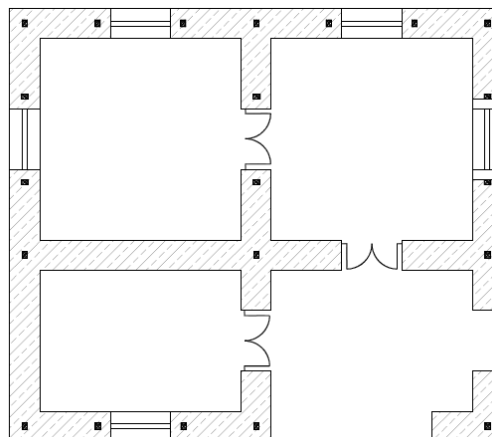
VERSION 2- 09/OCT/2015

10 KEY MESSAGES

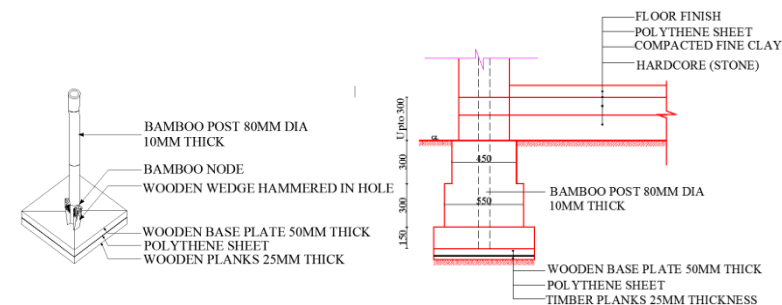
Technology for Earthquake Resistant Building Construction (One Storey Building, Stone in Mud Mortar)



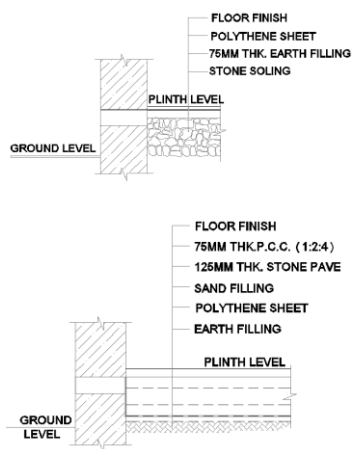
Earthquake Resistant Elements in Building



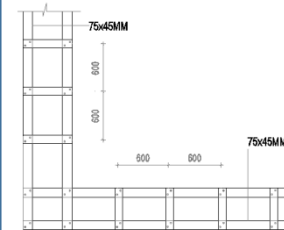
Building Plan



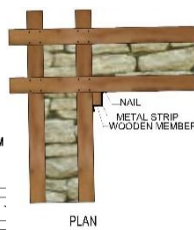
Foundation Details of Strip Footing Masonry Foundation and DPC
(Where cement and concrete not available)



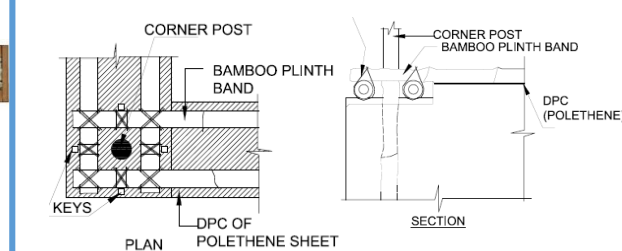
Ground Floor Detail



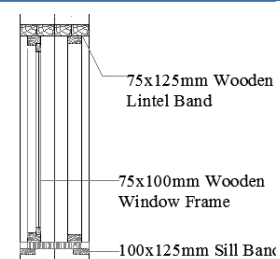
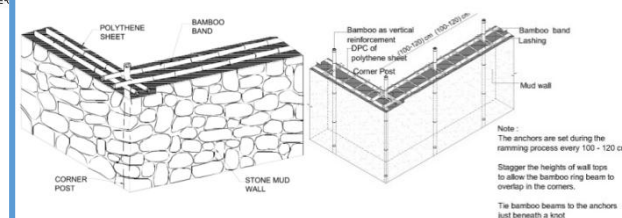
Dove Tail Joint for Wood Connection



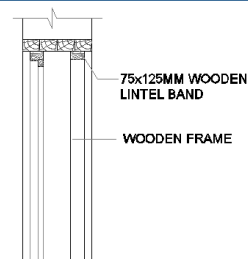
Wood for Horizontal and Vertical Band at Corner and T-Junction



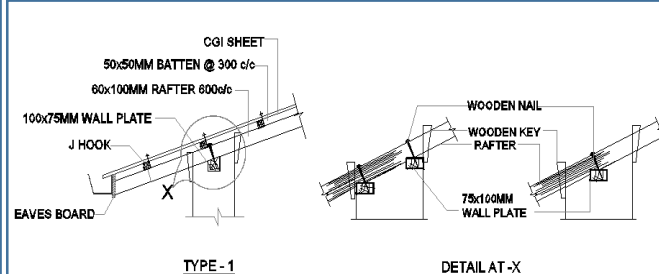
Bamboo for Horizontal and Vertical Band



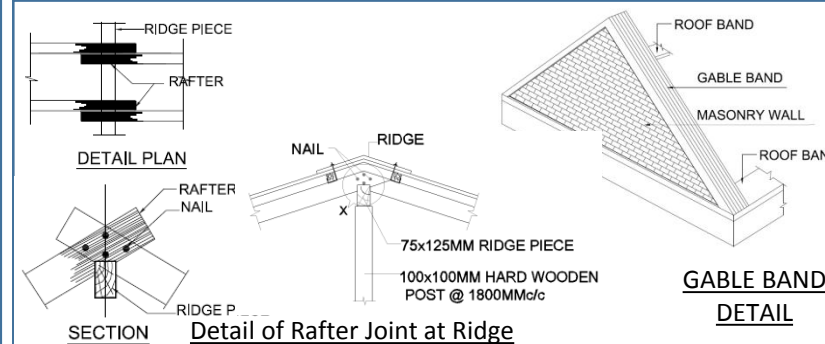
Window Section



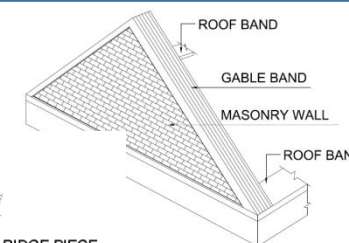
Door Section



Detail of Rafter Joint with Wall Plate

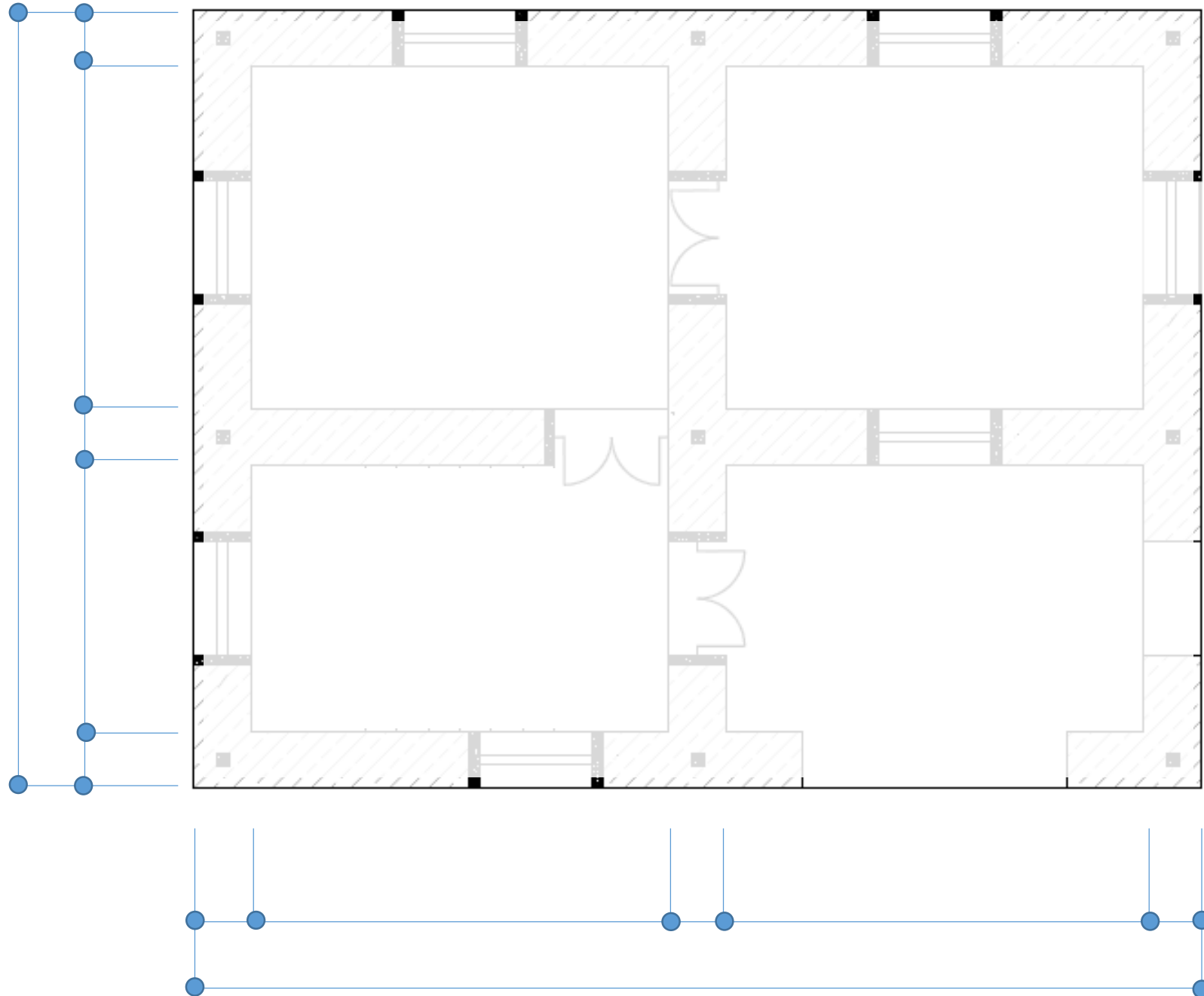


Detail of Rafter Joint at Ridge



GABLE BAND DETAIL

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.



Base drawing for Flexible design

Flexible design

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | | Page1 |
|---|----------------|----------------|--|-------|
| No. | Category | | | |
| 1 | Site Selection | | A building shall not be constructed if site is: | |
| | | | ✓ Prone to geological fault or ruptured area | |
| | | | ✓ Susceptible to landslide | |
| | | | ✓ Steep slope > 20% | |
| | | | ✓ Filled area | |
| 2 | Shape of House | No. of storeys | ✓ Two storey+ attic | |
| | | Proportion | ✓ The house shall be planned square, rectangular. House should not more than 3 times 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 be at least 750mm. | |
| | | Width | ✓ 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. | |
| 4 | Plinth | General | ✓ The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm. | |
| 5 | Walls | 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 large stones. The walls should be interlocked. | |
| | | Joints | ✓ Mortar joints should not be more than 20mm and less than 10mm in thickness. | |
| | | Though Stone | ✓ 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 insitu concrete can be used instead of through stone. | |
| | | 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 | ✓ The wall thickness should not be less than 350-450mm, 450mm respectively for one and two-storey houses. | |
| | | Height of wall | ✓ The height of wall between floors should not be more than 8 times wall thickness. | |

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | | Page2 |
|---|------------------------|--------------------------|---|---|
| No. | Category | | | |
| 6 | 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 of openings | ✓ | 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 opening | ✓ | 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 |
| 7 | 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. |
| | | Reinforcement | ✓ | 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. |
| 8 | Horizontal Band | General | ✓ | 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. |
| | | Plinth band | ✓ | 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. |
| | | 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 tie 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. |

| Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) | | | Page3 |
|---|-----------|---------------|---|
| No. | Category | | |
| 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 $f_y = 415 \text{ N/sqmm}$ or 550 N/sqmm could be used for reinforcements. |

BRICK MASONRY IN MUD MORTAR (BMM)

BMM

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.

Minimum Requirements (MRs)

| Minimum Requirements (MRs) for Brick Masonry house in Mud Mortar (NBC203) | | | | Page1 |
|---|----------------|--|---------------------------|---|
| No. | Category | | | |
| 1 | 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 |
| 2 | Shape of House | | No. of story | ✓ Two storey +attic |
| | | | Proportion | ✓ The house shall be planned square, rectangular. Avoid long and narrow house. The house should not be more than 3 times its |
| 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 be at least 750mm. |
| | | | 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. |
| 4 | Plinth | | General | ✓ The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm. |
| 5 | Walls | | 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. |
| | | | Joints | ✓ Mortar joints should not be more than 20mm and less than 10mm in thickness. |
| | | | 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 | ✓ The thickness of the wall should not be less than 230mm, 350mm respectively for one-storey and two-storey plus attic house. |
| | | | Height of wall | ✓ The height of wall between floors should not be more than 12 times wall thickness. |
| | | | 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. |
| 6 | Openings | | Lintel level | ✓ Keep lintel level same for doors and windows |

| Minimum Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203) | | | | Page2 |
|---|------------------------|---------------|---|--|
| No. | Category | | | |
| 7 | 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. |
| | | Reinforcement | ✓ | 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. |
| 8 | Horizontal Band | General | ✓ | 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. |
| | | Plinth band | ✓ | 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. |
| | | 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 2-12 mm 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. |
| | | 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. |

| Minimum Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203) | | | Page3 |
|---|-----------|---------------|-------|
| No. | Category | | |
| 9 | Roof | Light roof | ✓ |
| | | Connection | ✓ |
| | | Cross-tie | ✓ |
| 10 | Materials | Timber | ✓ |
| | | Mortar | ✓ |
| | | Brick | |
| | | Concrete | ✓ |
| | | Reinforcement | ✓ |

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.

All members of the timber truss or joints should be properly connected as shown in technical details.

Trusses should be properly cross-tied with wooden braces as shown in technical details.

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.

Mud should be free from organic material and pebbles, etc.

Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm.

The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate)

High Strength Deformed Bars – Fe415 or Fe500 respectively with $f_y = 415 \text{ N/sqmm}$ or 550 N/sqmm could be used for reinforcements.



BRICK MASONRY IN MUD MORTAR, ONE-STOREY

BMM-1.1

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 3000x 3000 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.

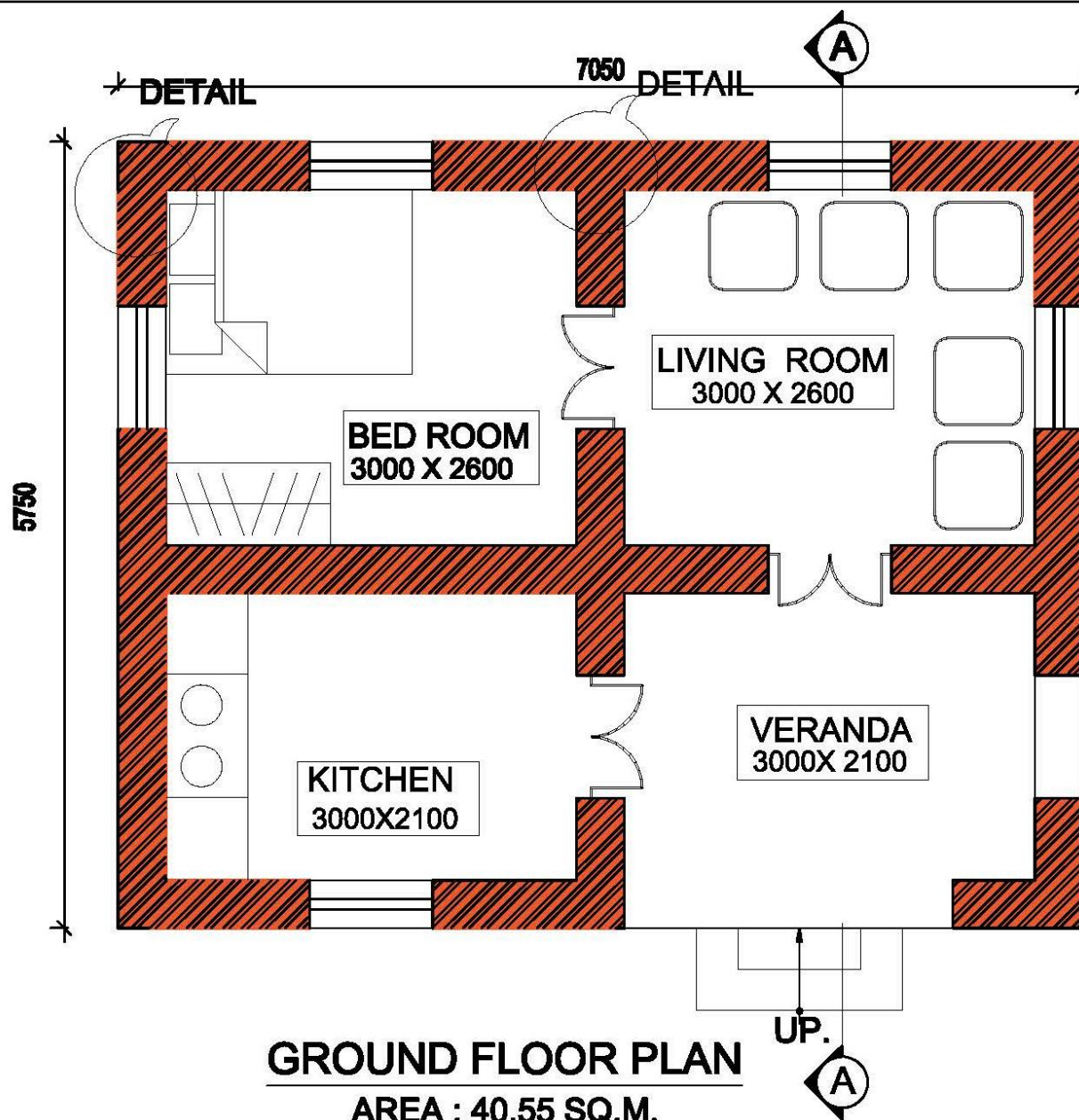
BMM-1.1



CONSTRUCTION MATERIAL AND MANPOWER

| LEVEL | MAN POWER | | MATERIALS | | | | |
|--------------------|-----------|-----------|-----------|-------|-------|-----------|----------|
| | Skilled | Unskilled | Brick | Mud | WOOD | CGI SHEET | GI SHEET |
| | Md | Md | Nos | Cu.m. | Cu.m. | Bundel | Rm |
| Up to Plinth Level | 38 | 57 | 9876 | 25 | 1.11 | 0 | 0 |
| Ground Floor | 66 | 46 | 13642 | 10 | 1.14 | 0 | 0 |
| ROOFING | 35 | 13 | 0 | 0 | 1.62 | 4 | 10 |
| TOTAL | 139 | 115 | 23518 | 35 | 3.87 | 4 | 10 |





Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMM1.1

2/4



FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION



LEFT SIDE ELEVATION



Nepal Housing
Reconstruction Programme

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

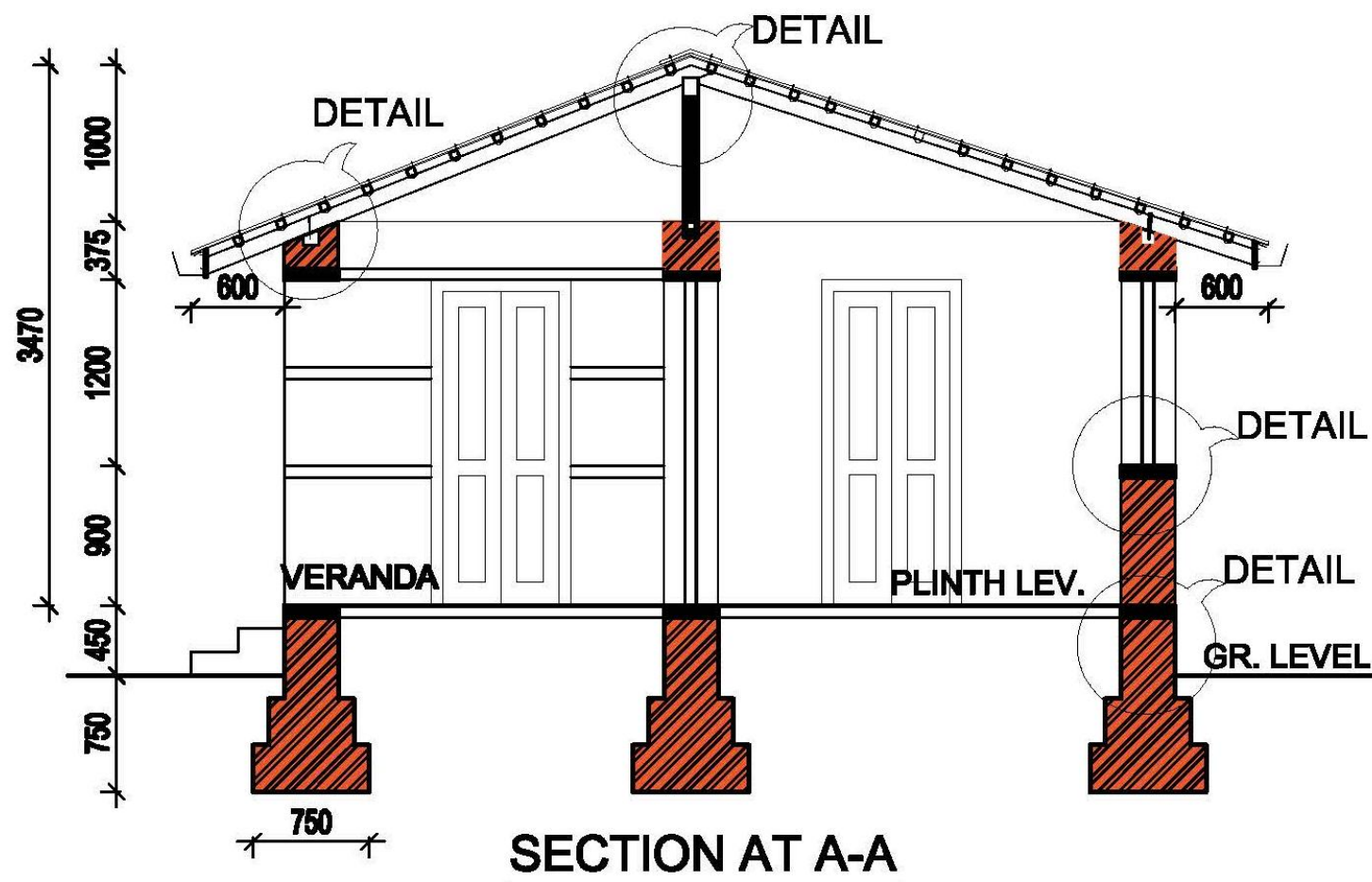
SCALE: 1:100

DATE:

DESIGNED BY: DUDBC

BMM-1.1

3/4



Nepal Housing
Reconstruction Programme

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

SCALE: 1:50

DATE:

DESIGNED BY: DUDBC

BMM-1.1

4/4

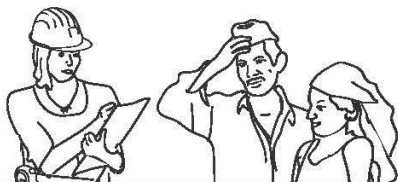
BRICK MASONRY IN MUD MORTAR (BMM)

Technical Details

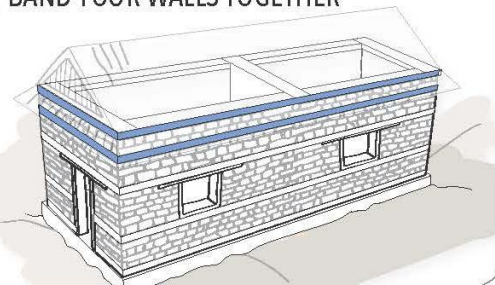


Well built **STONE** houses can better withstand earthquakes. Here are **10 TIPS ON HOW TO BUILD BACK SAFER**

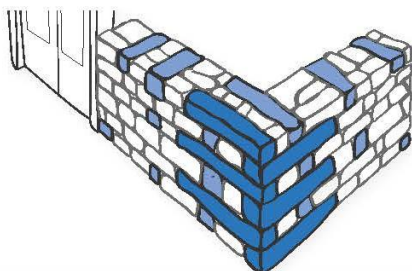
1 GET TECHNICAL ADVICE BEFORE YOU START



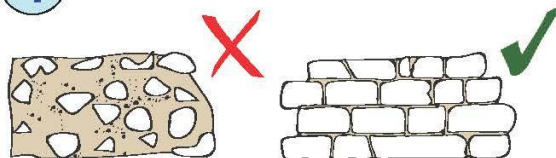
2 BAND YOUR WALLS TOGETHER



3 TIE YOUR HOUSE TOGETHER WITH TIESTONES



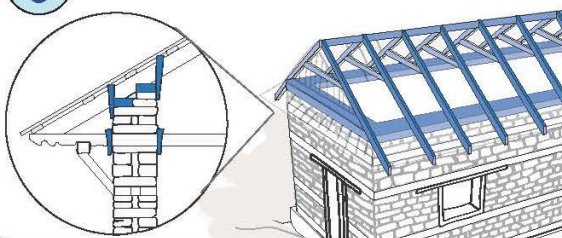
4 BUILD YOUR HOUSE WITH GOOD MATERIALS



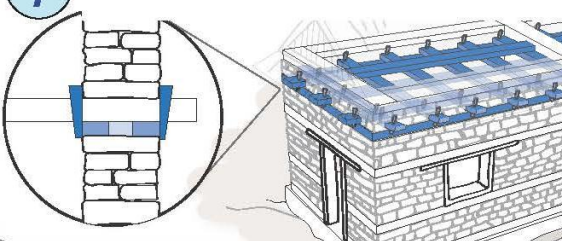
5 TIE YOUR GABLES UP



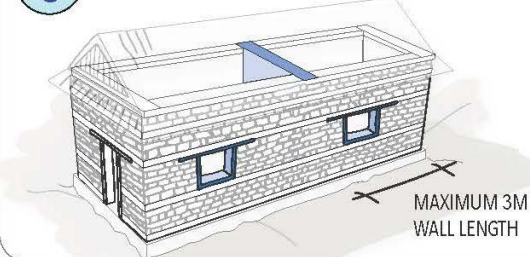
6 TIE YOUR ROOF DOWN



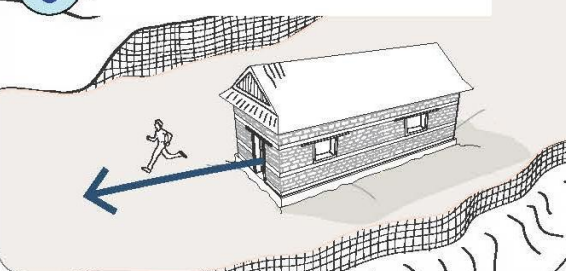
7 TIE YOUR FLOORS TO YOUR WALLS



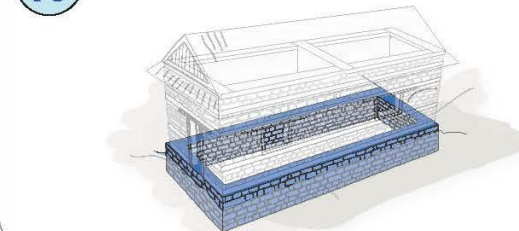
8 BUILD A STRONG SHAPE



9 HAVE A SAFE SITE AND A SAFE EXIT



10 BUILD ON STRONG FOUNDATIONS

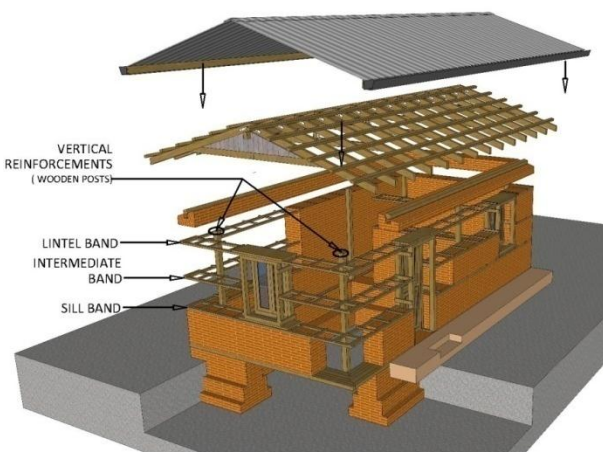


 **Shelter Cluster Nepal**
ShelterCluster.org
Coordinating Humanitarian Shelter

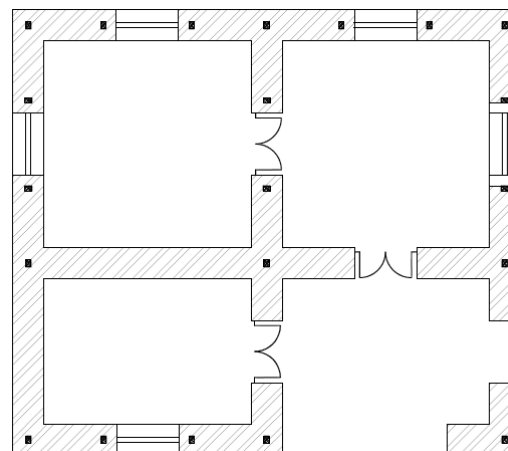
 **Government of Nepal**
Ministry of Urban Development
Department of Urban Development
and Building Construction

**10 KEY MESSAGES -
A VISUAL INDEX**
VERSION 2- 09/OCT/2015

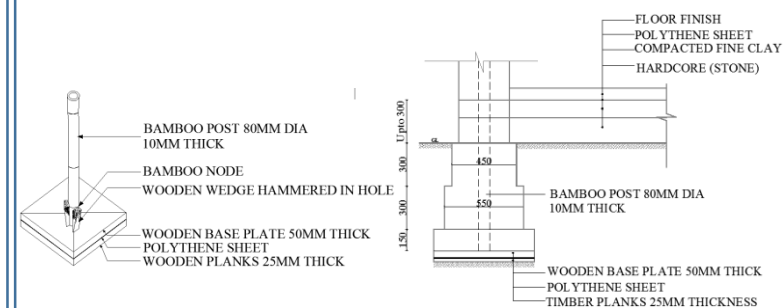
10 KEY MESSAGES



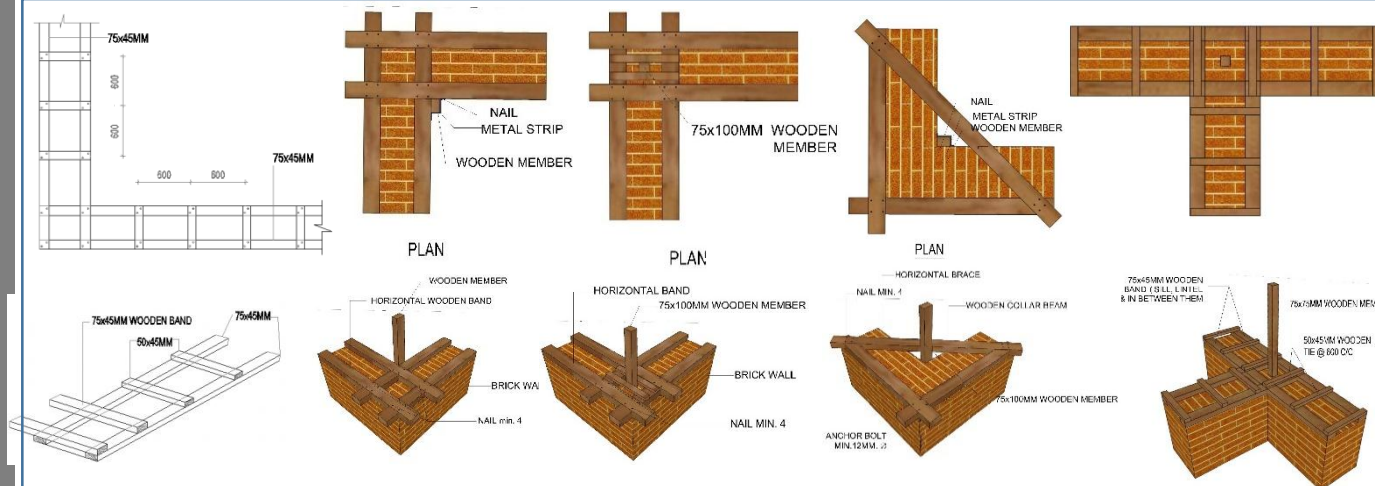
Earthquake Resistant Elements in Building



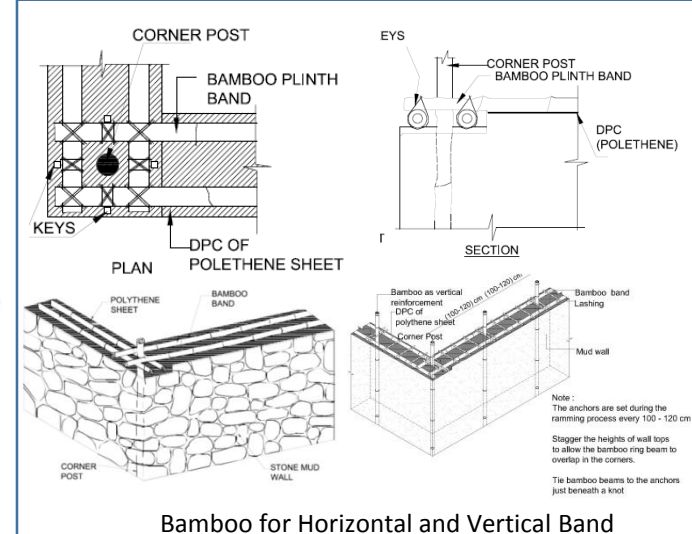
Building Plan



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



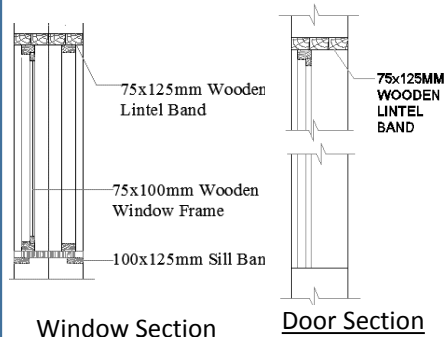
Wood for Horizontal and Vertical Band at Corner and T-Junction



Bamboo for Horizontal and Vertical Band

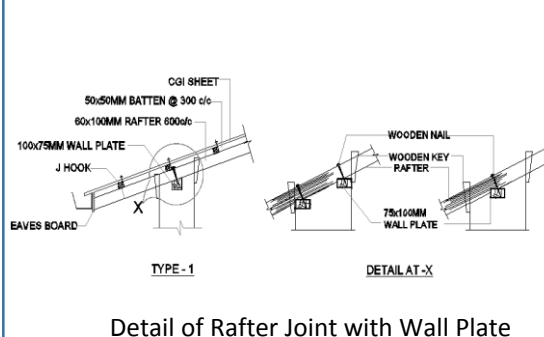


Dove Tail Joint for Wood Connection

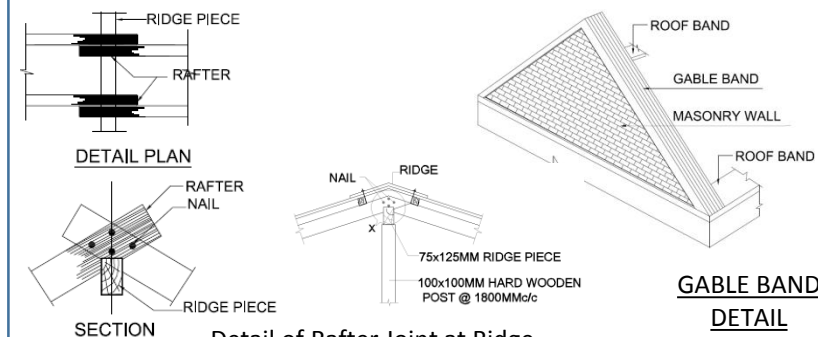


Window Section

Door Section

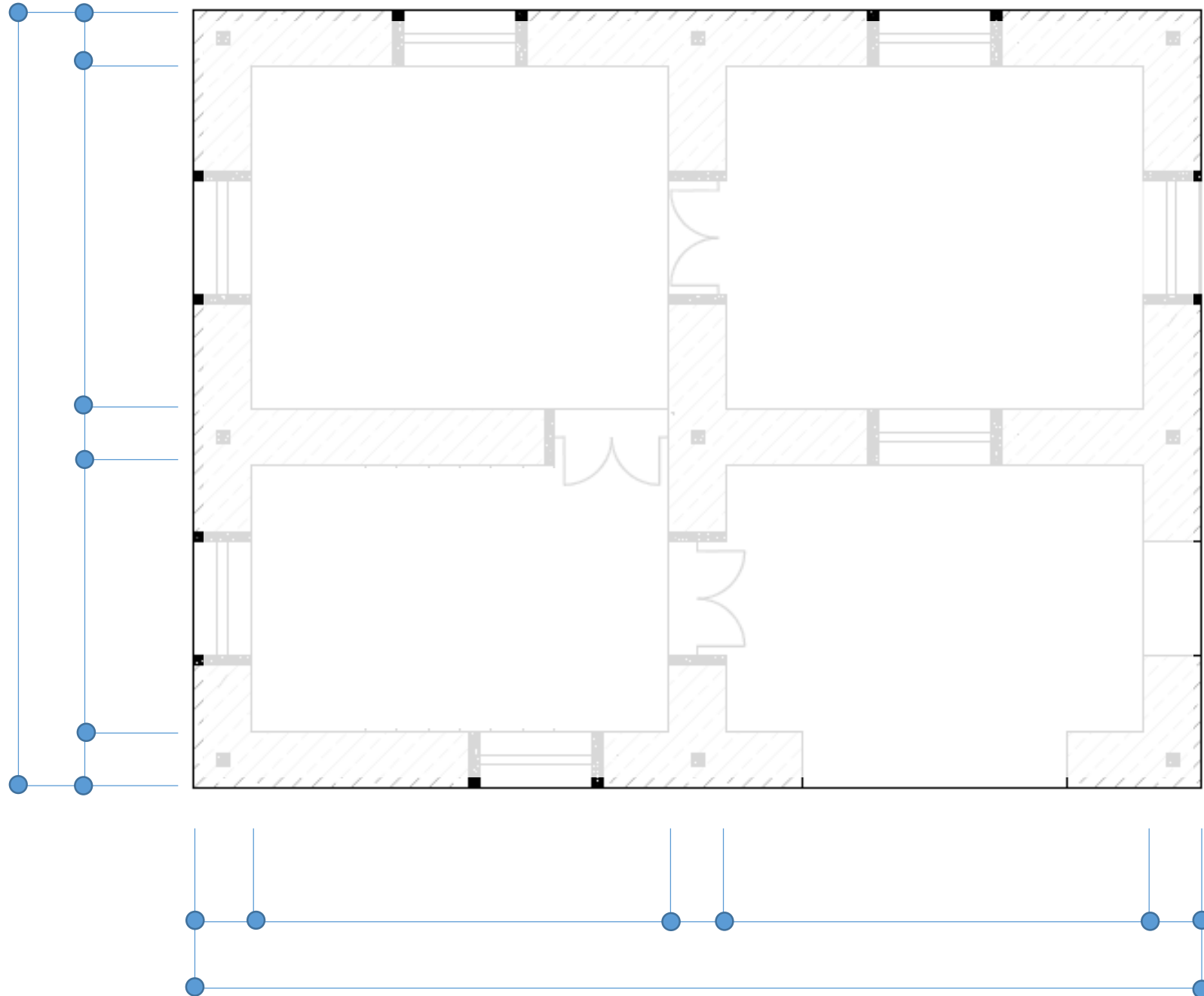


Detail of Rafter Joint with Wall Plate



Detail of Rafter Joint at Ridge

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 house in Mud Mortar (NBC203) | | | | Page1 |
|---|----------------|---------------------------|---|-------|
| No. | Category | | | |
| 1 | Site Selection | | A house shall not be constructed if site is: | |
| | | | ✓ Prone to geological fault or ruptured area | |
| | | | ✓ Susceptible to landslide | |
| | | | ✓ Steep slope > 20% | |
| | | | ✓ Filled area | |
| 2 | Shape of House | No. of story | ✓ Two storey +attic | |
| | | Proportion | ✓ The house shall be planned square, rectangular. Avoid long and narrow house. The house should not be more than 3 times its | |
| 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 be at least 750mm. | |
| | | 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. | |
| 4 | Plinth | General | ✓ The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm. | |
| 5 | Walls | 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. | |
| | | Joints | ✓ Mortar joints should not be more than 20mm and less than 10mm in thickness. | |
| | | 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 | ✓ The thickness of the wall should not be less than 230mm, 350mm respectively for one-storey and two-storey plus attic house. | |
| | | Height of wall | ✓ The height of wall between floors should not be more than 12 times wall thickness. | |
| 6 | 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 | |

| Minimum Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203) | | | | Page2 |
|---|------------------------|---------------|--|-------|
| No. | Category | | | |
| 7 | 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. | |
| | | Reinforcement | ✓ 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. | |
| 8 | Horizontal Band | General | ✓ 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. | |
| | | Plinth band | ✓ 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. | |
| | | 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. | |

| Minimum Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203) | | | | Page3 |
|---|-----------|---------------|---|---|
| No. | Category | | | |
| 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 $f_y = 415 \text{ N/sqmm}$ or 550 N/sqmm could be used for reinforcements. |

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