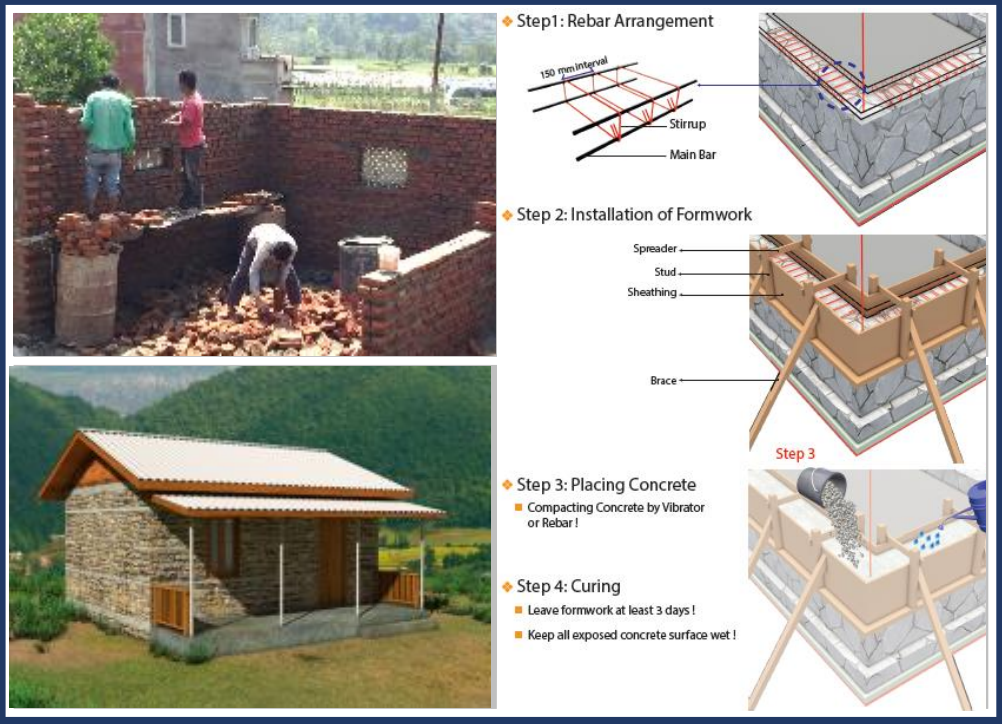
TECHNICAL HANDBOOK FOR

RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Supporting Compliance with the National Building Code, Nepal

For masons
and craftsmen



May, 2016

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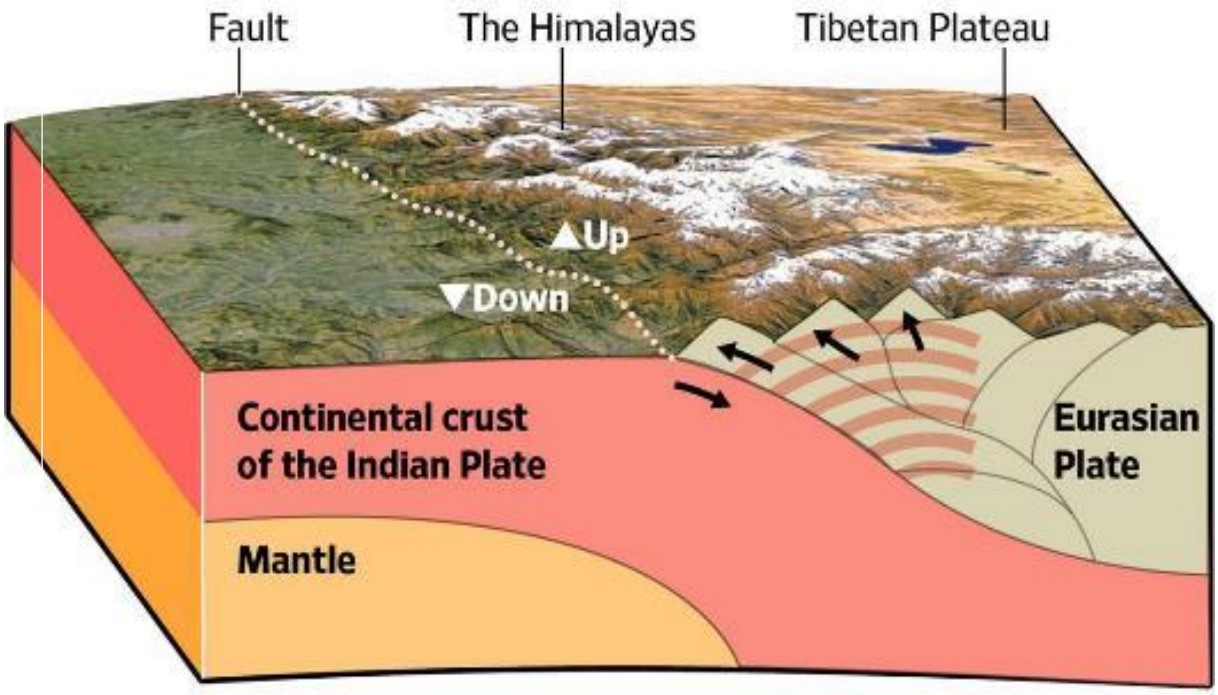
Japan International Cooperation Agency

Table of contents

Introduction

Nepal is located in a seismic area from time to time earthquake occur which affect inadequately constructed houses, causing major damage and in many case partial or total collapse.

Location of Nepal



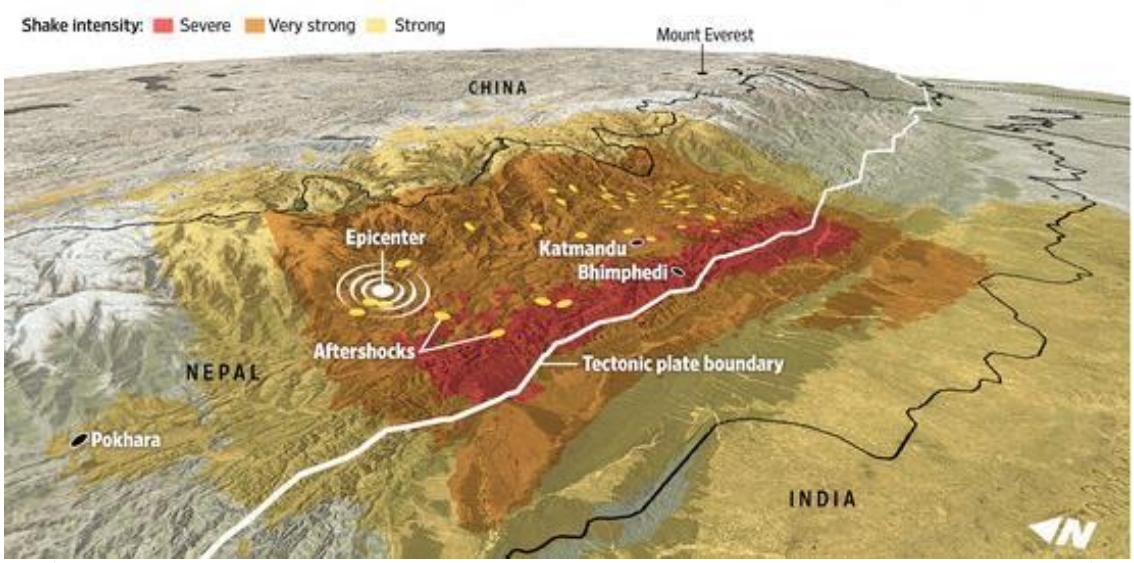
Source: USGS; Google Earth

As the Indian subcontinent pushes against Eurasia, pressure is released in the form of earthquakes. The constant crashing of the two plates forms the Himalayan mountain range.

An earthquake with a magnitude of 7.8 (*Mw*) struck at 11:56 NST, (local time) on 25 April 2015, in the central part of Nepal (Gorkha).

The epicenter was east-southeast of Lamjung, 77 km south-west of Kathmandu, the depth was 15 km (USGS).

According to the statistics by The Nepal Police on 22 June the number of deaths 8,660 and injured 21,952 for the main shock and deaths 172 and injured 3,470 for the aftershock. It was also reported that more than 5,000,000 buildings and houses were damaged and about half of those had collapsed.



Source: U.S. Geological Survey

Typical damage of masonry structure

The following are the main ways in which such masonry structure are seen to be damage.

Separation of walls

Separation of walls at corners and T-Junctions takes place due to poor connection between the walls.

Delamination of wall

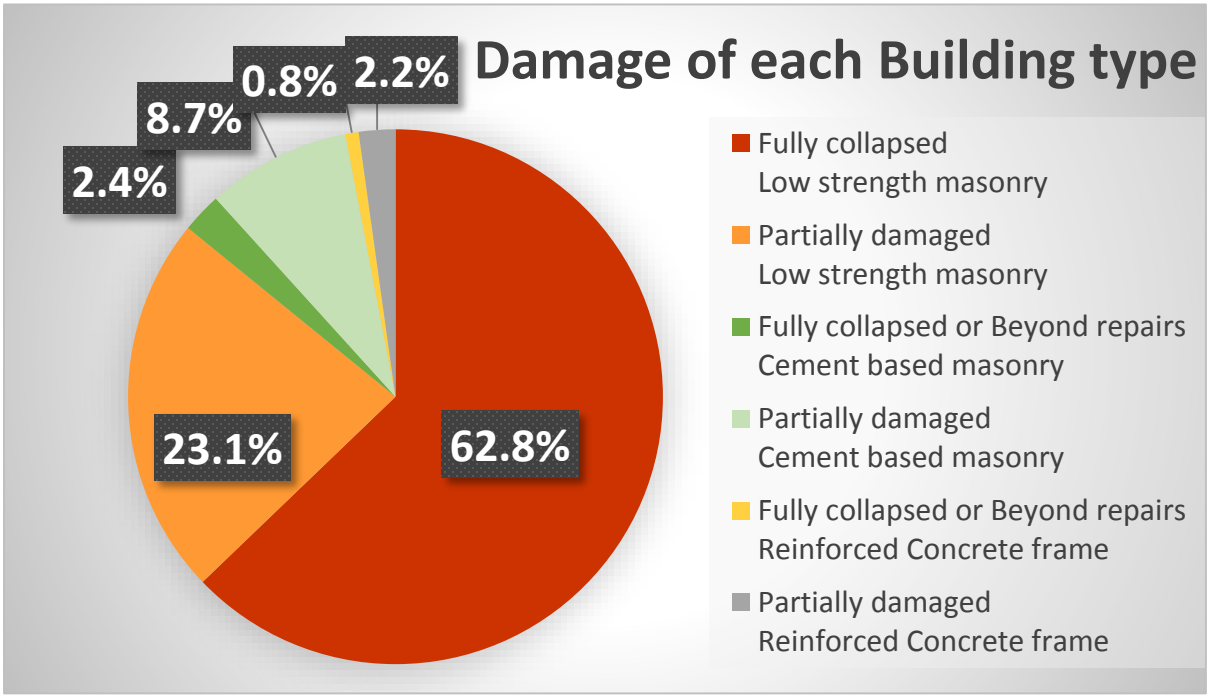
Delamination of wall is vertical separation of internal stone and external stone through middle of wall thickness, this occurs due to mainly to the absence of bonding elements and weak mortar filling in stone masonry wall.

Gable wall collapse

In case of gable wall the triangular of wall has no restraint. Hence, when the force is in perpendicular direction it shakes excessively. Under such pull and push a crack develops. In heavy shaking it can also collapse.

Advantage of cement mortar

The large-scale destruction of housing resulted primarily from the seismic vulnerability of un-reinforced masonry houses that predominate throughout the country. Most houses (85.9% of all housing construction) are low strength masonry stone or brick masonry with mud mortar, without seismic-resilient features.
Figures show the number of houses damaged in 31 districts.



Advantage of cement mortar

Mortar is a paste prepared by adding required quantity of water to a mixture of binding material like cement and fine aggregate like sand.
Depending on the kinds of binding materials used, there are five categories of mortars :Lime Mortar, surkhi Mortar, Gauged Mortar, Gypsum mortar, Cement mortar.
Mortars can also be classified based on nature of application:

- **Brick laying mortars**-used for brickwork and walls.
- **Finishing mortars**-used for developing architectural or ornamental features in a structure.

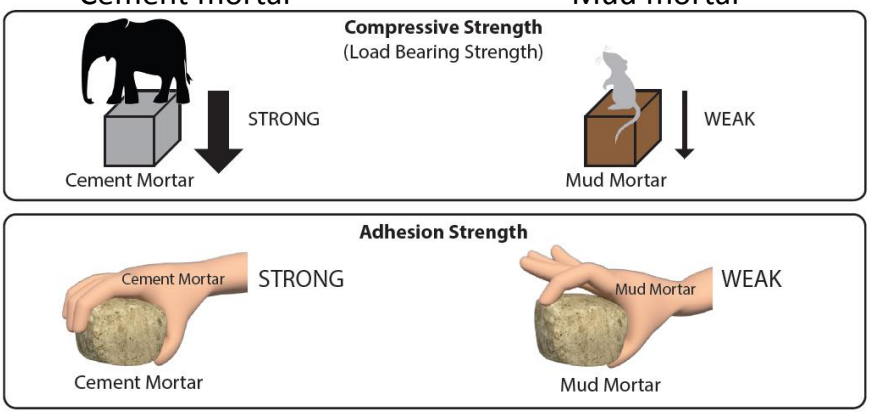
Among all mortars cement mortar has proved its capability to develop good adhesions with the building units such as brick, stone etc. since tensile and shear strength are important properties for seismic resistant, use of mud or very lean mortars is unsuitable in compare to cement mortar. Cement mortar helps to carry the weight placed on the wall and seal the joints where it has a high degree of impermeability and is more prone to shrinkage than others mortar.

Advantages of cement mortar over other mortars:

- It gives strength to masonry.
- It is an excellent binding material.
- It is easily workable.
- It offers good resistance to moisture
- It possess good plasticity.
- It hardens early and starts gaining strength in around 10 hours.

Cement mortar

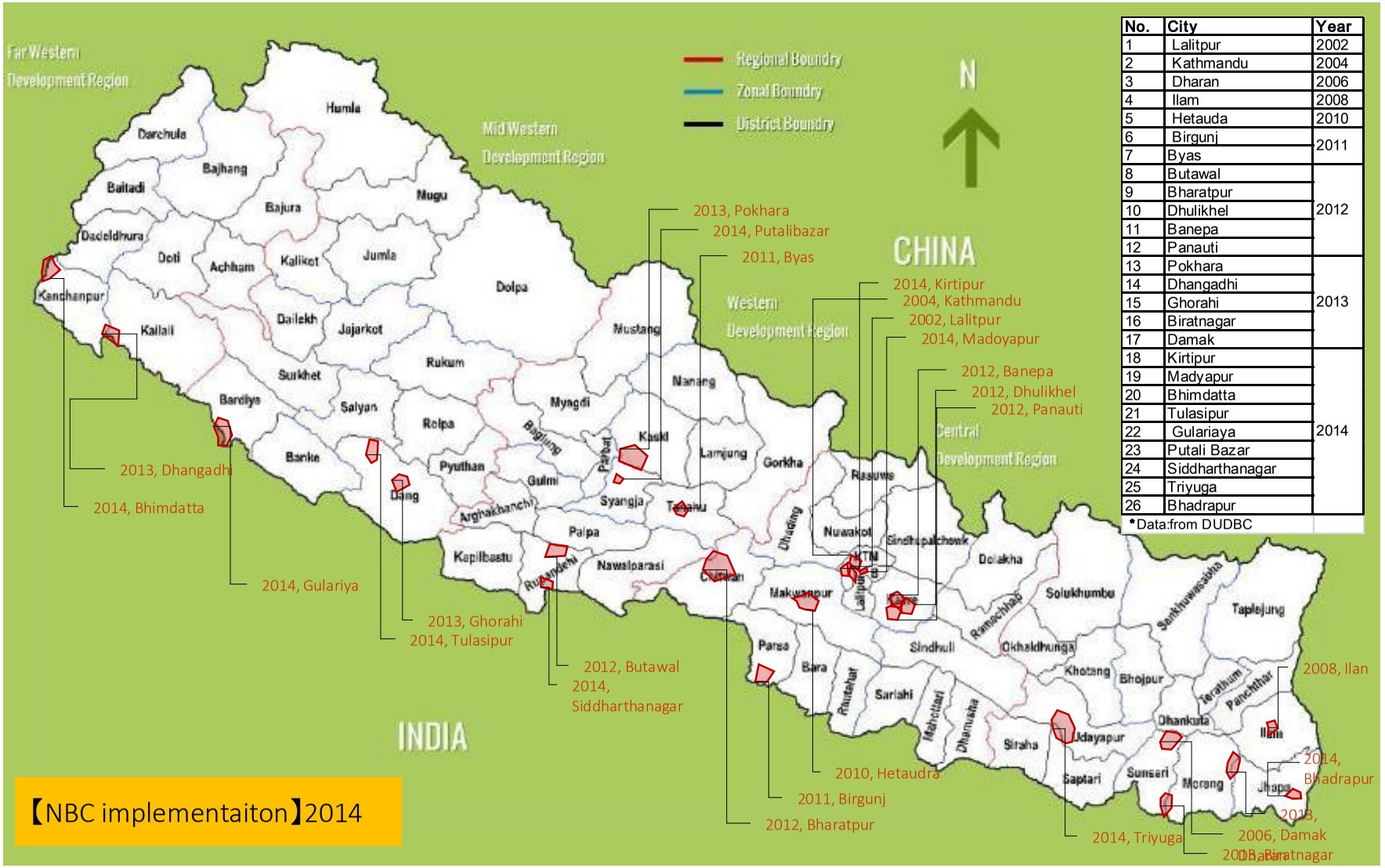
Mud mortar



National Building Code, Nepal (NBC)

The Department of Urban Development and Building Construction (DUDBC) of the Ministry of physical planning and works (MPPW) developed the Nepal National Building Code (NBC) in 1993. Improvement Committee(established by the Building Act 1998)authorized MPPW to implement the code. The Ministry published a notice in the Gazette in 2006 and the implementation of NBC became mandatory in all Municipalities and some Village Development Committees(VDCs) in Nepal.

Code Number	Code Title
NBC 000:1994	Requirements for State-of-the –Art Design :An introduction
NBC 101: 1994	Materials Specifications
NBC 102: 1994	Unit Weight of Materials
NBC 103: 1994	Occupancy Load
NBC 104: 1994	Wind Load
NBC 105: 1994	Seismic Design of Building in Nepal
NBC 106: 1994	Snow Load
NBC 107: 1994	Provisional Recommendation on Fire Safety
NBC 108: 1994	Site Consideration for Seismic Hazards
NBC 109: 1994	Masonry : Unreinforced
NBC 110: 1994	Plain and Reinforced Concrete
NBC 111: 1994	Steel
NBC 112: 1994	Timber
NBC 113: 1994	Aluminum
NBC 114: 1994	Construction Safety
NBC 201: 1994	Mandatory Rules of Thumb: Reinforced Concrete Building with Masonry Infill.
NBC 202: 1994	Mandatory Rules of Thumb: Load Bearing Masonry
NBC 203: 1994	Guidelines for Earthquake Resistant Building Construction : Low Strength Masonry
NBC 204: 1994	Guidelines for Earthquake Resistant Building Construction : Earthen Building (EB)
NBC 205: 1994	Mandatory Rules of Thumb: Reinforced Concrete Buildings Without Masonry Infill.
NBC 206: 2003	Architectural Design Requirements
NBC 207: 2003	Electrical Design Requirements for (Public Building)
NBC 208: 2003	Sanitary and Plumbing Design Requirements



No.	City	Year
1	Lalitpur	2002
2	Kathmandu	2004
3	Dharan	2006
4	Ilam	2008
5	Hetauda	2010
6	Birgunj	2011
7	Byas	
8	Butawal	2012
9	Bharatpur	
10	Dhulikhel	
11	Banepa	
12	Panauti	
13	Pokhara	2013
14	Dhangadhi	
15	Ghorahi	
16	Biratnagar	
17	Damak	
18	Kirtipur	2014
19	Madyapur	
20	Bhimdatta	
21	Tulasipur	
22	Gulariaya	
23	Putali Bazar	
24	Siddharthanagar	
25	Triyuga	
26	Bhadrapur	

*Data:from DUDBC

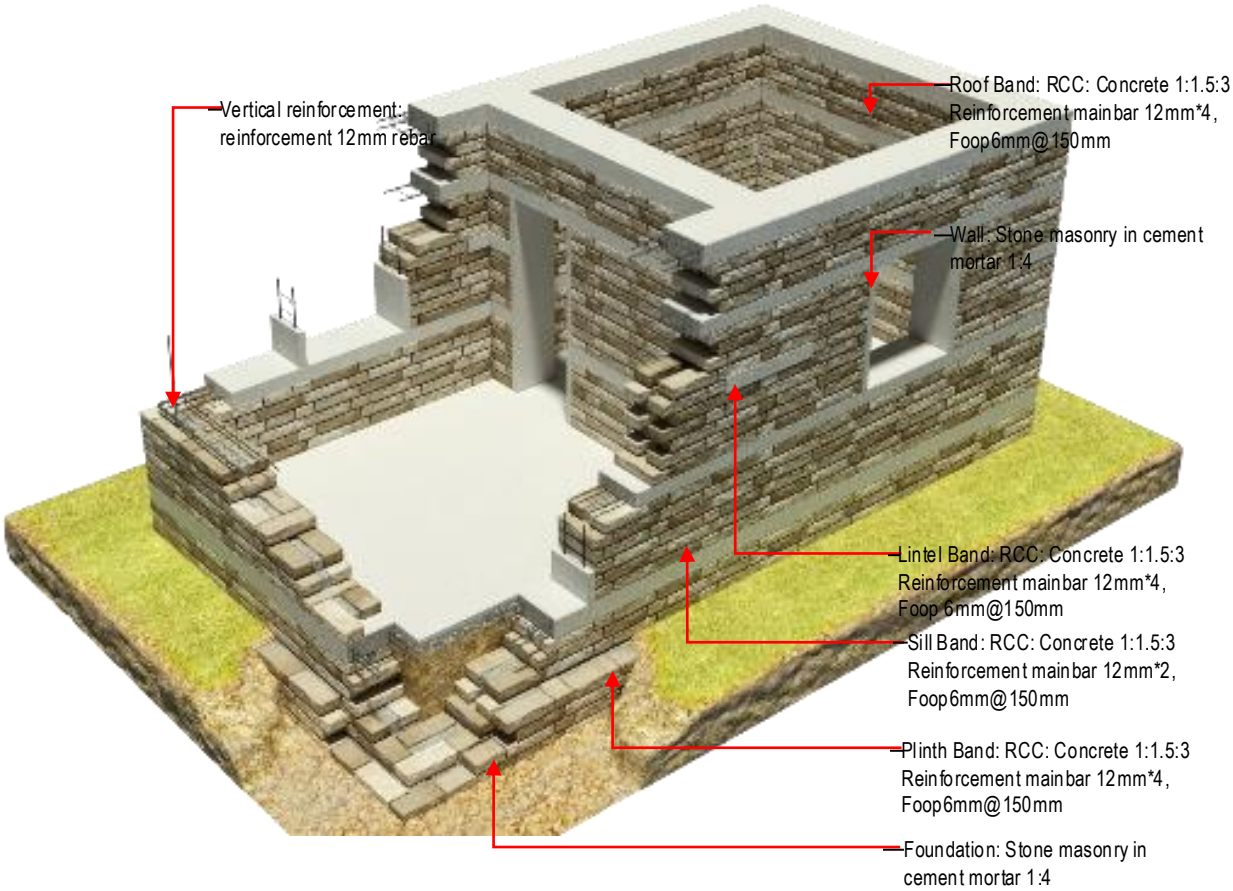
【NBC implementaiton】2014

The earthquake resistant house

6. Earth resistant house

6.1 Main components

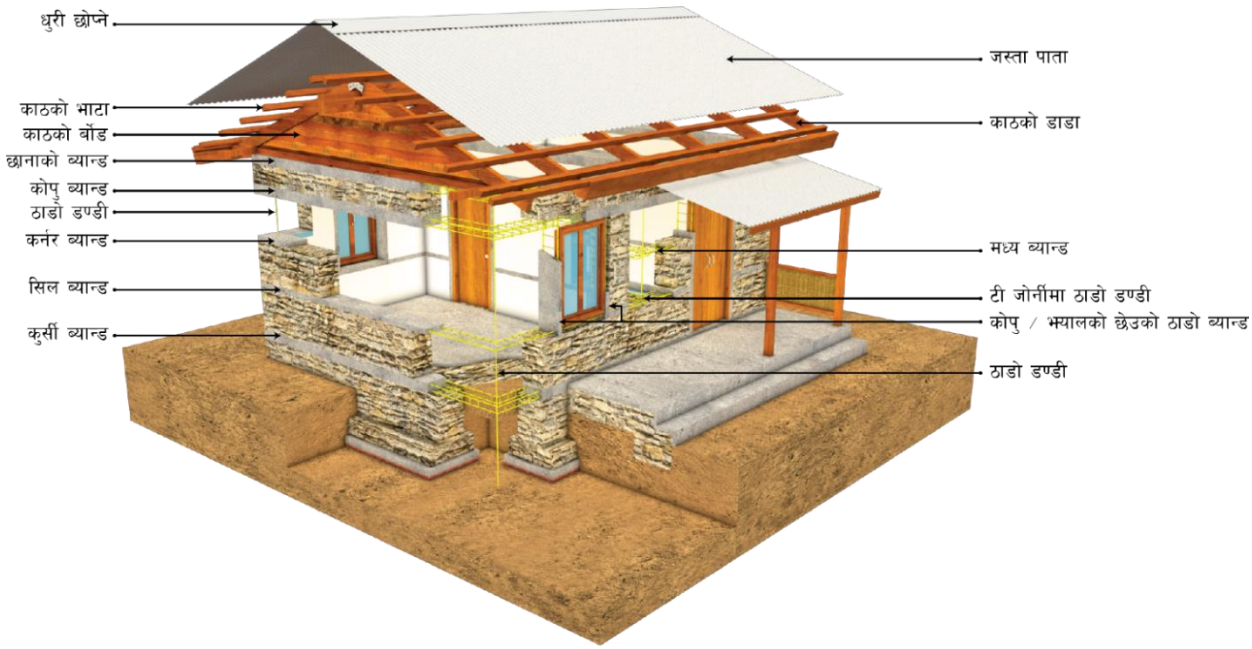
Earthquake resistance structures are designed to withstand earthquakes, while no structure an be entirely immune to damage from earthquakes. To construct earthquake resistant building number of factors such as site selection, shape of house, foundation, plinth, wall, opening, vertical reinforcement, horizontal band, roof, construction materials should be considered. The details of the seismic elements at different level of the buildings are clearly shown in the figure.



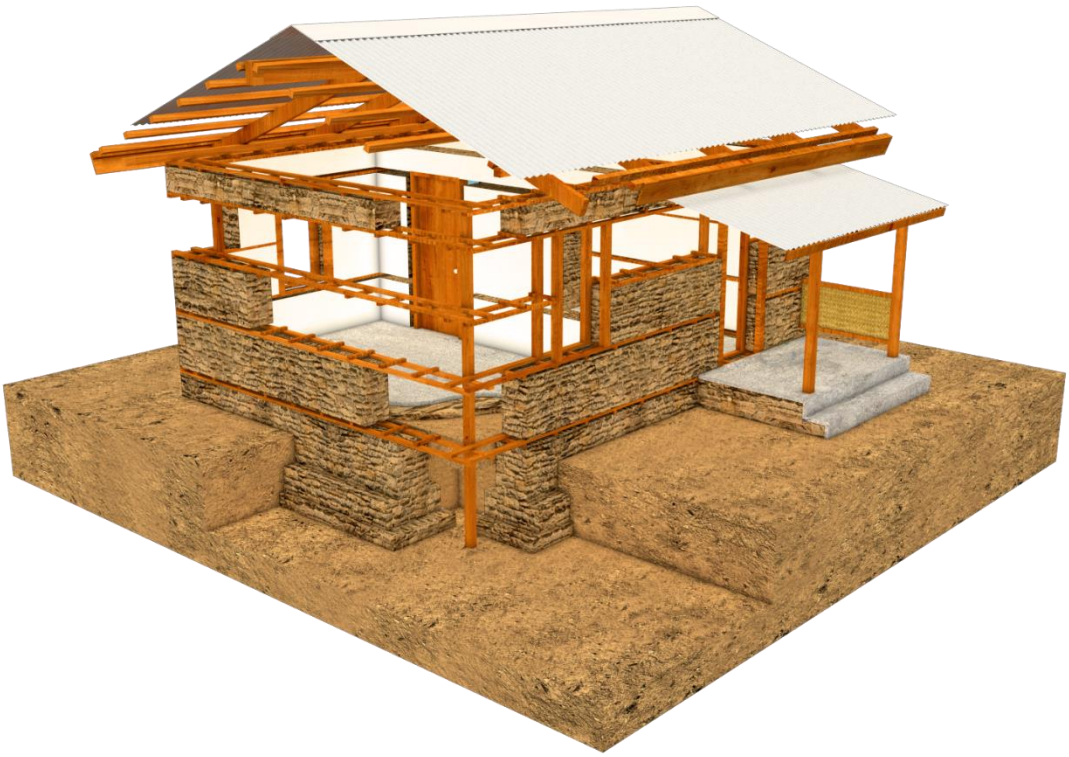
Technology for Earthquake Resistant Building Construction (Stone in Cement Mortar)

Seismic horizontal band:

A continuous band, also called 'ring beam' is a RC band at different levels in all walls of the building for tying walls together to enhance box action. It improves horizontal bending resistance thereby preventing out-of-plane collapse of walls. It also helps to prevent shrinkage, temperature and settlement cracks.



Stone in cement Mortar with R.C. band



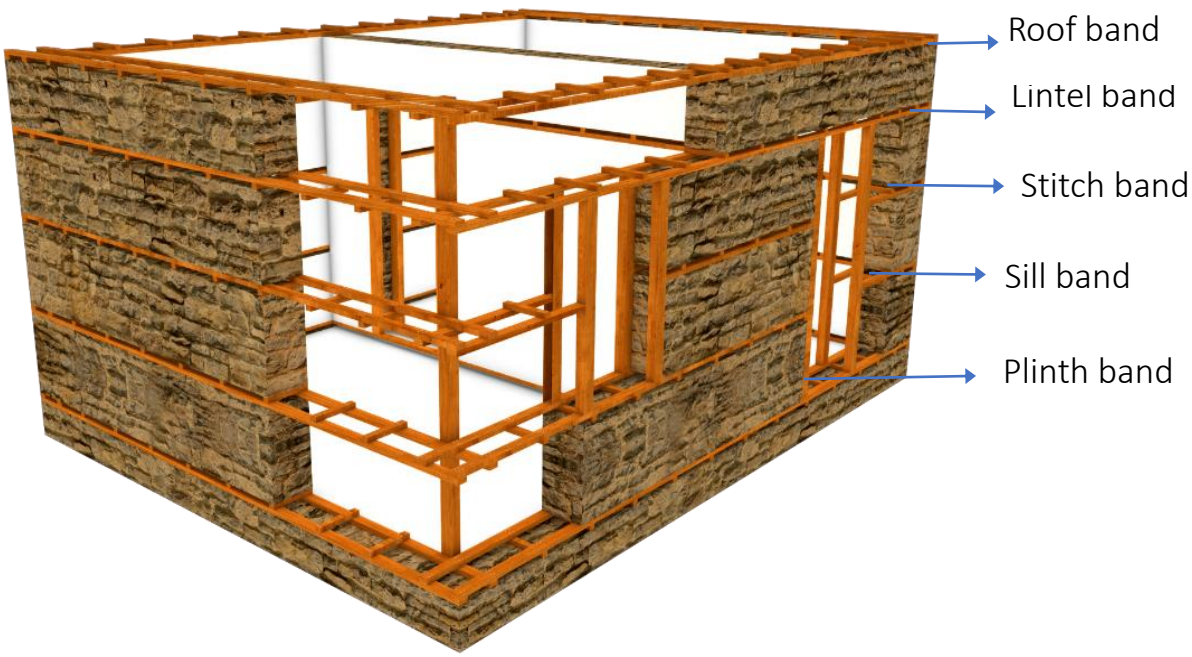
Stone in mud Mortar with wooden band

6. Earthquake resistant house

Seismic horizontal band:

Wooden band can be used in stone/brick masonry with mud mortar. Well seasoned hard wood without knots shall be used for horizontal band. Similarly, timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.

Two main wooden members, 75mm X 38mm should be placed along with the wall and should be properly connected with batten, 50mmX38mm @ 500c/c. Here, stitch (Mid band) shall be continuous. Main wooden member shall be properly connected with 4 nails and batten with 2 nails where 5mm wooden nail or 3.15mm galvanized steel nail can be used.



6. Earthquake resistant house

6.2 Design of house

6.2.1 Site selection

Related Minimum requirement No'1

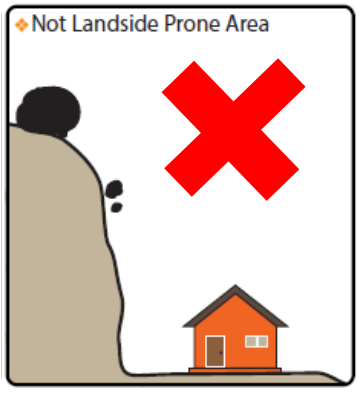
Adequate locations: Safe place to build houses are those located far from areas where natural Hazards may occur.

✓ Do not select near steep slope

Building built on sites with a narrow hill ridge, separated high hills, steep slopes or complicated terrain are susceptible to damage than a building built on sites with plain topography. so such sites should be avoided as far as possible. However, buildings can be constructed in such areas after the provision of proper precaution by retaining walls and its periphery must be improved by terracing and constructing breast.

✓ Do not select landside prone area

Landslides usually completely wash out buildings lying in its course. Rock fall damages buildings partially or completely. so its better not to select the sites on landslide prone area.

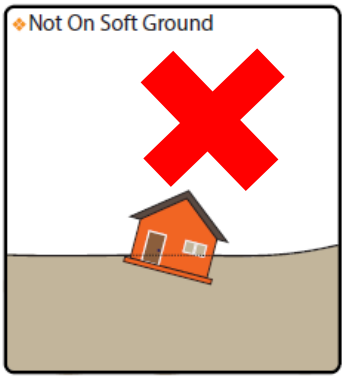


✓ Do not select near river bank

Since river banks are susceptible to frequent flooding and to liquefaction. Buildings should be far enough from the flooding zone of river and construction in such areas should be undertaken only after carrying out necessary protection works to avoid flash flood and earthquake damage.

✓ Do not select filled or soft ground

In a back filled area, the bearing capacity of foundation sub soil is low and settlement of foundation may occur. Also, foundation may be exposed due to easy scouring of backfilled soil .If a building is to be constructed on a filled ground, the foundation should be deep enough so as to rest on firm soil and not on filled up soil.



✓ Do not select Rock fall Area

✓ Do not select Geological fault or Ruptured Area

✓ Do not select Liquefaction susceptible Area

6. Earthquake resistant house

6.2 Design of house

6.2.2 Shape of house

Related Minimum requirement No'2

To make earthquake resistant house successfully, design must have a good shape and an adequate distribution of walls.

✓ Symmetry

The building, as a whole or its individual blocks, shall be planned symmetrical as far as possible.

✓ Regularity

Simple rectangular shapes behave better in an earthquake than shapes with projections. Torsional effects of ground motion are pronounced in long narrow rectangular blocks. The length of a block shall not be greater than three times its width of the building.
If longer lengths are required two separate blocks with sufficient separation between should be provided.

According to National Building Code, Nepal, the minimum requirement that should be considered are as follows:

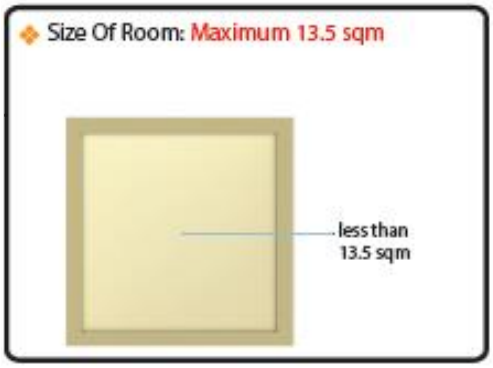
✓ Number of storey:

- It shouldn't be more than 2 storey + attic incase of the stone and brick masonry with cement mortar

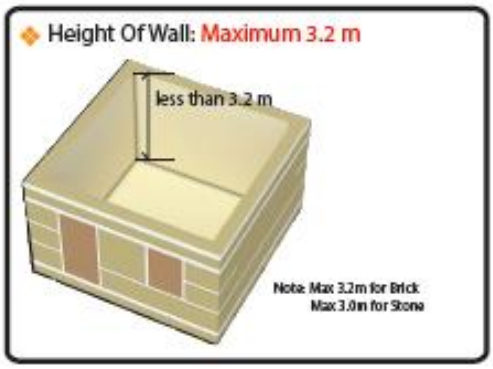
- Incase of stone/brick masonry in mud mortar with wooden band the total number of storey should be limited to one storey whereas if R.C band is used instead of wooden band then one plus attic floor can be constructed.

- ✓ The clear span of the wall shouldn't be more than 12 times thickness of the wall and not more than 4.5 m.

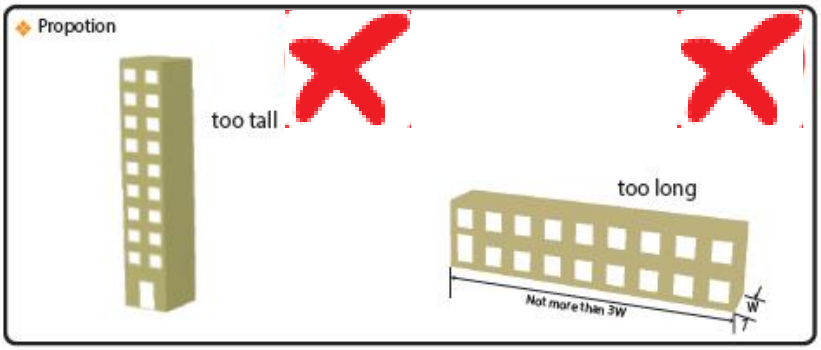
- ✓ Each room should not exceed 13.5 sq. m



- ✓ Floor height shall not be more than 3.0m. Incase of attic floor, maximum height from floor level to ridge level shall be 1.8 m and maximum height from floor level to eave level shall be 1.0m.



- ✓ The building should not be too long or too tall



6.2 Design of house

6.2.3 Opening of wall

Related Minimum requirement No'8

Large sizes and inappropriate locations of opening are another cause of severe damage of masonry buildings.

Openings are the voids in walls to make them weak. so, their sizes and locations are to be carefully decided while Construction. Some of rules for size and location of openings in masonry buildings are shown in next page. Following are the guidelines on the size and position of opening:

- ✓ **The total length of openings**

It shouldn't exceed 30% of the length of the wall between consecutive cross-walls in single storey mud masonry whereas incase of cement masonry construction, it shouldn't exceed 50 % in single storey construction and 42% in two storey construction.

- ✓ **Distance of opening from the end of a wall**

Openings are to be located away from inside corners by a clear distance equal to at least ¼ of the height of the opening, but not less than 0.6m.

- ✓ **The horizontal distance between two openings**

It should not be less than half of the height of the shorter opening, but not less than 0.6 m.

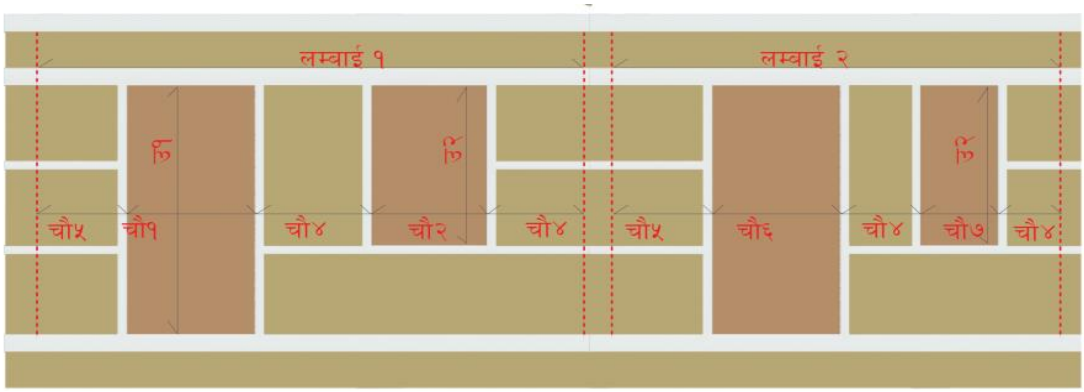
- ✓ **The vertical distance between two openings**

If there are two openings in the height of a wall, then vertical distance between the two openings should not be less than 600 mm or 50% of the width of the smaller opening.

- ✓ When the openings do not comply with requirements above points, they should either be boxed around in reinforced concrete or reinforcing bars provided at the jambs through the masonry as shown in figure below

- Any opening in the wall reduce load bearing capacity against the earthquake. The size of opening and location should be well considered and comply with the followings.

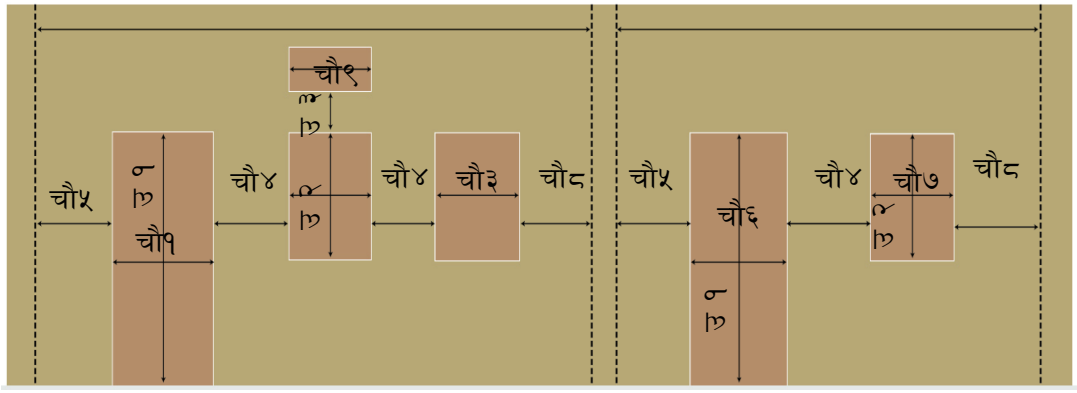
Brick/ Stone masonry with mud mortar:



नोट:

- चौ १ + चौ २ <०.३ लम्बाई १ एक तल्लाको लागि,०.२५ लम्बाई १ एक तल्ला र बुईगलको लागि
- चौ ६ + चौ ७ <०.३ लम्बाई २ एक तल्लाको लागि,०.२५ लम्बाई २ एक तल्ला र बुईगलको लागि
- चौ ४ >=०.५ चौ २ तर ६०० मि.मि भन्दा कम
- चौ ५ >=०.२५ चौ १ तर ४५० मि.मि भन्दा कम

Brick/ Stone masonry with cement mortar:



नोट:

- चौ १ + चौ २ + चौ ३ <=०.५ लम्बाई १ एक तल्लाको लागि,०.४२ लम्बाई १ दुई तल्लाको लागि
- चौ ६ + चौ ७ <=०.५ लम्बाई २ एक तल्लाको लागि,०.४२ लम्बाई २ दुई तल्लाको लागि
- चौ ४ >=०.५ उ२ तर ६०० मि.मि भन्दा कम
- चौ ८>=०.२५ उ२ तर ६०० मि.मि भन्दा कम
- चौ ५>=०.२५ उ १ तर ६०० मि.मि भन्दा कम
- चौ ३>=(०.५ चौ २ ,०.५ चौ ९ र ६०० मि.मि मध्यको अधिकतम

6. Earthquake resistant house

6.2 Design of house

6.2.4 Wall specification

Related Minimum requirement No'5

✓ Laying masonry

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.

✓ Mortar Mixture

Mortar joints should not be more than 20mm and less than 10mm in thickness. The ratio recommend 1:6(Cement: Sand).

✓ Through-stone

Through-stone of a length equal to the full wall thickness should be used in every 600 mm lift at not more than 1.2 m apart horizontally.

✓ Key Technical Points

- The pressure acting on stones should be vertical.
- Dressed stones are preferable than natural round shaped stones.
- Broken or small stones should not be used.
- Through stone should be laid in every 600mm lift and not more than 1.2m apart horizontally.
- Wet stone should be used to avoid sucking moisture from mortar.
- Stone should be cleaned no to loss bonding strength with mortar.
- Mortar should be packed and chipped in properly without void space
- Mortar joint should not be in one continuous vertical line.
- The plumb bob should be used to check verticality.

✓ Thickness of wall

MASONRY TYPE	MASONRY TYPE		
	One	Two	Two plus Attic
Stone	350-450	450	450
Brick	230	350	350

Related Minimum requirement No'10

6.3.1 Preparation of construction

a) Materials

Materials used in building construction is also one of the factor affecting the quality of building . So quality of construction materials used in construction has to be ensured for assuring the final quality of construction. The required quality of materials should be decided beforehand the construction is started; generally it is decided during planning and designing phase. Depending upon the construction type, structural element and location of site the quality of materials required should be differs.

The very commonly used construction materials are shown below in pictures.

SAND

- from rivers / quarries
- clean from mud
- clean from organic materials

WATER

- clean
- clear and does not smeel
- no oil, acid, alkali, salt, organic materials that can affect the R.C. Bars

GRAVEL

- from rivers / quarries
- clean from mud
- clean from organic materials
- ϕ 1-2 cm

RUBBLE STONE

- size as uniform as possible
- rough surface, not smooth

DRESSED (CUT) STONE

- treatment in cubic or cuboid shape
- suitable material for mosonry

SLATE STONE

- from quarries
- flat shaped
- good for masonry

BOULDER

- from rivers
- round shape
- need treatment of shape before use for masonry
- more mortar is required

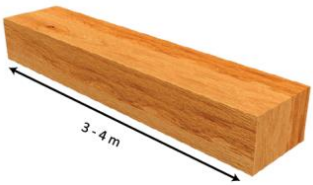
Boulder stone (River round stone) should not be used. Need treatment of shape.

Materials

CEMENT

- Portland Cement
- not hardened
- dry
- not mixed with other materials
- uniform color

TIMBER



- dry and straight
- no cracks and notch
- treated against termite
- hard wood shall be used for main structural elements

Hard Wood	Soft Wood
Babul, Black Siris, Dhaman, Indian Rose Wood (Shisam), Jaman, Mesua, Oak, Sain, Sal, Sandan, Sisso, Teak, Khair	Chir, Deodar, Jack, Mango, Salla, Simal, Uttis (Red), Uttis (White)

BRICKS

npletely burnt
- flat, not warping
- does not break easily
- uniform size
- corners not damaged
- standard size: 230 x 110 x 55 mm

R.C. BARS

- Fe415: High Strength Deformed Bar
- uniform size
- conform with standard bars
- not rusted
- straight
- diameter in accordance with drawing

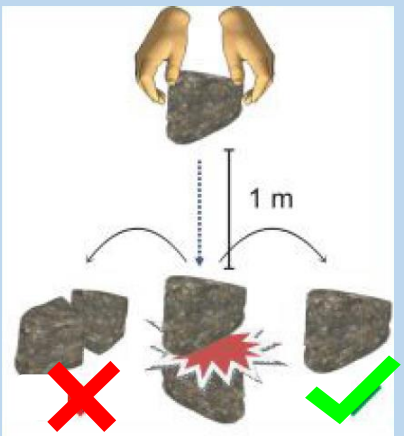
MUD

- Free from organic materials
- Neither too sandy nor too clayey
- Sand content not more than 40% by volume

CORRUGATED GALVANISED IRON (CGI) SHEET

- standard 26 gauge size
- thickness 0.55 mm

Quality Check!



Stone

Brick

Related Minimum requirement No'10

6.3.1 Preparation of construction

Equipment

a. Measurement meter
b. Bar cutter
c. Bar Bender
d. Forceps
e. Saw
f. Wire mesh cutter
g. Drilling machine
h. Concrete drill
i. Wood drill
j. Shovel
k. Hammer
l. Bucket
m. Measurement thread
n. Nail
o. Pencil
p. Imperator
q. Pick axe
r. Crow bar
s. Mortar pan
t. Plumb bob
u. Try square
v. Spirit level
w. Chisel
x. Mason's trowel
y. Steel float
z. Vibrator

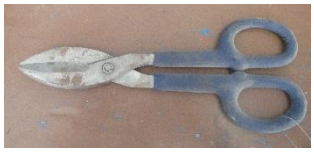
a


b


c


d


e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Equipment

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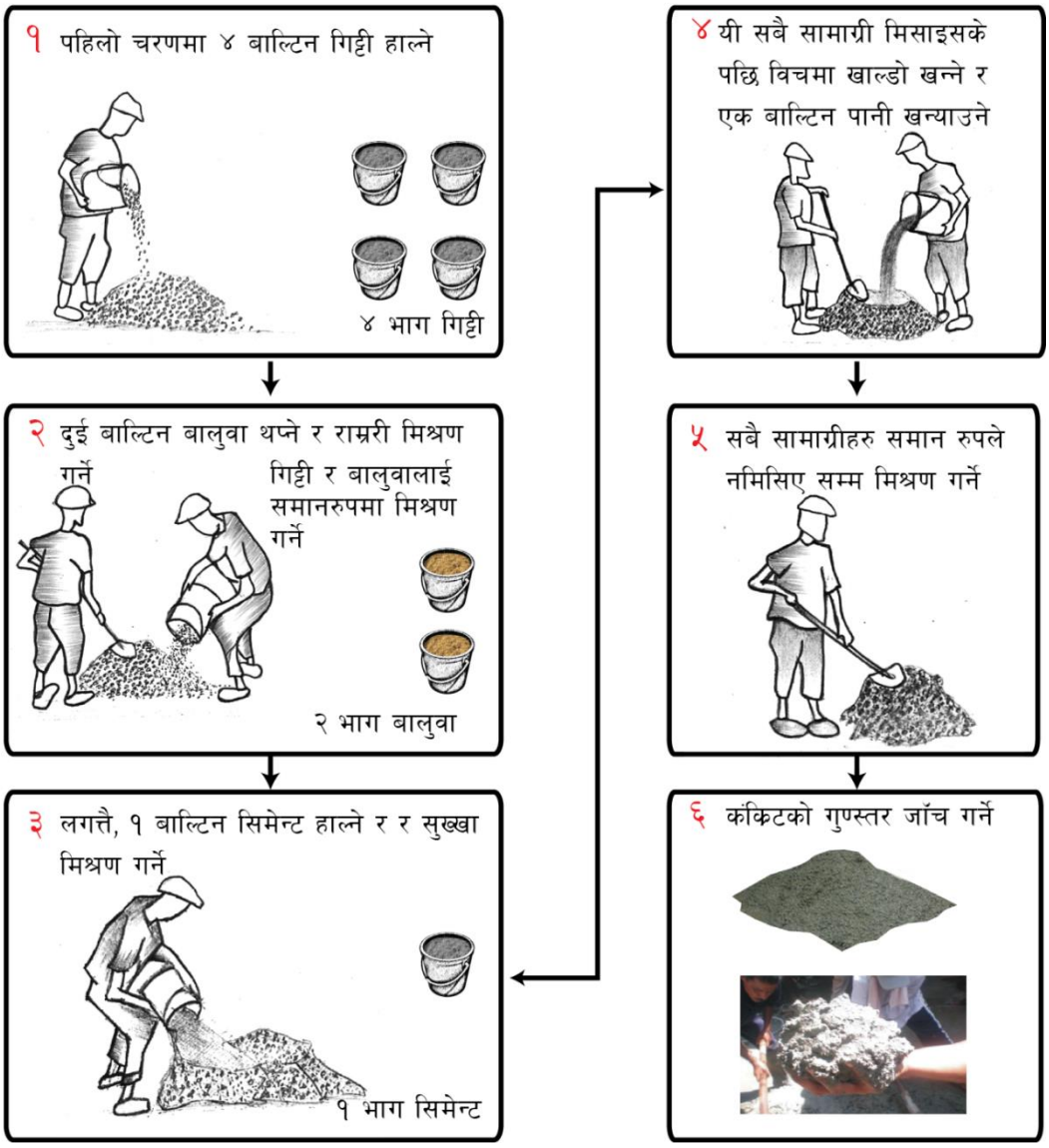
6.3 Construction of house

Related Minimum requirement No'10

6.3.2 Mixture of concrete

Cement concrete is a mixture of cement ,sand and stone aggregates in a specified proportions. Mixing may be done by mixer machine or by hand , Preferable is mixing by machine as it gives uniform quality and homogeneous concrete mix. Procedure for mixing concrete manually has been explained in the following diagrams.

M15 ग्रेड कंक्रिट
न्यूनतम कम्प्रेसिभ बल: 15N/mm² (15MPa)
नोमिनल मिश्रण अनुपात: १ : २ : ४ (सिमेन्ट : बालुवा : गिट्टी)
पानी र सिमेन्टको अनुपात: अधिकतम ०.६



Mixture of concrete

M20 ग्रेड कंक्रिट
न्यूनतम कम्प्रेसिभ बल: 20N/mm² (20MPa)
नोमिनल मिश्रण अनुपात: १ : १.५ : ३ (सिमेन्ट : बालुवा : गिट्टी)
पानी र सिमेन्टको अनुपात: अधिकतम ०.६

१ पहिलो चरणमा ३ बाल्टिन गिट्टी हाल्ने

३ भाग गिट्टी

२ १.५ बाल्टिन बालुवा थप्ने र राम्ररी मिश्रण गर्ने
गिट्टी र बालुवालाई समानरुपमा मिश्रण गर्ने

१.५ भाग बालुवा

३ लगत्तै, १ बाल्टिन सिमेन्ट हाल्ने र र सुख्खा मिश्रण गर्ने

१ भाग सिमेन्ट

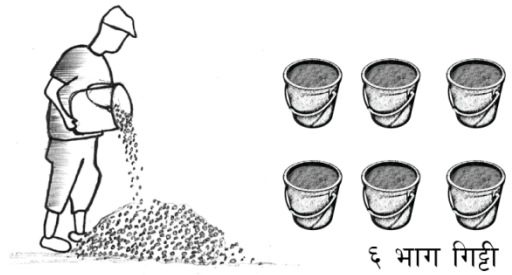
४ यी सबै सामाग्री मिसाइसके पछि विचमा खाल्डो खन्ने र एक बाल्टिन पानी खन्याउने

५ सबै सामाग्रीहरु समान रुपले नमिसिए सम्म मिश्रण गर्ने

६ कंक्रिटको गुण्स्तर जाँच गर्ने

M10 ग्रेड कंक्रिट
न्यूनतम कम्प्रेसिभ बल: 10N/mm² (10MPa)
नोमिनल मिश्रण अनुपात: १ : ३ : ६ (सिमेन्ट : बालुवा : गिट्टी)
पानी र सिमेन्टको अनुपात: अधिकतम ०.६

१ पहिलो चरणमा ६ बाल्टिन गिट्टी हाल्ने



२ तीन बाल्टिन बालुवा थप्ने र राम्ररी मिश्रण गर्ने

३ लगत्तै, १ बाल्टिन सिमेन्ट हाल्ने र सुख्खा मिश्रण गर्ने

४ यी सबै सामाग्री मिसाइसके पछि बिचमा खाल्डो खन्ने र एक बाल्टिन पानी खन्याउने

५ सबै सामाग्रीहरु समान रुपले नमिसिए सम्म मिश्रण गर्ने

६ कंक्रिटको गुणस्तर जाँच गर्ने

6. Earthquake resistant house

6.3 Construction of house

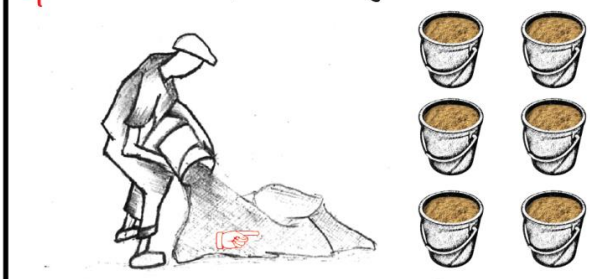
6.3.2 Mixture of mortar

Related Minimum requirement No'10

Cement Mortar is a paste prepared by adding required quantity of water to a mixture of binding material like cement and fine aggregate like sand. For the preparation of good mortar there should be quality cement, sand and water with appropriate proportions. Procedure to mix the mortar has been explained in the following diagrams.

१:६ मसला
नोमिनल मिश्रण अनुपात: १:६ (सिमेन्ट : बालुवा)

१ पहिलो चरणमा ६ बाल्टिन बालुवा हाल्ने



६ भाग बालुवा

२ एक बाल्टिन सिमेन्ट थप्ने र साबेलले राम्ररी मिश्रण गर्ने

१ भाग सिमेन्ट

बालुवा र सिमेन्टलाई साबेलले राम्ररी सुख्खा फेट्ने

३ यी सबै सामाग्रीहरु मिसाइसके पछि बिचमा खाल्डो खन्ने र आधा बाल्टिन पानी खन्याउने

४ सबै सामाग्रीहरु समान रुपले नमिसिए सम्म मिश्रण गर्ने

कंक्रिटको मिश्रण (१:१.५:३)

	सिमेन्ट		बालुवा		गिट्टी		पानी		जम्मा	
एक एकाई वजन	३,१५०		२,६००		२,६००		१,०००			
मिश्रण (प्रति घन मिटर)	१,४४०		१,५७०		१,७३५		१,०००			
मिश्रण (प्रति घन मिटर	केजी	लि.	केजी	लि.	केजी	लि.	केजी	लि.	केजी	लि.
	३४०	२३६	५५६	३५४	१२२७	७०७	२०४	२०४	२३२७	१५०१

पानी र सिमेन्टको अनुपात (प्रति वजन)	६० %
पानी र सिमेन्टको अनुपात (प्रति मात्रा)	८६.४ %
१ घन मिटर कंक्रिटमा चाहिने सुख्खा सामाग्रीको कुल मात्रा	१.५ घन.मि

५ मसलाको गुणस्तर जाँच गर्ने

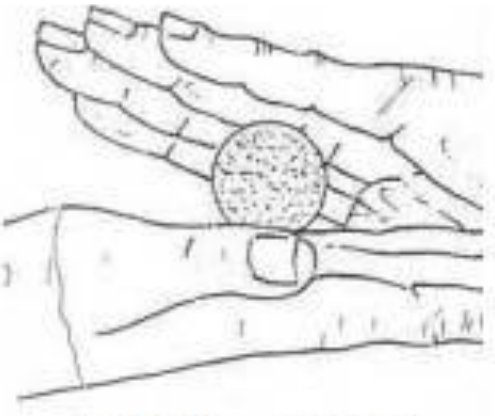
Mud mortar

The soil for preparation of mud mortar should be free from organic materials. It shall also be free from pebbles and other hard materials which could upset the mortar thickness. The sand content in the mud shall not be more than 30 % in order to achieve a proper cohesiveness. Dry mud shall be thoroughly kneaded with water in order to prepare the dense paste.

Field Test

a. Dry strength test

Five or Six small balls of soil of approximately 2 cm in diameter are made. Once they are dry (after 48 hours), each ball is crushed between the forefinger and the thumb. If they are strong enough that none of them breaks, the soil has enough clay to be used in the adobe construction, provided that some control over the mortar micro-fissures caused by the drying process is exercised, as shown in figure below. If some of the balls break, the soil is not considered to be adequate, because it does not have enough clay and should be discarded.



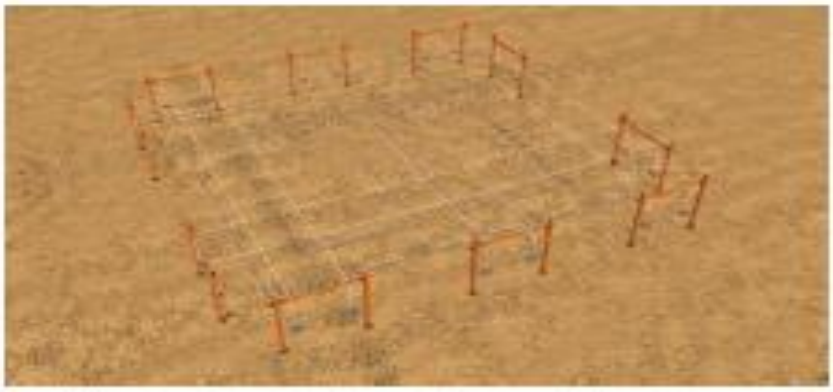
बल बनाउने तरिका

सुकेको बल जाँच्ने तरिका

6.3 Construction of house

6.3.4 Construction sequence

1. Layout plan

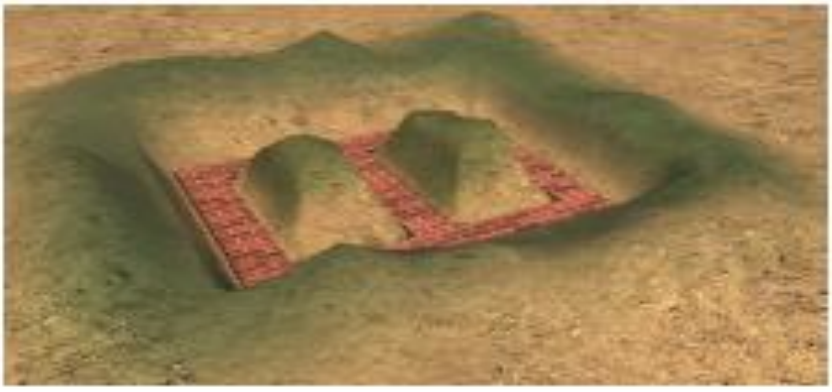


The first important step in construction of a foundation is the layout .It is an essential procedure before the start of work. Clean the ground from all organic or any odd elements. Then tightened the ropes using trestles made by wood poles nailed to a transversal stick and embed it to the ground, as shown in the figure. Trestles are placed at external part of build. Check the angle of 90{at the corners making triangle of 3-4-5 length sides} as shown here. Use chalk or gypsum powder to mark.

2. Excavation

It is important that foundation to be leveled below the ground level, on natural soil at a depth not less than 1.0 m. If thickness of the shallow landfill is greater than 1.0 m the trench should be over excavated until it reach the natural soil and refilled with simple concrete.

3. Laying Brick Bedding



The excavated area is then filled by a layer of brick.

4. Placing lean concrete

The layer of brick is covered by lean concrete

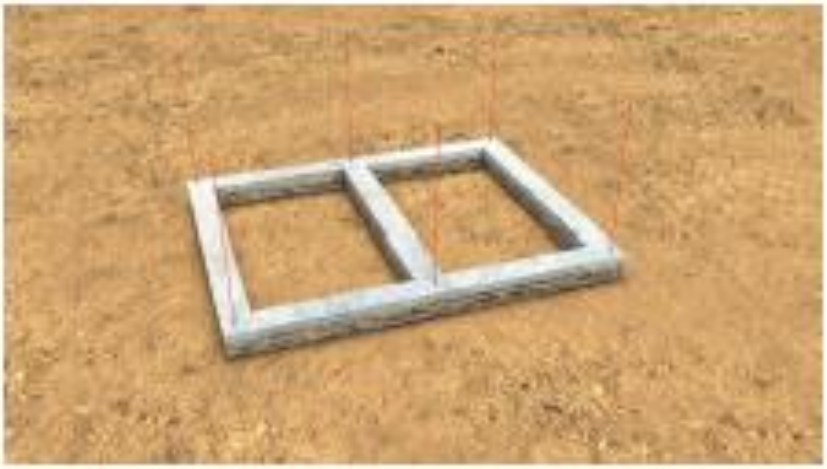
5. Construction of Foundation with installation of vertical Rebar

Reinforcement bars are placed and fixed into the foundation

6. Construction of plinth band

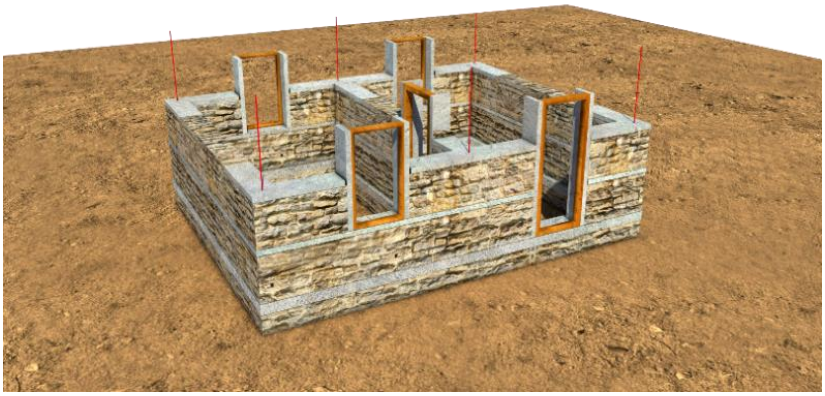
After the reinforcement a layer of concrete is placed over lean concrete.

7. Construction of Masonry wall and RC bands



Masonry wall is constructed above plinth band and openings are made and RC bands are placed over , middle and under masonry wall.

8. Construction of Corner and transverse bands

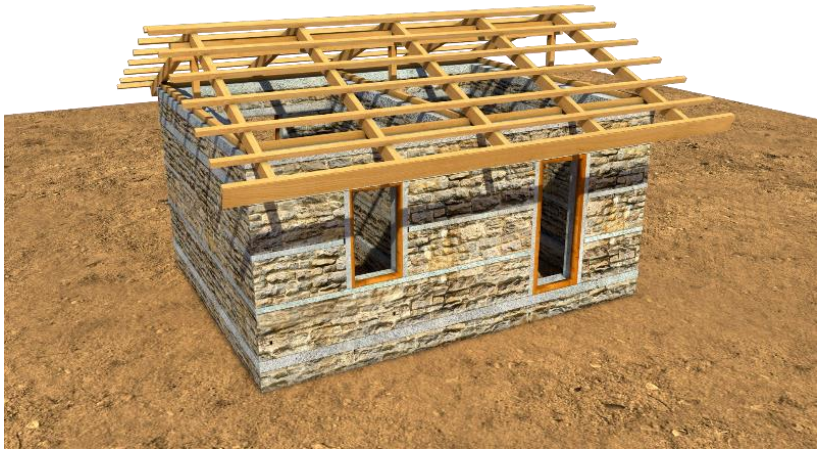


After the completion of the opening, the construction of the masonry wall is stopped to construct the corner and transverse band.

9. Construction of lintel band:

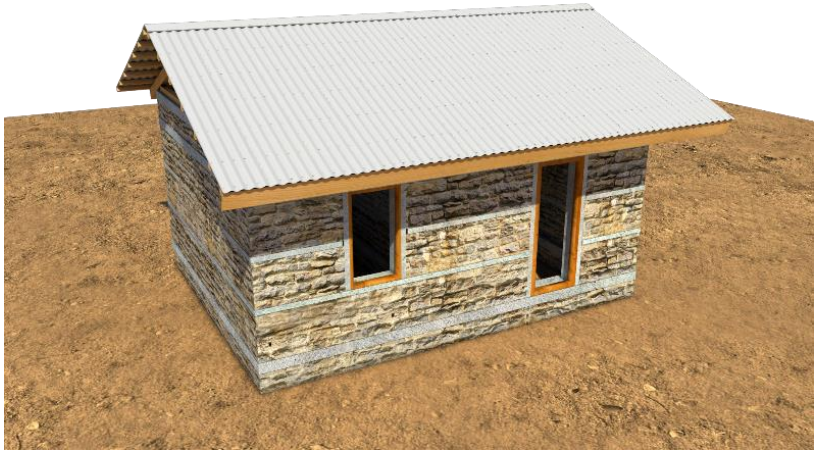
A continuous lintel band is constructed through walls at the top level of opening.

9. Construction of lintel band:



After completion of lintel band, masonry wall is constructed and above that roof band is constructed and above that timber truss is made.

11. Installation of roof



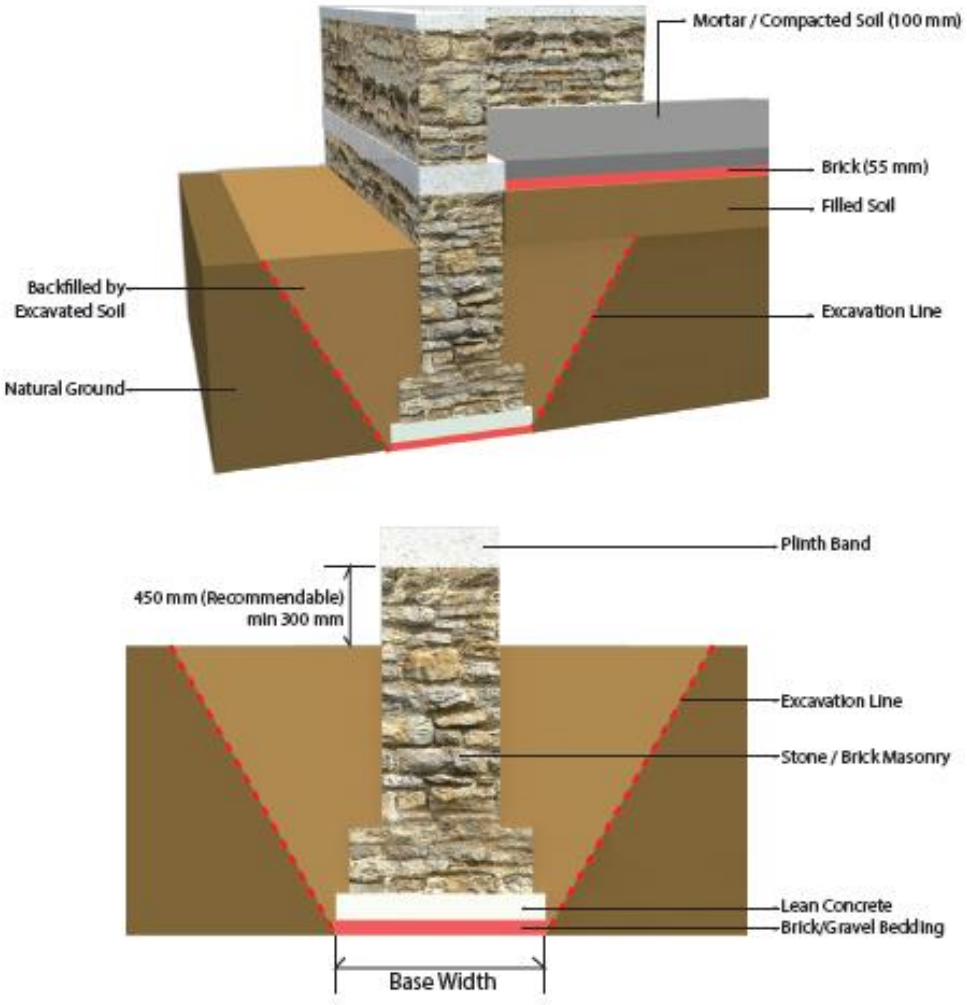
After the construction of wall , roof is placed over it.

6. Earthquake resistant house

6.3 Construction of house

6.3.5 Foundation

Foundation is a bottom-most part of the building which transfer the weight of the building to the ground. It plays vital role in overall stability of the structure. Foundation for a particular structure depends on type of structure and foundation sub soil. The foundation trench should be of uniform width and its bed should be on same level throughout the flat area.



The base width of foundation is varied depends on:
Wall material: Stone or Brick
No. of storey: 1 storey or 2 storey
Bearing strength of ground: Soft, Medium or Hard

Foundation for masonry Building

- For load bearing wall construction, strip footing of masonry, plain concrete or RC is commonly used.
- RC strip footing is most effective for seismic and settlement consideration in soft as well as firm soils.
- Masonry footings are most frequently used.

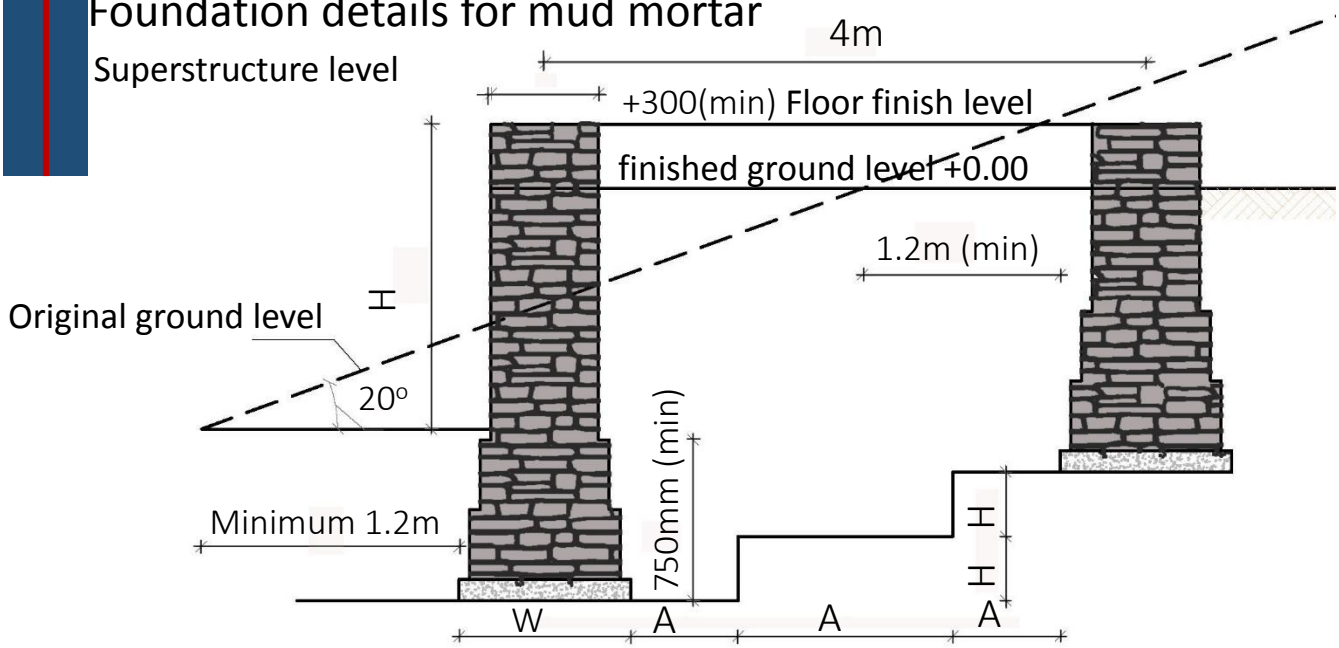
The depth of footing in the soil should go below the zone of deep freezing in cold regions and below the level of shrinkage crack in clay soil. It is the most common strip foundation, which can be constructed in cement or mud mortar. This type of footing is generally made of steps, the width at the bottom being more and the width at the top of the footing is equal to the width of the wall above. The footing wall may be of brick or stone depending upon the availability of it and the mortar also mud or the cement.

The minimum size of foundation for masonry footing in different types of foundation sub soil and different no. of stories should be as shown below in first table. The following picture explains the procedure of wall making with stone or brick.

Minimum base width(mm) of wall footing for soil type

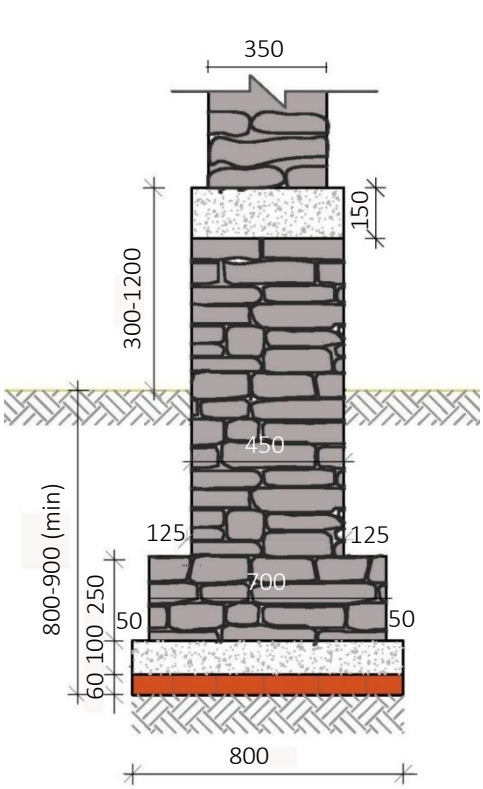
Masonry Type	No. of storey	Soft	Medium	Hard
Brick	Two	900	650	450
	One	650	550	450
Stone	Two	NA	800	600
	One	800	600	600

Foundation details for mud mortar

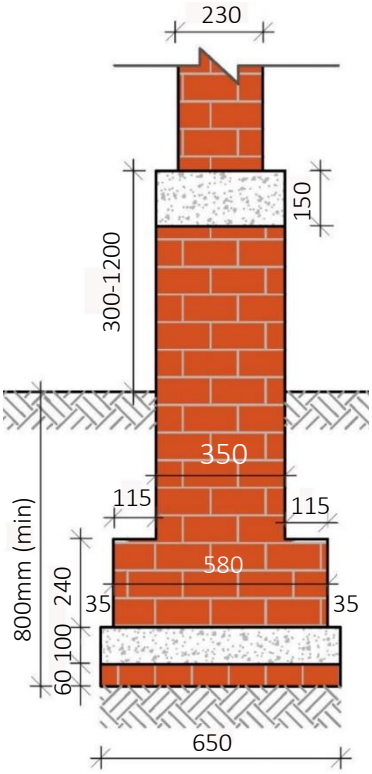


A= 2m or 1m whichever is greater
H= Not greater than 300mm
O= 20° (Maximum)

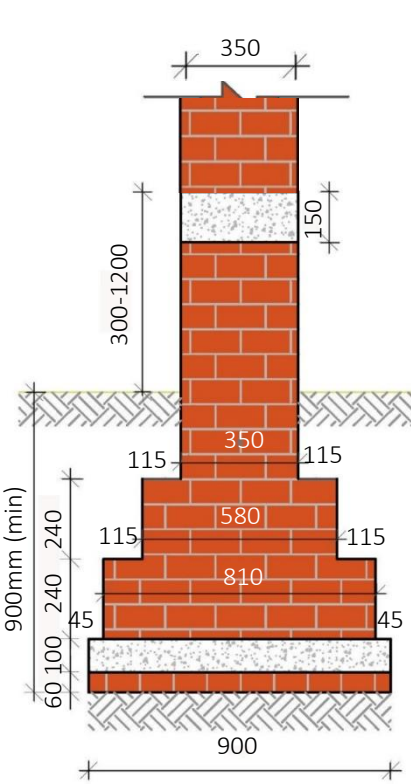
Foundation technique in slope ground



1 storey (soft soil)
2 storey (medium soil)

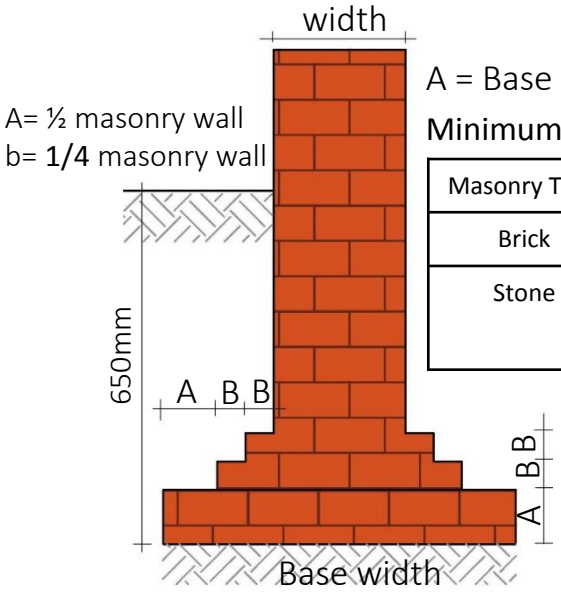


1 storey (soft soil)



2 storey (soft soil)

Foundation details for mud mortar

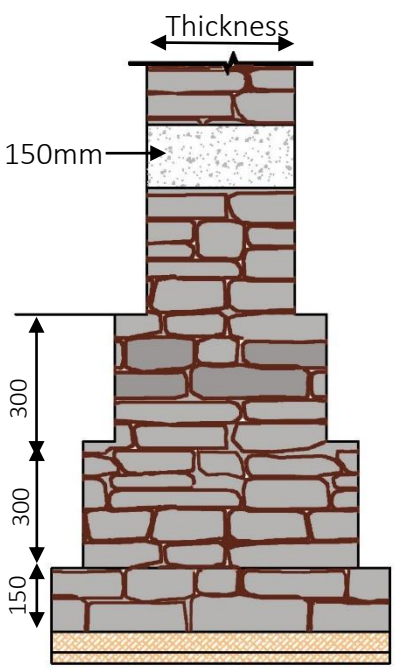


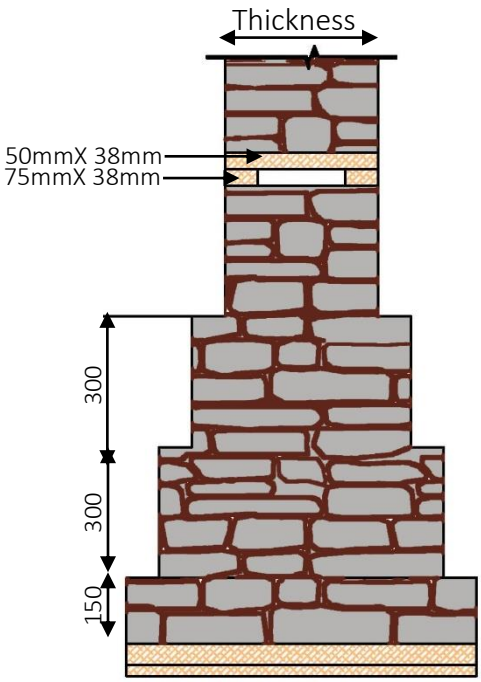
A = Base width – wall thickness/6

Minimum base width(mm) of wall footing for soil type:

Masonry Type	No. of storey	Soft	Medium	Hard
Brick	One	750	650	550
Stone	Two	NA	800	600
	One	800	600	600

Brick masonry with mud mortar





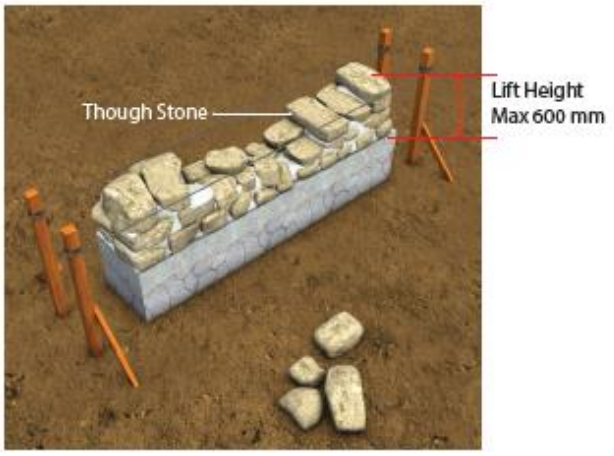
Stone masonry with mud mortar

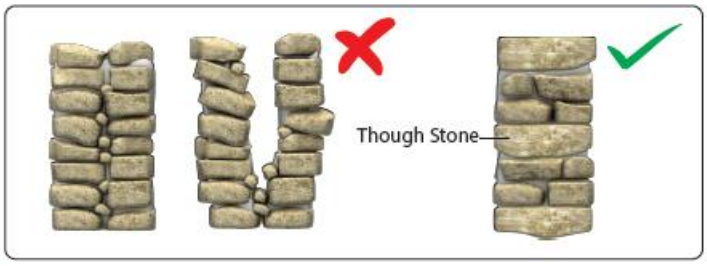
6. Earthquake resistant house

6.3 Construction of house

6.3.6 Wall of Stone masonry

Related Minimum requirement No'7

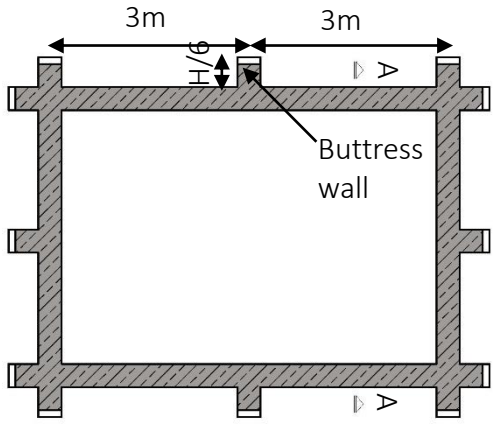


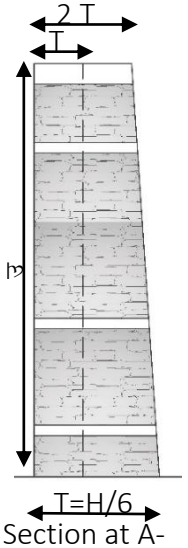


Stone masonry is made of stone units that are bonded together with a binder like mortar together to act as a homogenous mass. Stones are obtained from quarrying which is done by hand tools or by blasting . The strength of stone masonry depends on the quality of stones, mortar and method of bonding used. The following pictures describes the general principal for good stone masonry.

✓ Key Technical Points

- The pressure acting on stones should be vertical.
- Dressed stones are preferable than natural round shaped stones.
- Broken or small stones should not be used.
- Through stone should be laid in every 600mm lift and not more than 1.2m apart horizontally.
- Wet stone should be used to avoid sucking moisture from mortar.
- Stone should be cleaned no to loss bonding strength with mortar.
- Mortar should be packed and chipped in properly without void space
- Mortar joint should not be in one continuous vertical line.
- The plumb bob should be used to check verticality.





Section at A-A

No matter whether boulder stones or quarry stones are used in construction, it is a common practice that the inner parts of the walls are filled with small stones pieces and mortar. This way of constructing a wall makes the stone units of inner and outer faces not bonded together properly which results in separation of two faces of the wall, bulging and delamination. such deformation in stone walls may lead to collapse of the building even in normal times whereas they are fatal during an earthquake.

Laying The Stone

- ✓ Regularly diminish the thicknesses of the courses, if varied, from the bottom to the top of the wall. Keep a surplus supply of stones at the site to select from.
- ✓ Before laying the stone in the wall, shape and dress it so that it will not loosen after it is placed. No dressing or hammering which will loosen the stone will be permitted after it is placed.
- ✓ Clean each stone and saturate it with water before setting it. Clean and moisten the bed that will receive it.
- ✓ Bed the stones in freshly made mortar with full joints. Carefully settle the stones in place before the mortar sets.
- ✓ Ensure that the joints and beds have an average thickness of not more than 1 inch. (25 mm).
- ✓ If a stone is moved or if the joint is broken after the mortar has set, take the stone up and thoroughly clean the mortar from the bed and joints. Reset the stone in fresh mortar.
- ✓ Do not smear the stone face surfaces with the mortar forced out of the joints or the mortar used in pointing.
- ✓ Thoroughly wet the joints pointed after the stone is laid with clean water and fill with mortar.
- ✓ Drive the mortar into the joints and finish with an approved pointing tool.
- ✓ Keep the wall wet while pointing. In hot or dry weather, protect the pointed masonry from the sun and keep it wet for at least three days after the pointing is finished.
- ✓ After the pointing is completed and the mortar is set, thoroughly clean the walls and leave them in a neat condition.

6. Earthquake resistant house

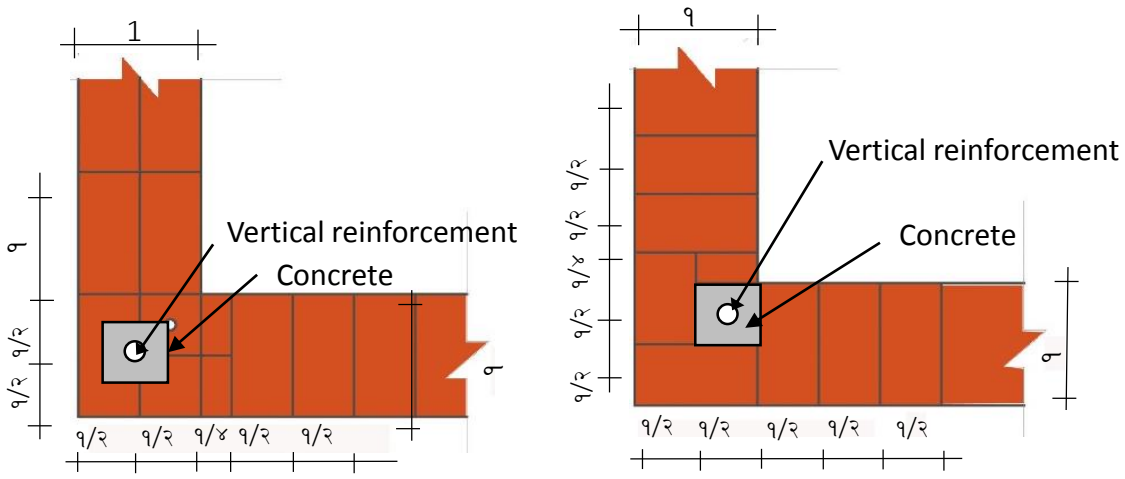
6.3 Construction of house

6.3.7 Wall of Brick masonry

Related Minimum requirement No'7

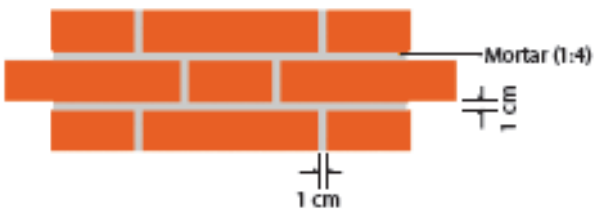
Brick masonry is made of brick units that are bonded together with a binder like mortar. The strength of brick masonry depends on the quality of bricks, mortar and method of bonding used. Brick masonry is used in construction of foundations, walls and columns. The principle for getting a good bond in brickwork is shown below in figure.

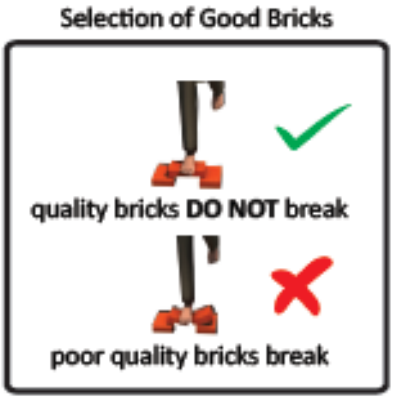
*Brick Masonry in Cement Mortar:



First layer Second layer

Layout detail of One brick wall





Key Technical Points

- Bricks should be burned, not sunbaked adobe bricks.
- Uniform size of bricks should be used.
- Bricks should be cleaned and soaked in water before use.
- Mortar thickness should be at least 1cm.
- Mortar joints should not be in one continuous vertical line.
- The plumb bob should be used to check verticality
- Mortar should be cured properly.

Bricks are soaked in water before use

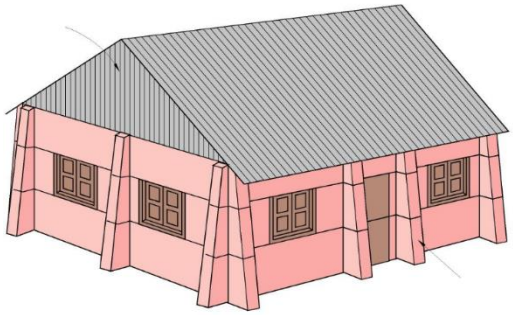
Wall of Brick masonry

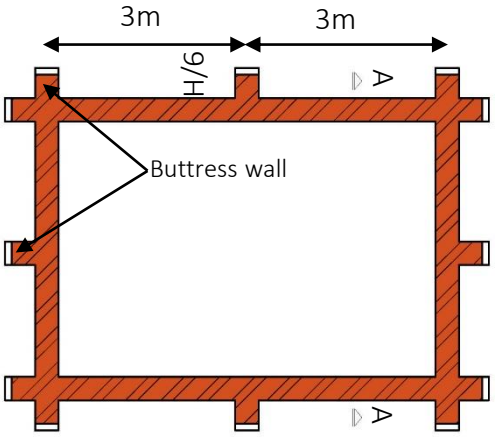
In load bearing walls brick masonry performs a variety of functions such as:

i. Supporting loads
ii. Sub-dividing space
iii. Providing thermal and acoustic insulation
iv. Affording fire and weather protection etc.

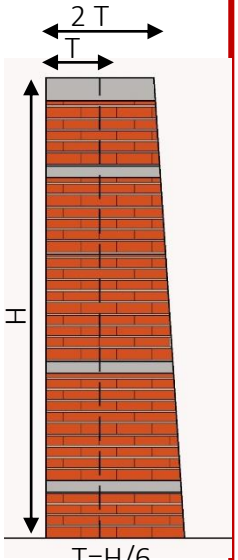
Brick Masonry Wall Making Process:

- ✓ Good brick masonry should utilize bricks which are sound, hard, well burnt and tough with uniform colour shape and size.
- ✓ The bricks should be compact, homogeneous, free from holes, cracks, flaws, air-bubbles and stone lumps. These bricks should be properly soaked in water for at least two hours before use.
- ✓ In the brick work, the bricks should be laid on their beds with the frogs pointing upwards.
- ✓ The brick courses should be laid truly horizontal and should have truly vertical joints.
- ✓ As far as possible the use of brick-bats should be discouraged.
- ✓ As far a possible the brick walls should be raised uniformly with proper bond. Generally the height of brick masonry construction in a day should be less than 1.5m. The maximum difference in rise of the wall between the different portions should not be more than one meter.
- ✓ When the mortar is green, the face joints should be raked to a depth of 12 to 19 mm in order to have a proper key for plastering or pointing. The mortar joints should be stuck flush and finished if no plastering or pointing is to be done.
- ✓ Finished brickwork in cement mortar should be cured for a period of 1 to 2 weeks.
- ✓ In order to carry out the brickwork at higher level, a single scaffolding is used.





Plan



Section at A-A

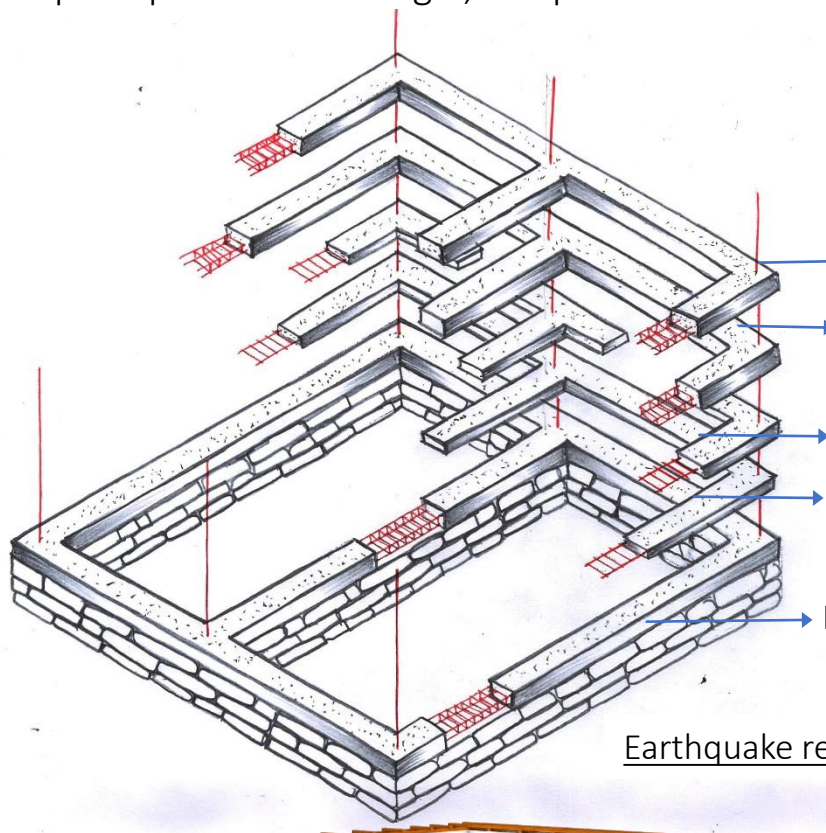
6. Earthquake resistant house

6.3 Construction of house

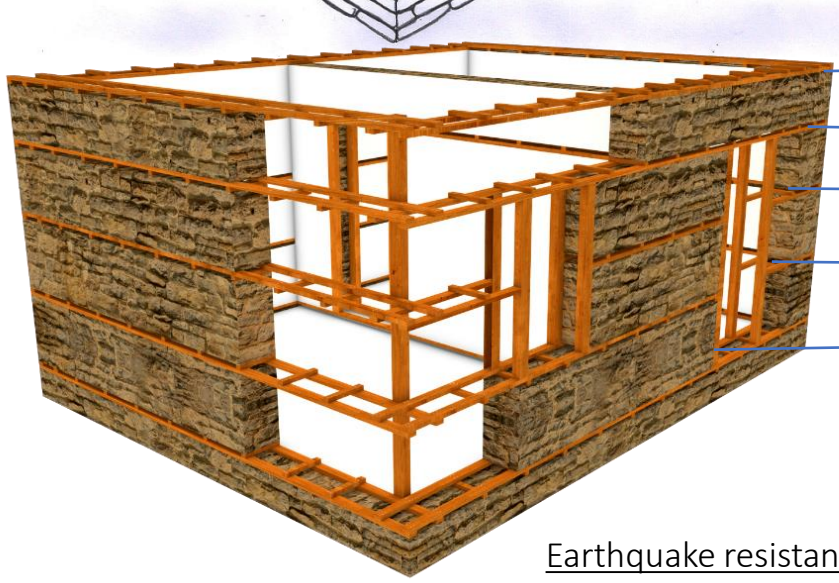
6.3.8 Seismic band

Related Minimum requirement No’9

Horizontal bands of walls is required in order to tie orthogonal walls together. There are mainly five different horizontal bands. They are plinth band ,sill band, lintel band ,roof band and gable band. The structure of all bands is similar. They improves horizontal bending resistance thereby preventing out of plane collapse of walls. It also helps to prevent shrinkage , temperature and settlement cracks.



Earthquake resistant R.C. band



Earthquake resistant wooden band

➢ Plinth band

This band is provided where soil is soft or uneven in their properties. It may also serve as a damp-proof course.

➢ Sill band

This band is provided just below the window openings through all walls at the bottom .it becomes critical if the floor height is high.

➢ Lintel band

A lintel band shall be provided through all walls at the top level of opening. thus the top-level of all the openings shall be made equal as far as practicable. it must be provided in all stories of the building as per table.

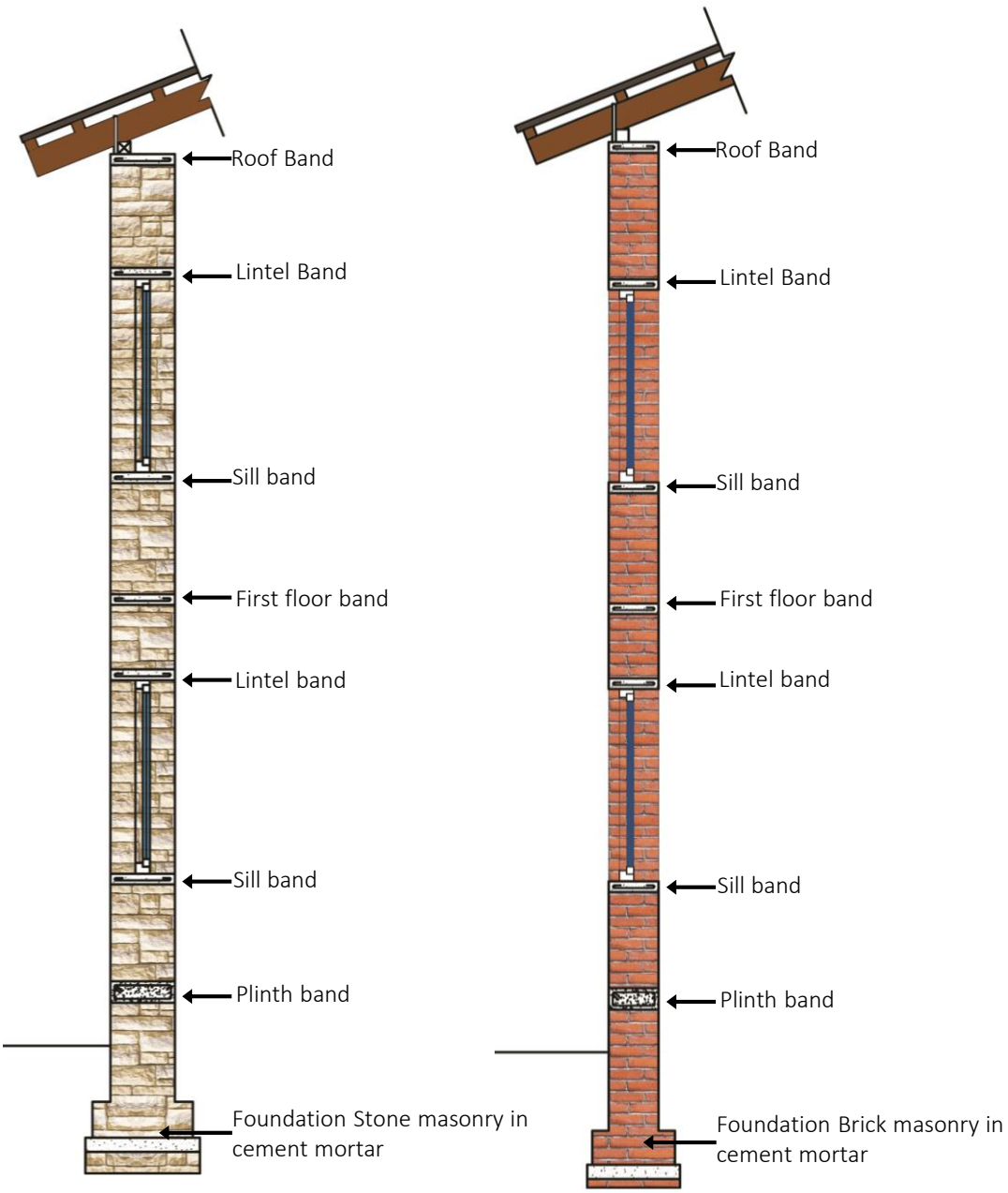
➢ Roof band

This band shall be provided at the eave-level of trussed roofs and also just below the joists on all such floors which consist of joists and covering elements (flexible floors), so as to integrate them properly at their ends and fix them into the walls

➢ Gable band

Masonry gable ends must have the triangular portion of masonry enclosed in a band, the horizontal part of which will be continuous with the eave-level band on the adjacent longitudinal

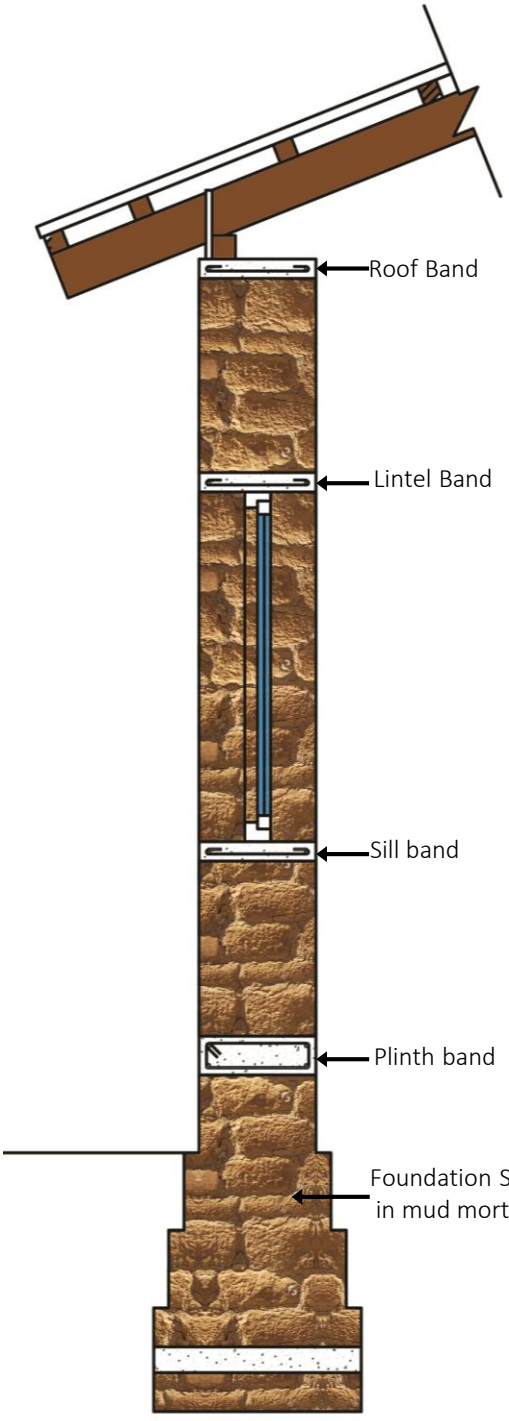
Seismic Band



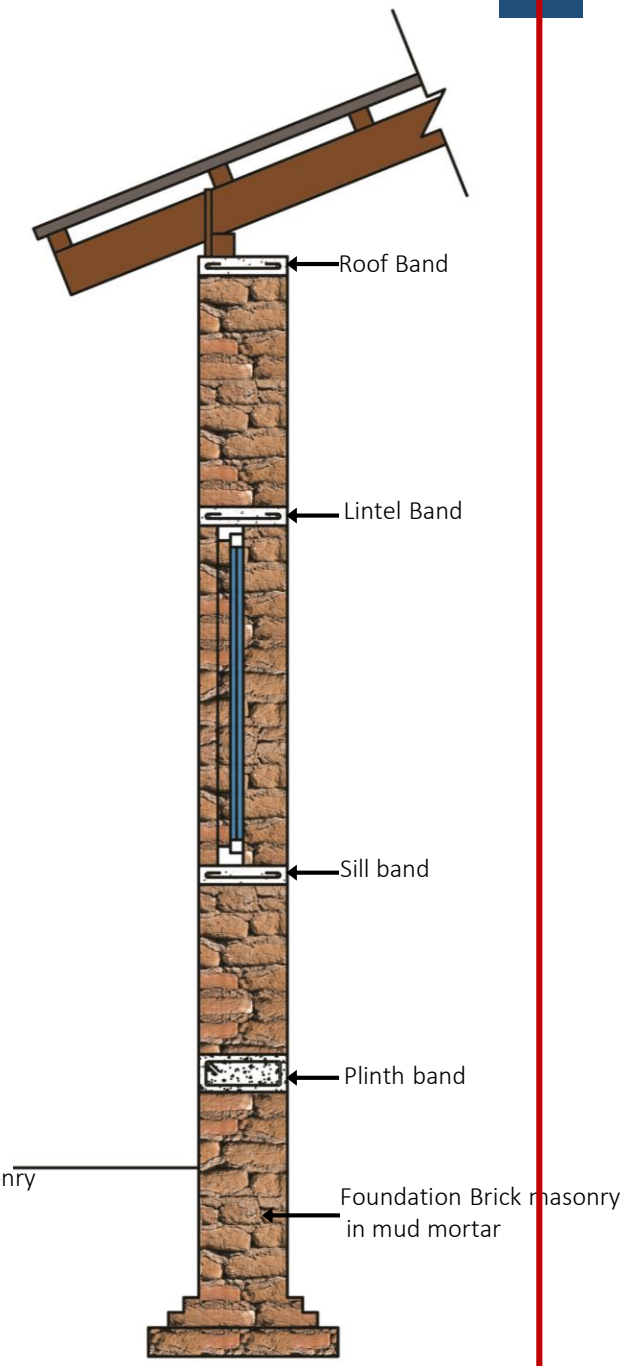
380-450 mm

300-350 mm

Cross section of stone wall

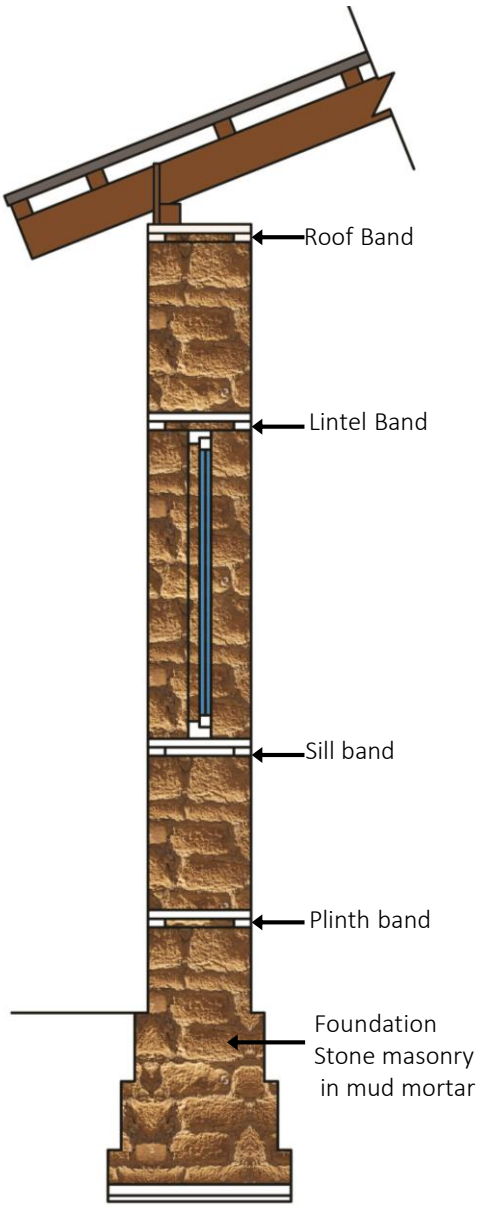


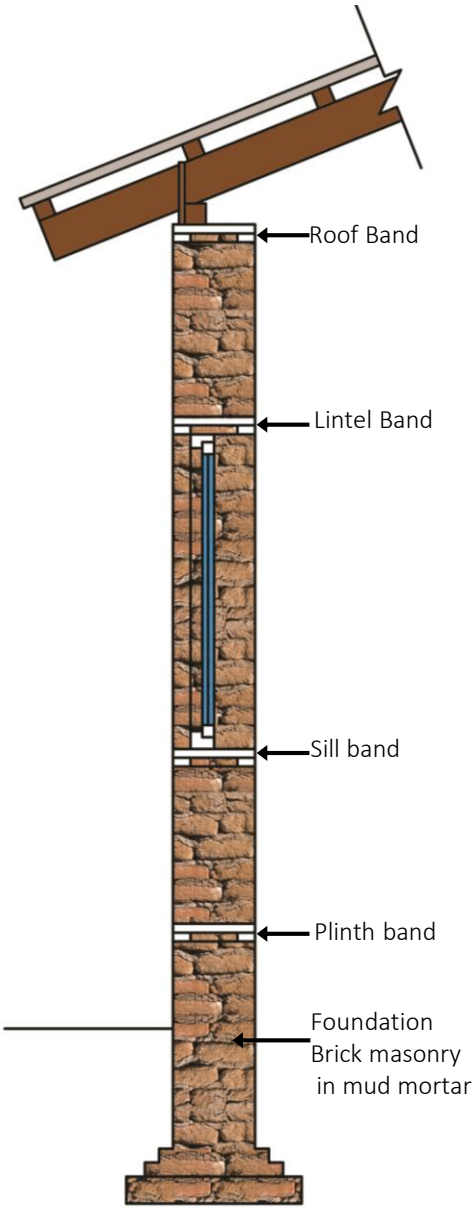
Stone masonry in mud mortar with R.C. band



Brick masonry in mud mortar with R.C. band

Seismic band





Stone masonry in mud mortar with wooden band

Brick masonry in mud mortar with wooden band

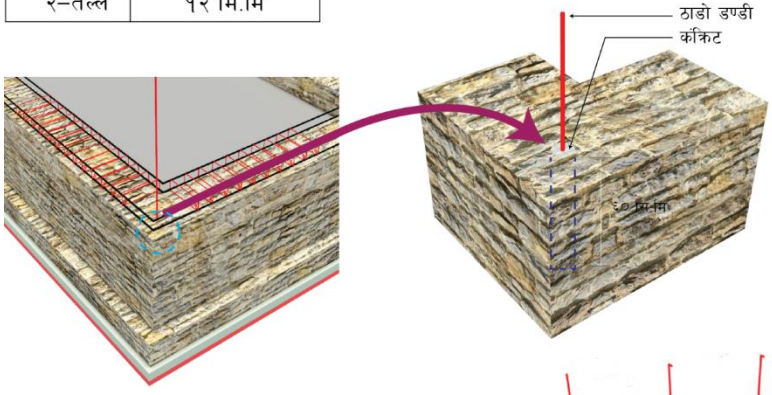
Related Minimum requirement No'5

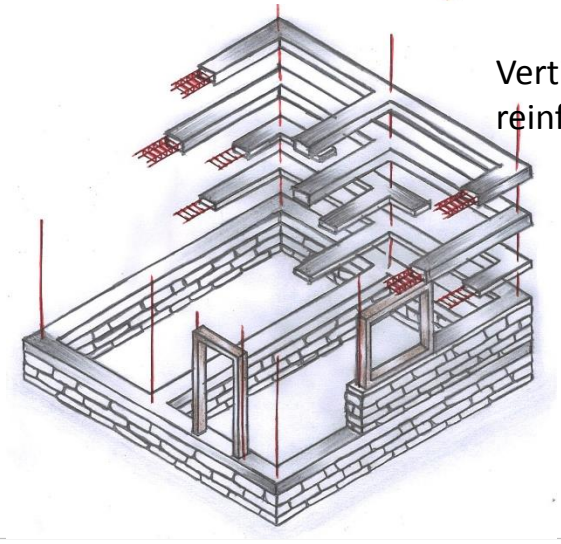
6.3.9 Vertical elements

Vertical reinforcement is used in masonry walls to resist tensile stresses that may arise from flexural and shear loads. Vertical bars should be provided at every L, T joints and sides of openings. These bars should start from the foundation and must be anchored in roof slab or roof band. Diameter of vertical reinforcement bars depends on the no. of stories and the span of the walls between two supports or joints are given in the table below.

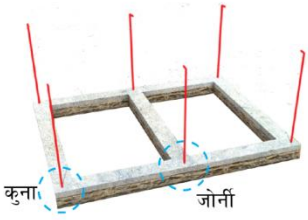
डण्डीको विवरण

तल्ला सँख्या	डण्डीको मोटाई
१–तल्ले	१२ मि.मि
२–तल्ले	१२ मि.मि





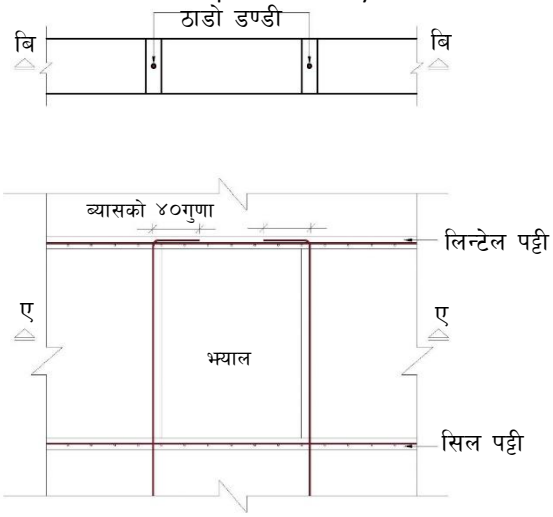
Vertical reinforcement

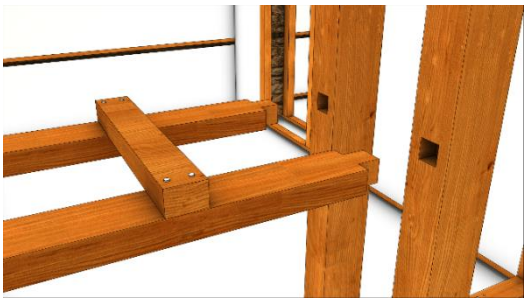


In brick masonry

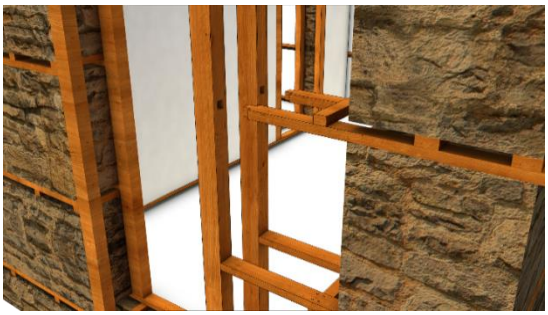
The arrangement for providing vertical reinforcing steel in brick wall is shown in fig below for one brick, one and half brick walls. It is not unusual to provide thicker walls in lower storey and thinner walls in upper storey. It is important to arrange the bars in various storeys in the same vertical line. These bars should start from the foundation and must be anchored in roof slab or roof band .

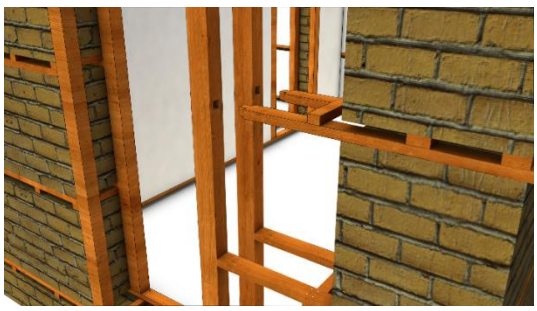
The appropriate location of splicing is just above the lintel band and below the sill band of subsequent upper storey. An overlap length equivalent to 60 times diameter of the bar is recommended, bound well by binding wire. These bars should be covered with cement concrete or cement grout in cavities made around them during masonry construction. The concrete mix should be kept 1:2:4 by volume or richer.





- काठको मुख्य स्ट्रिपलाई ४ वटा किल्ला र काठको पट्टिलाई २ वटा किल्लाले ठोक्नुपर्छ।
- ५मिमि काठको किल्ला अथवा ३.१५ मिमि जस्ता किल्ला प्रयोग गर्न सकिन्छ।

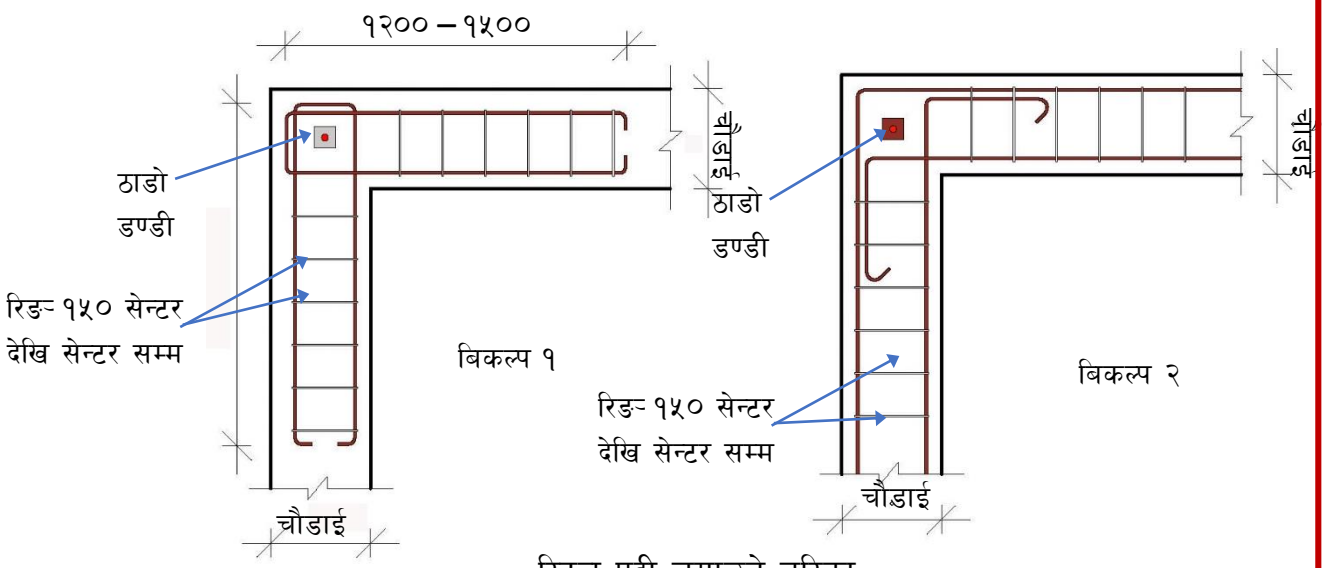




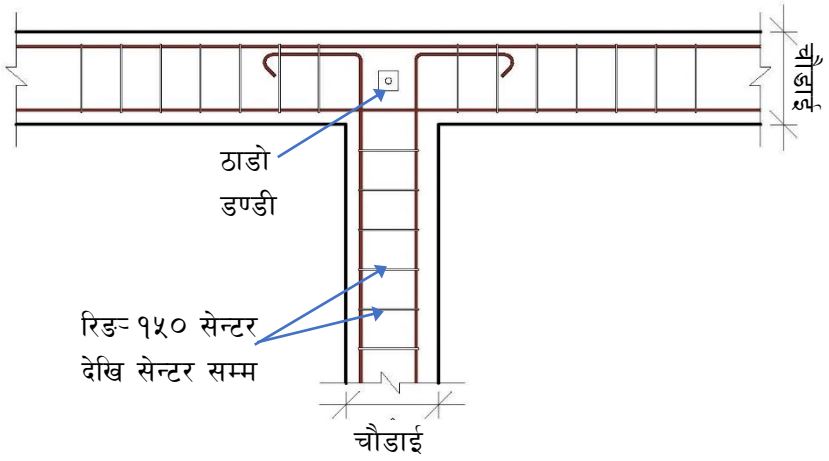
Related Minimum requirement No'9

6.3.9 Bar details

The detail measurement of splice , hook and embedment are discussed below.



स्टिच पट्टी लगाउने तरिका

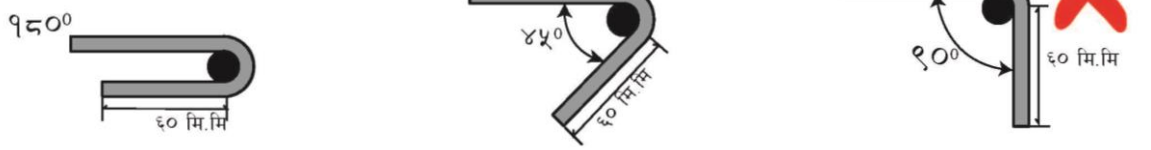


तेस्रो पट्टी (सिल, लिन्टेल, छाना) लगाउने तरिका

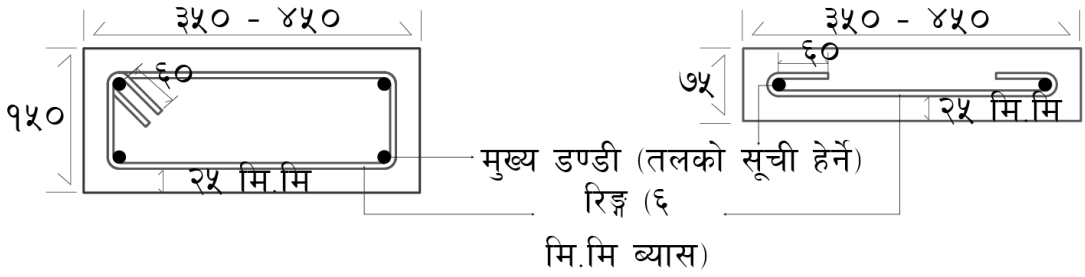
6.3 Construction of house

6.3.10 Bar details

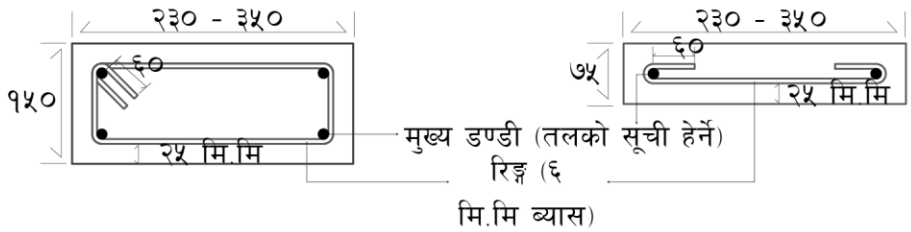
❖ हुक



❖ **ढुङ्गाको गारोमा रिङ लाई बङ्न्याउने तरिका**



❖ **माटोको गारोमा रिङ लाई बङ्न्याउने तरिका**



❖ रिबारको नाप (मुख्य डण्डी)

पट्टी	प्रवलित सिमेन्ट ब्यान्डको न्यूनतम मोटाई		फलामे डण्डीको न्यूनतम सँख्या	फलामे डण्डीको न्यूनतम ब्यास (मि.मि)
कुर्सी सतह (डि.पि.सी)	नरम, मध्यम	१५० मि.मि	४	१२
	कडा	७५ मि.मि	२	१२
सिल पट्टी (झ्यालको तल्लो सतह)	७५ मि.मि		२	१२
स्टिच पट्टी	७५मि.मि		२	८
लिन्तेल पट्टी (झ्याल ढोकाको माथिल्लो सतह)	१५० मि.मि (*१)		४	१२
	७५ मि.मि (*२)		२	१२
छाना पट्टी	७५ मि.मि		२	१२

नोट:

१) यदि खुल्ला भागको चौडाई ९०० मि.मि भन्दा बढी भएमा १५० मि.मि मोटाईको लिन्टेल ब्यान्डको प्रयोग गर्नुपर्छ।

२) यदि झ्याल ढोकाको चौडाई र खुल्ला भाग माथिको उचाई १००० मि.मि र ९०० मि.मि छ भने यसको न्यूनतम मोटाई ७५ मि.मि को हुन्छ।

Splicing length

All longitudinal bars should be anchored or spliced for full strength development. All splices should be contained within at least two stirrups at each end of the splice so as to avoid spalling of cover concrete.

- ✓ overlapping of bars should be done with hook at plinth,sill,lintel and roof band with anchoring distance 40D .
- ✓ overlapping of bars should be done without hook at plinth ,sill,lintel and roof band with 50 D.

Hook

- ✓ Has a larger concrete strength area,to counter the steel bar breaking free
- ✓ Stronger

6. Earthquake resistant house

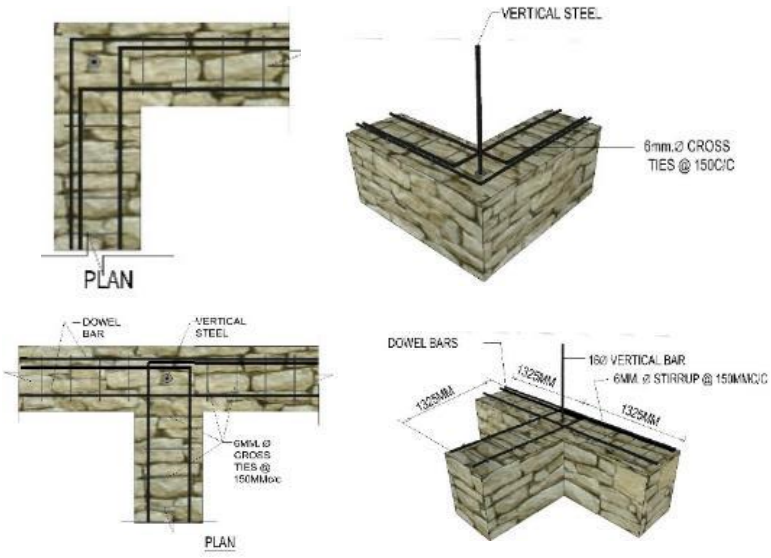
6.3 Construction of house

6.3.11 Strengthen of Junction

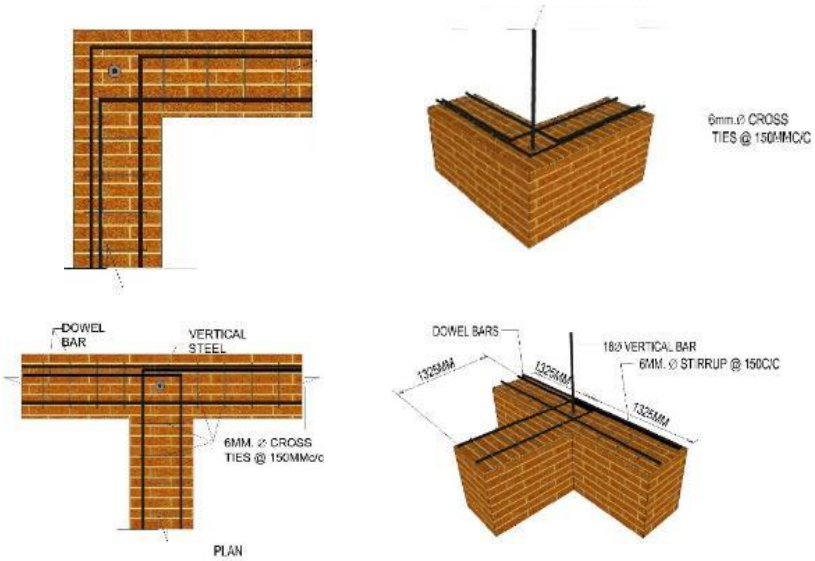
It is common practice to provide vertical toothed joint at wall junctions, which is generally left hollow and weak.

To strengthen the connection between perpendicular walls, it is necessary to make uniform.

Hence, horizontal band were provide to different levels of in walls.

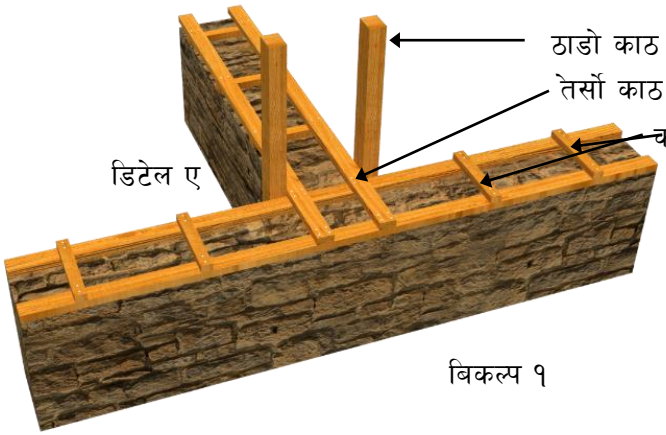


RCC BAND AT CORNER and T-Junction (stone masonry)

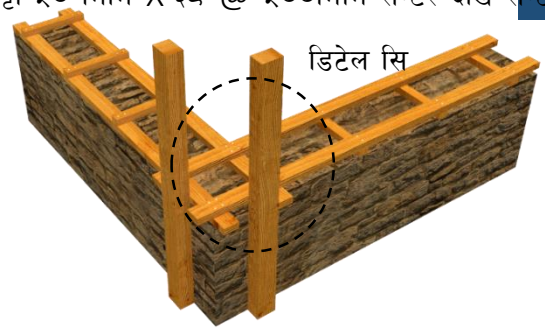


RCC BAND AT CORNER and T-Junction (Brick masonry)

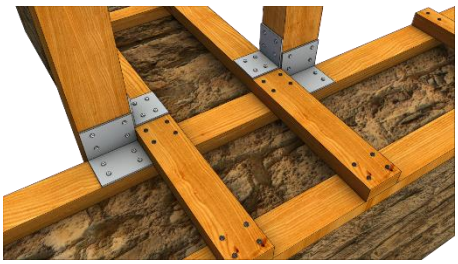
Strengthen of Junctions



बिकल्प १



डिटेल ए

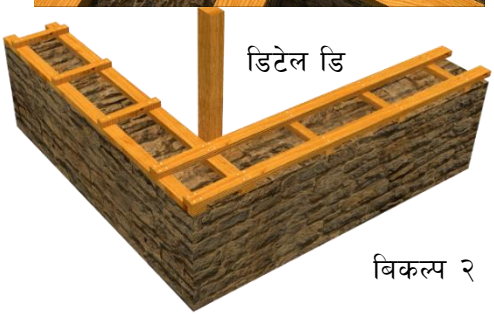


डिटेल सि

डिटेल बि

बिकल्प २

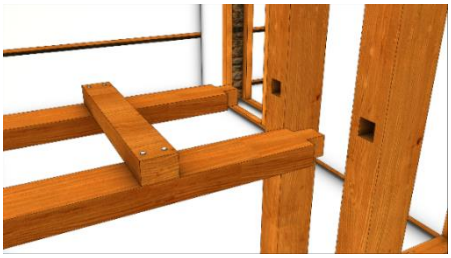
डिटेल डि



बिकल्प २

डिटेल बि

डिटेल डि



तेस्रो पट्टी (सिल, लिन्टेल, स्टिच, छाना) लगाउने तरिका

- काठको मुख्य स्ट्रिपलाई ४ वटा किल्ला र काठको पट्टिलाई २ वटा किल्लाले ठोक्नुपर्छ।
- ५मिमि काठको किल्ला अथवा ३.१५ मिमि जस्ता किल्ला प्रयोग गर्न सकिन्छ।

Strengthen of Junctions

Photographs

6. Earthquake resistant house

6.3 Construction of house

6.3.12 Casting concrete

Concrete is a substance used for building which is made by mixing together cement, sand, small stones, and water.

Procedure for concreting are described below:

✓ Rebar Arrangement

Rebar should be arranged properly, Minimum clear cover to the reinforcement: 15 mm to the bars in slabs, 25 mm in beams in general .Lap length should not be less than 60 times the diameter of the bar. stirrups should not be more than 100 mm apart over the reinforcement lapping region. The ends of bars should be hooked by bending through 180◌̊◌̊◌̊ in mild steel bars and 135 I deformed bars.

✓ Installation of Formwork

Create a formwork using board timber at a width of 15 cm and a height of 20 cm. The formwork must be strong and thick. Then cover the formwork cavity with wet paper cement. To maintain a thick 2 cm concrete cover, make the concrete 2 cm thick or alternatively over with 2 cm of gravel.

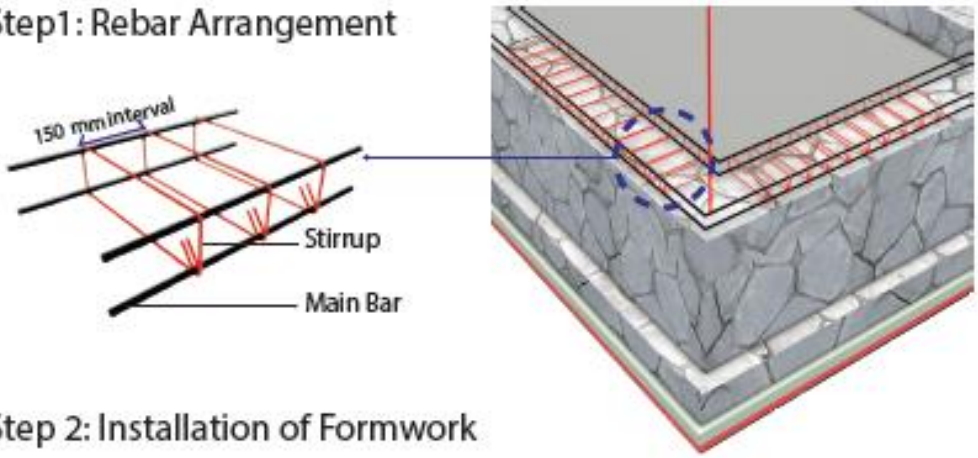
✓ Placing Concrete

Do casting with already prepared concrete mixture. The concrete must be compacted by using vibrator or Rebar.

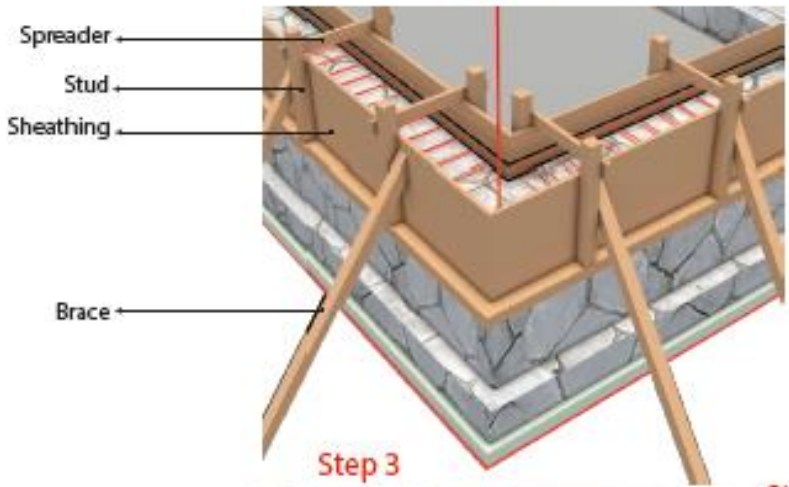
✓ Curing

Leave formwork at least 3 days and keep all exposed concrete surface wet.

Step1: Rebar Arrangement



Step 2: Installation of Formwork

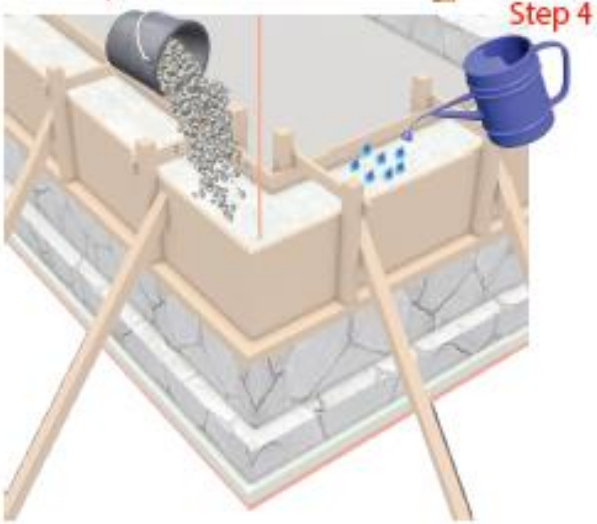


Step 3

Step 4

Step 3: Placing Concrete

- Compacting Concrete by Vibrator or Rebar !



Step 4: Curing

- Leave formwork at least 3 days !
- Keep all exposed concrete surface wet !

6.3 Construction of house

6.3.13 Roof

As a general rule, heavy roofs are a seismic hazard. Hence, roofs as well as floors should
be made as light as structurally and functionally possible.

Pitched Roofs:

Pitched roofs may be trussed, with the top of the walls generally at one level except for the masonry gables at the ends of the building. Alternatively, the longitudinal and cross-walls may be raised to varying heights up to the roof slope and the rooms spanned by rafters and purlins. From a seismic design point of view, the trussed arrangement is preferable, particularly for school buildings.

Trussed Roofs:

In trussed roofs, all trusses shall be supported on the eave or roof-band. Where a trussed roof adjoins a masonry gable, the ends of the purlins shall be carried on and secured to a plate securely bolted to the band at the top of gable-end masonry.

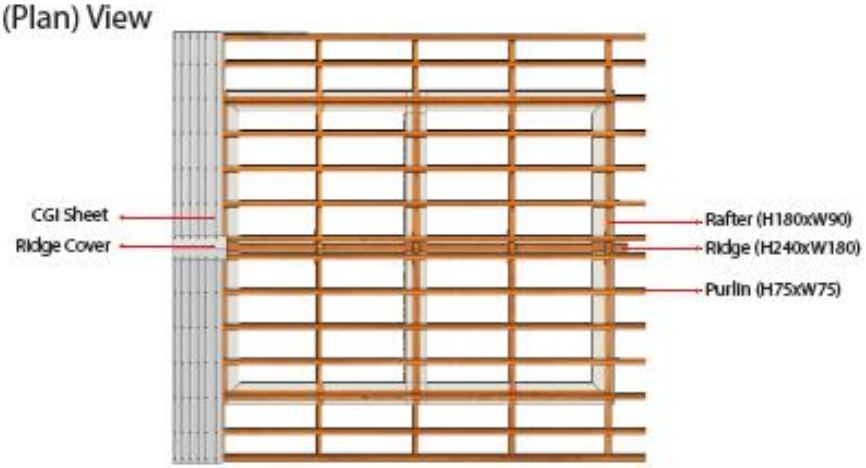
Lean-to Roofs

All masonry walls shall be topped by a reinforced concrete roof-band securely held by means of bolts. Alternatively, wall plates may be used which are bolted to the band and to which the rafters and purlins are fixed.

The roofing structure must be light, well-connected and adequately tied to the walls :

- ✓ The roof beams, rafters or trusses should preferably be supported on longitudinal wooden elements for distributing the load on walls
- ✓ The roof beams or rafters should be located so as to avoid their being placed above door or window lintels. Otherwise, the lintel should be reinforced by an additional piece of timber).

❖ Top (Plan) View



❖ Side View

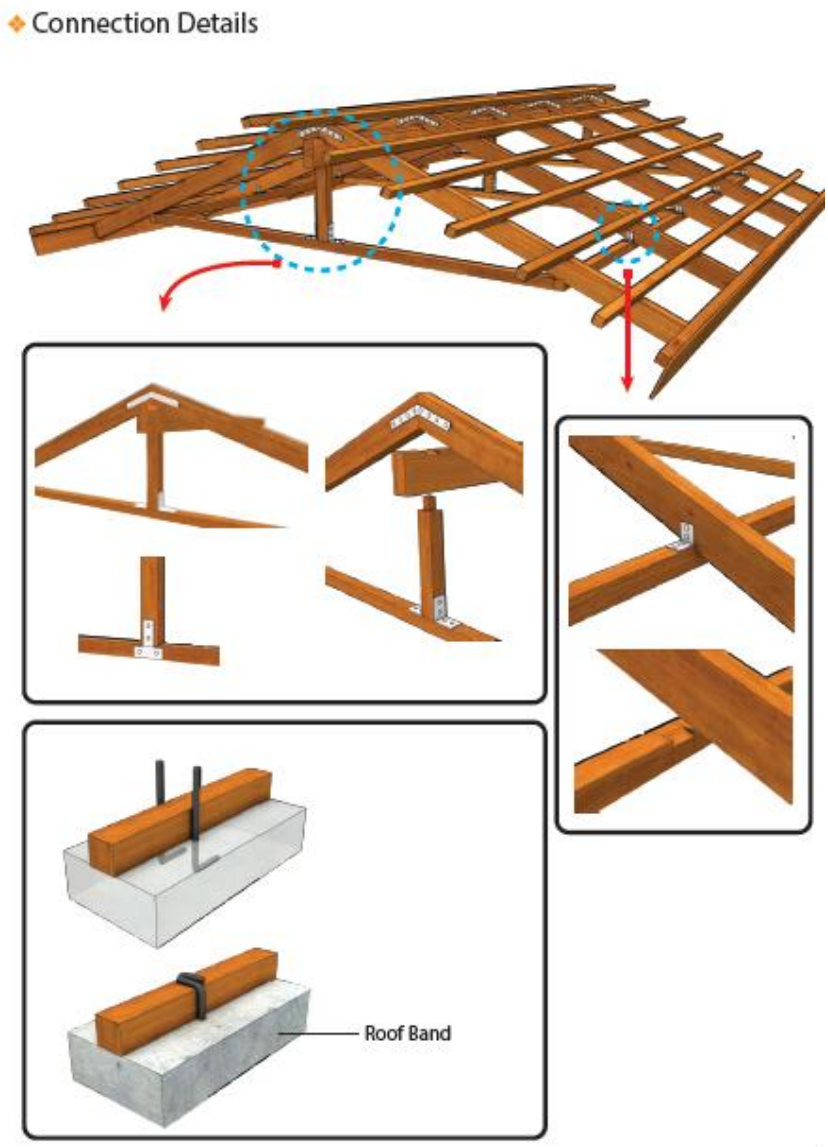
❖ Isometric View

6. Earthquake resistant house

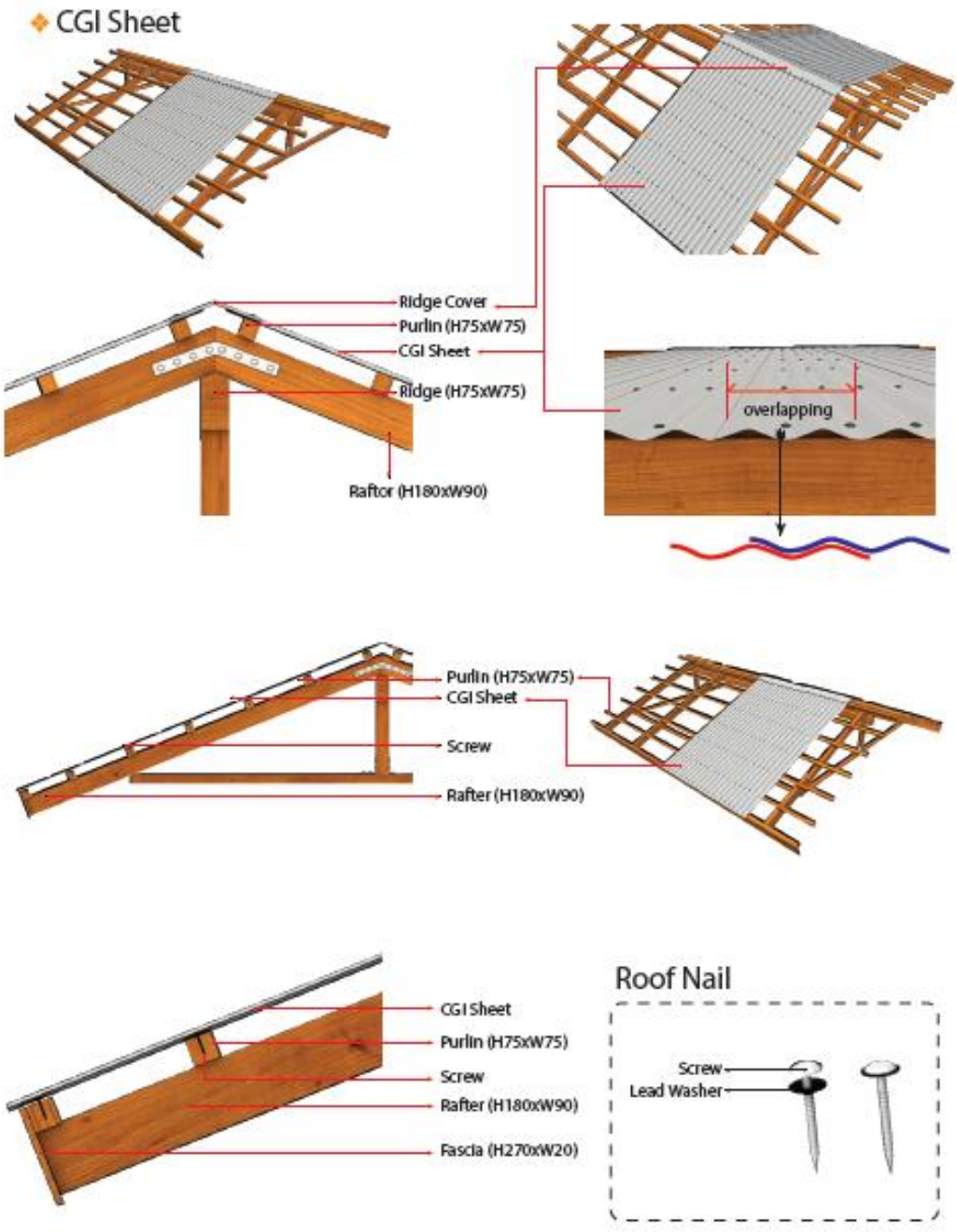
6.3 Construction of house

6.3.13 Roof

Here, bottom chord which is also known as the joist or tensile member is laid over the roof beam, Similarly, depending upon the span of the building other two number of bottom chord is also joined in the transverse direction as shown in figure and after that the king post is tied at the middle of the bottom chord using bolts and steel clams. After securing the king post ridge beam is placed above it with the use of tongue and groove joint as shown in figure. The two piece of the top chord typically known as rafter is joined by the use of bolts and steel clams and fixed along with the rafter which acts as the compression member. Depending upon the size of the roof, these rafter must be placed at the equal interval which helps to bear the compressive load.



Above the rafter, purlin is placed at the equal interval depending upon the length of the rafter. After securing purlin above the rafter roof covering i.e. CGI sheet is nailed to the purlin. Since, the size of the CGI sheet is limited, and number of piece of C.G.I. sheet should be used to cover the roof, hence the overlapping of these sheet should be kept into mind. The overlapping of the C.G.I sheet should be made as shown in the figure below. In order to avoid the leakage of rain water from the roof plain sheet should be used as the ridge cover. Similarly, at the eaves level eaves board should be used.



Photographs

Photographs

Photographs

Standard Design

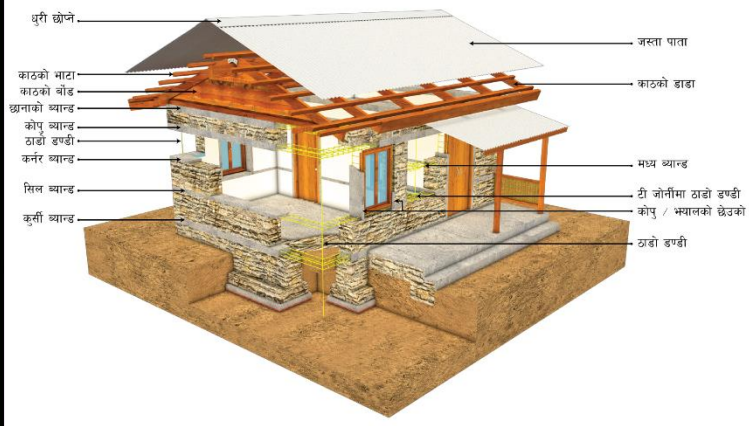
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ढुङ्गा सिमेन्टको जोडाइ

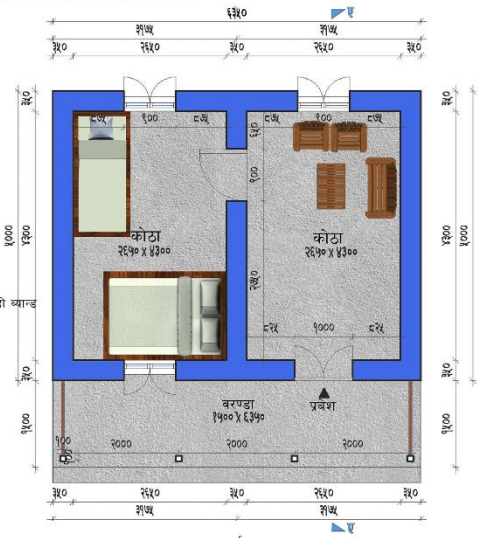
कुल क्षेत्रफल-३१.७५वर्ग.मि

नमुना नं:
एस एम सि १.१

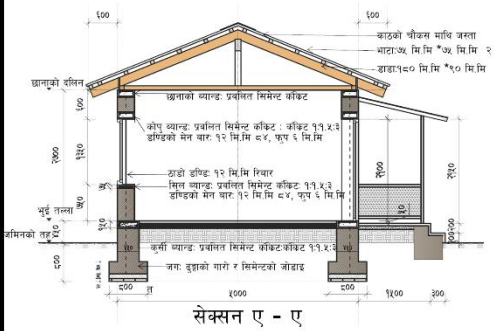
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्रग दृश्य



भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



सेक्सन ए - ए

अगाडिको मोहोडा

दाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ढुँगा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(घन मिटर)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
१७१	३५८	३४	१४६	२१	१०	२.२७	४.७१	४६०

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: एस एम सि १.१
डिजाइन गर्ने: जाईका

स्केल: None

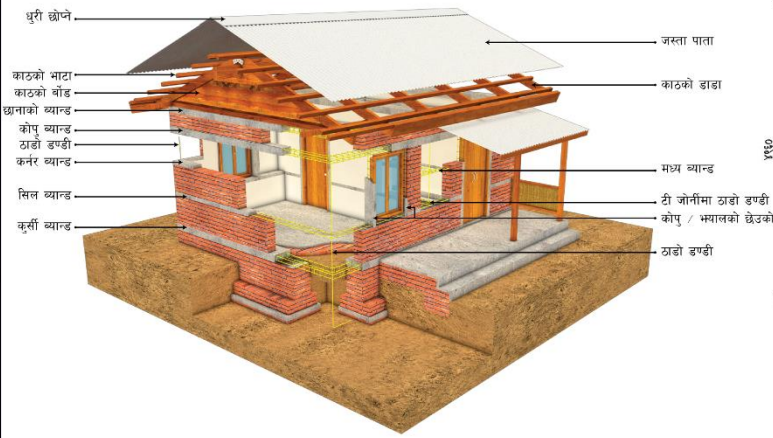
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

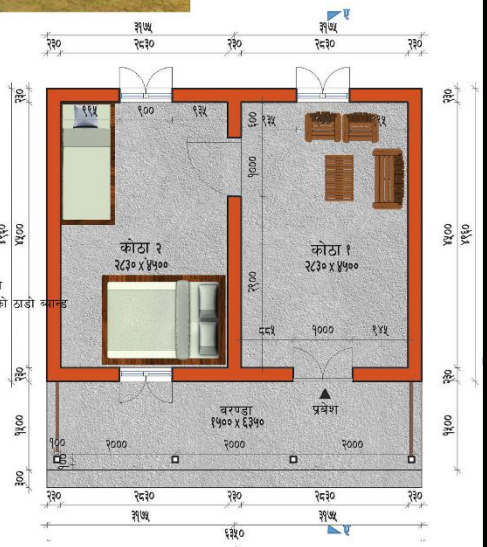
नमुना नं:
बि एम सि १.१

कुल क्षेत्रफल-३१.७५वर्ग.मि

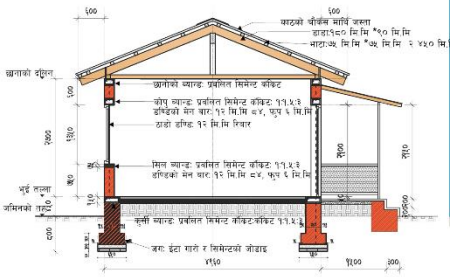
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग द्रश्य



भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



सेक्सन ए - ए

अगाडिको मोहोडा

दाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ईटा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(सँख्या)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
१५१	१८१	२१३५३	१२३	१५	८	२.२७	५	४६०

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: बि एम सि १.१
डिजाइन गर्ने: जाईका

स्केल: None

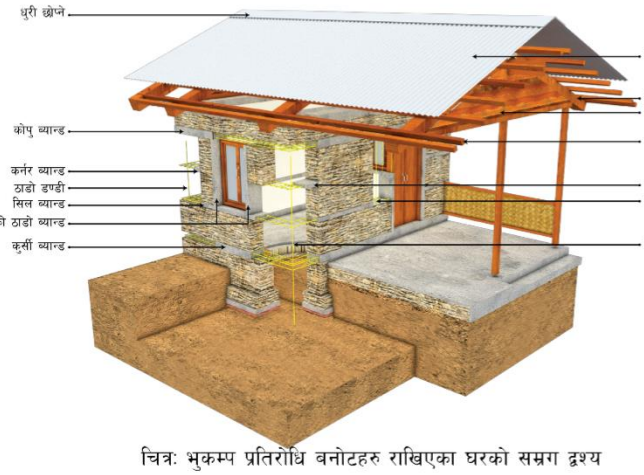
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ढुङ्गा सिमेन्टको जोडाइ

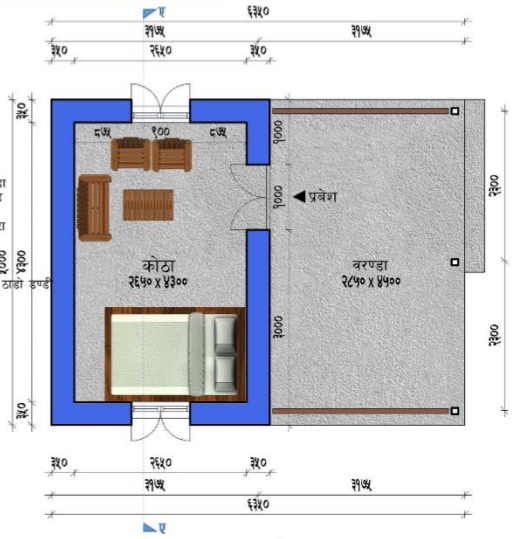
कुल क्षेत्रफल-३१.७५ वर्ग.मि

नमुना नं:
एस एम सि १.२

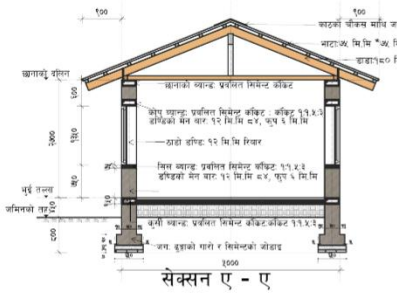
बाहिरी बनावट



चित्रः भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग दृश्य



भुई तल्ला प्लानः
क्षेत्रफलः ३१.७५ वर्ग.मि



सेक्सन ए - ए

अगाडिको मोहोडा

बाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ढुँगा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(घन मिटर)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
१२४	२४९	२५	९७	१५	६	१.९६	४	२५२

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: एस एम सि १.२
डिजाइन गर्ने: जाईका

स्केल: None

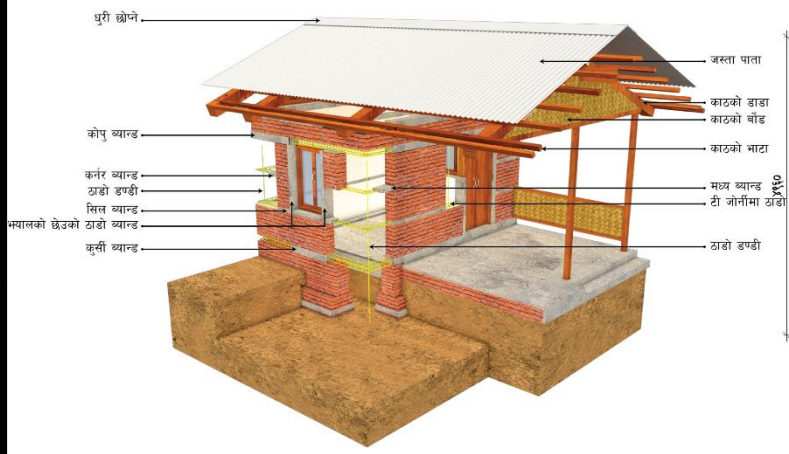
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

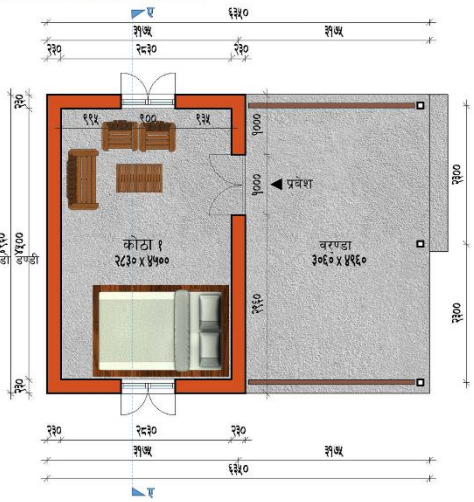
नमुना नं:
बि एम सि १.२

कुल क्षेत्रफल-३१.७५वर्ग.मि

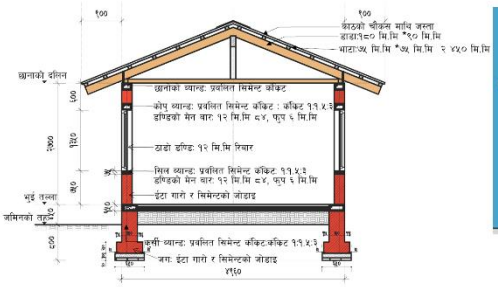
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग द्रश्य

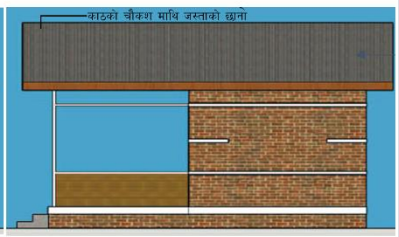


भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



सेक्सन ए - ए

अगाडिको मोहोडा



दाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ईटा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(सँख्या)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
१०७	१२१	१३६६२	८०	१०	६	१.९४	४	२५२

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: बि एम सि १.२
डिजाइन गर्ने: जाईका

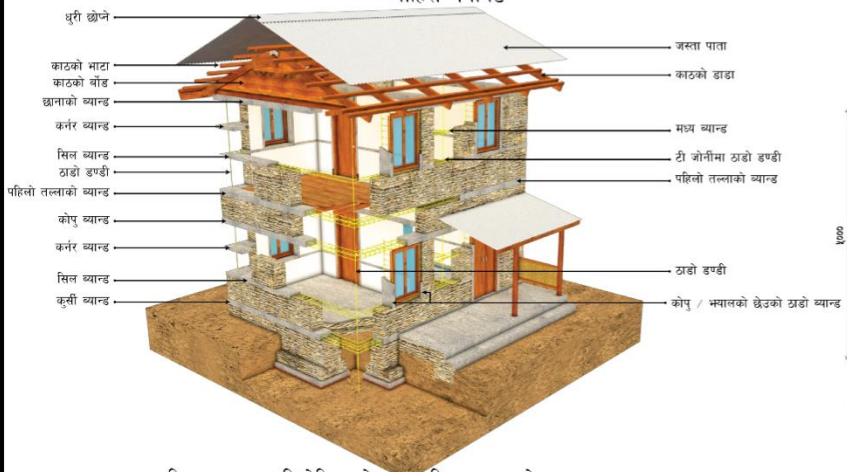
स्केल: None

भुकम्प प्रतिरोधी नमुना आवास डिजाइन (दुई तल्ले)
गारे भवन, ढुङ्गा सिमेन्टको जोडाइ

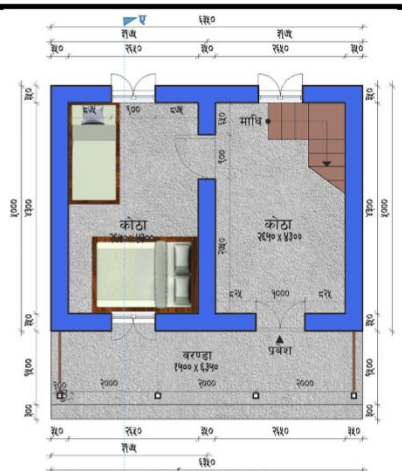
नमुना नं:
एस एम सि २.१

कुल क्षेत्रफल-६३.५वर्ग.मि
भुई तल्लाको क्षेत्रफल-३१.७५वर्ग.मि+पहिलो तल्लाको क्षेत्रफल-३१.७५वर्ग.मि

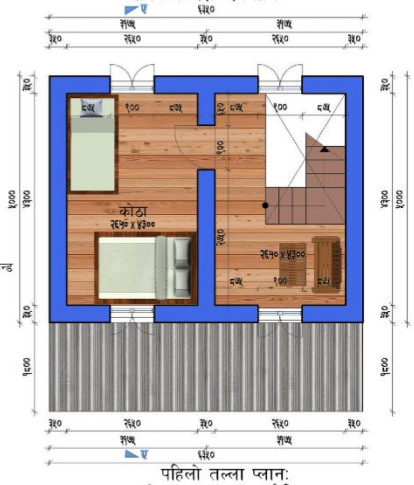
बाहिरी बनावट



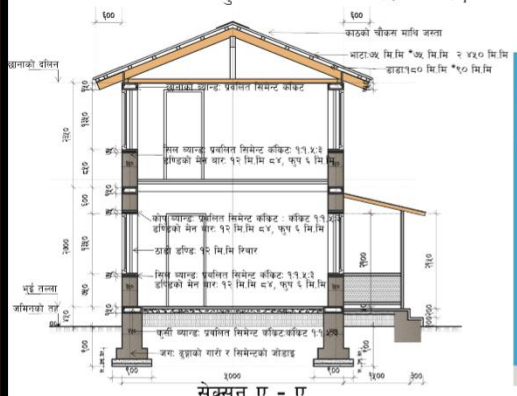
चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग दृश्य



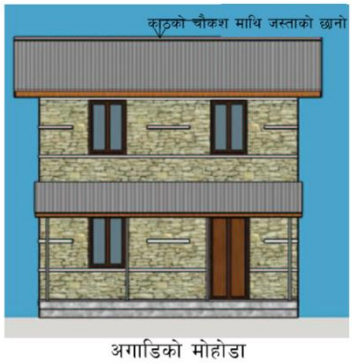
भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५वर्ग.मि



पहिलो तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



सेक्सन ए - ए



अगाडिको मोहोडा

दाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ढुँगा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(घन मिटर)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
२६८	५२४	५०	२२०	३०	१४	३.७७	५	७७६

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: एस एम सि २.१
डिजाइन गर्ने: जाईका

स्केल: None

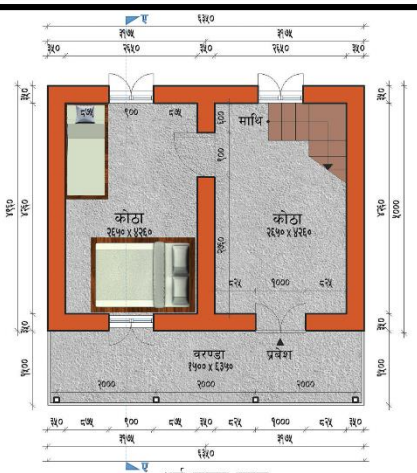
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (दुई तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

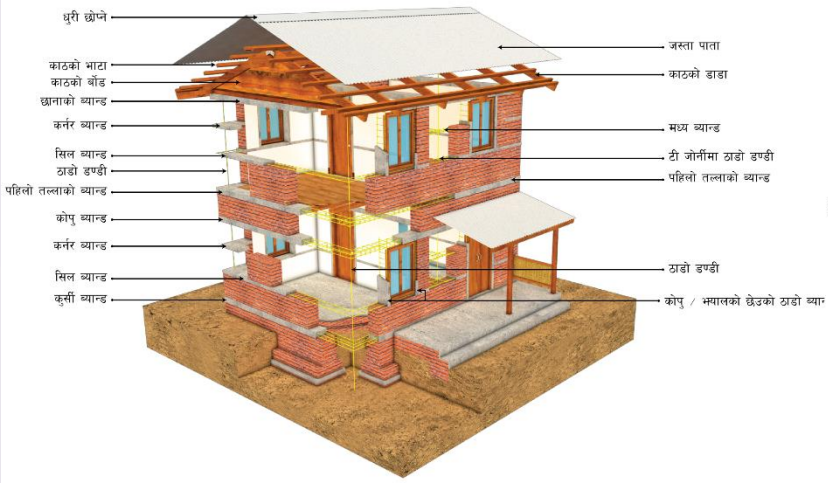
नमुना नं:
बि एम सि २.१

कुल क्षेत्रफल-६३.५वर्ग.मि
भुई तल्लाको क्षेत्रफल-३१.७५वर्ग.मि+पहिलो तल्लाको क्षेत्रफल-३१.७५वर्ग.मि

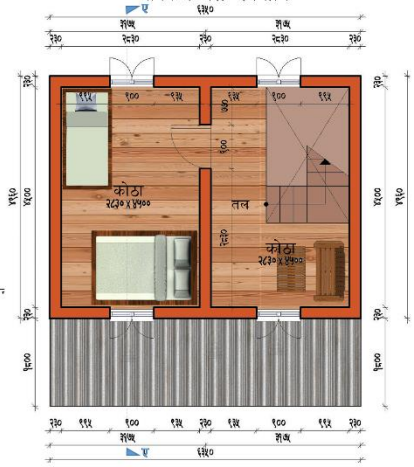
वाहिरी बनावट



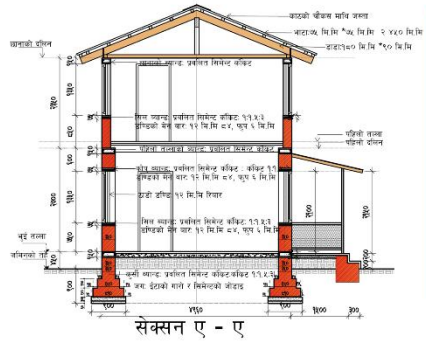
भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५वर्ग.मि



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्रग द्रश्य



पहिलो तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



सेक्सन ए - ए

अगाडिको मोहोडा

दाँया मोहोडा

जनशक्ति		सामाग्री						
सिपालु	ज्यामी	ईटा	सिमेन्ट	बालुवा	एग्रिगेट	काठ	जस्ता पाता	डण्डि
जना	जना	(सँख्या)	(बोरा)	(घन मिटर)	(घन मिटर)	(घन मिटर)	(बन्डल)	(केजि)
२५५	२९०	३४७७८	१८६	२२	११	४.४३	५	७७७

नेपाल सरकार
सहरी विकास मन्त्रालय
सहरी विकास तथा भवन निर्माण विभाग
बबरमहल,काठमाण्डौ फोन नं ४-२६२३६५/४-२६२४६६
www.dudbc.gov.np
Email:www.dudbchousing@gmail.com

नमुना नं: बि एम सि २.१
डिजाइन गर्ने: जाईका

स्केल: None