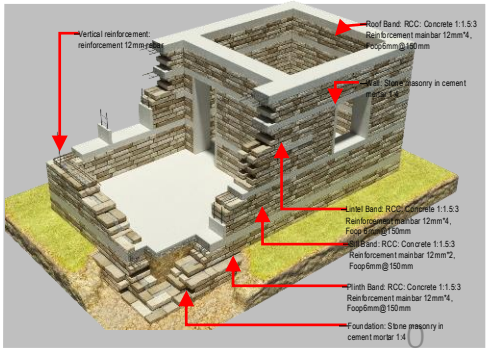
GUIDEBOOK FOR

RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

Supporting Compliance with the National Building Code, Nepal

For House owners



June, 2016

GUIDEBOOK FOR RECONSTRUCTION OF EARTHQUAKE RESISTANT HOUSES

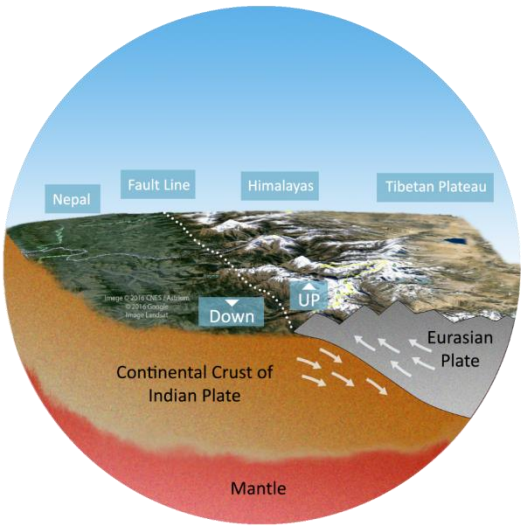
Supporting Compliance with the National Building Code, Nepal

Japan International Co-operation Agency

contents

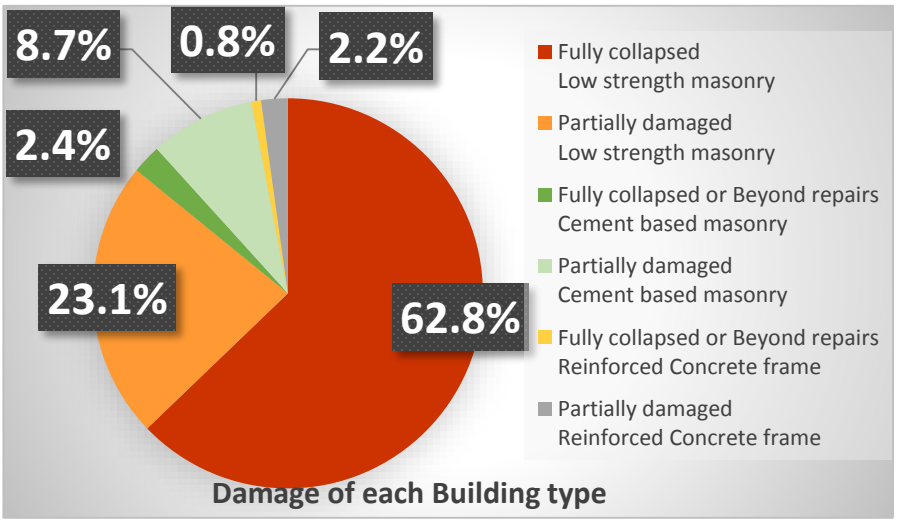
1.1 Housing reconstruction

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



The 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.



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

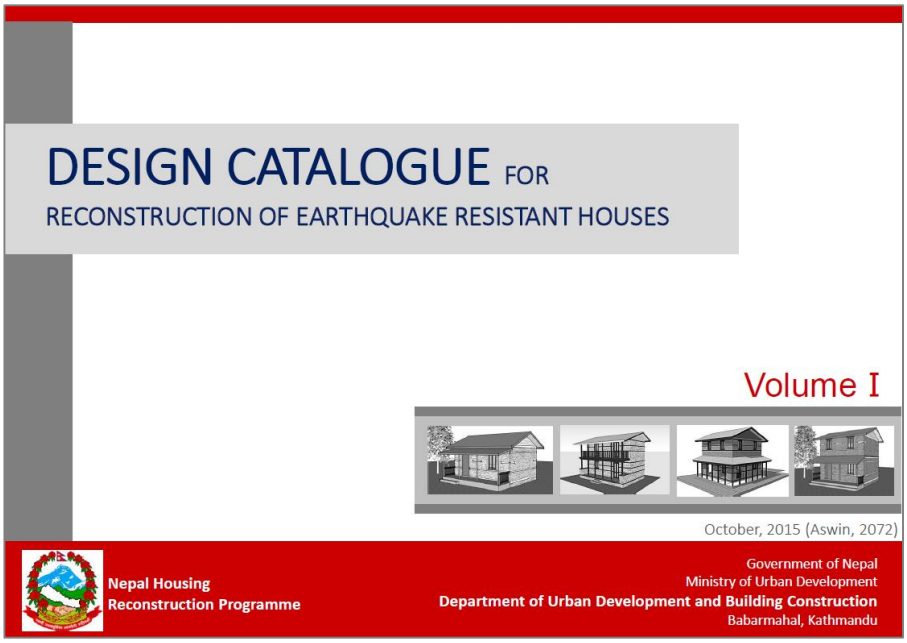
1. Encourage the participation of communities by empowering them to take control of reconstruction of their houses and ensuring facilitation of Owner Driven Reconstruction.
2. A comprehensive view of housing reconstruction should include holistic habitat development, with basic services and community 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.

Heavy Damaged house by 25th April,2015

1.2 Design Catalogue for
Reconstruction of earthquake resistant houses

Design catalogue for reconstruction of earthquake resistant houses has been produced by the Department of Urban Development and Building Construction (DUDBC) to support rural households in the reconstruction of their houses.

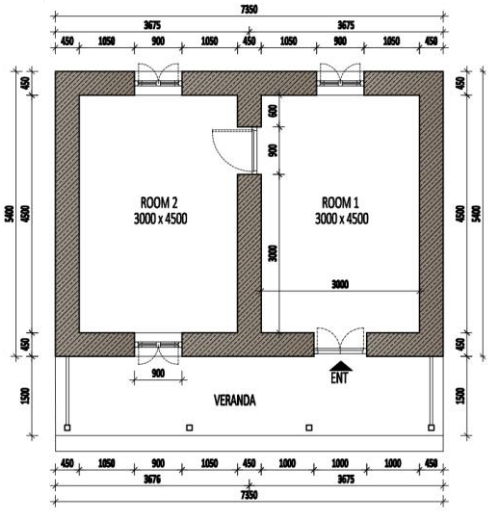
The objective of this document is to provide rural households with clear guidance regarding earthquake resistant construction techniques and to support them to have house designs in compliance with the National Building Code of Nepal.



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.

Structural Type	No. of Floor	Model No.	Designed by	Page
Stone masonry in cement mortar, P5-SMC	1	SMC-1.1	JICA	9
	1	SMC-1.2	JICA	15
	2	SMC-2.1	JICA	21
	2	SMC-2.2	DUDBC	27
	2	SMC-2.3	DUDBC	33
	2	SMC-2.4	DUDBC	39
	2+ATTIC	SMC-2.5	DUDBC	45
	2+TERRACE	SMC-2.6	DUDBC	51
		Technical details		57
		Flexible design		67
Brick masonry in cement mortar P71-BMC	1	BMC-1.1	JICA	75
	1	BMC-1.2	JICA	81
	2	BMC-2.1	JICA	87
	2	BMC-2.2	DUDBC	93
	2	BMC-2.3	DUDBC	99
	2+ATTIC	BMC-2.4	DUDBC	105
	2+TERRACE	BMC-2.5	DUDBC	111
		Technical details		117
		Flexible design		126
Stone masonry in mud mortar, P129-SMM	1	SMM-1.1	DUDBC	135
		Technical details		141
		Flexible design		143
Brick masonry in mud mortar, P147-BMM	1	BMM-1.1	DUDBC	153
		Technical details		159
		Flexible design		161

List of Model Houses in design catalogue Vol.1



GROUND FLOOR PLAN
FLOOR AREA: 39.69sqm

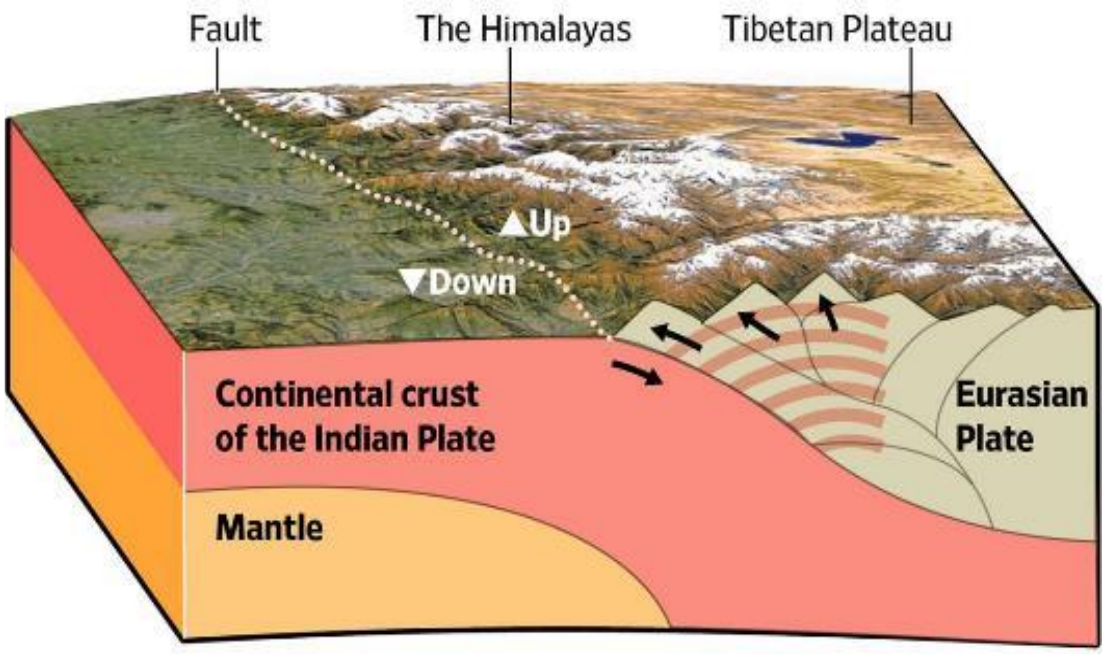
Minimum Requirements for building construction with Stone Masonry in Mud Mortar for Residential Building

No.	Category			
1	Site selection	It shall be done to minimize risk against natural hazards. A building shall not be constructed if any of the following conditions exist.		
		☐Geological fault or Ruptured Area	☐Steep Slope > 20° (1:3, Vertical : Horizontal)	
		☐Landslide susceptible Area	☐River bank and Water logged Area	
		☐Rock-fall Area	☐Liquefaction susceptible Area	
		☐Filled Area		
		If it is in these areas, consult with expert.		
2	Shape/Size of building	No. of storey	RC band	Not more than one plus habitable attic.
			Timber band	Not more than one storey.
		If additional storey required, consult with expert to adopt extra measures.		
		Clear span of wall	Not more than 12 times thickness of wall and not more than 4.5m.	
		Size of room	Not more than 13.5sq.m.	
		Height of wall	Floor height shall not be more than 3.0m. In case of attic floor,maximum height from flor level to ridge level shall be 1.8m and maximun height from floor level to eave level shall be 1.0m.	
		Proportion	Simple and regular shaped as square and rectangular. The length of house shall not be more than 3 times of its width. Avoid setbacks.	
3	Materials	Stone	Avoid use of rounded, subrounded, easily breakable soft stone and boulder stones in its natural shape. River stone shall be dressed. Size of stone shall not be smaller than 50mm in thickness and 150mm in length or breadth.	
		Mortar	Mud mortar	Free from organic materials, pebbles, hard materials.
			Cement mortar	Cement sand mortar shall not be leaner than 1:6 (1 part cement and 6 parts sand by volume) for masonry.
		Concrete	It shall not be leaner than M15 grade concrete, or mix ratio 1:2:4. (1 part cement, 2 parts sand and 4 parts aggregate by volume)	
		Rebar	High strength deformed bars with fy = 415 Mpa /500 Mpa.	
			Well seasoned hard wood without knots shall be used for structural purpose.	

1.3 Earthquakes

An earthquake is a sudden and violent motion of the earth caused by plate tectonics which lasts for a short time, and within a very limited region. Most earthquakes last for less than a minute. The larger earthquakes are followed by a series of after shocks which also may be dangerous.

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.



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.

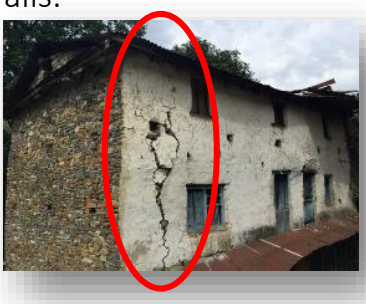
1.4 Effects of Earthquake on Buildings

Typical failure pattern of masonry structure

During an earthquake, a building is shaking in all possible directions. The shaking loosens the joints of different components of building that leads to subsequent damage or collapse.

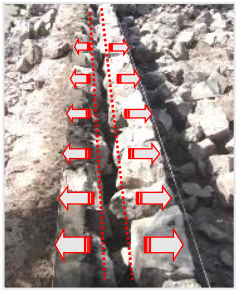
➢ Separation of walls

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.



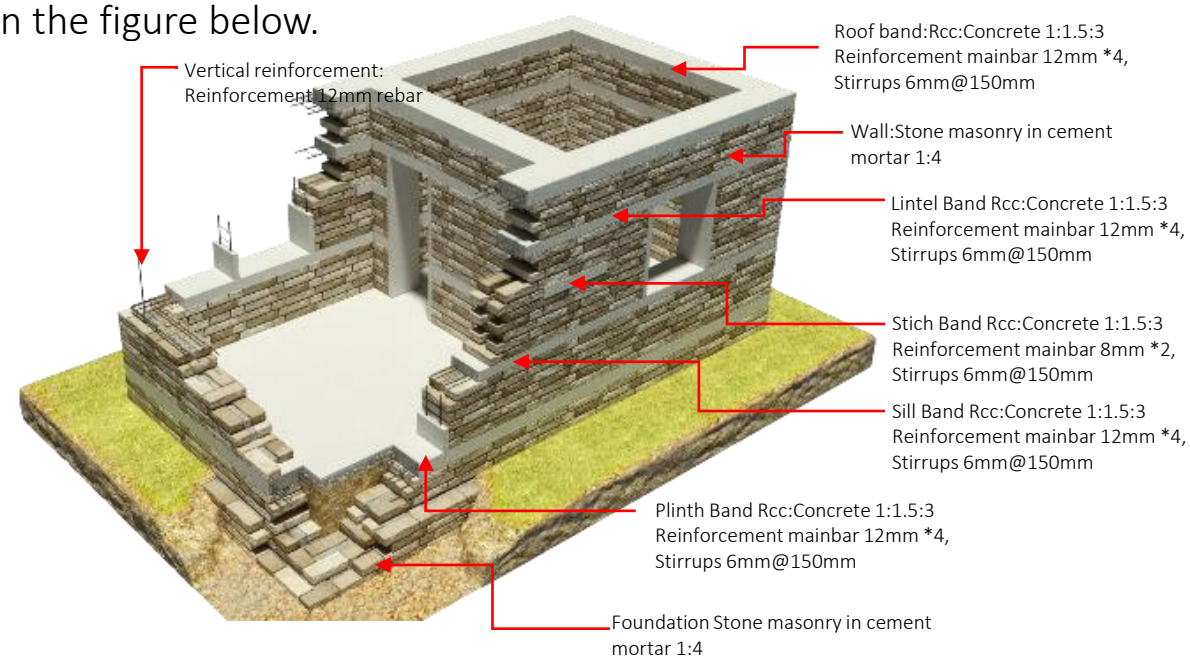
➢ Gable wall collapse

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.

Earthquake resistant design

Earthquake-resistant structures are designed to withstand earthquakes. while no structure can be entirely immune to damage from earthquakes.

To construct earthquake resistant building no. of factors such as site selection, shape of house, foundation, Plinth, walls, opening, vertical reinforcement, horizontal Band, roof, materials should be considered. The details of the seismic elements at different level of the buildings are clearly shown in the figure below.

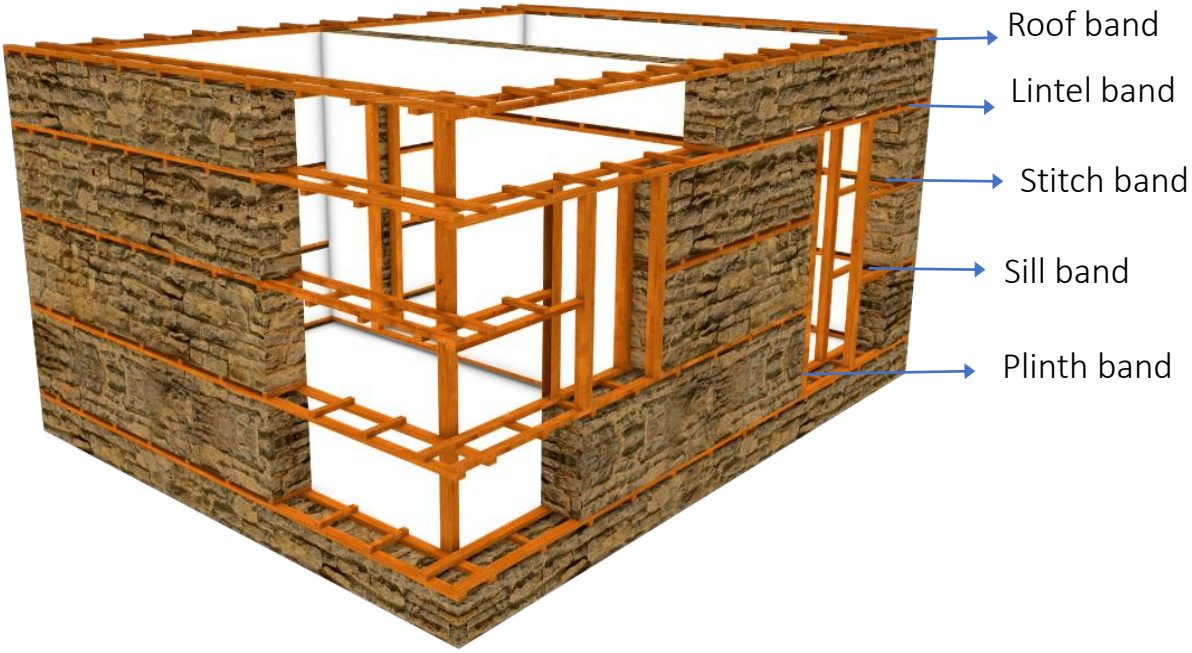


Technology for Earthquake Resistant Building Construction
(Stone in Cement Mortar)

Eg:.Technology for Earthquake Resistant Building Construction
(Charikot, Dorakha)

Components of building

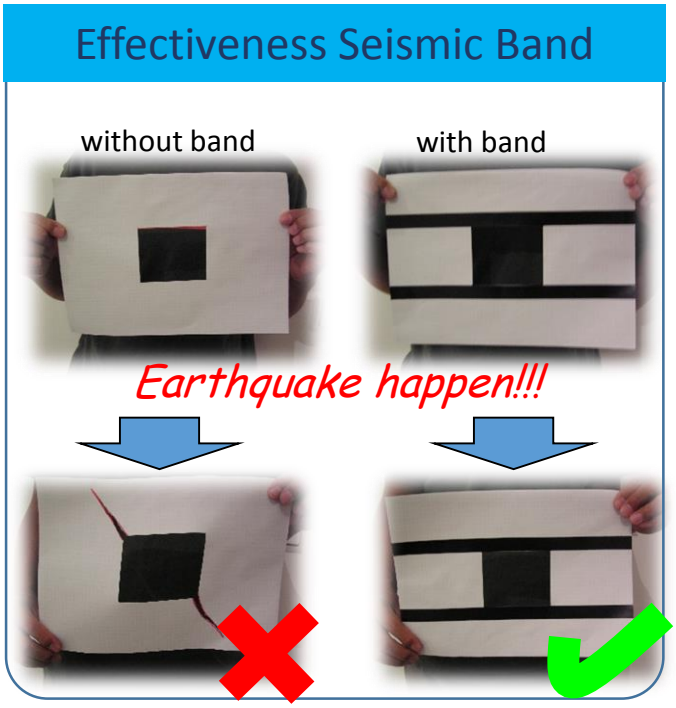
The pictures shows the main components of building.



Seismic Horizontal wooden band

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.



1.6 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.

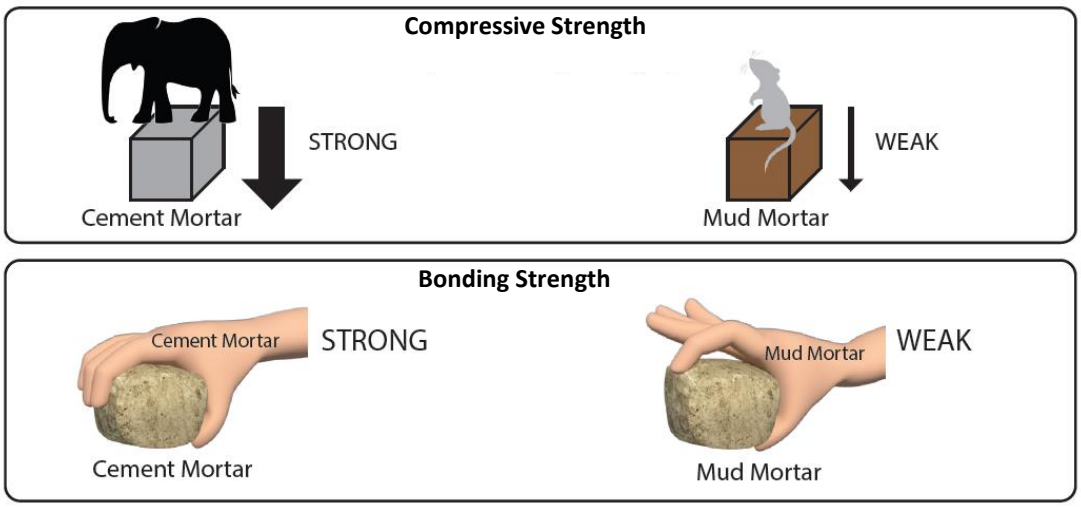
Cement mortar helps to carry the weight placed on the wall and seal the joints where it has a high degree of impermeability and is more prone to shrinkage than others mortar.

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



Part 2:The earthquake resistant house

2.1 Design of house

2.2 Construction

2.2.1 Preparation of Construction

2.2.2 Appropriate Construction process

2.1 Design of house

a. Site selection

Related Minimum requirement No'1

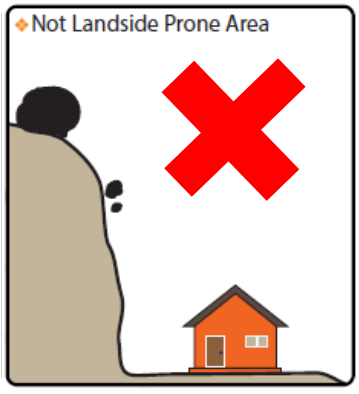
Adequate locations: Safe place to build houses are those located far from areas where natural Hazards may occur.

✓ 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.

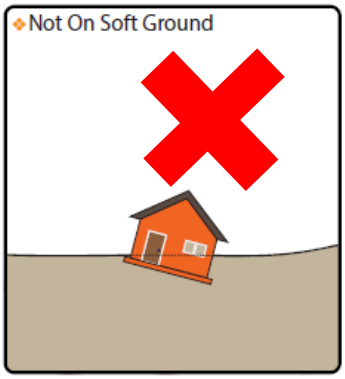


✓ Do not select near river bank

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

b.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

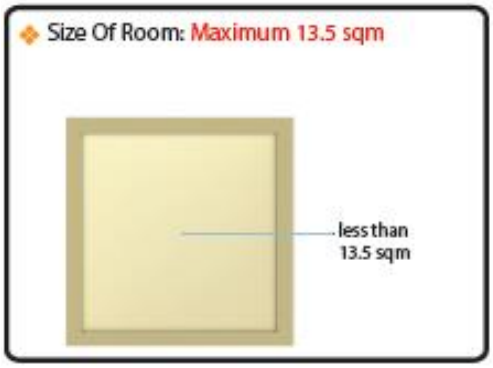
- Incase of stone/brick masonry in mud mortar with wooden band the total number of storey should be limited to one storey whereas if R.C band is used instead of wooden band then one plus attic floor can be constructed.

2.1 Design of house

b.Shape of House

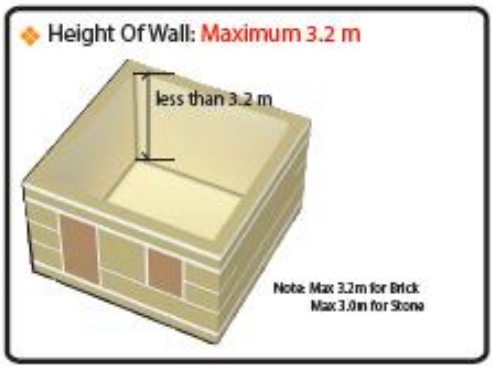
- Span of wall

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



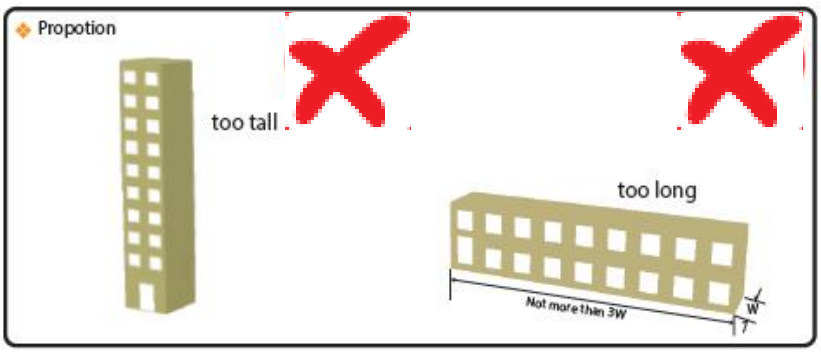
- Size of Room

Each room should not exceed 13.5 sq. m.



- Height of wall

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

2.1 Design of House

C. Opening of wall

Related Minimum requirement No'8

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 should not be more than 50% of total length of the walls in case the building is of single storey. But it should not be more than 42% at ground floor when the building is 2 storied.

✓ Distance of opening from the end of a wall

It should be more than ¼ of the height of the opening but not less than 0.6 m.

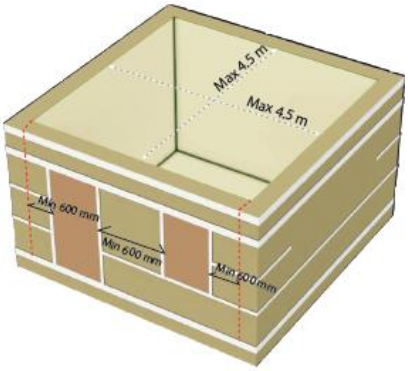
✓ The horizontal distance between two openings

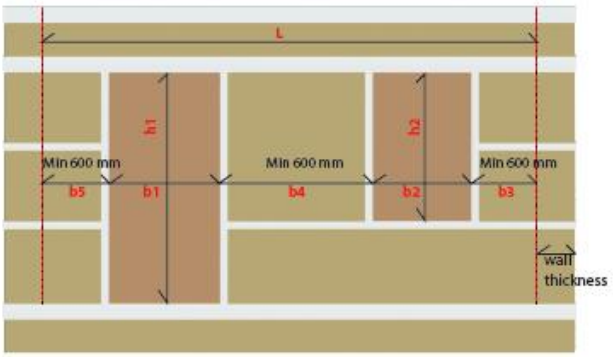
It should not be less than half of the height of the shorter opening, but not less than 0.6 m.

✓ 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.

- L = b1 + b2 + b3 + b4 + b5 <= 4.5m
- b1 + b2 <= 0.5L for 1-storey
- b1 + b2 <= 0.42L for 2-storey
- b4>= 0.5h2, but no less than 600 mm
- b5>= 0.25h1, but no less than 600 mm
- b3>= 0.25h2, but not less than 600 mm

Related Minimum requirement No'8

C. Opening of wall

Large sizes and inappropriate locations of opening are another cause 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.

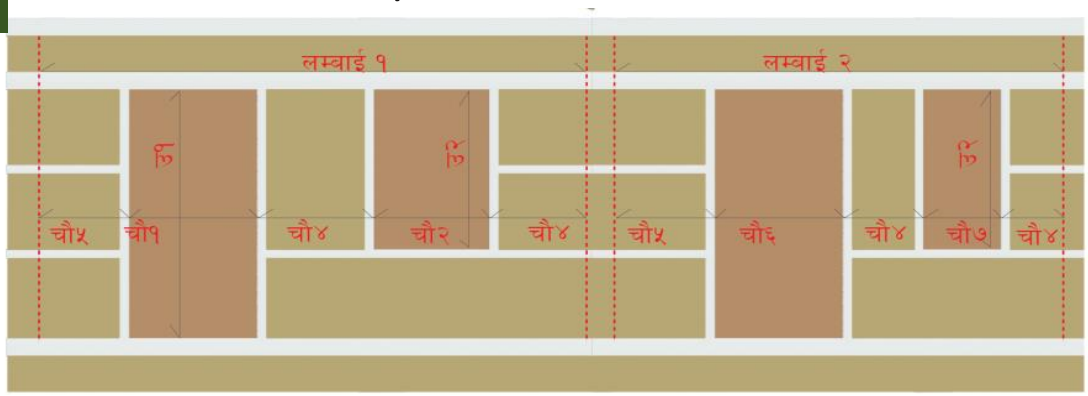
- **The vertical distance between two openings**

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

2.1 Design of house

Brick/ Stone masonry with mud mortar:



नोट:

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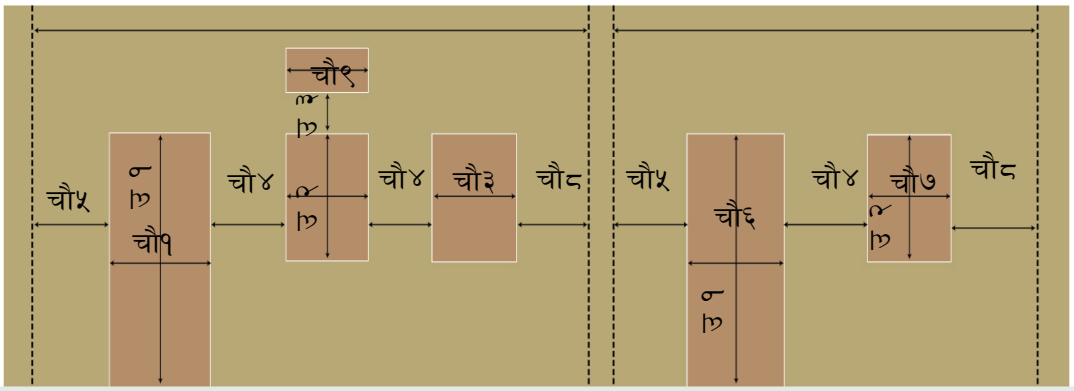
- ❖ चौ ६ + चौ ७ <०.३ लम्बाई २ एक तल्लाको लागि,०.२५ लम्बाई २ एक तल्ला र बुईगलको लागि
- ❖ चौ ४ >=०.५ चौ २ तर ६०० मि.मि भन्दा कम
- ❖ चौ ५ >=०.२५ चौ १ तर ४५० मि.मि भन्दा कम

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
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- ❖ 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

Related Minimum requirement No'5

d.Wall specification

✓ 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

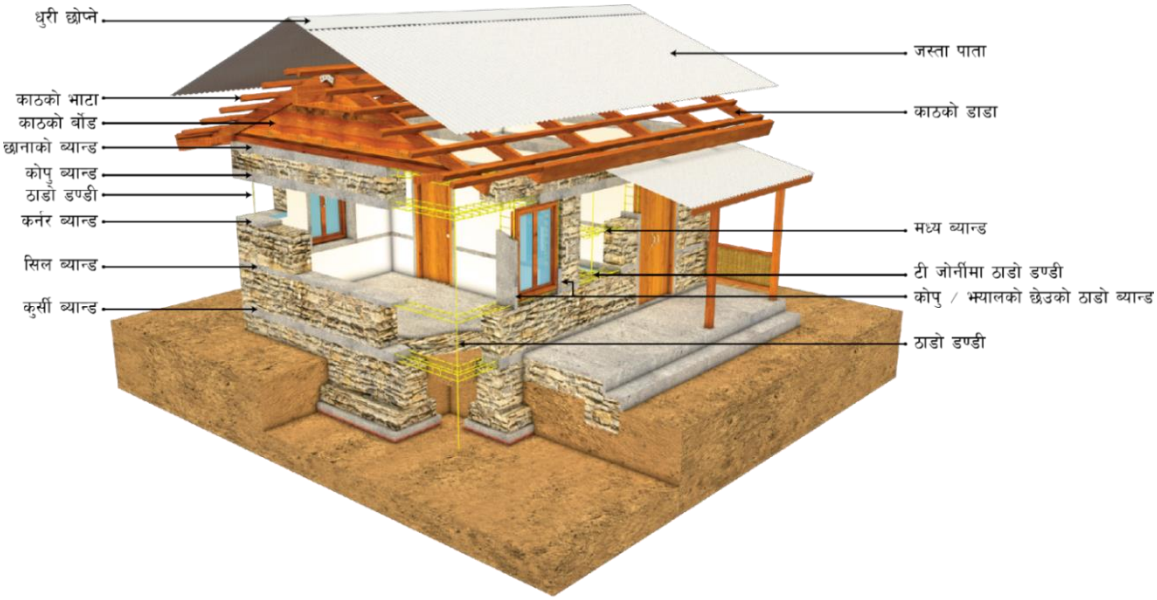
MASONRY TYPE	MASONRY TYPE		
	One	Two	Two plus Attic
Stone	350-450	450	450
Brick	230	350	350

2.1 Design of house

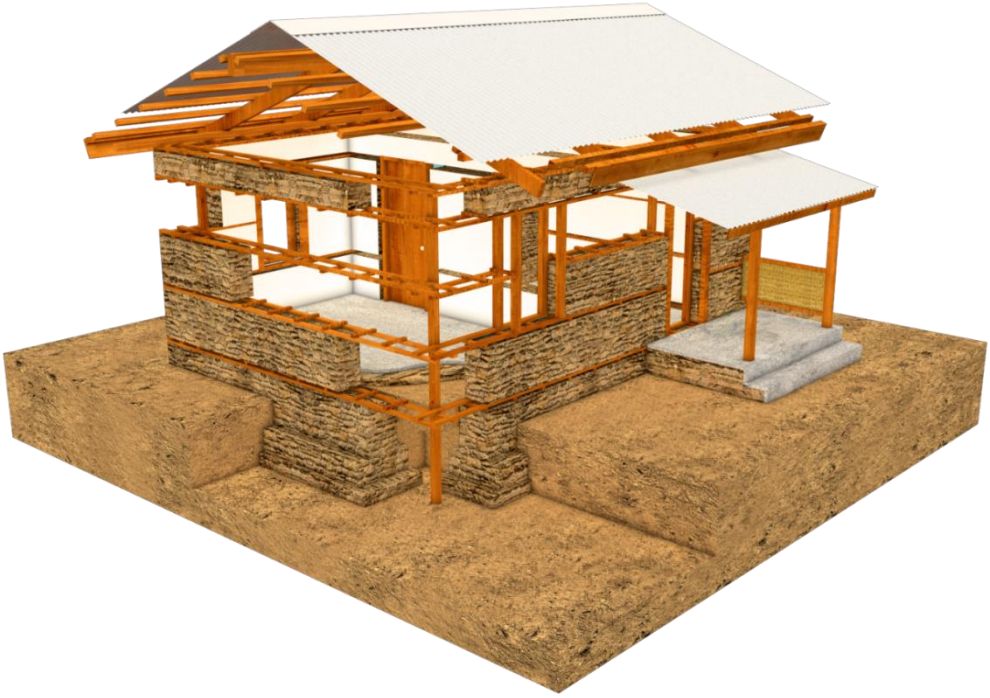
Related Minimum requirement No'4,No'7 and No'8

e.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

➢ 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.

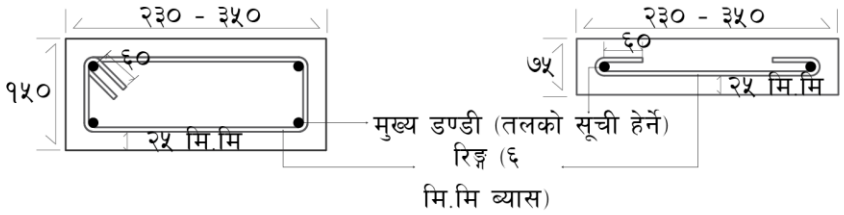
➢ Lintel band

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

❖ रिङ्गलाई बङ्ग्याउने तरिका



❖ रिबारको नाप (मुख्य डण्डी)

पट्टी	प्रवलित सिमेन्ट ब्यान्डको न्यूनतम मोटाई		फलामे डण्डीको न्यूनतम संख्या	फलामे डण्डीको न्यूनतम ब्यास (मि.मि)
कुर्सी सतह (डि.पि.सी)	नरम, मध्ययम	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
लिन्टेल 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 ।

तल्लाको संख्या	डण्डीको ब्यास
१ तल्ले	१२ मि.मि
२ तल्ले	१६ मि.मि

2.2 Construction

2.2.2 Preparation of Construction 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 material

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

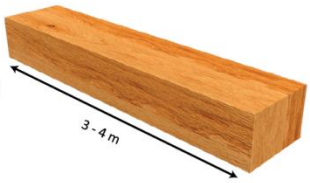
- from rivers
- round shape
- need treatment of shape before use for masonry
- more mortar is required

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

CEMENT

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

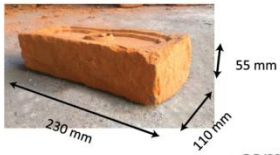
TIMBER



- 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



- completely 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

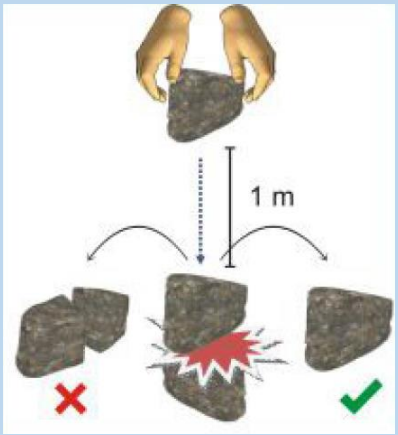
MUD MORTAR

- 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

2.2 Construction

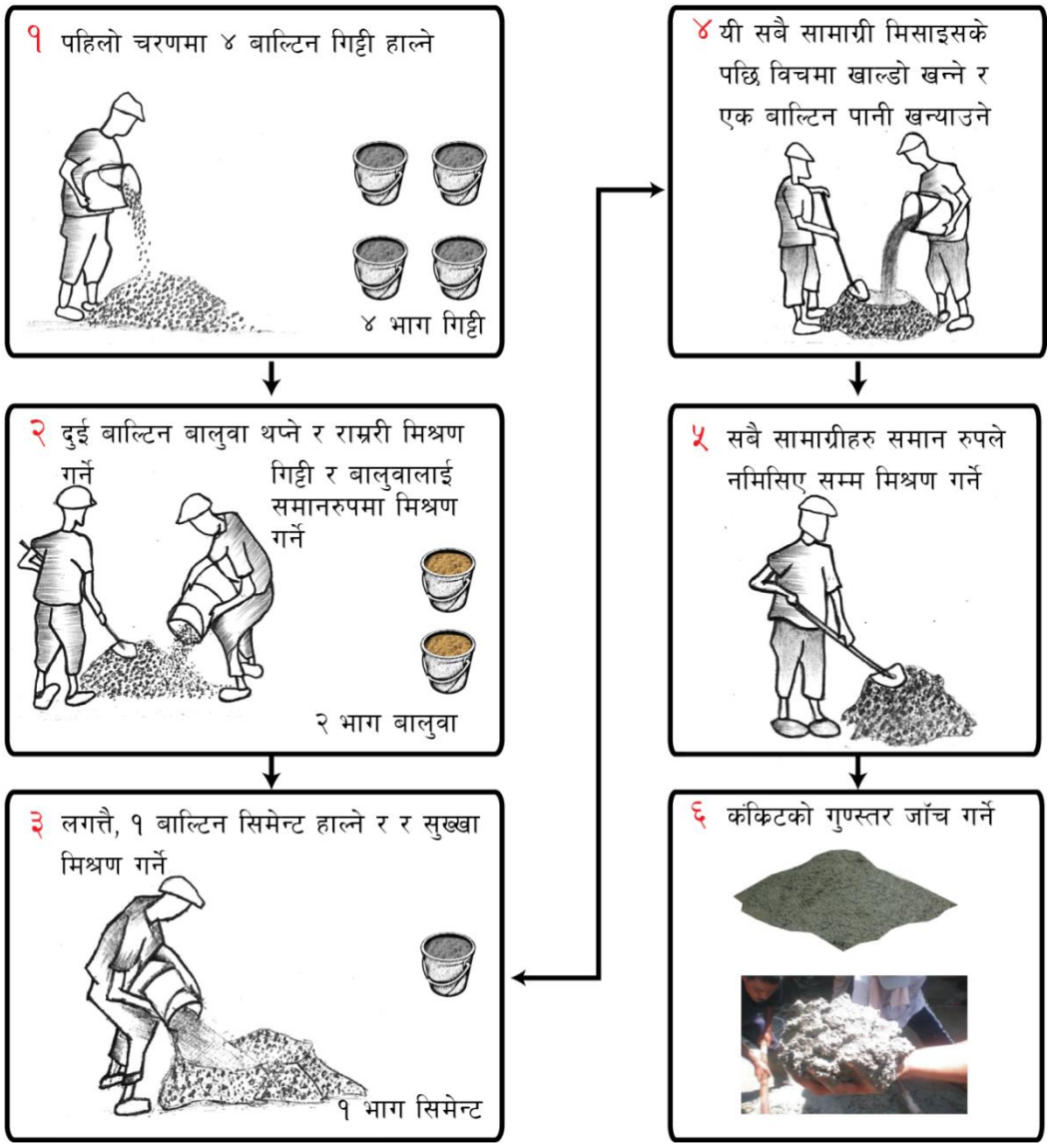
2.2.2 Appropriate Construction Process:

a.Mixture of concrete

Related Minimum requirement No'10

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



2.2 Construction

2.2.2 Appropriate Construction Process:

Related Minimum requirement No'10

a.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 गुणस्तर जाँच गर्ने

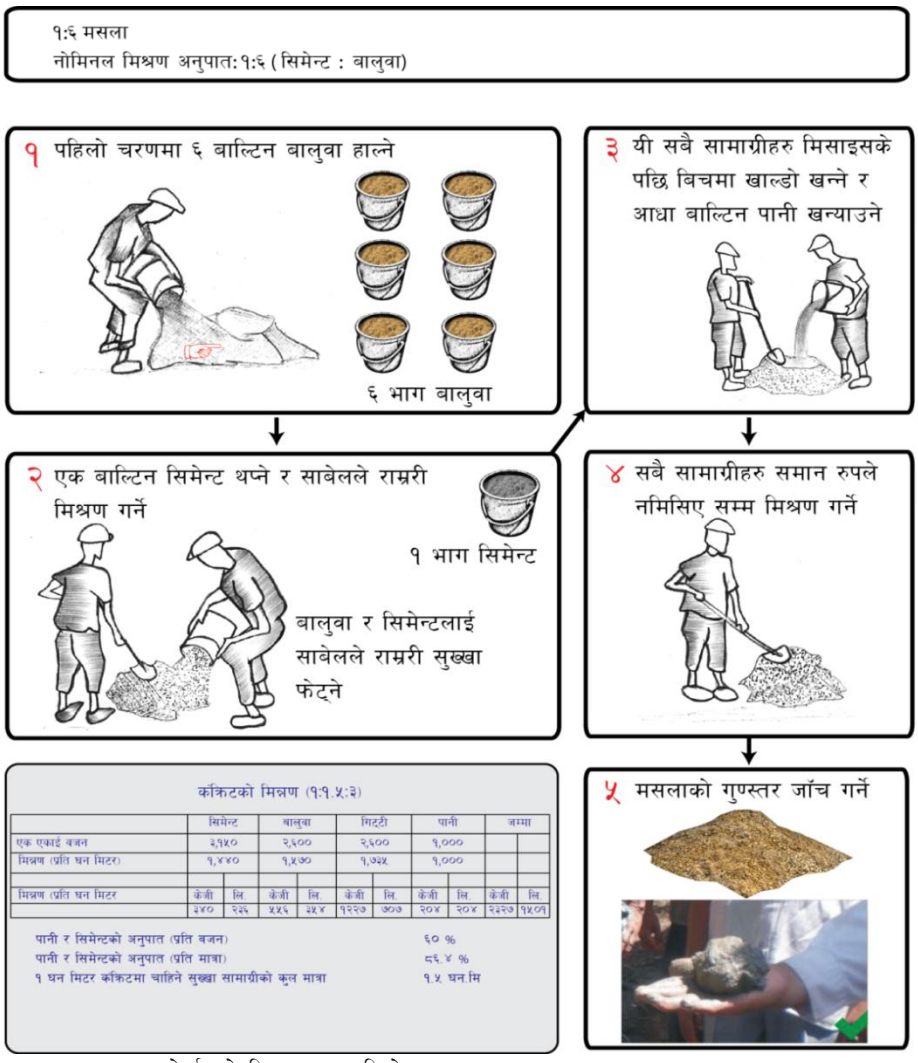
2.2 Construction

2.2.2 Appropriate Construction Process:

a.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.



मोर्टारको मिश्रण १:६ (सिमेन्ट १ : बालुवा ६ मात्रा)

सिमन्टको गुणस्तर

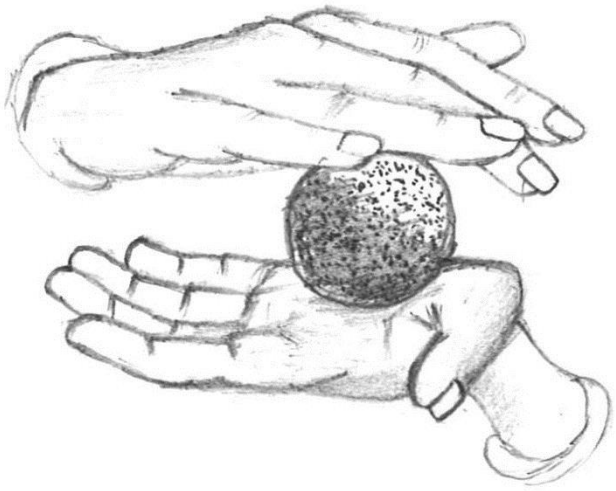
Mud mortar

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

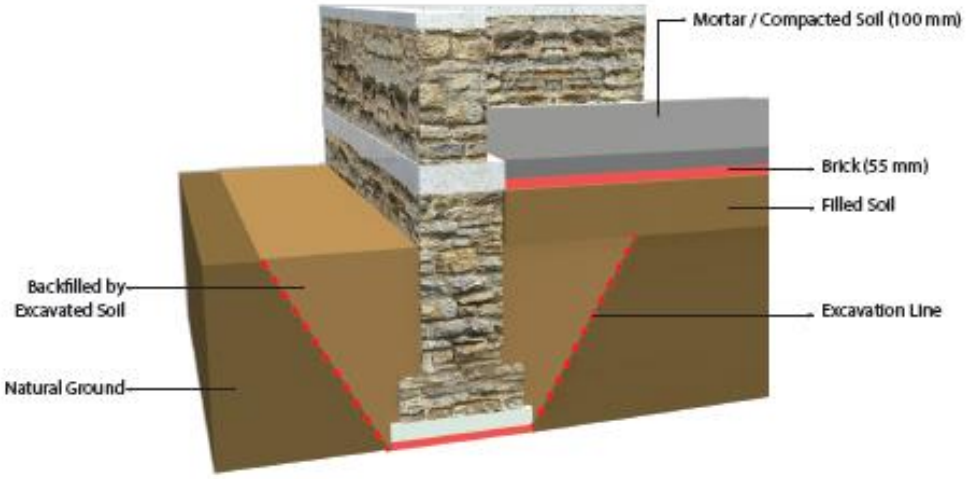
2.2 Construction

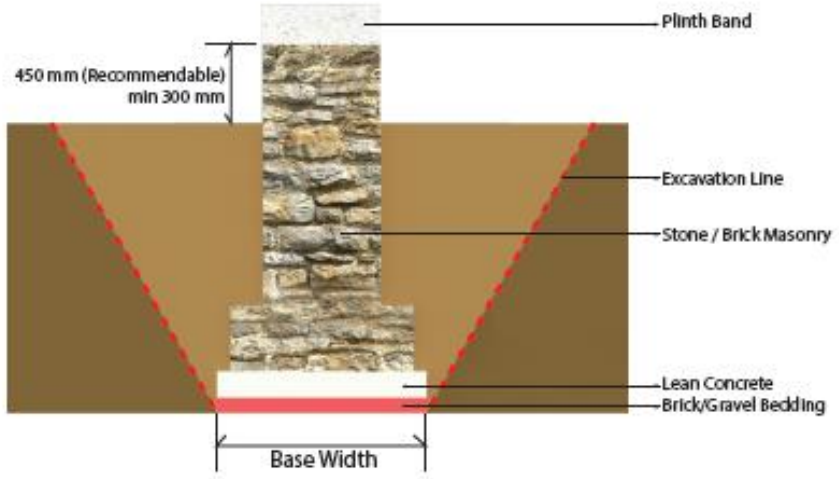
2.2.2 Appropriate Construction Process:

c. Foundation

Related Minimum requirement No'3

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 depend on;

- Wall Material: Stone or Brick
- No. of Story: 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 table.

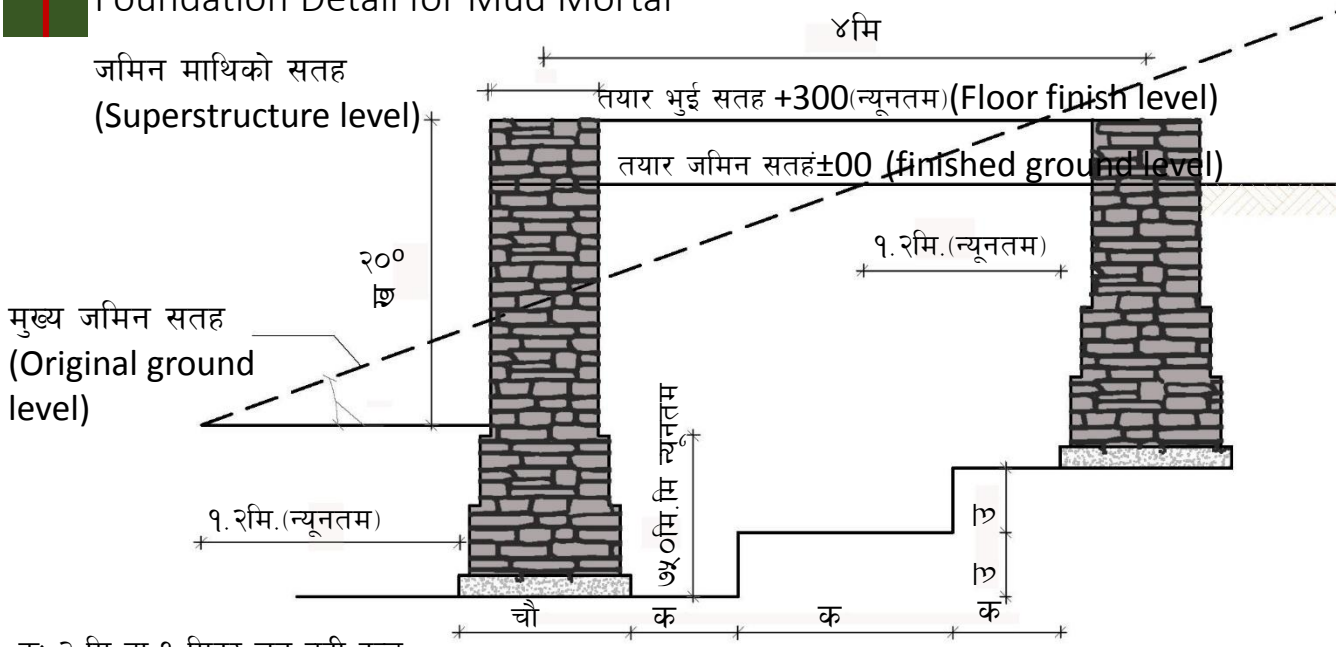
Types of Masonry	Storey	Soft	Medium	Hard
Brick	2-Storey	900	650	450
	1-Storey	650	550	450
Stone	2-Storey	-	800	600
	1-Storey	800	600	600

2.2 Construction

2.2.2 Proper Construction Process:

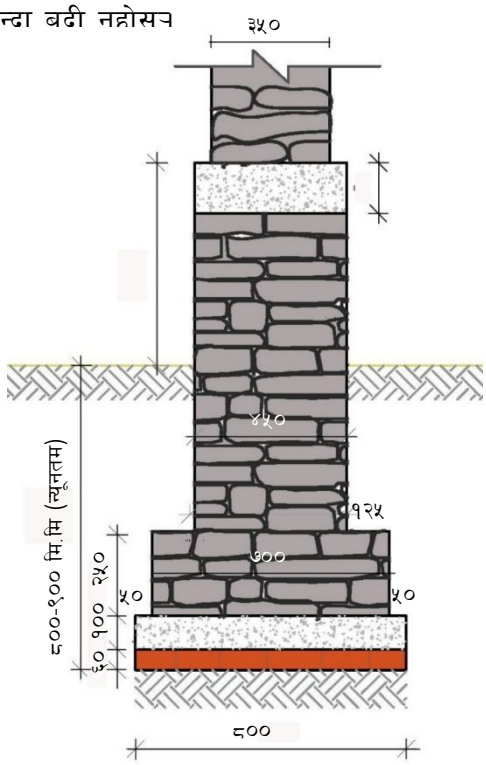
c. Foundation

Foundation Detail for Mud Mortar

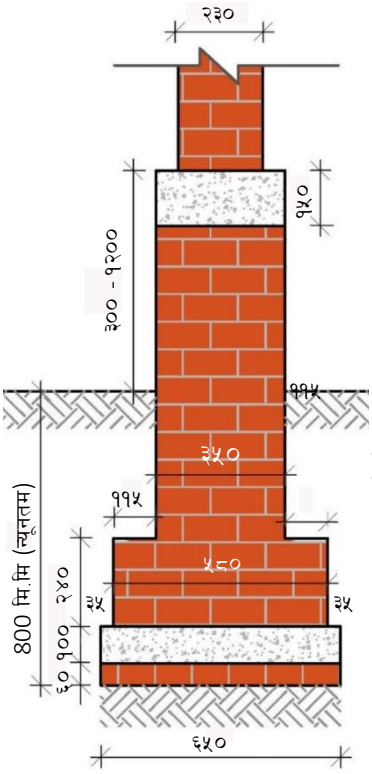


भिरालो जमिनमा जग बनाउने तरिका

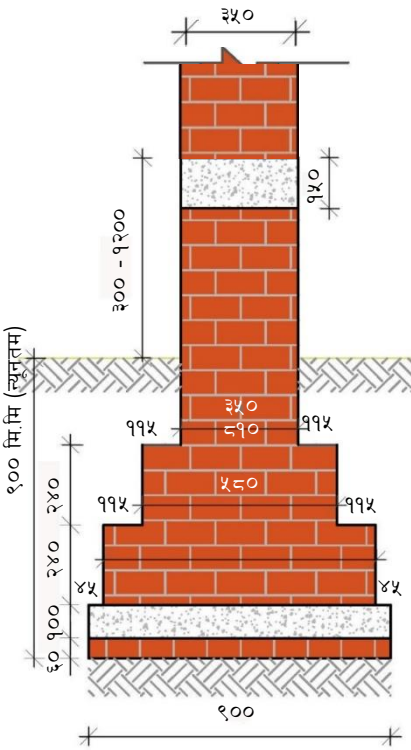
क: २ मि वा १ मिटर जुन बढी हुन्छ
उ: ३०० मि.मि. भन्दा बदी नहोस
ग: अधिकतम ढाल २०°
ख:अडयाउने टेवा पर्खाल नराख्दा १ मिटर भन्दा बढी नहोस



१ – तल्ला (नरम माटो)
२ – तल्ला (मध्यम माटो)

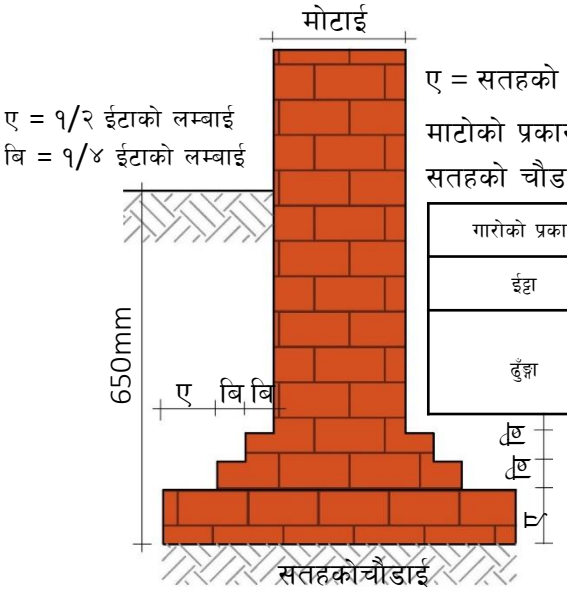


१ – तल्ला (नरम माटो)



२ – तल्ला (नरम माटो)

Foundation Detail for Mud Mortar

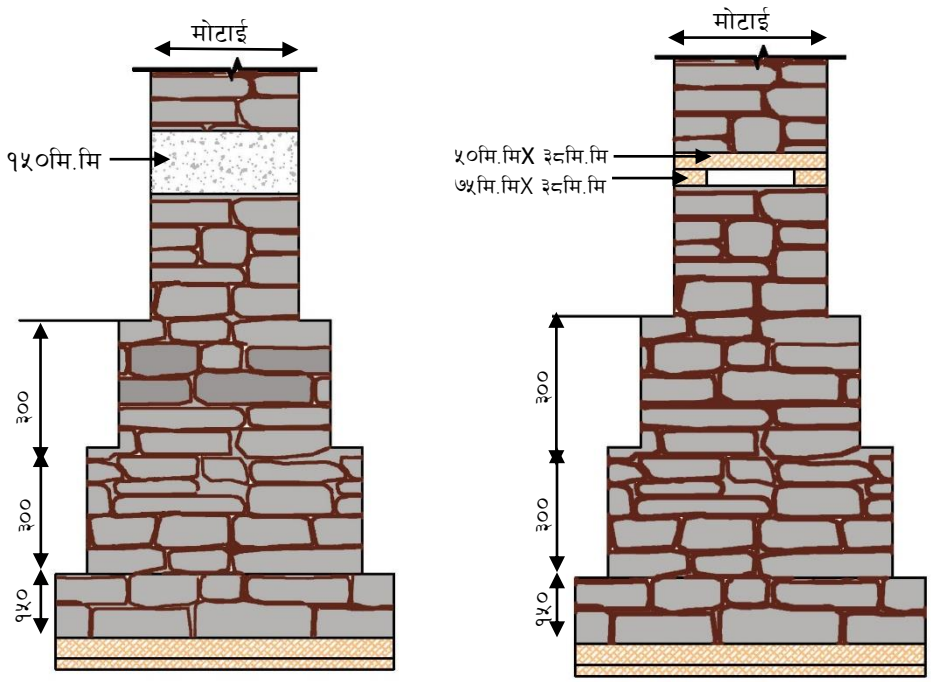


ए = सतहको चौडाई– गारोको चौडाई/६

माटोको प्रकार अनुरुप गारोबाट निर्मित जगको लागि चाहिने न्यूनतम सतहको चौडाई (मि.मि)

गारोको प्रकार	तल्ला	नरम	मध्यम	कडा
ईट्टा	१ – तल्ला	७५०	६५०	५५०
ढुँङ्गा	२ – तल्ला	-	८००	६००
	१ – तल्ला	८००	६००	६००

ईटाको गारोमा माटो मसला



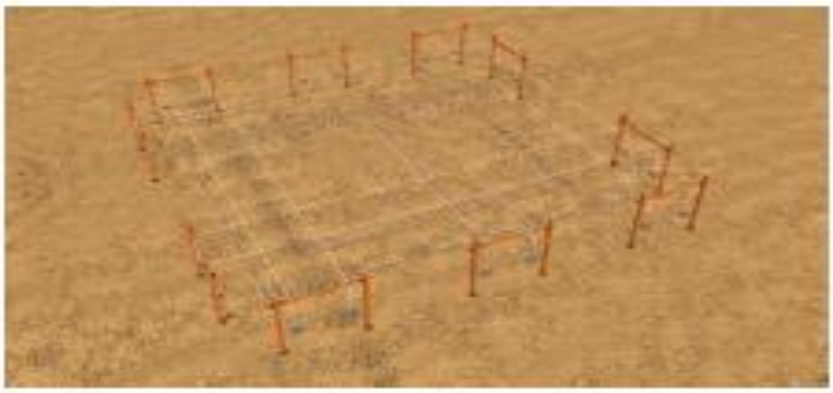
ढुँङ्गाको गारोमा माटो मसला

2.2 Construction

2.2.2 Proper Construction Process:

d. Construction Sequence

1. Layout plan

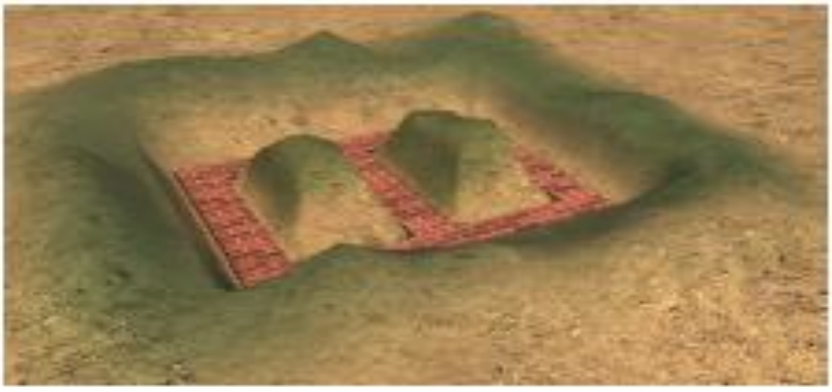


The first important step in construction of a foundation is the layout .It is an essential procedure before the start of work. Clean the ground from all organic or any odd elements. Then tightened the ropes using trestles made by wood poles nailed to a transversal stick and embed it to the ground, as 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

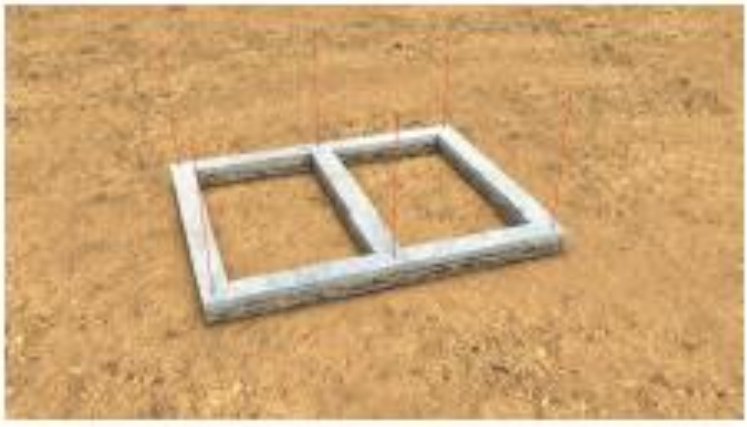
2.2 Construction

d. Construction Sequence

6. Construction of plinth band

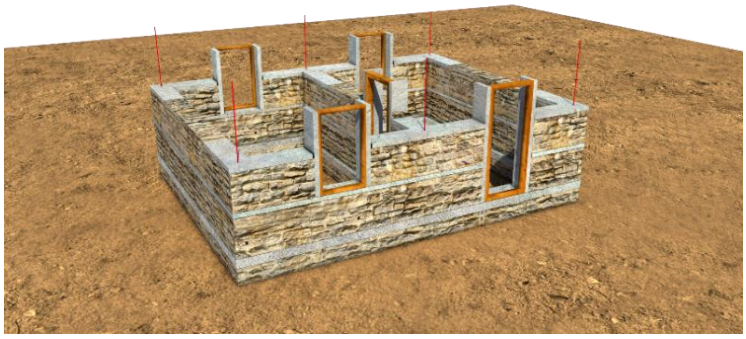
After the reinforcement a layer of concrete is placed over lean concrete.

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

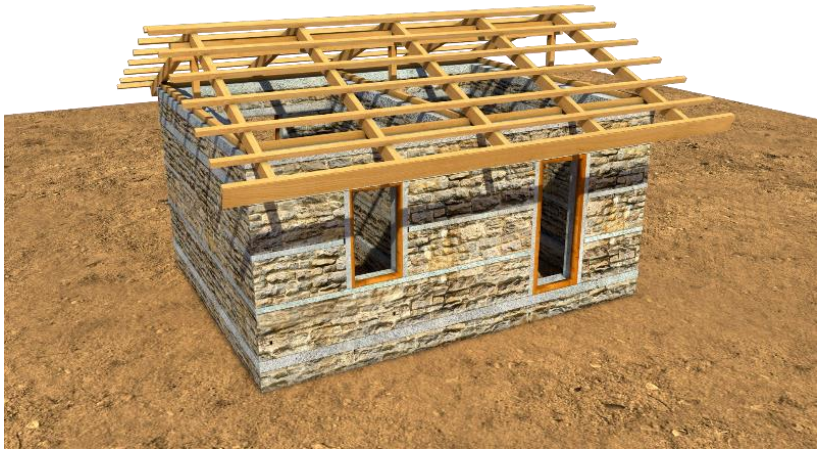


After the completion of the opening, the construction of the masonry wall is stopped to construct the corner and transverse band.

9. Construction of lintel band:

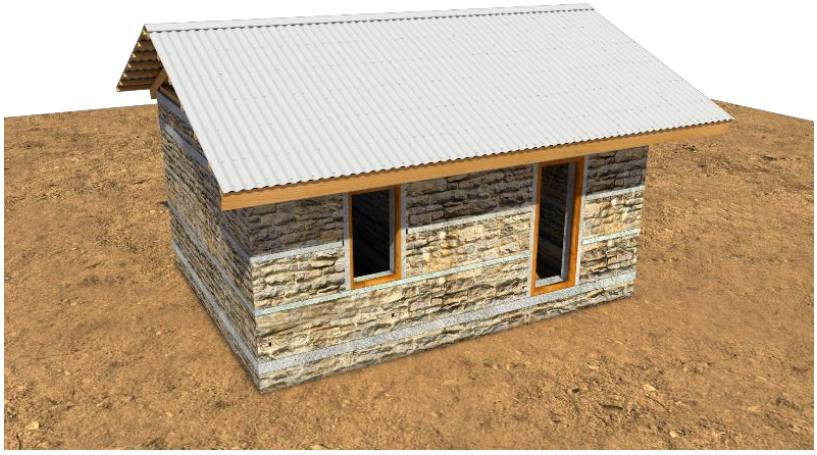
A continuous lintel band is constructed through walls at the top level of opening.

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.


Treatment of shape


Mixing mortar


Though Stone


Laying properly


Bar bending


Fook 135degree


Seismic band


Seismic band

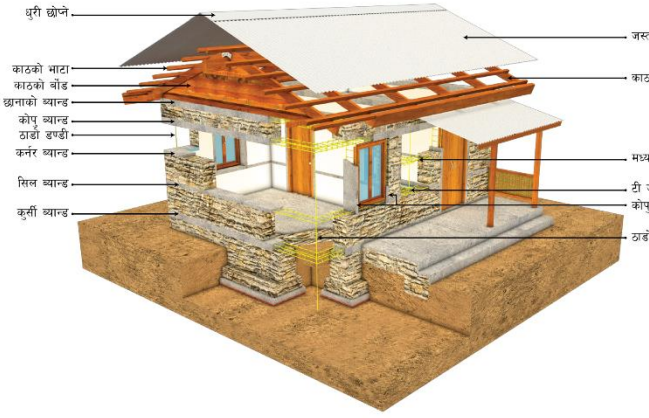
Part-3 Standard Design

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

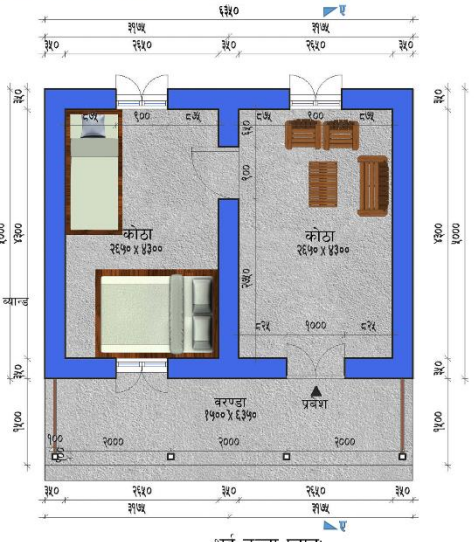
कुल क्षेत्रफल-३१.७५वर्ग.मि

नमुना नं:
एस एम सि १.१

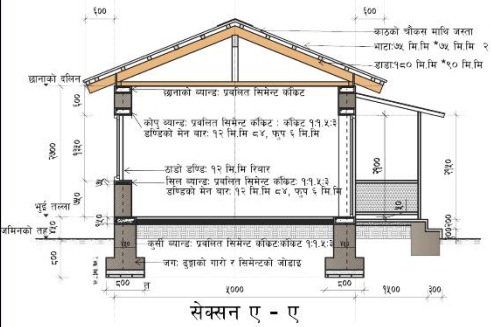
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग द्रश्य



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

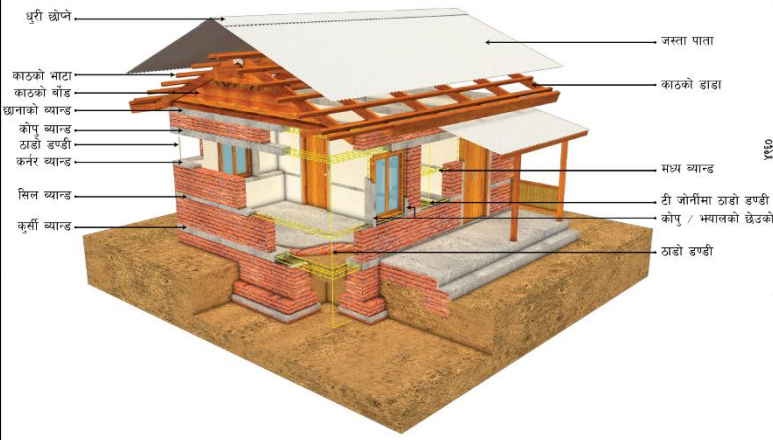
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

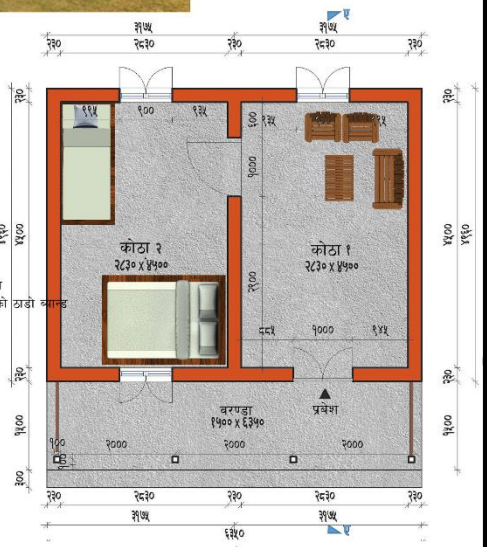
नमुना नं:
बि एम सि १.१

कुल क्षेत्रफल-३१.७५वर्ग.मि

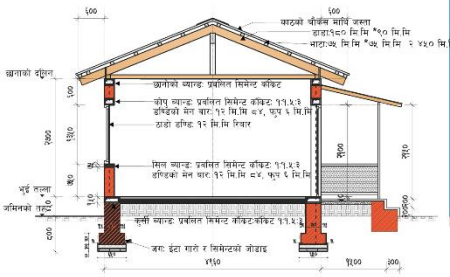
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्रग 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

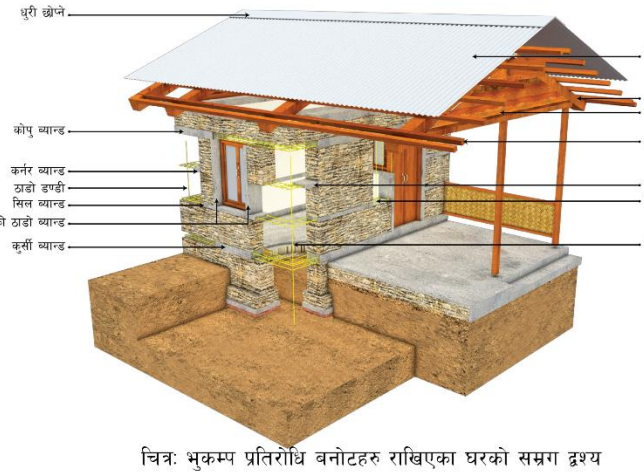
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ढुङ्गा सिमेन्टको जोडाइ

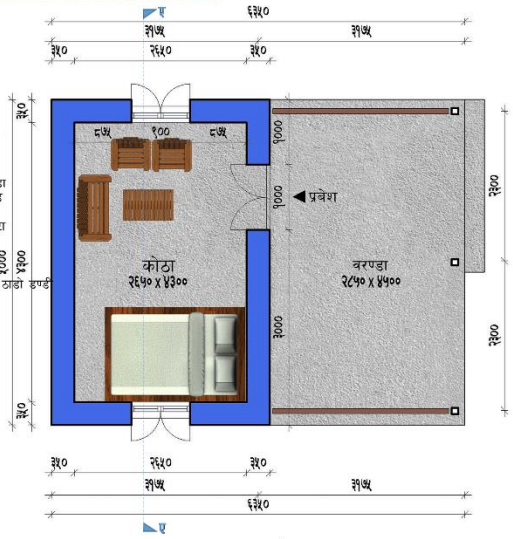
कुल क्षेत्रफल-३१.७५वर्ग.मि

नमुना नं:
एस एम सि १.२

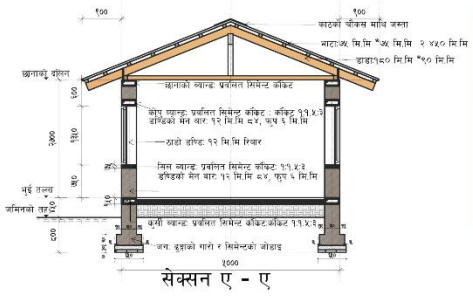
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग दृश्य



भुई तल्ला प्लान:
क्षेत्रफल: 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

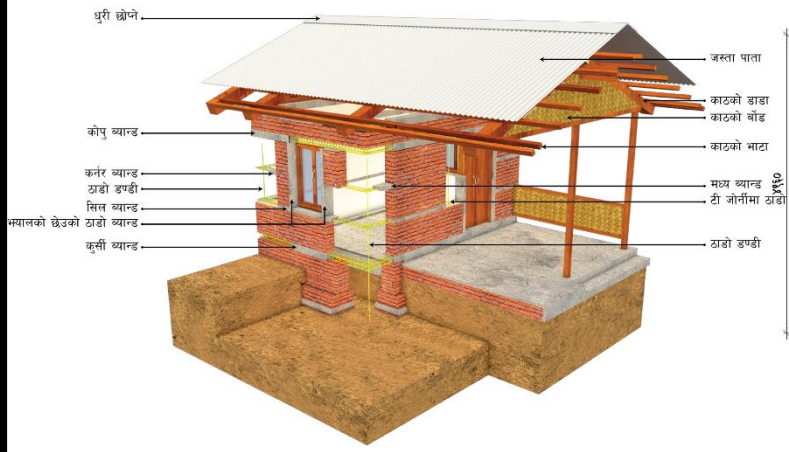
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (एक तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

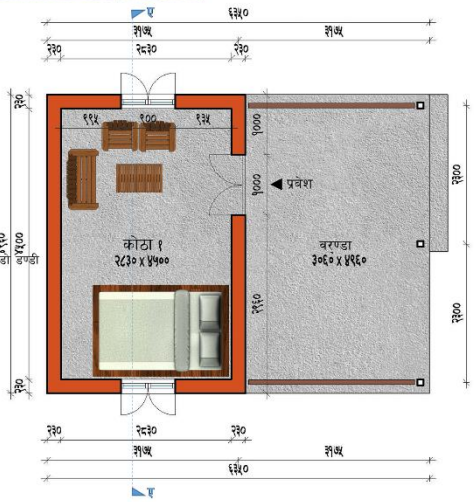
नमुना नं:
बि एम सि १.२

कुल क्षेत्रफल-३१.७५वर्ग.मि

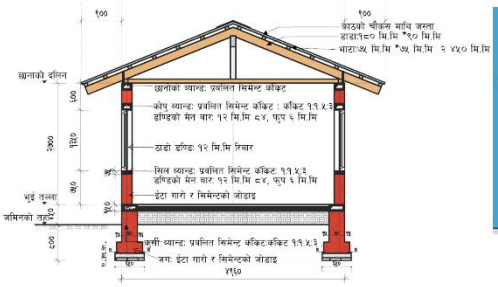
बाहिरी बनावट



चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग द्रश्य

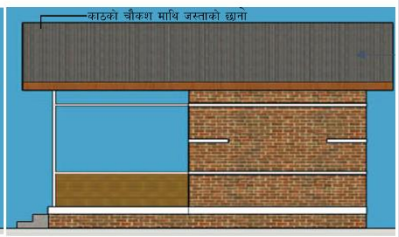


भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



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
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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)

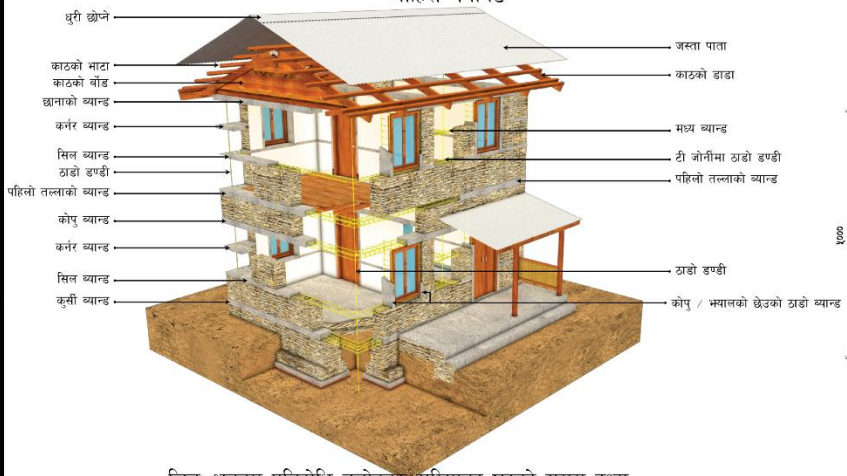
गारे भवन, ढुङ्गा सिमेन्टको जोडाइ

नमुना नं:
एस एम सि २.१

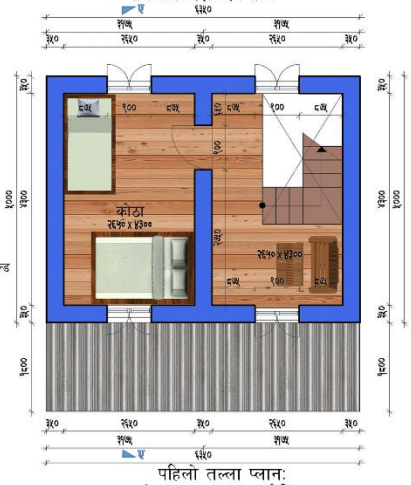
कुल क्षेत्रफल-६३.५वर्ग.मि
भुई तल्लाको क्षेत्रफल-३१.७५वर्ग.मि+पहिलो तल्लाको क्षेत्रफल-३१.७५वर्ग.मि

बाहिरी बनावट

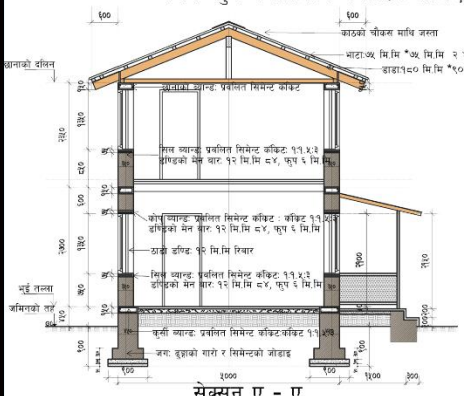
भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५वर्ग.मि



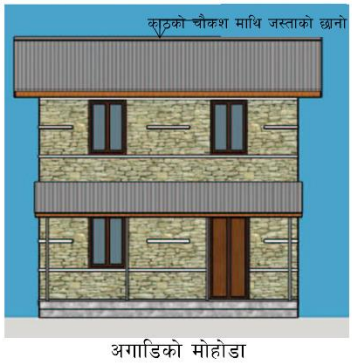
चित्र: भुकम्प प्रतिरोधि बनोटहरु राखिएका घरको सम्मग दृश्य



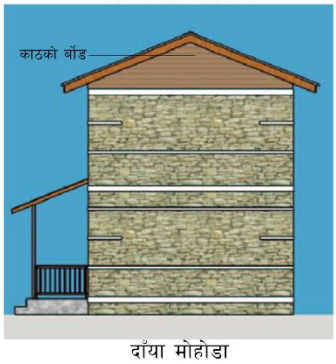
पहिलो तल्ला प्लान:
क्षेत्रफल: ३१.७५ वर्ग.मि



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

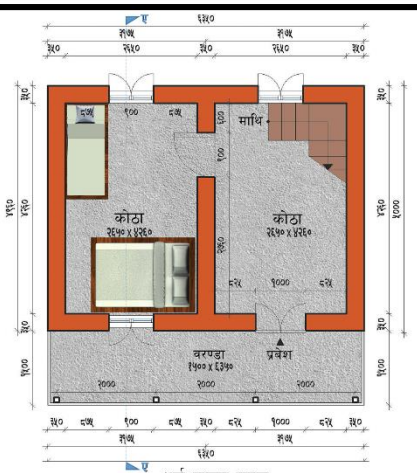
भुकम्प प्रतिरोधी नमुना आवास डिजाइन (दुई तल्ले)

गारे भवन, ईटा सिमेन्टको जोडाइ

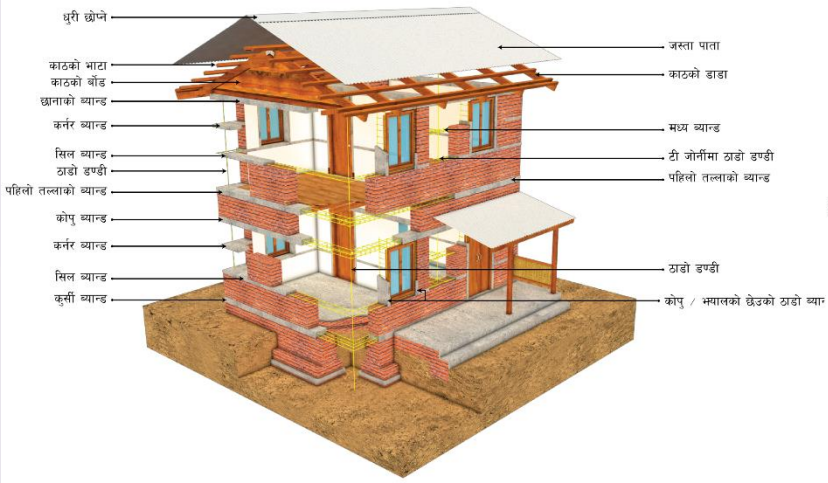
नमुना नं:
बि एम सि २.१

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

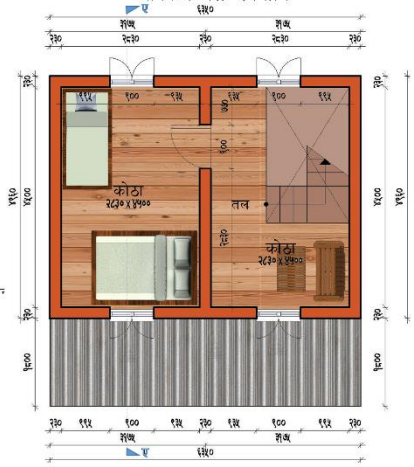
बाहिरी बनावट



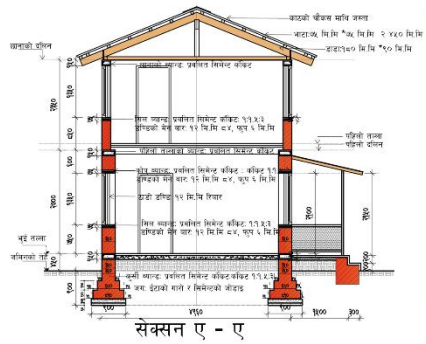
भुई तल्ला प्लान:
क्षेत्रफल: ३१.७५वर्ग.मि



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
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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