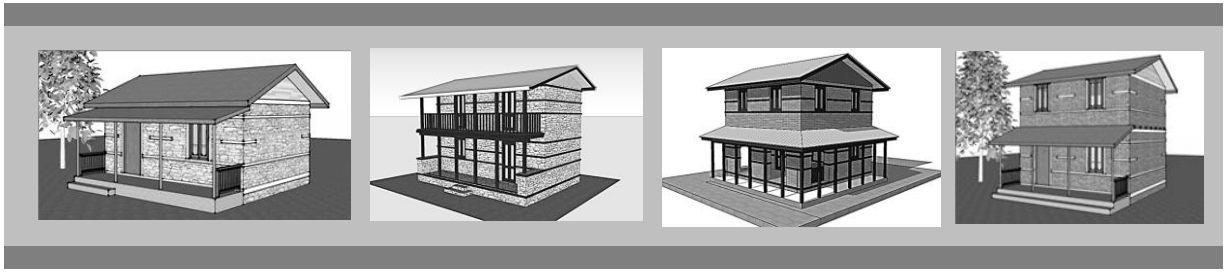
DESIGN CATALOGUE FOR

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

Published by:
Government of Nepal
Ministry of Urban Development
Department of Urban Development and Building Construction

Copyright: Housing Division
Volume Ⅰ: October, 2015 (Aswin, 2072)
Printed Copy: 500pcs

DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Volume I

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

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

Table of Contents

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

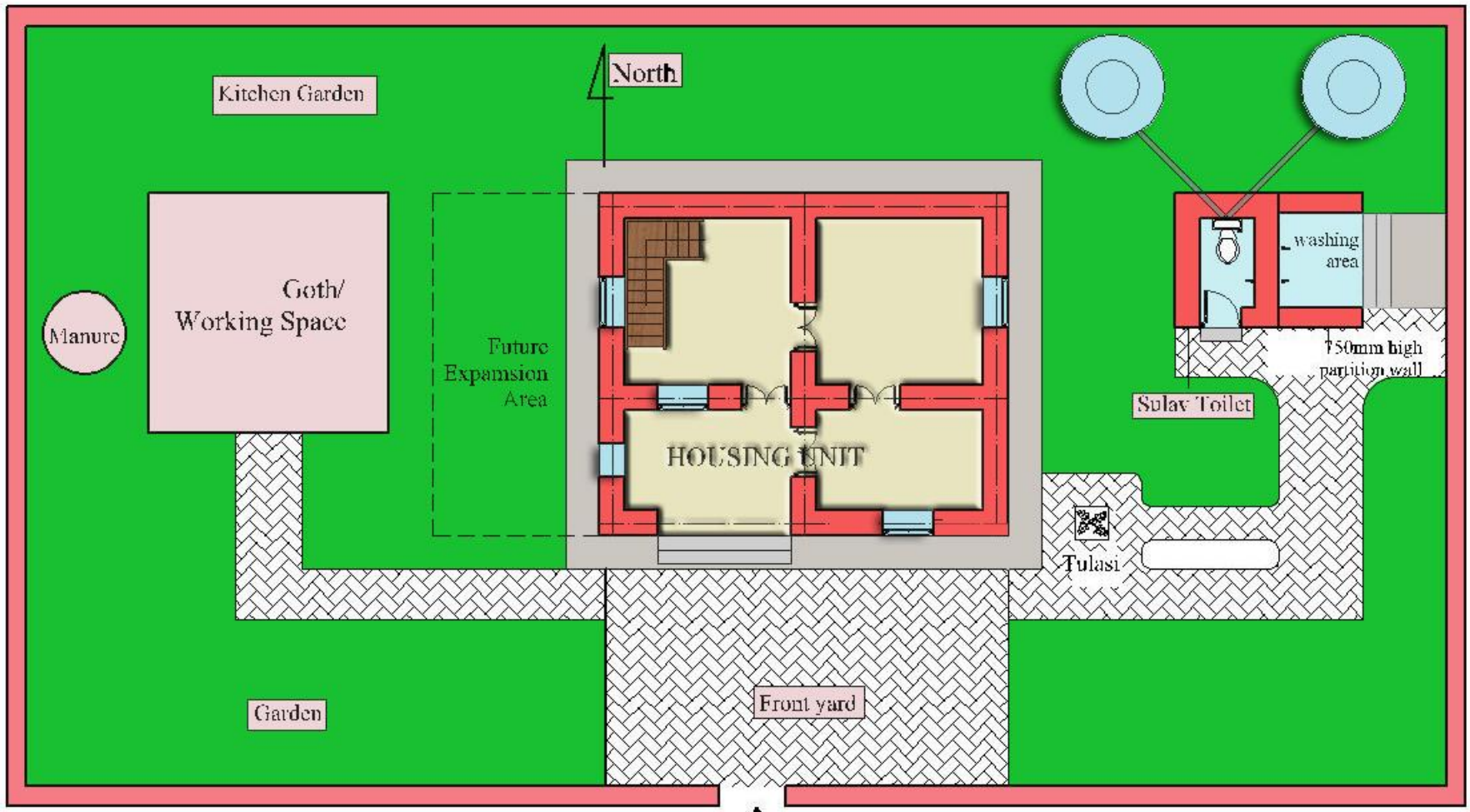
The number of manpower days for skilled and unskilled labour, as well as the quantity of materials required for the construction of the design is also provided and is broken down in terms of requirements to construct up to plinth level, up to ring beam level, and for the construction of the roof.

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

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



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 for Stone Masonry in Cement Mortar (NBC202)

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.
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. 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.
		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 fy = 415 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.

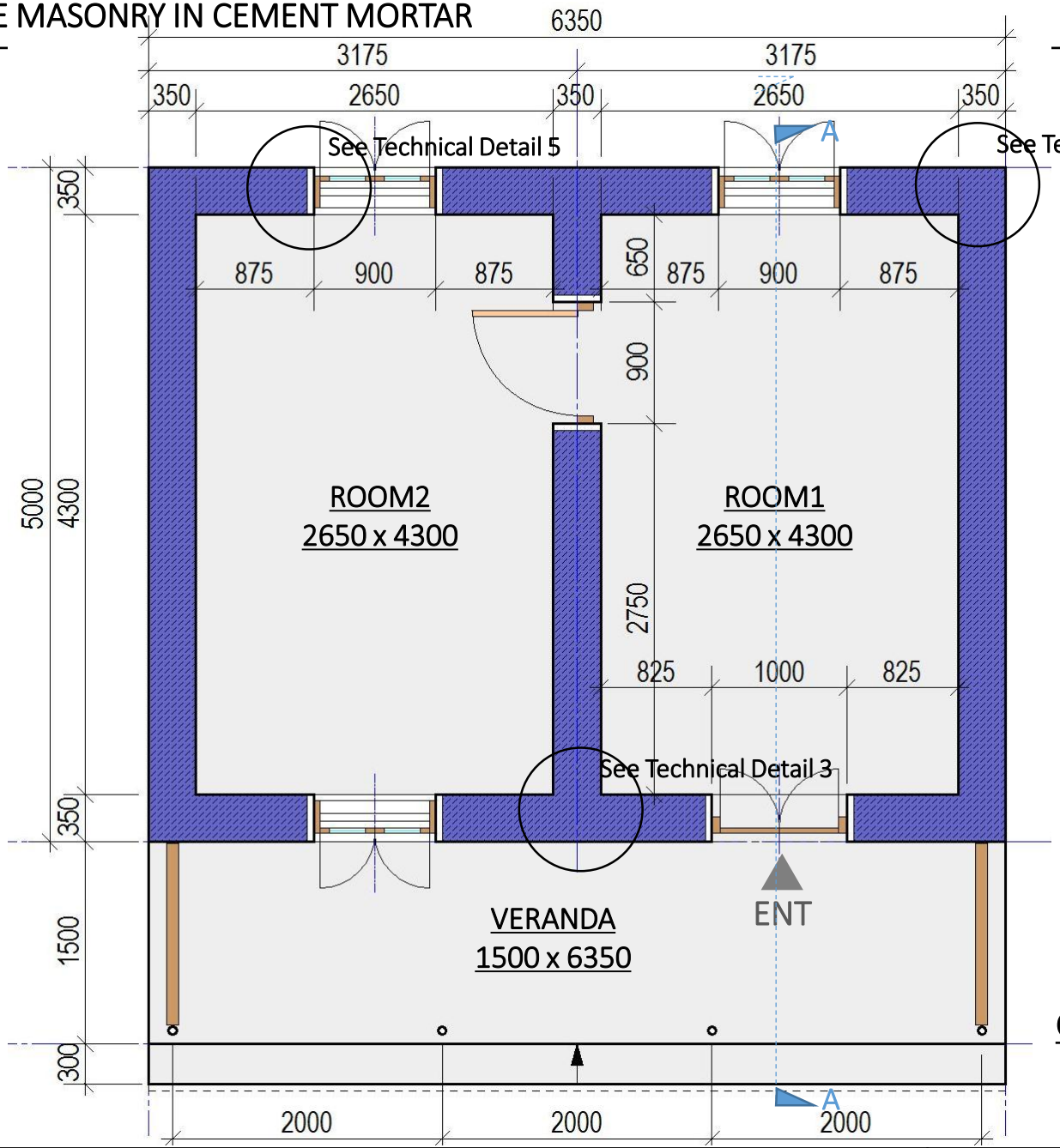
SMC-1.1

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	SCALE: None	DATE:	SMC-1.1
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA		1/4

Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY



GROUND FLOOR PLAN

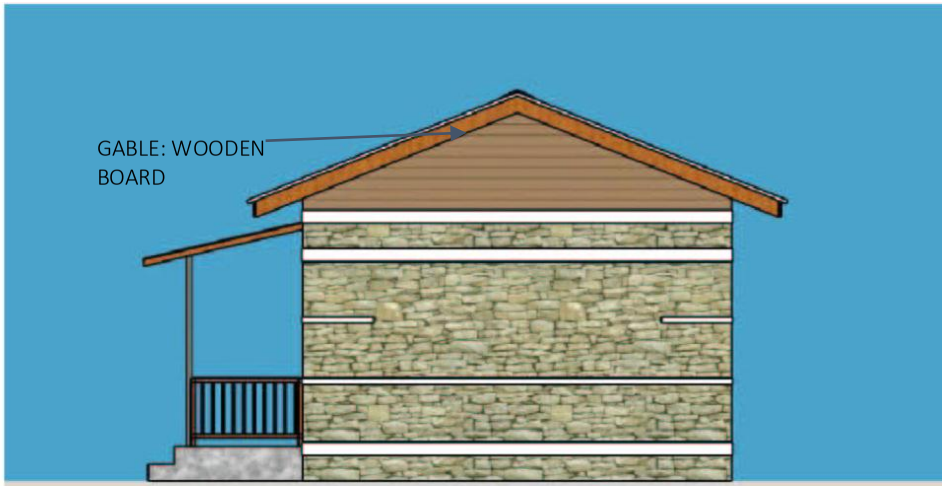
FLOOR AREA: 31.75sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.1	SCALE: 1:50	DATE:	SMC-1.1
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4

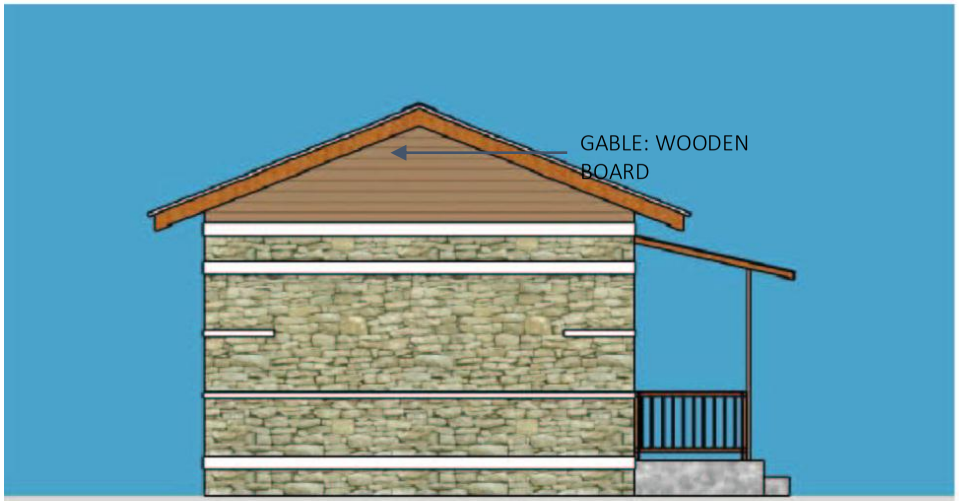
Model SMC-1.1: STONE MASONRY IN CEMENT MORTAR

ONE-STOREY

FRONT ELEVATION



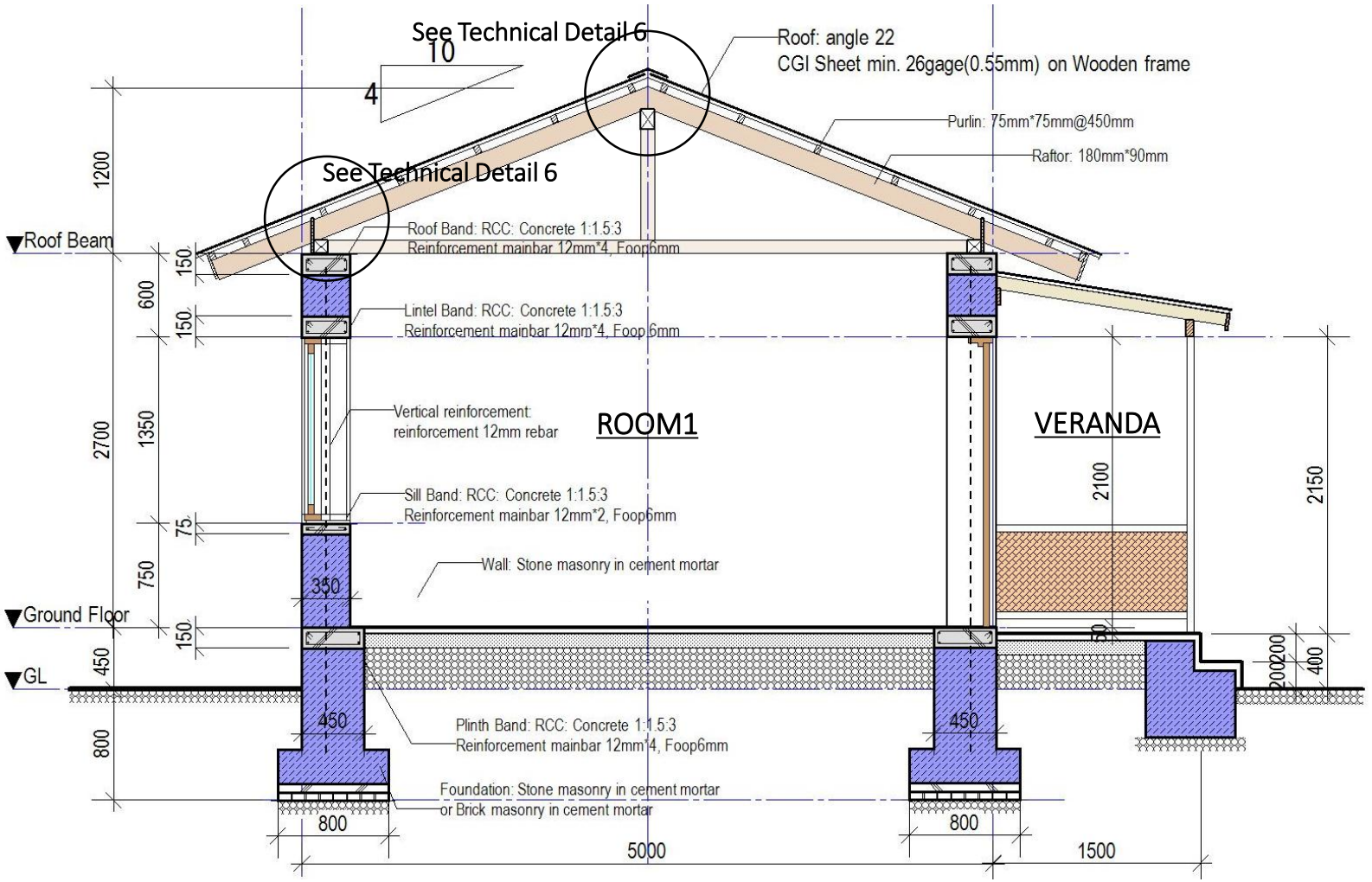
SIDE ELEVATION



SIDE ELEVATION

BACK ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.1	SCALE: None	DATE:	SMC-1.1
	DRAWING TITLE: ELEVATION	DESIGNED BY: JICA		3/4



SECTION A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.1	SCALE: 1:50	DATE:	SMC-1.1
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		4/4

STONE MASONRY IN CEMENT MORTAR, ONE-STOREY

SMC-1.2

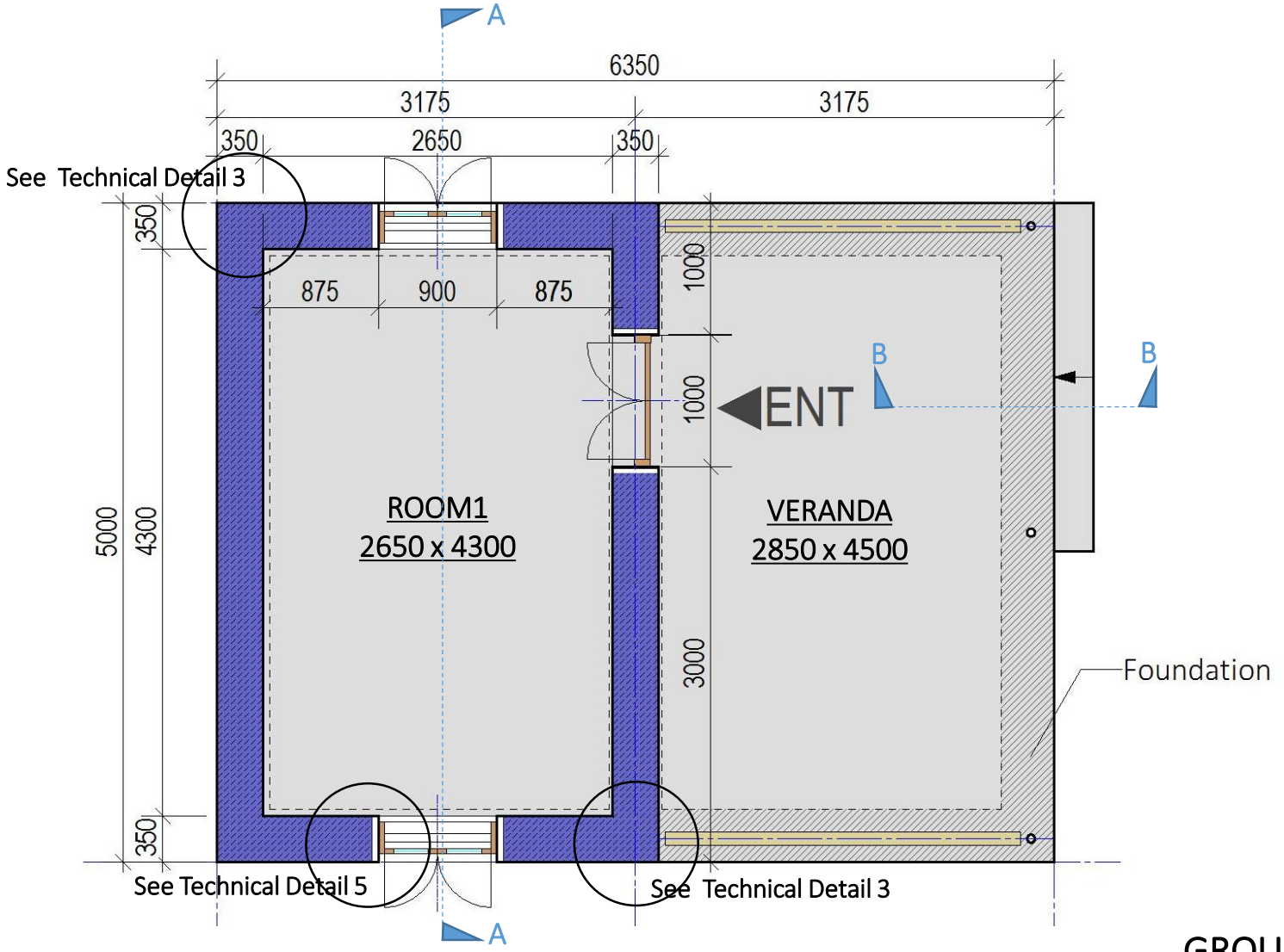
Model SMC-1.2 is a one-storey house which can accommodate 1-3 people. It consists of one room with dimensions of 2650 x 4300, and a verandah with dimensions of 2850 x 4500. The design focuses on earthquake resistant construction using locally available construction materials. Similarly stone masonry 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

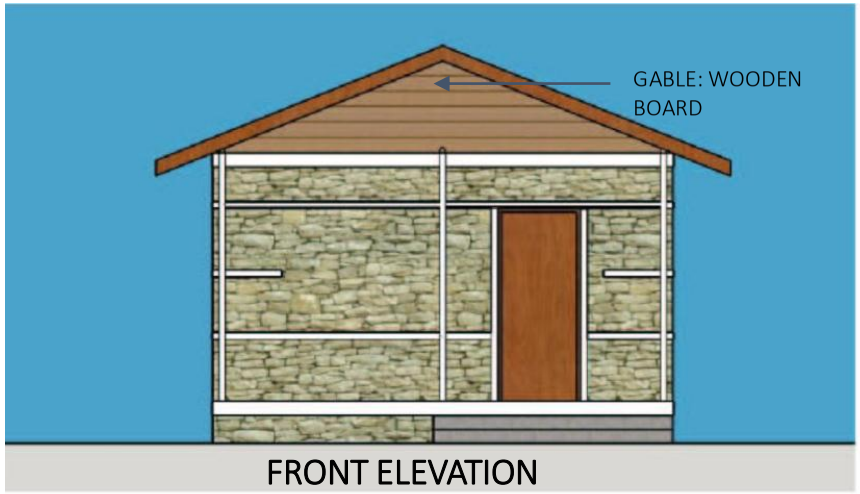
LEVEL	MAN POWER		MATERIALS						
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar
	Md	Md	cu.m.	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Kg
Up to Plinth Level	40	144	15	47	9	3	0	0	87
SUPERSTRUCTURE	49	97	10	45	6	2	0.46	0	165
ROOFING	8	11	0	0	0	0	1.48	3.69	0
TOTAL	97	252	25	92	14	6	1.94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



GROUND FLOOR PLAN

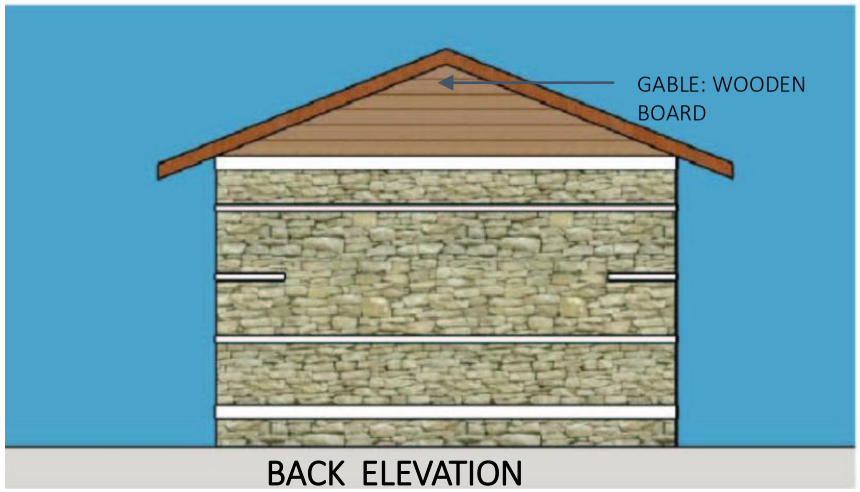
FLOOR AREA: 15.88sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.2	SCALE: 1:50	DATE:	SMC-1.2
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4

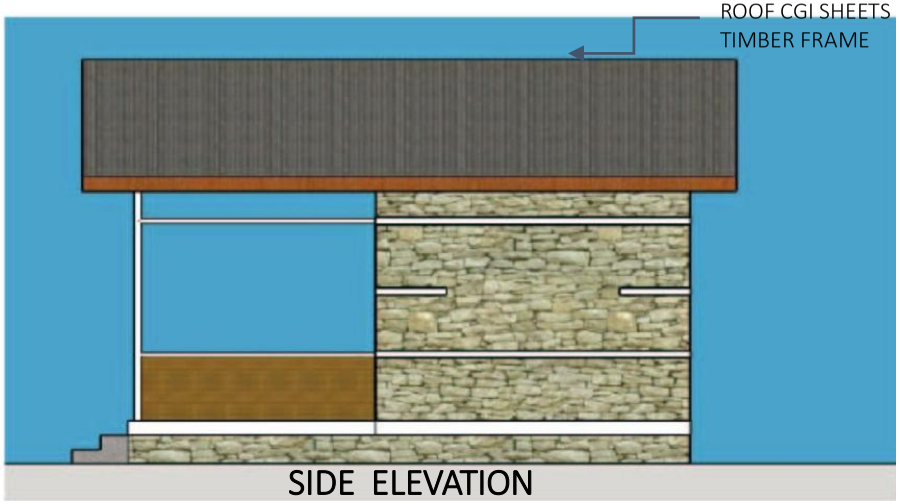


FRONT ELEVATION

SIDE ELEVATION

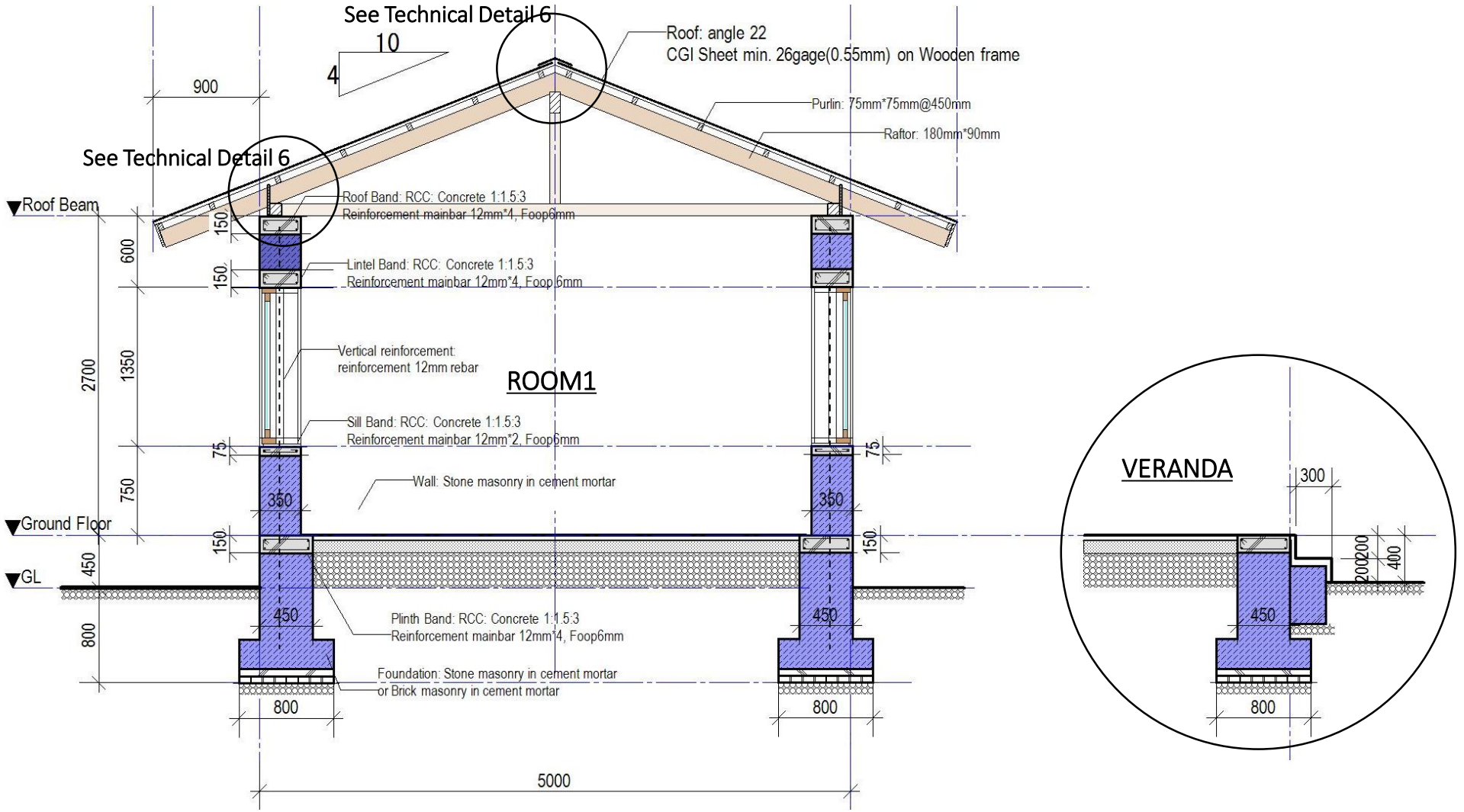


BACK ELEVATION



SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.2	SCALE: None	DATE:	SMC-1.2
	DRAWING TITLE: ELEVATION	DESIGNED BY: JICA		3/4



SECTION A-A

SECTION B-B

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-1.2	SCALE: 1:50	DATE:	SMC-1.2
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		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.

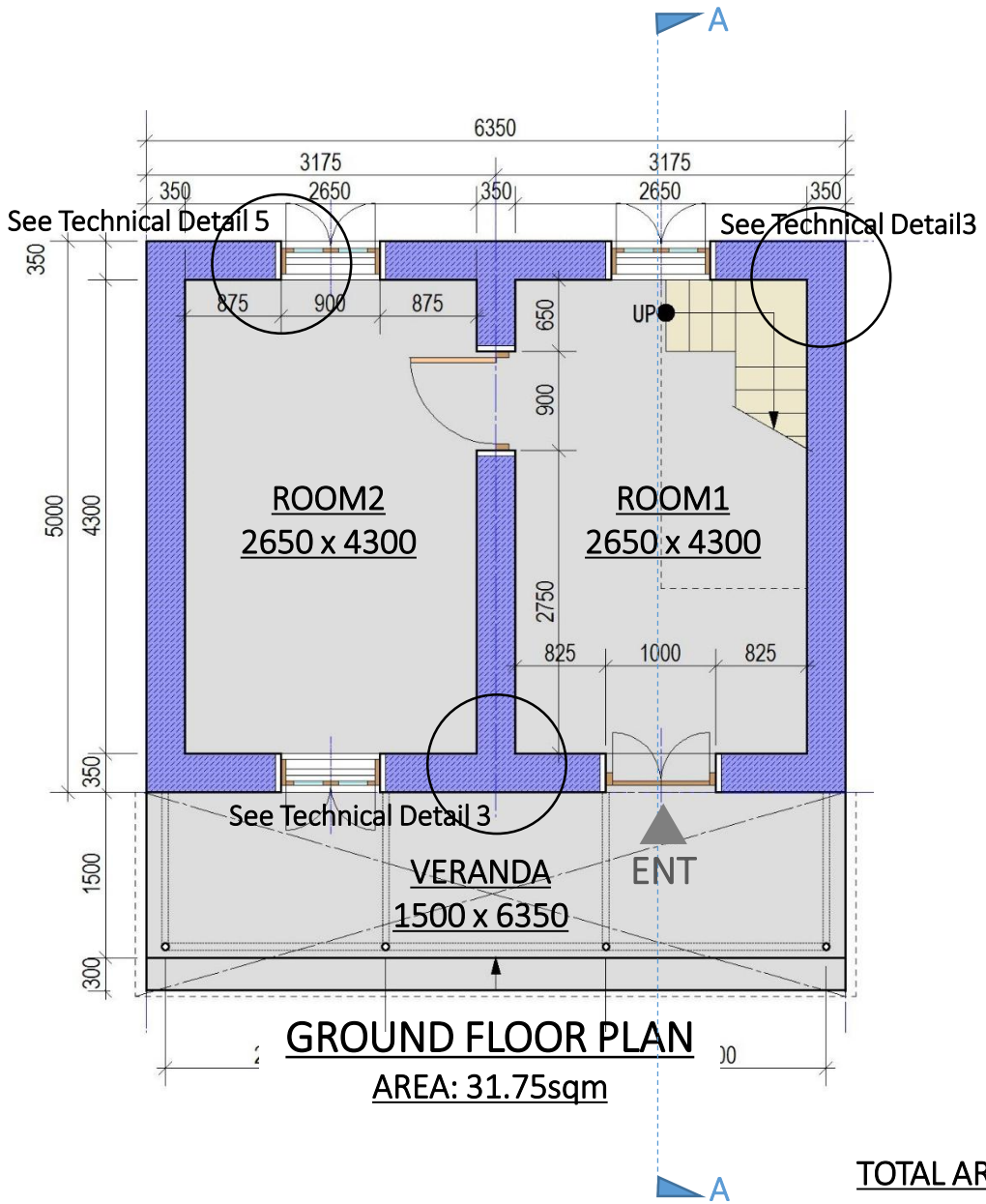
The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.

.

SMC-2.1

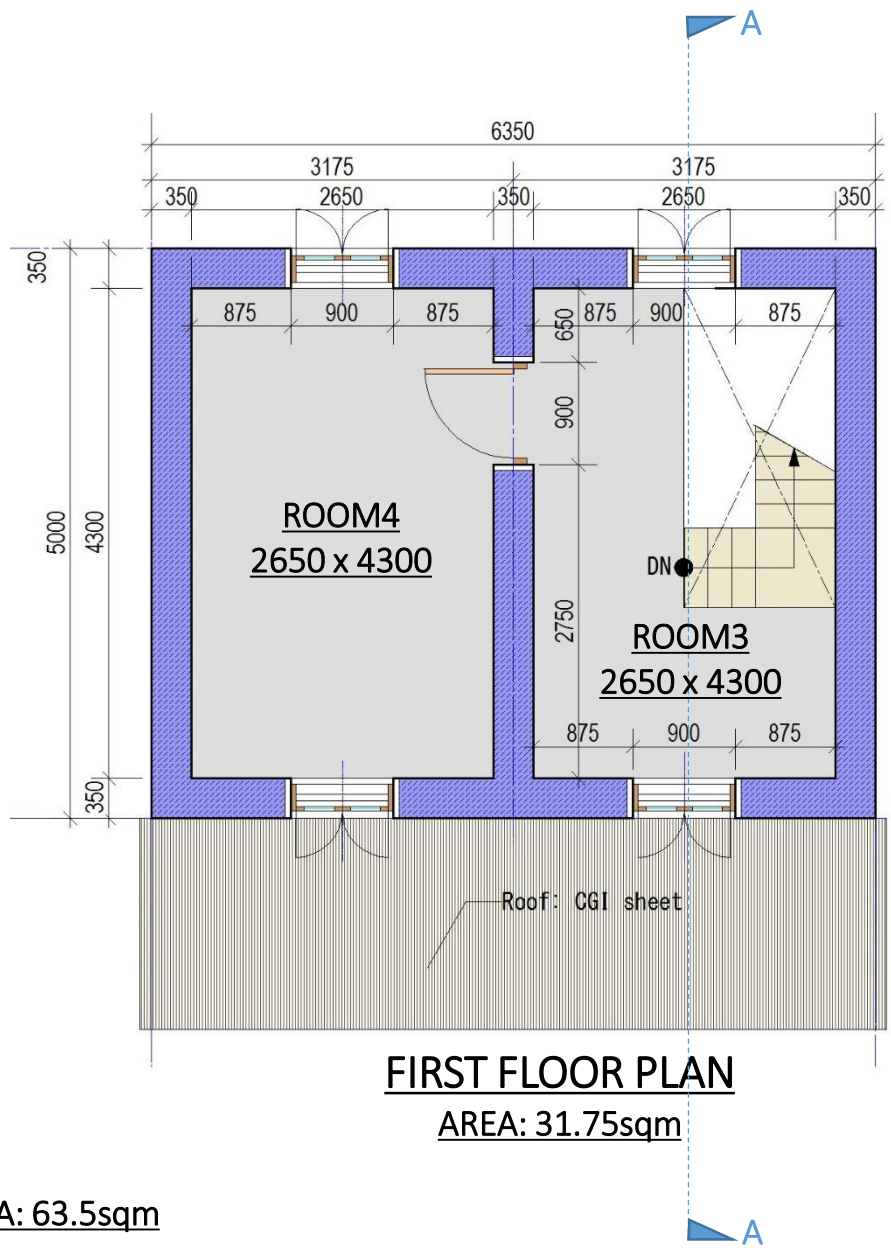
LEVEL	MAN POWER		MATERIALS						
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar
	Md	Md	cu.m.	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Kg
Up to Plinth Level	86	317	17	76	12	6	0	0	146
SUPERSTRUCTURE	175	290	31	111	17	4	2.95	1.02	631
ROOFING	17	20	0	0	0	0	1.48	3.69	0
TOTAL	279	626	48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

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.1	SCALE: None	DATE:	SMC-2.1
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA		1/4



GROUND FLOOR PLAN

AREA: 31.75sqm



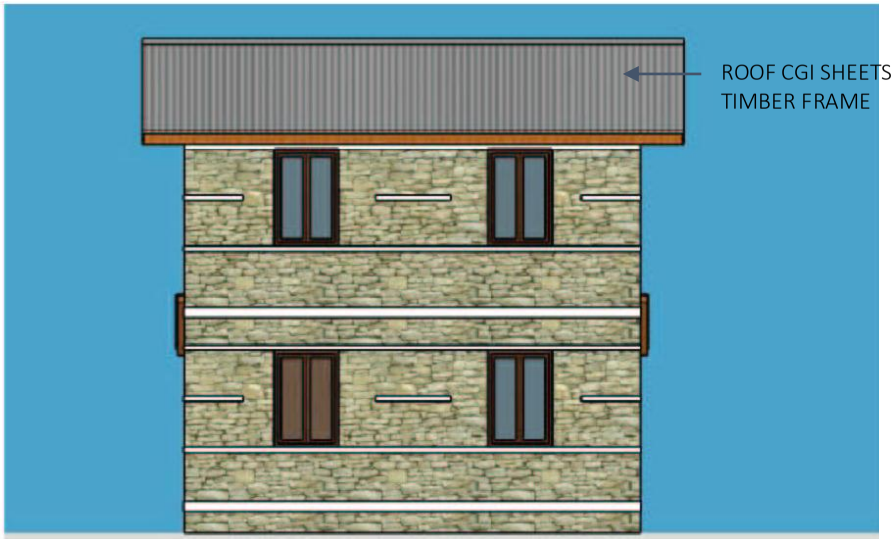
FIRST FLOOR PLAN

AREA: 31.75sqm

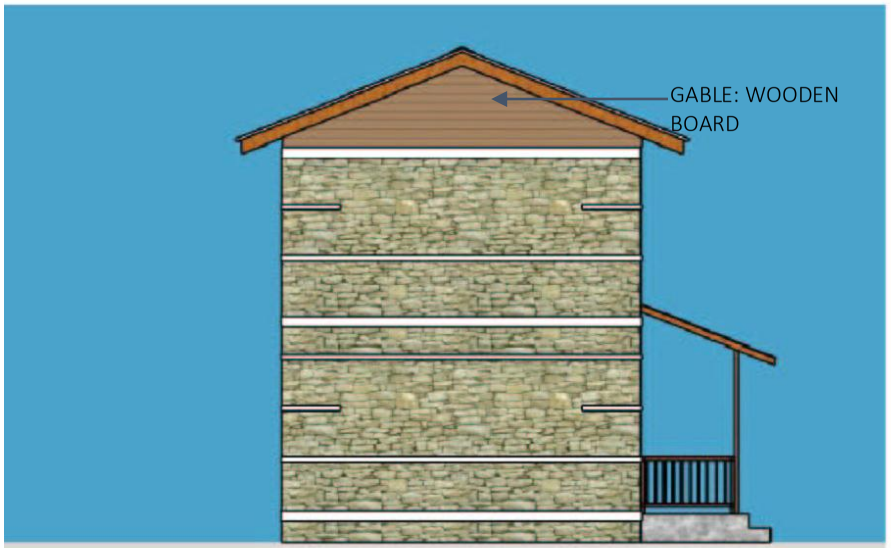
TOTAL AREA: 63.5sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.1	SCALE: None	DATE:	SMC-2.1
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4

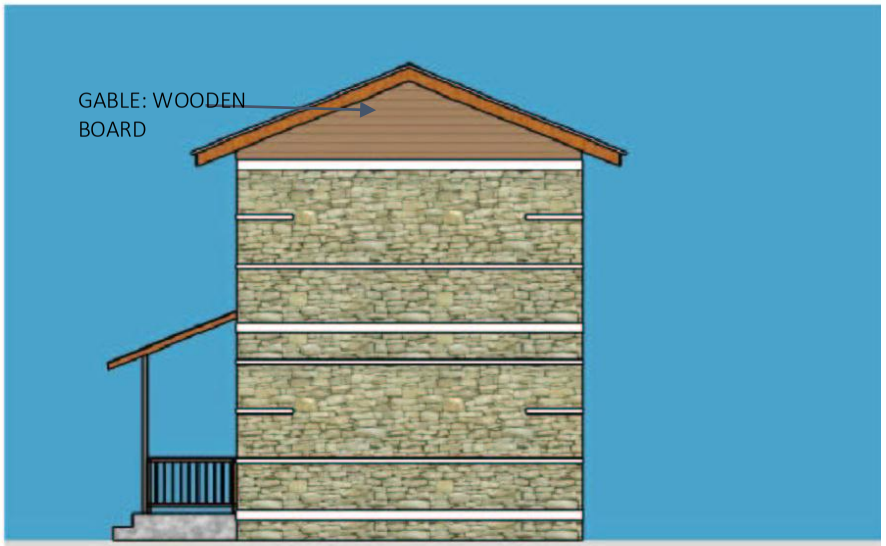
FRONT ELEVATION



BACK ELEVATION



SIDE ELEVATION

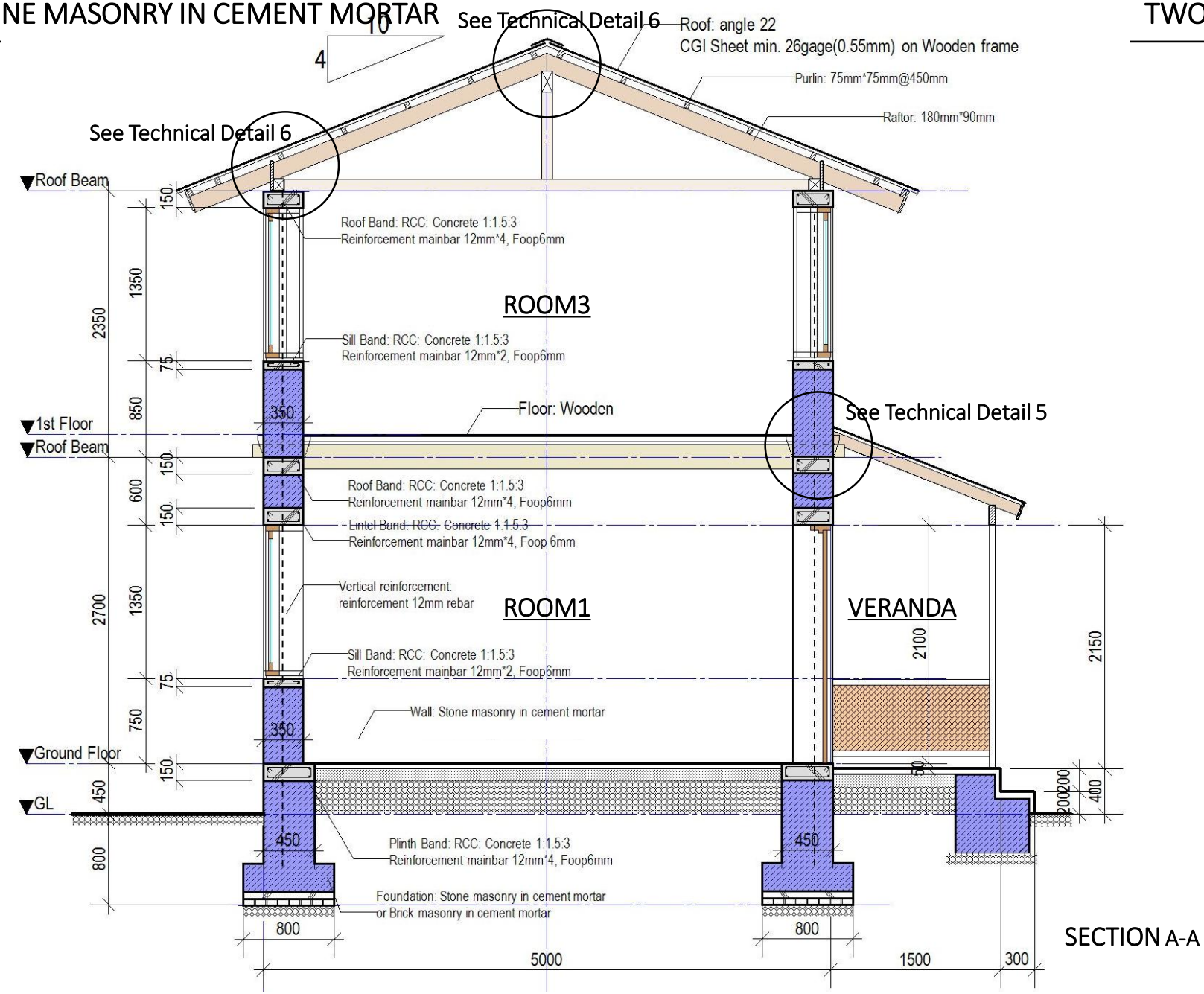


SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.1	SCALE: None	DATE:	SMC-2.1
	DRAWING TITLE: ELEVATION	DESIGNED BY: JICA		3/4

Model SMC-2.1: STONE MASONRY IN CEMENT MORTAR

TWO-STOREY



SECTION A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.1	SCALE: 1:50	DATE:	SMC-2.1
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		4/4

STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

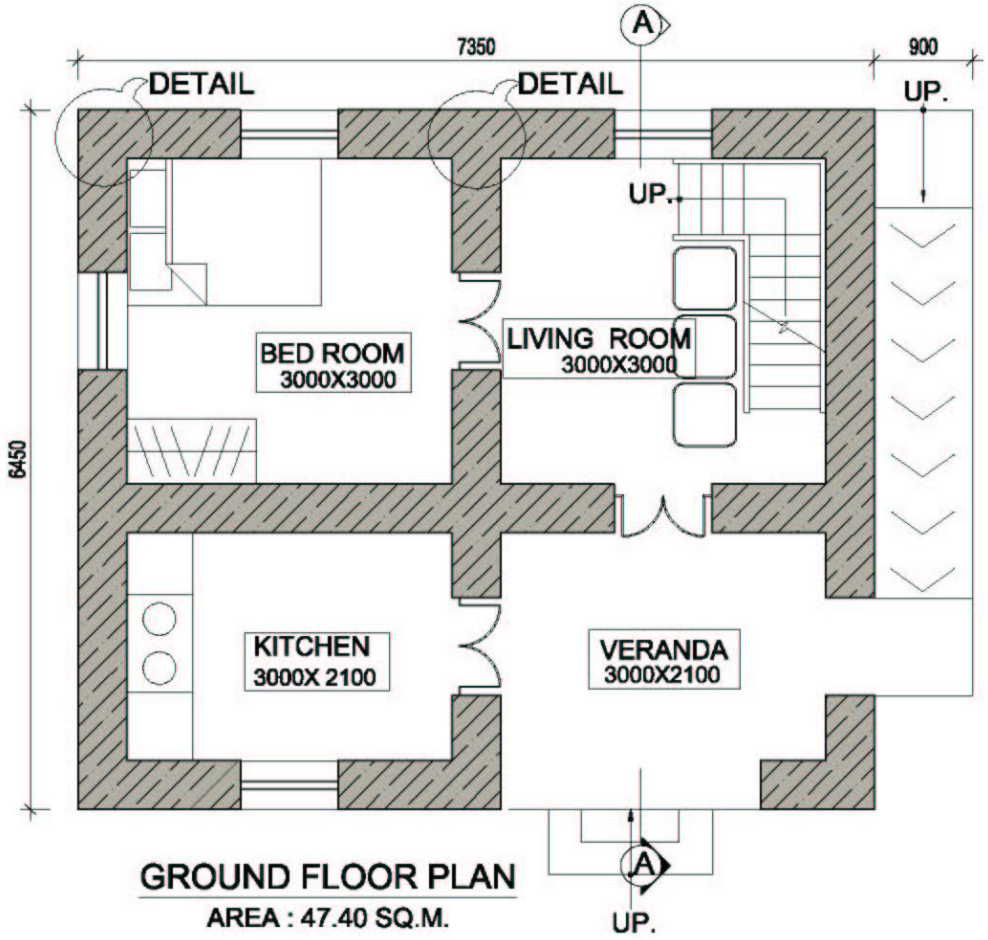
SMC-2.2

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

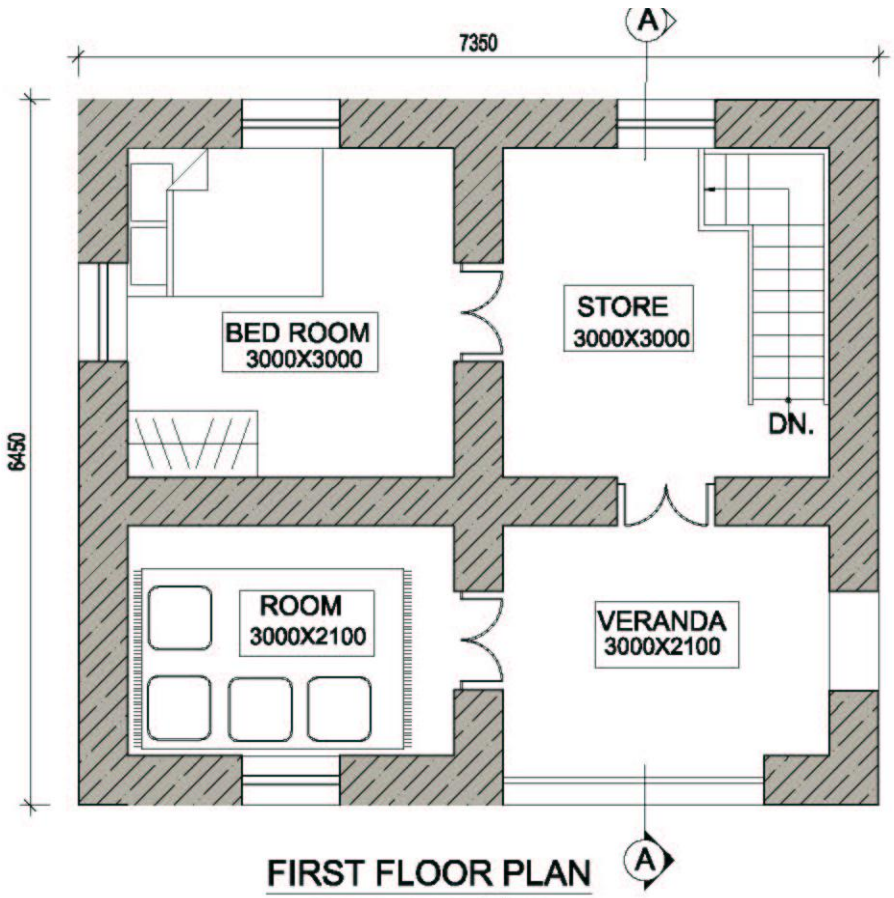
SMC-2.2

CONSTRUCTION MATERIAL AND MANPOWER

LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	Rod	CGI SHEET	WOOD	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



GROUND FLOOR PLAN
AREA : 47.40 SQ.M.

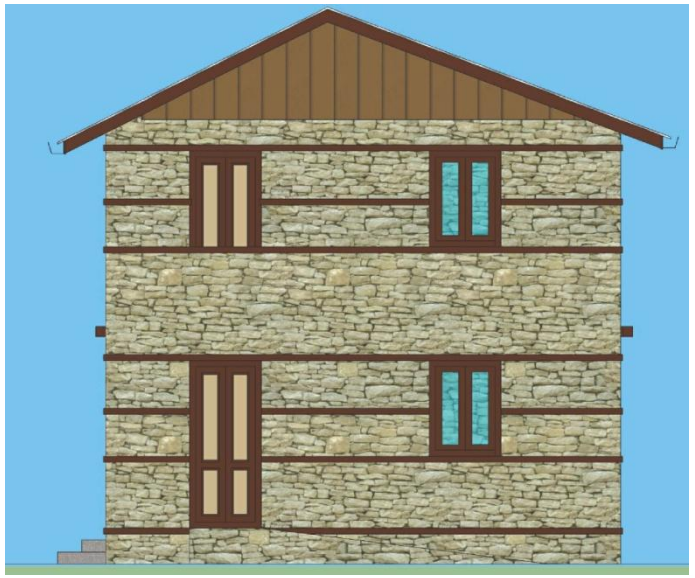


FIRST FLOOR PLAN
AREA : 47.40 SQ.M.

TOTAL AREA: 94.8sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.2	SCALE: None	DATE:	SMC-2.2
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION

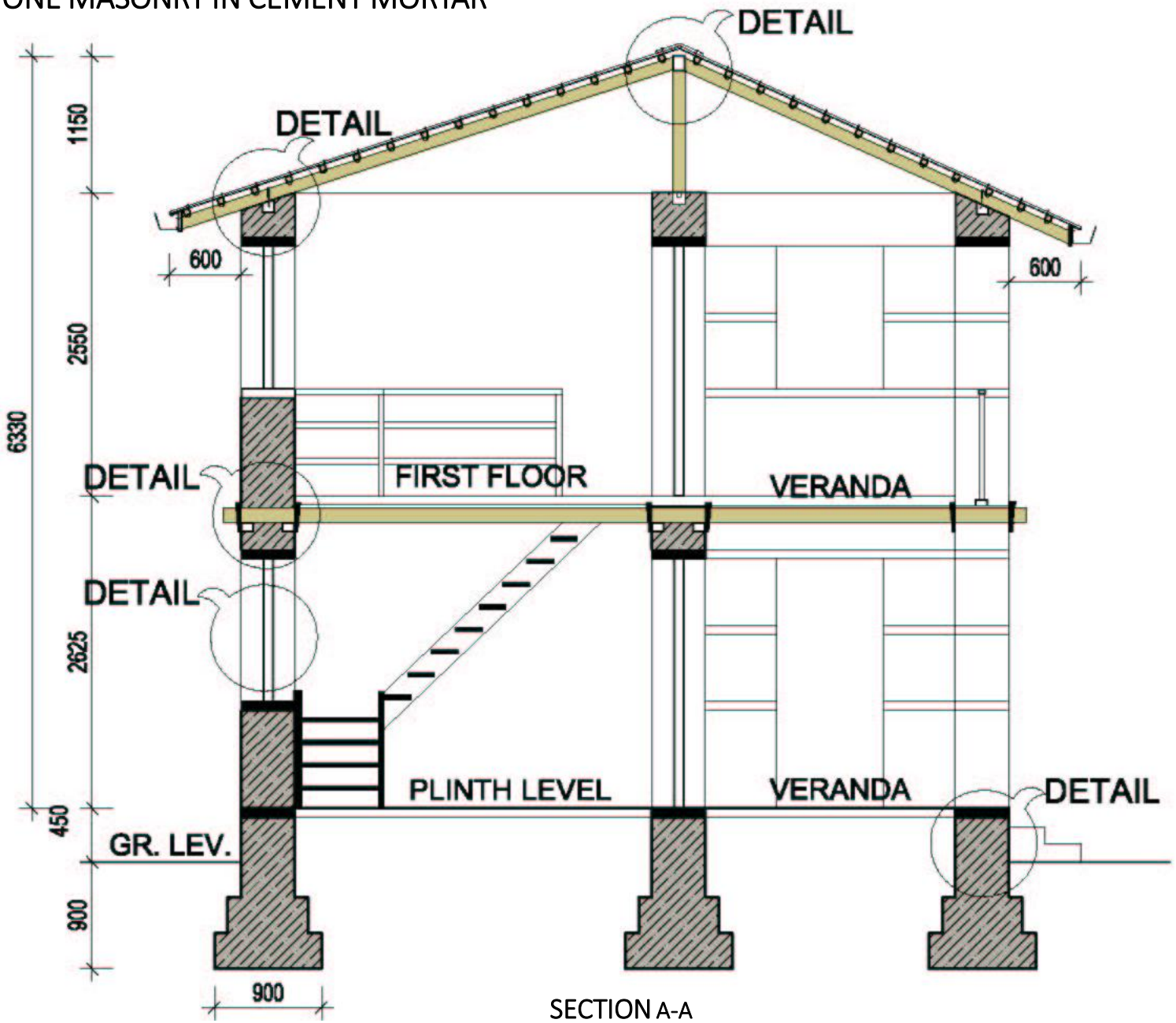


RIGHT SIDE ELEVATION

BACK ELEVATION

LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.2	SCALE: None	DATE:	SMC-2.2
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4



SECTION A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.2	SCALE: 1:50	DATE:	SMC-2.2
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		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.

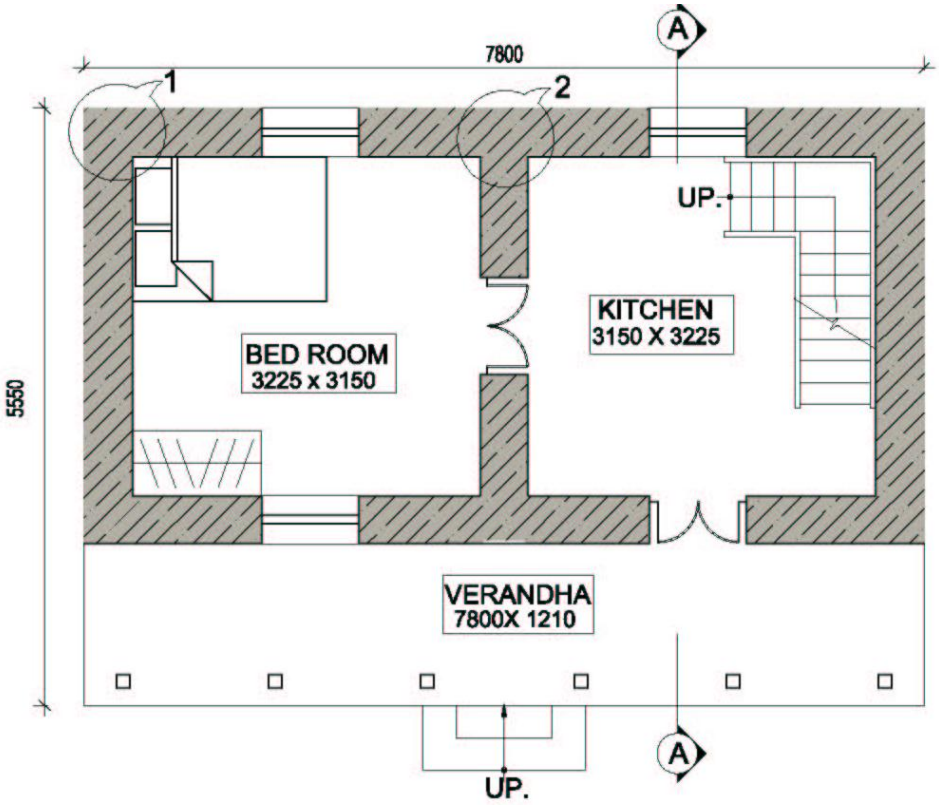
SMC-2.3

Model SMC-2.3: STONE MASONRY IN CEMENT MORTAR — TWO-STOREY

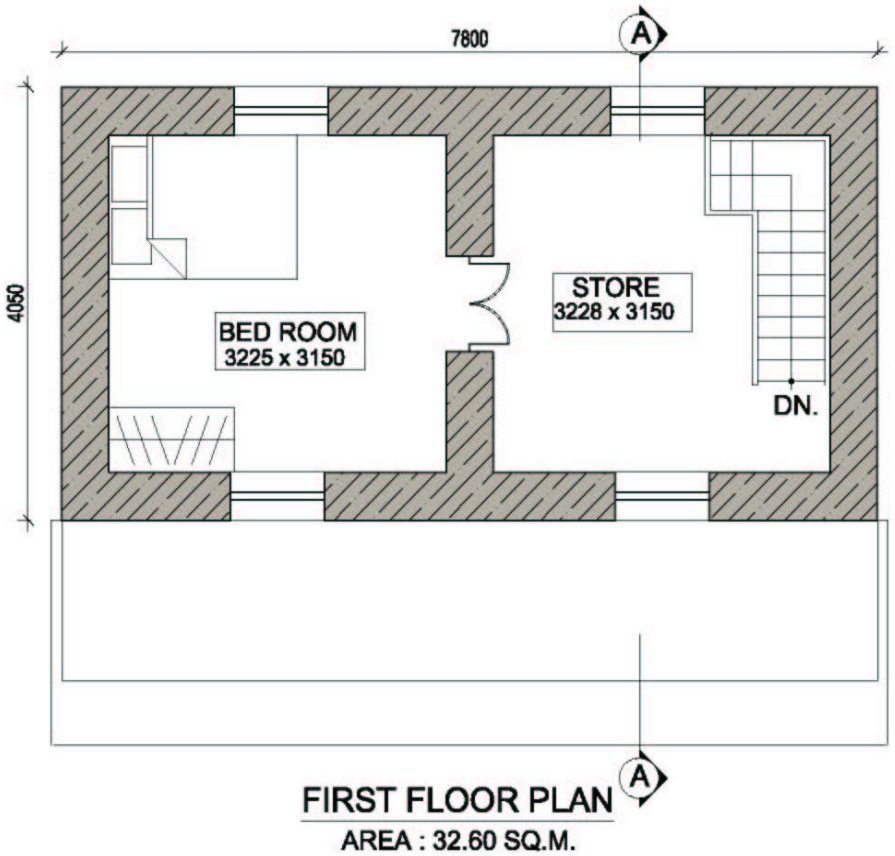
CONSTRUCTION MATERIAL AND MANPOWER

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	SCALE: NONE	DATE:	SMC-2.3
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC		1/4



GROUND FLOOR PLAN
AREA :43.30 SQ.M.

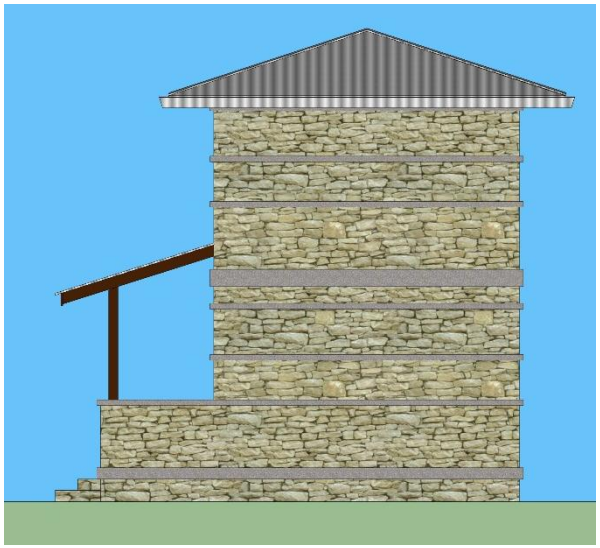


FIRST FLOOR PLAN
AREA : 32.60 SQ.M.

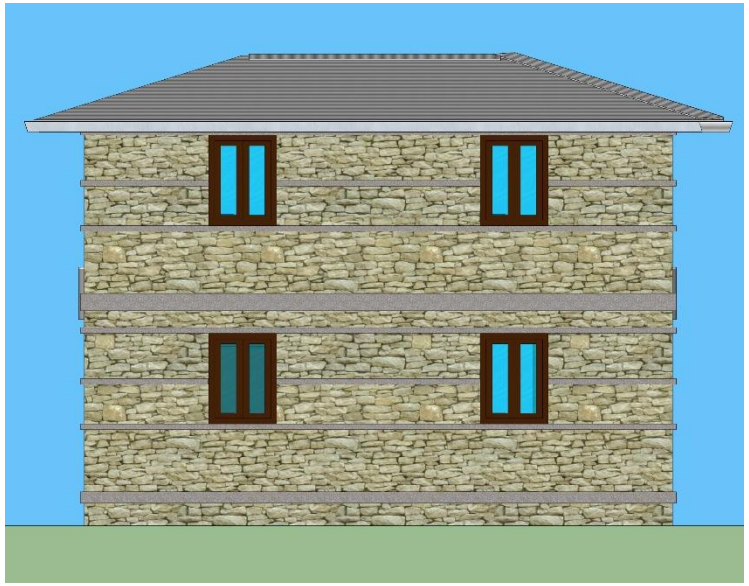
TOTAL AREA: 75.9sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.3	SCALE: None	DATE:	SMC-2.3
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

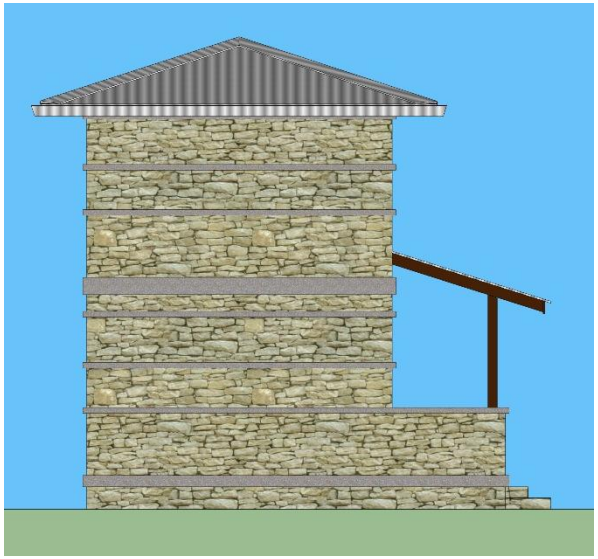
FRONT ELEVATION



RIGHT SIDE ELEVATION

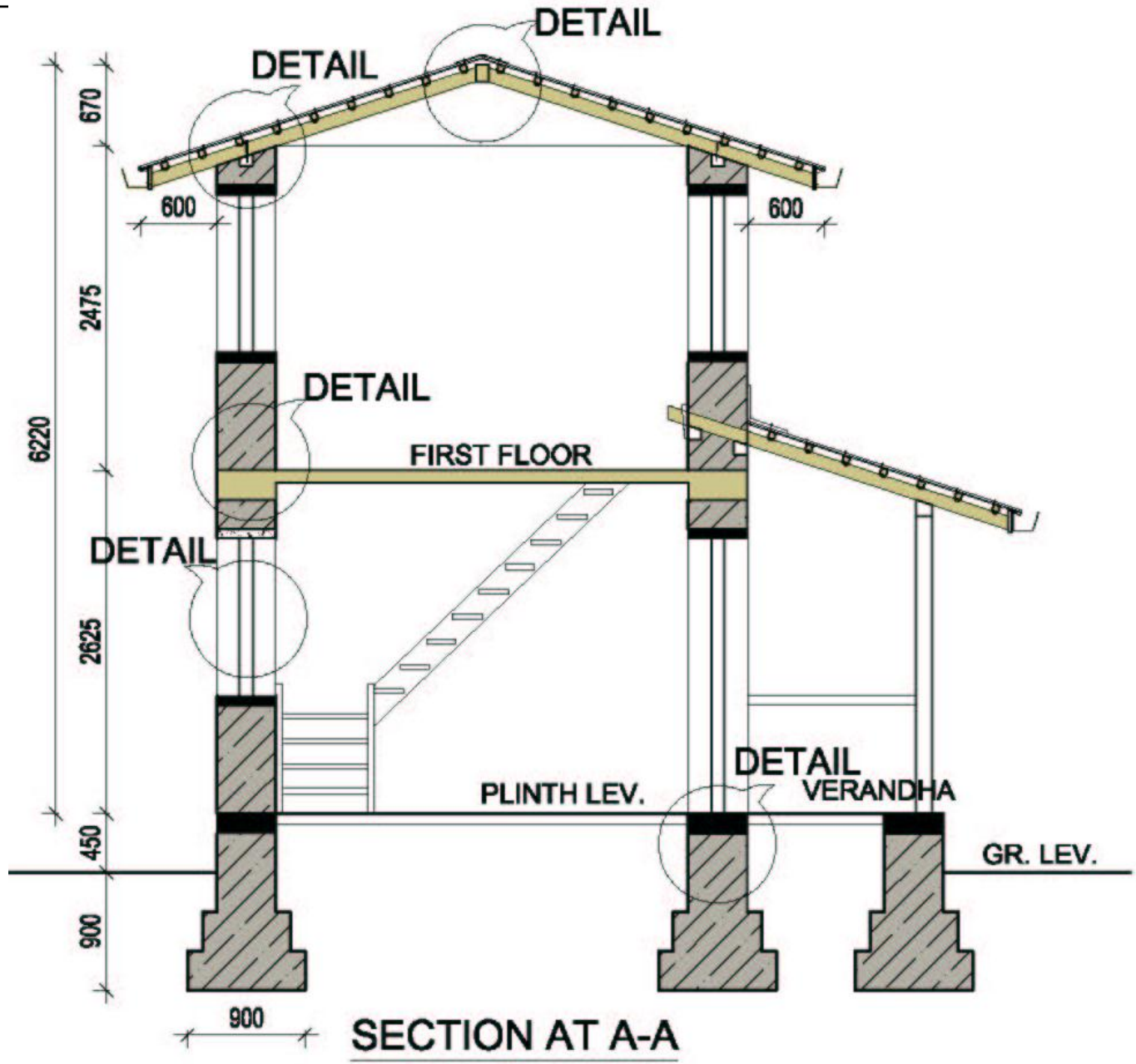


BACK ELEVATION



LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.3	SCALE: None	DATE:	SMC-2.3
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4



Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.3	SCALE: 1:50	DATE:	SMC-2.3
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

SMC-2.4

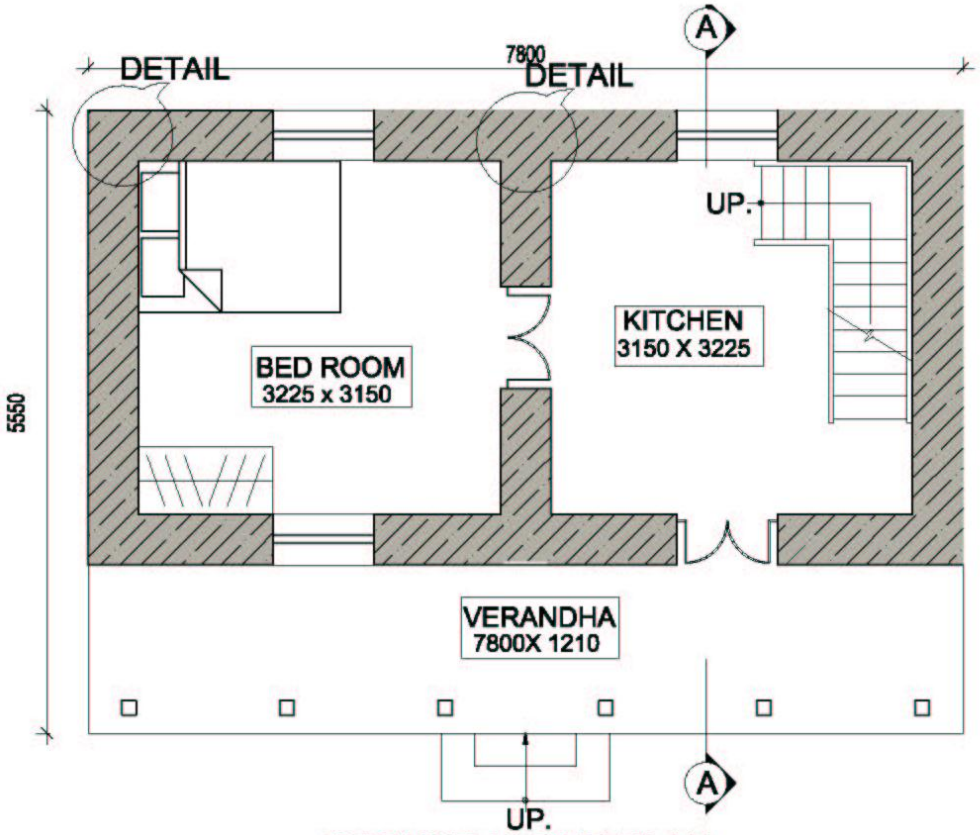
Model SMC-2.4 is a two storey house which can accommodate 8-10 people, On both floors there are two rooms with dimensions 3225x3150 and a covered verandah with dimensions 7300X1250 in the first floor. The design focuses on earthquake resistant construction using locally available construction materials. 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

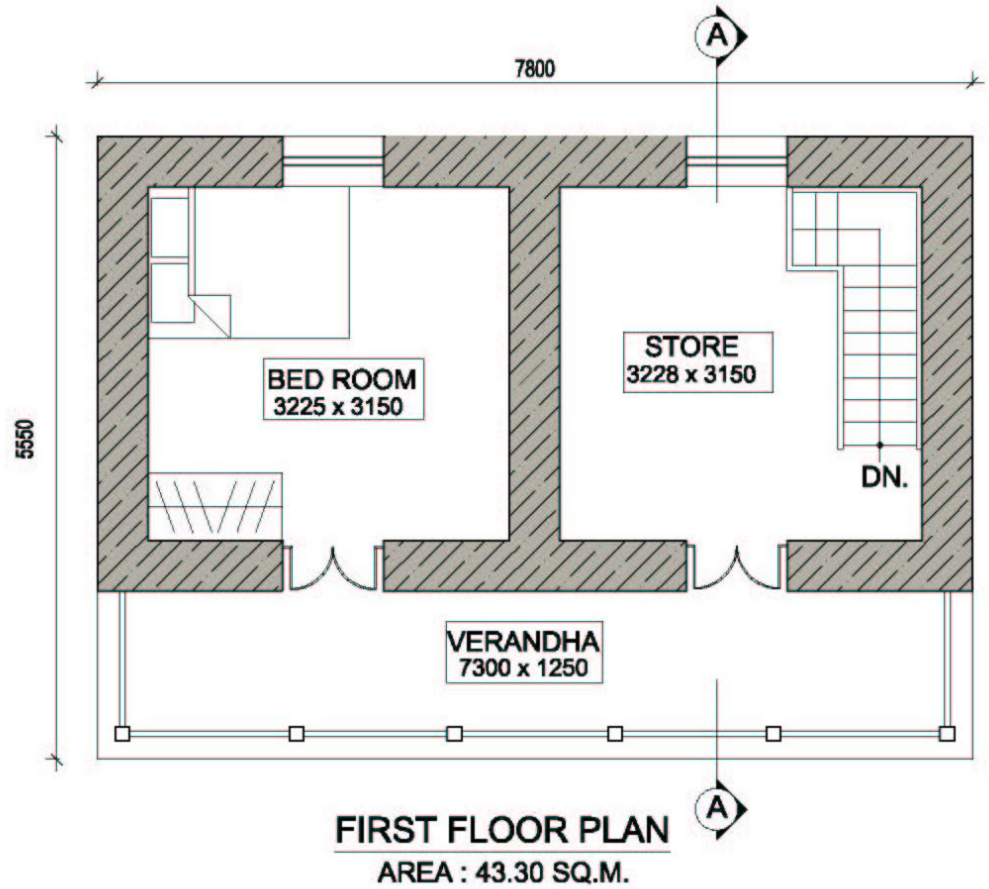
LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	GI SHEET	Rod (Steel)
	Md	Md	Cu.m	Bags	Cu.m	Cu.m	Cu.m	Bundel	Rm.	Kg
Up to Plinth Level	50	184	1038	73	15	4	0	0	0	207
SUPERSTRUCTURE	190	381	2745	180	34	4	3.16	0	0	496
ROOFING	46	0	0	0	0	0	2.19	4.36	11	0
TOTAL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

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.4	SCALE: NONE	DATE:	SMC-2.4
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC		1/4



GROUND FLOOR PLAN

AREA :43.30 SQ.M.



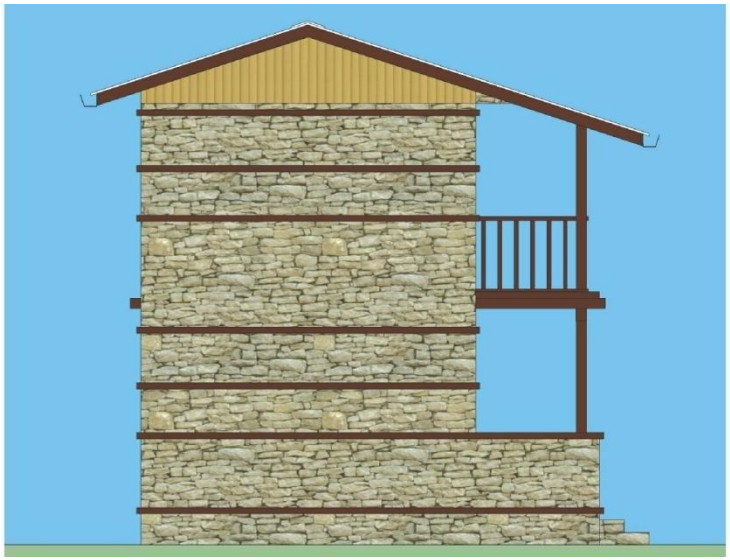
FIRST FLOOR PLAN

AREA : 43.30 SQ.M.

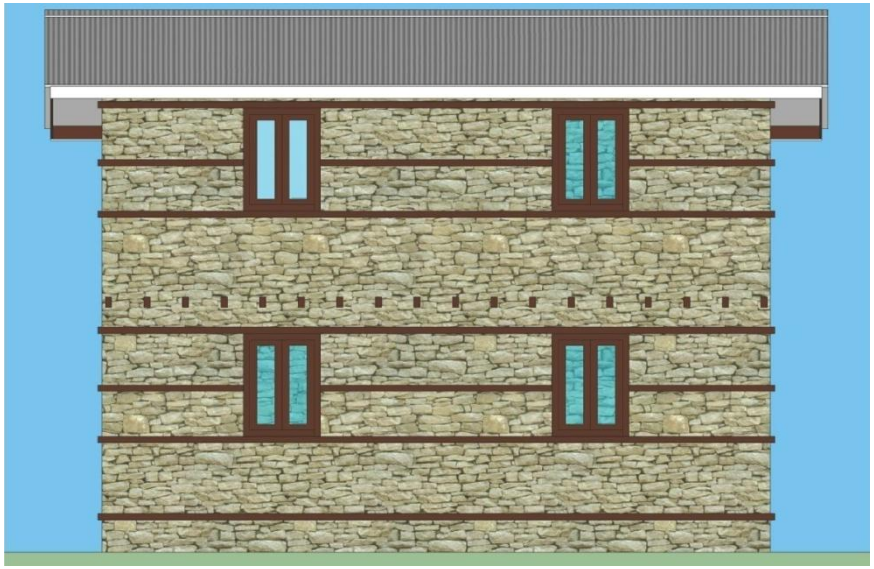
TOTAL AREA: 86.6sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.4	SCALE: None	DATE:	SMC-2.4
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION



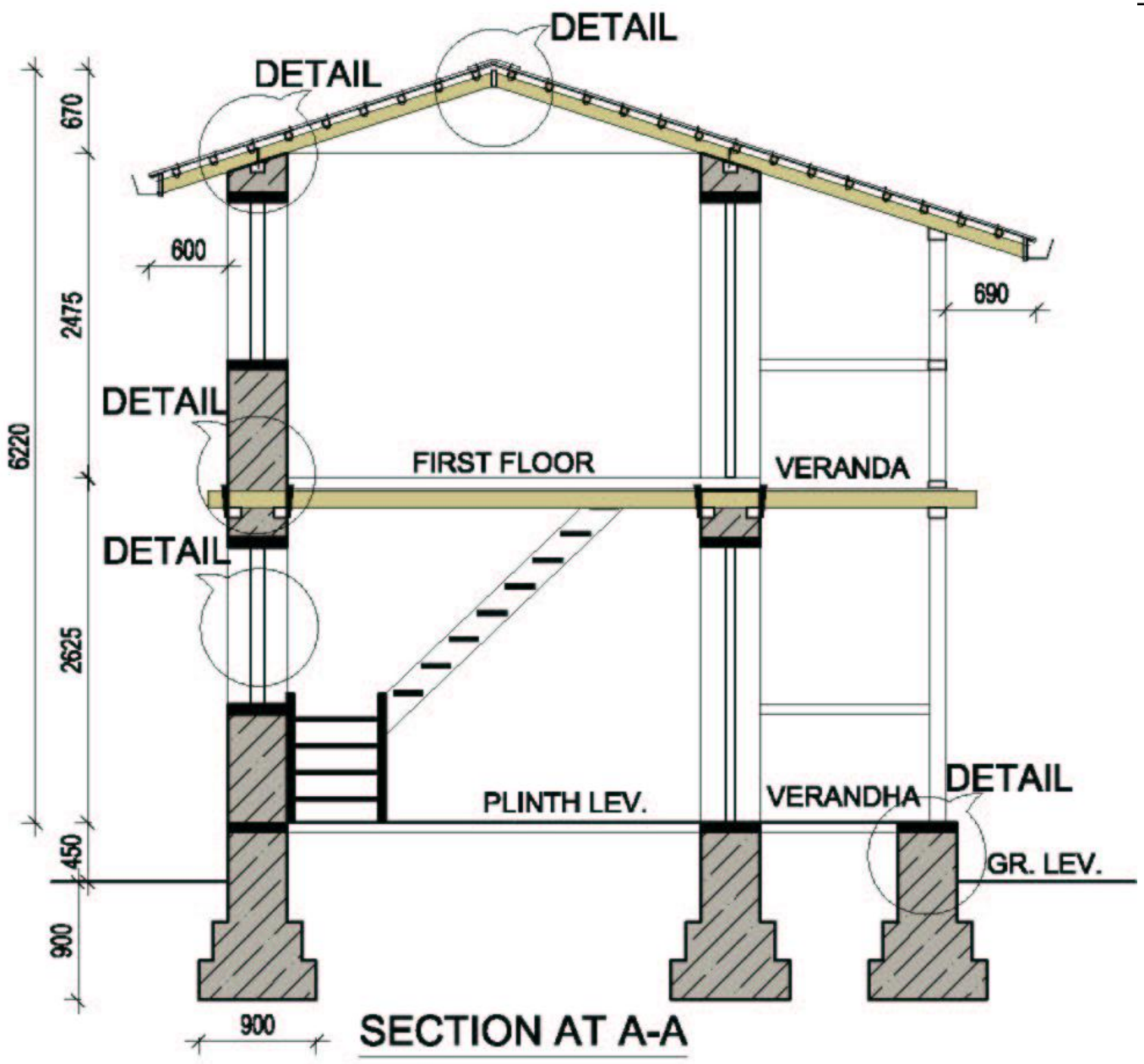
RIGHT SIDE ELEVATION



BACK ELEVATION

LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.4	SCALE: None	DATE:	SMC-2.4
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4



Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.4	SCALE: 1:50	DATE:	SMC-2.4
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

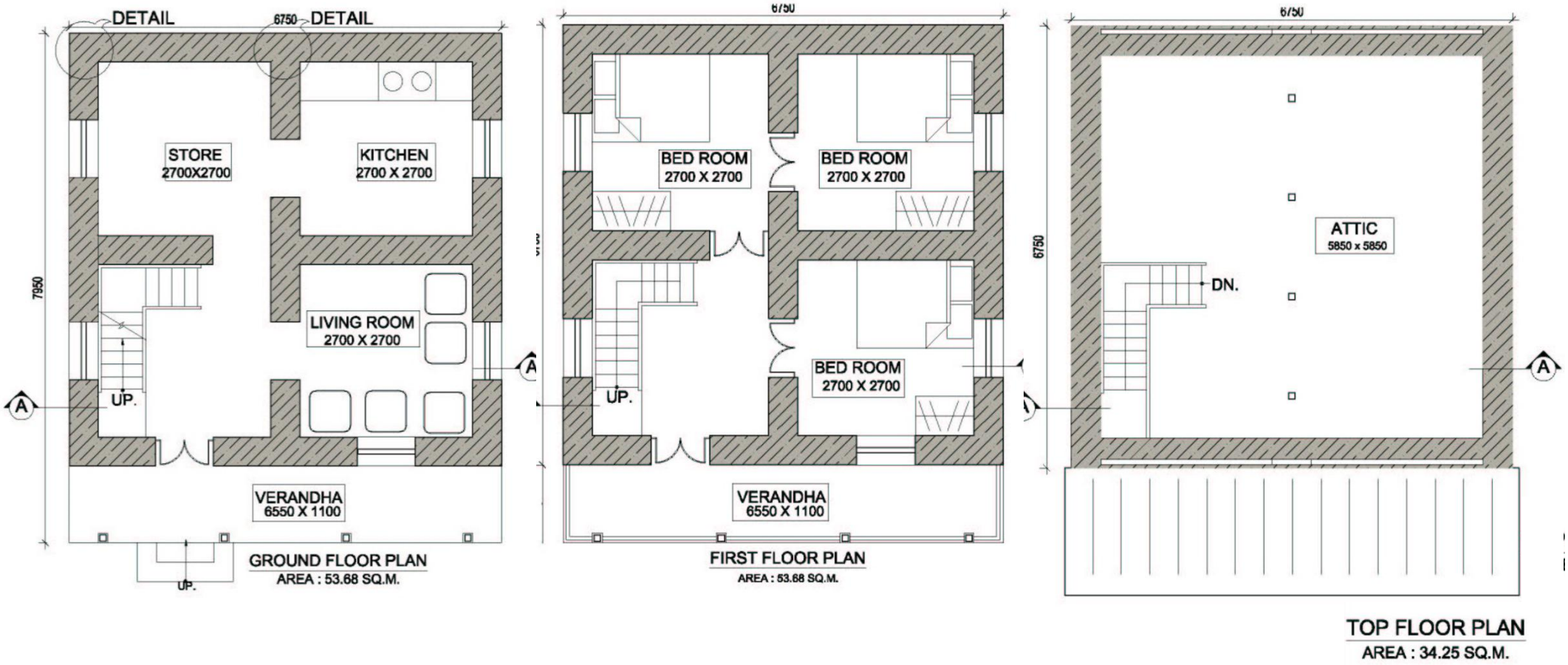
SMC-2.5

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

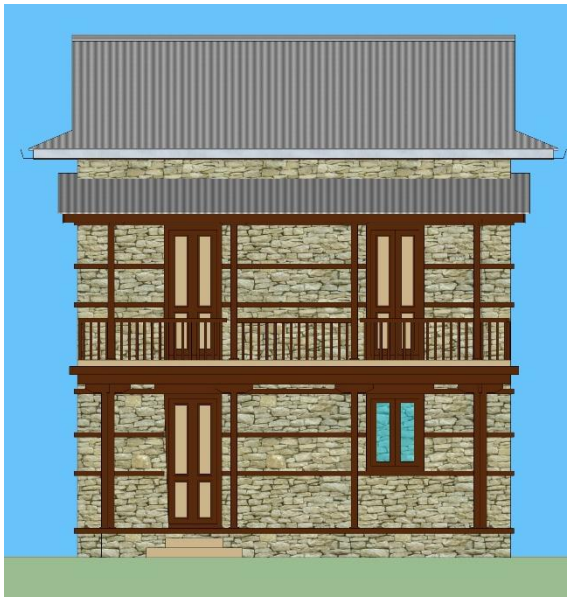
CONSTRUCTION MATERIALS AND MANPOWER

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

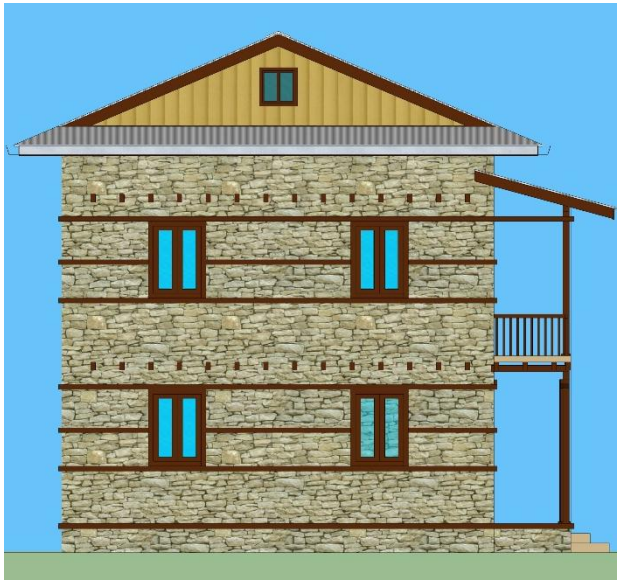


TOTAL AREA: 107.36sqm

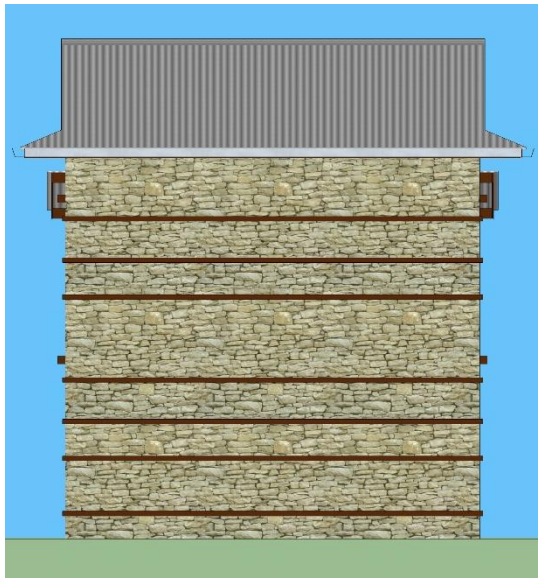
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.5	SCALE: None	DATE:	SMC-2.5
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4



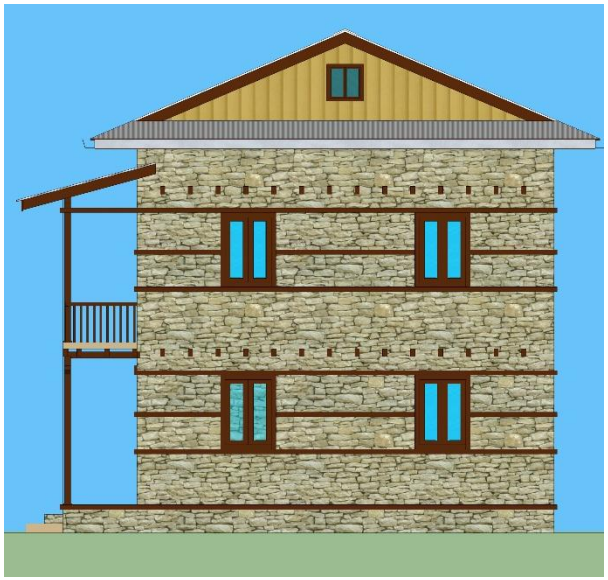
FRONT ELEVATION



RIGHT SIDE ELEVATION

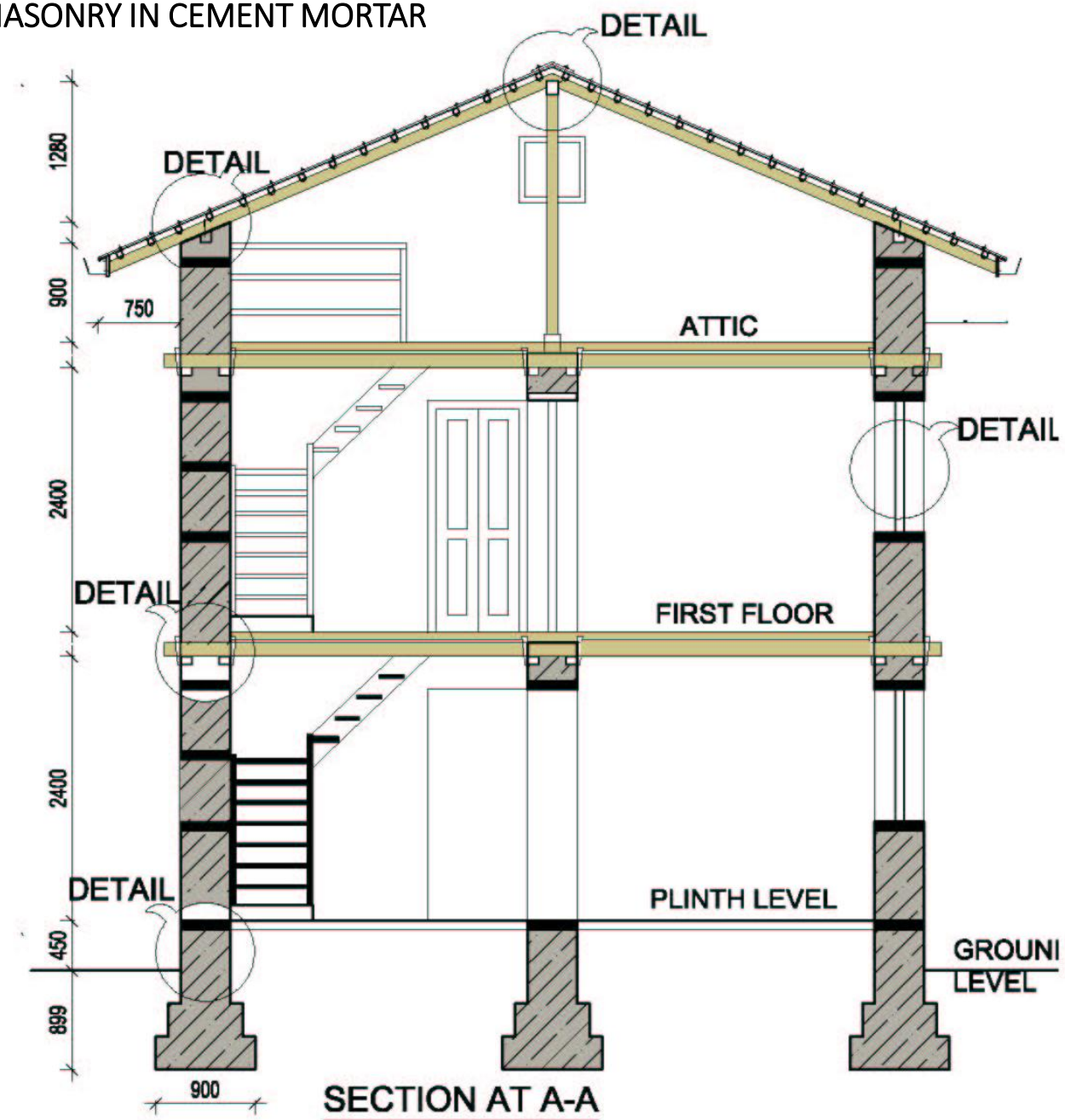


BACK ELEVATION



LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.5	SCALE: None	DATE:	SMC-2.5
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4



SECTION AT A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.5		SCALE: 1:50	DATE:	SMC-2.5
	DRAWING TITLE: SECTION		DESIGNED BY: DUDBC		4/4

STONE MASONRY IN CEMENT MORTAR, TWO-STOREY

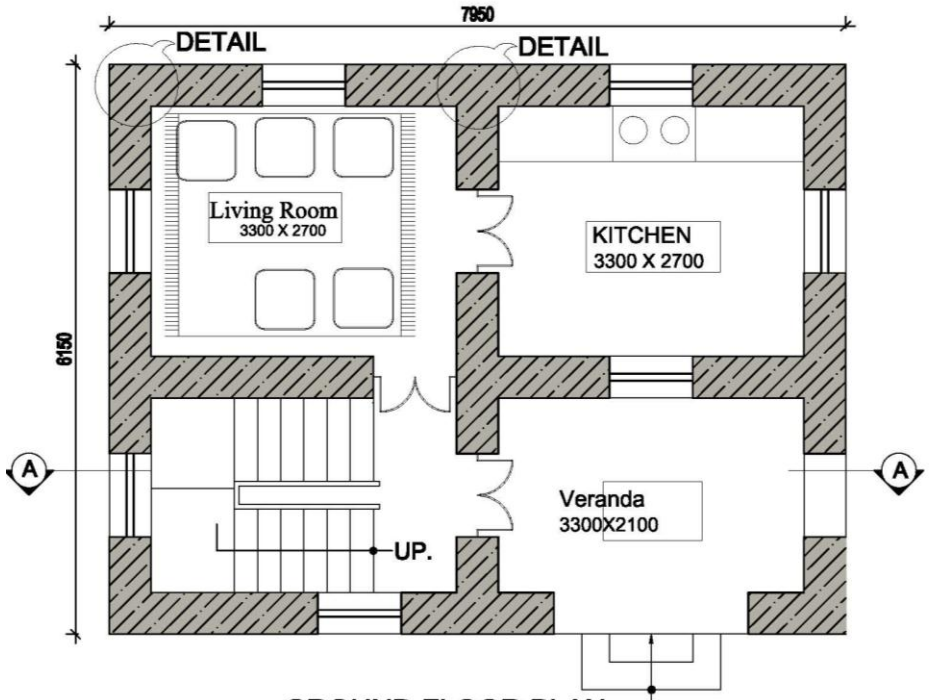
SMC-2.6

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.

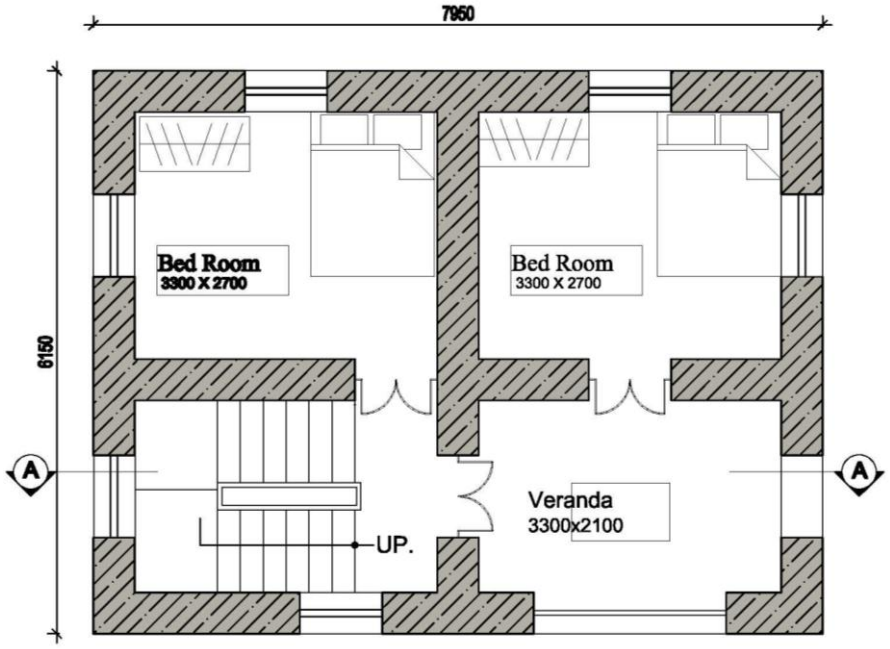
SMC-2.6

CONSTRUCTION MATERIALS AND MANPOWER

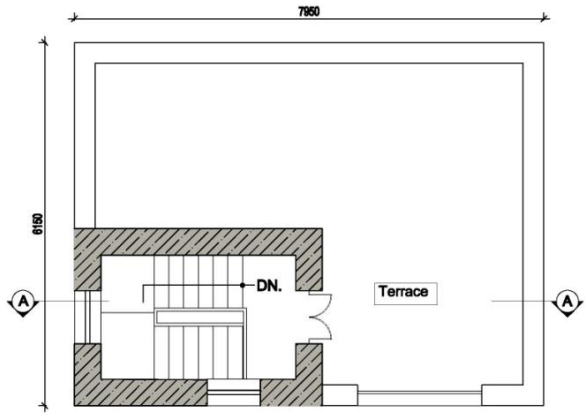
LEVEL	MAN POWER		MATERIALS					
	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	ROD
	Md	Md	Cu.m.	Bags	Cu.m	Cu.m	Cu.m	KG
Up to Plinth Band	65	241	38	103	27	9	0	160
Up to Roof Band	346	721	93	409	54	22	2.09	2654
TOTAL	412	962	132	504	81	31	2.09	2814



GROUND FLOOR PLAN
AREA 48.90 SQ.M.



FIRST FLOOR PLAN
AREA 48.90 SQ.M.

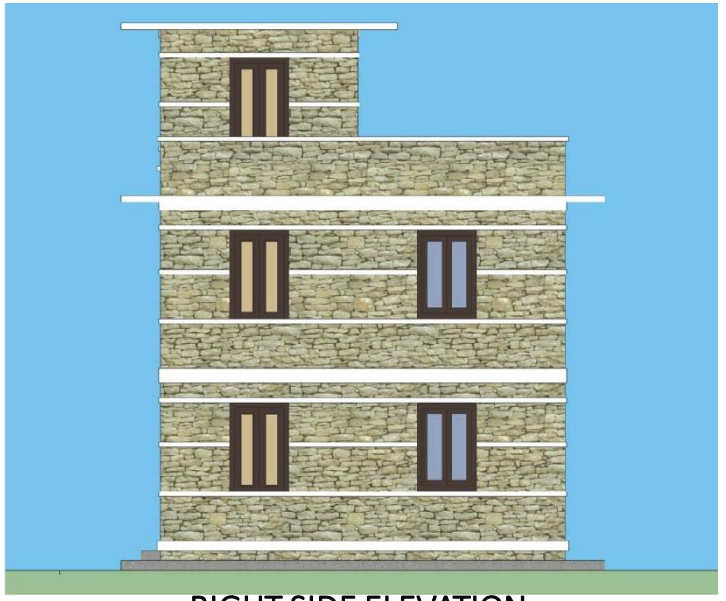


TOP FLOOR PLAN
Area=12.60 SQ.M.

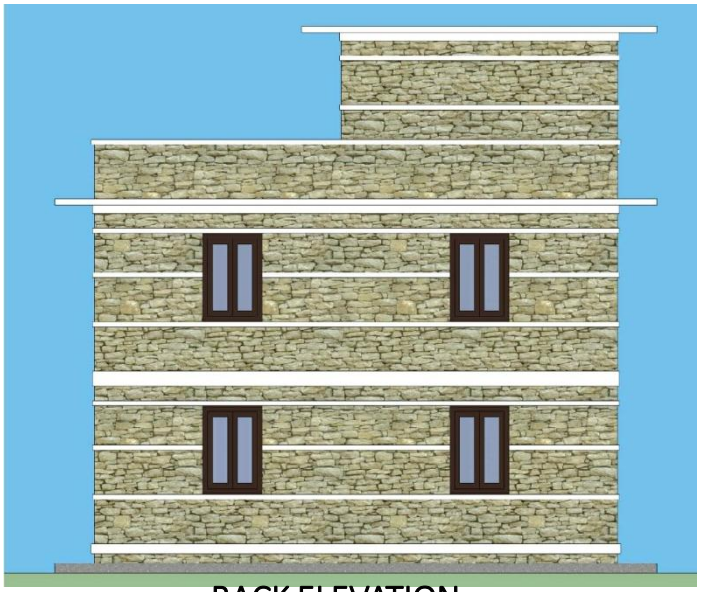
TOTAL AREA: 97.8sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.6	SCALE: None	DATE:	SMC-2.6
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

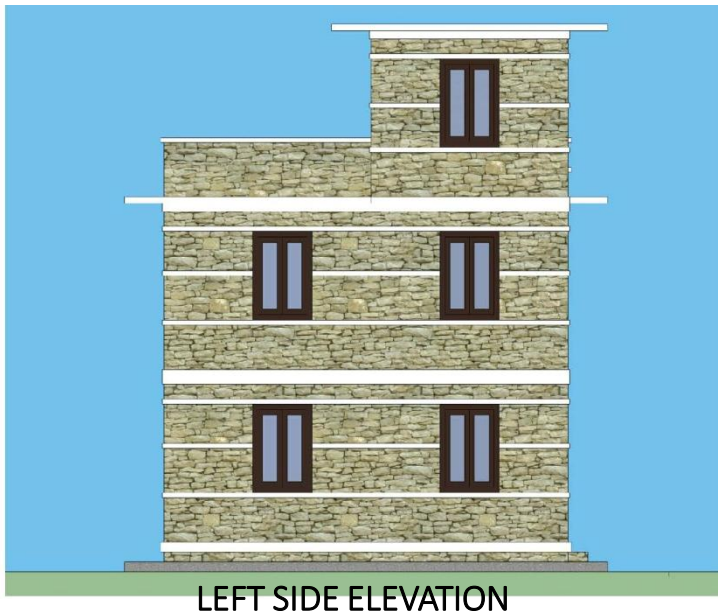
FRONT ELEVATION



RIGHT SIDE ELEVATION

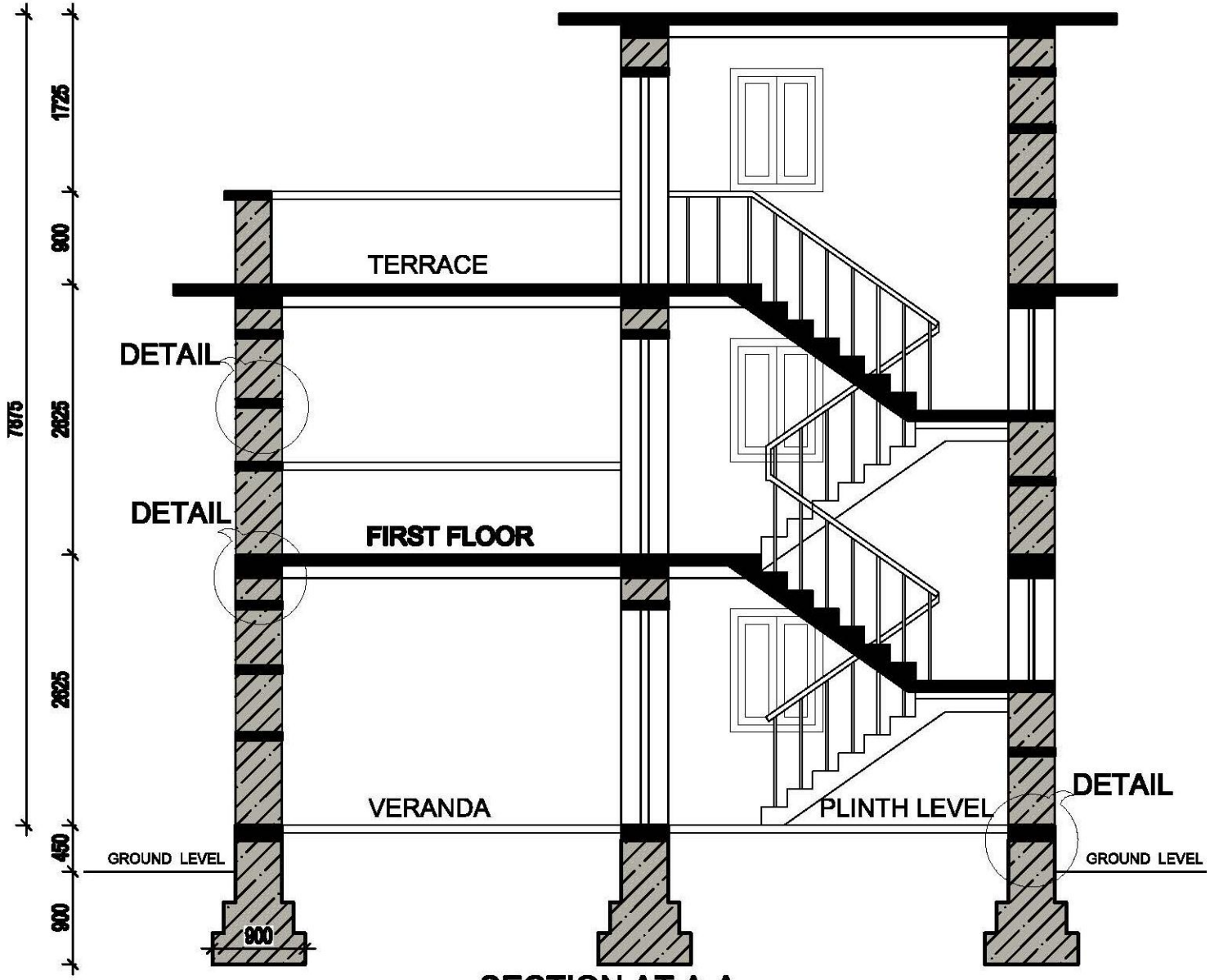


BACK ELEVATION



LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.6	SCALE: None	DATE:	SMC-2.6
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4

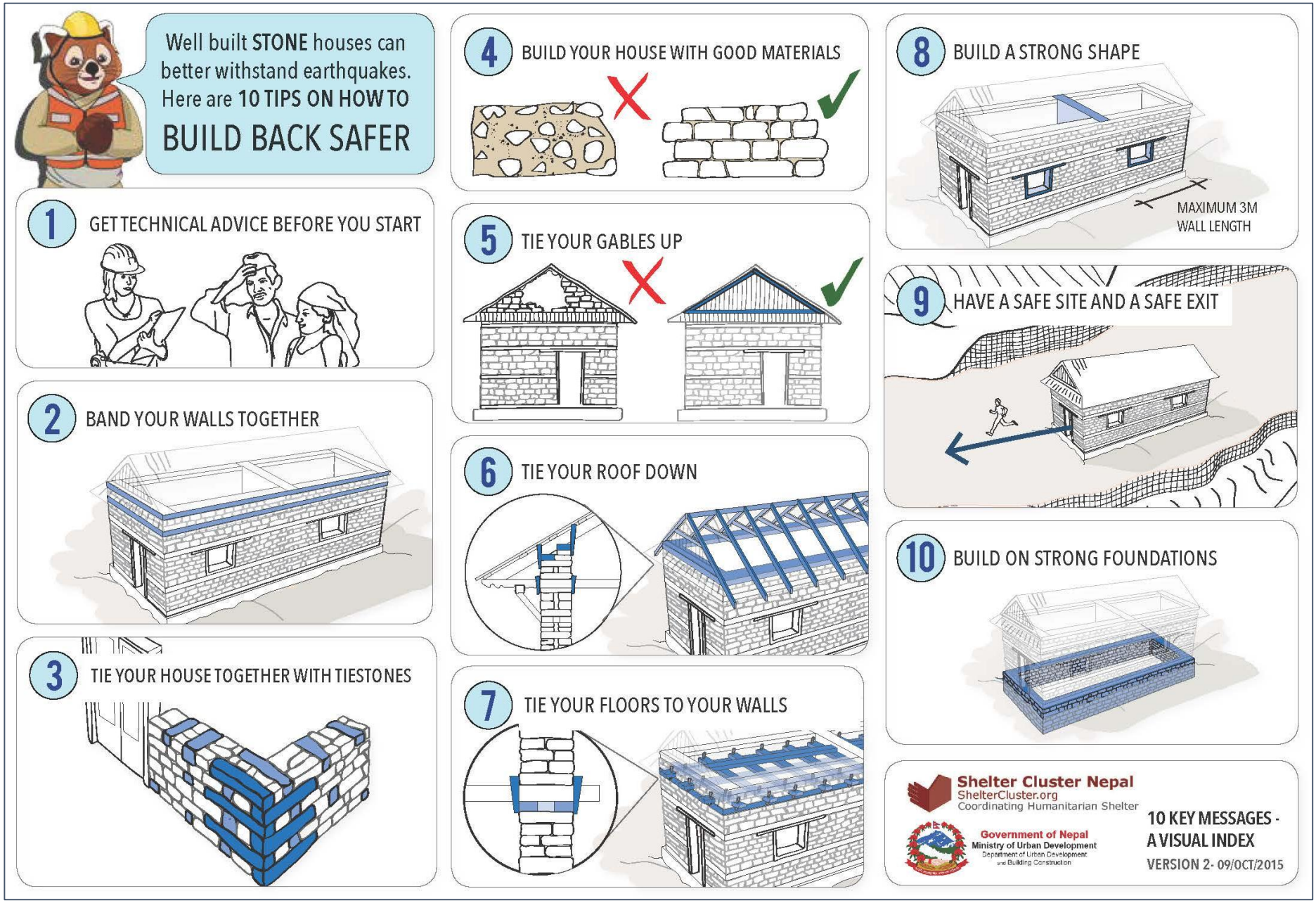


SECTION AT A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.6	SCALE: None	DATE:	SMC-2.6
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

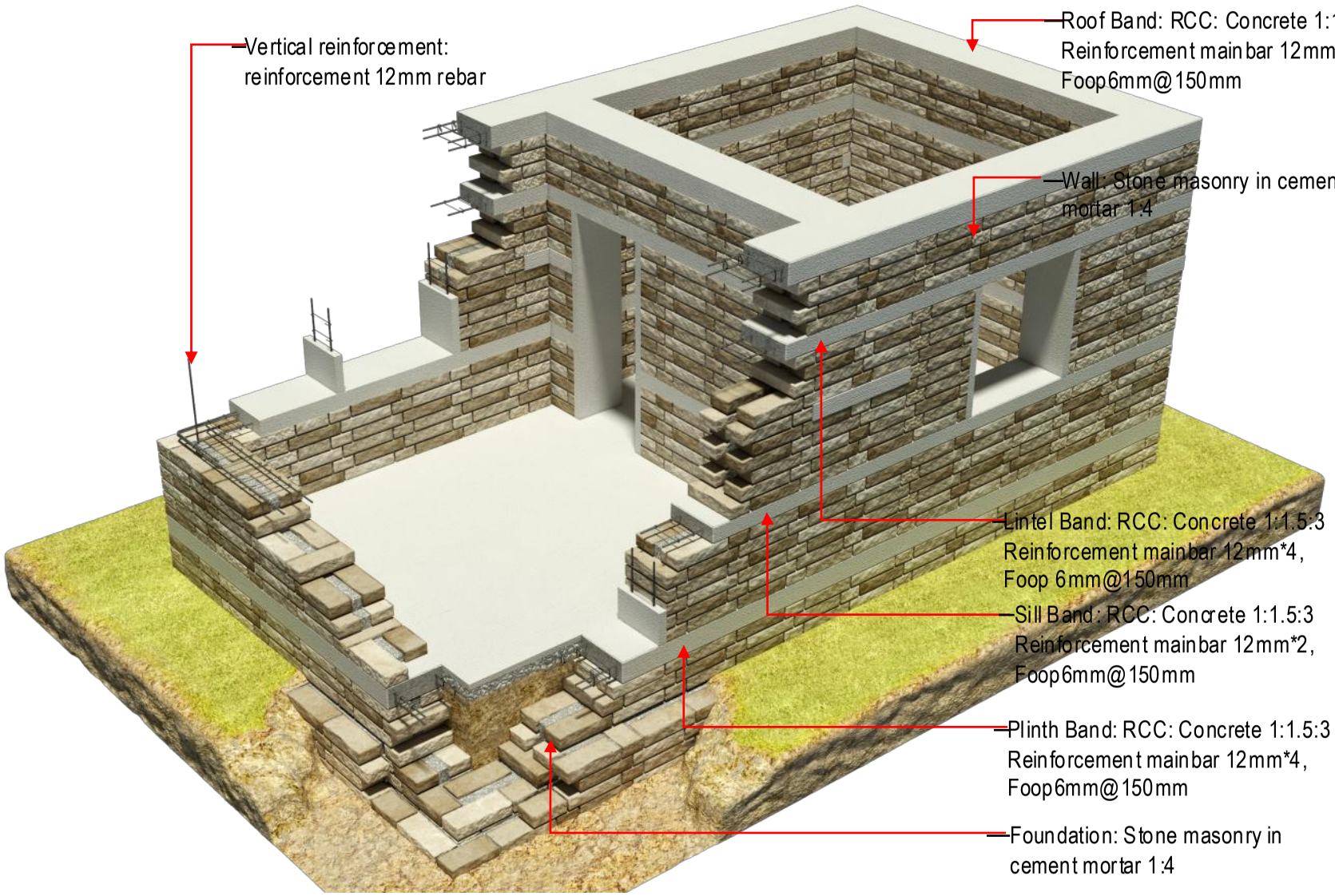
STONE MASONRY IN CEMENT MORTAR (SMC)

Technical Details



10 KEY MESSAGES

STONE MASONRY IN CEMENT MORTAR



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

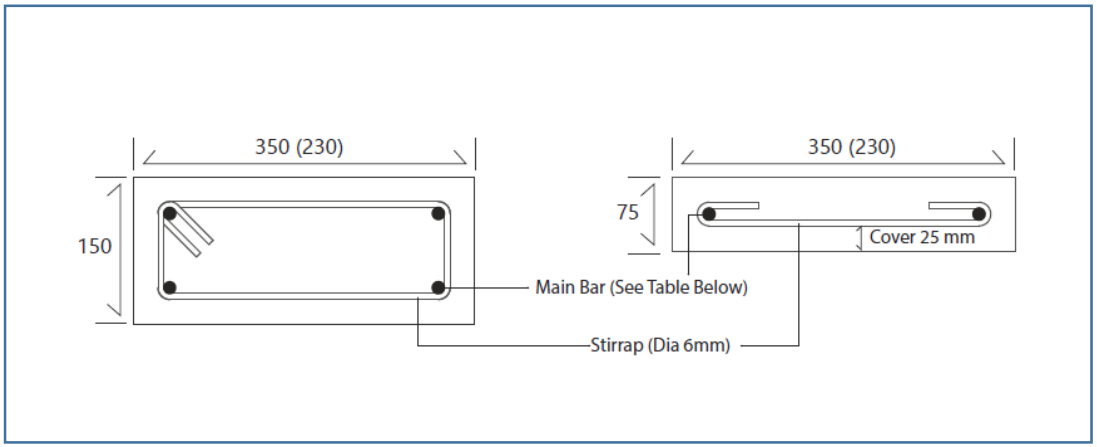
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)	DESIGNED BY: JICA		

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	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 2 (SEISMIC ELEMENTS)	DESIGNED BY: DUDBC		

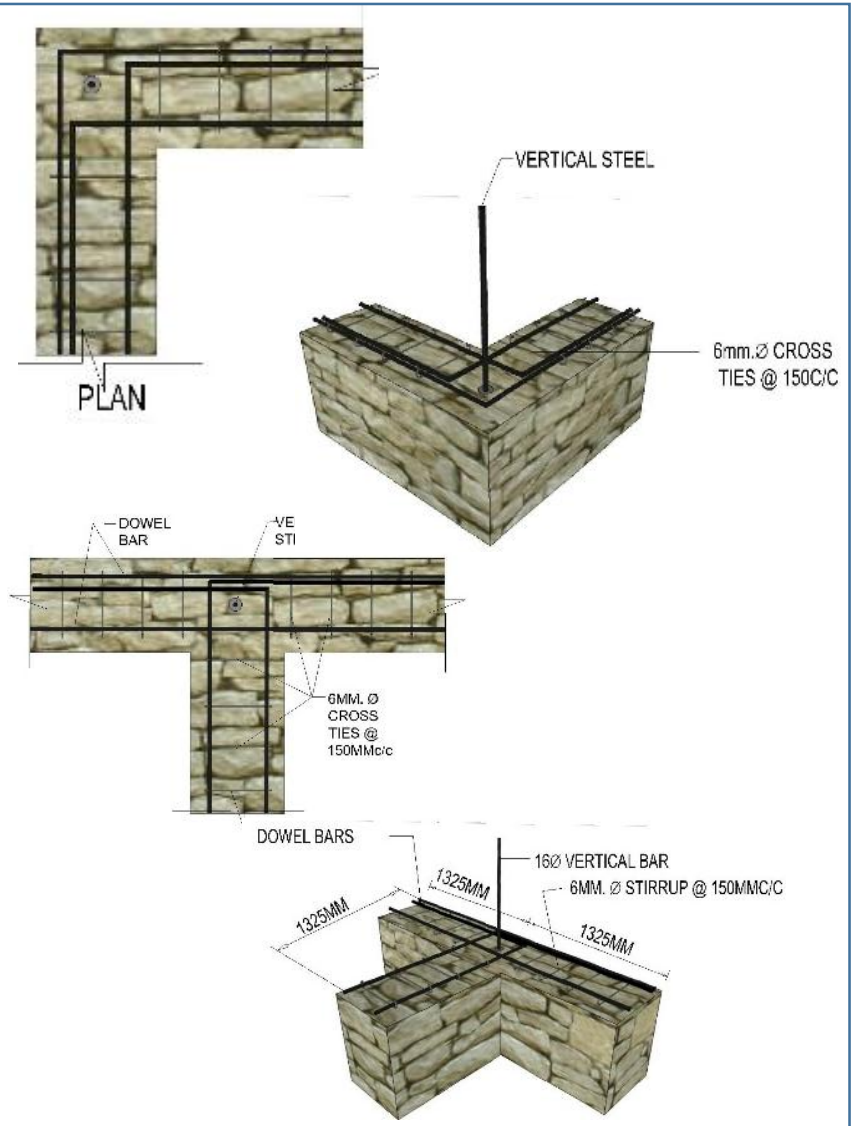
STONE MASONRY IN CEMENT MORTAR



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)
		2	12 (bottom)
Roof	75mm	2	12
	300mm	4	12
Dowel (Stitch)	75mm	2	8

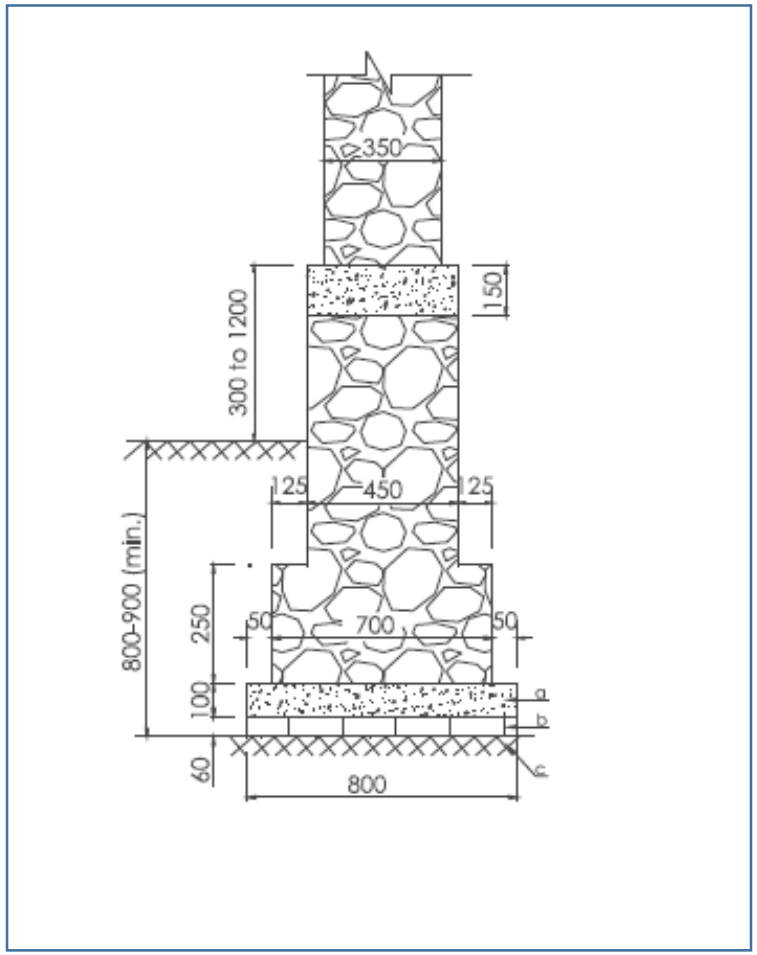


RCC BAND AT CORNER and T-Junction

*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 3 (Reinforcing bar arrangement)	DESIGNED BY:		

STONE MASONRY IN CEMENT MORTAR



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

Base width of footing

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

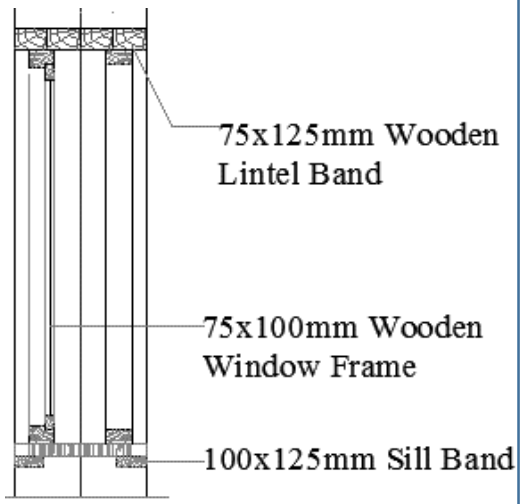
Classification of Foundation Soil and Safe Bearing Capacity

Foundation Soil Classification	Types of Foundation Materials	Presumed Safe Bearing Capacity, KN/m²
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

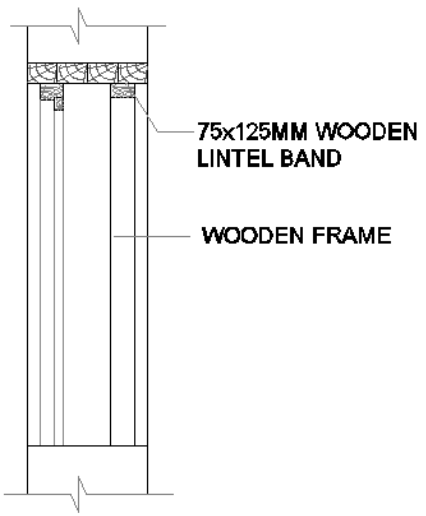
*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 4 (Foundation)	DESIGNED BY:		

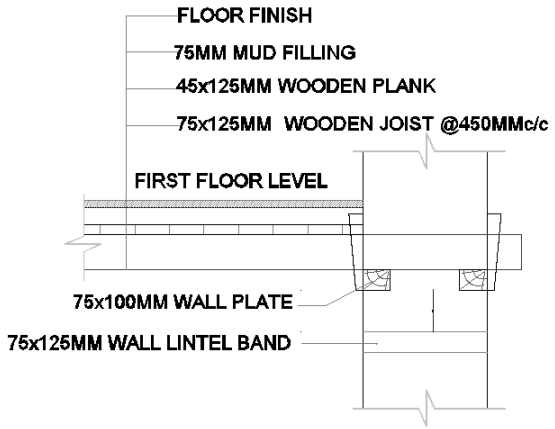
STONE MASONRY IN CEMENT MORTAR



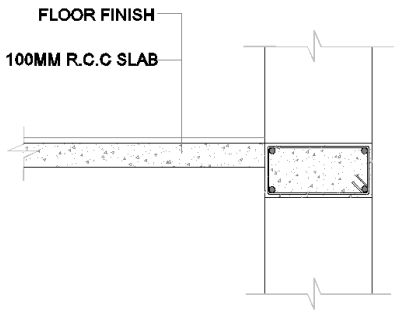
Window Section



Door Section



Type 1



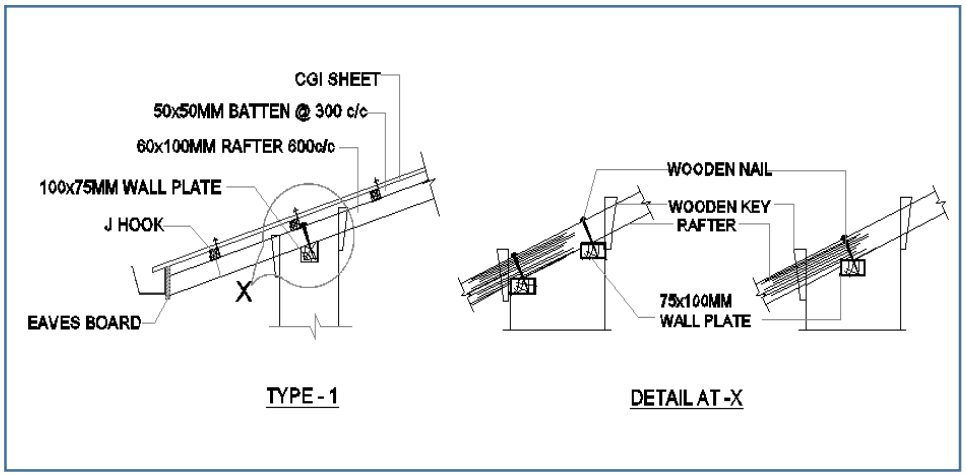
Type 2

First Floor Detail

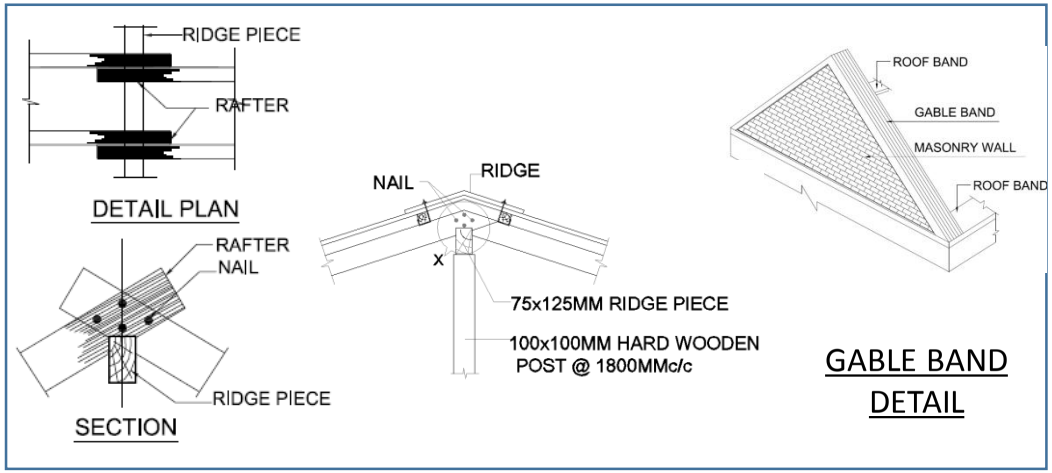
*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 5 (Opening and Floor)	DESIGNED BY:		

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	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 6 (Roof)	DESIGNED BY:		

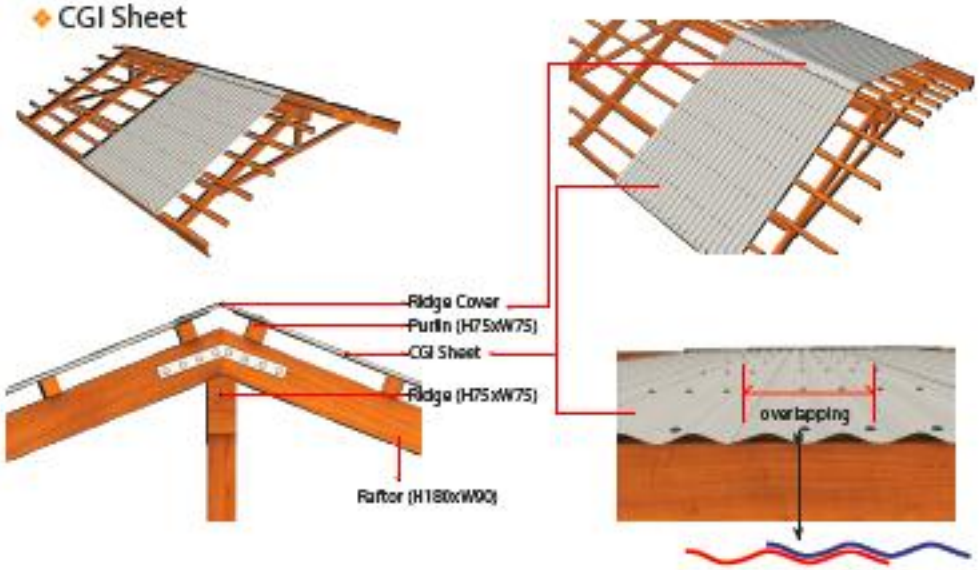
STONE MASONRY IN CEMENT MORTAR

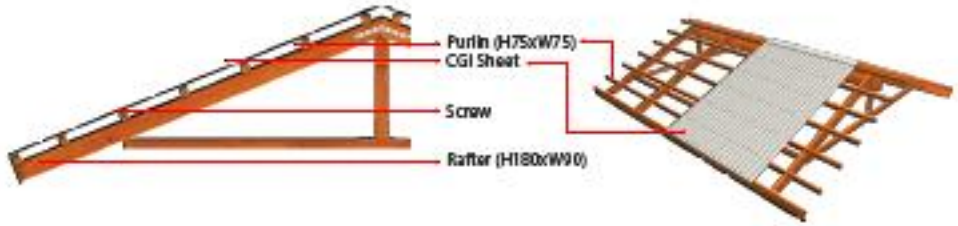
Top (Plan) View

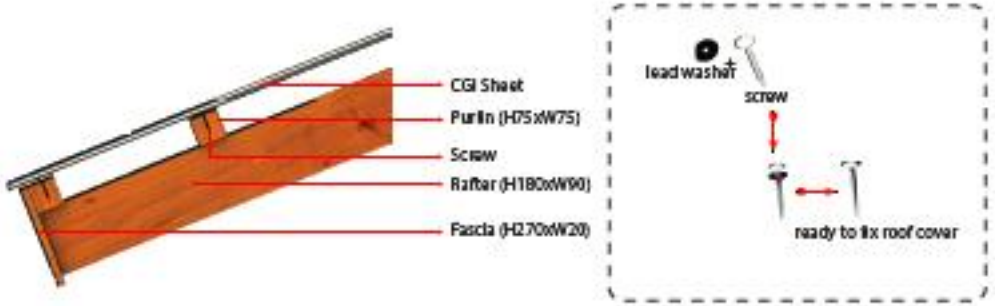
Side View

Isometric View

CGI Sheet

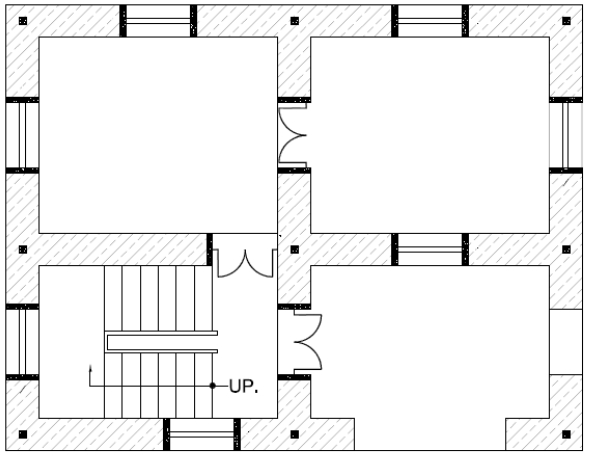




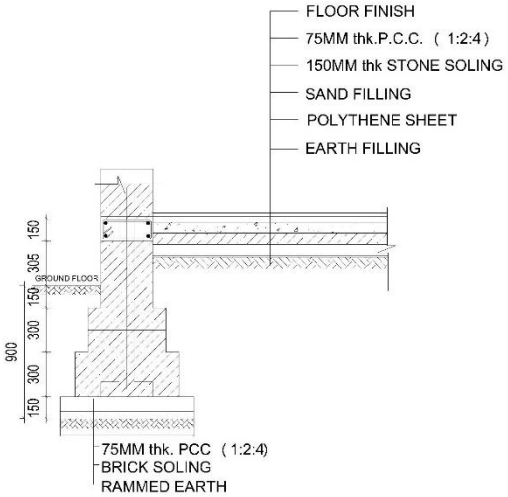


Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 7 (Roofing)	DESIGNED BY:		

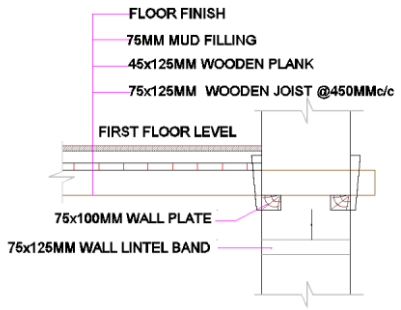
Earthquake Resistant Elements in Building



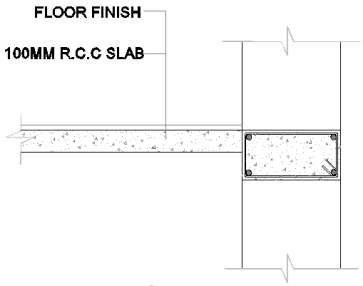
Typical Ground/ First Floor Plan



Foundation Detail

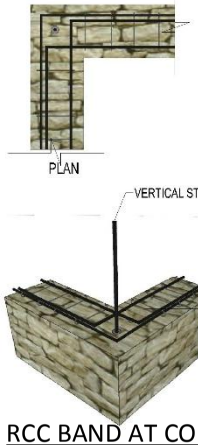


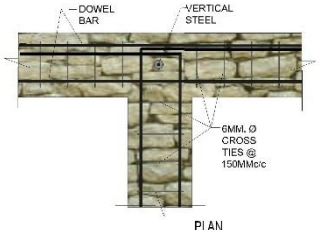
Type 1

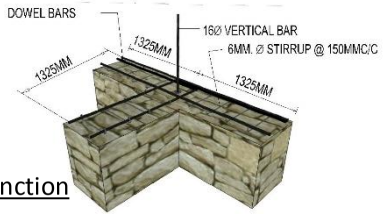


Type 2

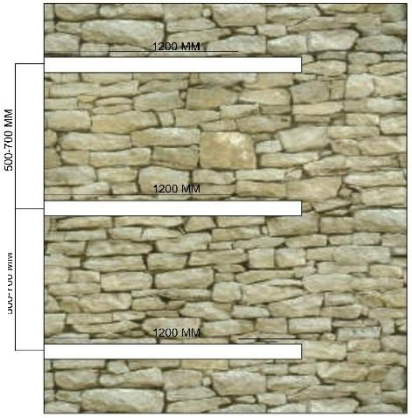
First Floor Detail



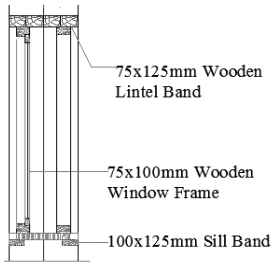




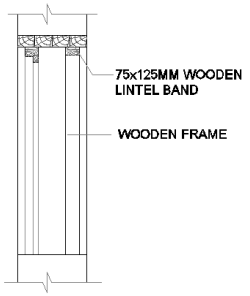
RCC BAND AT CORNER and T-Junction



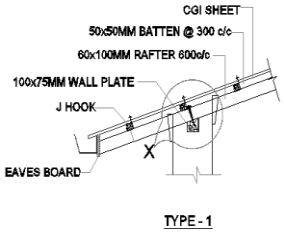
Corner Strengthening Band



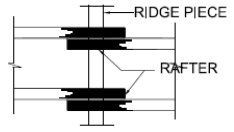
Window Section



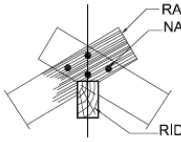
Door Section



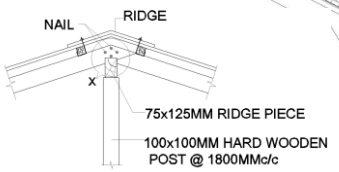
Detail of Rafter Joint with Wall Plate

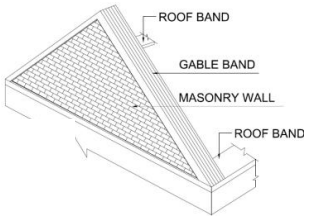


DETAIL PLAN



SECTION





GABLE BAND DETAIL

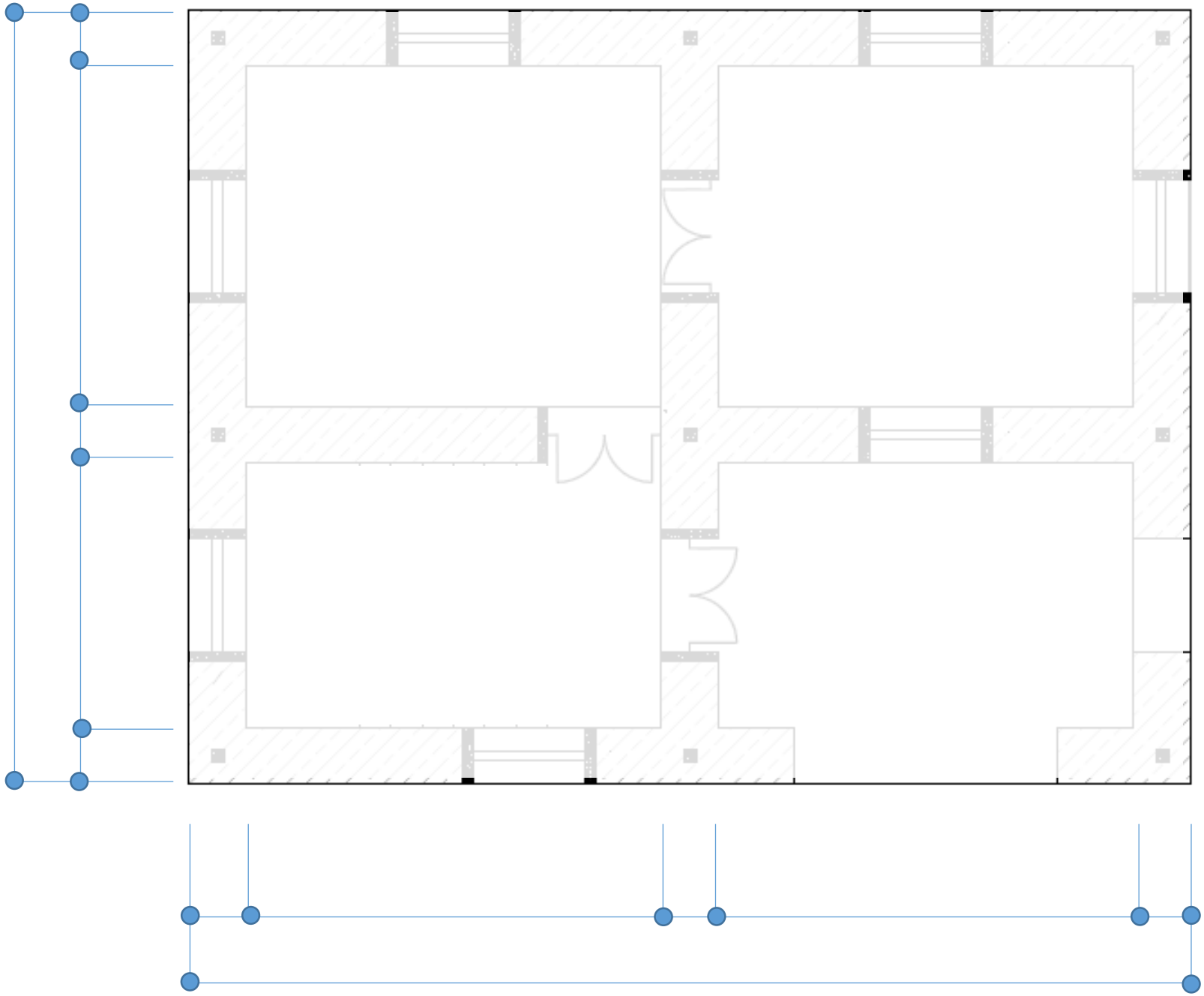
Detail of Rafter Joint at Ridge

Flexible design

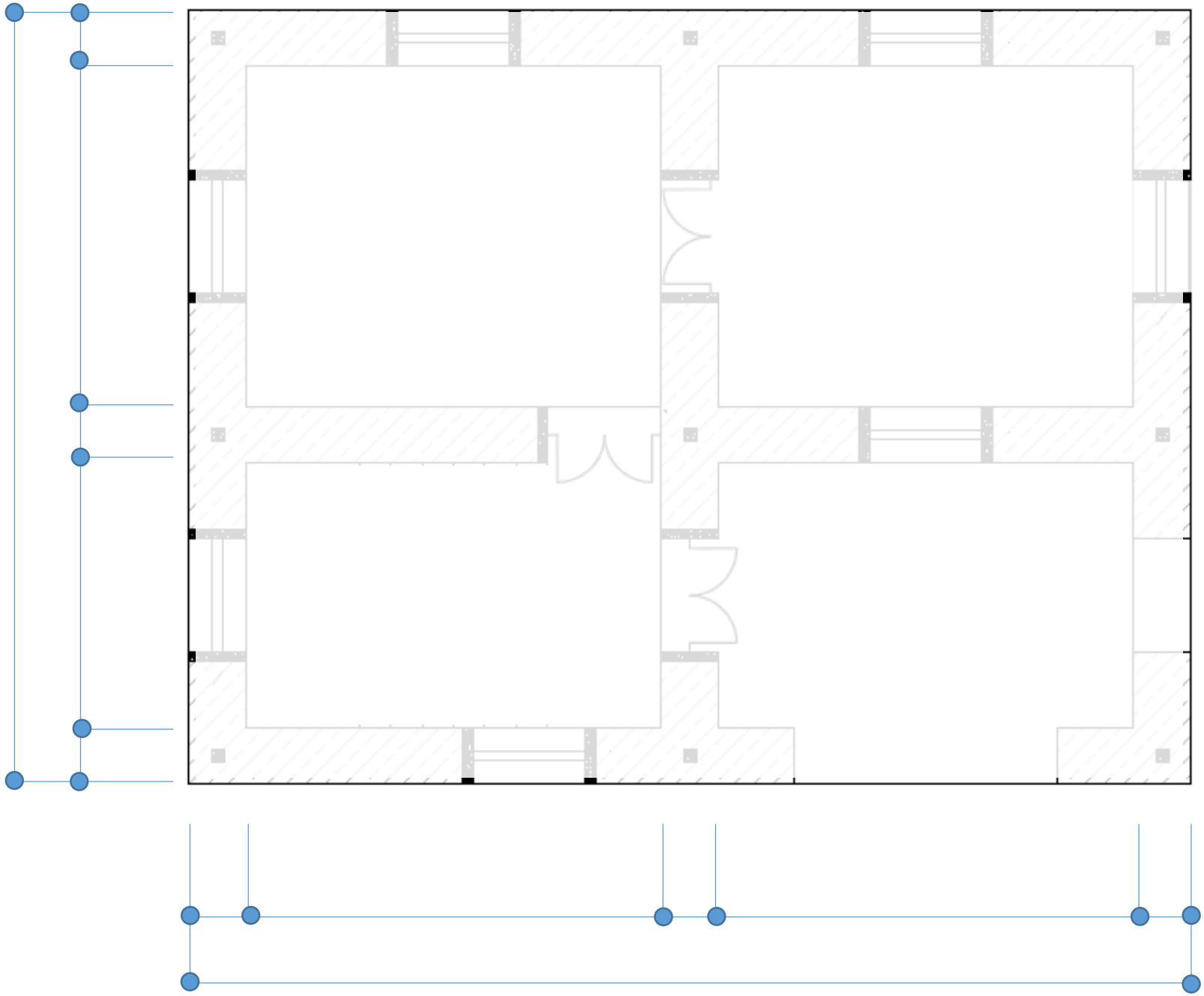
Minimum Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) Page1				
No.	Category			
1	Site Selection	A building shall not be constructed if site is:		
			✔	Geological fault or Raptured Area
			✔	Areas Susceptible to Landslide
			✔	Steep Slope > 20%
			✔	Filled Area
			✔	River Bank and Water-logged 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.
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. 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.
		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 fy = 415 N/

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



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



BRICK MASONRY IN CEMENT MORTAR (BMC)

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			
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.
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. 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.
		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 fy = 415 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.

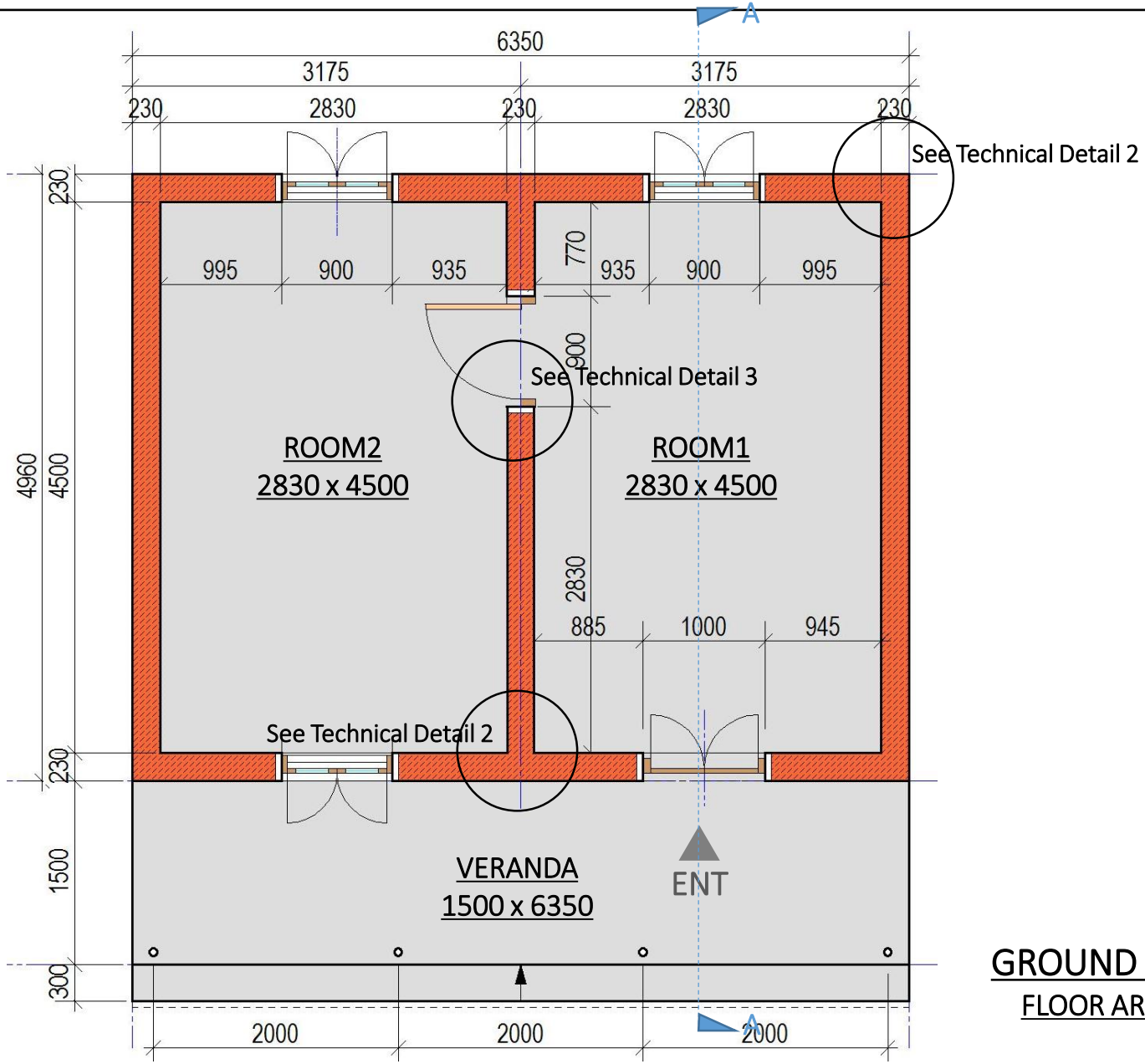
.

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	SCALE: None	DATE:
DRAWING TITLE:	PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA	BMC-1.1 1/4



GROUND FLOOR PLAN

FLOOR AREA: 31.75sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.1	SCALE: 1:50	DATE:	BMC-1.1
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4

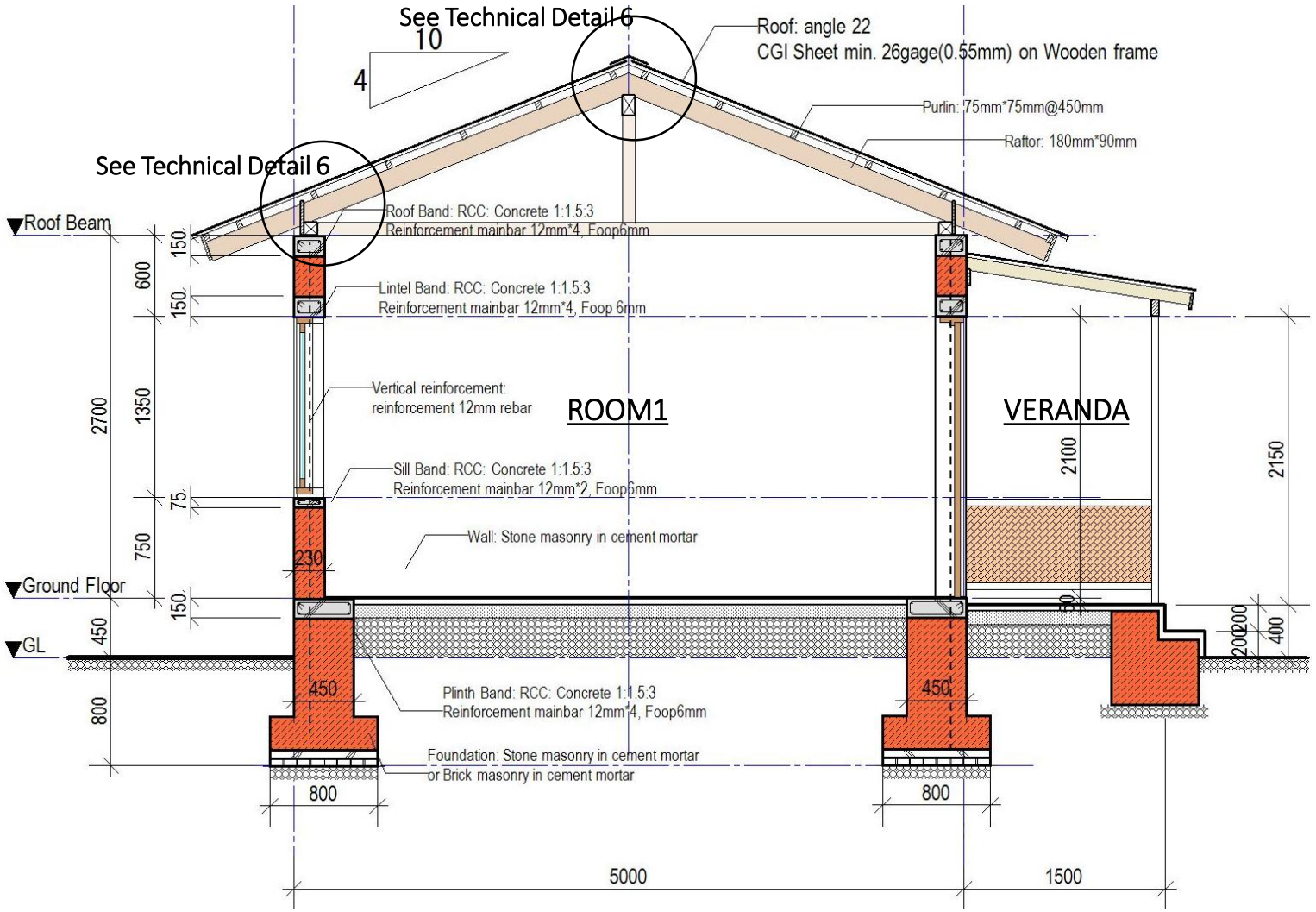
FRONT ELEVATION

BACK ELEVATION

SIDE ELEVATION

SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.1	SCALE: None	DATE:	BMC-1.1
	DRAWING TITLE: ELAVATION	DESIGNED BY: JICA		3/4



SECTION A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.1	SCALE: 1:50	DATE:	BMC-1.1
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		4/4

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 rooms with dimensions of 2830 x 4500, and a verandah with dimensions of 3090 x4960The 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.

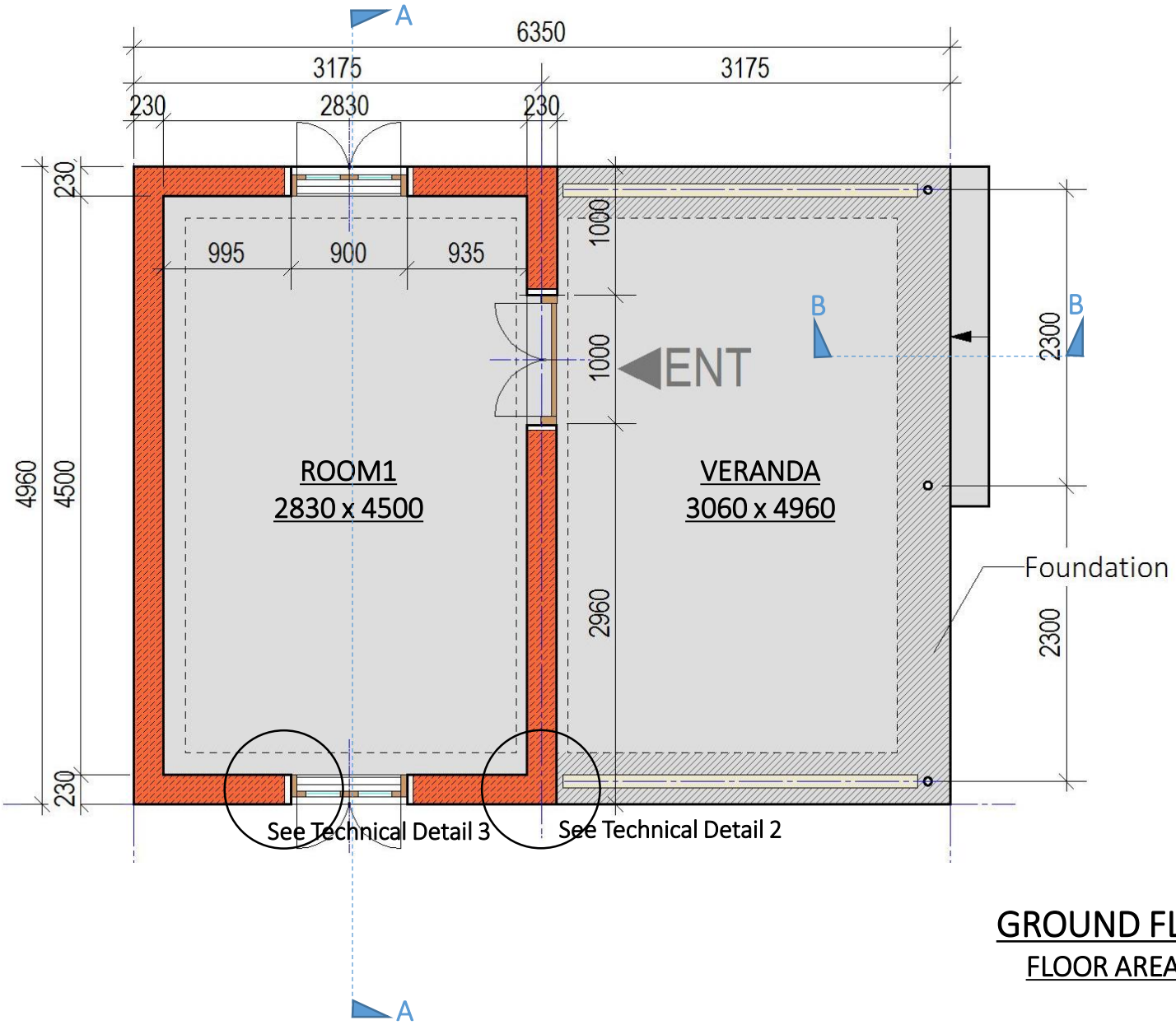
The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.

BMC-1.2

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

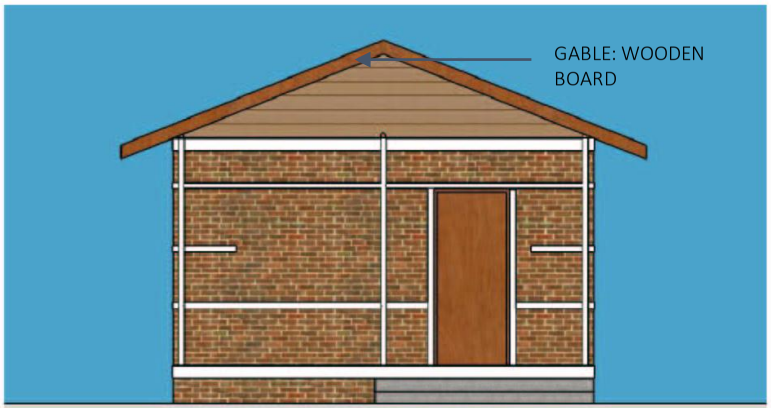
TYPE OF HOUSE:	MODEL BMC-1.2	SCALE: None / DATE:	BMC-1.2
DRAWING TITLE:	PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA	1/4



GROUND FLOOR PLAN

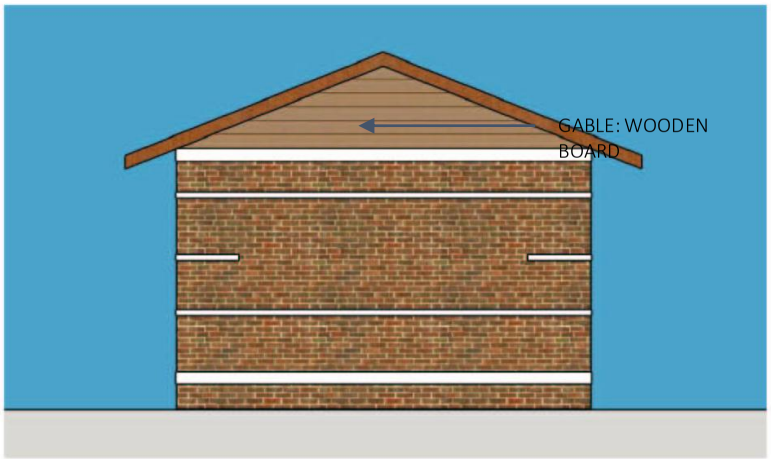
FLOOR AREA: 16.31sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.2	SCALE: 1:50	DATE:	BMC-1.2
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4



FRONT ELEVATION

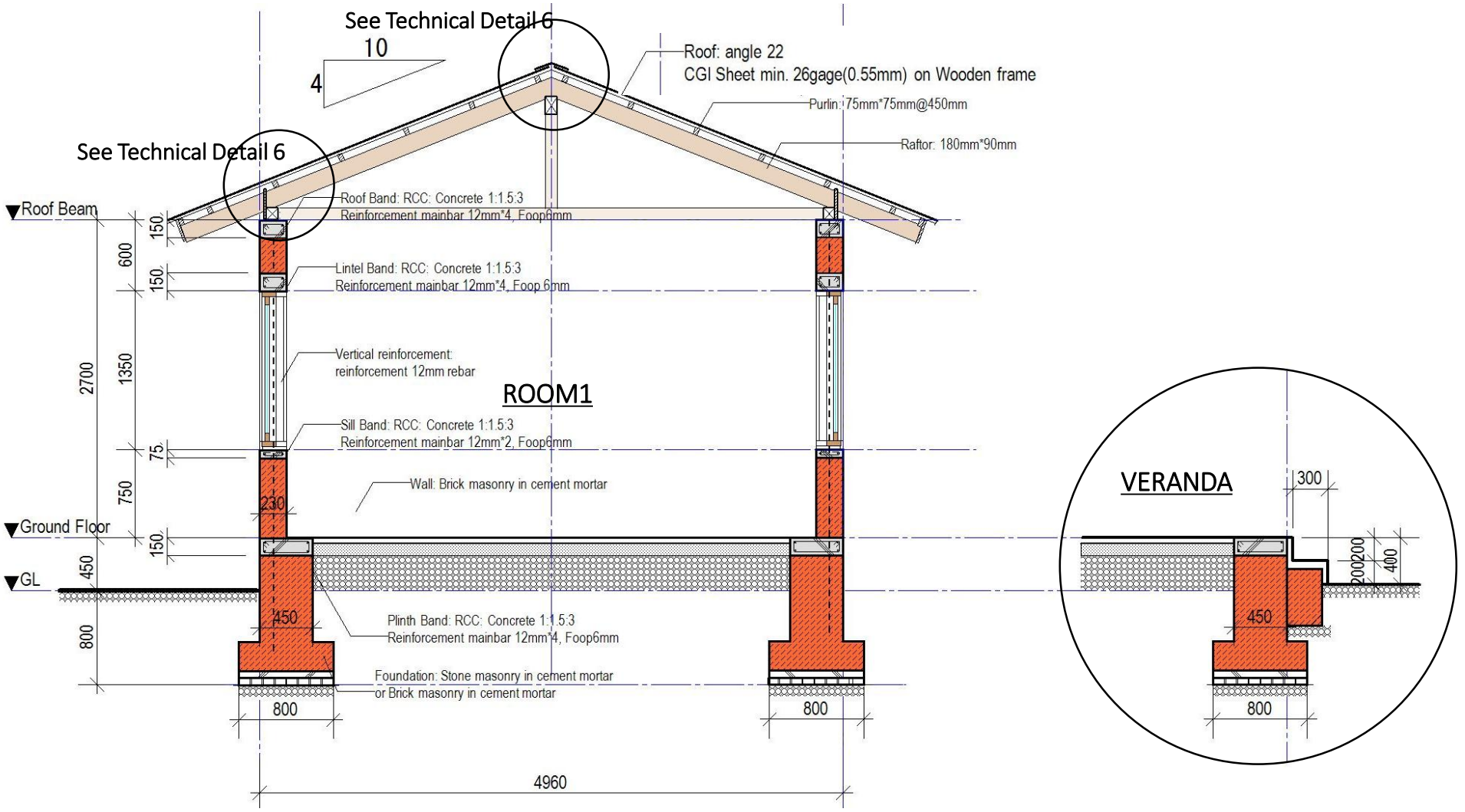
SIDE ELEVATION



BACK ELEVATION

SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.2	SCALE: None	DATE:	BMC-1.2
	DRAWING TITLE: ELAVATION	DESIGNED BY: JICA		3/4



SECTION A-A

SECTION B-B

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-1.2	SCALE: 1:50	DATE:	BMC-1.2
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		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.

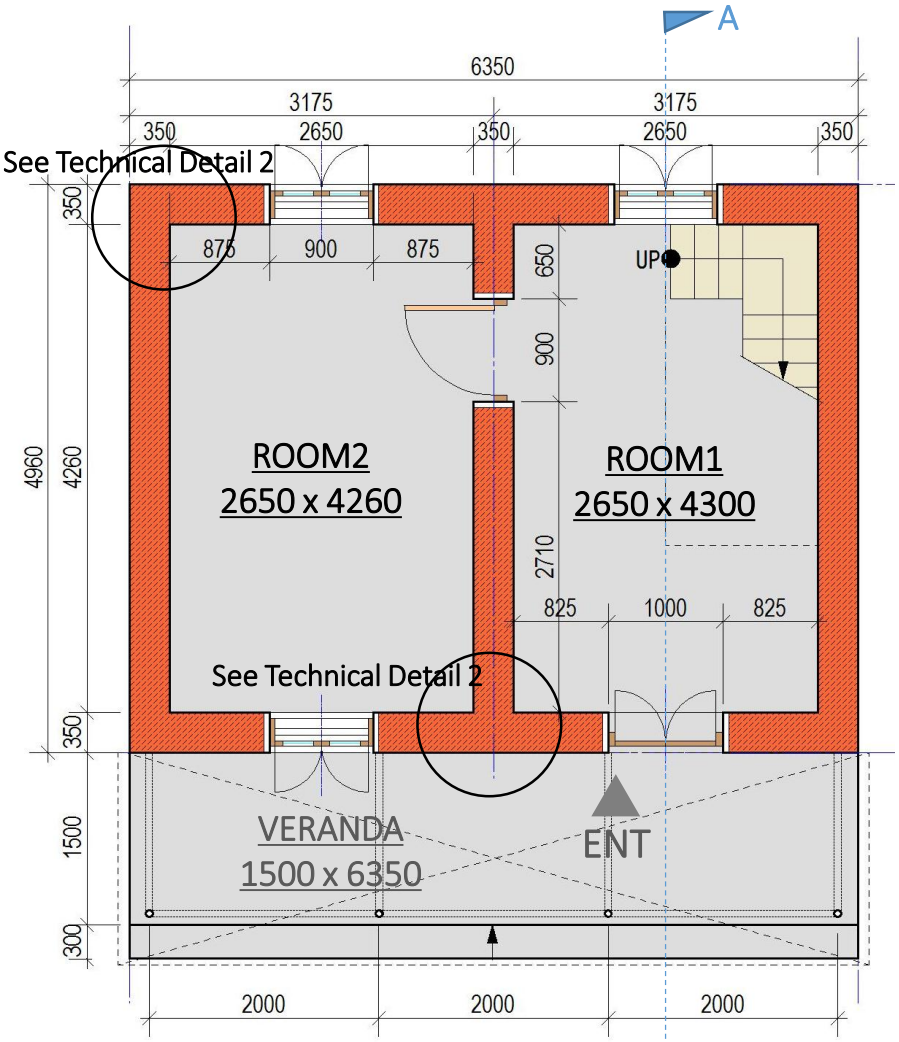
The design concept, and the objective of the design is to contribute towards resilient models to improve safety in future earthquakes.

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

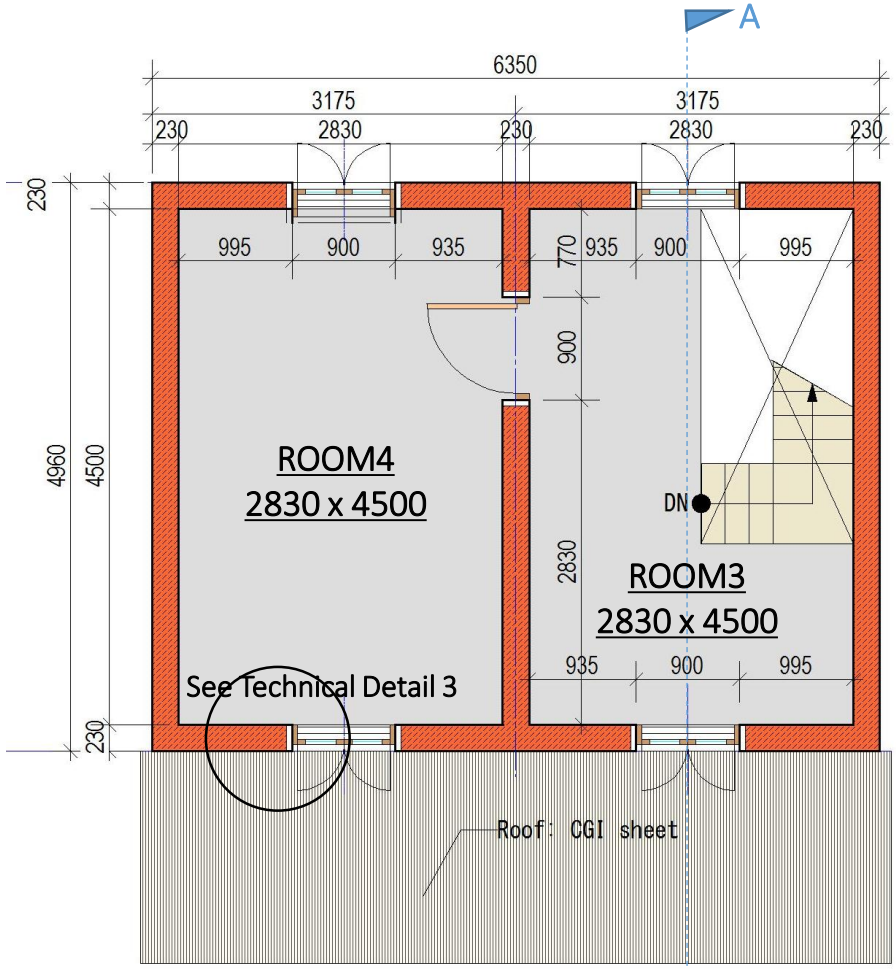
Nepal Housing Reconstruction Programme

TYPE OF HOUSE:	MODEL BMC-2.1	SCALE: None / DATE:	BMC-2.1
DRAWING TITLE:	PERSPECTIVE AND ESTIMATION	DESIGNED BY: JICA	1/4



GROUND FLOOR PLAN

AREA: 31.75sqm



FIRST FLOOR PLAN

AREA: 31.75sqm

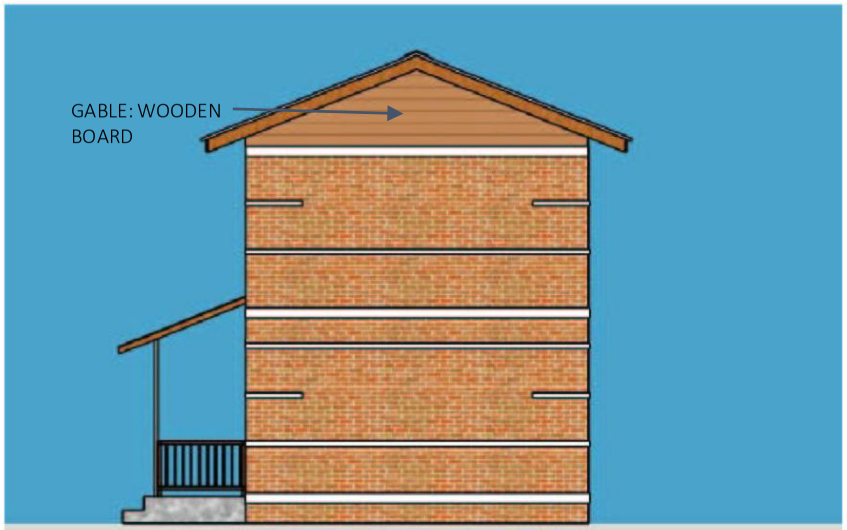
TOTAL AREA: 63.5sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.1	SCALE: None	DATE:	BMC-2.1
	DRAWING TITLE: PLAN	DESIGNED BY: JICA		2/4

FRONT ELEVATION

BACK ELEVATION

SIDE ELEVATION

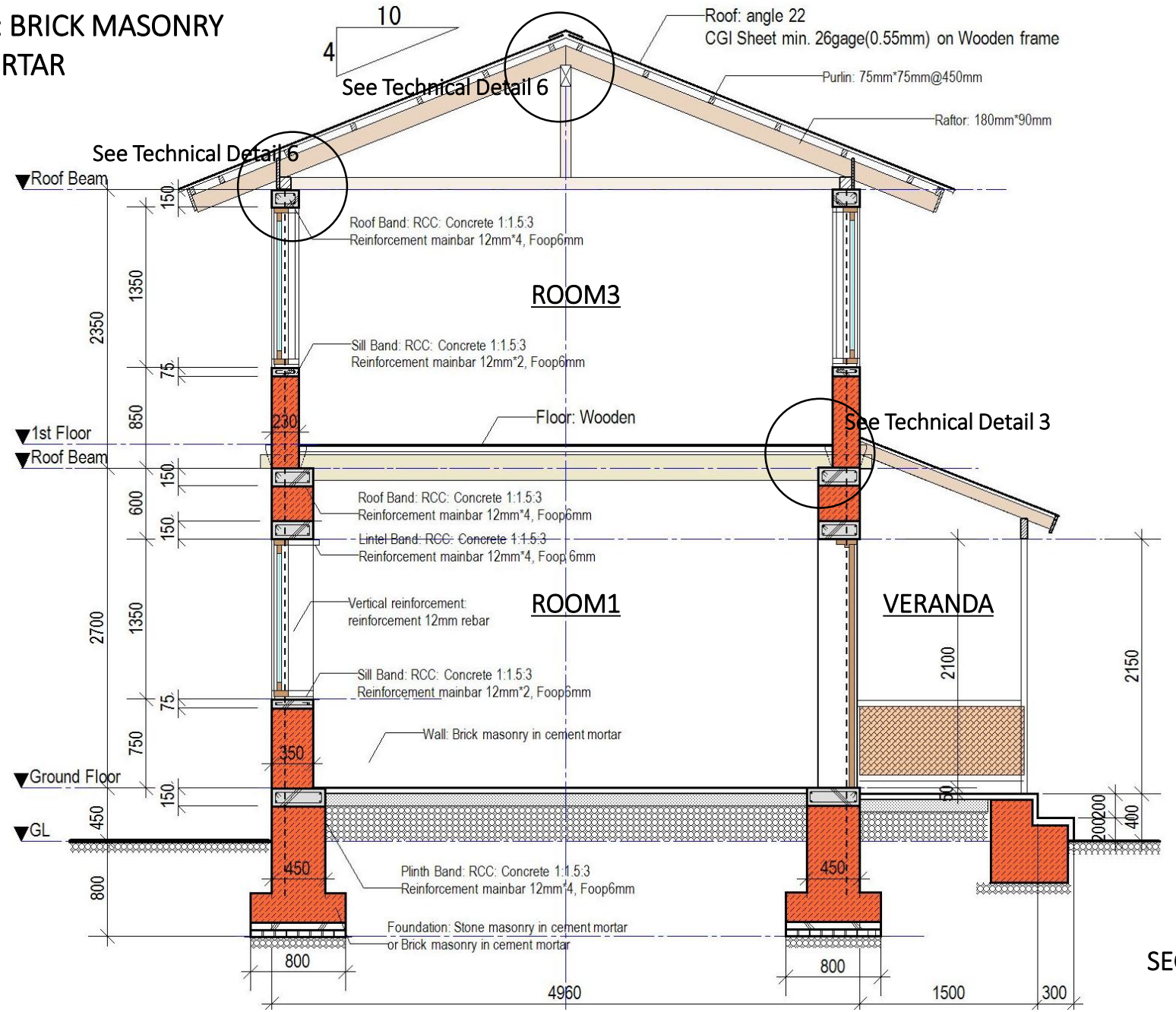


SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.1	SCALE: 1:100	DATE:	BMC-2.1
	DRAWING TITLE: ELEVATION	DESIGNED BY: JICA		3/4

Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY



SECTION A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.1	SCALE: 1:50	DATE:	BMC-2.1
	DRAWING TITLE: SECTION	DESIGNED BY: JICA		4/4

BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

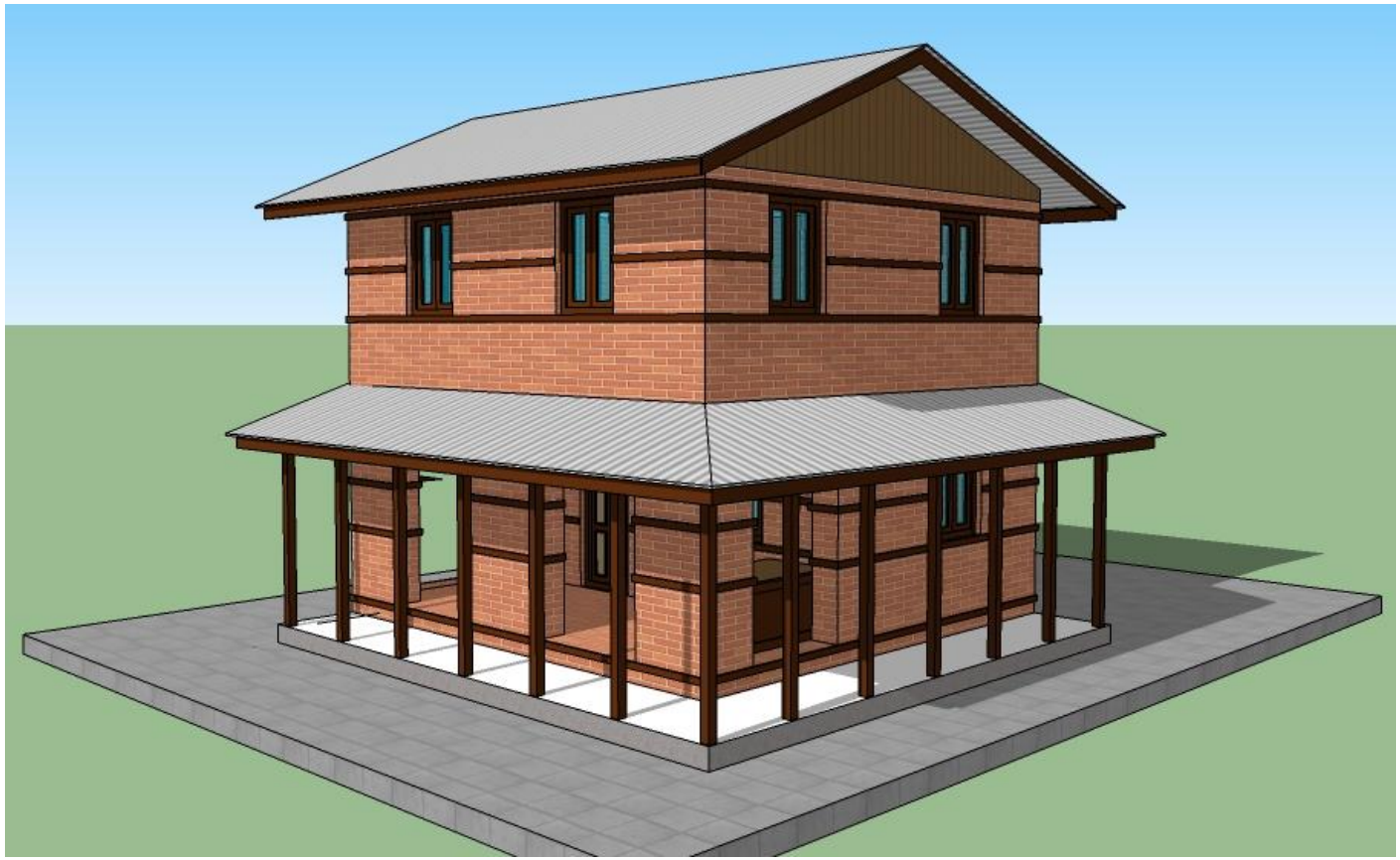
BMC-2.2

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

Model BMC 2.2 BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY



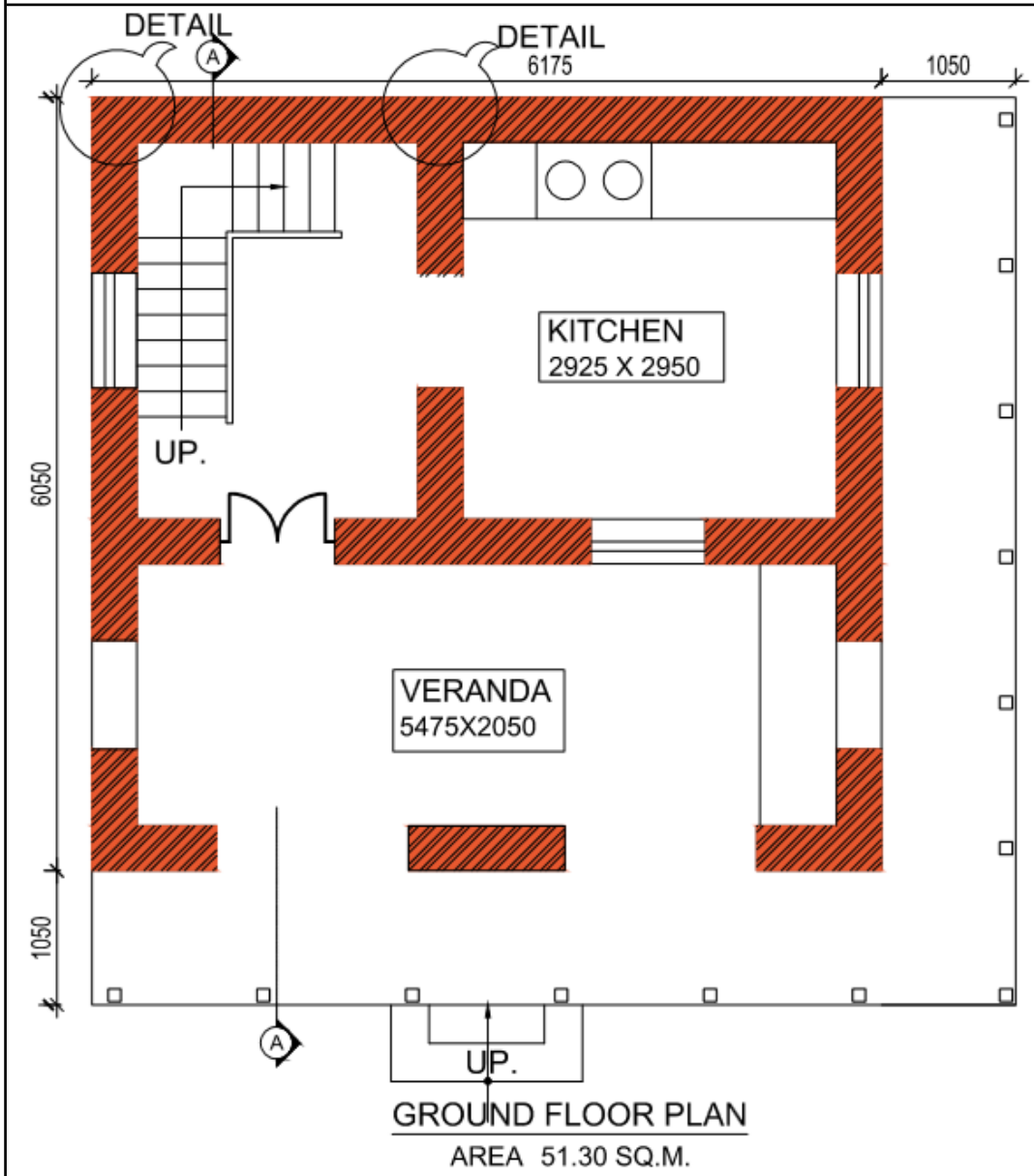
CONSTRUCTION MATERIALS AND MANPOWER

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	SCALE: NONE	DATE:	BMC-2.2
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC		1/4

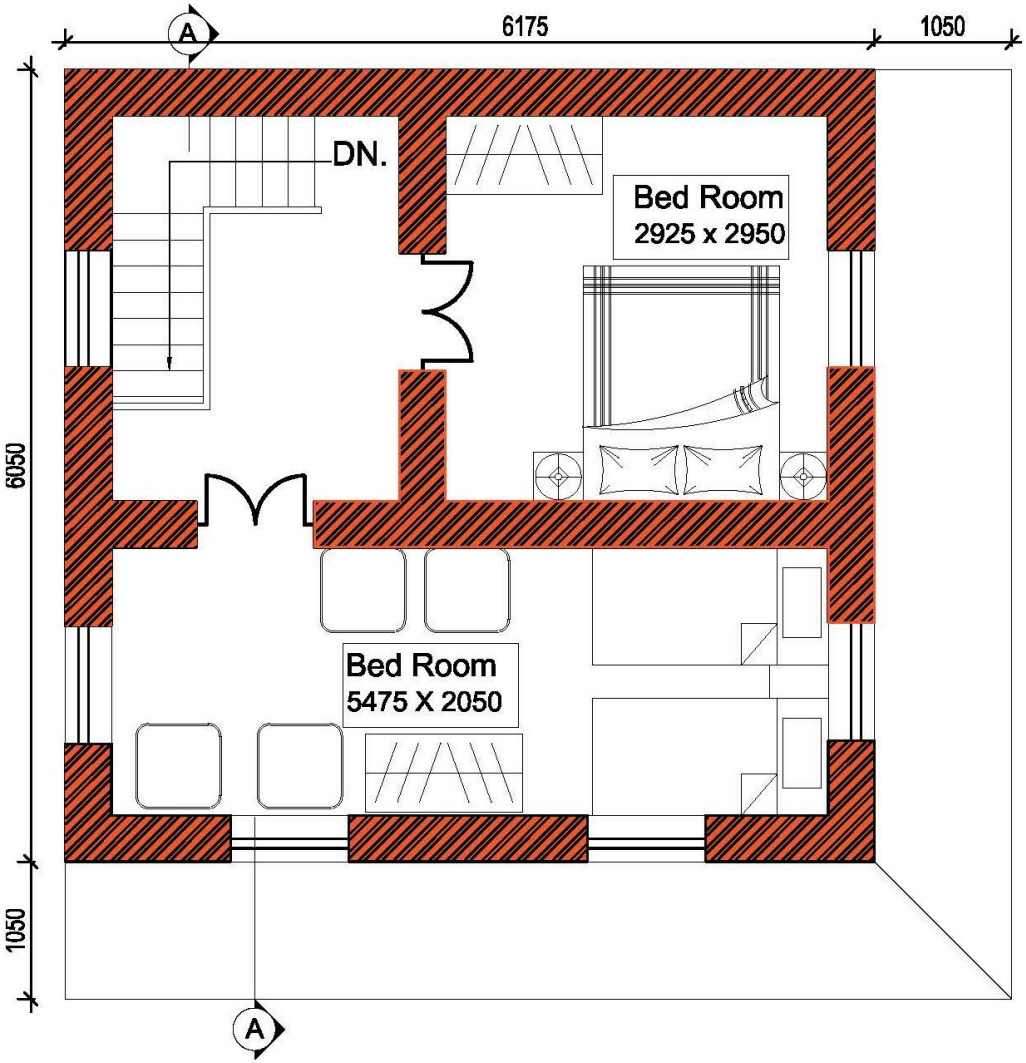
Model BMC 2.2 BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY



GROUND FLOOR PLAN

AREA 51.30 SQ.M.



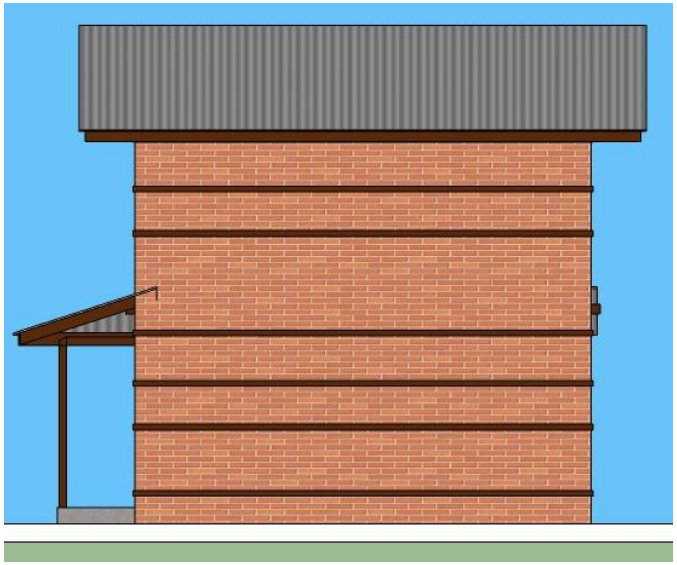
FIRST FLOOR PLAN

AREA 37.35 SQ.M.

TOTAL AREA: 88.65 SQ.M.

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.2	SCALE: None	DATE:	BMC-2.2
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION



BACK ELEVATION

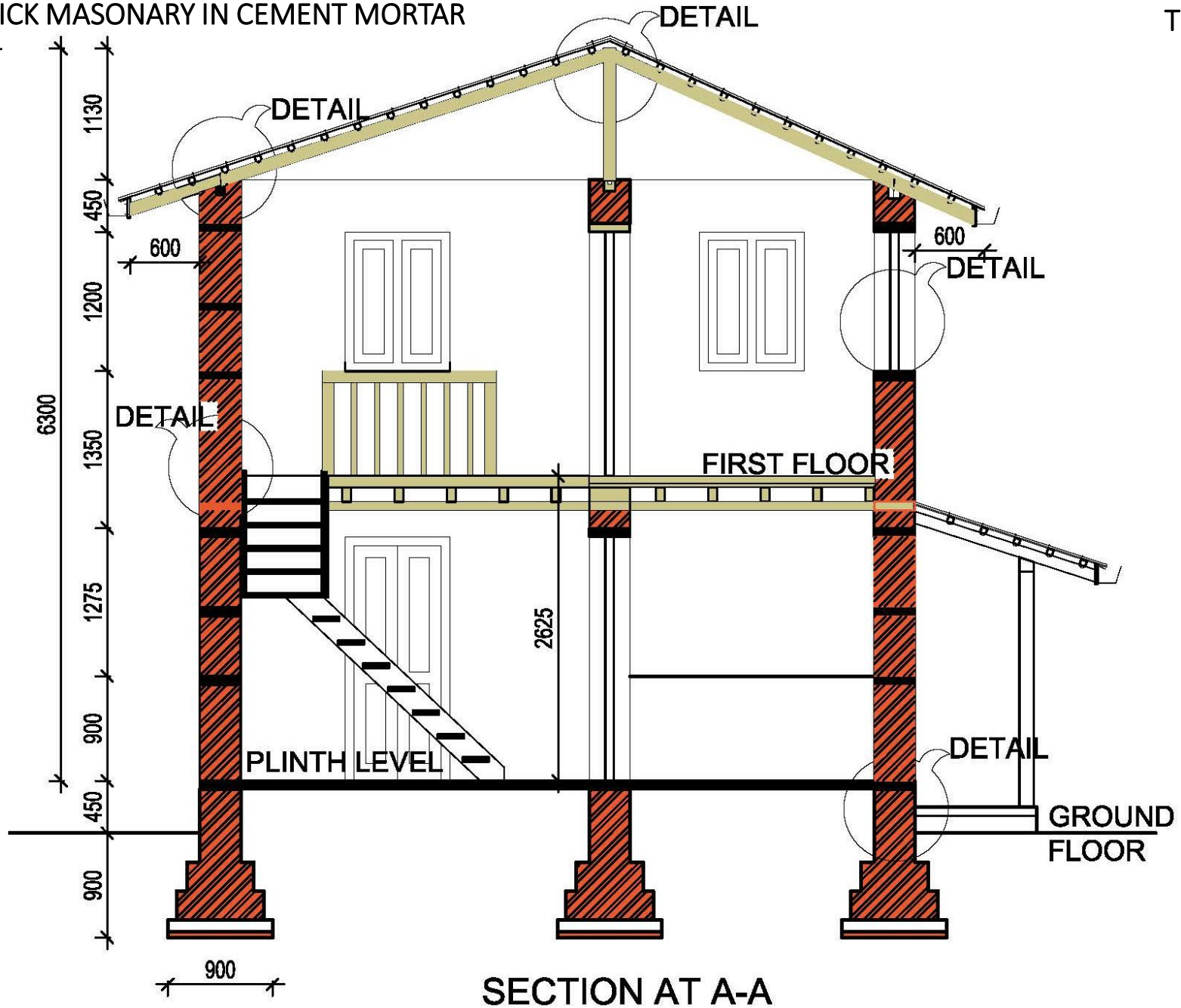
LEFT SIDE ELEVATION

RIGHT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.2	SCALE: 1:100	DATE:	BMC-2.2
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4

Model BMC- 2.2: BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY



SECTION AT A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.2	SCALE: 1:50	DATE:	BMC-2.2
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		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.

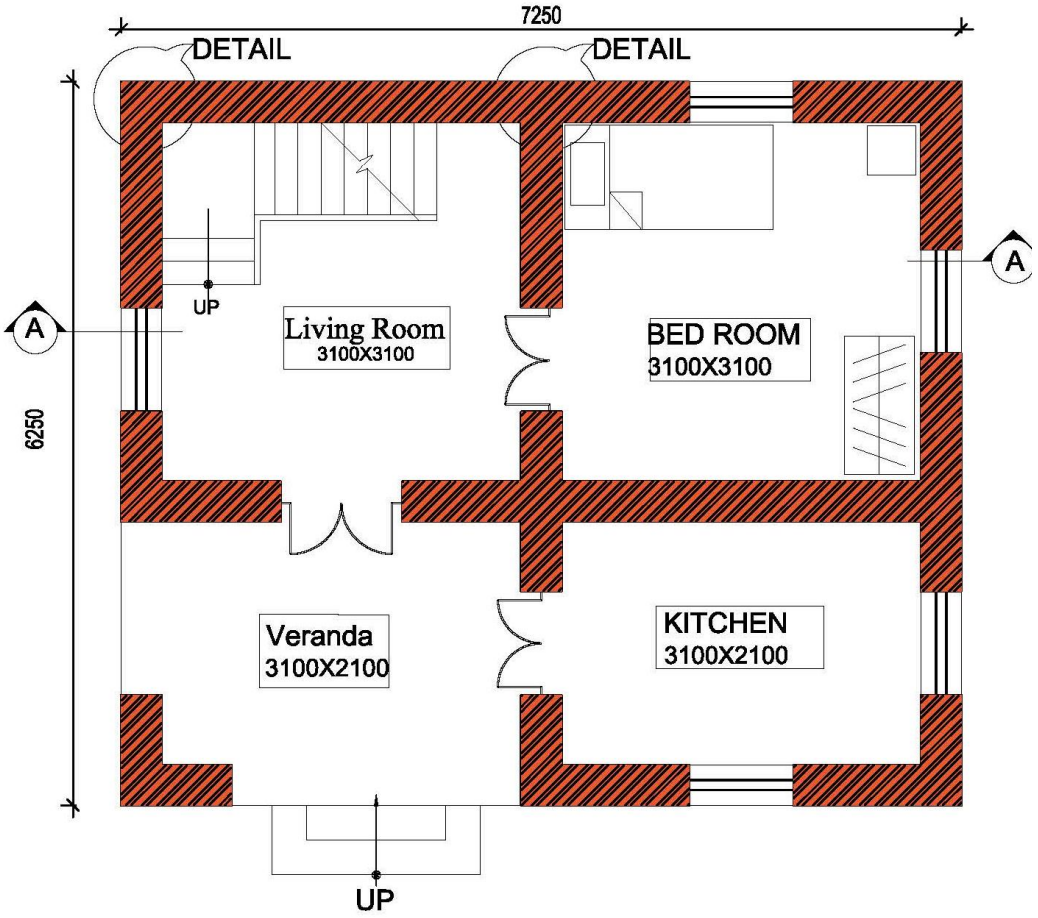
BMC-2.3

CONSTRUCTION MATERIALS AND MANPOWER

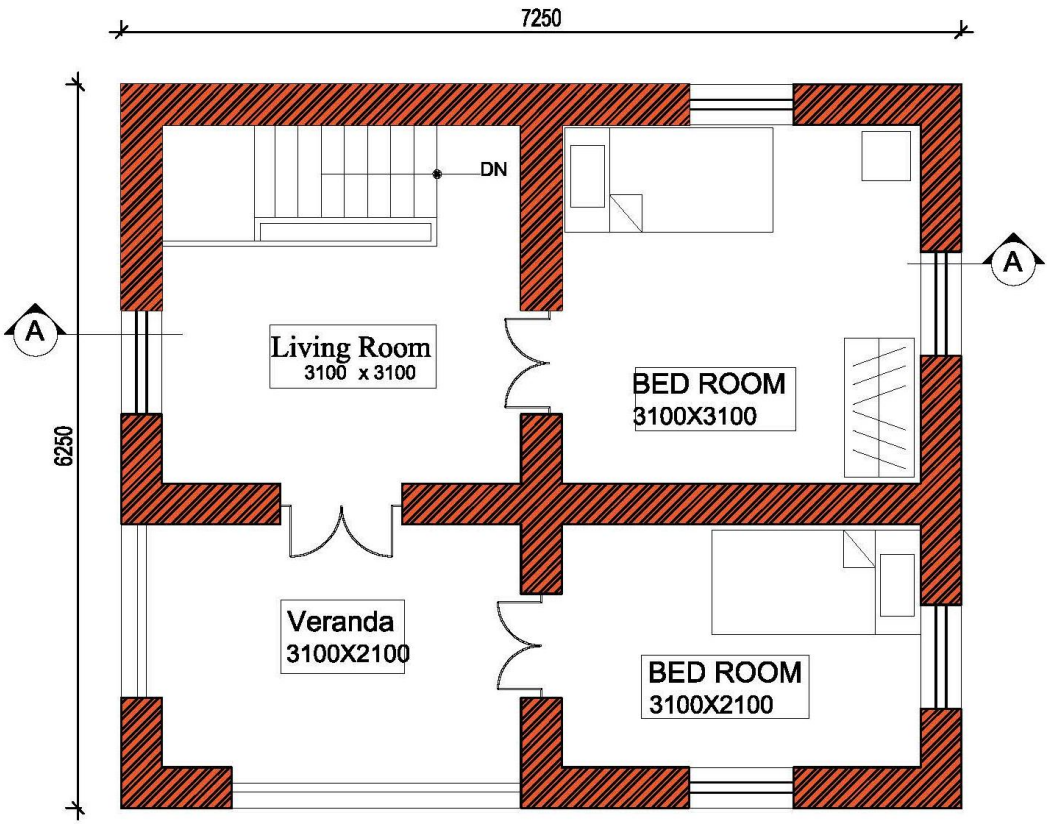
LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	Brick	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	GI SHEET	Rod
	Md	Md	Nos	Bags	Cu.m	Cu.m	Cu.m	Bundel	Rm.	Kg
Up to Plinth Level	59	132	14769	82	14	7	2	0	0	242
SUPERSTRUCTURE	166	127	23537	92	12	0	2	0	0	521
ROOFING	42	14	0	0	0	0	2	4.51	9	0
TOTAL	267	273	38306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

Nepal Housing Reconstruction Programme

TYPE OF HOUSE: MODEL BMC-2.3	SCALE: NONE	DATE:	BMC-2.3
DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC		1/4



GROUND FLOOR PLAN
AREA 45.35 SQ.M.



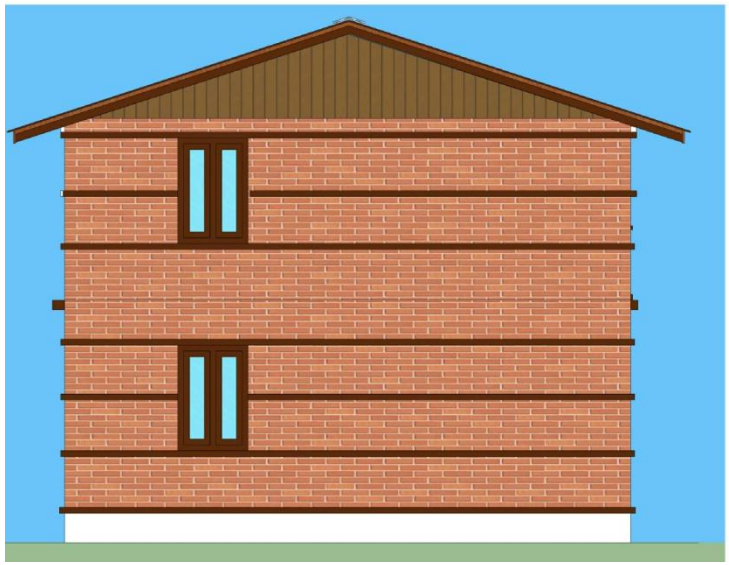
FIRST FLOOR PLAN
AREA 45.35 SQ.M.

TOTAL AREA: 90.7sqm

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.3	SCALE: None	DATE:	BMC-2.3
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION

RIGHT SIDE ELEVATION



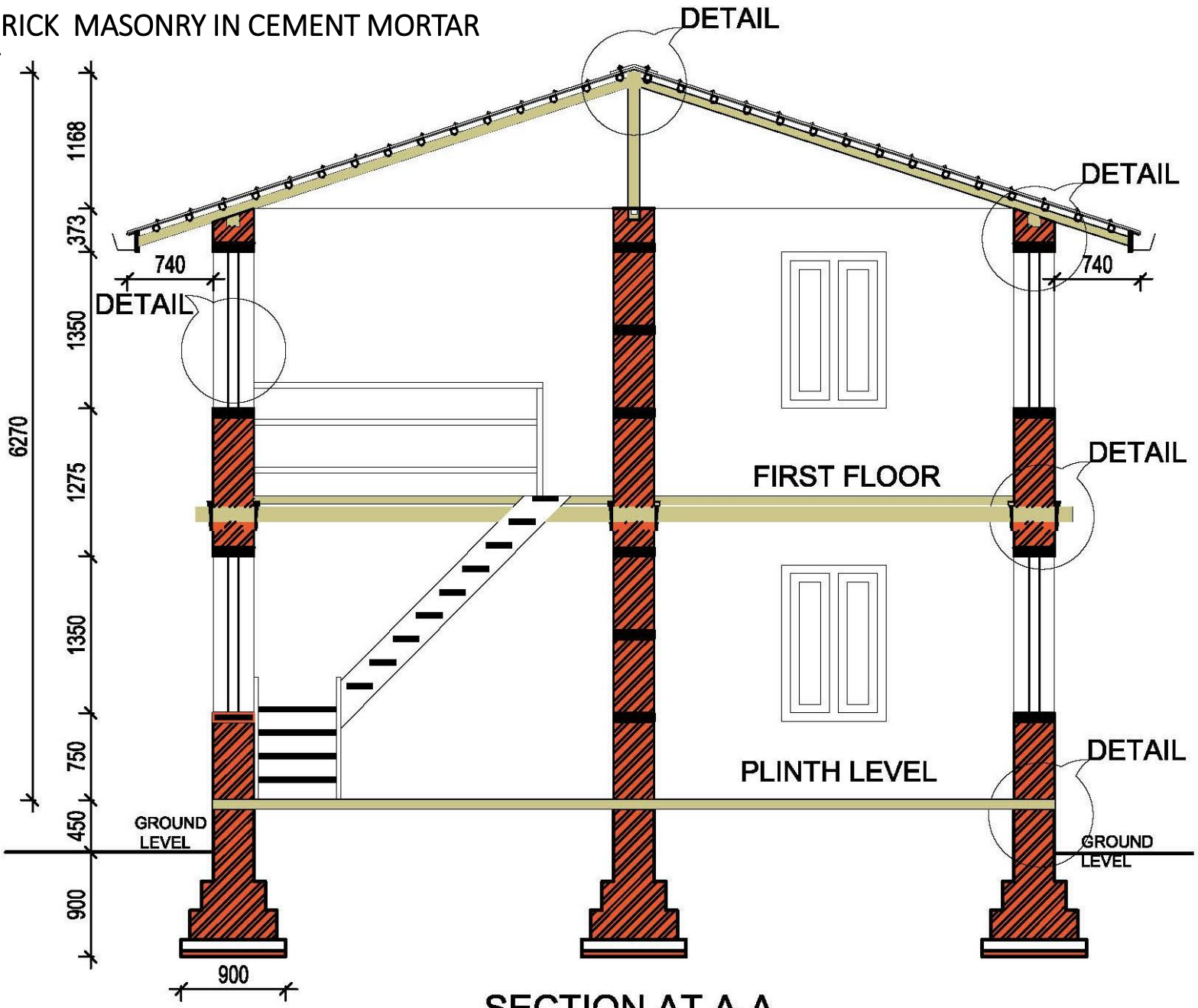
LEFT SIDE ELEVATION

BACK ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.3	SCALE: 1:100	DATE:	BMC-2.3
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4

Model BMC-2.3: BRICK MASONRY IN CEMENT MORTAR

TWO-STOREY



SECTION AT A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.3	SCALE: 1:50	DATE:	BMC-2.3
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY

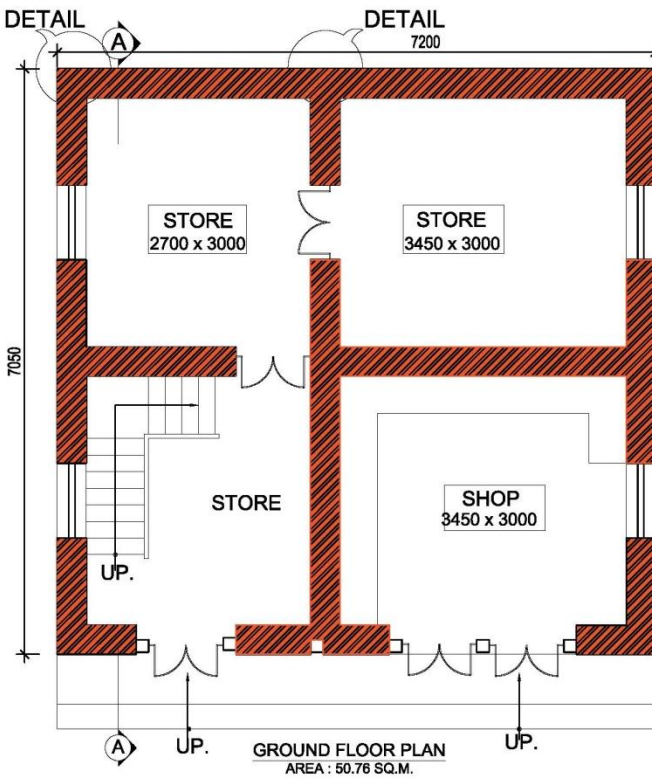
BMC-2.4

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 o2700 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

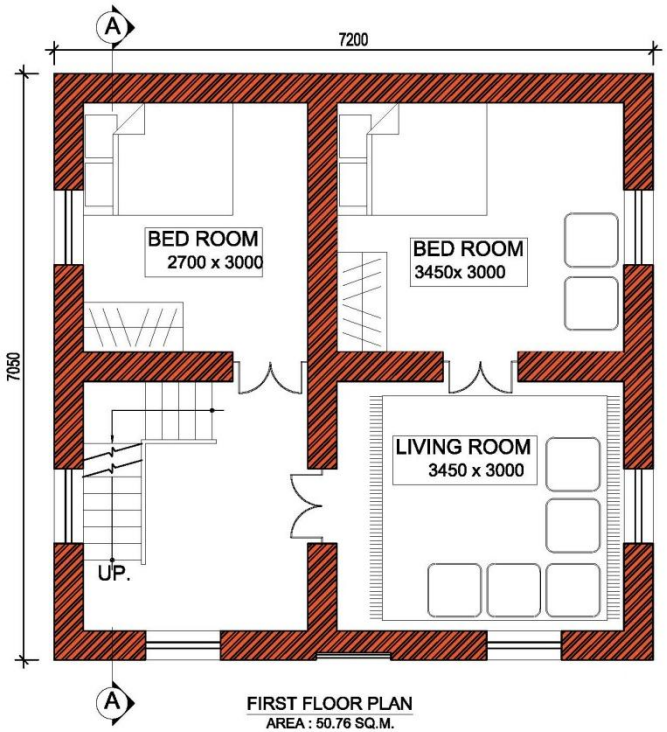
BMC-2.4

CONSTRUCTION MATERIALS AND MANPOWER

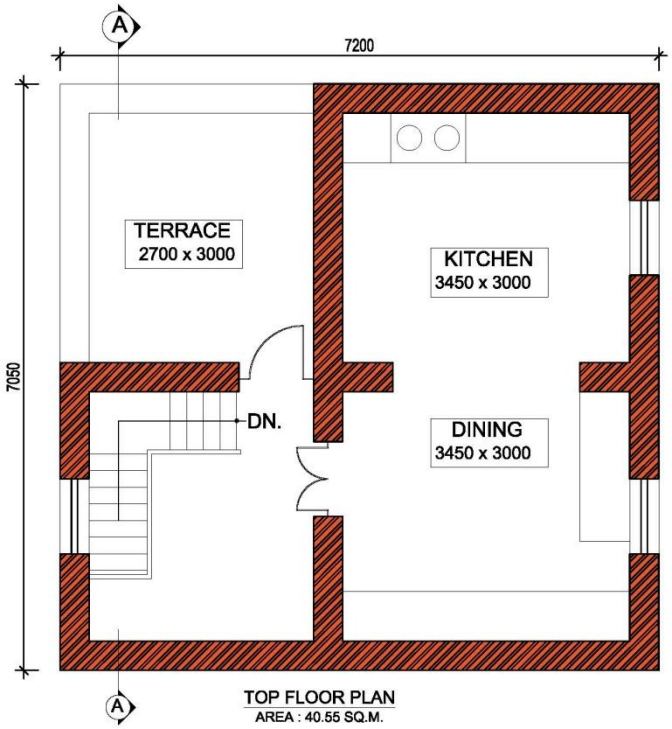
LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	Brick	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	GI SHEET	Rod
	Md	Md	Nos	Bags	Cu.m	Cu.m	Cu.m	Bundel	Rm.	Kg
Up to Plinth Level	48	115	14446	77	13	6	0	0	0	271
SUPERSTRUCTURE	319	216	37112	176	21	5	5	0	0	557
ROOFING	41	15	0	0	0	0	2	4.97	32	0
TOTAL	408	345	51559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



GROUND FLOOR PLAN
AREA : 50.76 SQ.M.

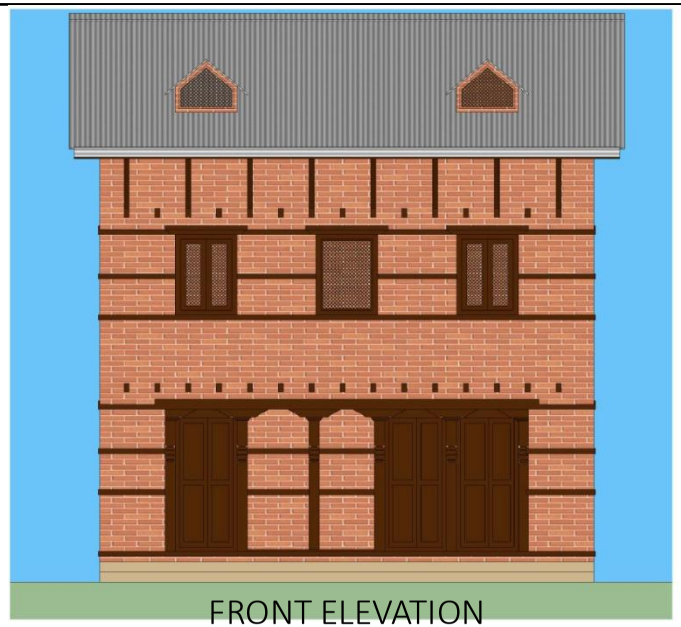


FIRST FLOOR PLAN
AREA : 50.76 SQ.M.

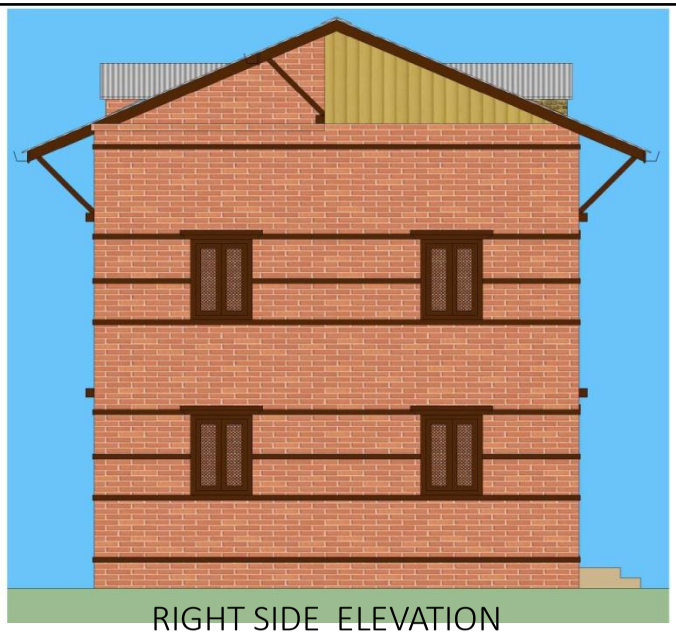


TOP FLOOR PLAN
AREA : 40.55 SQ.M.

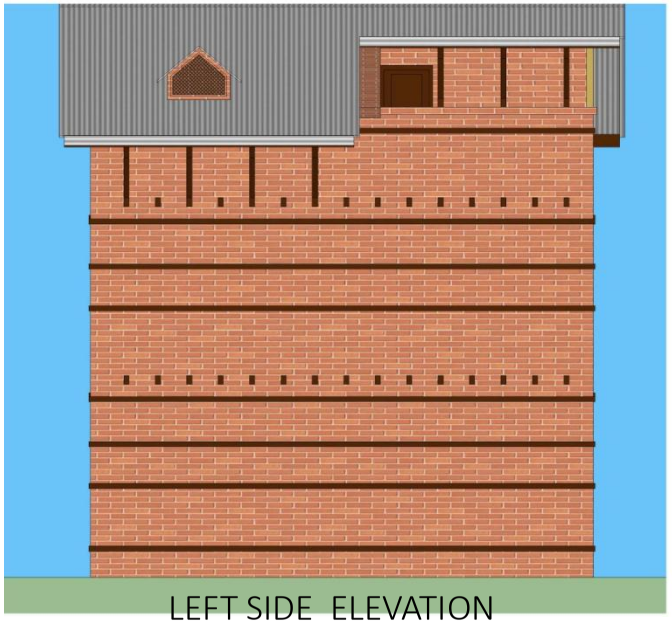
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.4	SCALE: 1:50	DATE:	BMC-2.4
	DRAWING TITLE: FLOOR PLAN	DESIGNED BY: DUDBC		2/4



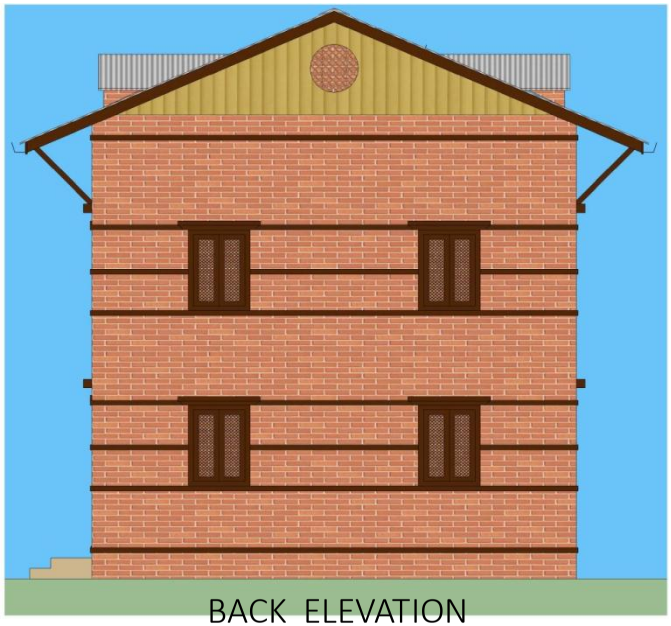
FRONT ELEVATION



RIGHT SIDE ELEVATION

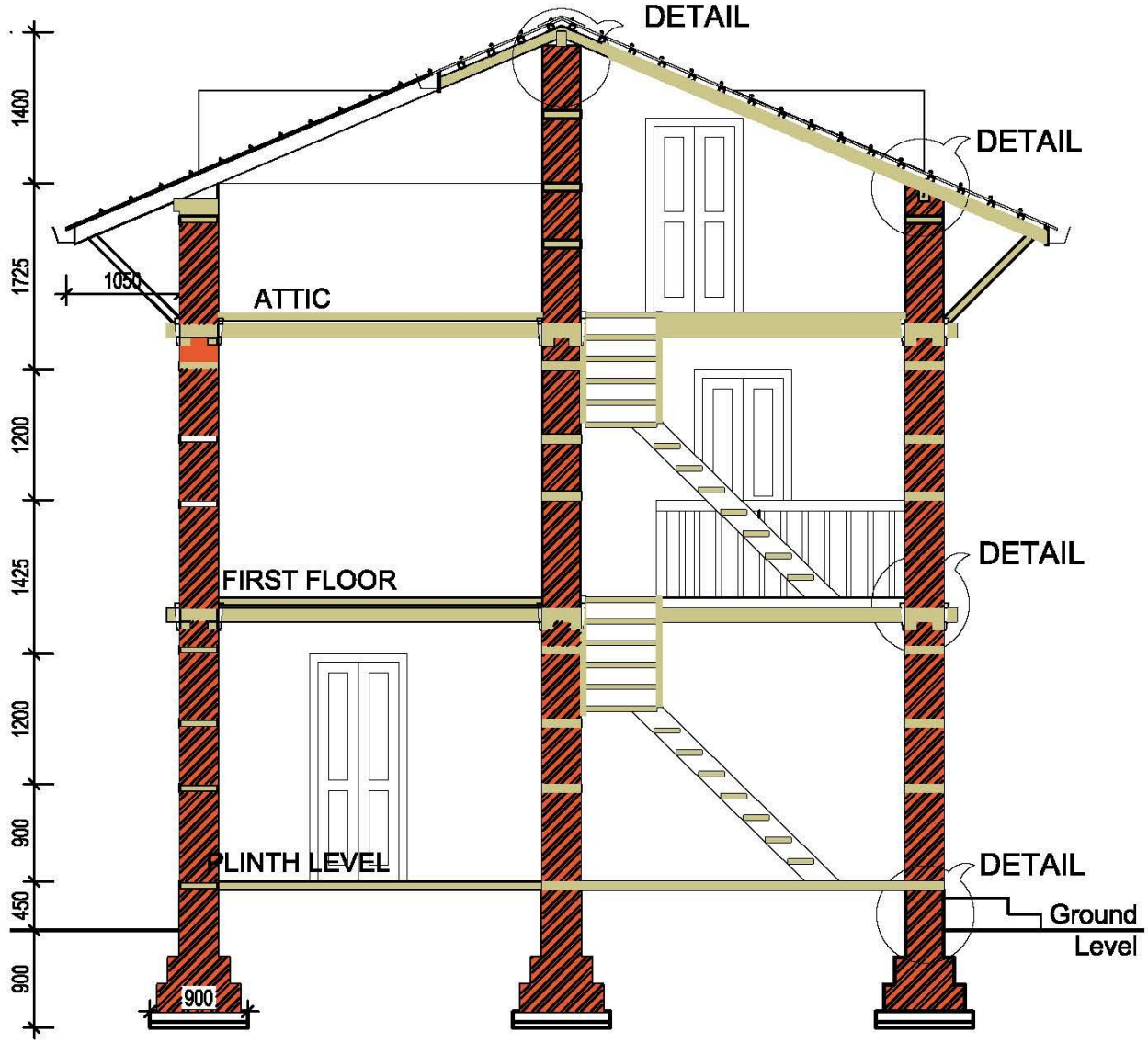


LEFT SIDE ELEVATION



BACK ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.4	SCALE: 1:100	DATE:	BMC-2.4
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4



SECTION AT A-A

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.4	SCALE: None	DATE:	BMC-2.4
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		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

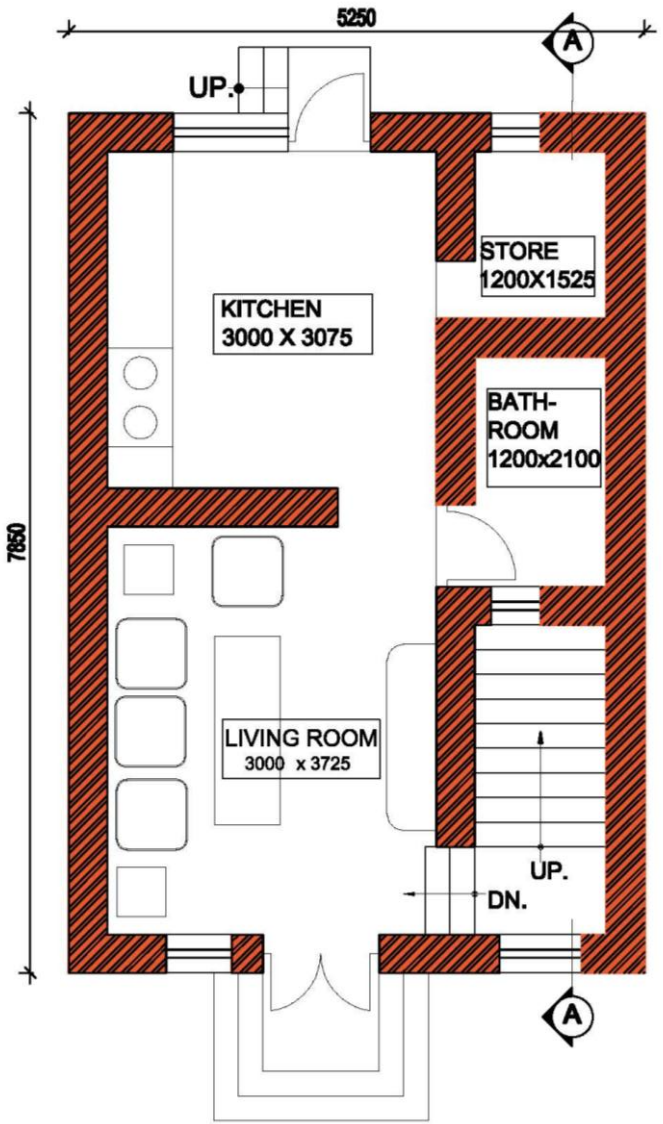
BMC-2.5

CONSTRUCTION MATERIALS AND MANPOWER

LEVEL	MAN POWER		MATERIALS						
	Skilled	Unskilled	Brick	MUD	CEMENT	SAND	AGGREGATE	WOOD	REINFORCEMENT BAR
	Md	Md	Nos	Cu.m	Bags	Cu.m	Cu.m	Cu.m	KG
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

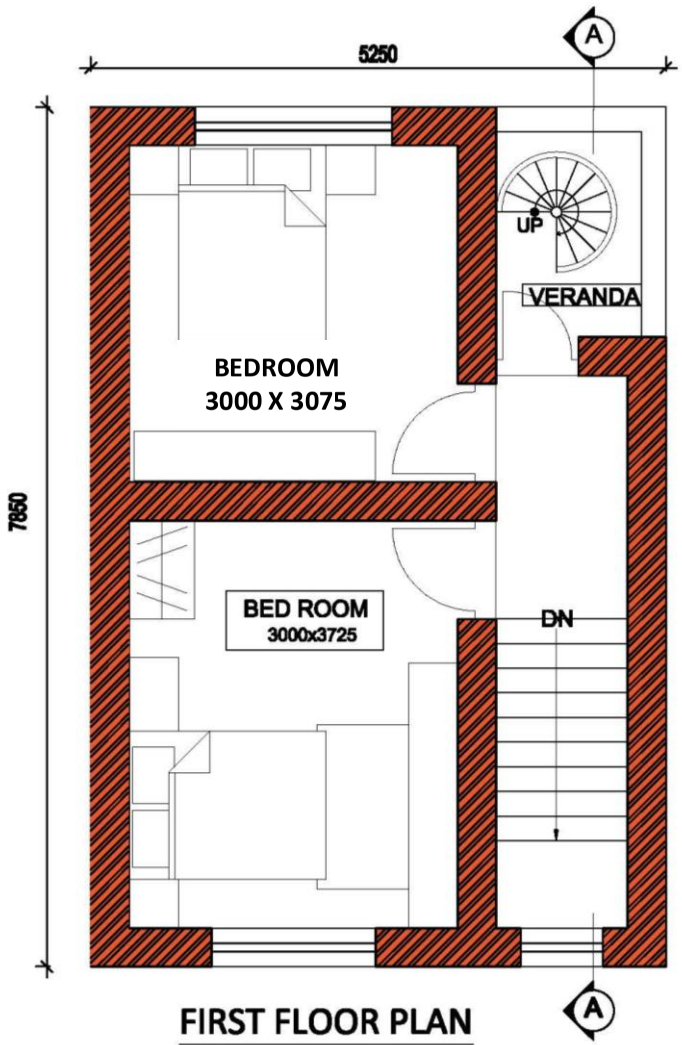
Model BMC 2.5 BRICK MASONARY IN CEMENT MORTAR

TWO-STOREY+TERRACE



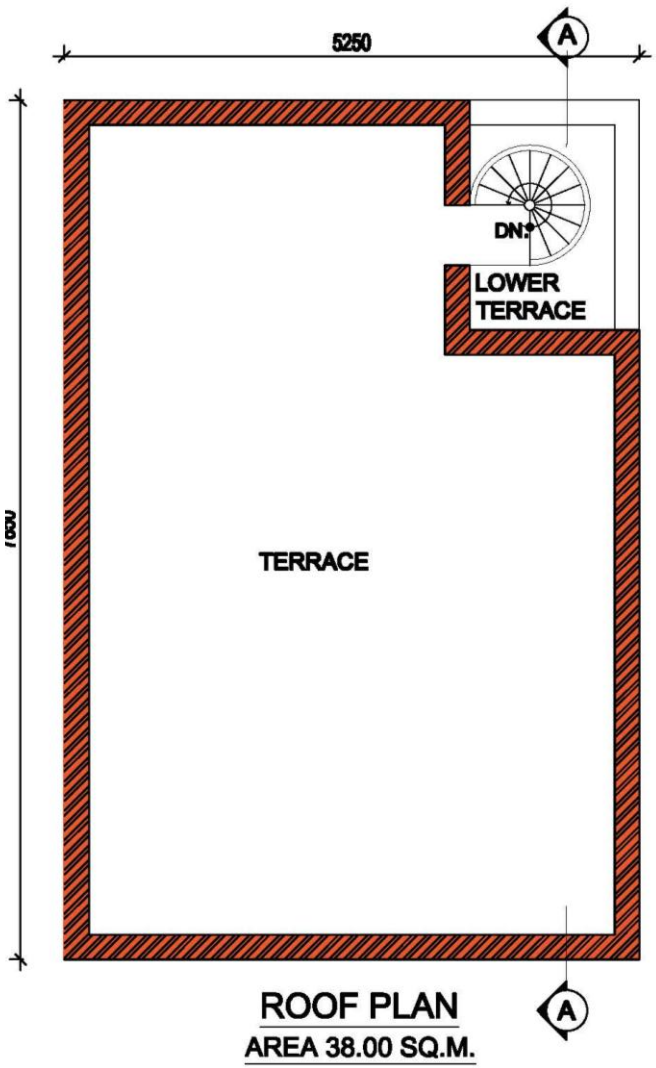
GROUND FLOOR PLAN

AREA 41.22 SQ.M.



FIRST FLOOR PLAN

AREA 41.52 SQ.M.

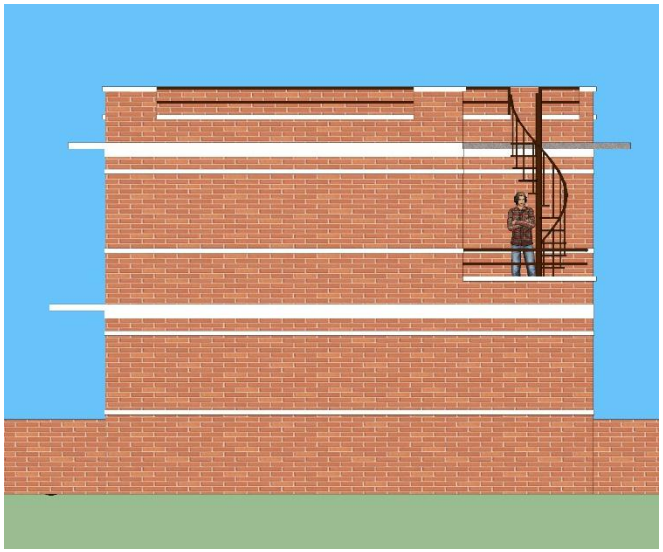


ROOF PLAN

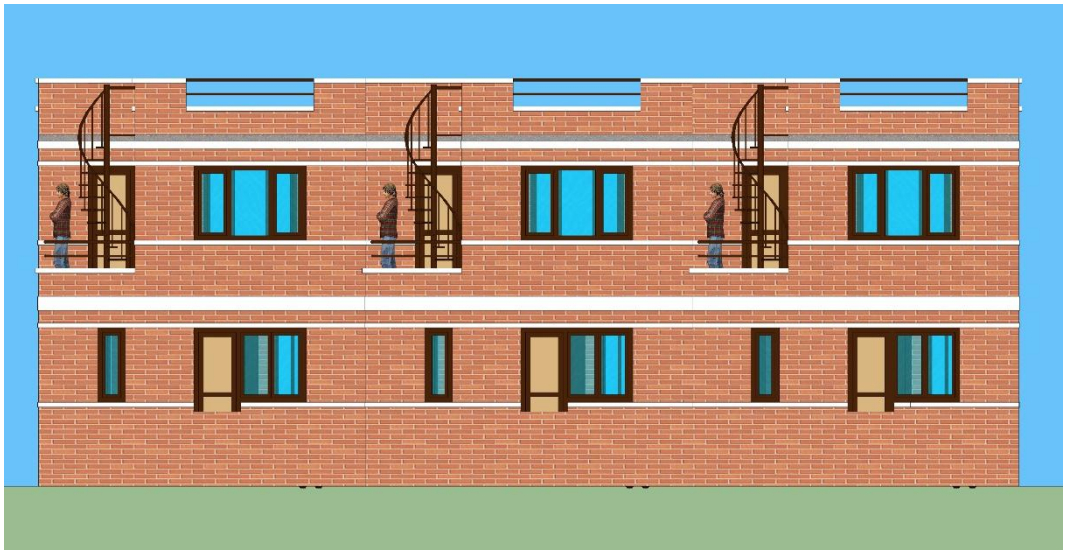
AREA 38.00 SQ.M.

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.5	SCALE: None	DATE:	BMC-2.5
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

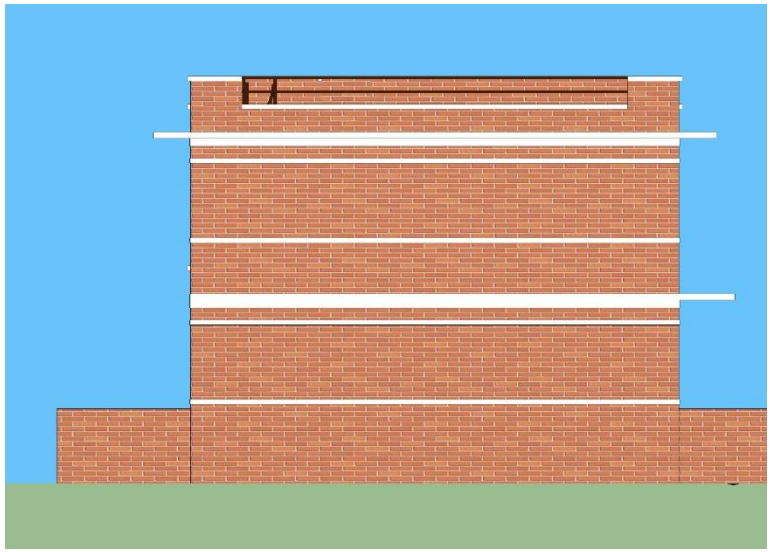
FRONT ELEVATION



RIGHT SIDE ELEVATION



BACK ELEVATION

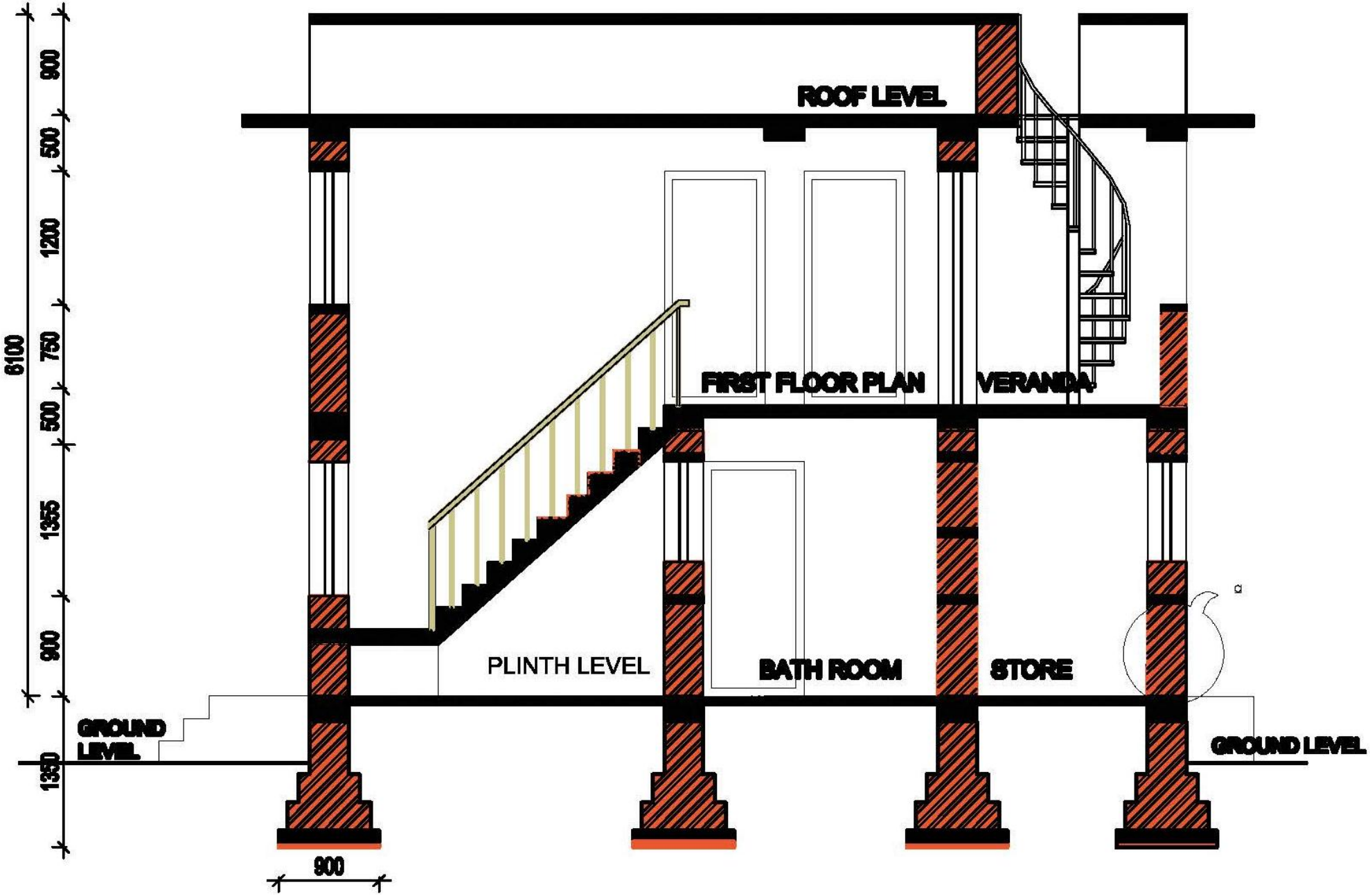


LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.5	SCALE: None	DATE:	BMC-2.5
	DRAWING TITLE: ELEVATION	DESIGNED BY: DUDBC		3/4

Model BMC 2.5 BRICK MASONARY IN CEMENT MORTAR

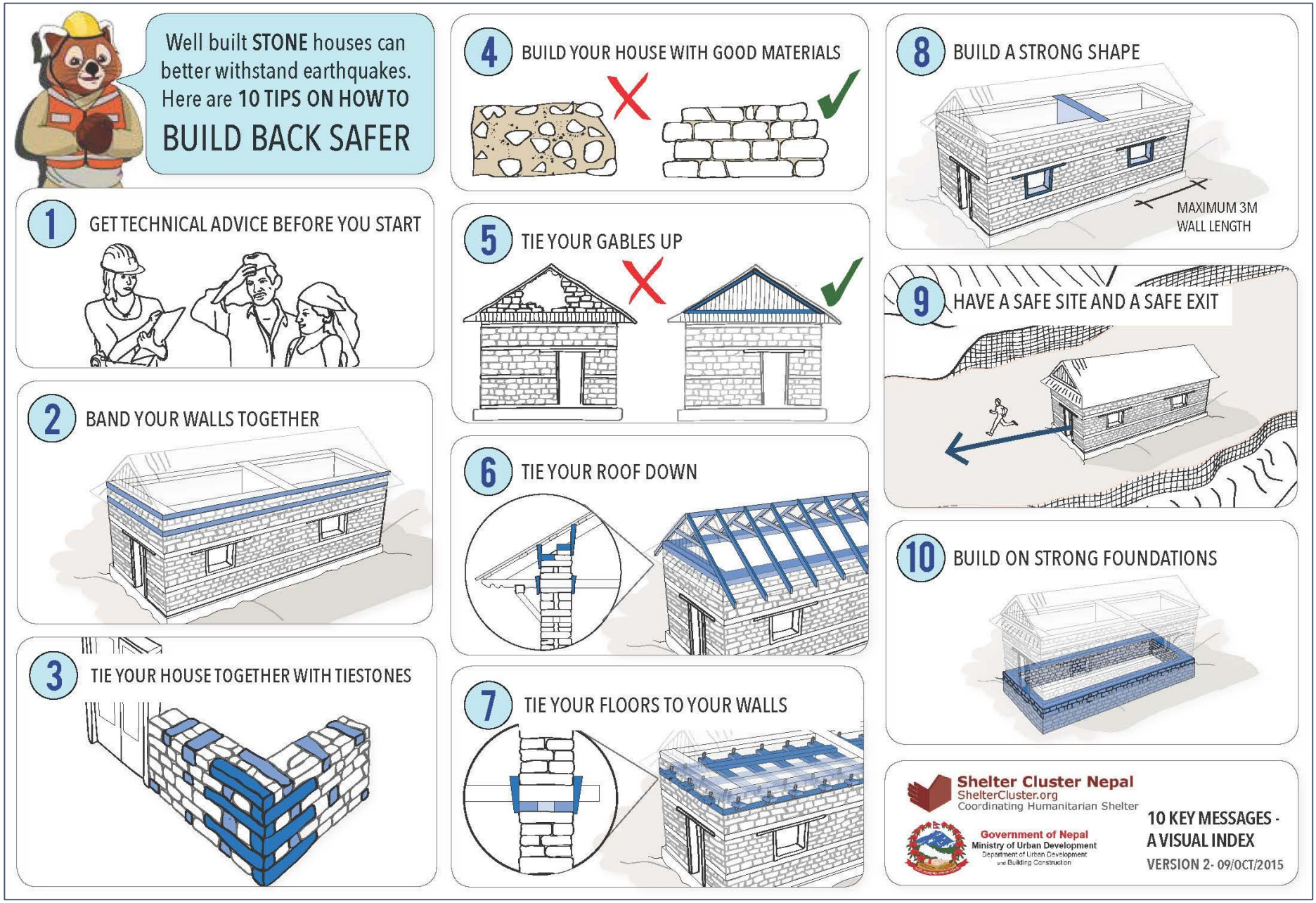
TWO-STOREY+TERRACE



Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC-2.5	SCALE: 1:50	DATE:	BMC-2.5
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

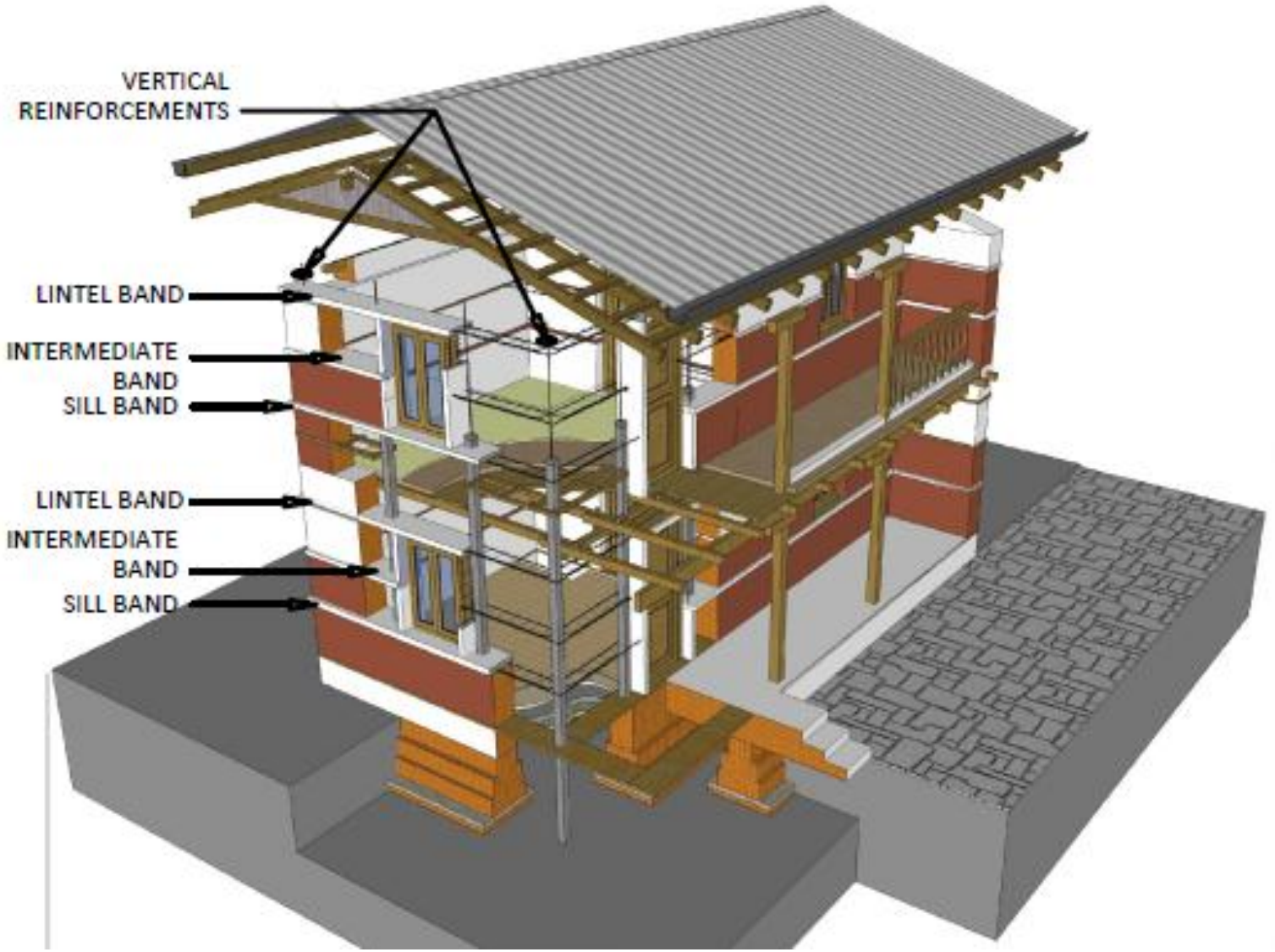
BRICK MASONRY IN CEMENT MORTAR (BMC)

Technical Details



10 KEY MESSAGES

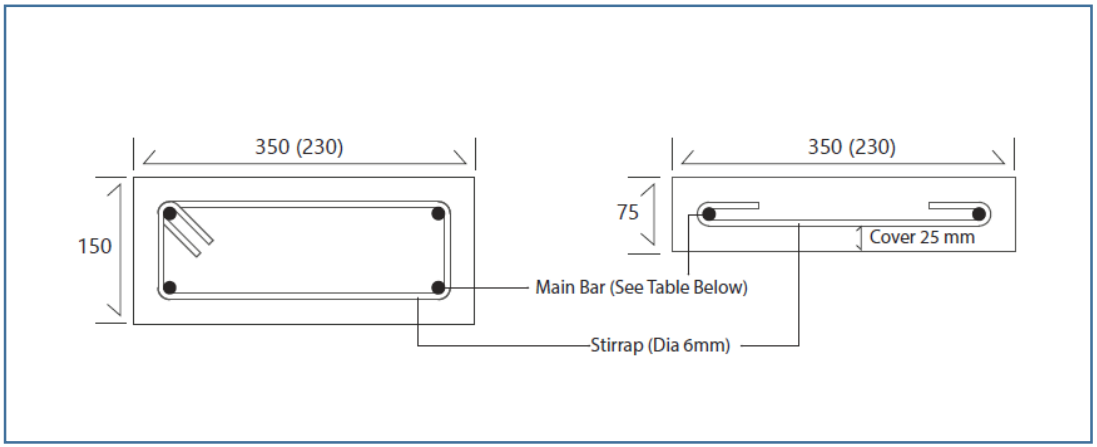
BRICK MASONRY IN CEMENT MORTAR



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

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC	SCALE: None	DATE:	BMC
	DRAWING TITLE: TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)	DESIGNED BY: DUDBC		

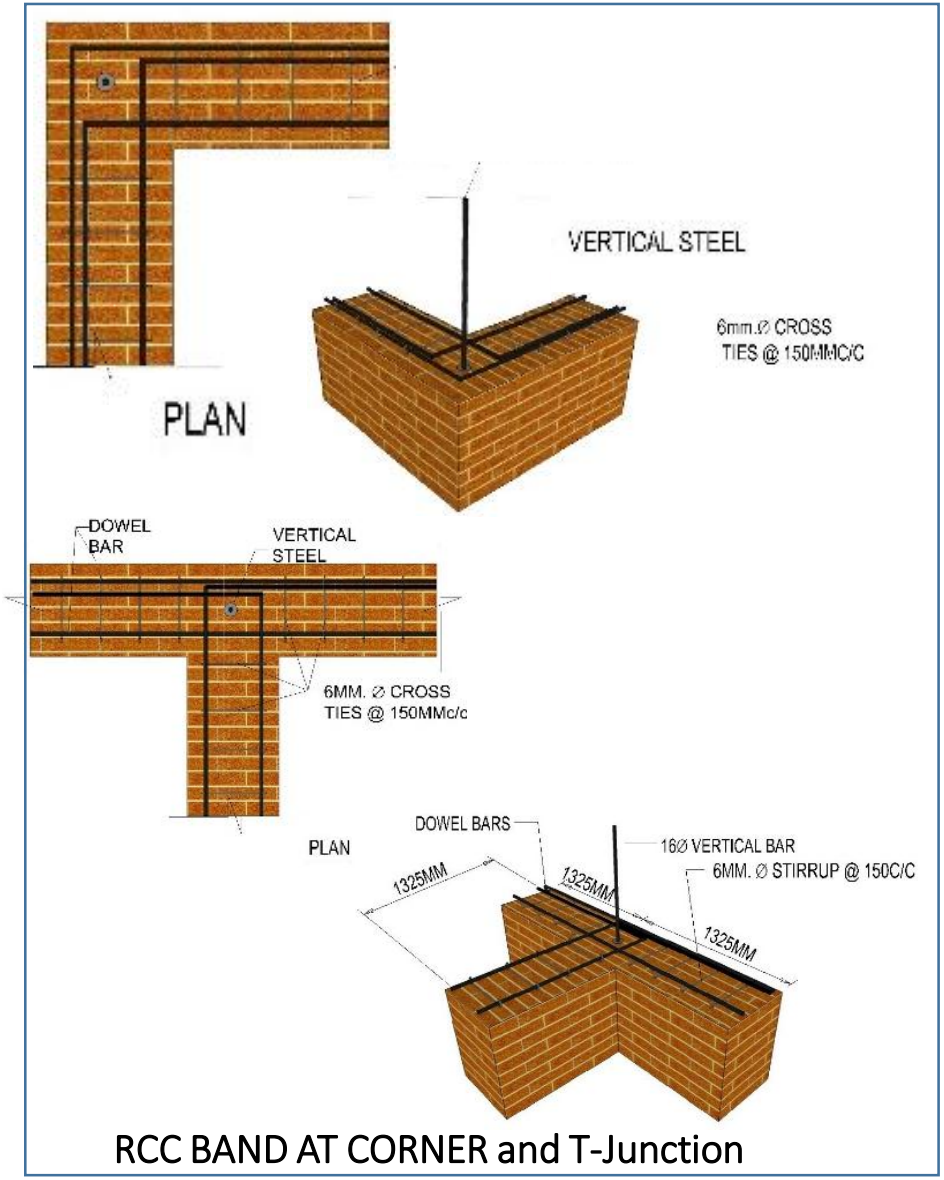
BRICK MASONRY IN CEMENT MORTAR



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)
		2	12 (bottom)
Roof	75mm	2	12
	300mm	4	12
Dowel (Stitch)	75mm	2	8

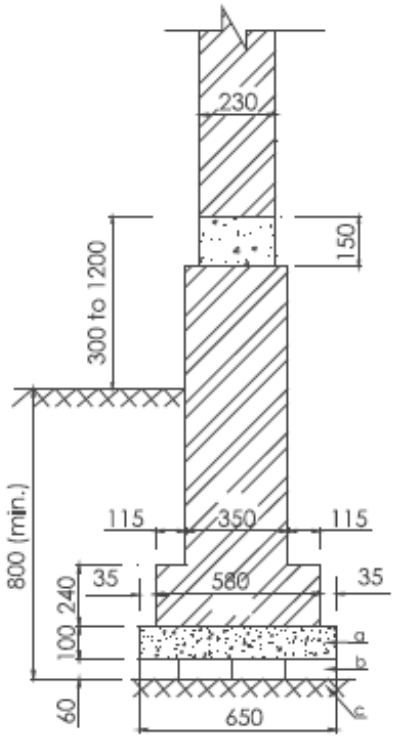


RCC BAND AT CORNER and T-Junction

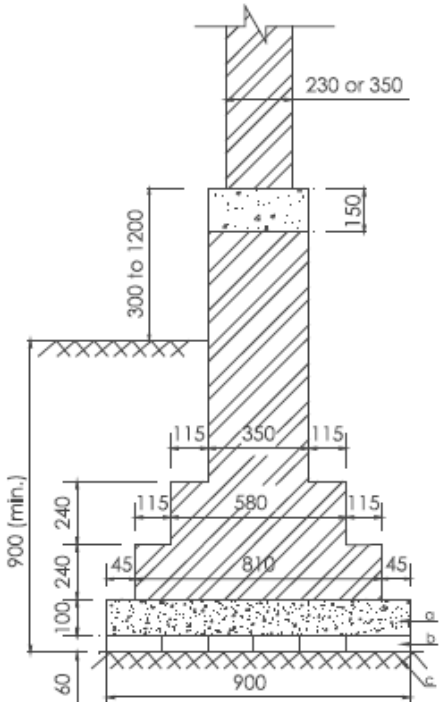
*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC	SCALE: None	DATE:	SMC
	DRAWING TITLE: TECHNICAL DETAIL 2 (Reinforcing bar arrangement)	DESIGNED BY:		

BRICK MASONRY IN CEMENT MORTAR



For one-storey building (in soft soil)
(Brick in cement mortar)



For two-storey building (in soft soil)
(Brick 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

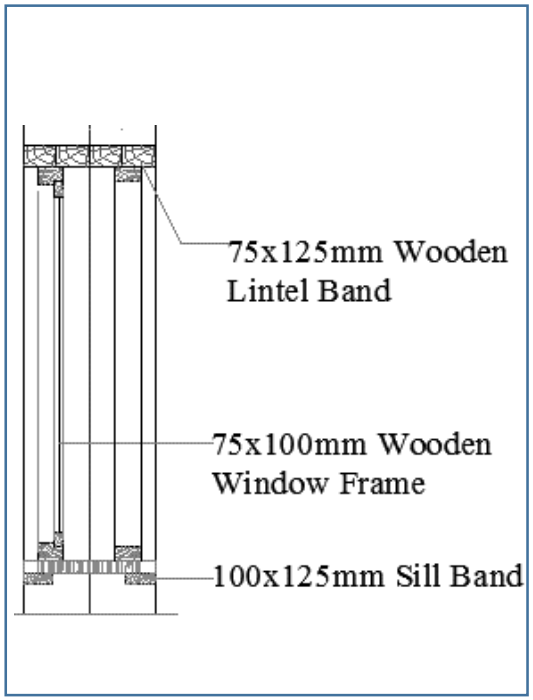
Classification of Foundation Soil and Safe Bearing Capacity

Foundation Soil Classification	Types of Foundation Materials	Presumed Safe Bearing Capacity, KN/m²
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

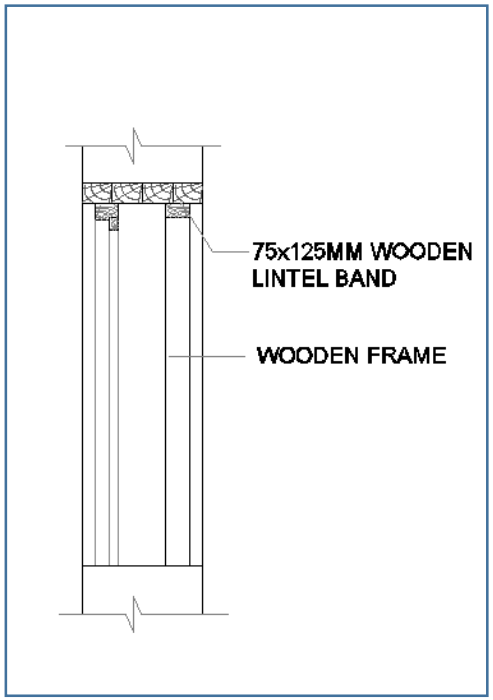
*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC	SCALE: None	DATE:	BMC
	DRAWING TITLE: TECHNICAL DETAIL 3 (Foundation)	DESIGNED BY:		

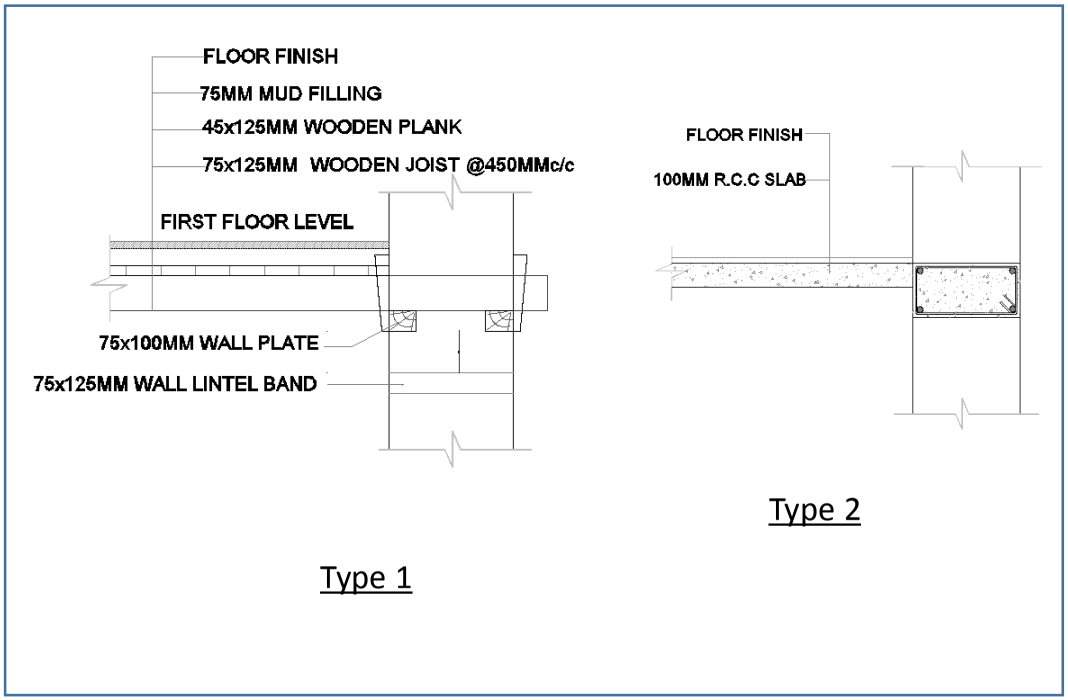
BRICK MASONRY IN CEMENT MORTAR



Window Section



Door Section

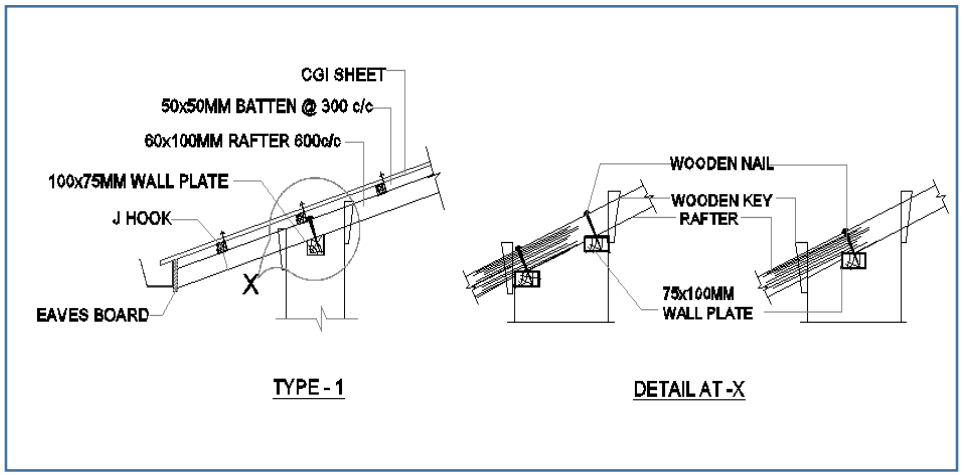


First Floor Detail

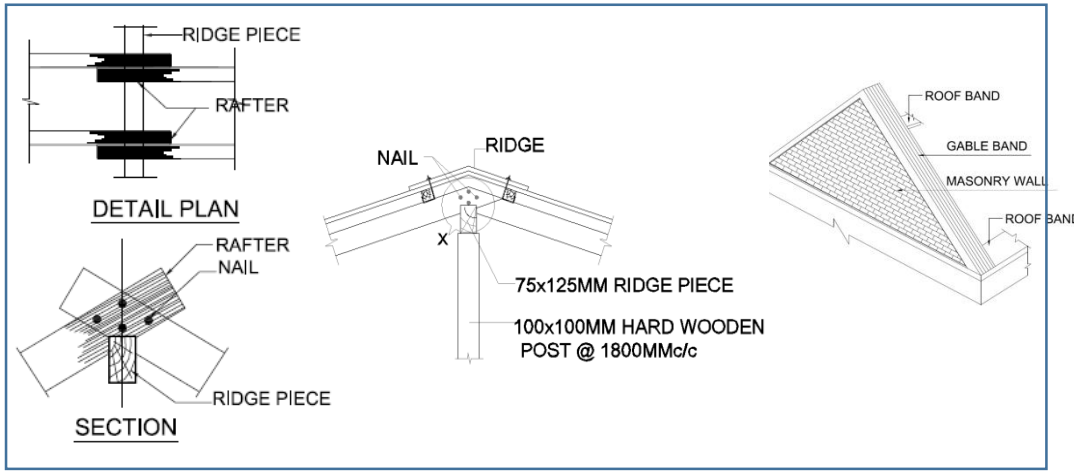
*Source : NBC202

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC	SCALE: None	DATE:	BMC
	DRAWING TITLE: TECHNICAL DETAIL 4 (Opening and Floor)	DESIGNED BY:		

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	SCALE: None	DATE:	BMC
	DRAWING TITLE: TECHNICAL DETAIL 5 (Roof)	DESIGNED BY:		

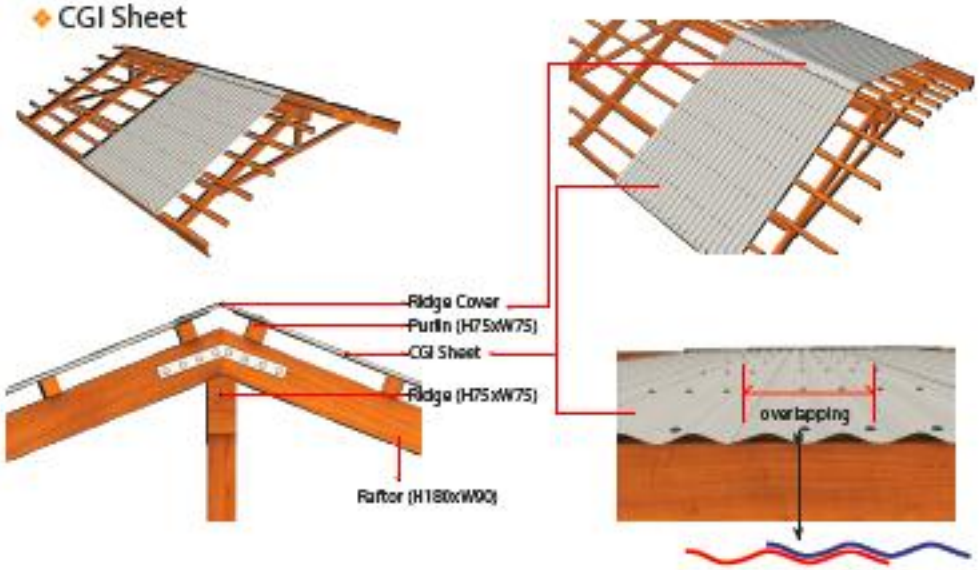
BRICK MASONRY IN CEMENT MORTAR

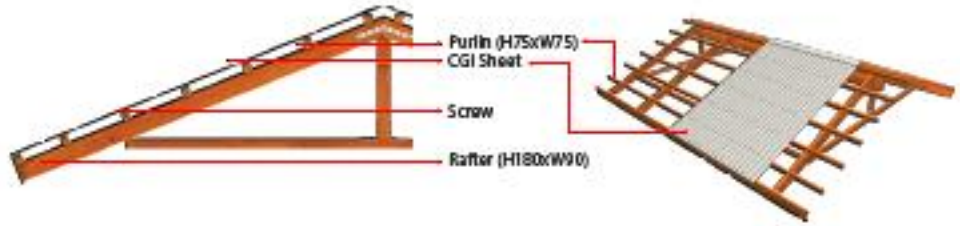
Top (Plan) View

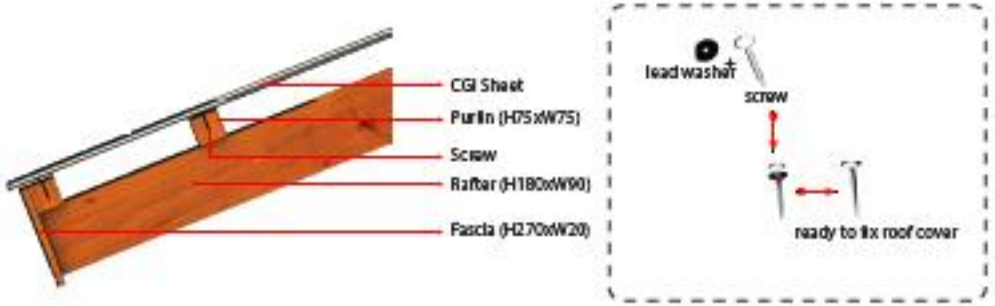
Side View

Isometric View

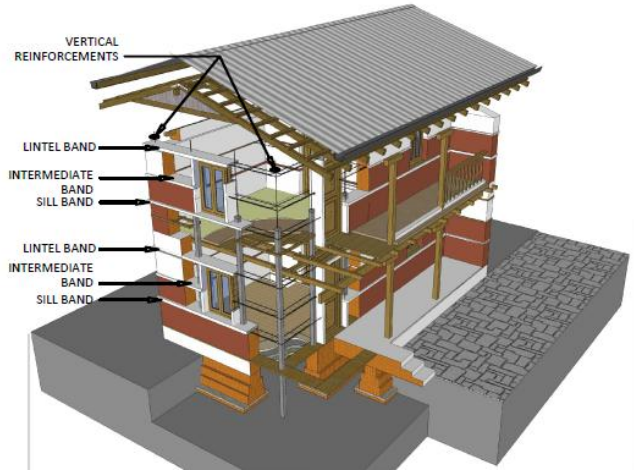
CGI Sheet



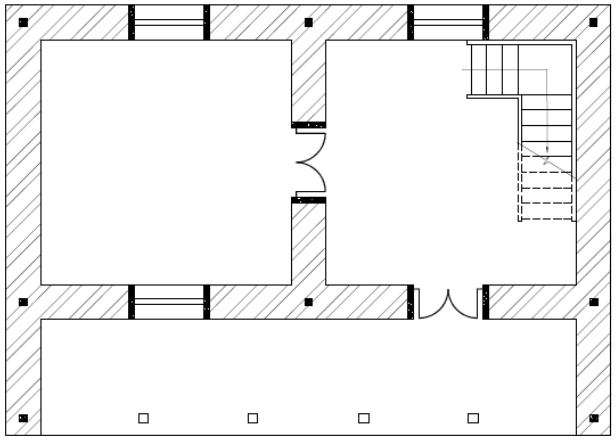




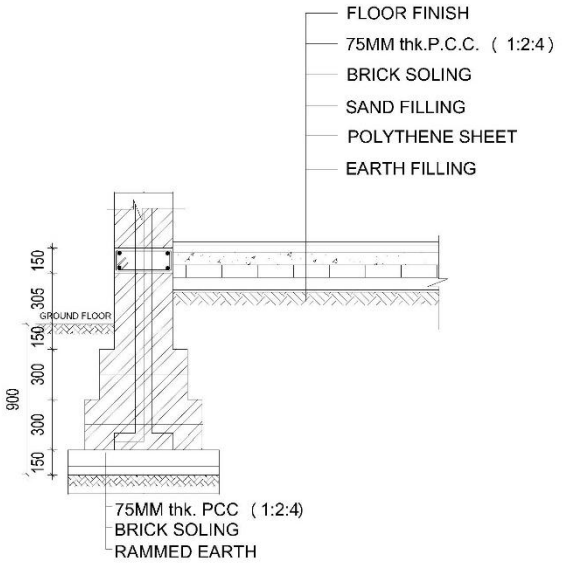
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMC	SCALE: None	DATE:	BMC
	DRAWING TITLE: TECHNICAL DETAIL 6 (Roofing)	DESIGNED BY:		



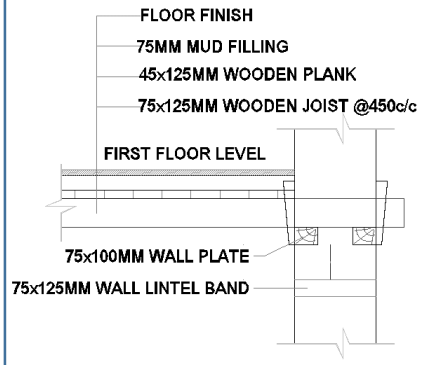
Earthquake Resistant Elements in Building



Typical Ground/ First Floor Plan

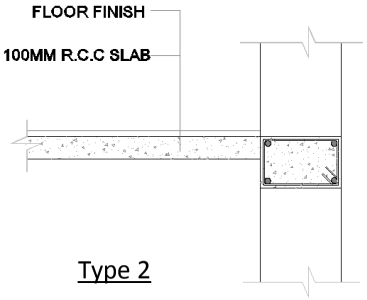


Foundation Detail



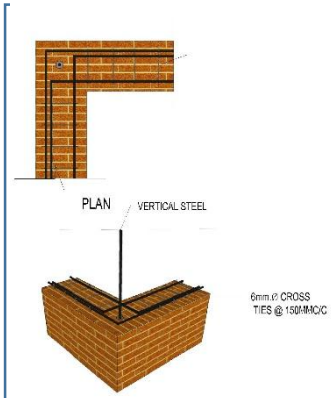
Type 1

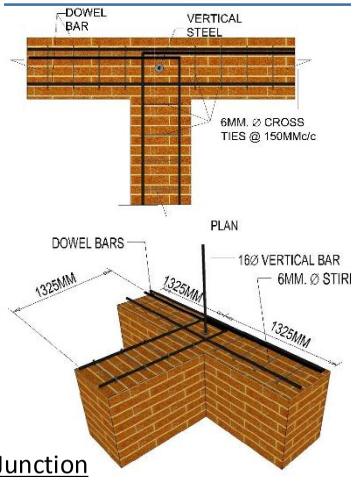
Wooden Floor Detail



Type 2

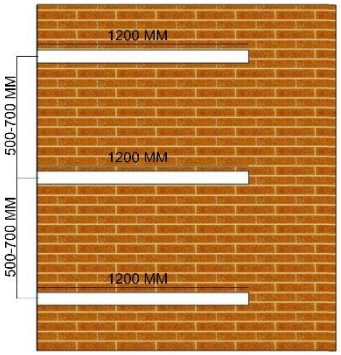
RCC Floor Detail



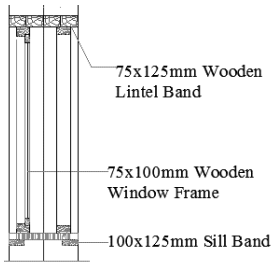


RCC BAND

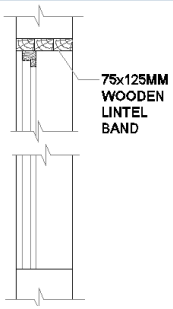
AT CORNER and T-Junction



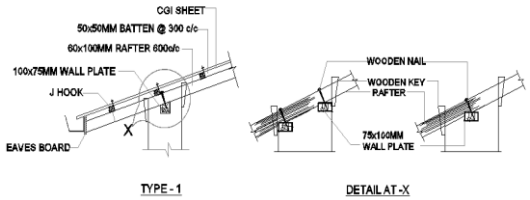
Corner Strengthening Band



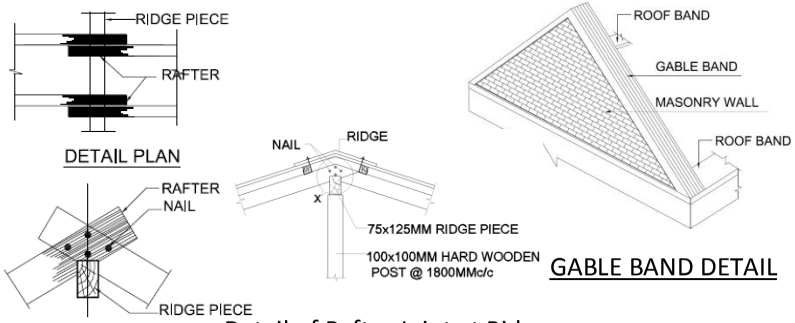
Window Section



Door Section



Detail of Rafter Joint with Wall Plate



GABLE BAND DETAIL

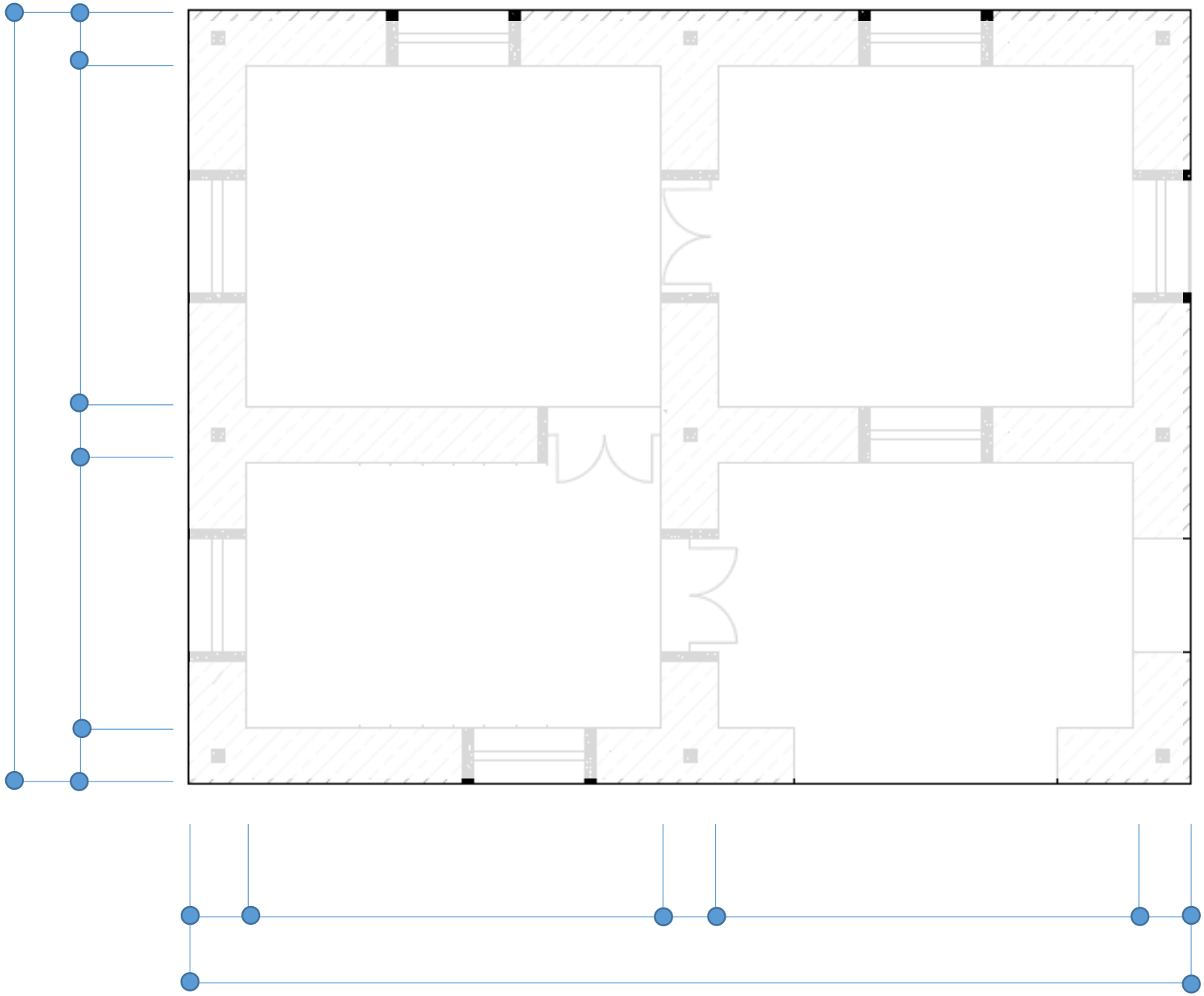
Detail of Rafter Joint at Ridge

Flexible design

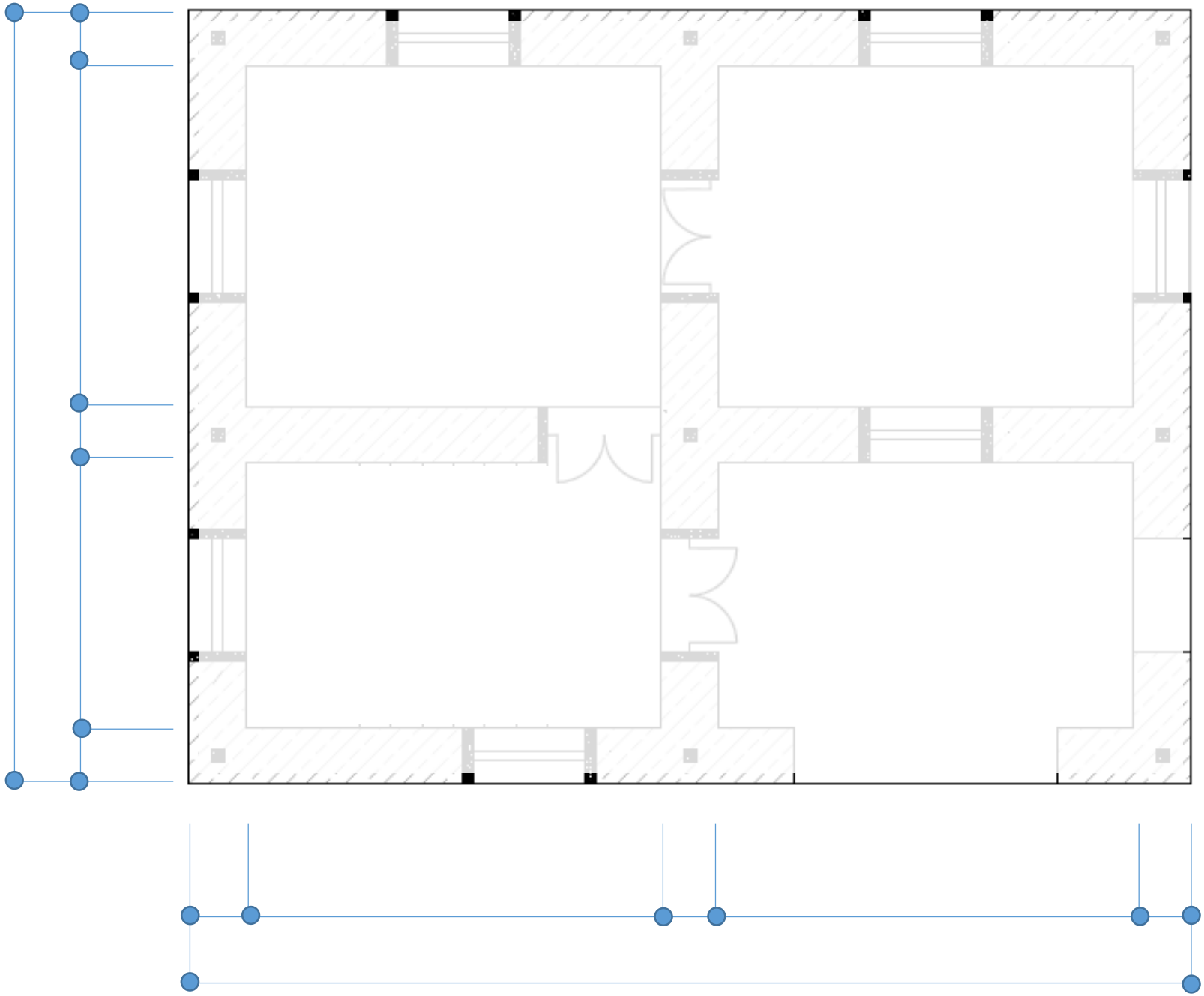
Minimum Requirements (MRs) for Brick Masonry in Cement Mortar (NBC202) Page1				
No.	Category			
1	Site Selection	A building shall not be constructed if site is:		
			✔	Geological fault or Raptured Area
			✔	Areas Susceptible to Landslide
			✔	Steep Slope > 20%
			✔	Filled Area
			✔	River Bank and Water-logged Area
2	Shape of House	No. of story	✔	Two storey+ attic, load bearing masonry buildings constructed in cement mortar
		Span of wall	✔	The span of wall shall not more than 4.5 meters
		Size of room	✔	The area of individual floor panel not more than 13.5 square metres
		Height of wall	✔	The height of wall should not be more than 3.0 meters
		Proportion	✔	The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.
3	Foundation	General	✔	The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.
		Depth	✔	The depth of footing should not be less than 800mm for one story, 900mm for two storey.
		Width	✔	The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings.
4	Plinth	General	✔	Provide a reinforced concrete band at plinth level, as shown in detail drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.
		Height	✔	Minimum height of Plinth band is 150mm.
		Width	✔	Minimum thickness of plinth band width should be equal to wall thickness. 230mm for brick 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. 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.
		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 fy = 415 N/

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



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



STONE MASONRY IN MUD MORTAR (SMM)

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 raptured 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 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 fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements.

STONE MASONRY IN MUD MORTAR, TWO-STOREY

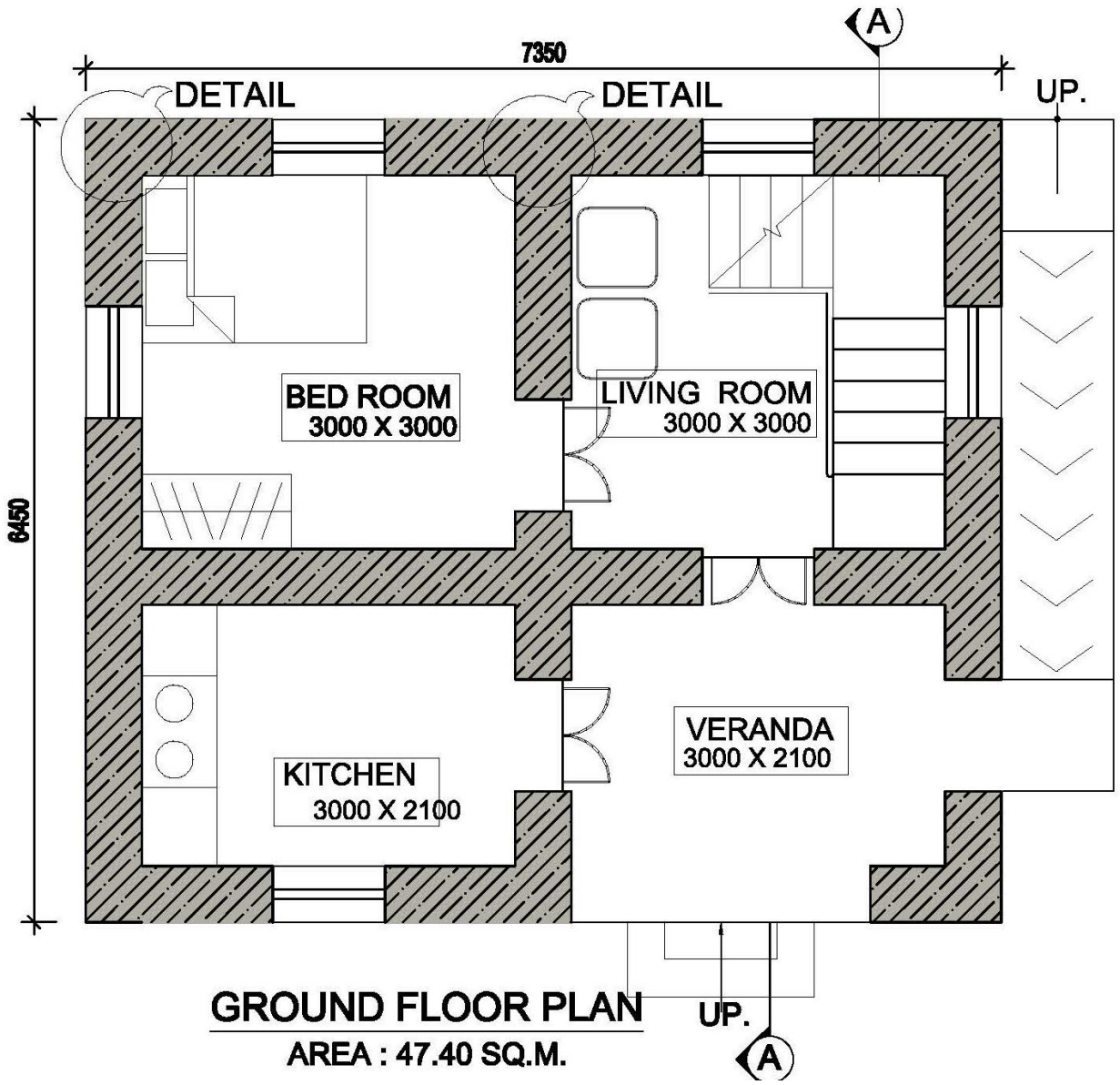
SMM-1.1

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			
	Skilled	Unskilled	Stone	MUD	WOOD	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

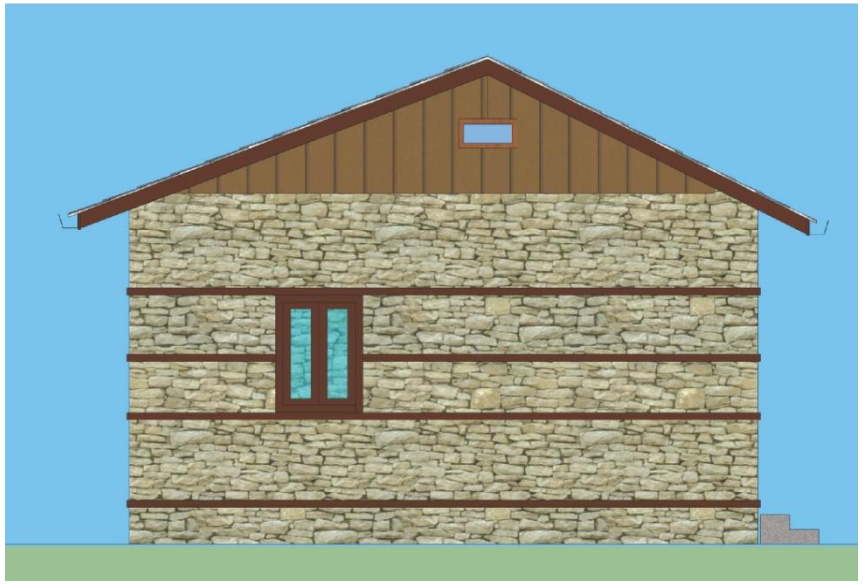


GROUND FLOOR PLAN

AREA : 47.40 SQ.M.

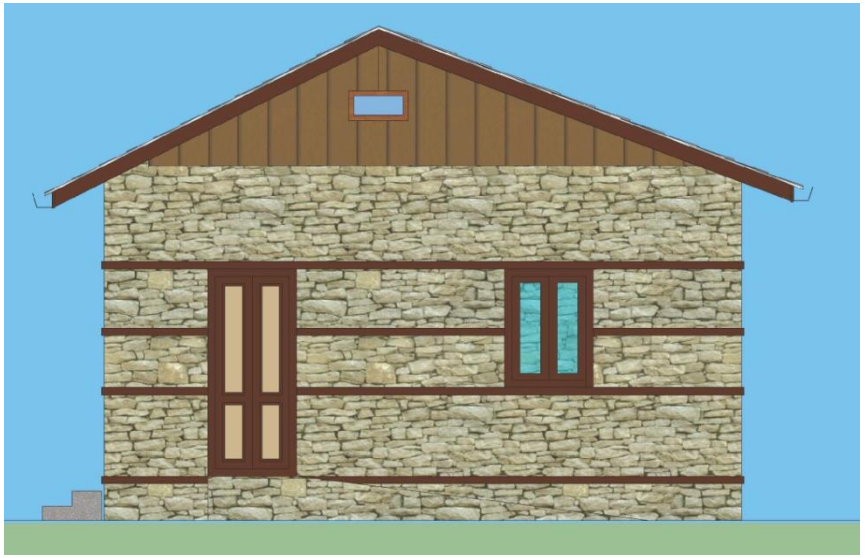
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMM-1.1	SCALE: None	DATE:	SMM-1.1
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION



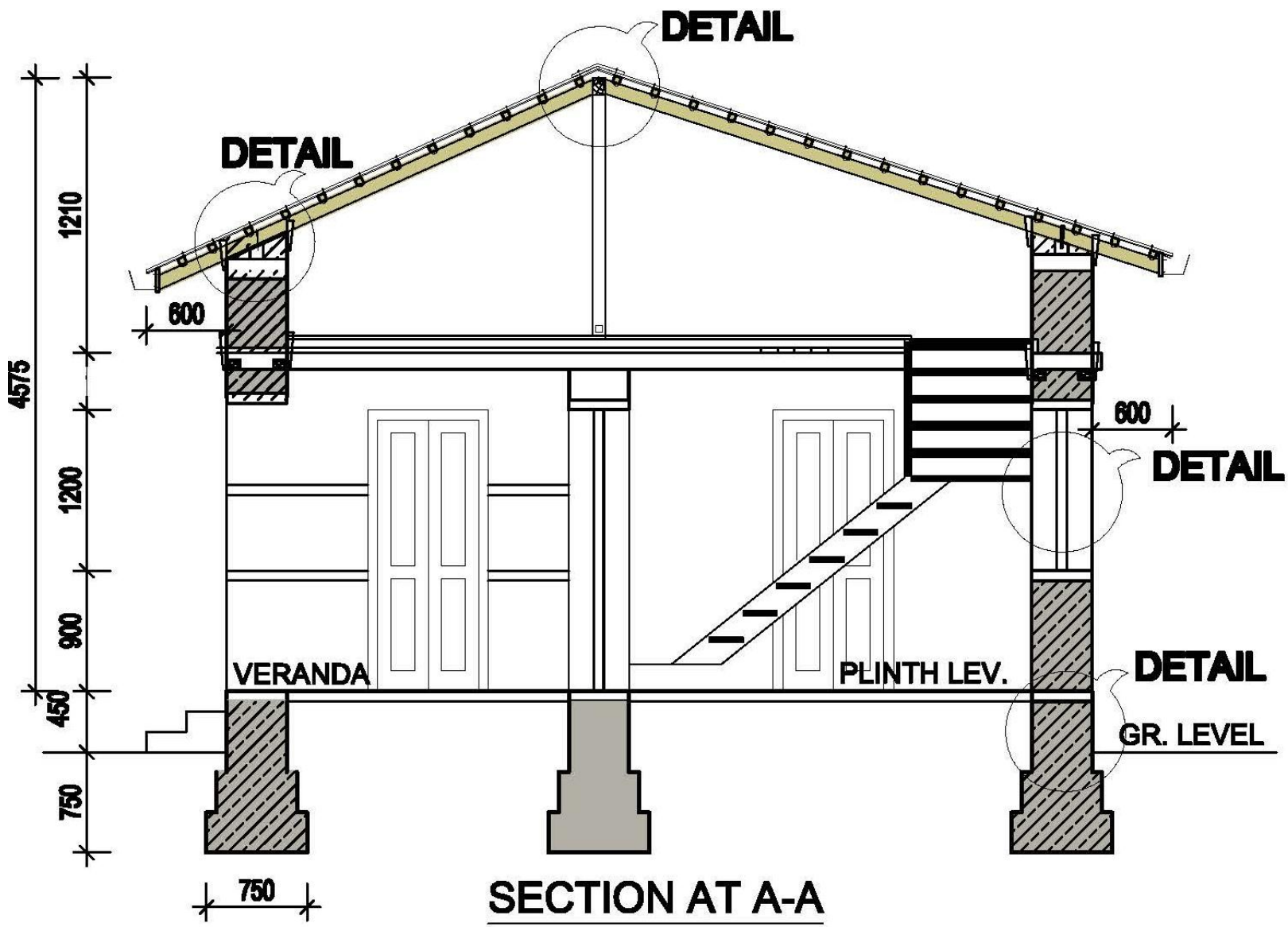
RIGHT SIDE ELEVATION

BACK ELEVATION



LEFT SIDE ELEVATION

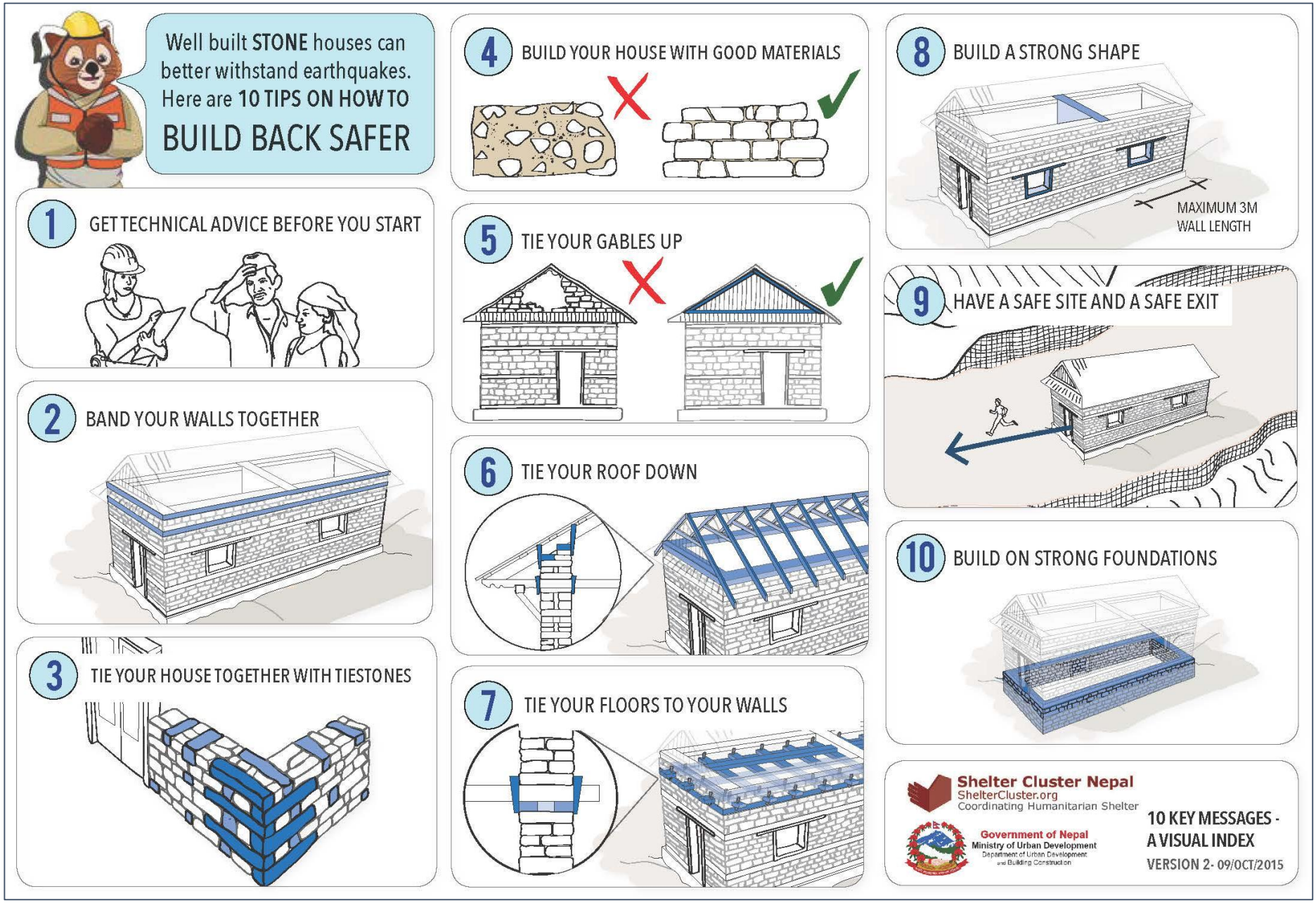
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODELSMM-1.1	SCALE: None	DATE:	SMM-1.1
	DRAWING TITLE: ELAVATION	DESIGNED BY: DUDBC		3/4



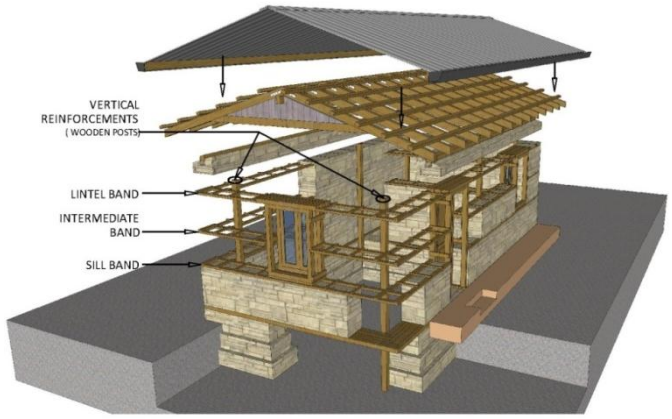
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMM-1.1	SCALE: 1:50	DATE:	SMM-1.1
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

STONE MASONRY IN MUD MORTAR (SMM)

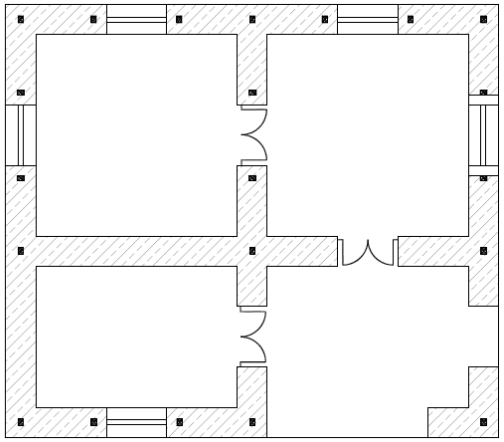
Technical Details



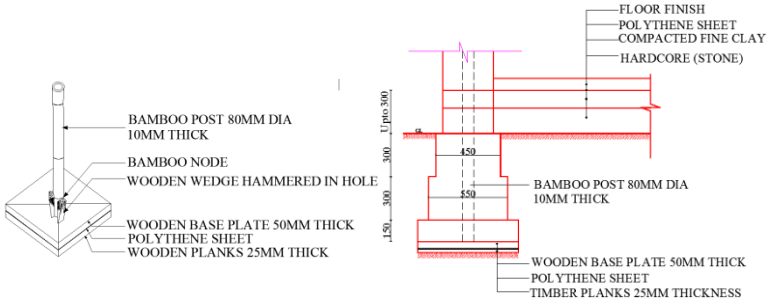
10 KEY MESSAGES



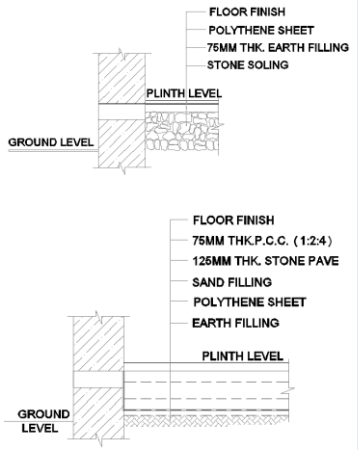
Earthquake Resistant Elements in Building



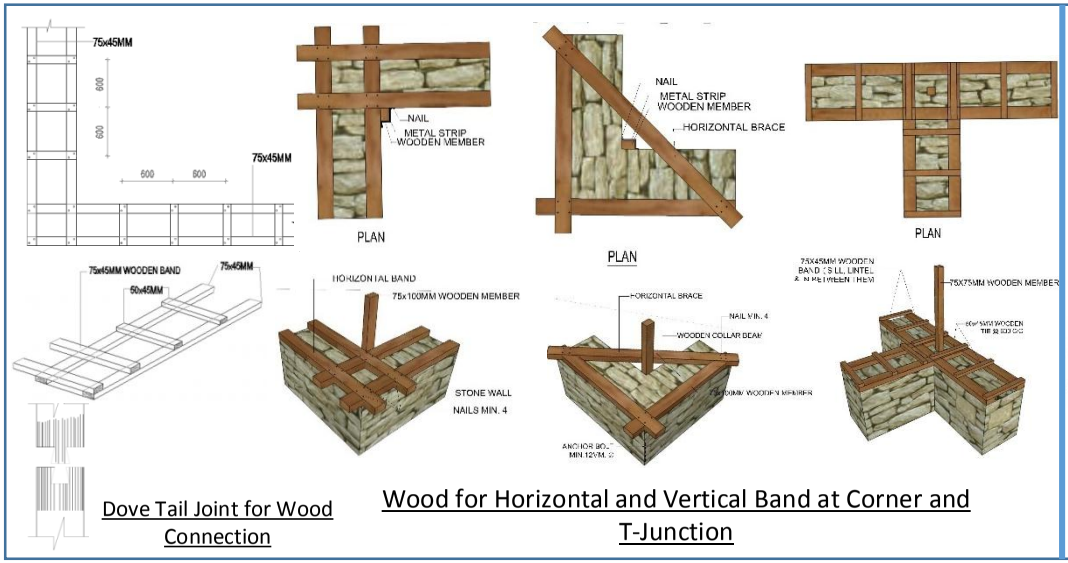
Building Plan



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

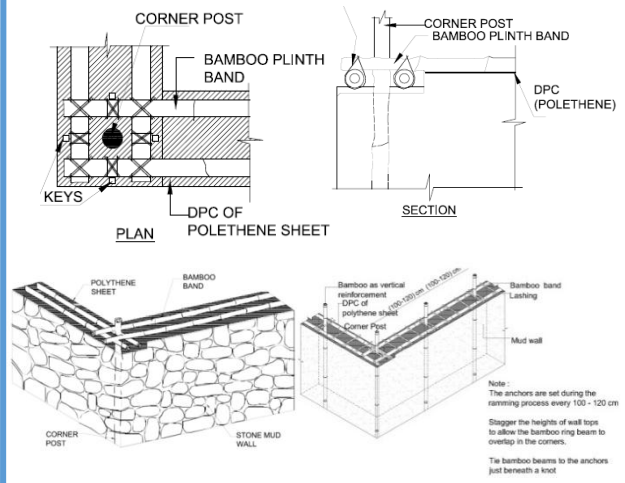


Ground Floor Detail

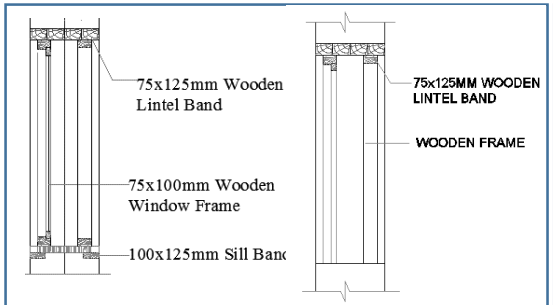


Dove Tail Joint for Wood Connection

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

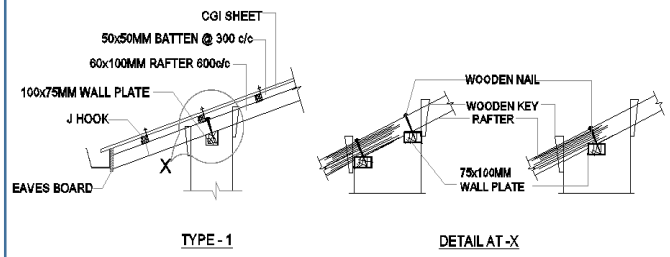


Bamboo for Horizontal and Vertical Band

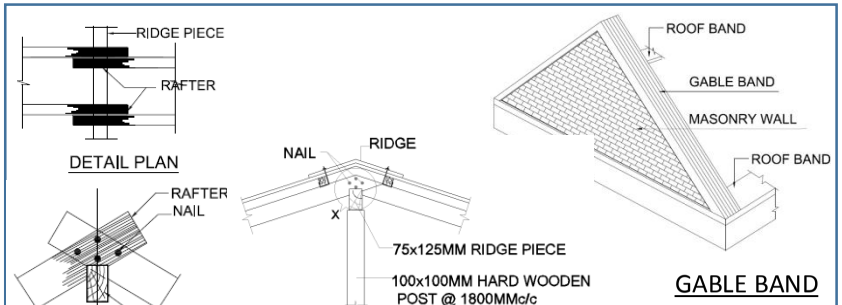


Window Section

Door Section



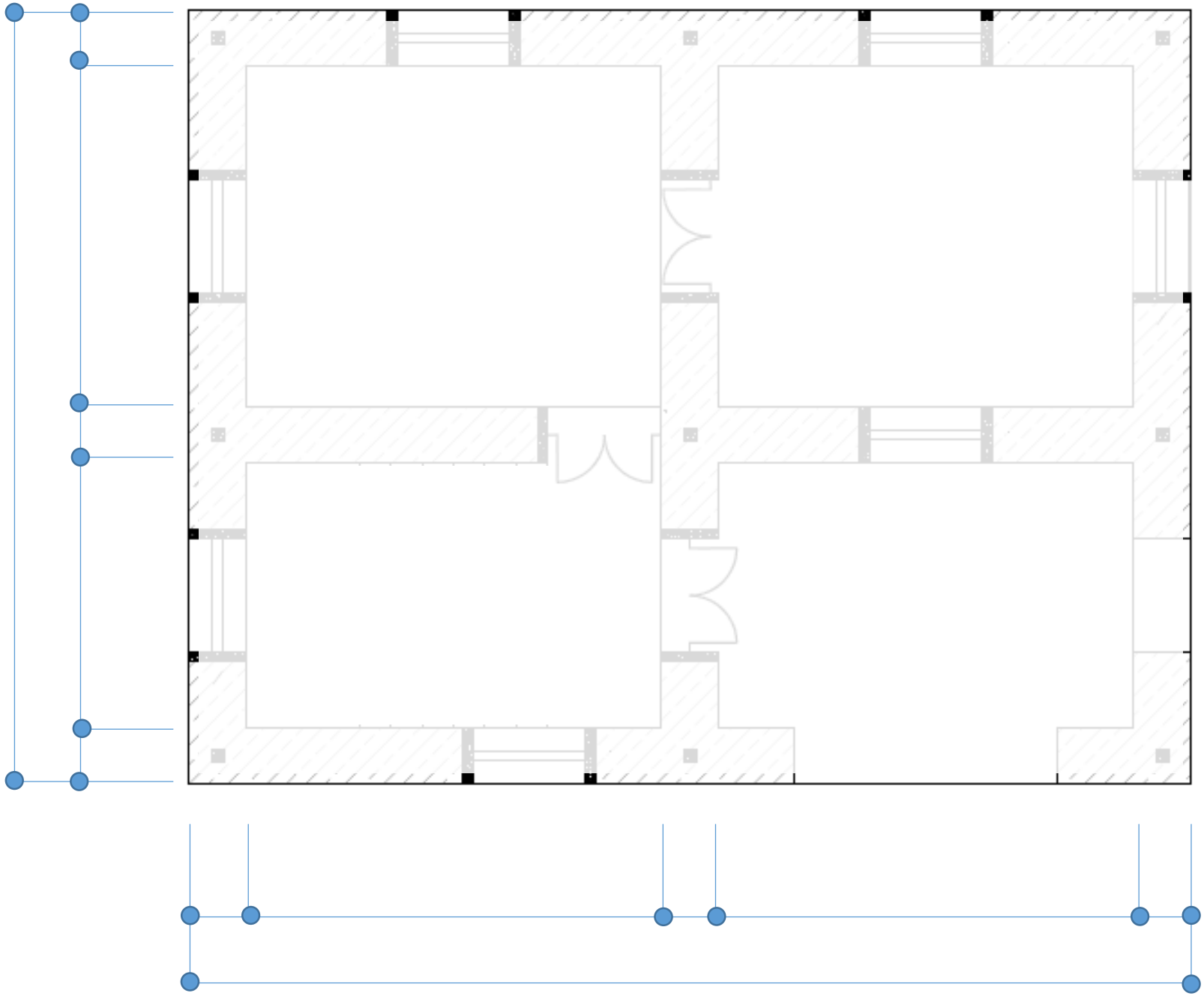
Detail of Rafter Joint with Wall Plate



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.



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 raptured 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 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 fy = 415 N/sqmm or 550N/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.
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 strctural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.
		Mortar	✔	Mud should be free from organic material and pebbles, etc.
		Brick		Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm.
		Concrete	✔	The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate)
		Reinforcement	✔	High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements.

BRICK MASONRY IN MUD MORTAR, ONE-STOREY

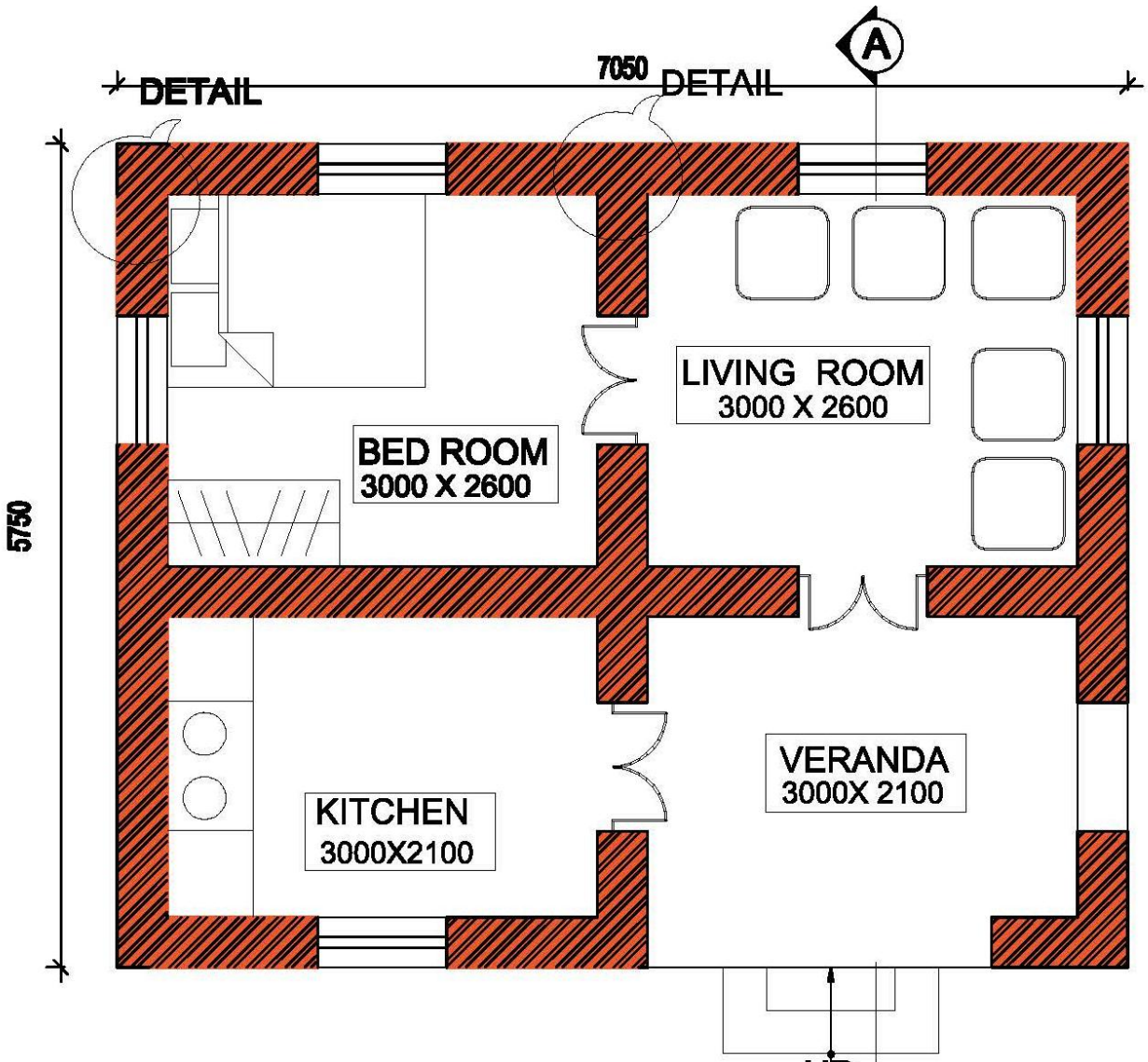
BMM-1.1

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



GROUND FLOOR PLAN

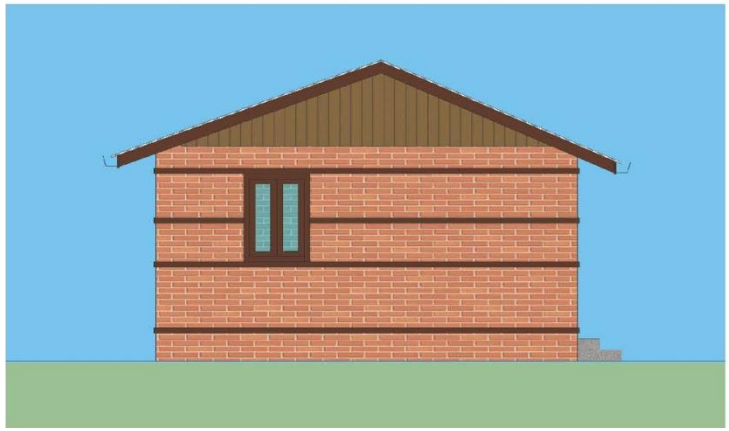
AREA : 40.55 SQ.M.

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMM-1.1	SCALE: 1:50	DATE:	BMM1.1
	DRAWING TITLE: PLAN	DESIGNED BY: DUDBC		2/4

FRONT ELEVATION

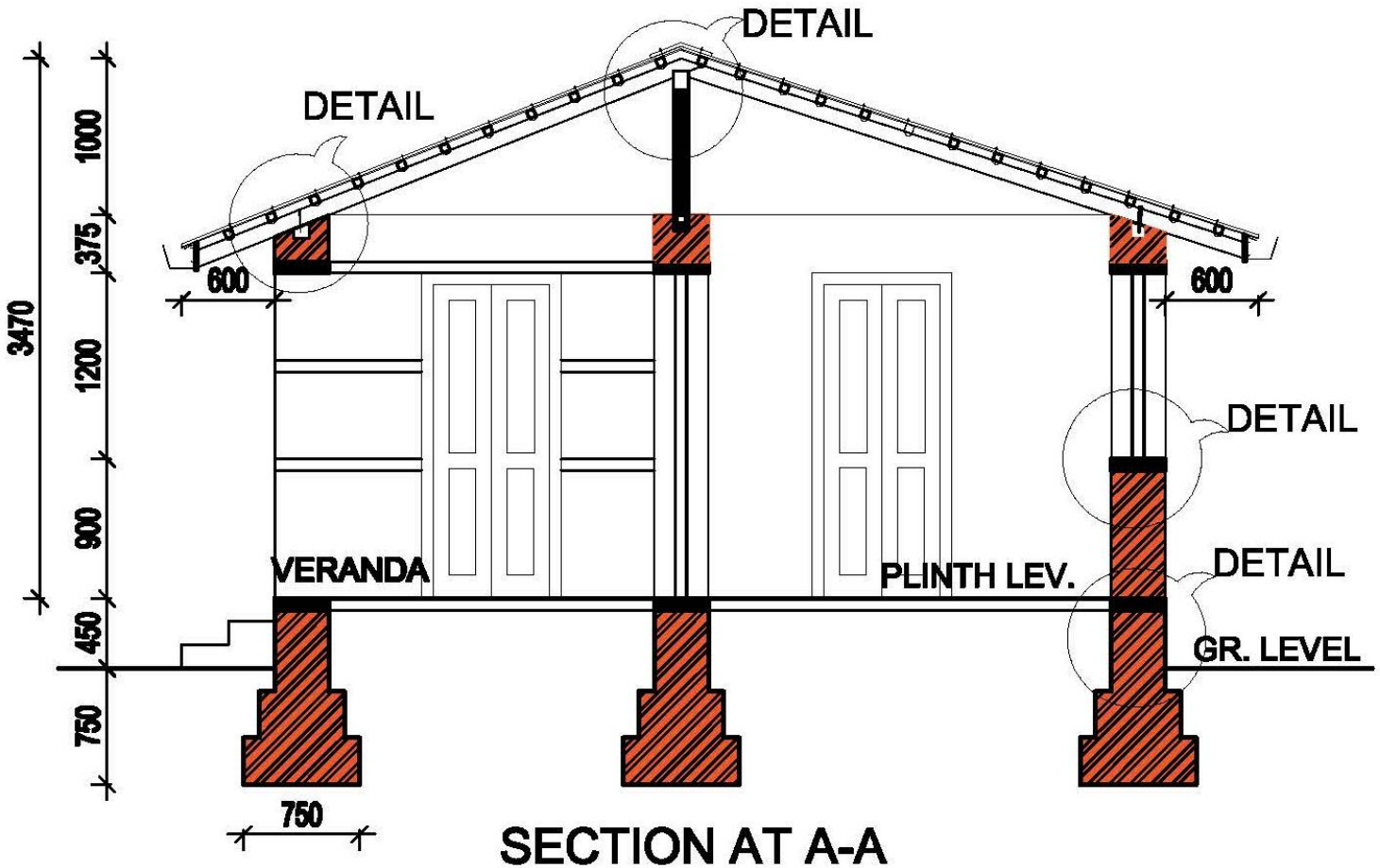
RIGHT SIDE ELEVATION

BACK ELEVATION



LEFT SIDE ELEVATION

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMM-1.1	SCALE: 1:100	DATE:	BMM-1.1
	DRAWING TITLE: ELAVATION	DESIGNED BY: DUDBC		3/4

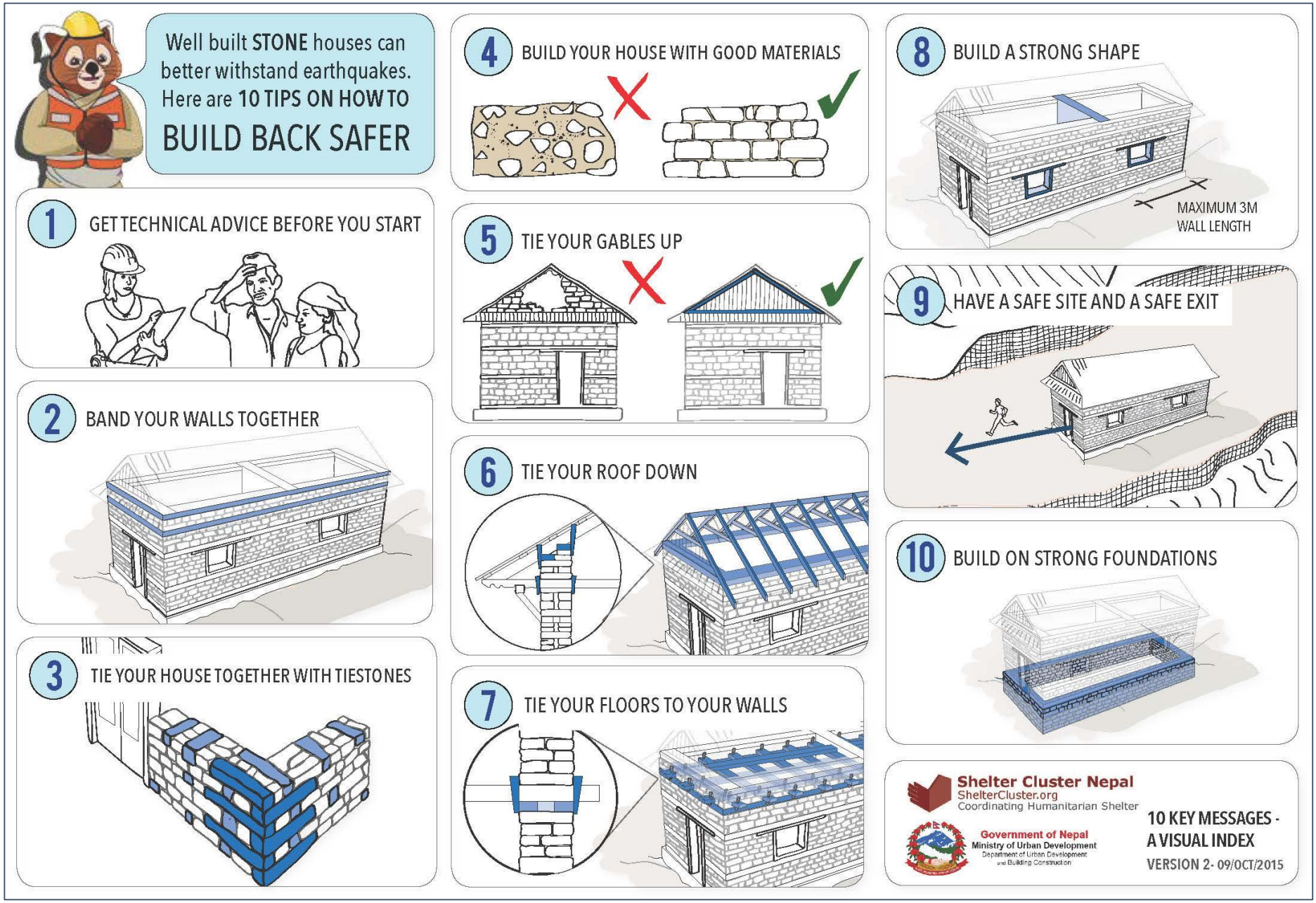


SECTION AT A-A

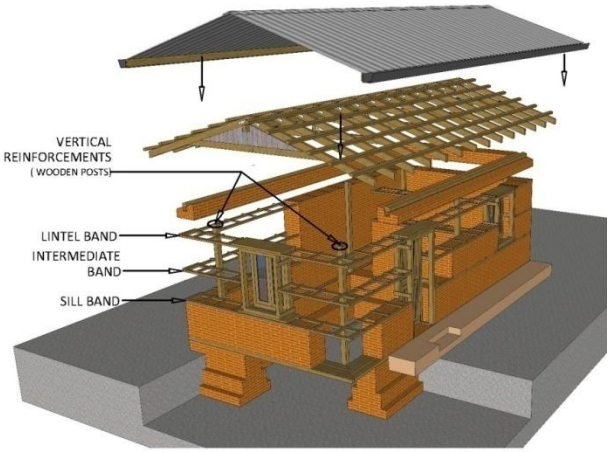
Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL BMM-1.1	SCALE: 1:50	DATE:	BMM-1.1
	DRAWING TITLE: SECTION	DESIGNED BY: DUDBC		4/4

BRICK MASONRY IN MUD MORTAR (BMM)

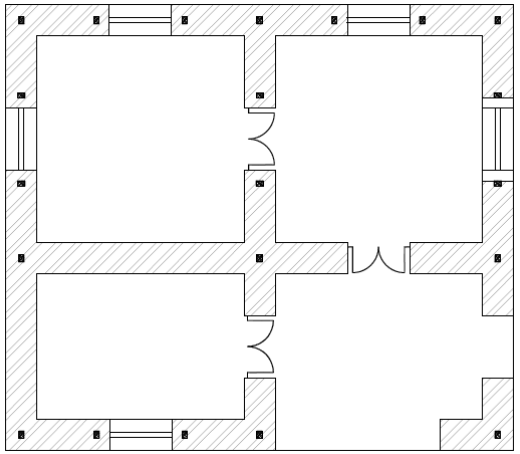
Technical Details



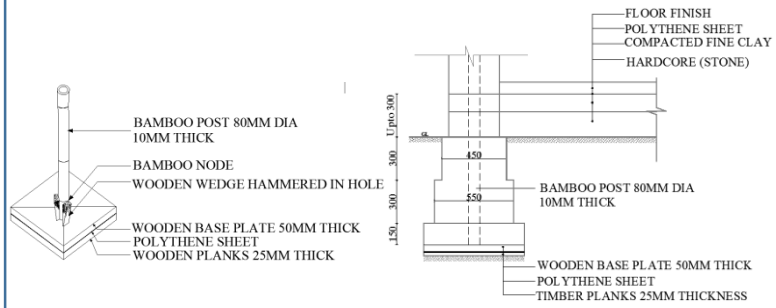
10 KEY MESSAGES



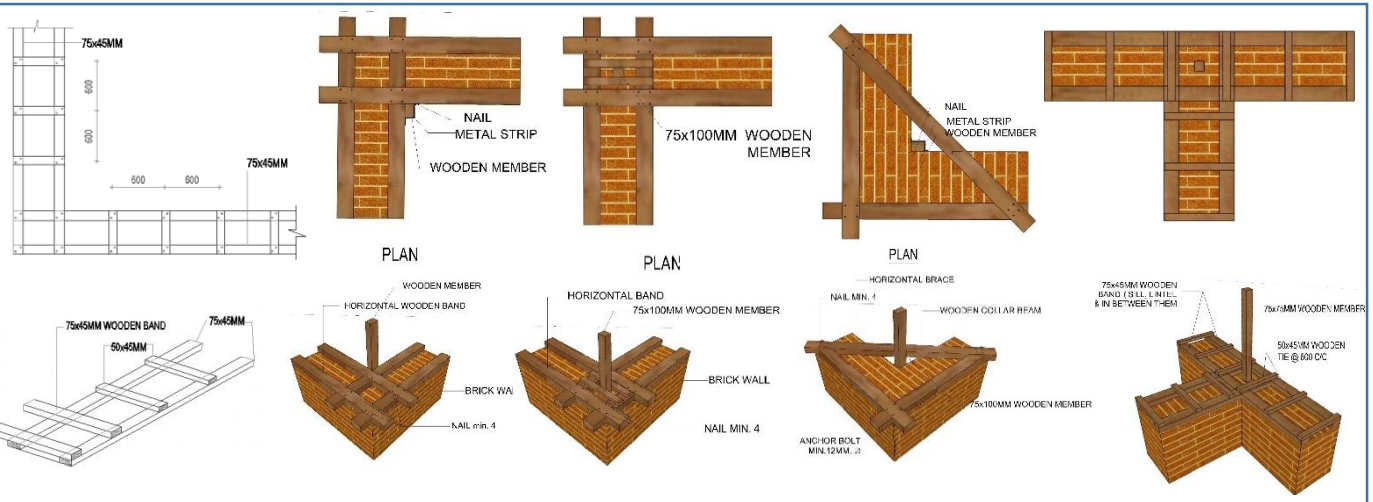
Earthquake Resistant Elements in Building



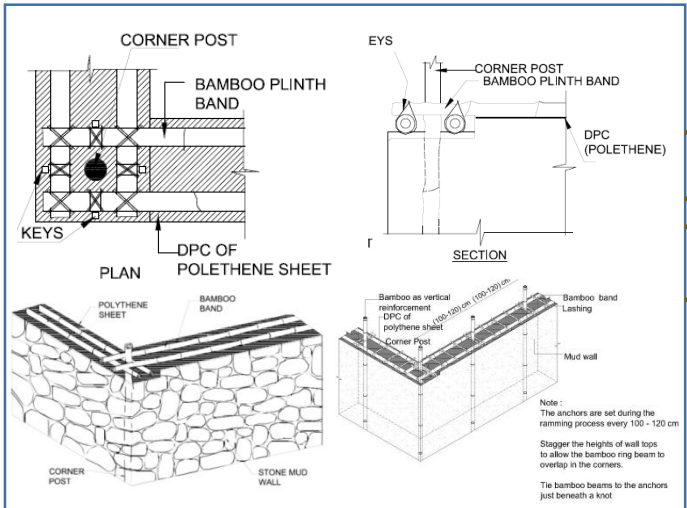
Building Plan



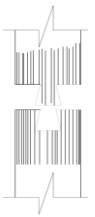
Foundation Detail of Strip Footing Masonry Foundation
And DPC(Where cement and Concrete not available)



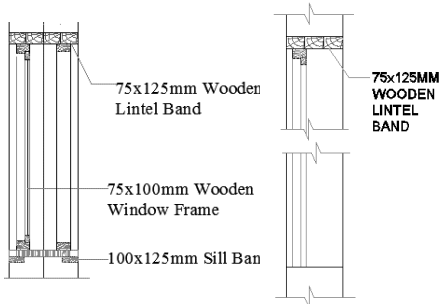
Wood for Horizontal and Vertical Band at Corner and T-Junction



Bamboo for Horizontal and Vertical Band

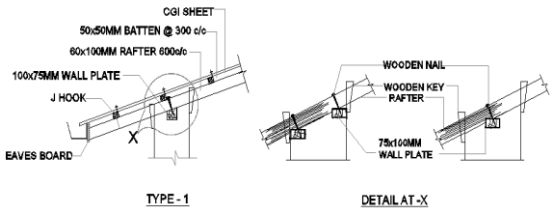


Dove Tail
Joint for
Wood
Connection

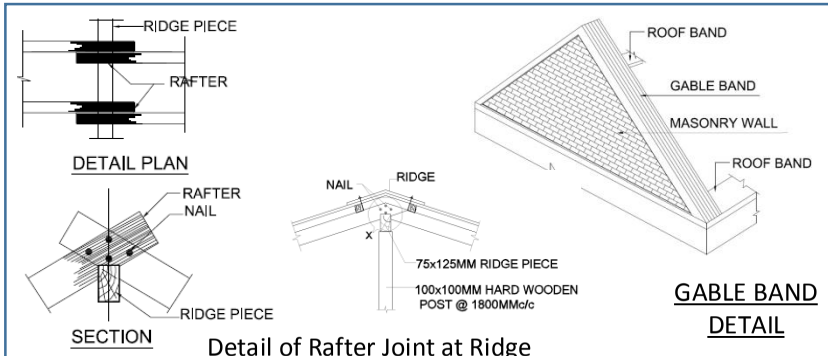


Window Section

Door Section



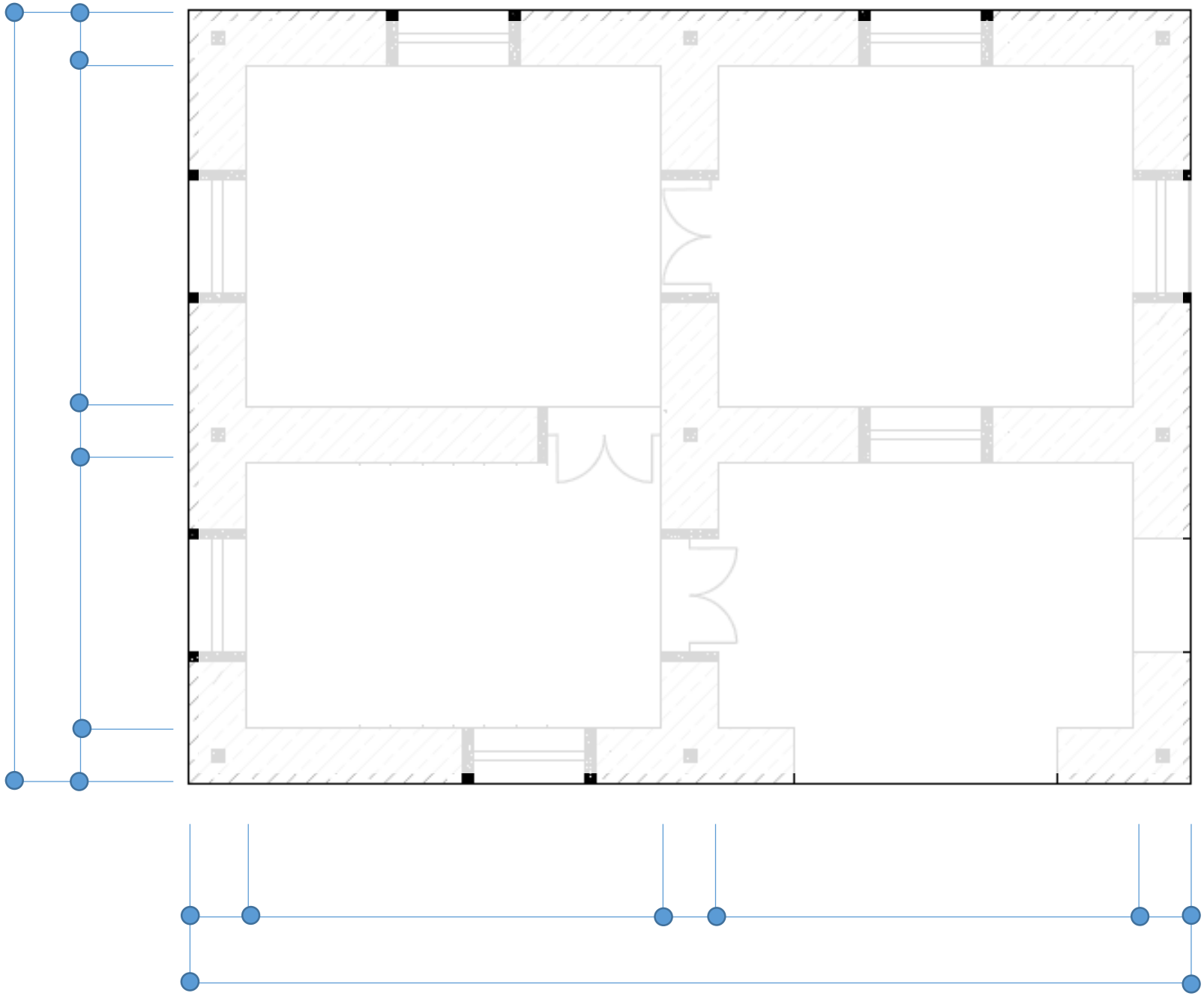
Detail of Rafter Joint with Wall Plate



Detail of Rafter Joint at Ridge

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.



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.
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 strctural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.
		Mortar	✔	Mud should be free from organic material and pebbles, etc.
		Brick		Brick should be class A1 or A2 with compressive strength not less than 3.5N/sqmm.
		Concrete	✔	The concrete mix for seismic bands should not be leaner than 1:2:4 (1 part cement, 2 parts sand and 4 parts aggregate)
		Reinforcement	✔	High Strength Deformed Bars – Fe415 or Fe500 respectively with fy = 415 N/sqmm or 550N/sqmm could be used for reinforcements.

Personnel involved in preparing this catalogue

DUDBC(Housing Division)

Er. Pratigya Manandhar
Er.Chandra kaji Gurung
Er. Jeeta Gurung
Er. Machaman Dangol
Er. Dhurba Man Manandhar
Er. Deepa Syangderpa
Ar. Meeta Prajapati
Er. Pratik Pradhan
Ar. Sunil Shakya
Ar. Bibek Kumar Shrestha
Sub Er. Sashi Yadav
Comp. Op. Ram Krishna Khatri

Support team

Er. Jitendra Bothara (WB consultant)
Dr. Hiroshi Imai (JICA consultant team)
Ar. Sabika Mastran(JICA consultant team)
Ar. Ambu Chaudhary(JICA consultant team)
Er. Siobhán Kennedy (Shelter Cluster Nepal)

DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

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