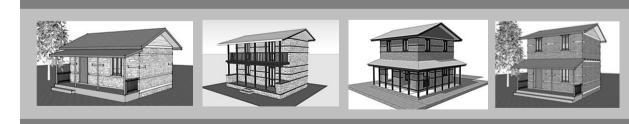
# DESIGN CATALOGUE FOR

## **RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES**

# Volume I



October, 2015 (Aswin, 2072)



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

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# 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 25<sup>th</sup> April , 2015 and 12<sup>th</sup> May 2015 earthquakes in Nepal were enormous, both in terms of loss of lives and properties. More than 8000 people lost their lives and 22,000 number of people were injured. More than 6,400 Government buildings were damaged. More than 960 health buildings and 8500 schools as well as 600,000 private homes were fully damaged. In addition, more than 285,000 private homes were partially damaged.

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

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

## Preface



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

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

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

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

> **Rabi Shah** Deputy Director General, DUDBC

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# Background



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

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

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

## Introduction

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

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

The designs provided in this catalogue have all been prepared in compliance with the revised National Building Code of Nepal and are approved by the Department of Urban Development and Building Construction (DUDBC). For each design included in the catalogue the following information is provided:

- •3D view of the design
- •Floor plan
- Elevations
- Section
- •Technical Details

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

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

# List of Model Houses

# housing model Volume $\,I$

Structural Type	No. of Floor	Model No.	Designed by	Page
	1	SMC-1.1	JICA	9
Stone masonry in cement mortar, P5-	1	SMC-1.2	JICA	15
	2	SMC-2.1	JICA	21
SMC	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
	1	BMC-1.1	JICA	74
Brick masonry in cement mortar P71-	1	BMC-1.2	JICA	80
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DIVIC	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
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BMM		Flexible design		161



Site Plan

# STONE MASONRY IN CEMENT MORTAR (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)

No.	Minimum Requii Category	rements (MRs) fi	or S	Requirements (MRs) for Stone Masonry in Cement Mortar (NBC202) Page1
		A building shall n	ot b	A building shall not be constructed if site is:
			2	Geological fault or Raptured Area
~	Sita Salaction		7	Areas Susceptible to Landslide
-	אונפ אבוברנותו		2	Steep Slope > 20%
			2	Filled Area
			7	River Bank and Water-logged Area
		No. of story	7	Two storey+ attic, load bearing masonry buildings constructed in cement mortar
		Span of wall	2	The span of wall shall not more than 4.5 meters
2	Shape of House	House Size of room	2	The area of individual floor panel not more than 13.5 square metres
		Height of wall	2	The height of wall should not be more than 3.0 meters
		Proportion	2	The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.
		General	7	The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.
ŝ	Foundation	Depth	7	The depth of footing should not be less than 800mm for one story, 900mm for two storey.
		Width	7	The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. As depend on soil condition. Shown in detail drawings.
		General	7	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.
4	Plinth	Width	7	Minimum thickness of plinth band width should be equal to wall thickness. 350mm for Stone masorny.
		Reinforcement	7	Main reinforcement should be 4-12 dia. bars. Use 6mm diameter rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.
		General	7	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.
Ы	Walls	Joints	7	Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).
		Through Stone	7	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 for Stone Masonry in Cement Mortar (NBC202)

Altinuum Requirements (Mis) for Stone Masonry in Cernent Mortar (MBC.00)         Page2           Altinuum Requirements (Mis) for Stone Masonry in Cernent Mortar (MBC.00)         Page2           Icentin              found in a since the sectied away from inside corners by a clear distance             icentine               pound in a since the sectied away from inside corners by a clear distance            Openings              the toricontal distance between two openings is to be not less than             inset invertine               cortage and             inside storey construction.               provide storey construction.            Netriforcement              Control in evel               Control in the vertical steel bars in the wall at all corners, junctions of walls and             controp and distance between two openings is to be not less than            Netriforcement              Control in the vertical steel bars in the wall at all corners, junctions of walls and             controp walls the not work with             minimum requirements for masonry houses.            Reinforcement              The vertical steel bars in the wall at all commers, junctions of walls            Reinforcement              A continuous line bard should be provided through all wells            Interviewed with the minimum regular memory is given in detail dawings.            Interviewed with the minimum regular memory is given in detail dawings.
Minimum 7 Reinforce 9 Roo 10 Materi

# STONE MASONRY IN CEMENT MORTAR, ONE-STOREY



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**

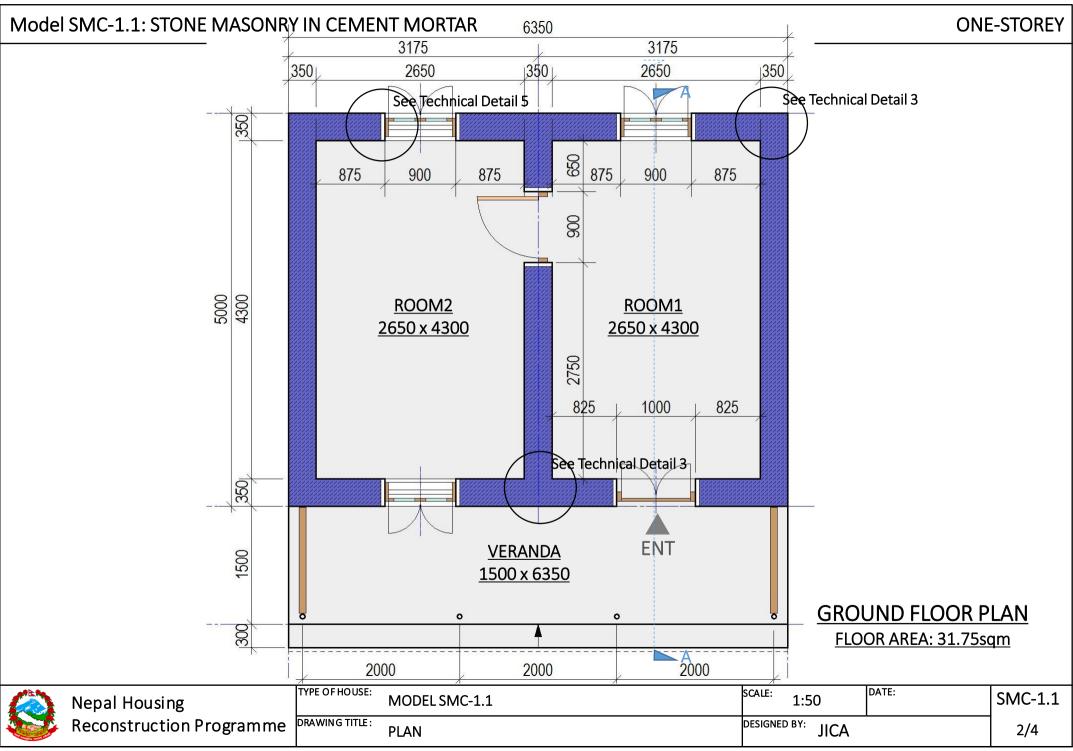
### ONE-STOREY



	MAN	POWER				MATERIALS			
LEVEL	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	TYPE OF HOUSE:	MODEL SMC-1.1	SCALE:	None	DATE:	SMC-1.1
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNE	<sup>DBY:</sup> JICA		1/4



### **ONE-STOREY**

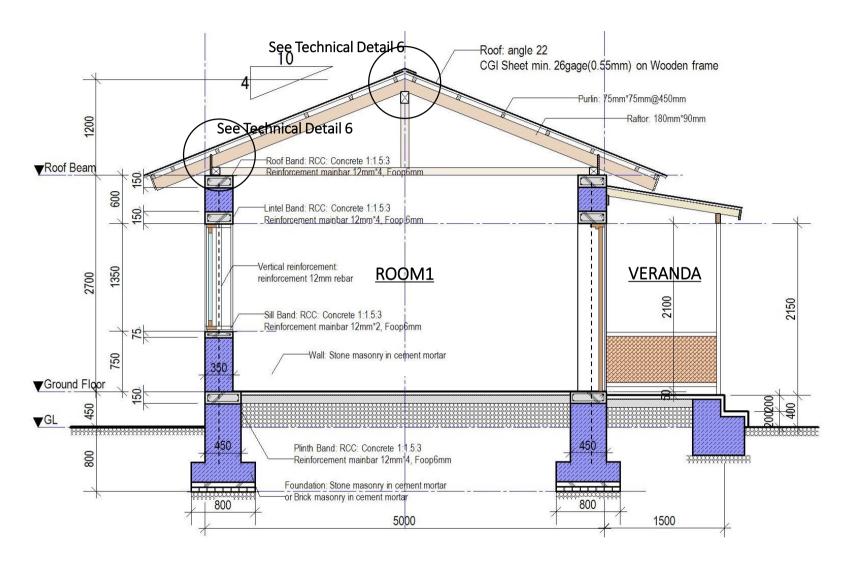






 Nepal Housing
 TYPE OF HOUSE:
 MODEL SMC-1.1
 SCALE:
 None
 DATE:
 SMC-1.1

 Reconstruction Programme
 DRAWING TITLE:
 ELEVATION
 DESIGNED BY:
 JICA
 3/4



**SECTION A-A** 



Nepal Housing	TYPE OF HOUSE:	MODEL SMC-1.1	SCALE:	1:50	DATE:	SMC-1.1
Reconstruction Programme	DRAWING TITLE :	SECTION	DESIGNEI	<sup>d by:</sup> 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**

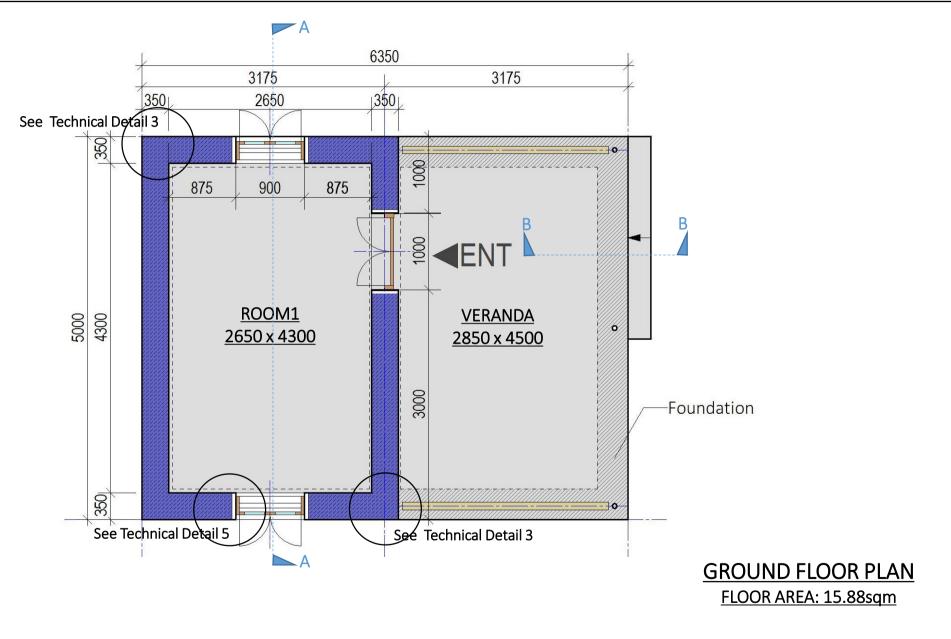
### ONE-STOREY



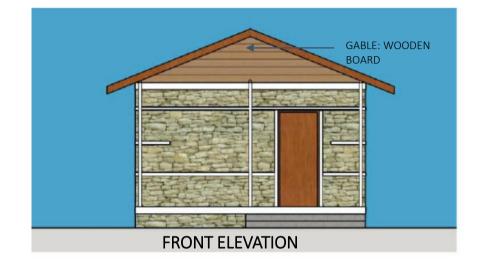
	<u>MAN F</u>	<u>OWER</u>				MATERIALS		-	
LEVEL	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar
	Md	Md	cu.m.	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Kg
Up to Plinth Level	40	144	15	47	9	3	0	0	87
SUPERSTRUCTURE	49	97	10	45	6	2	0.46	0	165
ROOFING	8	11	0	0	0	0	1.48	3.69	0
TOTAL	97	252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



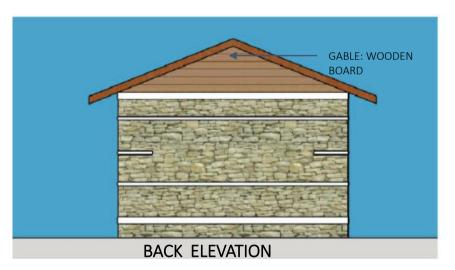
Nepal Housing	TYPE OF HOUSE:	MODEL SMC-1.2	SCALE:	None	DATE:	SMC-1.2
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	d by: JICA		1/4







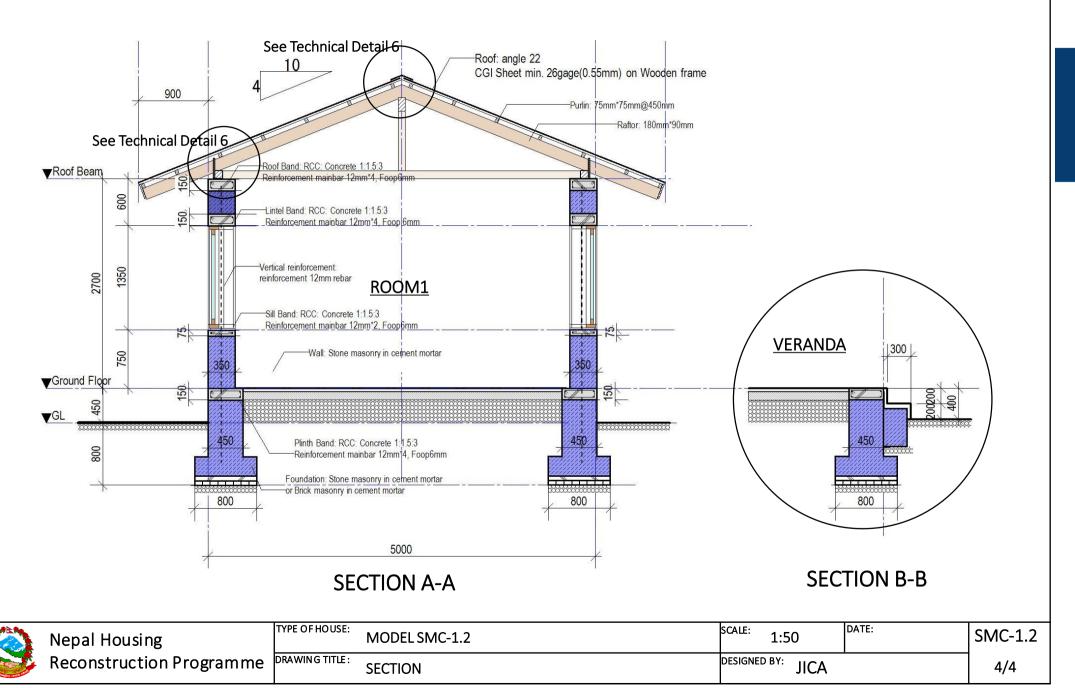








Nepal Housing	TYPE OF HOUSE:	MODEL SMC-1.2	SCALE:	None	DATE:	SMC-1.2
Reconstruction Programme	DRAWING TITLE :	ELEVATION	DESIGNED	<sup>D BY:</sup> JICA		3/4



# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



21

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**

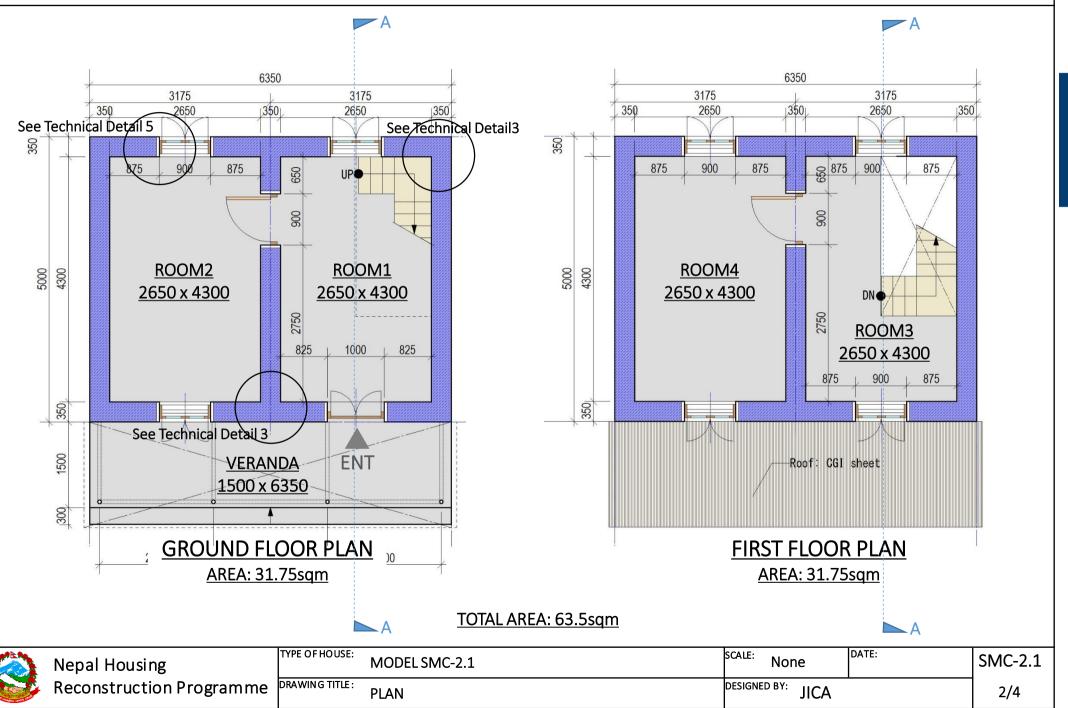


	MAN P	OWER				MATERIALS			
LEVEL	Skilled	Unskilled	Stone	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar
	Md	Md	cu.m.	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Kg
Up to Plinth Level	86	317	17	76	12	6	0	0	146
SUPERSTRUCTURE	175	290	31	111	17	4	2.95	1.02	631
ROOFING	17	20	0	0	0	0	1.48	3.69	0
TOTAL	279	626	48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

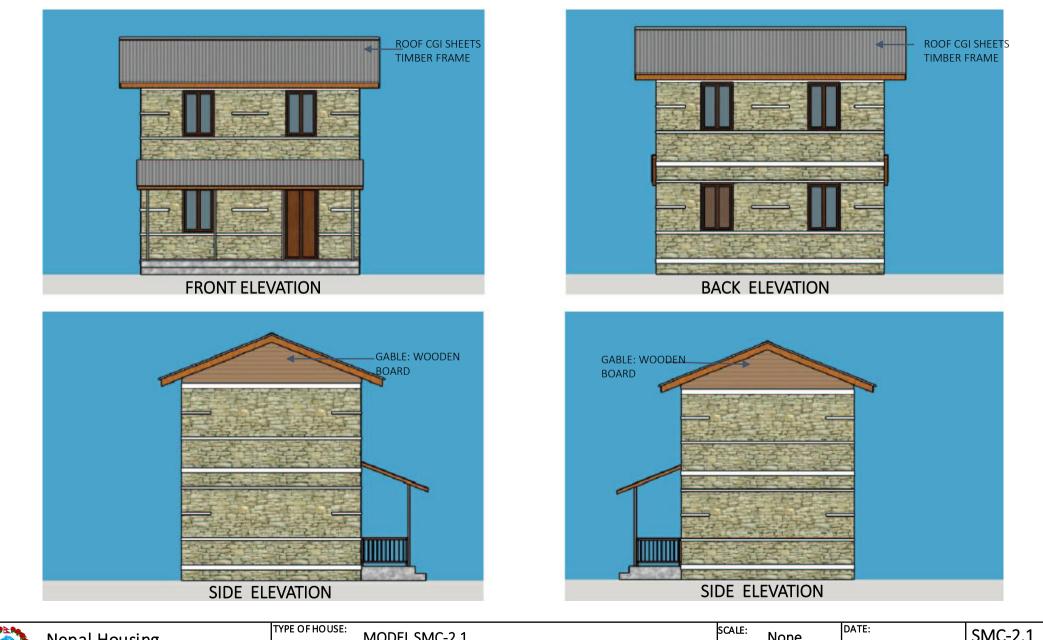


Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.1	SCALE:	None	DATE:	SMC-2.1
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	d by: JICA		1/4

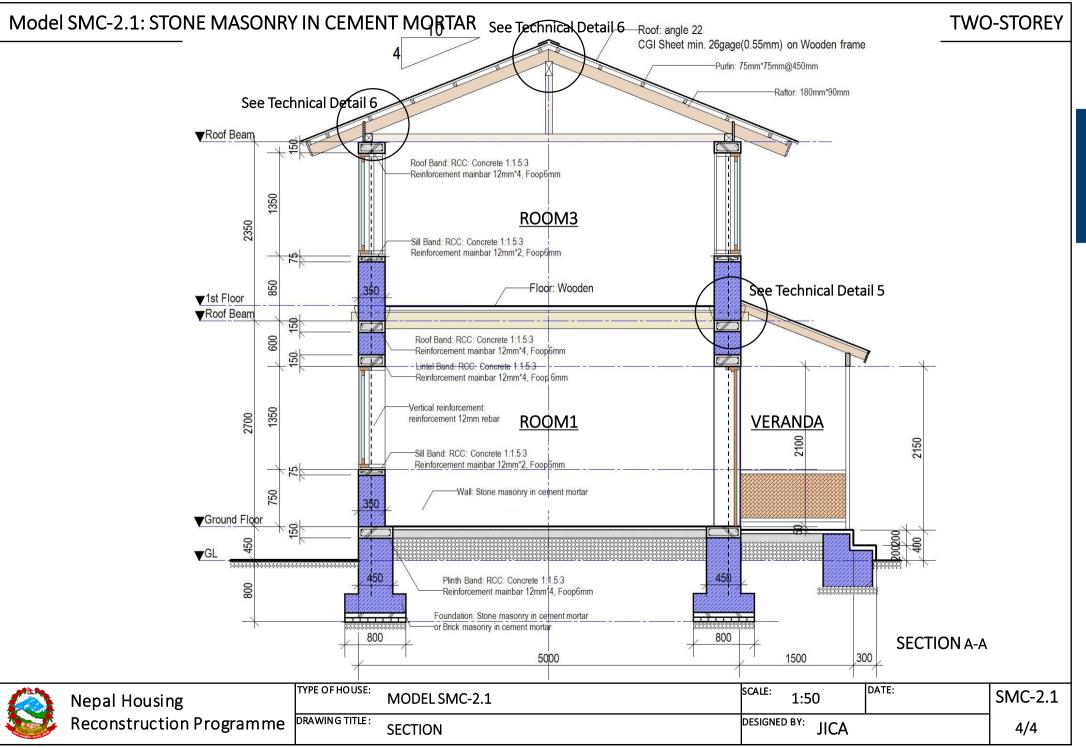
#### TWO-STOREY



#### TWO-STOREY



Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.1	SCALE:	None	DATE:	SMC-2.1
Reconstruction Programme	DRAWING TITLE :	ELEVATION	DESIGNEE	<sup>DBY:</sup> JICA		3/4



# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

#### TWO-STOREY

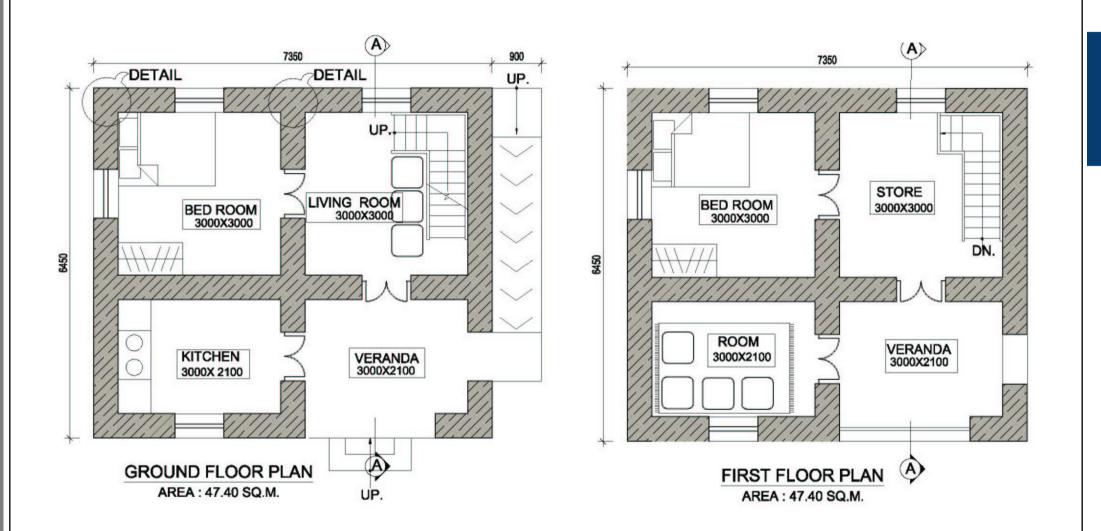


#### CONSTRUCTION MATERIAL AND MANPOWER

	MAN F	<u>POWER</u>				MATERIALS	<u>.</u>			
<u>LEVEL</u>	<u>Skilled</u>	<u>Unskilled</u>	<u>Stone</u>	<u>CEMENT</u>	<u>SAND</u>	<u>AGGREGATE</u>	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



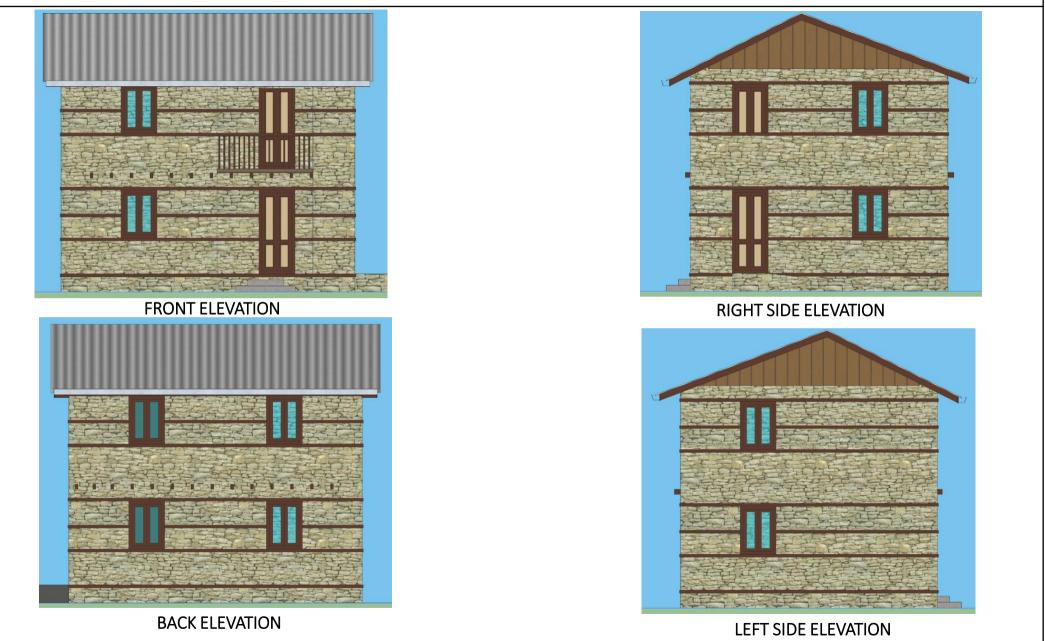
Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.2	SCALE:	NONE	DATE:	SMC-2.2
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	DUDB	С	1/4



#### TOTAL AREA: 94.8sqm

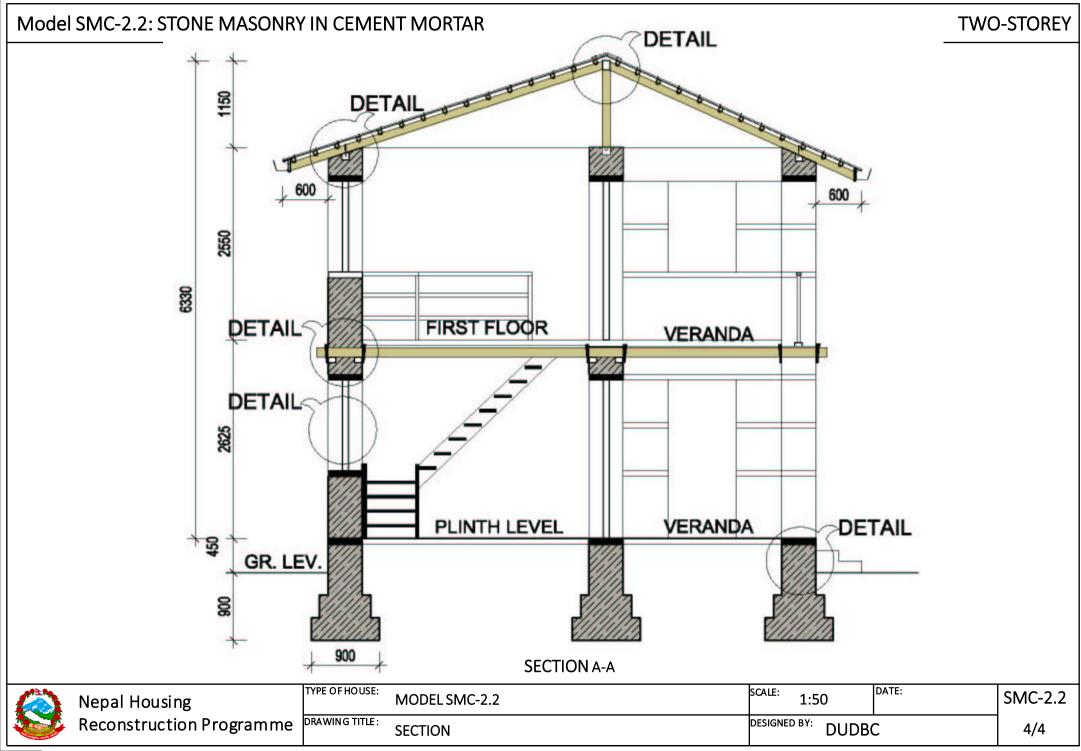
	Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.2	SCALE:	None	DATE:	SMC-2.2
	Reconstruction Programme	DRAWING TITLE :	PLAN	DUDBC		2/4	

# TWO-STOREY





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



# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

# TWO-STOREY

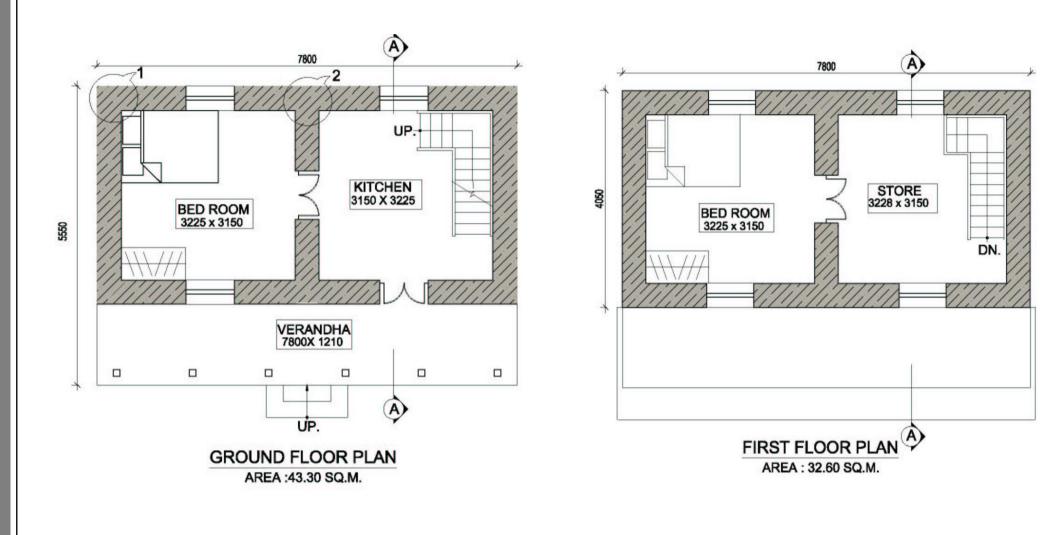


#### CONSTRUCTION MATERIAL AND MANPOWER

	MAN POWER		MATERIALS									
<u>LEVEL</u>	<u>Skilled</u>	<u>Unskilled</u>	<u>STONE</u>	<u>CEMENT</u>	<u>SAND</u>	<u>AGGREGATE</u>	<u>WOOD</u>	ROD	<u>CGI SHEET</u>	GI SHEET		
	Md	Md	Cu.m	Bags	Cu.m	Cu.m	Cu.m	KG	Bundel	Rm.		
<u>Up to Plinth Level</u>	61	220	33	95	17	9	0	305	0	0		
<u>Ground &amp; First floor</u>	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	TYPE OF HOUSE:	MODEL SMC-2.3	SCALE:	NONE	DATE:	SMC-2.3
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEE	DUDB	C	1/4

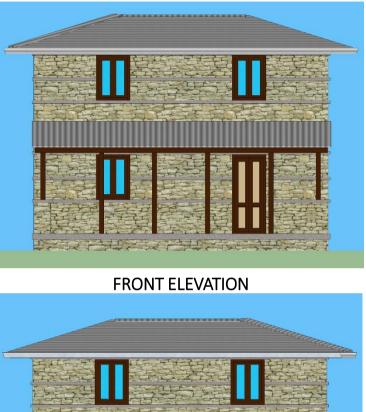


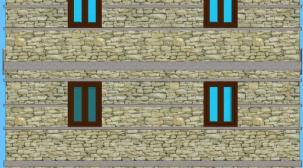
### TOTAL AREA: 75.9sqm

Ν
R

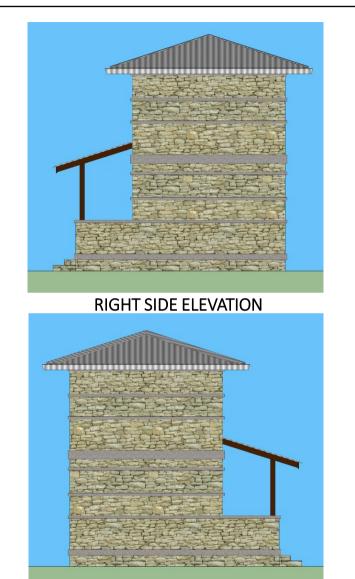
Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.3	SCALE:	None	DATE:	SMC-2.3
Reconstruction Programme	DRAWING TITLE :	PLAN	DESIGNE	DUDB	C	2/4

# TWO-STOREY





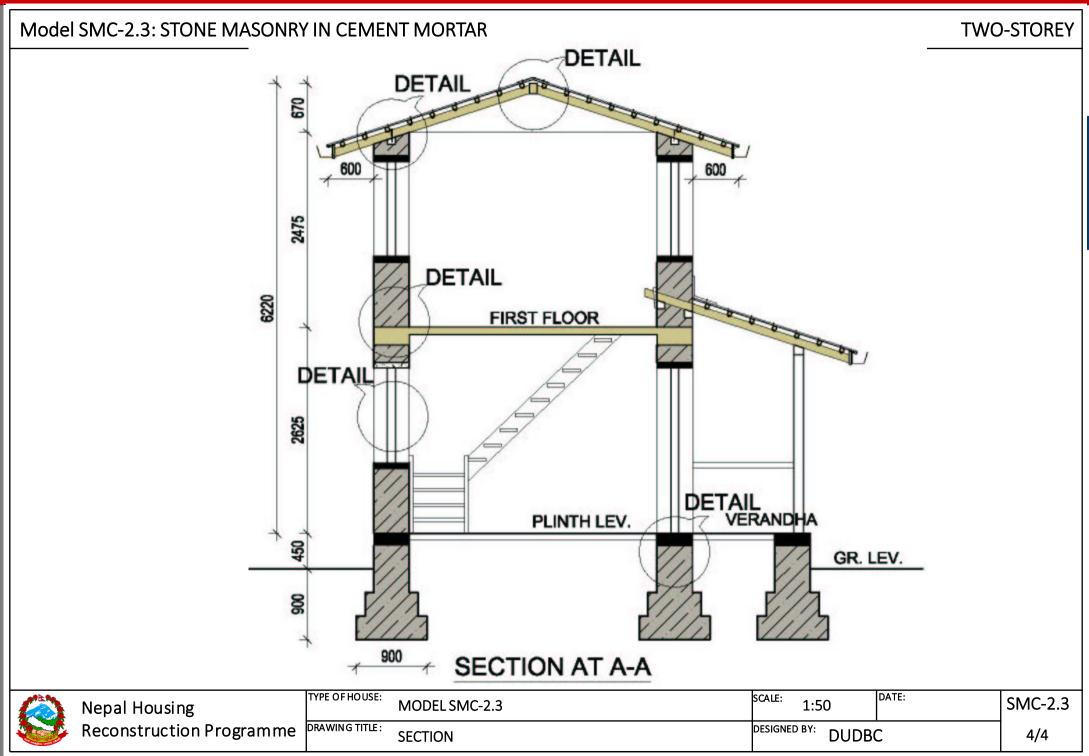
# BACK ELEVATION



### LEFT SIDE ELEVATION



Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.3	SCALE:	None	DATE:	SMC-2.3
Reconstruction Programme	DRAWING TITLE :	ELEVATION	DESIGNED	<sup>BY:</sup> DUDBO	0	3/4



# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



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

# **SMC-2.4**

# TWO-STOREY



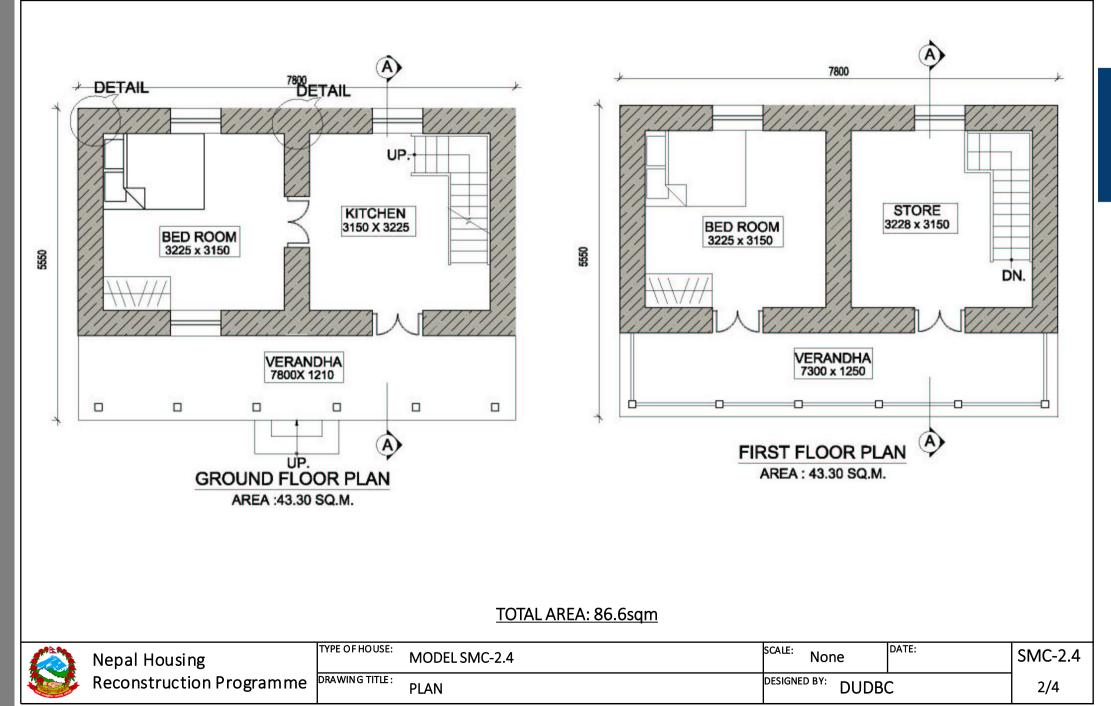
#### CONSTRUCTION MATERIAL AND MANPOWER

	MAN POWER			MATERIALS									
<u>LEVEL</u>	Skilled	Unskille d	Stone	CEMEN T	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			

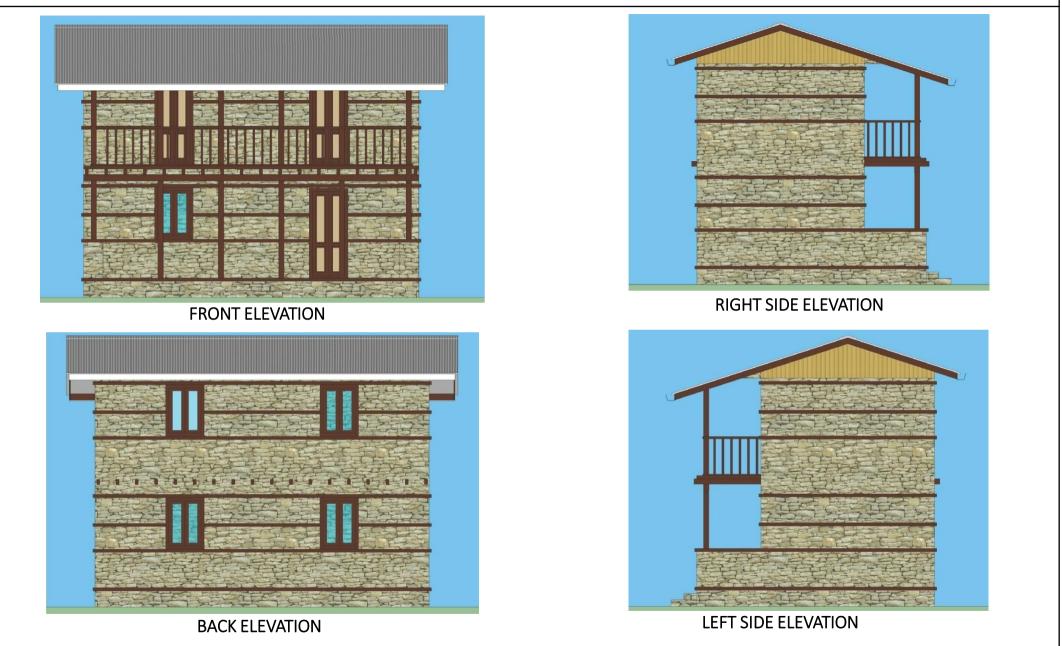


Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.4	SCALE:	NONE	DATE:	SMC-2.4
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	DUDB	С	1/4

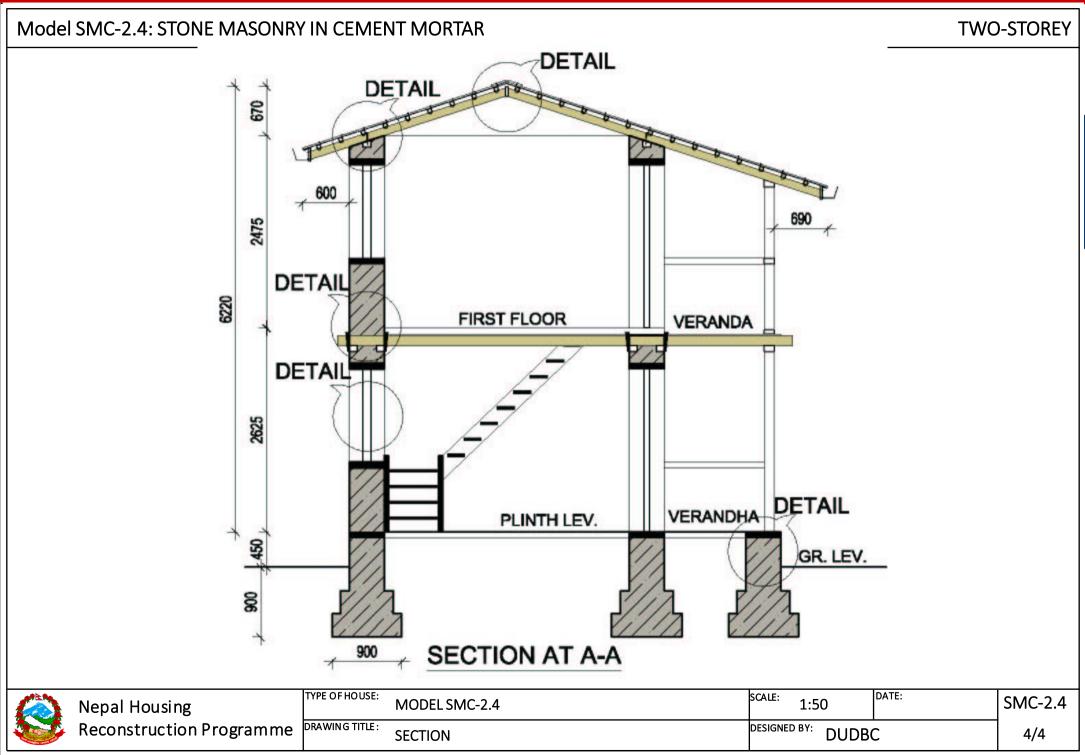
# **TWO-STOREY**



# TWO-STOREY



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



# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

# TWO-STOREY+ATTIC



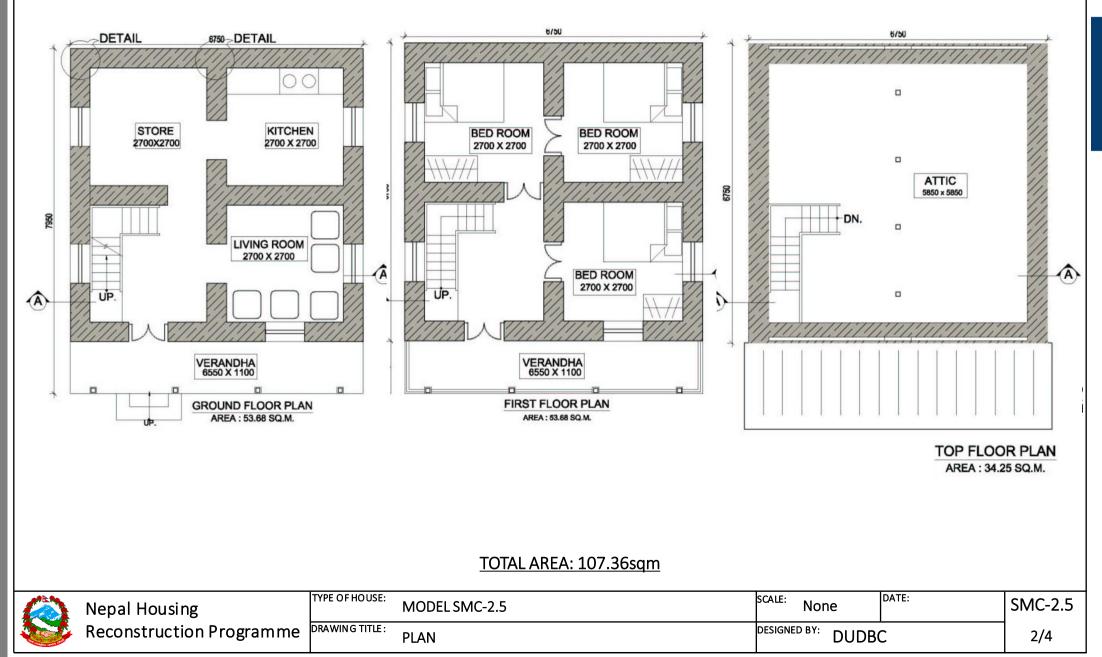
#### CONSTRUCTION MATERIALS AND MANPOWER

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

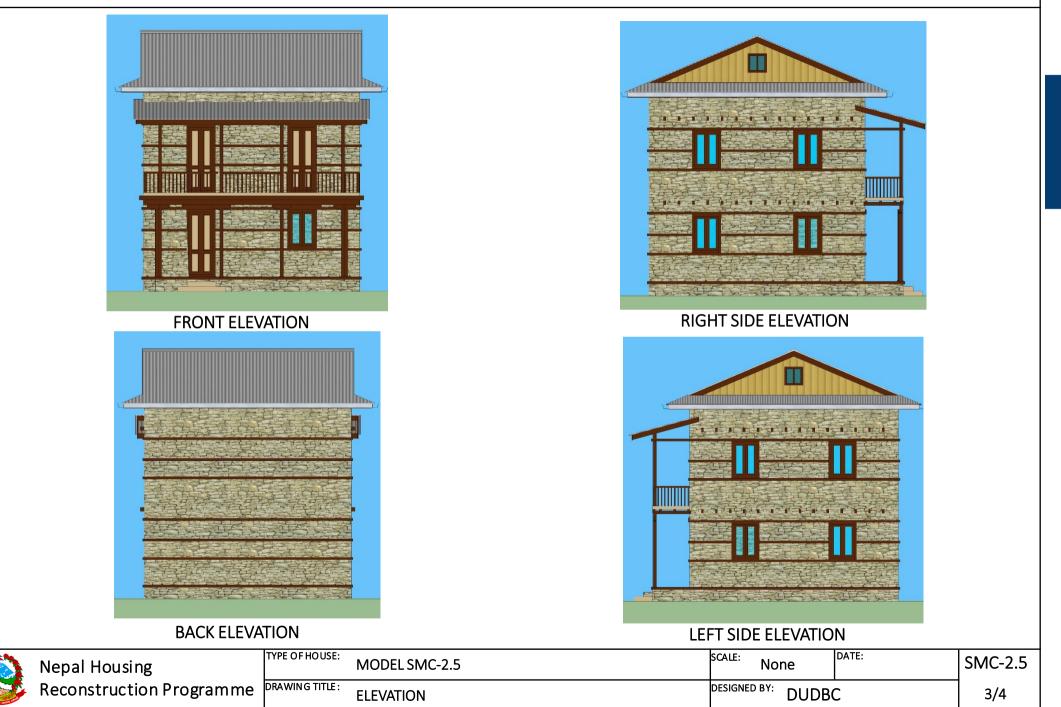


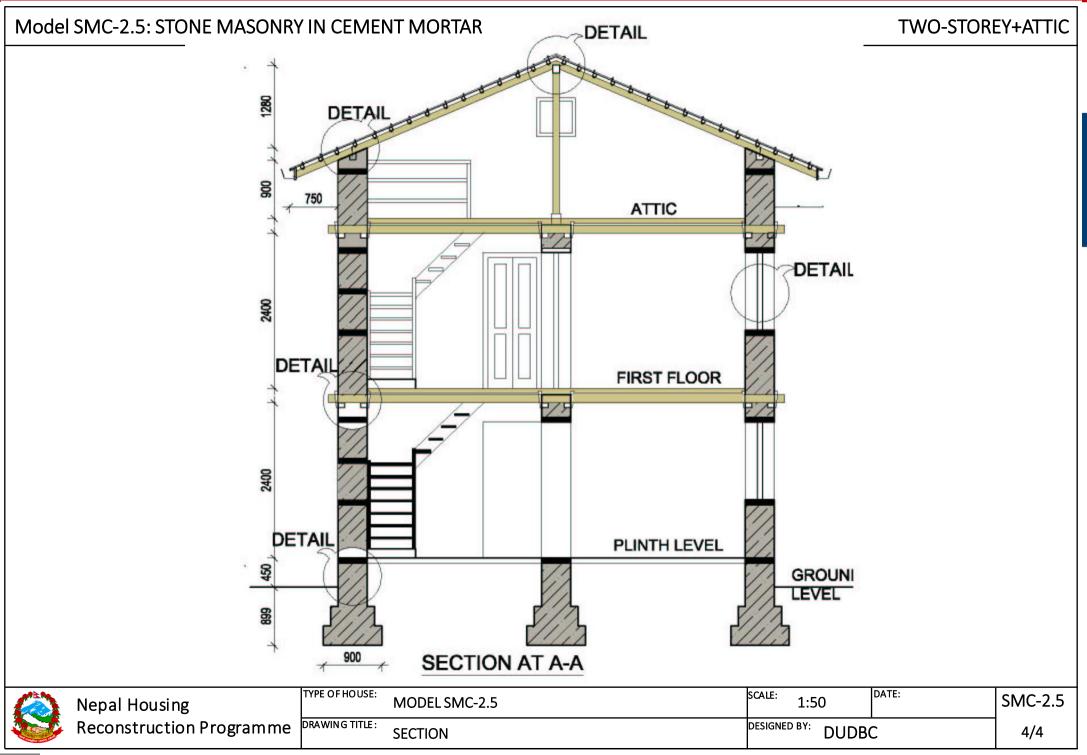
Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.5	SCALE:	NONE	DATE:	SMC-2.5
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNED	DUDB	C	1/4

### TWO-STOREY+ATTIC



# TWO-STOREY+ATTIC





# STONE MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

# TWO-STOREY+TERRACE



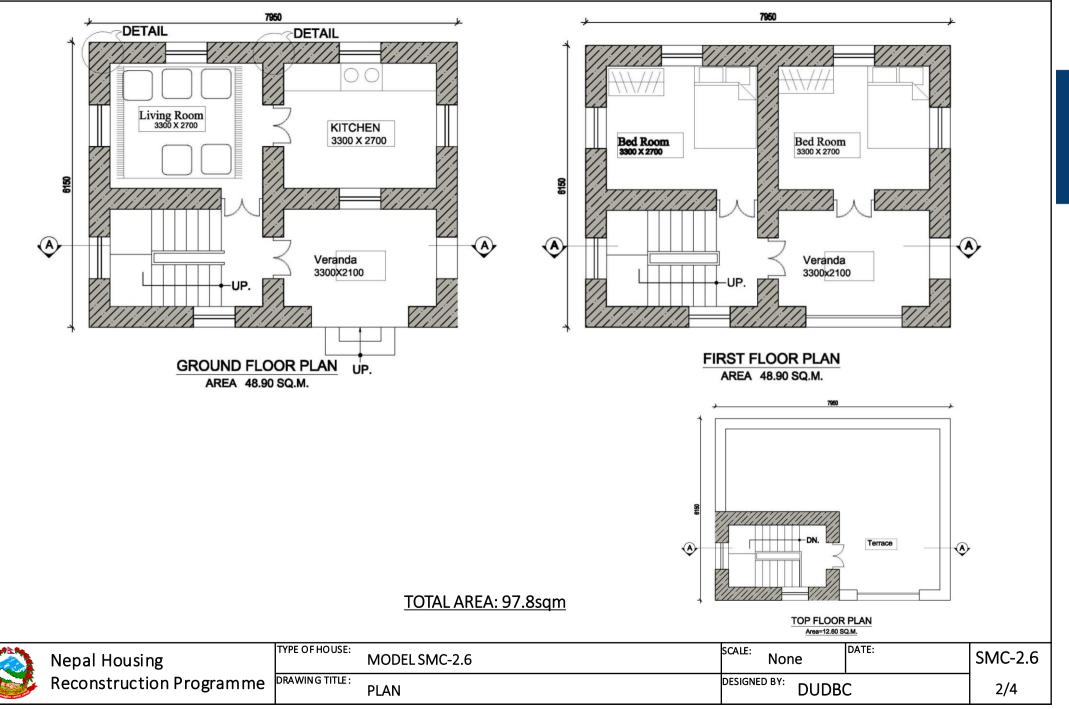
#### CONSTRUCTION MATERIALS AND MANPOWER

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



Nepal Housing	TYPE OF HOUSE:	MODEL SMC-2.6	SCALE:	None	DATE:	SMC-2.6
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNE	DUDB	C	1/4

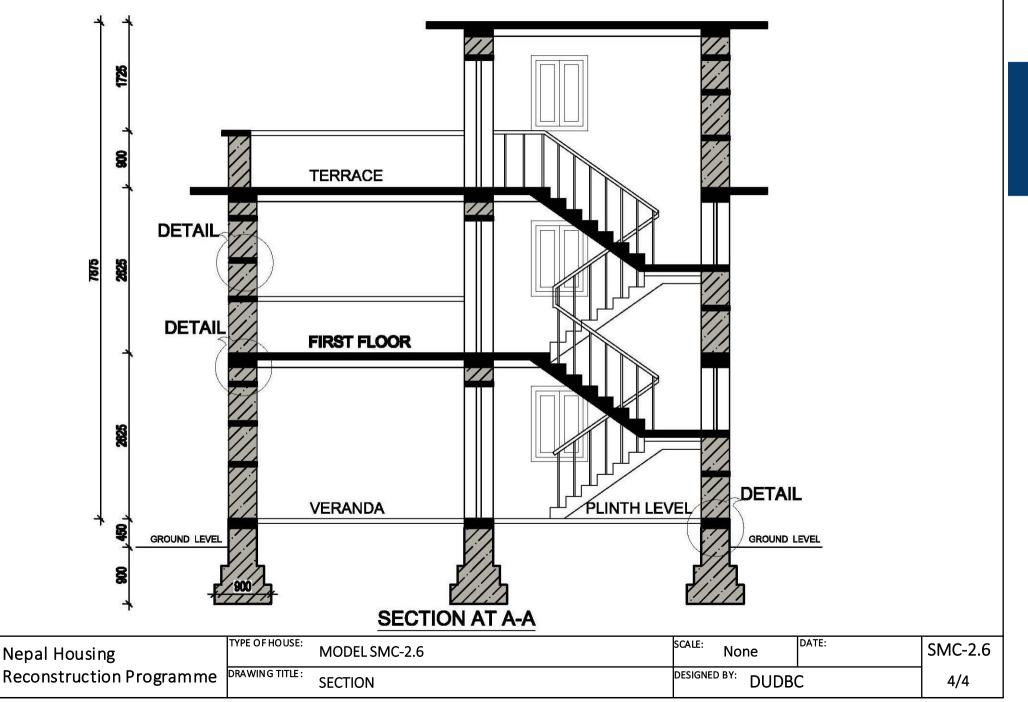
# TWO-STOREY+TERRACE



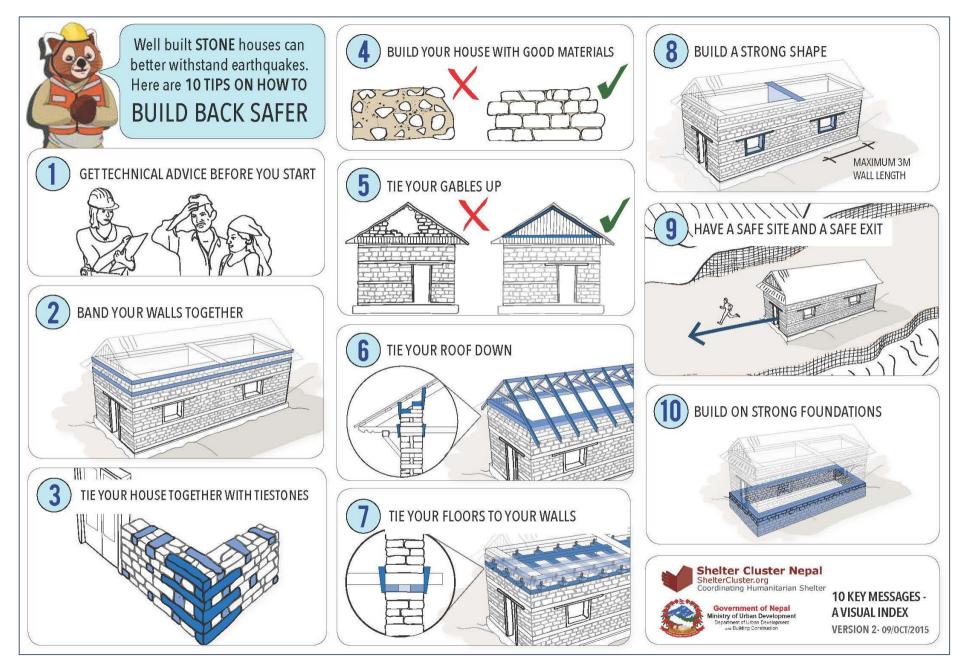
# TWO-STOREY+TERRACE



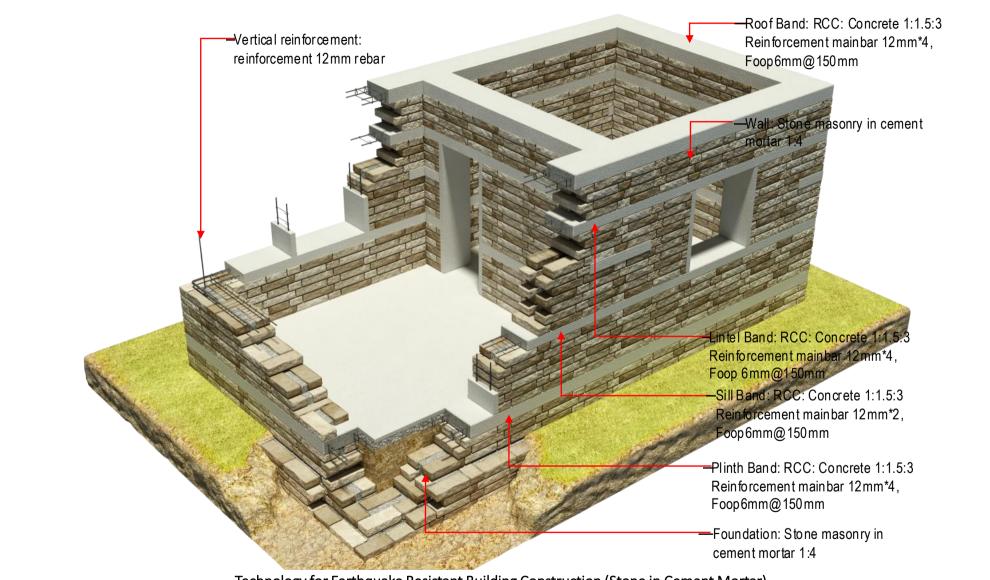
# TWO-STOREY+TERRACE



# **Technical Details**

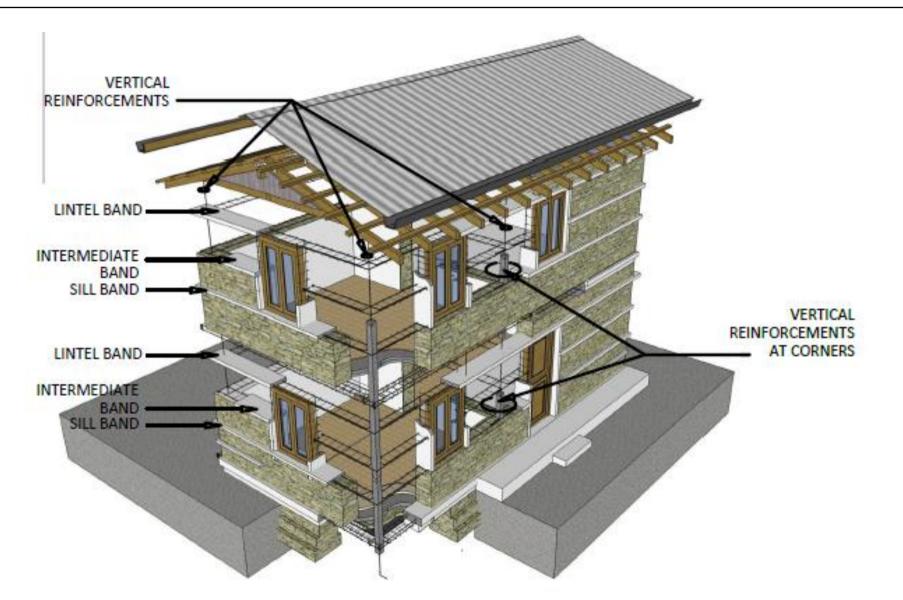


# **10 KEY MESSAGES**



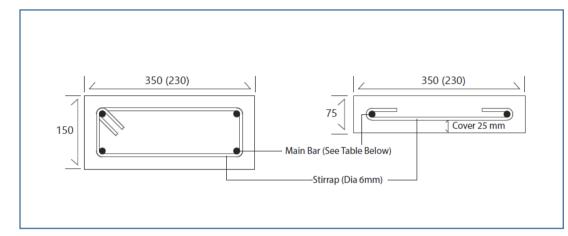
### Technology for Earthquake Resistant Building Construction (Stone in Cement Mortar)

Nepal Housing	TYPE OF HOUSE:	MODELSMC	<sup>scale:</sup> Non	ne	DATE:	SMC	
Reconstruction Programme	DRAWING TITLE :	TECHNICAL DETAIL 1 (SEISMIC ELEMENTS)	DESIGNED BY: JI	ICA		SIVIC	



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

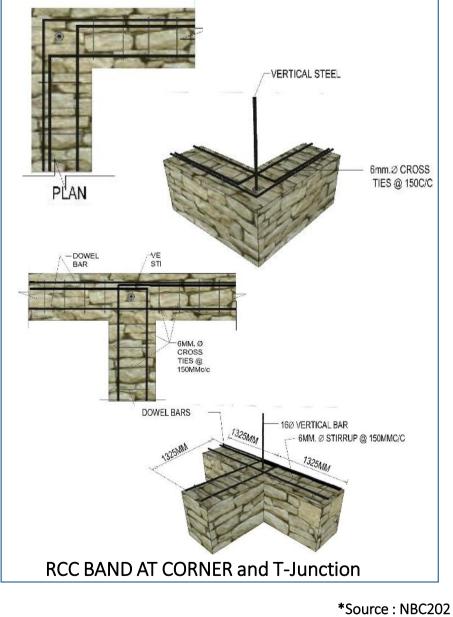
Nepal Housing	TYPE OF HOUSE:	MODEL SMC	SCALE:	None	DATE:	SMC	
Reconstruction Programme	DRAWING TITLE :	TECHNICAL DETAIL 2 (SEISMIC ELEMENTS)	DESIGNED	<sup>OBY:</sup> DUDBC			

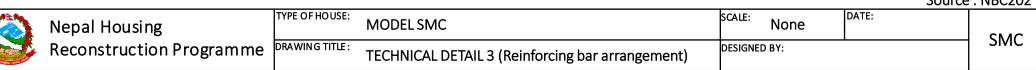


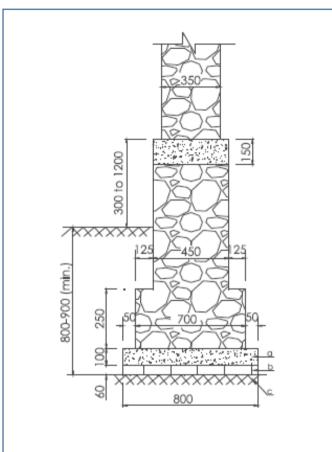
Cross section of RC bands for two bars and four bars

# 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







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

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

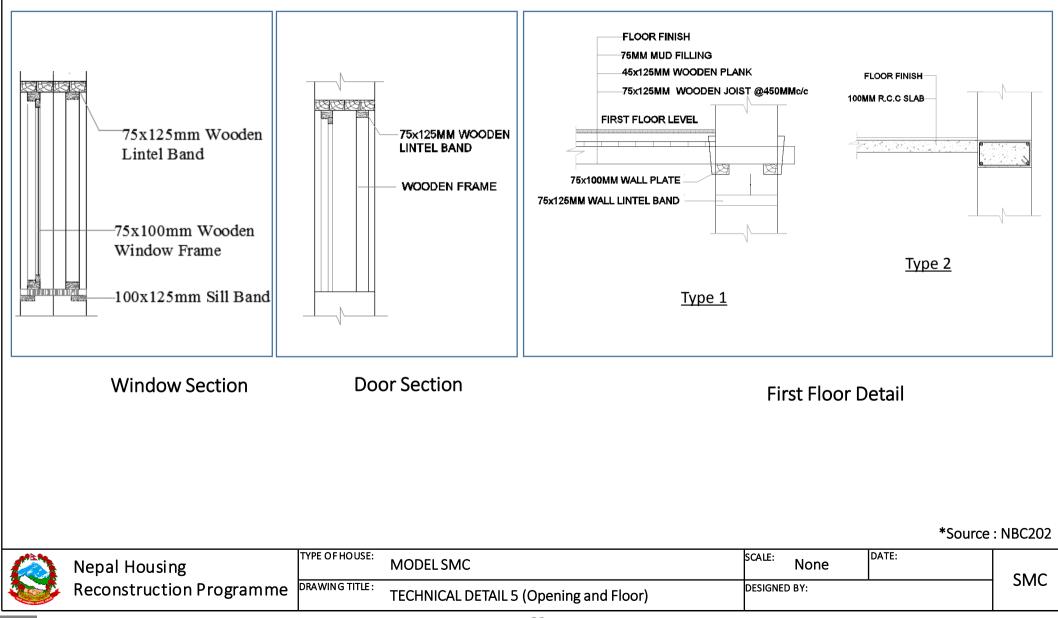
#### Base width of footing

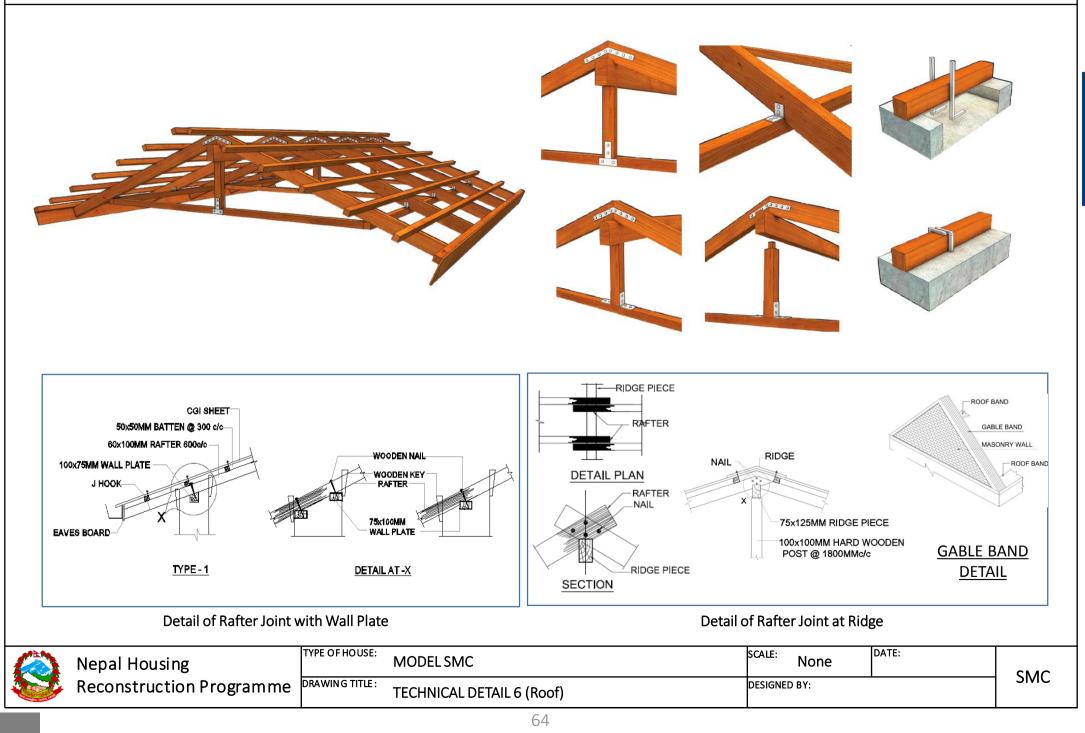
### Classification of Foundation Soil and Safe Bearing Capacity

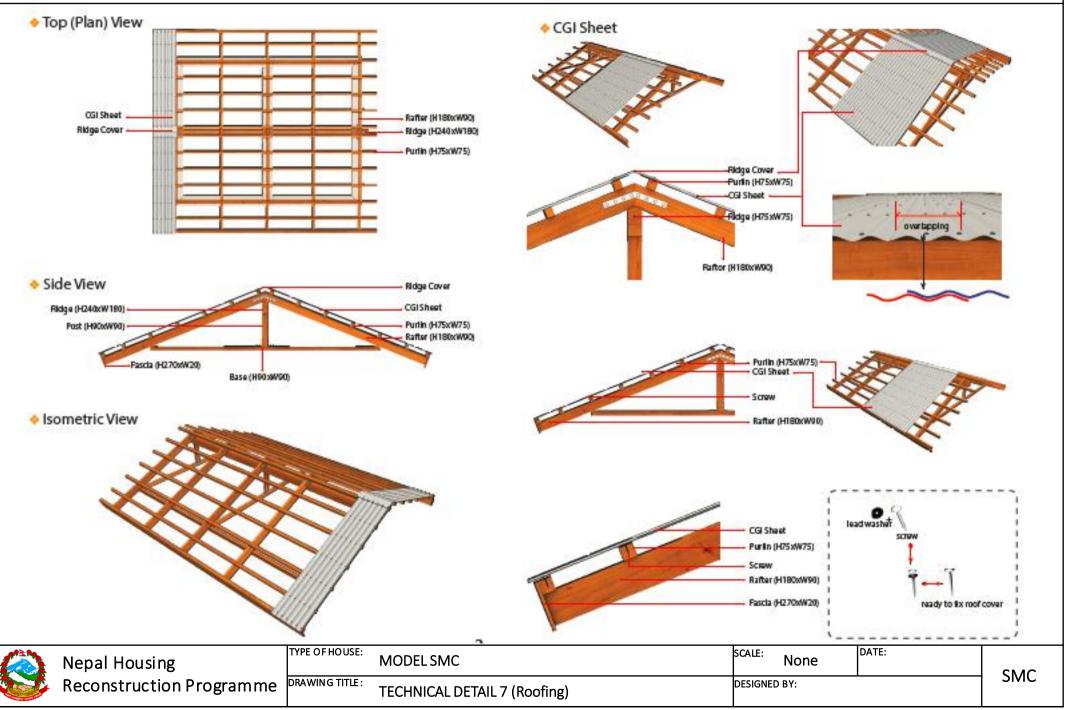
Foundation Soil Classification	Types of Foundation Materials	Presumed Safe Bearing Capacity, KN/m <sup>2</sup>
Hard	Rocks in different state of wearthing, boulder bed, gravel, sandy gravel and sand-gravel mixture, dense or loose coarse to medium sand offering high resitance to penetration when excavated 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

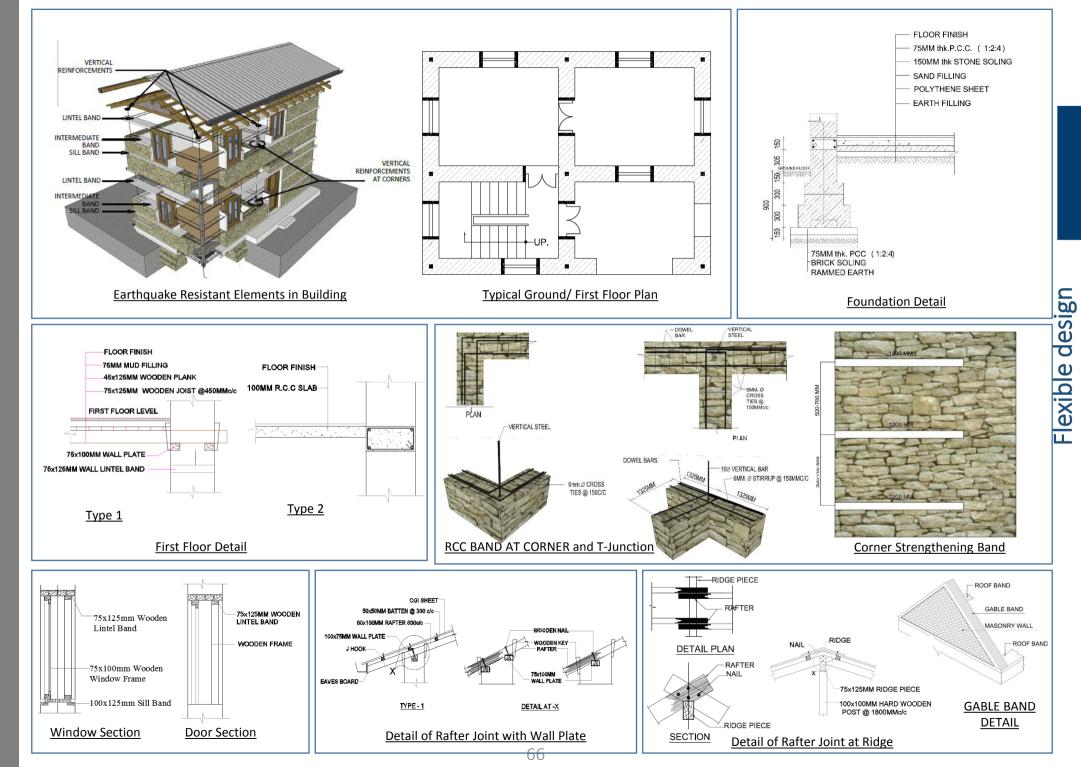
Nepal Housing	TYPE OF HOUSE:	MODEL SMC	SCALE:	None	DATE:	SM	10
Reconstruction Programme	DRAWING TITLE :	TECHNICAL DETAIL 4 (Foundation)	DESIGNED	) BY:		SIV	VIC





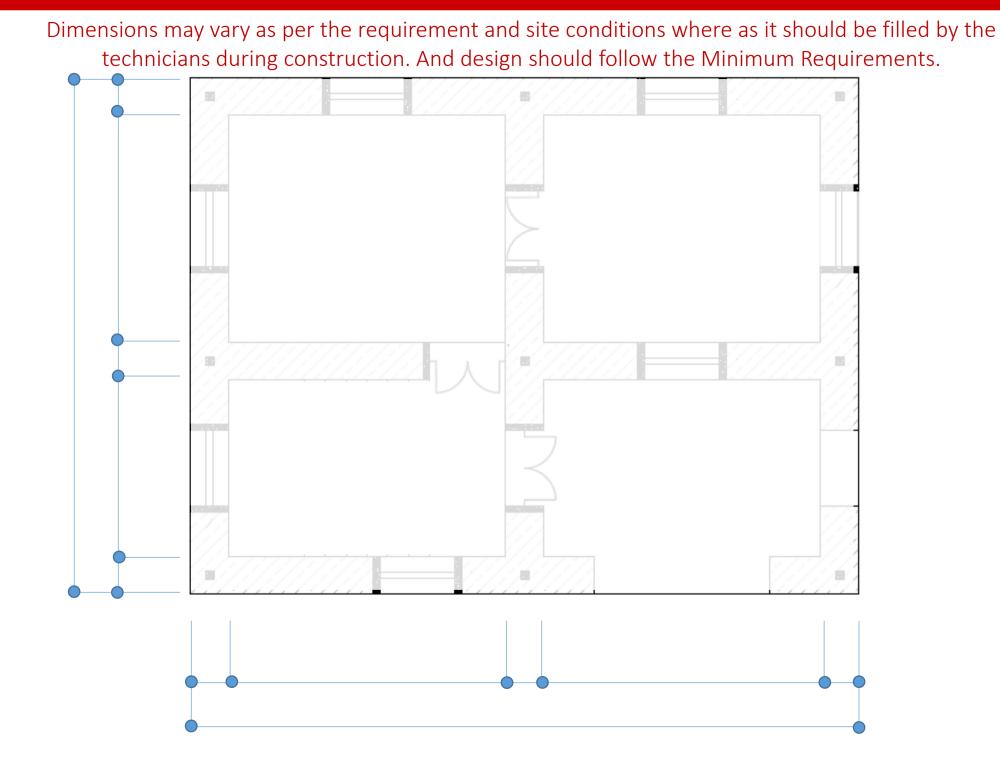


# Technology for Earthquake Resistant Building Construction (Two Storied Building, Stone in Cement Mortar)

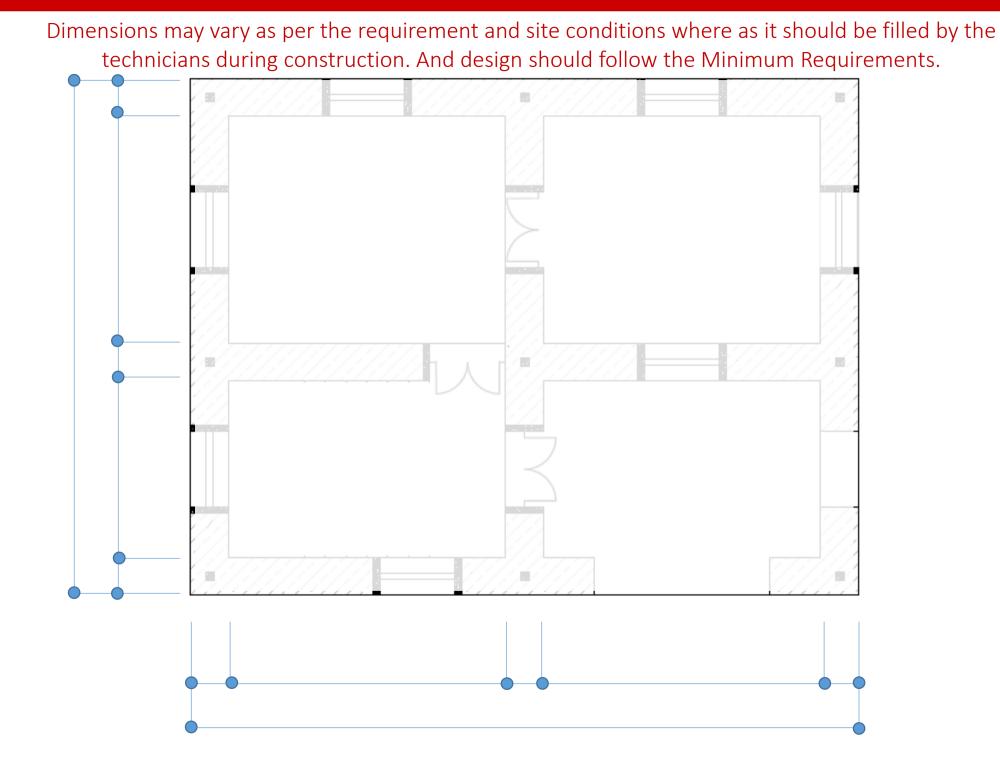


	Category			Stone Masonry in Cement Mortar (NBC202) Page1				for Stone Masonry in Cement Mortar (NBC202) Page2 Openings are to be located away from inside corners by a clear distance
101		A building shal	l not k	be constructed if site is:			Location	should not be less than 600 mm.
			~	Geological fault or Raptured Area				The total length of openings in a wall is not to exceed half of the length
1	Sita Salastian		~	Areas Susceptible to Landslide	6	Openings	Total length	of the wall in single-storey construction.
T	Site Selection		~	Steep Slope > 20%			Distance	The horizontal distance between two openings is to be not less than
			~	Filled Area			Distance	600 mm.
			~	River Bank and Water-logged Area			Lintel level	✓ Keep lintel level same for doors and windows.
		No. of story	~	Two storey+ attic, load bearing masonry buildings constructed in cement mortar		Vertical	Location	<ul> <li>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</li> </ul>
		Span of wall	~	The span of wall shall not more than 4.5 meters	7	Reinforcement		construction.
2	Shape of House	Size of room	~	The area of individual floor panel not more than 13.5 square metres			Reinforcement	The vertical reinforcing bar for masonry is given in detail drawings.
		Height of wall	~	The height of wall should not be more than 3.0 meters				12mm dia is minimum requirements for masonry houses.
		Proportion	~	The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.				Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:
		General		The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.			Sill band	<ul> <li>✔ A continuous sill band shall be provided through all walls at the botton level of opening (specially windows). The minimum height is 75mm.</li> </ul>
3	Foundation	Depth	~	The depth of footing should not be less than 800mm for one story, 900mm for two storey.			Lintel band	✔ A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.
		Width	/idth  The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings.		8	Horizontal Band	Stitch	<ul> <li>This band shall be provided where dowel-bars are required at all corners, junctions of walls. The minimum height is 75mm.</li> </ul>
		General	1	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.			Roof band	<ul> <li>Roof band shall be provided at the top-level of walls, so as to integrate</li> <li>them properly at their ends and fix them into the walls. The minimum height is 75mm.</li> </ul>
		Height	~	Minimum height of Plinth band is 150mm.				Main reinforcement should be 4or 2-12 dia. bars. Use 6mm diameter
4	Plinth	Width		Minimum thickness of plinth band width should be equal to wall thickness. 350mm for Stone masorny.			Reinforcement	✓ rings at 150mm. Hook length should be 500mm. Bars shall have a clear cover of 25mm concrete.
		Reinforcement	1	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	-		Light roof	Use light roof comprising wooden or steel truss covered with CGI sheets.
				of 25mm concrete. Masonry should not be laid staggered or straggled in order to avoid			Connection	All members of the timber truss or joints should be properly connected as shown in detail drawings.
		General	continuous vertical joints. At corners or wall junctions, through vertical		9	Roof	Cross-tie	<ul> <li>Trusses should be properly cross-tied with wooden braces as shown in detail drawings.</li> </ul>
				interlocked.				Well seasoned hard wood without knots should be used for roofing,
5	Walls	Joints	~	Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:4 (Cement: Sand).			Timber	✓ timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects
		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.			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		
		Width Vidth Vidth Vidth of wall is 350mm for one-storey and two-storey.	10	Materials	Concrete	<ul> <li>The concrete mix for seismic bands should not be leaner than 1:1.5:3 ( part cement, 1.5 parts sand and 3 parts aggregate)</li> </ul>		
							Reinforcement	✔ High Strength Deformed Bars – Fe415: High strength deformed bars with fy = 415 N/

Minimum Requirements for Flexible design



Flexible design



Flexible design

# BRICK MASONRY IN CEMENT MORTAR (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)

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# Minimum Requirements for Brick Masonry in Cement Mortar (NBC202)

Minimum Requirements Site Selection Foundation Reduined Requirements Shape of Hous Walls Walls
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# Minimum Requirements for Brick Masonry in Cement Mortar (NBC202)

Brick Masonry in Cement Mortar (NBC202) Page2	Openings are to be located away from inside corners by a clear distance should not be less than 600 mm.	The total length of openings in a wall is not to exceed half of the length of the wall in single-storey construction.	The horizontal distance between two openings is to be not less than 600 mm.	Keep lintel level same for doors and windows.	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	The vertical reinforcing bar for masonry is given in detail drawings. 12mm dia is minimum requirements for masonry houses.	Horizontal bands should be provided throughout the entire wall with minimum thickness of 75 to 150 mm at following locations:	A continuous sill band shall be provided through all walls at the bottom level of opening (specially windows). The minimum height is 75mm.	A continuous lintel band shall be provided through all walls at the top level of opening. The minimum height is 150mm.	This band shall be provided where dowel-bars are required at all corners, junctions of walls. The minimum height is 75mm.	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.	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.	Use light roof comprising wooden or steel truss covered with CGI sheets	All members of the timber truss or joints should be properly connected as shown in detail drawings.	Trusses should be properly cross-tied with wooden braces as shown in detail drawings.	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	Cement sand mortar should not be leaner than 1:4 (1 part cement and 4 parts sand) for masonry and 1:6 for plaster	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)	High Strength Deformed Bars – Fe415: High strength deformed bars with fy = 415 N/
for E	>	>	7	2	2	7	Horiz minii	7	7	7	7	2	2	>	7	7	2	2	2
Requirements (MRs) for	Location	Total length	Distance	Lintel level	Location	Reinforcement		Sill band	Lintel band	Stitch	Roof band	Reinforcement	Light roof	Connection	Cross-tie	Timber	Mortar	Concrete	Reinforcement
Minimum Require Category		Openings		ı <u> </u>	Vertical	•••••••				Horizontal Band					Roof			Materials	
No.									$\infty$					б			10		

# 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**

### Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR

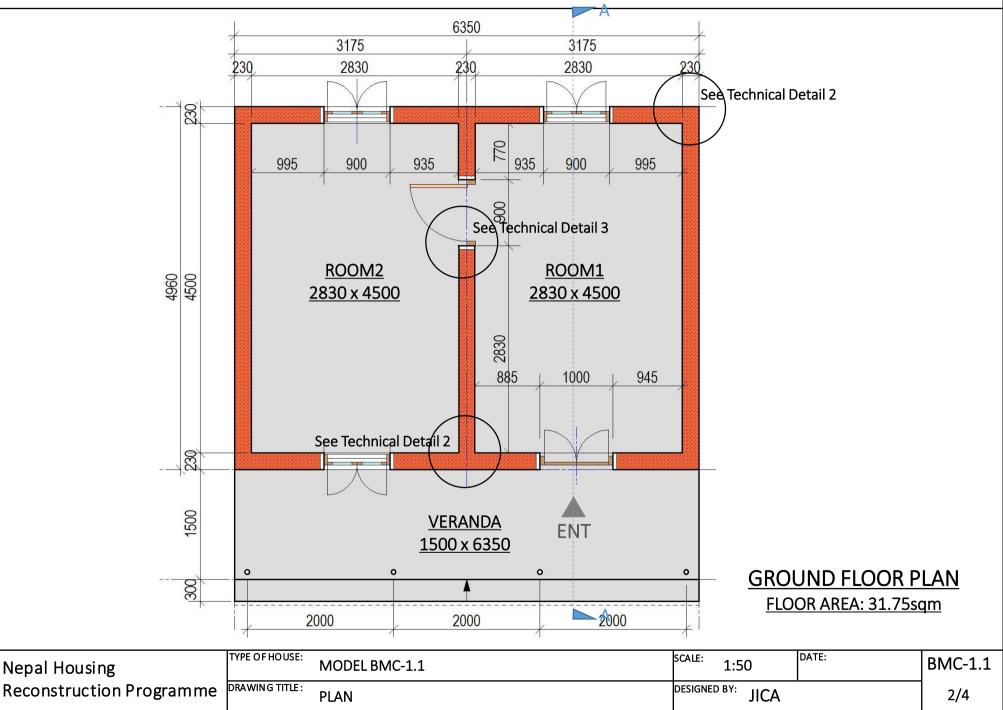


		IVIAN	OWER				IVIATERIALS				
	<u>LEVEL</u>	Skilled	Unskilled	Brick	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar	
		Md	Md	Nos	Bags	Cu.m	Cu.m	Cu.m	Bundel	Kg	
	Up to Plinth Level	45	104	13115	81	11	7	0	0	146	
	SUPERSTRUCTURE	67	59	8984	46	5	2	0.79	0	314	
	ROOFING	17	20	0	0	0	0	1.48	4.71	0	
	TOTAL	129	183	22099	127	15	9	2.27	4.71	460	
Nepal Housin	g	TYPE OF HOUS	e: Mode	EL BMC-1.1				SCALE:	None	DATE:	BMC-1.1
Reconstructio	on Programme	DRAWING TITL	e: PERSP	PECTIVE AN	D ESTIMA	TION		DESIGNE	d by: JIC	A	1/4

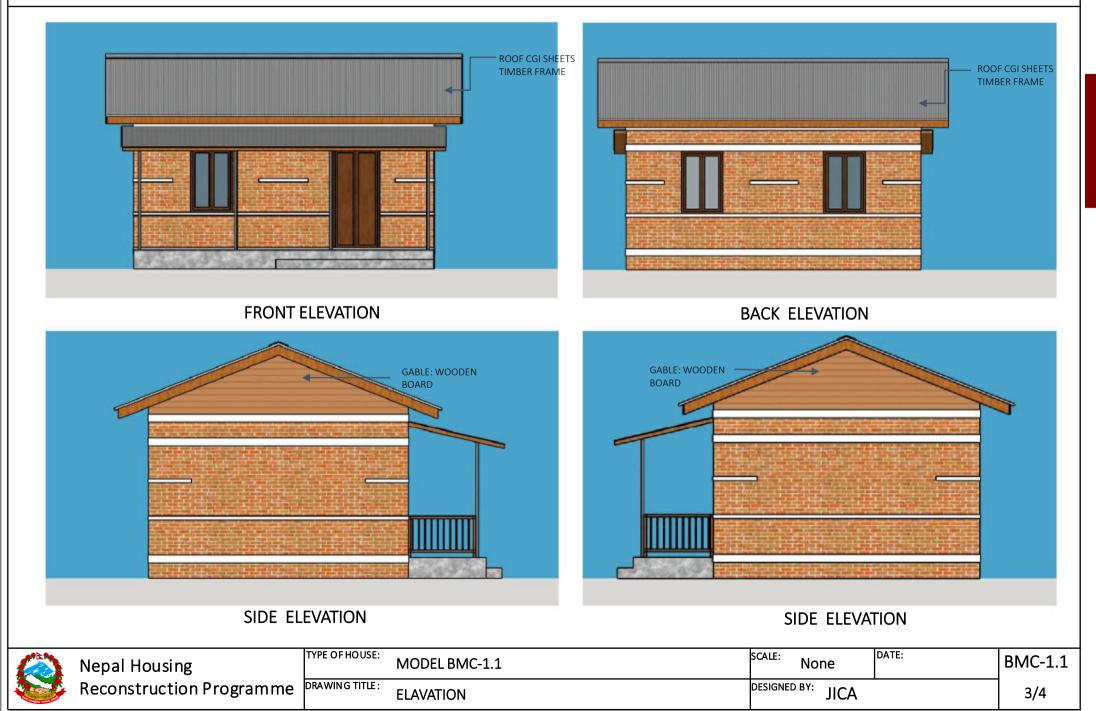


SPECTIVE AND ES	IIMAIION
	76

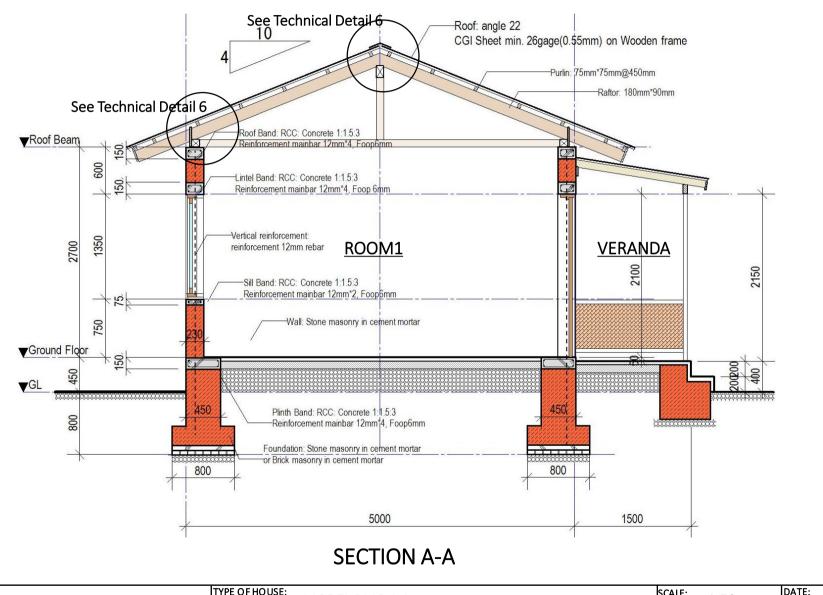
### Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR



Model BMC-1.1: BRICK MASONRY IN CEMENT MORTAR



### Model SMC-1.1: BRICK MASONRY IN CEMENT MORTAR



Nepal Housing	TYPE OF HOUSE:	MODEL BMC-1.1	SCALE:	1:50	DATE:	BMC-1.1
Reconstruction Programme	DRAWING TITLE :	SECTION	DESIGNEI	<sup>d by:</sup> JICA		4/4

# BRICK MASONRY IN CEMENT MORTAR, ONE-STOREY

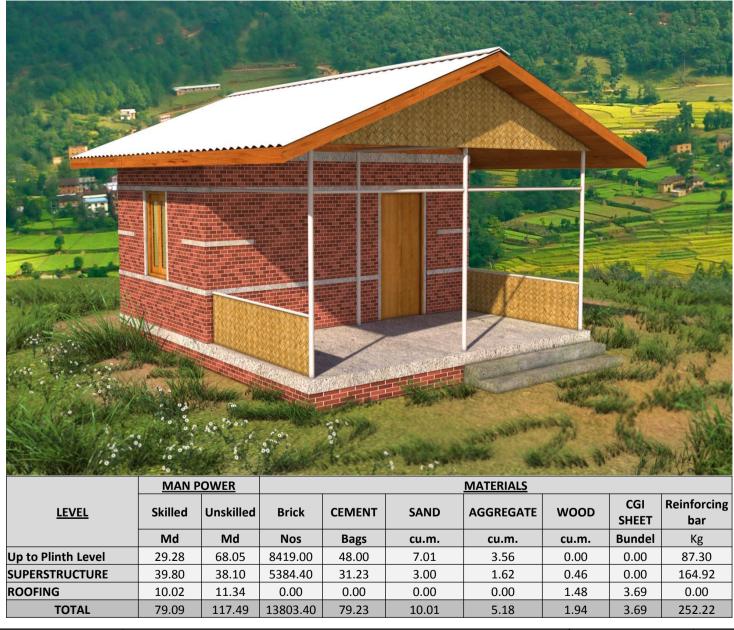
# **BMC-1.2**

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**

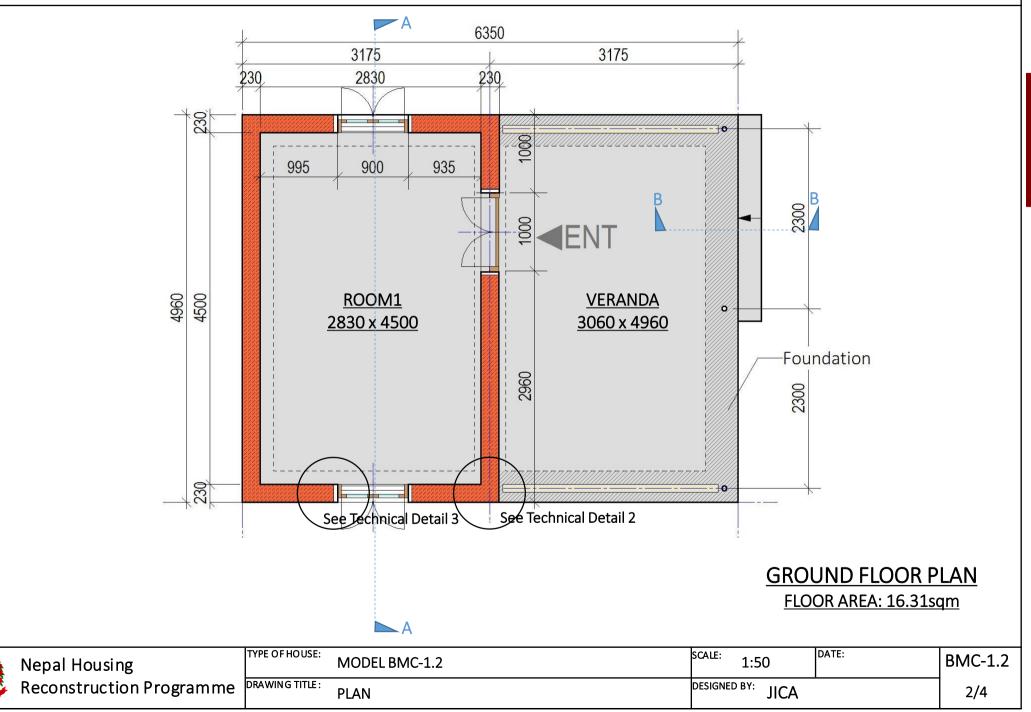
### Model BMC-1.2: BRICK MASONRY IN CEMENT MORTAR





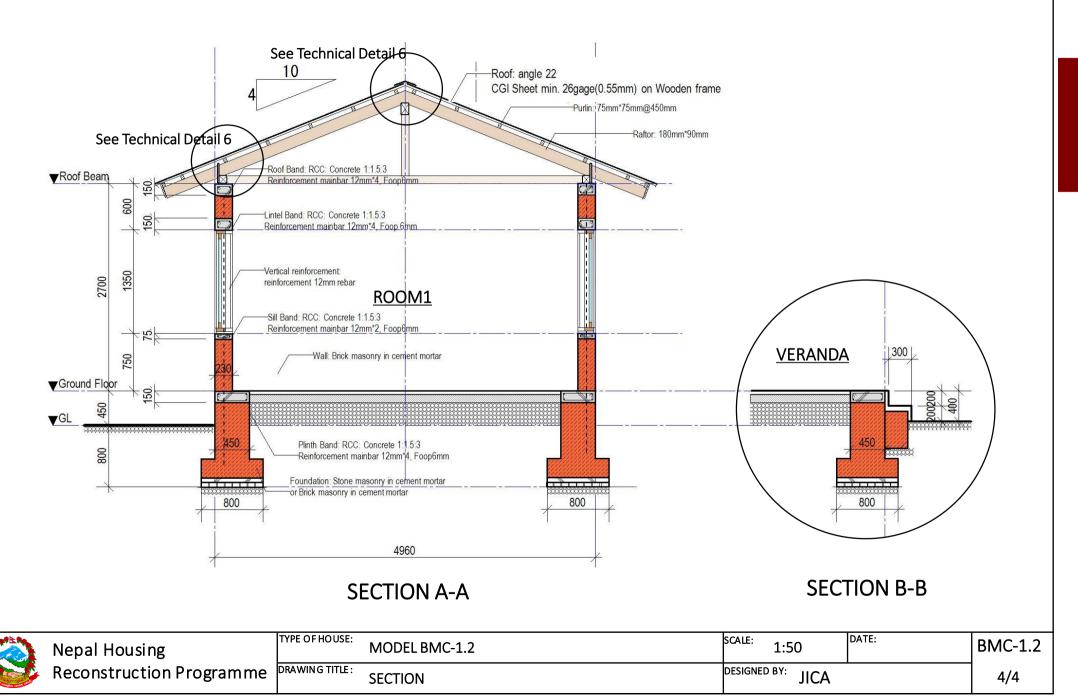
Nepal Housing	TYPE OF HOUSE:	MODEL BMC-1.2	SCALE:	None	DATE:	BMC-1.2
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	<sup>d by:</sup> JICA		1/4

### Model BMC-1.2: BRICK MASONRY IN CEMENT MORTAR





### Model SMC-1.2: BRICK MASONRY IN CEMENT MORTAR



# BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

### Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR



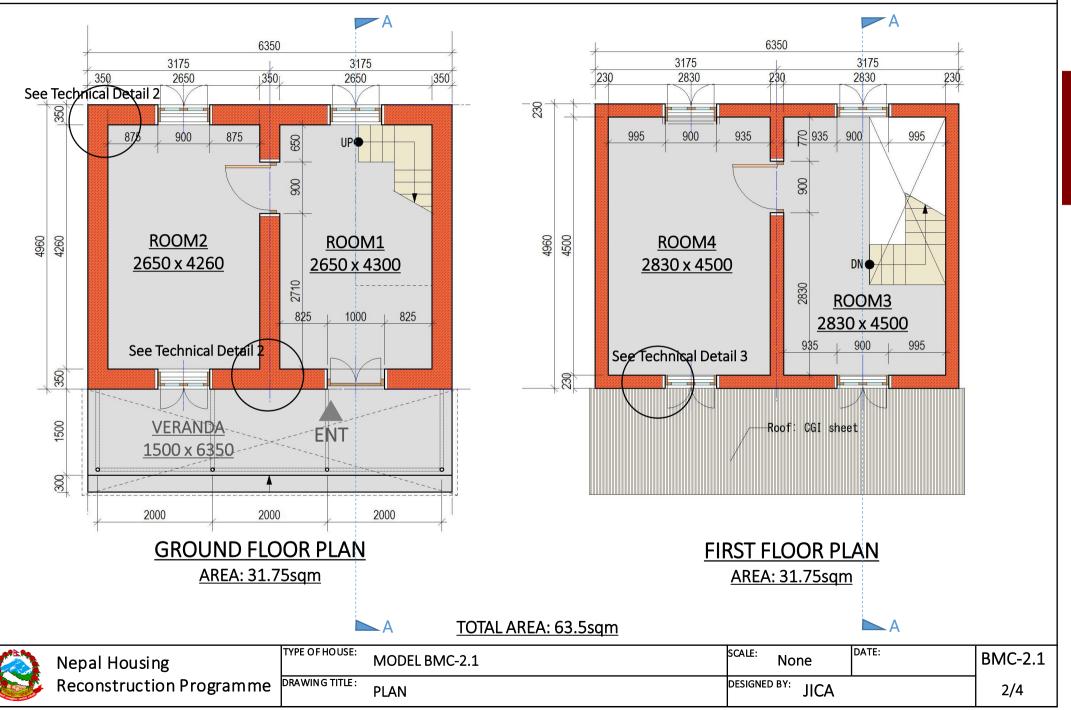
	MAN P	OWER		MATERIALS									
LEVEL	Skilled	Unskilled	Brick	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	Reinforcing bar				
	Md	Md	Nos	Bags	cu.m.	cu.m.	cu.m.	Bundel	Kg				
Up to Plinth Level	46.93	118.50	13288.00	87.75	11.41	6.71	0.00	0.00	145.85				
SUPERSTRUCTURE	81.80	144.21	23648.00	109.12	11.66	4.20	2.95	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	TYPE OF HOUSE:	MODEL BMC-2.1	SCALE:	None	DATE:	BMC-2.1
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEE	<sup>d by:</sup> JICA		1/4

### Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

### TWO-STOREY



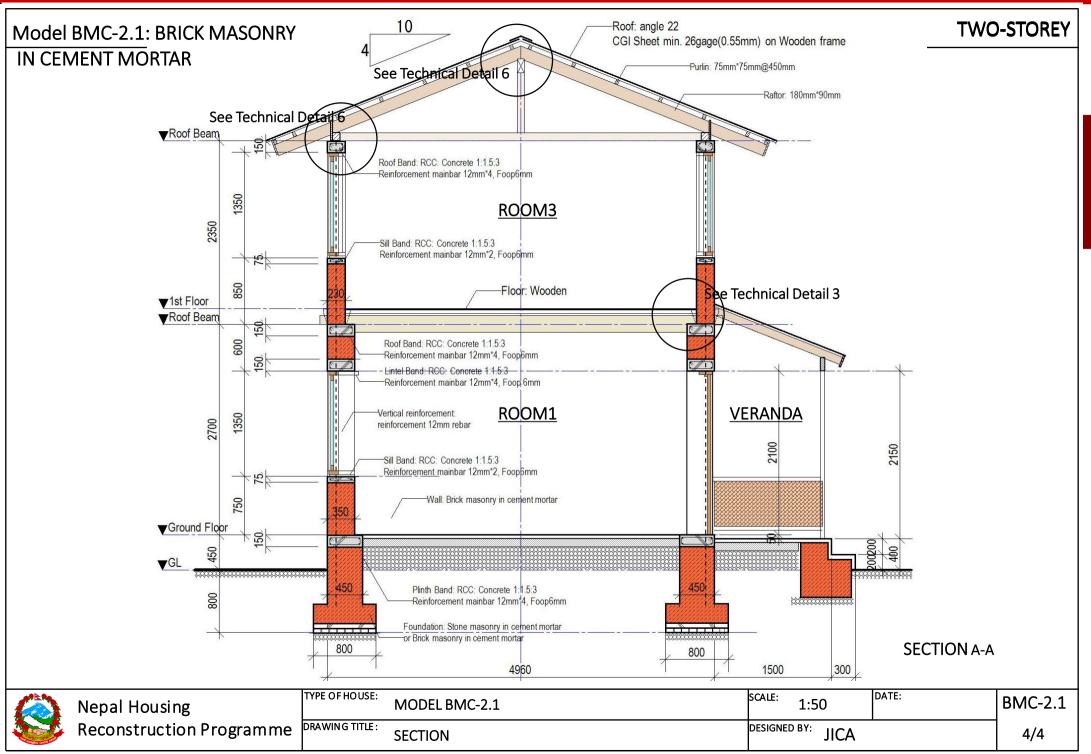
### Model BMC-2.1: BRICK MASONRY IN CEMENT MORTAR

### TWO-STOREY



And being the stand

Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.1	SCALE:	1:100	DATE:	BMC-2.1
Reconstruction Programme	DRAWING TITLE :	ELEVATION	DESIGNE	<sup>d by:</sup> JICA		3/4



# 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

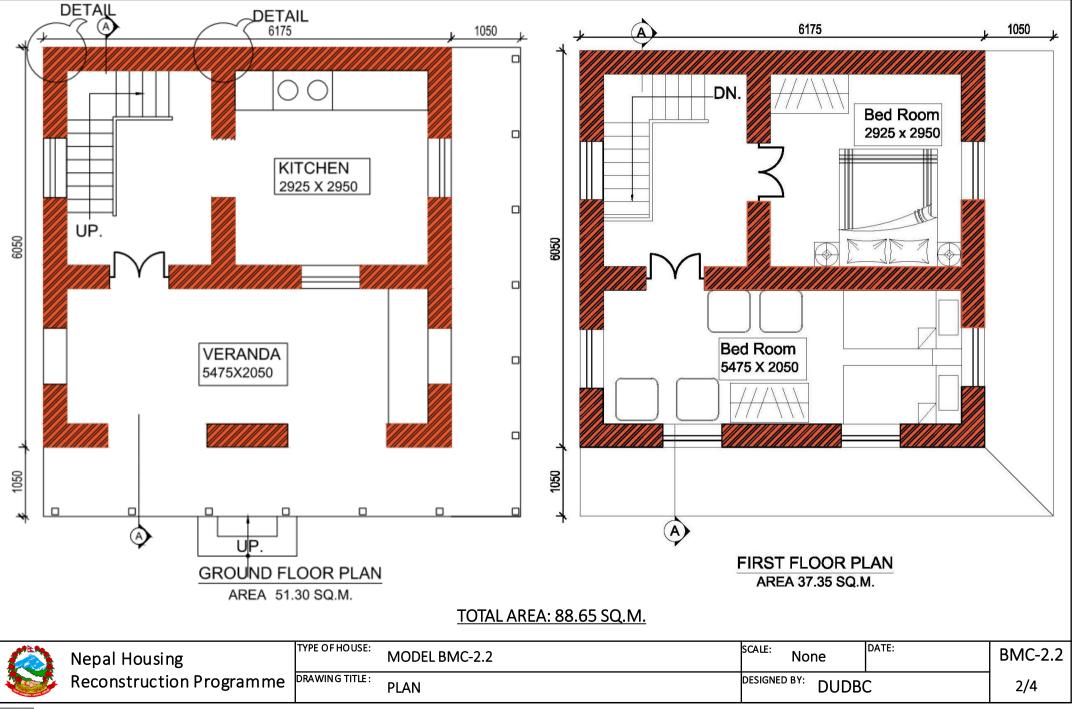
	MAN POWER		MATERIALS								
<u>LEVEL</u>	Skilled	Unskilled	Brick	CEMENT	SAND	AGGREGATE	WOOD	CGI SHEET	GI SHEET	Rod	
	Md	Md	Nos	Bags	Cu.m.	Cu.m.	Cu.m.	Bundel	Rm.	Kg	
Up to Plinth Level	52	113	14296	62	11	3	0	0	0	256	
SUPERSTRUCTURE	181	110	23652	121	14	4	3.01	0	0	607	
ROOFING	47	18	0	0	0	0	2.13	5.15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



Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.2	SCALE:	NONE	DATE:	BMC-2.2
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNED	DUDB	C	1/4

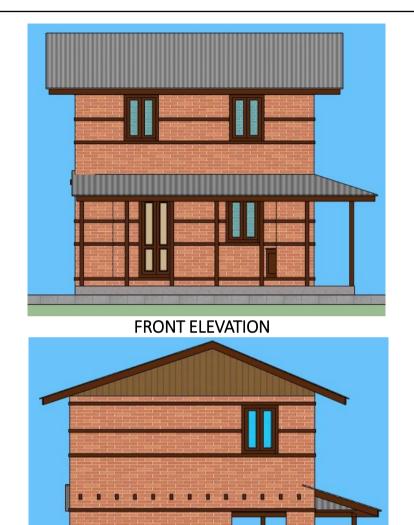
### Model BMC 2.2 BRICK MASONARY IN CEMENT MORTAR

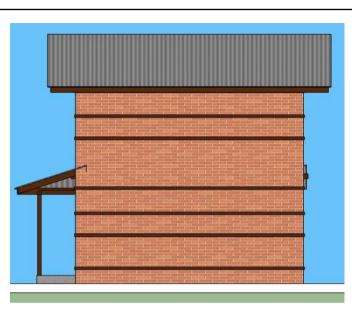
### **TWO-STOREY**



### Model BMC- 2.2: BRICK MASONARY IN CEMENT MORTAR

### **TWO-STOREY**

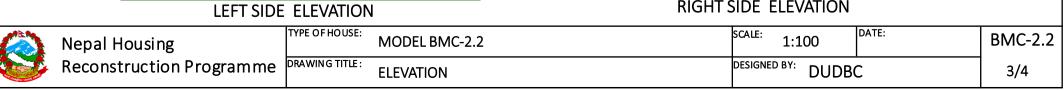


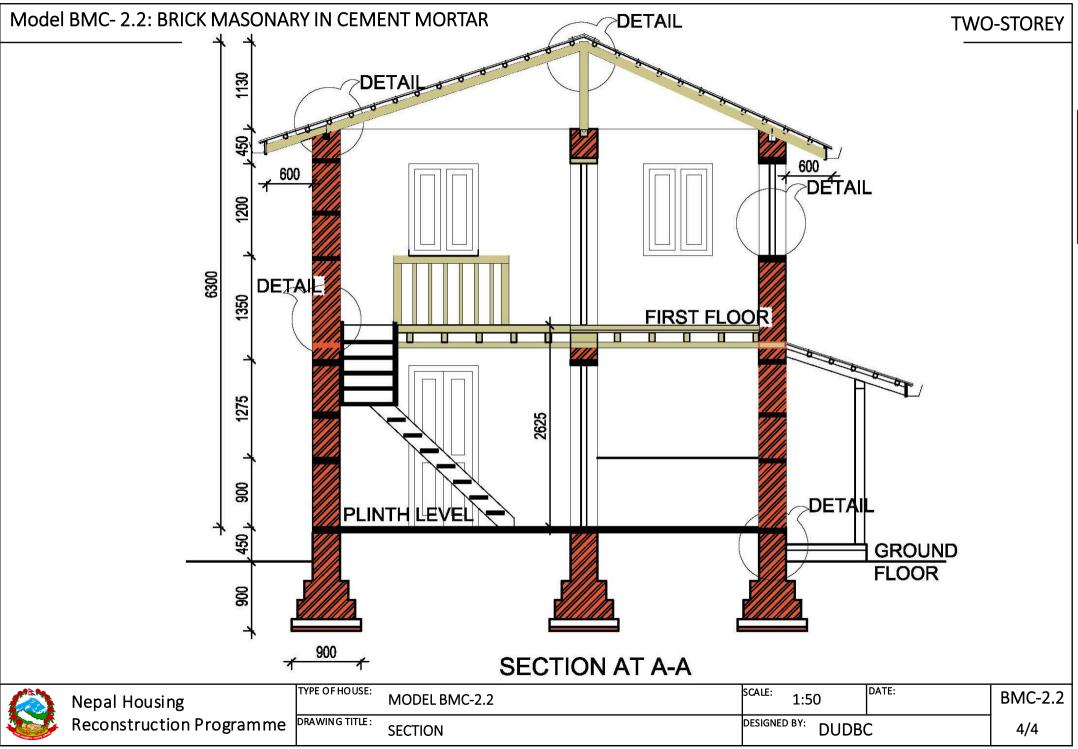


BACK ELEVATION



**RIGHT SIDE ELEVATION** 





# 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**

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

### TWO-STOREY

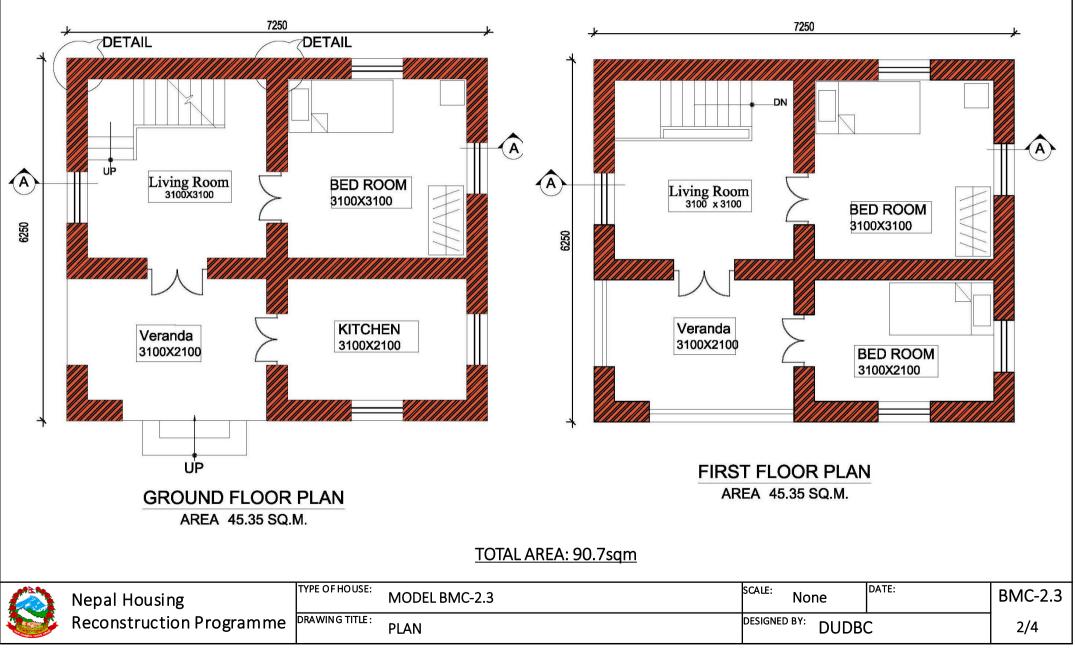


### CONSTRUCTION MATERIALS AND MANPOWER

	MAN POWER		MATERIALS									
<u>LEVEL</u>	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		



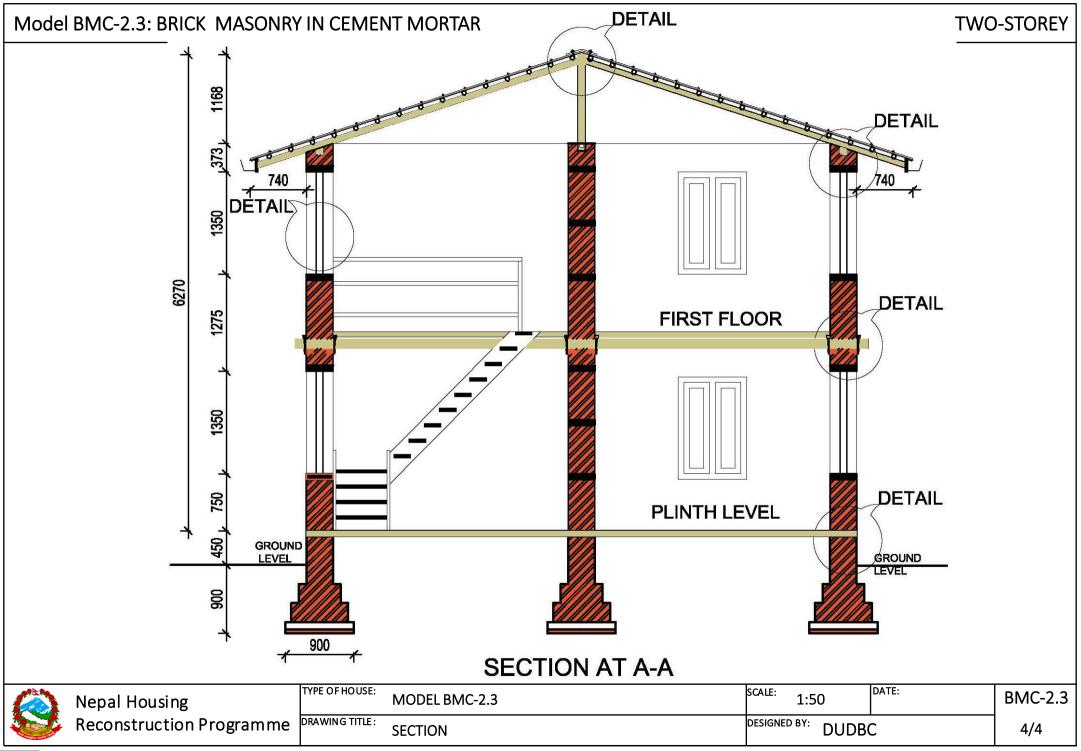
Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.3	SCALE:	NONE	DATE:	BMC-2.3
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNED	DUDB	С	1/4



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

### TWO-STOREY





## BRICK MASONRY IN CEMENT MORTAR, TWO-STOREY



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**

#### TWO-STOREY+ATTIC



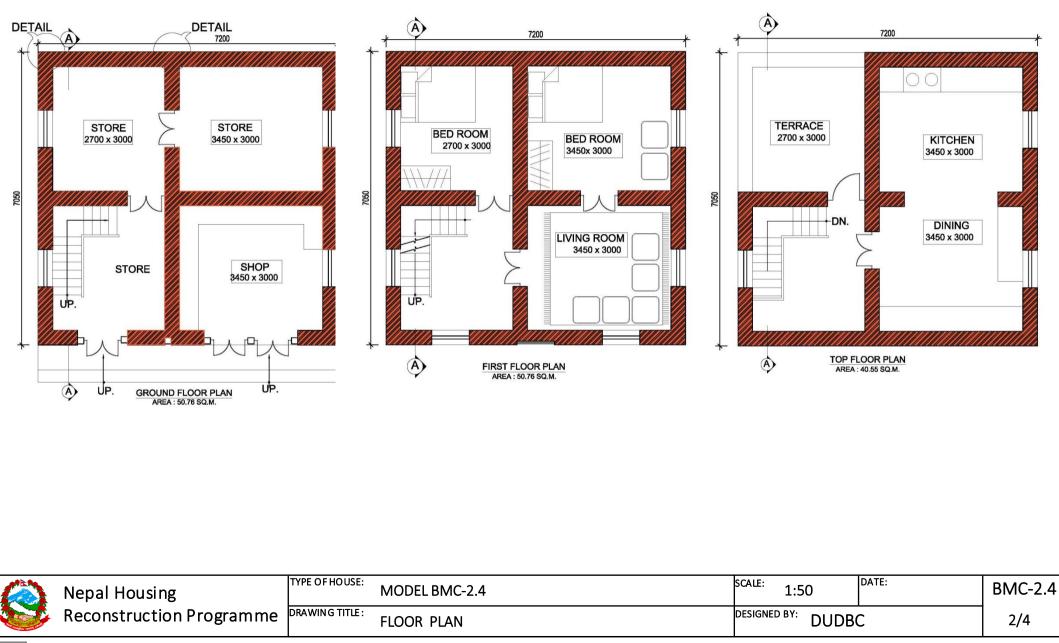
#### CONSTRUCTION MATERIALS AND MANPOWER

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

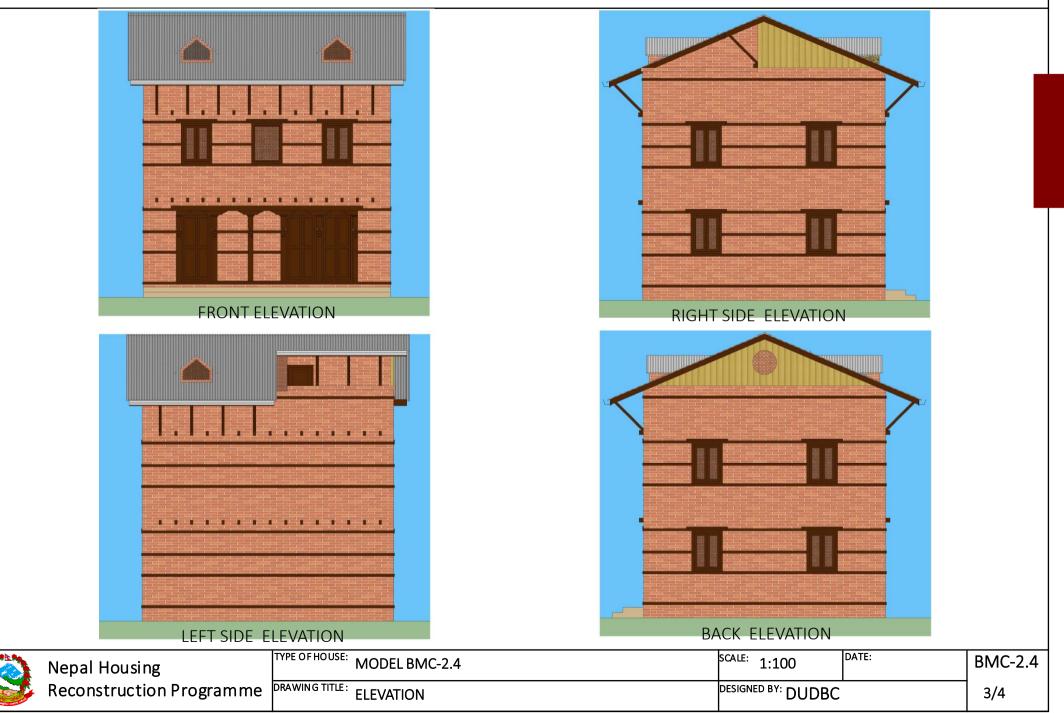


Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.4	SCALE:	NONE	DATE:	BMC-2.4
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNE	DUDB	0	1/4

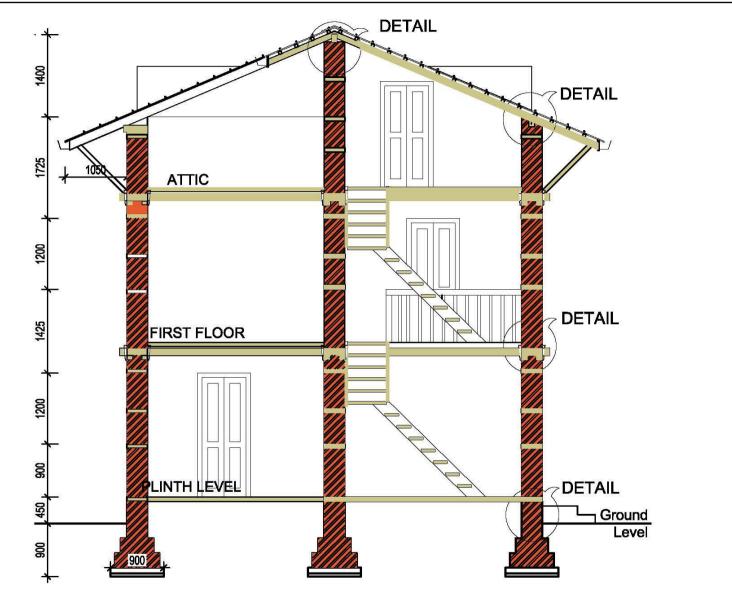
#### TWO-STOREY+ATTIC



#### TWO-STOREY+ATTIC



#### TWO-STOREY+ATTIC



#### **SECTION AT A-A**

	Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.4	SCALE:	None	DATE:	BMC-2.4
ý	Reconstruction Programme	DRAWING TITLE :	SECTION	DESIGNE	DUDB	C	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**

#### TWO-STOREY+TERRACE



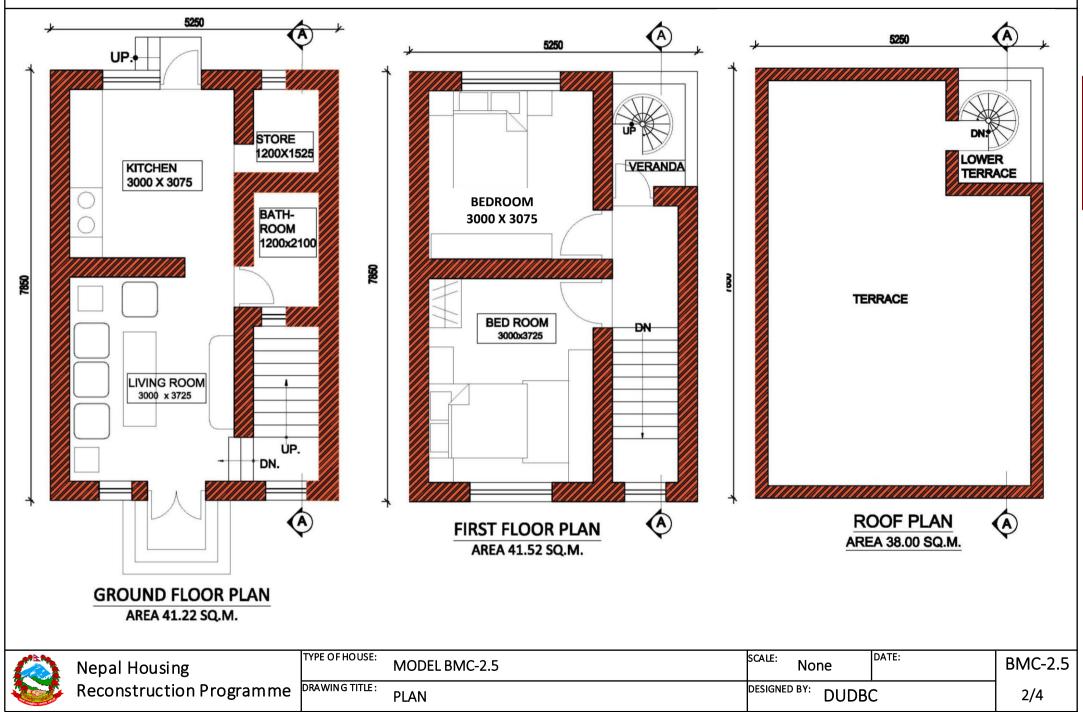
#### CONSTRUCTION MATERIALS AND MANPOWER

	<u>MAN P</u>	OWER				MA	TERIALS		
<u>LEVEL</u>	Skilled	Unskilled	Brick	MUD	CEMENT	SAND	AGGREGATE	WOOD	REINFORCEMENT
		<u></u>	<u></u>	<u></u>	<u></u>	<u></u>		<u></u>	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



Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.5	SCALE:	None	DATE:	BMC-2.5
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNED	DUDB	0	1/4

TWO-STOREY+TERRACE

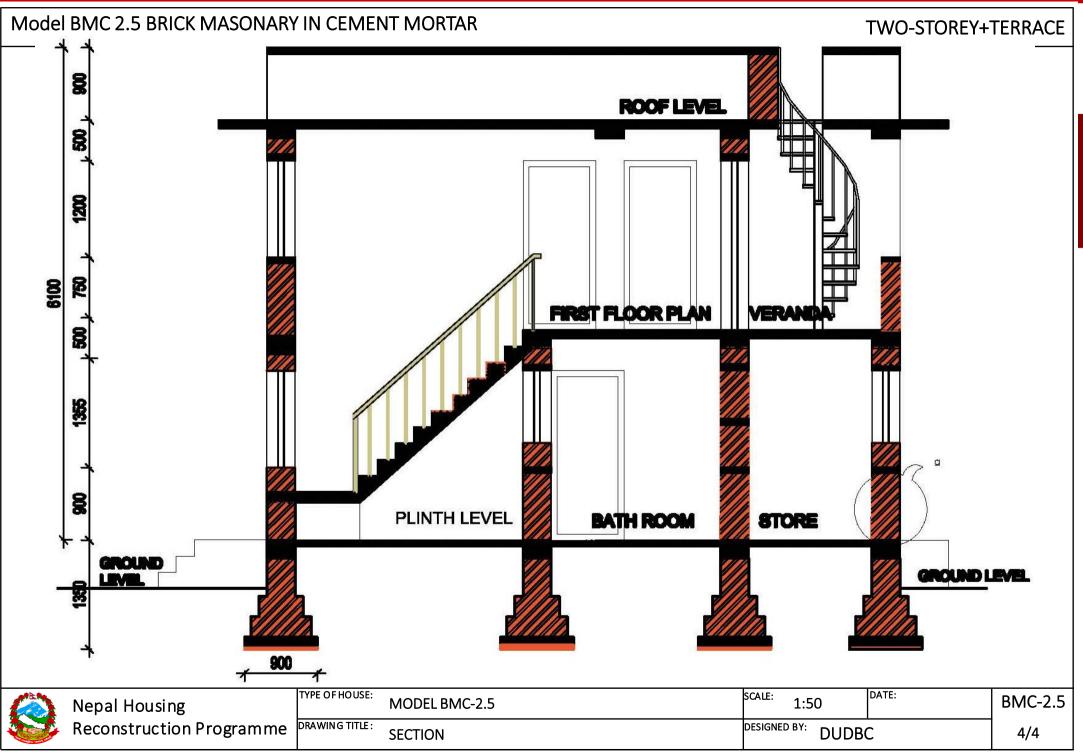


#### TWO-STOREY+TERRACE

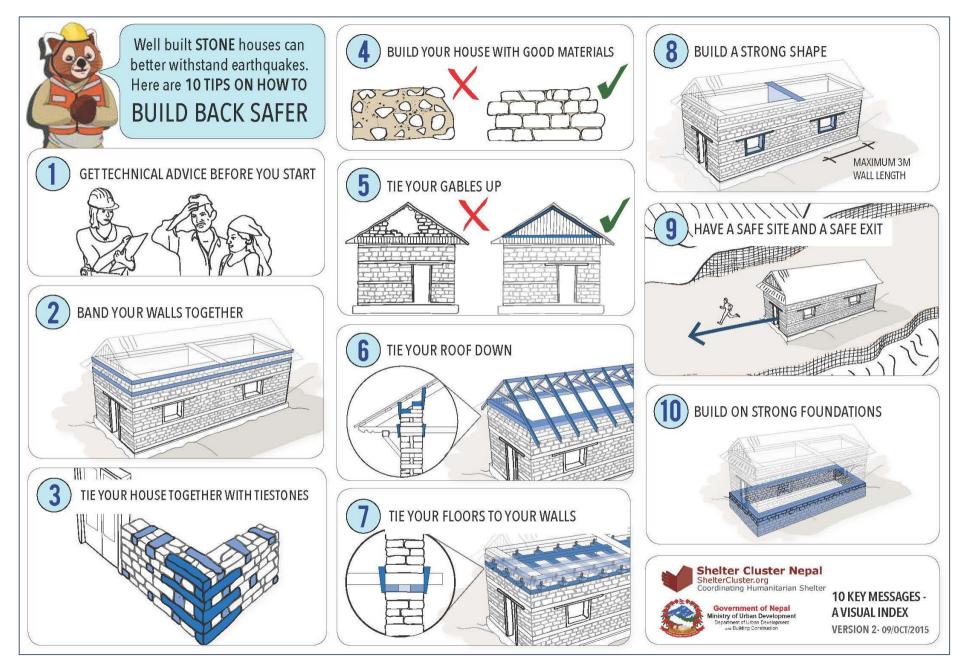


The local day states

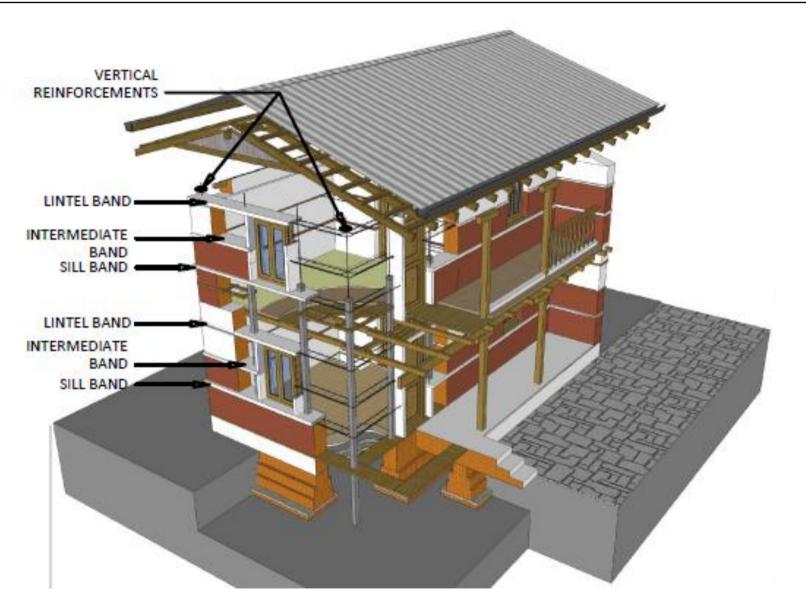
Nepal Housing	TYPE OF HOUSE:	MODEL BMC-2.5	SCALE:	None	DATE:	BMC-2.5
Reconstruction Programme	DRAWING TITLE :	ELEVATION	DESIGNEE	DUDB	С	3/4



# **Technical Details**



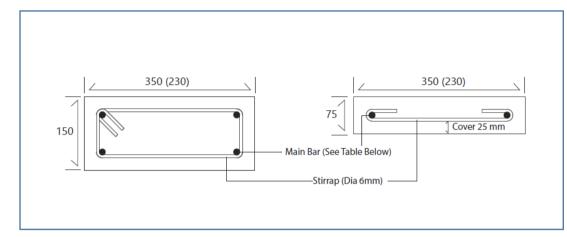
#### **10 KEY MESSAGES**



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



Nepal Housing	YPE OF HOUSE: MODEL BMC	SCALE: None DATE:	– BMC
Reconstruction Programme	RAWING TITLE: TECHNICAL DETAIL 1 (SEISMIC ELEMENTS	5) DUDBC	



Cross section of RC bands for two bars and four bars

2

4

2

Nequilei		anus			
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		
	75mm	2	12		
Lintel	150mm	2	10 (top)		
		2	12 (bottom)		

#### Requirement of bar for RC bands

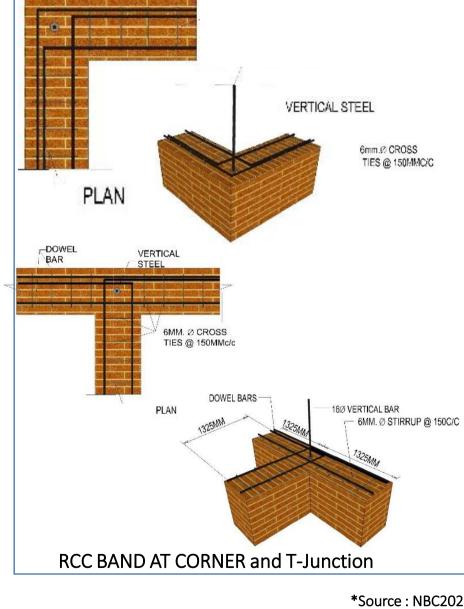
75mm

300mm

75mm

Roof

Dowel (Stitch)

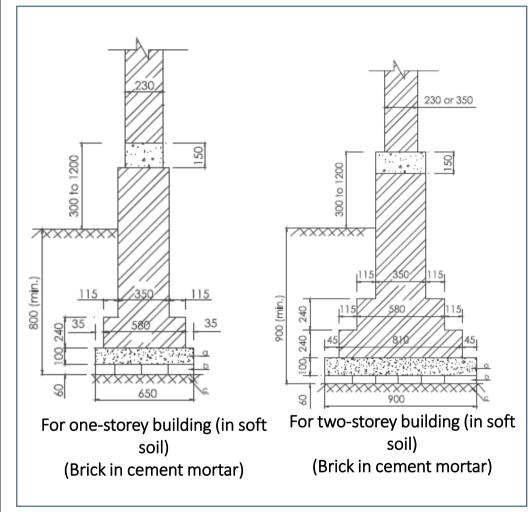


					*Source	: NBC202
Nepal Housing	TYPE OF HOUSE:	MODELSMC	SCALE:	None	DATE:	SMC
Reconstruction Programme	DRAWING TITLE :	TECHNICAL DETAIL 2 (Reinforcing bar arrangement)	DESIGNE	) BY:		SIVIC

12

12

8



Masonry Type	No. Of Story	Minimum base wi	dth (mm) of wall foot	ting for soil type:
	Story	Soft	Medium	Hard
Brick	Two	900	650	550
Briek	One	650	550	550
Channe	Two	*	600	600
Stone	One	800	600	600

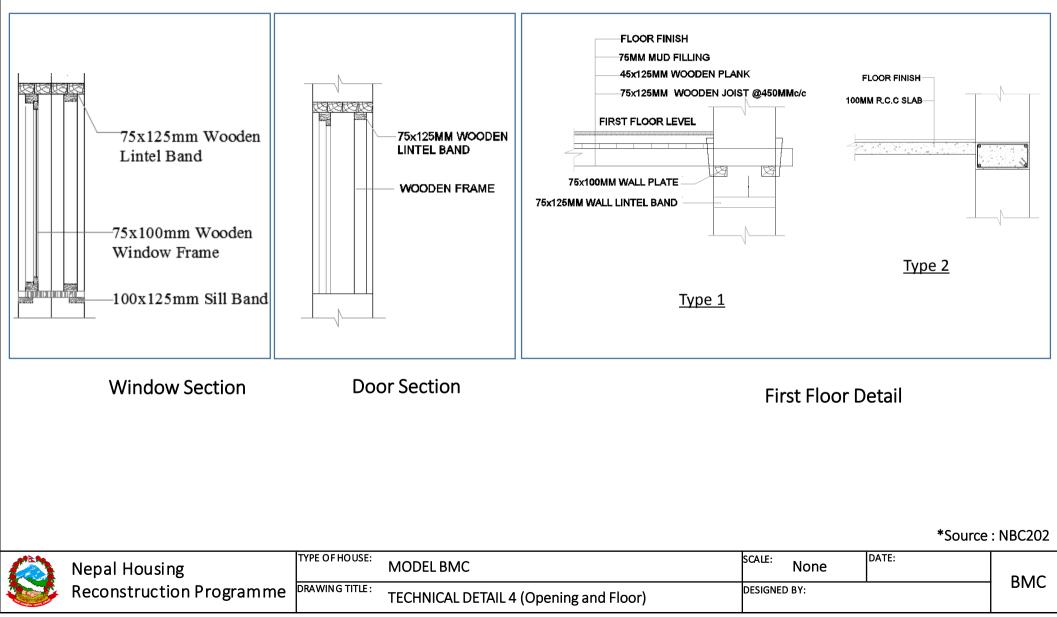
#### Base width of footing

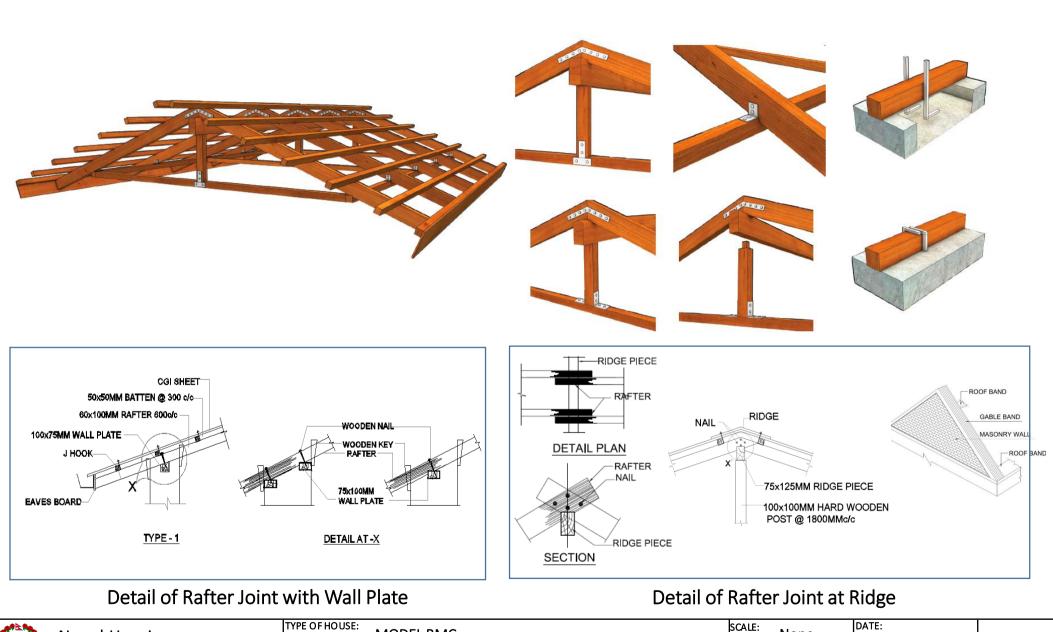
#### Classification of Foundation Soil and Safe Bearing Capacity

Foundation Soil Classification	Types of Foundation Materials	Presumed Safe Bearing Capacity, KN/m <sup>2</sup>
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

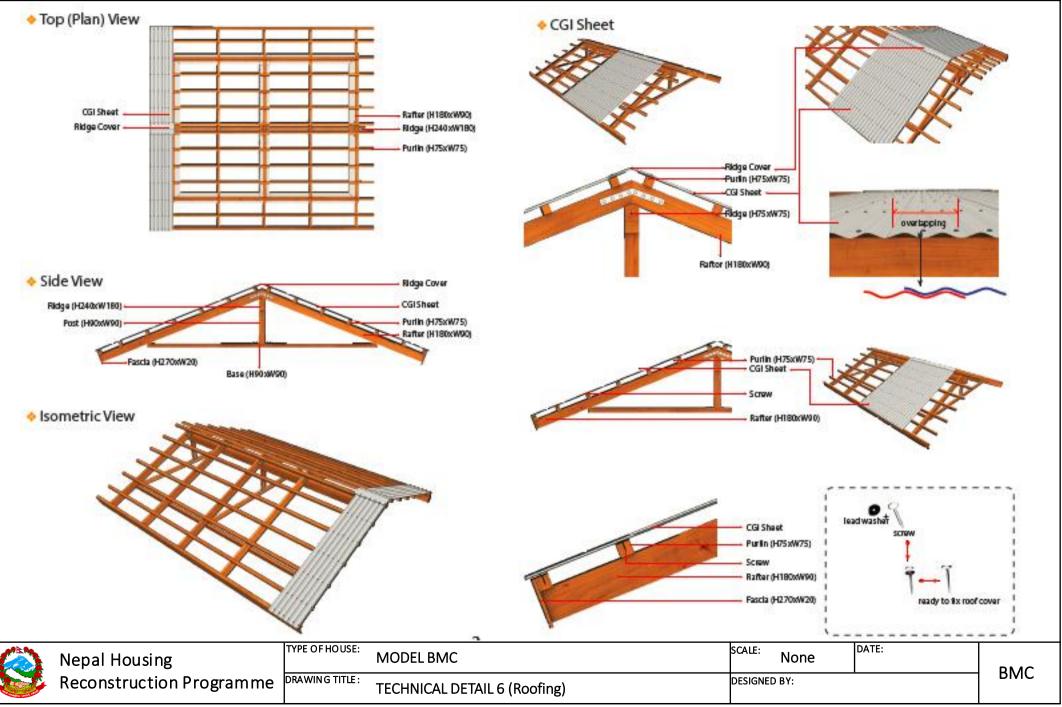
\*Source : NBC202

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

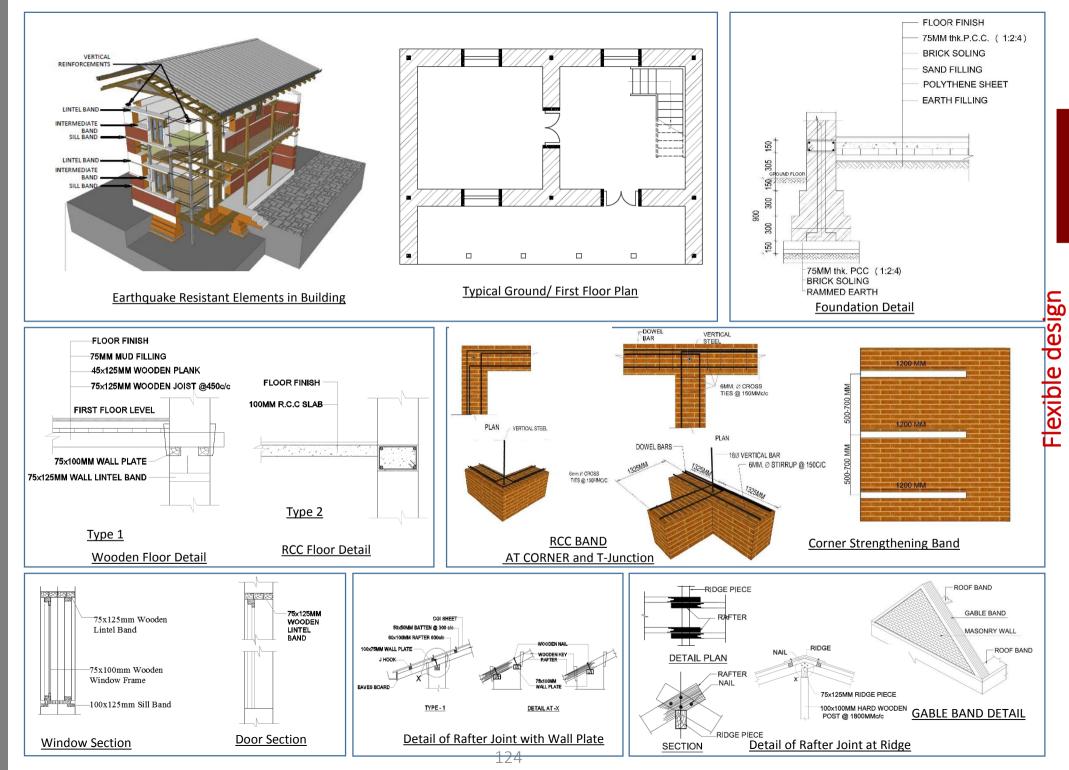




Nepal Housing	TYPE OF HOUSE:	MODEL BMC	SCALE:	None	DATE:	BMC
Reconstruction Programme	DRAWING TITLE :	TECHNICAL DETAIL 5 (Roof)	DESIGNEI	DBY:		DIVIC



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

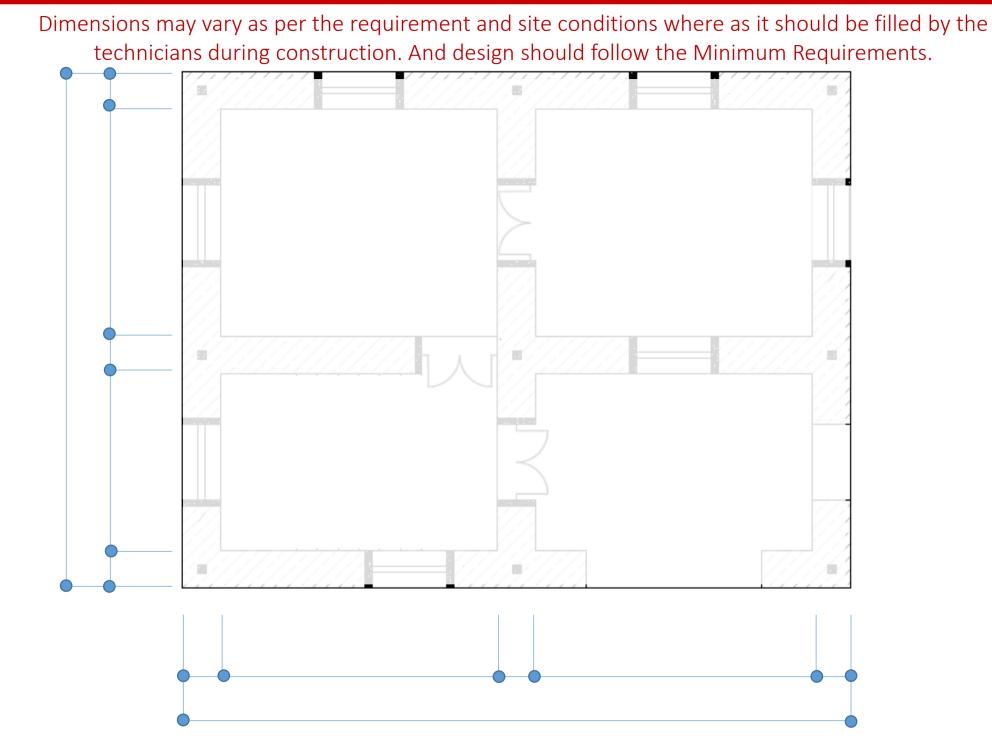


		ements (IVIRS	) for Brick Masonry in Cement Mortar (NBC202) Page1
No.	Category	8	
		A building shal	I not be constructed if site is:
			Geological fault or Raptured Area
1	Site Selection		✓ Areas Susceptible to Landslide
			✓ Steep Slope > 20%
			✓ Filled Area
			✓ River Bank and Water-logged Area
		No. of story	✔ Two storey+ attic, load bearing masonry buildings constructed in cement mortar
		Span of wall	✓ The span of wall shall not more than 4.5 meters
2	Shape of House	Size of room	$\checkmark$ The area of individual floor panel not more than 13.5 square metres
		Height of wall	✓ The height of wall should not be more than 3.0 meters
		Proportion	The house shall be planned in square, rectangular. Avoid long and narrow structure should not be more than 3 times of its width.
		General	The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.
3	Foundation	Depth	<ul> <li>The depth of footing should not be less than 800mm for one story, 900mm for two storey.</li> </ul>
		Width	The width of footing should not be less than 600mm in medium soil condition. As depend on soil condition. Shown in detail drawings.
		General	<ul> <li>Provide a reinforced concrete band at plinth level, as shown in detail</li> <li>drawings. The top level of plinth should not be less than 300mm from existing ground level. Recommendation is 450mm.</li> </ul>
	Plinth	Height	✓ Minimum height of Plinth band is 150mm.
4		Width	Minimum thickness of plinth band width should be equal to wall thickness. 230mm for brick masorny.
		Reinforcement	<ul> <li>✓ 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.</li> </ul>
		General	<ul> <li>Masonry should not be laid staggered or straggled in order to avoid continuous vertical joints. At corners or wall junctions, through vertica joints should be avoided by properly laying the masonry. It should be interlocked.</li> </ul>
5	Walls	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.

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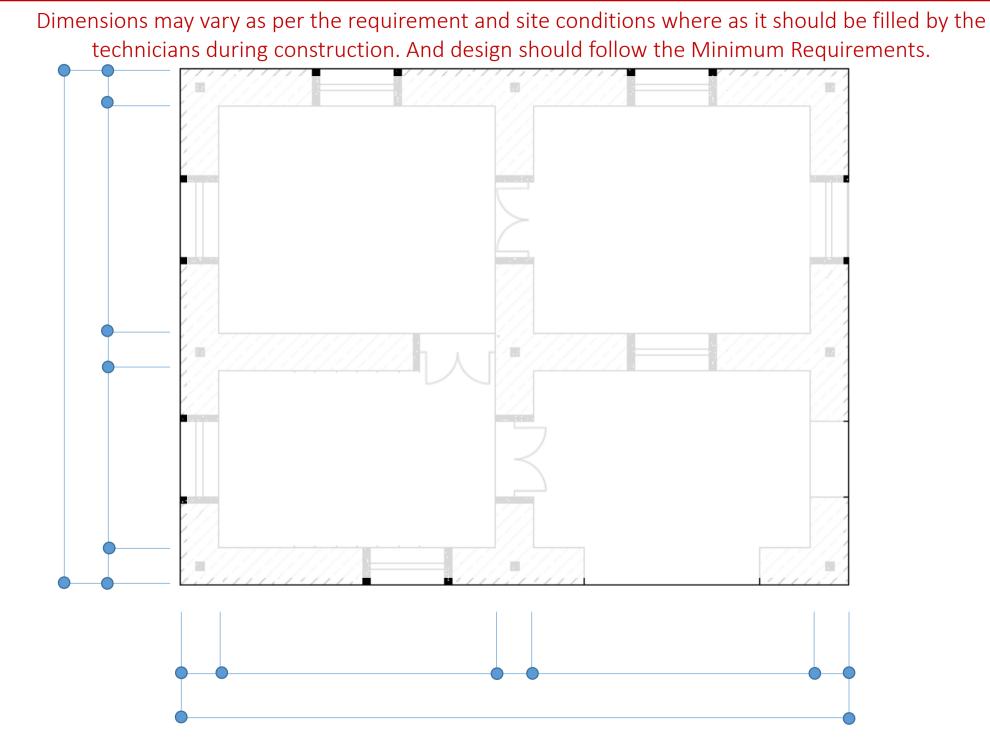
9

	Minimum Requir	rements (MRs)	for	Brick Masonry in Cement Mortar (NBC202) Page2
No.	Category			
		Location	~	Openings are to be located away from inside corners by a clear distance should not be less than 600 mm.
6	Openings	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	V	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.
	Kennorcement	Reinforcement	r	The vertical reinforcing bar for masonry is given in detail drawings. 12mm dia is minimum requirements for masonry houses.
			1	izontal bands should be provided throughout the entire wall with imum 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.
8	Horizontal Band	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.
		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.
9	Roof	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
		Mortar	r	Cement sand mortar should not be leaner than 1:4 (1 part cement and 4 parts sand) for masonry and 1:6 for plaster
10	Materials	Concrete	r	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/



Flexible design

Base drawing for Flexible design



Flexible design

## STONE MASONRY IN MUD MORTAR (SMM)



## STONE MASONRY IN MUD MORTAR (SMM)

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

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

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

# Minimum Requirements (MRs)

# Minimum Requirements for Stone Masonry in Mud Mortar (NBC203)

No.	Minimum Requ Category	uirements (MRs) f	or St	m Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) Page1
			A bu	A building shall not be constructed if site is:
			2	Prone to geological fault or raptured area
~	Cito Coloction		2	Susceptible to landslide
-1			2	Steep slope > 20%
			>	Filled area
			>	River bank and water-logged area
		No. of storeys	>	Two storey+ attic
2	Shape of House	Proportion	3	The house shall be planned square, rectangular. House should not
			>	more than 3 times its width.
		General	2	The foundation trench shall be of uniform width. The foundation bed
			•	shall be on the same level throughout the foundation in flat area.
		Depth	2	The depth of footing should be at least 750mm.
ŝ	Foundation			The width of footing should not be less than 750mm and 800mm
		Width	2	respectively for one and two-storeyed houses in medium soil
				condition. Width depends on soil type. Refer to technical drawings.
			<b>`</b>	The top level of plinth should be at least 300mm above existing
4		General	2	ground level. Recommended plinth height from the ground is 450mm.
				Masonry should be laid staggered to avoid formation of continuous
			2	vertical joint. At corners or wall junctions, continuous vertical joints
		מקופוס	2	should be avoided by properly laying large stones. The walls should be interlocked.
				Mortar ioints chould not he more than 20mm and less than 10mm in
		Joints	2	ואוטו גמו שנוע איז אוטטוט ווטר שב וווטו ב נוומון בטווווון מווע ובאא נוומון בטווווון ווו thickness.
				Spacing of through stone shall not be more than 1200mm in the
		Though Stone	3	horizontal direction and 600mm in the vertical direction. Seasoned
ഗ	slleW			timber, precast or cast insitu concrete can be used instead of through
ר				stone.
				Maximum length of unsupported wall shall not exceed 12 times its
		Length of wall	2	thickness. If unsupported length of wall is more than this, buttress
				shall be provided at an interval not exceeding 12 times wall thickness.
		W/all thickness	:	The wall thickness should not be less than 350-450mm, 450mm
			>	respectively for one and two-storey houses.
		Height of wall	7	The height of wall between floors should not be more than 8 times wall thickness

130

U N	Ca	uirements (MRs) fo	or St	Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) Page2 tegory
		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.
9	Openings	Total length of openings	2	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	7	Distance between two openings shall be larger of half the height of shorter opening or 600mm.
		Lintel level	7	Keep lintel level same for doors and windows
		Location	7	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.
►	verucai Reinforcement	Reinforcement	2	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.
		General	2	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	2	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	2	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.
$\infty$	Horizontal Band	Lintel band	7	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	2	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	2	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 Reg	uirements (MRs) fo	or St	Minimum Requirements (MRs) for Stone Masonry in Mud Mortar (NBC203) Page3
No.	Category			
				Use light roof comprising of wooden or steel structure covered with
		Light roof	>	🗸  light roofing materials. Heavy roofing materials such as stone slabs or
				mud should be avoided.
б	Roof		`	, All members of the timber truss or joints should be properly
		CUILIECTION	>	connected as shown in technical details.
			`	Trusses should be properly cross-tied with wooden braces as shown in
		רו האש - רוב	>	technical details.
				Well seasoned hard wood / local wood without knots should be used
		Timbor	2	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	7	🖌 $ $ Mud should be free from organic material and pebbles, etc.
10	Materials			Brick should be class A1 or A2 with compressive strength not less than
				3.5N/sqmm.
		Concrete	3	The concrete mix for seismic bands should not be leaner than 1:2:4 (1
		collicie e le	>	part cement, 2 parts sand and 4 parts aggregate)
		Bainforcement	2	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**

#### Model SMM-1.1: STONE MASONRY IN MUD MORTAR

#### **ONE-STOREY**

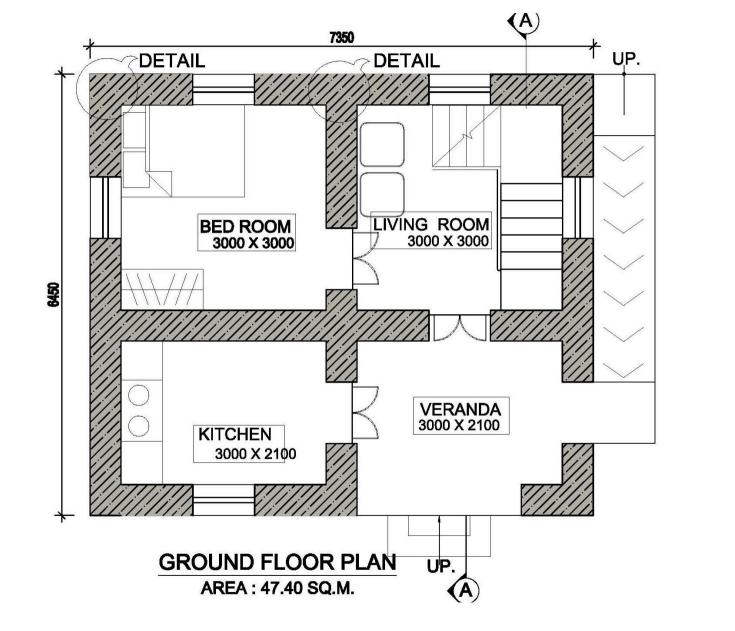


#### CONSTRUCTION MATERIALS AND MANPOWER

	<u>MAN F</u>	OWER	MATERIALS						
<u>LEVEL</u>	<u>Skilled</u>	<u>Unskilled</u>	<u>Stone</u>	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			



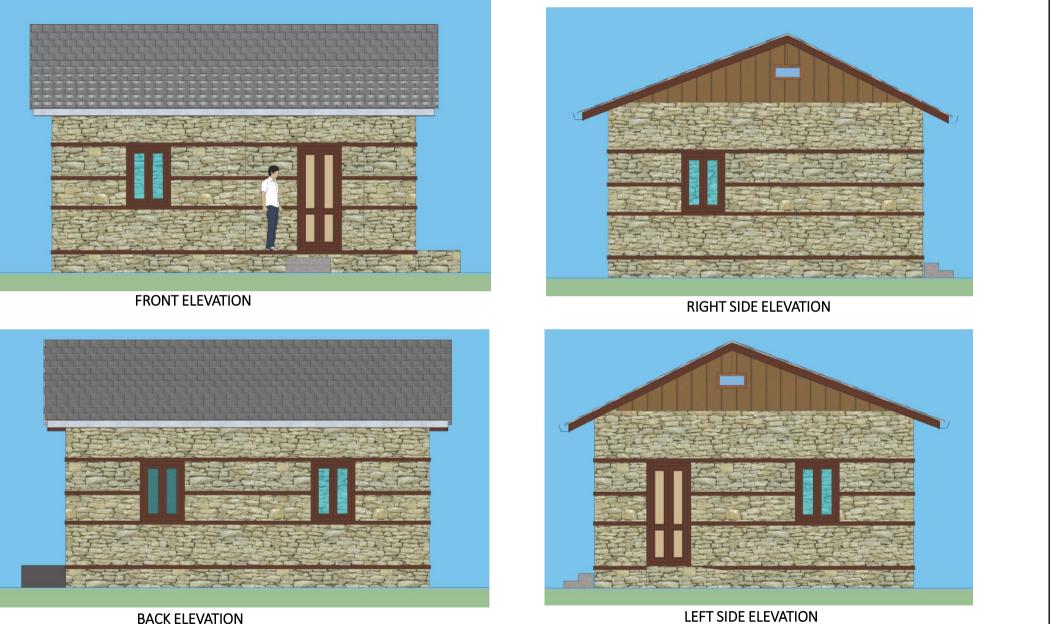
Nepal Housing	TYPE OF HOUSE:	MODELSMM-1.1	SCALE:	NONE	DATE:	SMM-1.1
Reconstruction Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNEI	DUDB	C	1/4



Nepal Housing	TYPE OF HOUSE:	MODEL SMM-1.1	SCALE:	None	DATE:	SMM-1.1
Reconstruction Programme	DRAWING TITLE :	PLAN	DESIGNEI	DUDB	C	2/4

#### Model SMM-1.1: STONE MASONRY IN MUD MORTAR

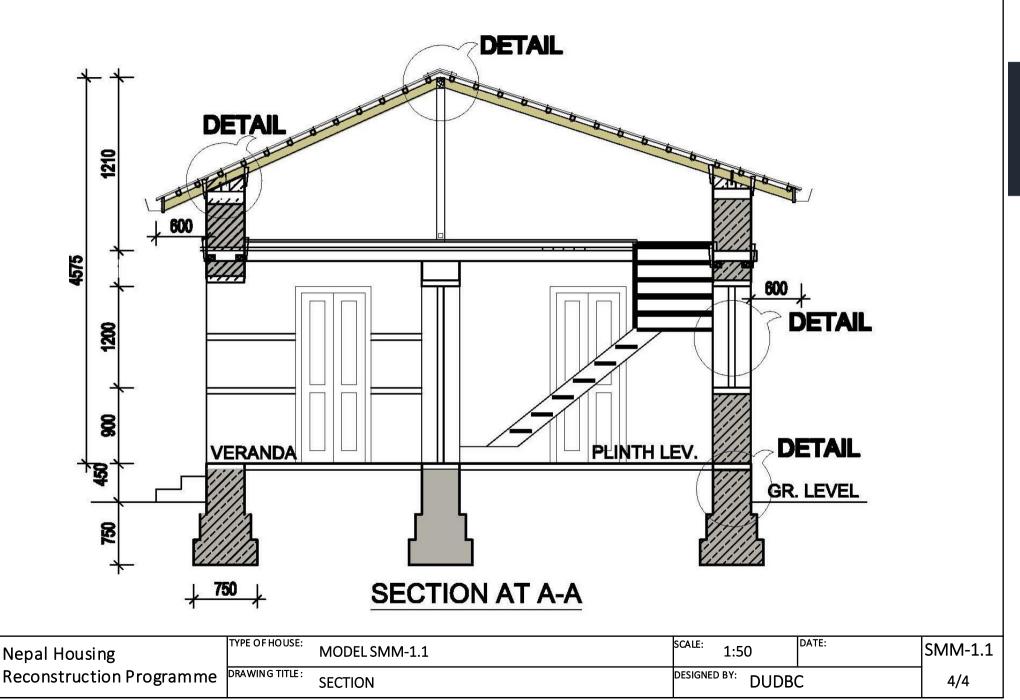
#### **ONE-STOREY**



#### **BACK ELEVATION**

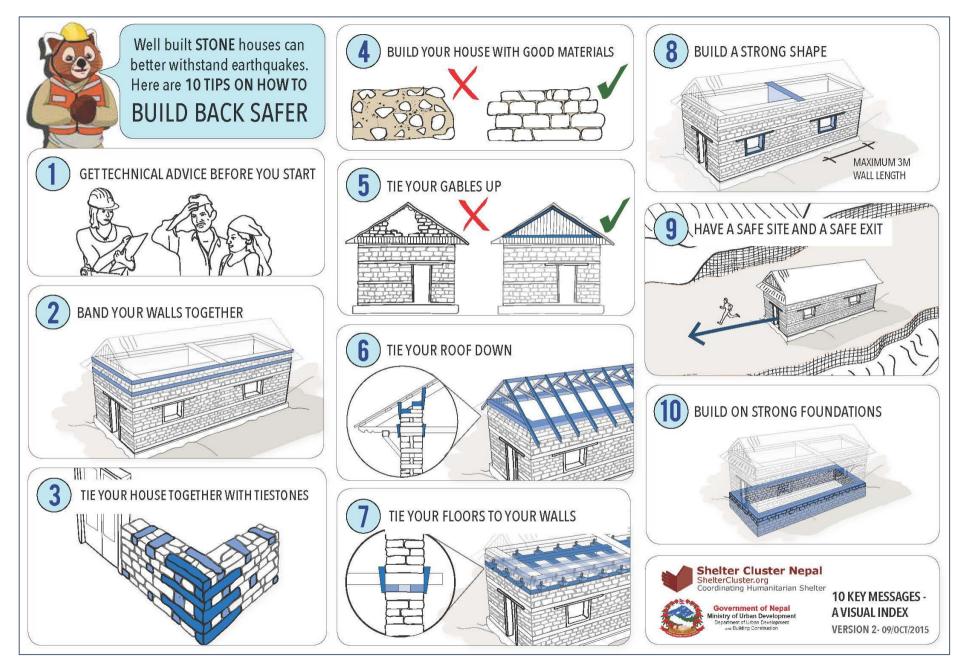
And the second second	

Nepal Housing	TYPE OF HOUSE:	MODELSMM-1.1	SCALE:	None	DATE:	SMM-1.1
Reconstruction Programme	DRAWING TITLE :	ELAVATION	DESIGNE	DUDB	C	3/4



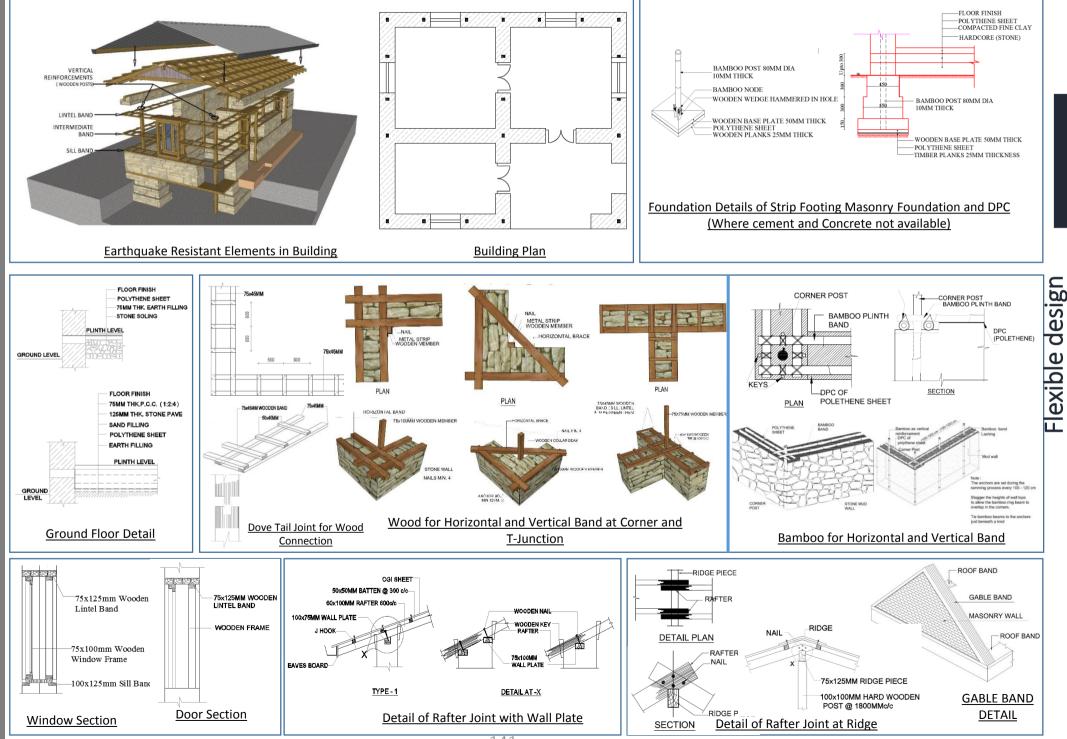
## STONE MASONRY IN MUD MORTAR (SMM)

# **Technical Details**



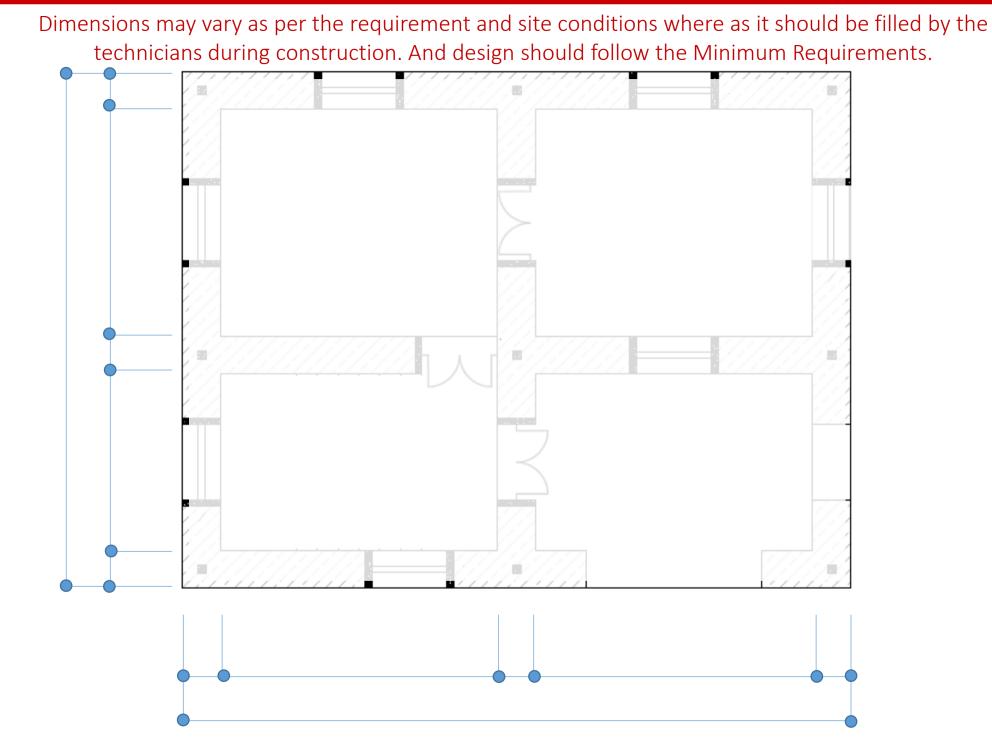
## **10 KEY MESSAGES**

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



Flexible design

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Base drawing for Flexible design

No		uirements (MRs)	for S	tone Masonry in Mud Mortar (NBC203) Page1	No	Minimum Req Category	uirements (MRs)	for S	tone Masonry in Mud Mortar (NBC203) Page2
No.	Category		gamaaaaaa	uilding shall not be constructed if site is: Prone to geological fault or raptured area	~		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.
1	Site Selection		ン ン	Susceptible to landslide Steep slope > 20% Filled area	- 6	Openings	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.
		No. of storeys		River bank and water-logged area Two storey+ attic			Distance between opening	~	Distance between two openings shall be larger of half the height of shorter opening or 600mm.
2	Shape of House		, ,	The house shall be planned square, rectangular. House should not more than 3 times its width.	1_		Lintel level		Keep lintel level same for doors and windows Place vertical steel bars in the wall at all corners, wall junctions and
		General	~	The foundation trench shall be of uniform width. The foundation bed shall be on the same level throughout the foundation in flat area.		Vertical	Location	~	adjacent to all doors and windows. They shall be covered with cement concrete in cavities made around them.
3	Foundation	Depth Width		The depth of footing should be at least 750mm. The width of footing should not be less than 750mm and 800mm respectively for one and two-storeyed houses in medium soil	7	Reinforcement	Reinforcement	r	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.
4	Plinth	General	~	condition. Width depends on soil type. Refer to technical drawings. The top level of plinth should be at least 300mm above existing ground level. Recommended plinth height from the ground is 450mm.			General	v	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
		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					clear cover of 25mm. Where reinforced concrete is not available, timber bands and stitches could be used.
		Joints	~	interlocked. Mortar joints should not be more than 20mm and less than 10mm in thickness.			Plinth band	v	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-
		Though Stone	r	Spacing of through stone shall not be more than 1200mm in the horizontal direction and 600mm in the vertical direction. Seasoned					12 reinforcement. Use 6mm dia. stirrups at 150mm centres.
5	Walls			timber, precast or cast insitu concrete can be used instead of through stone. Maximum length of unsupported wall shall not exceed 12 times its	~		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
		Length of wall	~	thickness. If unsupported length of wall is more than this, buttress shall be provided at an interval not exceeding 12 times wall thickness.	8	Horizontal Band			150mm centres. A continuous lintel band shall be provided through all walls at the top
		Wall thickness	~	The wall thickness should not be less than 350-450mm, 450mm respectively for one and two-storey houses.			Lintel band	~	level of opening. The minimum height is 75mm with 2-12mm bars. Use 6mm stirrups at 150mm centres. Extra thickening should be
		Height of wall	~	The height of wall between floors should not be more than 8 times wall thickness.	]			-	provided where openings are more than 1m wide. Roof band shall be provided at the top of walls, so as to tie the walls at
							Roof band	~	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	r	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.
							Chitagh		The stitches shall be provided at all corners, junctions of walls to

Stitch

✓ strengthen connections. The min. height is 75mm with 2-8mm bars.

Use 6mm dia. Stirrups at 150mm centres.

	Minimum Requ	uirements (MRs) fo	or St	tone Masonry in Mud Mortar (NBC203) Page3
No.	Category			
		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.
9	Roof	Connection	1	All members of the timber truss or joints should be properly connected as shown in technical details.
		Cross-tie	1	Trusses should be properly cross-tied with wooden braces as shown in technical details.
		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.
	Materials	Mortar	V	Mud should be free from organic material and pebbles, etc.
10		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)



## 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)

No.         Category         Anouse shall not be constructed if site is:           1         Site Selection <ul> <li>Site Selection</li> <li>Consecting elogical flatt or raptured area</li> <li>Sitape of House</li> <li>Sitape of House</li></ul>	Mi	nimum Require	quirements (MRs) for	r Bri	for Brick Masonry house in Mud Mortar (NBC203) Page1
Site Selection       Ahoto         Site Selection       No. of story         Shape of       No. of story         Shape of       Proportion         Proportion       No. of story         Nalls       Length of wall         Proportion       No. of story         Proportion       No. of story         Properings       Properings	No.	Category			
Site Selection       No. of story       Image: Constraint of story         Shape of       No. of story       Image: Constraint of story         Shape of       Proportion       Image: Constraint of story         Shape of       Proportion       Image: Constraint of story         Plinth       Bepth       Image: Constraint of story       Image: Constraint of story         Plinth       Bepth       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Walls       Length of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Openings       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Openings       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story       Image: Constraint of story         Image: Constraint of story       Image: Constory       Image: Constraint of story				A hc	use shall not be constructed if site is:
Site Selection       No. of story       Image of the story         Shape of House       No. of story       Image of the story         Shape of House       Proportion       Image of the story         Plinth       General       Image of the story       Image of the story         Plinth       General       Image of the story       Image of the story       Image of the story         Nulls       Depth       General       Image of the story       Image of the story       Image of the story         Nulls       Length of wall       Image of the story         Openings       Distance between       Image of the story       Image of the story </td <td></td> <td></td> <td></td> <td>2</td> <td>Prone to geological fault or raptured area</td>				2	Prone to geological fault or raptured area
Non-off story     Non-off story       Shape of House     Non-off story     Image: Control       Shape of House     Non-off story     Image: Control       Shape of House     Proportion     Image: Control       Pinth     Bepth     Image: Control       Plinth     General     Image: Control       Nalls     Length of wall     Image: Control       Valls     Length of wall     Image: Control       Openings     Distance between     Image: Control       Distance between     Distance between     Image: Control	~	cito coloction		3	Susceptible to landslide
No. of story $         Shape of House       No. of story                Proportion       Proportion                House       General                Foundation       Width                Plinth       General                Valls       Length of wall                Valls       Length of wall                Openings       Total length                Openings       Total length                Distance between       Distance between        $	-	אור אבוברווחו		2	Steep slope > 20%
No. of story        Shape of House     No. of story        Proportion     Proportion        House     General        Pointh     General        Plinth     General        Nalls     Length of wall        Valls     Nall thickness        Openings     Total length        Dintel level     Distance between			·········	3	Filled area
Shape of House       No. of story $         House       Proportion                Proportion       Bepth                Poundation       Midth                Plinth       General                Valls       General                Valls       Length of wall                Valls       Length of wall                Plinth       General                Valls       Length of wall                Valls       Length of wall                Plinth       Length of wall                Valls       Location                 Vall thickness       Location                 Vall thickness                   Vall thickness               <$				2	River bank and water-logged area
Jundpe of House     Proportion     Image of General       Foundation     General     Image of Seneral       Plinth     General     Image of Seneral       Valls     General     Image of Seneral       Valls     Length of wall       Vobenings     Location       Interleven     Image of Seneral		chana of	No. of story	2	Two storey +attic
Foundation     Repth       Foundation     General       Foundation     width       Plinth     General       Plinth     General       Valls     Length of wall       Vall thickness     Malls       Location     Mall       Dopenings     Distance between       Distance between     Distance between	2		Droportion		The house shall be planned square, rectangular. Avoid long and
Foundation     General        Foundation     width        Plinth     General        Plinth     General        Valls     Joints        Valls     Length of wall        Valls     Location        Openings     Total length        Distance between     Distance between		nouse	Proportion	2	narrow house. The house should not be more than 3 times its
Foundation     Depth        Foundation     width        Plinth     General        Nalls     Joints        Walls     Length of wall        Nalls     Length of wall        Dopenings     Location        Distance between     Distance between					The foundation trench shall be of uniform width. The foundation bed
Foundation       Depth $\checkmark$ Width       width $\checkmark$ Plinth       General $\checkmark$ Plinth       General $\checkmark$ Vall       Joints $\checkmark$ Walls       Length of wall $\checkmark$ Vall thickness $\checkmark$ $\checkmark$ Openings       Location $\checkmark$ Distance between $\checkmark$ $\checkmark$ Distance between       Distance between $\checkmark$ Distance between $\checkmark$ $\checkmark$			פנובופו	2	shall be on the same level throughout the foundation in flat area.
Foundation     width       Plinth     General       Plinth     General       Nalls     Joints       Walls     Length of wall       Walls     Length of wall       Openings     Location       Distance between     Openings       Distance between     Distance between	ſ	• • • • • • • • • • • • • • • • • • •	Depth	2	The depth of footing should be at least 750mm.
Width     Width       Plinth     General       Reneral     Ceneral       General     Ceneral       Joints     Joints       Valls     Length of wall       Valls     Length of wall       Vall thickness     Coention       Joints     Coention       Distance between     Copenings       Distance between     Copenings       Distance between     Copenings       Distance between     Copenings	n				The width of footing should not be less than 650mm and 750mm
Plinth     General        Plinth     General        Reading     General        Malls     Joints        Walls     Length of wall        Wall thickness        Plinth     Location       Openings     Distance between       Distance between        Distance between			Width	7	respectively for one and two-storey houses in medium soil
Plinth     General       Plinth     General       Seneral     Seneral       General     Seneral       Joints     Seneral       Valls     Length of wall       Valls     Seneral       Vall thickness     Seneral       Openings     Total length       Distance between     Sistance between       Distance between     Sistance between					condition. Width depends on soil type. Refer to technical drawings.
Plinth     General        General     General        General     General        Valls     Length of wall        Walls     Length of wall        Valls     Length of wall        Openings     Location        Distance between     Openings     Distance between       Distance between     Openings        Lintel level					The top level of plinth should be at least 300mm above existing
Malls     General        General     General        Joints     Joints        Walls     Length of wall        Malls     Length of wall        Denings     Total length        Distance between        Distance between        Lintel level	4	Plinth	General	7	ground level. Recommended plinth height from the ground is
General     General       General     Ioints       Joints     Joints       Valls     Length of wall       Walls     Wall thickness       Mall thickness     Mall thickness       Peight of wall     Mall       Iocation     Mall       Openings     Distance between       Distance between     Mall       Intel level     Mall					450mm.
General     General       Joints     Joints       Walls     Length of wall       Wall thickness        Peight of wall        Total length        Openings     Distance between       Distance between        Lintel level					Masonry should be laid staggered to avoid formation of continuous
Valls     Joints        Joints     Joints        Walls     Length of wall        Walls     Wall thickness        Vall thickness         Distance between         Distance between         Distance between         Lintel level				`	vertical joint. At corners or wall junctions, continuous vertical joints
Walls     Joints        Valls     Length of wall        Wall thickness        Mall thickness        Deenings     Total length       Distance between        Distance between        Lintel level			General	2	should be avoided by properly laying the masonry. The walls should
Walls     Joints     Image: Constraint of the second secon					be interlocked.
Walls Length of wall Length of wall Valls Length of wall Length of wall thickness Vall the value of the valu			-	•	Mortar joints should not be more than 20mm and less than 10mm
Walls     Length of wall       Length of wall       Wall thickness       Wall thickness       Wall thickness       Location       Openings       Distance between       Distance between       Distance between       Distance between       Lintel level			Joints	2	in thickness.
Vod115 Length of wall Length of wall Height of wall Location Copenings Distance between Distance between Distance between Distance between Distance between	L	11.0			Maximum length of unsupported wall shall not exceed 12 times its
Under Build of Wall thickness       Wall thickness       Wall thickness       Wall thickness       Height of Wall       Location       Distance between       Openings       Distance between       Distance between       Lintel level	r	2110			thickness. If unsupported length of wall is more than this, buttress
Wall thickness        Wall thickness        Height of wall        Location        Openings     Total length       Distance between        Distance between        Lintel level			Lengun ol wall		shall be provided at an interval not exceeding 12 times wall
Wall thickness     Image: Construction of the sector of the					thickness.
Wait underess     Wait underess       Height of wall     Image: Constraint of the second of the sec			Muall thickness		The thickness of the wall should not be less than 230mm, 350mm
Height of wall        Height of wall        Incation        Dpenings        Distance between        Distance between        Intel level				>	respectively for one-storey and two-storey plus attic house.
Openings     Total length       Distance between        Intel level			Height of wall	3	The height of wall between floors should not be more than 12 times
Location        Openings     Total length       Distance between        openings        Lintel level					wall thickness.
Openings     Total length       Distance between        Openings        Lintel level			l ocation	3	Openings are to be located away from inside corners by 1/4 of the
Openings     Total length        Distance between        openings        Lintel level			LOCATION		height of the adjoining opening, but not less than 600 mm.
Openings Distance between openings Distance between openings			Total langth	3	Total length of opening should be less than 0.3 and 0.25 of
etween	9	Openings	59		individual wall length respectively for one and two-storey house.
> >			Distance between	3	Distance between two openings shall be larger of half the height of
7			openings		shorter opening or 600mm.
			Lintel level	2	Keep lintel level same for doors and windows

	Minimum Reg	n Requirements (MRs) for	for	Brick Masonry in Mud Mortar (NBC203) Page2
No.	Category			
				Place vertical steel bars in the wall at all corners, wall junctions and
		Location	7	adjacent to all doors and windows. They shall be covered with
	Vertical			cement concrete in cavities made around them.
2	Reinforcemen			At corners and junctions vertical reinforcing bar should be 12mm for
	t	Reinforcement	3	one storey, and 16 mm in the ground floor and 12mm in the upper
			2	storey in case of two storey house. At jambs, the reinforcing bars
				should be 12mm.
				Horizontal reinforced concrete bands should be provided
				throughout the entire wall with minimum thickness of 75 to 150 mm
			2	at following locations. Minimum width of bands should be equal to
		ספופו	2	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.
				A continuous plinth band shall be provided through all walls at the
				plinth level. The minimum height is 75mm with 2-12 reinforcing bars
			2	for hard soil. In case of soft soil, band should be 150mm high with 4-
				12 reinforcement. Use 6mm dia. stirrups at 150mm centers.
				A continuous sill band shall be provided through all walls at the
		כנון איזייל	2	bottom level of opening (specially windows). The minimum height is
			>	75mm with 2-10 reinforcing bars. Use 6mm diameter stirrups at
				150mm centres.
o	Horizontal			A continuous lintel band shall be provided through all walls at the
0	Band			top level of opening. The minimum height is 75mm with 2-12mm
		בווונבו ממוומ	2	bars. Use 6mm stirrups at 150mm centres. Extra thickening should
				be provided where openings are more than 1m wide.
				Roof band shall be provided at the top of walls, so as to tie the walls
		Roof hand	2	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.
				Masonry gable wall must have the triangular portion of masonry
				enclosed in a reinforced concrete band. The minimum height of band
		Gable band	7	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.
				The stitches shall be provided at all corners, junctions of walls to
		Stitch	7	strengthen connections. The min. height is 75mm with 2-8mm bars.
				Use 6mm dia. Stirrups at 150mm centres.

No.       Category       Use light roof comprising of woo         9       Ught roof       Use light roof comprising of woo         9       Roof       Usht roof       Use light roof comprising of woo         9       Roof       Light roof       Mud should be avoided.         9       Roof       Connection       All members of the timber truss of the timber trus of the timber true of the timber true of the timber true of the true of the timber true of the true of true of the true of t		Minimum Requ	uirements (MRs) for	Requirements (MRs) for Brick Masonry in Mud Mortar (NBC203) Page3
Roof Light roof Roof Connection Cross-tie Mortar Mortar Brick Brick Brick Reinforcement	No.	Category		
Roof Light roof Connection Cross-tie Cross-tie Timber Mortar Mortar Brick Concrete				Use light roof comprising of wooden or steel structure covered with
Roof     Connection       Consectie        Cross-tie        Timber        Materials     Brick       Concrete        Reinforcement				$oldsymbol{ u}$  ight roofing materials. Heavy roofing materials such as stone slabs or
Roof     Connection       Cross-tie        Cross-tie        Timber        Materials     Brick       Concrete        Reinforcement				mud should be avoided.
Cross-tie Cross-tie Timber Materials Brick Concrete Reinforcement	6	Roof	Connoction	All members of the timber truss or joints should be properly
Cross-tie Timber Materials Brick Concrete Reinforcement				connected as shown in technical details.
Materials Brick Concrete Concr				Trusses should be properly cross-tied with wooden braces as shown
Timber     Timber       Mortar     Image: Concrete       Brick     Image: Concrete       Concrete     Image: Concrete       Reinforcement     Image: Concrete				in technical details.
Timber     Timber       Mortar     K       Materials     Brick       Concrete     K       Reinforcement     K				Well seasoned hard wood / local wood without knots should be used
Mortar Materials Brick Concrete				for strctural purpose. Timber treatment such as use of coal tar or any
Mortar Materials Brick Concrete Reinforcement				other preservative can prevent timber from being decayed and
Mortar Materials Brick Concrete				attacked by insects.
Materials Brick Concrete Reinforcement				Mud should be free from organic material and pebbles, etc.
C C	10	Materials		Brick should be class A1 or A2 with compressive strength not less
<b>K</b>				than 3.5N/sqmm.
iment C			Concrete	The concrete mix for seismic bands should not be leaner than 1:2:4
2				(1 part cement, 2 parts sand and 4 parts aggregate)
2				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**

#### Model BMM-1.1: BRICK MASONRY IN MUD MORTAR



#### CONSTRUCTION MATERIAL AND MANPOWER

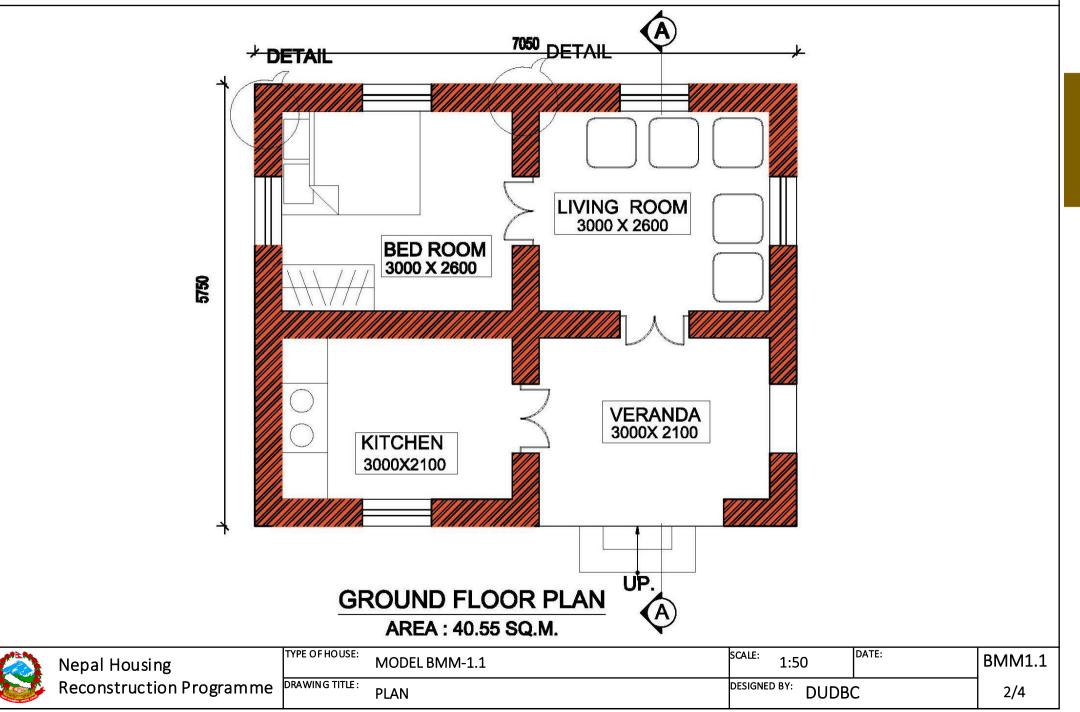
	<u>MAN P</u>	<u>OWER</u>		M	IATERIALS		
<u>LEVEL</u>	Skilled	Unskilled	Brick	Mud	WOOD	CGI SHEET	GI SHEET
	Md	Md	Nos	Cu.m.	Cu.m.	Bundel	Rm
Up to Plinth Level	38	57	9876	25	1.11	0	0
Ground Floor	66	46	13642	10	1.14	0	0
ROOFING	35	13	0	0	1.62	4	10
TOTAL	139	115	23518	35	3.87	4	10



Nepal Hou	sing	TYPE OF HOUSE:	MODEL BMM-1.1	SCALE:	NONE	DATE:	BMM-1.1
Reconstruction	tion Programme	DRAWING TITLE :	PERSPECTIVE AND ESTIMATION	DESIGNED	BY: DUDB	0	1/4

#### Model BMM-1.1: BRICK MASONRY IN MUD MORTAR

#### **ONE-STOREY**



### Model BMM-1.1: BRICK MASONRY IN MUD MORTAR

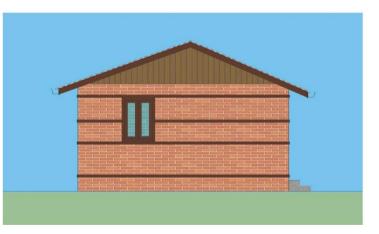


FRONT ELEVATION

BACK ELEVATION



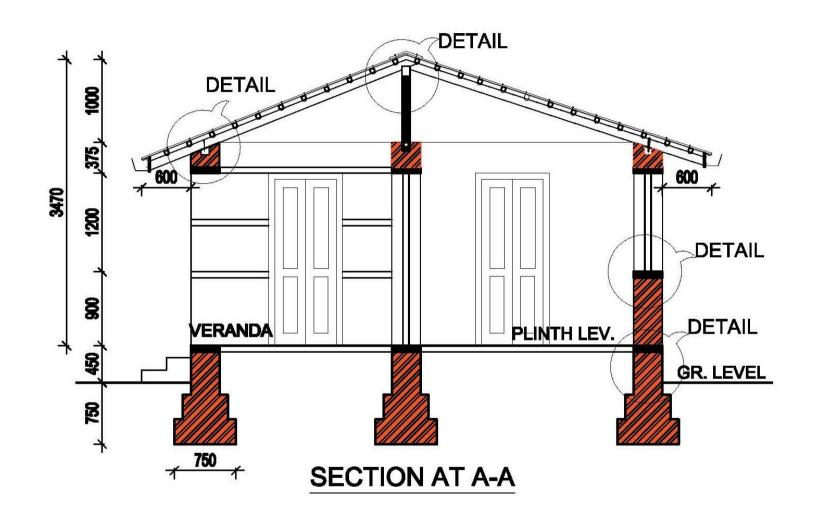
**RIGHT SIDE ELEVATION** 



LEFT SIDE ELEVATION



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





Nepal Housing	TYPE OF HOUSE:	MODEL BMM-1.1	SCALE:	1:50	DATE:	BMM-1.1
Reconstruction Programme	DRAWING TITLE :	SECTION	DESIGNED	<sup>BY:</sup> DUDB	C	4/4

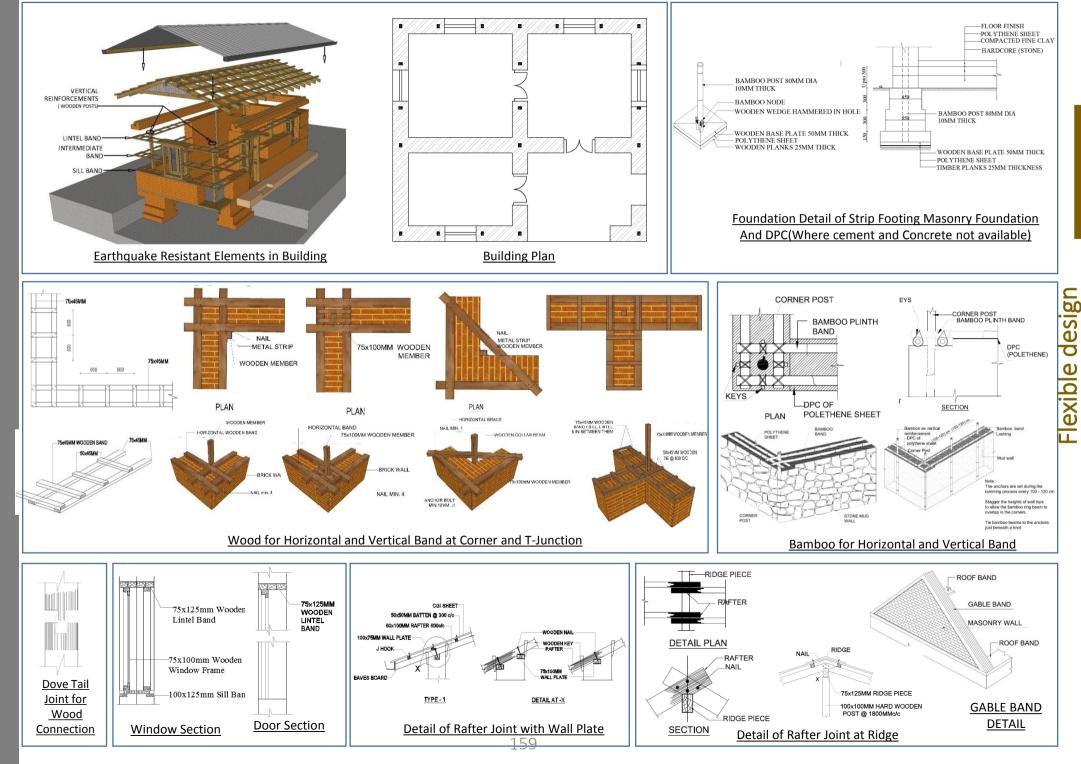
## BRICK MASONRY IN MUD MORTAR (BMM)

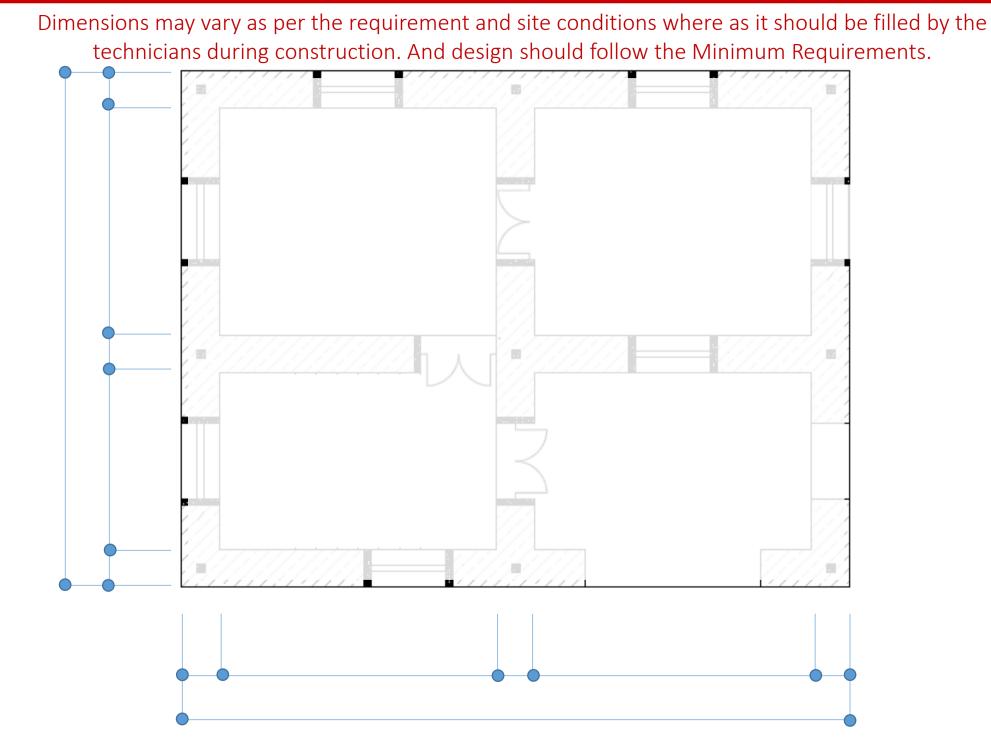
## **Technical Details**



## **10 KEY MESSAGES**

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





Flexible design

Mi	nimum Require	ements (MRs) fo	r Bri	ck Masonry house in Mud Mortar (NBC203) Page1
No.	Category			
			Aho	buse shall not be constructed if site is:
			~	Prone to geological fault or raptured area
1	Site Selection		~	Susceptible to landslide
1	Site selection		~	Steep slope > 20%
			V	Filled area
			V	River bank and water-logged area
	Shape of	No. of story	~	Two storey +attic
2	House	Dresseties	~	The house shall be planned square, rectangular. Avoid long and
	House	Proportion	V	narrow house. The house should not be more than 3 times its
		General	~	The foundation trench shall be of uniform width. The foundation bed
		General	V	shall be on the same level throughout the foundation in flat area.
3	Foundation	Depth	~	The depth of footing should be at least 750mm.
3	Foundation			The width of footing should not be less than 650mm and 750mm
		Width	V	respectively for one and two-storey houses in medium soil
				condition. Width depends on soil type. Refer to technical drawings.
				The top level of plinth should be at least 300mm above existing
4	Plinth	General	~	ground level. Recommended plinth height from the ground is
				450mm.
				Masonry should be laid staggered to avoid formation of continuous
		General	~	vertical joint. At corners or wall junctions, continuous vertical joints
		General	V	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
		JOINES	V	in thickness.
5	Walls			Maximum length of unsupported wall shall not exceed 12 times its
5	vvalis	Length of wall		thickness. If unsupported length of wall is more than this, buttress
		Length of wall		shall be provided at an interval not exceeding 12 times wall
				thickness.
		Wall thickness 🖌	1	The thickness of the wall should not be less than 230mm, 350mm
			V	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
		neight of wall		wall thickness.
		Location	~	Openings are to be located away from inside corners by 1/4 of the
				height of the adjoining opening, but not less than 600 mm.
		Total length	~	Total length of opening should be less than 0.3 and 0.25 of
6	Openings		ľ	individual wall length respectively for one and two-storey house.
1		Distance between	~	Distance between two openings shall be larger of half the height of
		openings	~	shorter opening or 600mm.
		Lintel level	~	Keep lintel level same for doors and windows

	Minimum Requ	uirements (MRs	) for	Brick Masonry in Mud Mortar (NBC203) Page2
No.	Category			
	Vertical	Location	8	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.
7	Reinforcemen t	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.
		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.
	8 Horizontal Band	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.
8		Lintel band	8	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	8	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 Requ	uirements (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	V	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	V	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

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#### DESIGN CATALOGUE FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

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