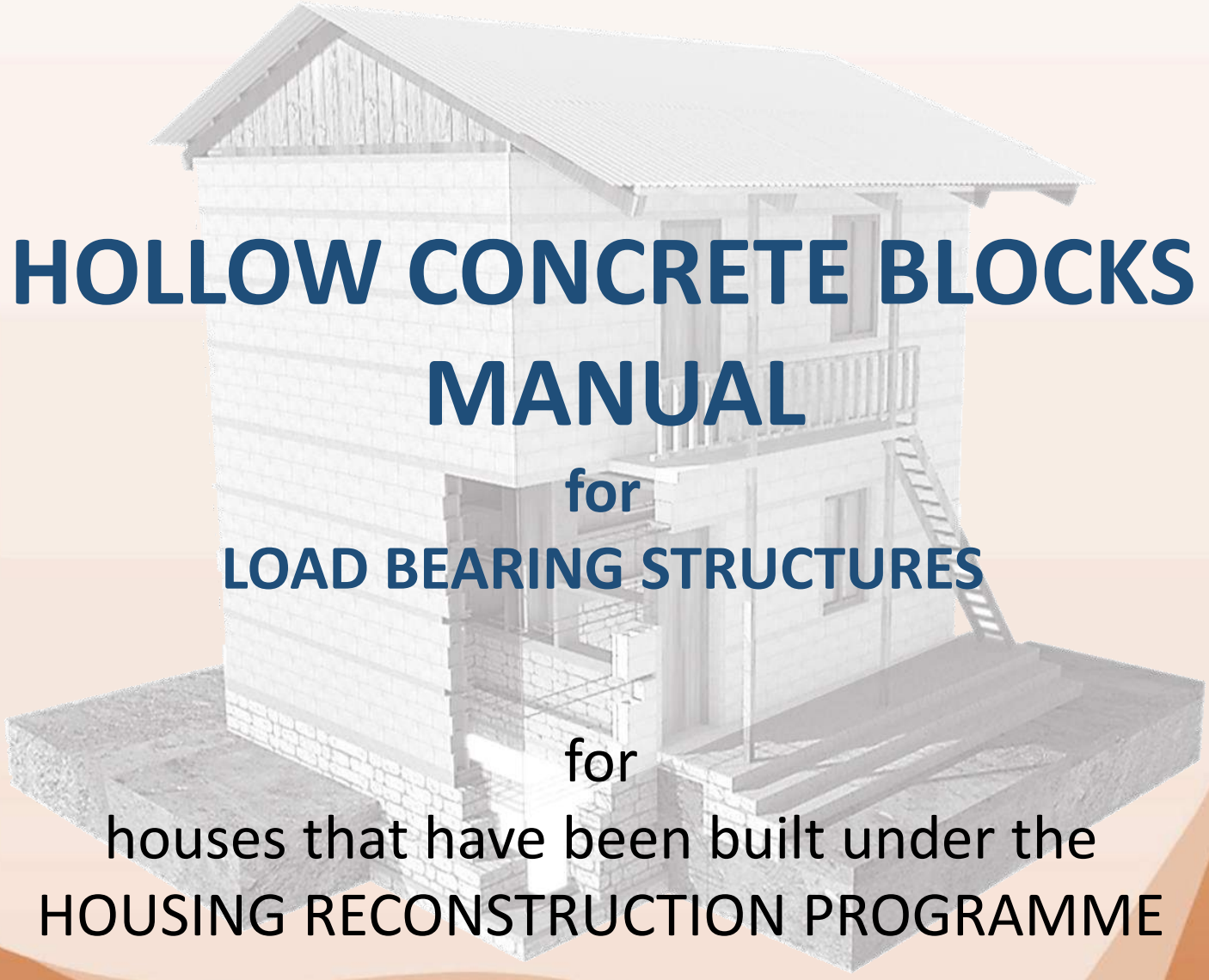
Government of Nepal

National Reconstruction Authority

Singhadurbar, Kathmandu



HOLLOW CONCRETE BLOCKS MANUAL

for

LOAD BEARING STRUCTURES

for

houses that have been built under the

HOUSING RECONSTRUCTION PROGRAMME

2019

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FOREWORD

I would sincerely like to congratulate everyone involved in the development of the "Hollow Concrete Blocks Manual for Load Bearing Structures" for Reconstruction of Earthquake Resistant Houses, which has been published by the National Reconstruction Authority (NRA). This manual will support houses that have been constructing using concrete blocks in various district .

Thirty-one districts have been identified by the GoN Post Disaster Needs Assessment (PDNA) as being earthquake affected. To date, almost 750,000 households across the 31 districts have been identified as being eligible to receive 300,000 NPRs housing reconstruction grant.

I look forward to seeing the manual implemented across the earthquake affected districts and to seeing the impact that it will have. This represents another positive step forward in the reconstruction process, and will support households to overcome non-compliance issues and secure approval to receive tranches of the reconstruction grant and to have safe, compliant and resilient in the face of future disasters.

Sushil Gyewali
Chief Executive Officer, NRA

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PREFACE

Under housing reconstruction programme “Build Back Better" (3B) shall be achieved in construction and should be ensured by with design and construction. One way of achieving 3B will be making design and construction compliant to NBC 105 : 1994 requirement . This manual is developed so that its is easy for engineers in Technical Assistance (TA) to inspect and guide the masons in the field.

This manuals covers mainly inspection forms with comprehensive inspection methodology and cost effective correction measures for non-compliant cases were suggested in order to guide Inspectors/Engineers while providing Social Technical Assistance (STA).

This manual will be used by all the engineers who are working for the reconstruction and have been developed by the GoN to carry out inspections.

This manual has been divided into five parts and five annexes:
PART-1: Background
PART-2: Building Typology and Inspection
PART-3: Technical Specification
PART-4: Correction Measures
PART-5: Ready to Use Design
Annex A: HCB Unit Quality Test at Site
Annex B: Structural Analysis and Design
Annex C: Estimate of Correction Measures
Annex D: Case Study on Inspection
Annex E: Inspection Forms (HCB Masonry)

I am hopeful that this manual will fulfill the knowledge gap incase of concrete block constructions and give STA to right direction, eventually the construction would be as per the spirit of Nepal National Building Codes along with ease in distribution grants.

Dr. Hari Ram Parajuli
Executive member, NRA

Earthquake resistant private housing standardization committee, NRA

Member

Dr. Hari Ram Parajuli	Chairman, Executive member, NRA
Er. Prakash Thapa	Member, Joint-secretary, NRA
Dr. Jagat Kumar Shrestha	Member, Associate Professor, IOE,TU
Er. Nava Raj Pyakurel	Member, NRA-CLPIU (Building)
Hari Prasad Sharma	Representative from, NRA-CLPIU (GMaLI)
Representative	Representative from MoUD

Invited Experts

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Prof. Dr. Hikmat Raj Joshi	IOE, TU
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Er. Hima Gurubacharya	EERT Director, NSET
Ar. Bhubaneswari Parajuli	National Technical Coordinator, HRRP
Er. Kuber Bogati	National Technical Co-ordination officer, HRRP

Technical Working Group (TWG)

Dr. Hiroshi Imai	Consultant
Er. Kuber Bogati	HRRP
Er. Nabin Poudel	NRA
Er. Deepak Saud	HRRP
Er. Aasish Tiwari	NSET
Ar. Sabika Mastran	Consultant
Mr. Laxmi Pd. Bhatta	HRRP
Ar. Reshma Shrestha	HRRP
Ar. Animesh Raj Bajracharya	Consultant

ACKNOWLEDGEMENTS

We would like to express our deepest gratitude to IOE/TU, NSET and HRRP-Nepal for their initiation and continuous involvement during the preparation of this manual.

Our sincere thanks to the respected senior experts Prof. Dr. Hikmat Raj Joshi, Prof. Dr. Prem Nath Maskey, Prof. Dr. Gokarna Bahadur Motra, Er. Manohar Raj Bhandari, Associate Prof. Dr. Jagat Kumar Shrestha Dr. Narayan Marasini, Dr. Hiroshi Imai, Mr. Surya Narayan Shrestha and Dr. Ramesh Guragain for their support and suggestions during the discussions on critical issues which were vital while finalizing the content.

Thanks to Central Material Testing Laboratory Team- Pulchowk Campus, Earthquake Engineering Research and Training Division (EERT)-Team-NSET, Er. Abhishek Ghimire, Er. Pukar Regmi, Er. Subash Dawadi and Er. Januka Bhattarai.

We are thankful to NRA technical Working Group: JICA TPIS-ERP, NSET and HRRP-Nepal. We would also like to thank Dr. Hiroshi Imai, Senior St. Er. Kuber Bogati, Senior St. Er. Nabin Paudel, St. Aasish Tiwari, Er. Deepak Saud , Ar. Sabika Mastran,, Asst. Er. Laxmi Prasad Bhatta and Ar. Animesh Raj Bajracharya for their continuous work during the preparation of this manual.

We would like to congratulate all personnel involved, directly and indirectly, for their valuable contribution to the preparation of this manual.

Standardization Committee, NRA
for Reconstruction of Earthquake Resistant Houses

ACRONYMS

BMC	**Brick Masonry in Cement mortar**
C	Compliance
C/S	Cement to sand ratio
CGI	Corrugated Galvanized Iron
CL-PIU	Central Level Project Implementation Unit
CMU	Concrete Masonry Unit
DL-PIU	District Level Project Implementation Unit
DSE	District Support Engineer
DUDBC	Department of Urban Development and Building Construction
EERT	Earthquake Engineering Research and Training Division
GI	Galvanized Iron
GoN	Government of Nepal
HCB	Hollow Concrete Block
HRRP	Housing Recovery and Reconstruction Platform-Nepal
IOE, TU	Institute of Engineering, Tribhuvan University
IS	Indian Standard
MoFALD	Ministry of Federal Affairs and Local Development
MoUD	Ministry of Urban Development
MRs	Minimum Requirements
NBC	Nepal National Building Code
NC	Non-compliance
NK	Not know
NRA	National Reconstruction Authority
NSET	National Society for Earthquake Technology-Nepal
P	Passage
PDNA	Post Disaster Needs Assessment
R	Room
RC	Reinforced Concrete
RCC	Reinforced Cement Concrete
SMC	Stone Masonry in Mud mortar
SMC	Stone Masonry in Cement mortar
STA	Social Technical Assistance
TA	Technical Assistance
TWG	Technical Working Group
USAID	United States Agency for International Development

Contents

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PART-1: BACKGROUND

1.1 Background
1.2 Rationale
1.3 Limitation of Manual

1. 1 Background

Hollow concrete blocks (HCBs) were becoming an increasingly prevalent material for housing construction. The demand for this product is high across the earthquake affected districts due to various reasons. [**Size of HCB Building Units:]** Buildings being built are typically constructed in the sizes of two roomed, three roomed and four roomed with and without verandah and CGI roofing. [**Major non-complaint issues in HCB Construction]** the quality of block units during production and the provision of seismic banding during house construction are major non-compliant issues found in the site, on which performance of buildings is greatly relay. Also, the Department of Urban Development and Building Construction (DUDBC) Design Catalogue for Reconstruction of Earthquake Resistant House Volume 2, published in March 2017, includes approved designs for two-storey HCB confined masonry and masonry building. However, households are generally not following these designs and GoN engineers are unable to provide other alternatives or information. [**Standards**] Nepal Standard: 119/2042 ensures the quality control requirements for HCBs production in Nepal, if followed properly. [**Size of HCB units**] HCBs are typically available in the nominal block sizes of 400x200x200mm, 400x150x200mm, and 400x100x200mm as per NS 119/042.

Photographs: HCB construction at Kaski

1.2 Rationale

[Case load] Almost all the EQ. affected district has buildings constructed using HCB. Approximately, 3000 HHs were reported in grant MIS system till date. [**Gaps]** There is no Inspection form (checklist to be used) and supporting manual on HCB construction for Inspectors/Engineers (with corrective measures).

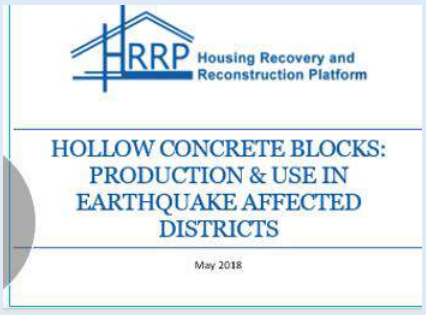
[Research works & Recommendation]

A report which presents the findings of two rounds of HRRP data collection on the production and use of Hollow Concrete Blocks (HCBs) across the districts affected by the 25 April 2015 Gorkha earthquake, from this report this volume of manual addresses mainly

- Method of Inspection and checklist
- Correctives measures on existing Construction to guide Inspectors/Engineers for suggesting masons and home owners.

[Efforts and Initiation]

NRA did take initiation to resolve the issues regarding HCB construction, in particular, a technical working group (TWG) were formed and task were assigned accordingly, the completed works were presented in front of NRA Standardization Committee.



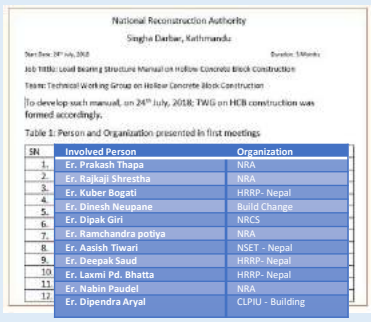

National Reconstruction Authority
Singha Darbar, Kathmandu

Table 1: Person and Organization presented in first meetings

SN	Involved Person	Organization
1.	Er. Prakash Thapa	NRA
2.	Er. Rajkaji Shrestha	NRA
3.	Er. Kuber Bogati	HRRP- Nepal
4.	Er. Dinesh Neupane	Build Change
5.	Er. Dipak Giri	NRCS
6.	Er. Ramchandra potiya	NRA
7.	Er. Aasish Tiwari	NSET - Nepal
8.	Er. Deepak Saud	HRRP- Nepal
9.	Er. Laxmi Pd. Bhatta	HRRP- Nepal
10	Er. Nabin Paudel	NRA
11	Er. Dipendra Aryal	CLPIU - Building
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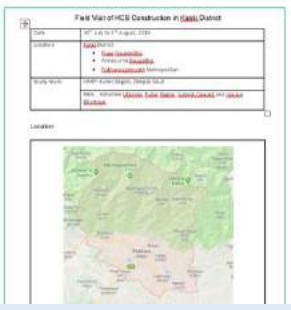


[Rationale] Under housing reconstruction programme “Build Back Better" (3B) shall be achieved in construction and should be ensured by with design and construction. One way of achieving 3B will be making design and construction compliant to NBC 105 : 1994 requirement . This manual is developed so that its is easy for engineers in Technical Assistance (TA) to inspect and guide the masons in the field.

1.3 Scope and Limitation

[Scope of Manual]

- ✓ This manual has been prepared on the basis of NBC105 : 1994, NBC202:1994 and IS 2185 : 2005.
- ✓ The designs presented in the manual are ready-to-use designs structural components.
- ✓ This design results are equally applicable to solid concrete blocks Buildings too provided that the strength and mechanical properties related parameters shall be equivalent to HCBs.
- ✓ Steel pipes provisioned in existing cases shall be acceptable if the net cross sectional area of steel is twice the TMT bars.
- ✓ EXCEPTION/CORRECTION MANUAL for Masonry Structures [2017], HYBRID STRUCTURES MANUAL [2017] and LIGHT TIMBER/STEEL FRAME STRUCTURE MANUAL [2018] are equally applicable in case of HCB buildings[where applicable].

[Limitations of Manual]

This manual covers the reinforced masonry structural wall system building which are newly constructed or under construction using concrete blocks (Hollow or Solid) under the GoN housing reconstruction programme.

This manual has certain limitations and is only relevant for buildings which are:

I.Residential and fall under category ‘C’ of NBC 2002:1994.

- ✓ Category "A": Modern building to be built, based on the international state-of-the-art, also in pursuance of the building codes to be followed in developed countries.
- ✓ Category "B": Buildings with plinth area of more than One Thousand square feet, with more than three floors including the ground floor or with structural span of more than 4.5 meters.
- ✓ Category "C": Buildings with plinth area of up to One Thousand square feet, with up to three floors including the ground floor or with structural span of up to 4.05 meters.

PART-2: BUILDING TYPOLOGY & INSPECTION

2.1 Concrete Block Units
2.2 Compressive Strength
2.3 Structural Use of Concrete Blocks
2.4 Inspection Method

2.1 Concrete Block Units

A concrete block is primarily used as a building material in the construction of walls. It is sometimes called a concrete masonry units (CMU). Concrete blocks are produced in a large variety of shapes and sizes. They can be produced manually or with the help of machines. A concrete block is one of several precast concrete products used in construction.

The term **precast** refers to the fact that the blocks are formed and harden before they are brought to the job site.

Most concrete blocks have one or more hollow cavities, and their sides may be cast smooth or with a design. In use, concrete blocks are stacked one at a time and held together with fresh concrete mortar to form the desired length and height of the wall.

Solid blocks – a block which has solid material not less than 75 percent of the total volume of the block calculated from the overall dimension (according to US standards-have no voids amounting to not more than 25% of the gross cross-sectional area).

Hollow (Open or Closed Cavity) blocks – A block having one or more large holes or Cavities which – either pass through the block (open cavity) or do not effectively pass through the block (closed cavity) and having solid materials between 50 to 75 percent of the total volume of the block calculated from the overall dimensions.

In our case, closed cavity hollow blocks are in use as shown below.

Length	Height	Thickness
400 mm full block 200 mm half block	200 mm	100 mm 150 mm 200 mm

External Wall Thickness:

Length	Minimum External Shell Thickness
400X200X100 mm 400X200X150 mm 400X200X200 mm	35 mm 40 mm 40 mm

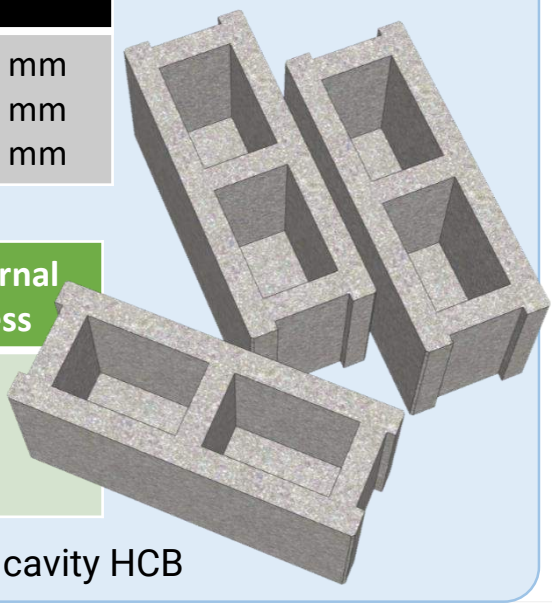


Photo : Closed cavity HCB

[Advantages of Concrete Blocks]

- ✓ Highly durable: Good concrete compacted by high pressure and vibration gives substantial strength to the block.
- ✓ It is a faster and easier construction system, when compared to the conventional construction systems.
- ✓ Economical
- ✓ Proper curing increases compressive strength of the block.
- ✓ Load bearing strength can be achieved as per the requirement.
- ✓ Fire resistant
- ✓ Color and brilliance of masonry withstand outdoor elements.
- ✓ Provide thermal and sound insulation: Air inside the hollow gap of block does not allow transfer of outside heat or cold inside the house; keeping the house cool in summer and warm in winter.
- ✓ Reduced air conducting load: Approx. 50% saving.
- ✓ Environment friendly if fly ash is used as one of the raw materials.
- ✓ Low maintenance required.
- ✓ In this construction system, structurally each wall and slab behaves as a shear wall and a diaphragm respectively, reducing the vulnerability of disastrous damage to the structure/building during natural hazards.

[Limits of Application of Concrete Block]

- ✓ Raw material must be locally available, of good quality and economically viable.
- ✓ Relatively large amount of cement is needed, which can be expensive and difficult to obtain.
- ✓ Special knowledge and experience of the production process is required.

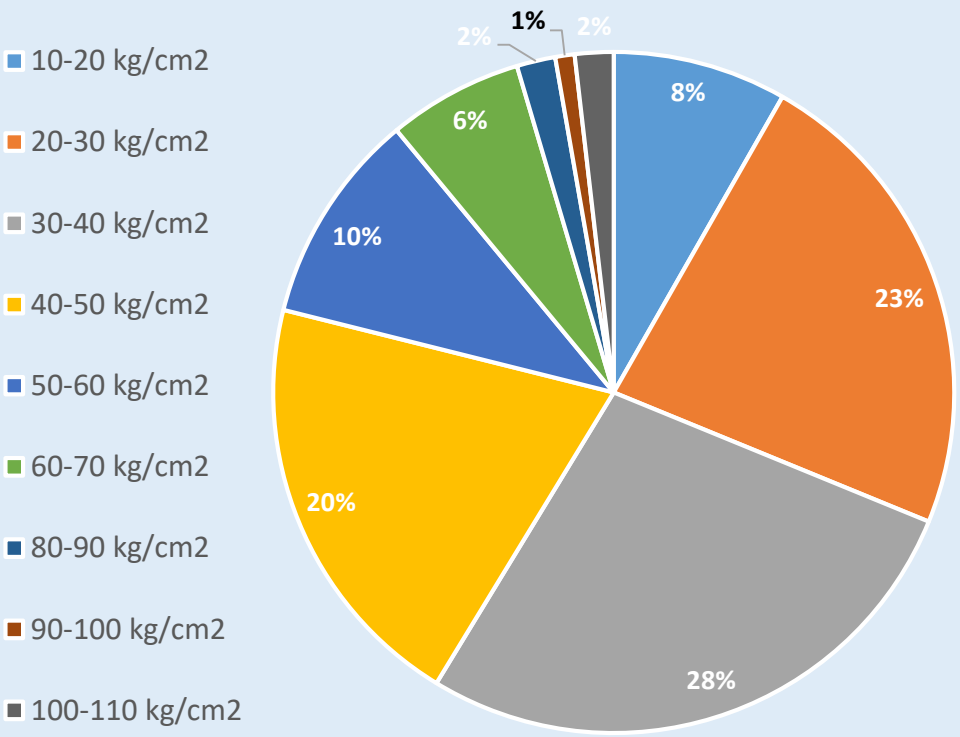
2.2 Compressive Strength

[Compressive Strength Tests for HCB Units]

The value of crushing strengths of blocks tested in accordance with the method of test for Precast concrete blocks.
Blocks are tested for compressive strength in accordance with the specification of NS 119/2042. Table below gives the crushing strength scenario in the districts:

Type	Average Block	Lowest Individual Block
5 MPa (or More)	6.8 MPa	5.1MPa
5 MPa (Less)	3.4MPa	1.4MPa

* [Conclusion of Test] Majority of the block units failed to meet the specification as per NS 119/2042.



[Sample collection of Block] Six producers of HCB were selected on the basis of their selling capacity in each districts, from each producers four HCBs were collected and three blocks were tested.

Compressive Strength

[Compressive Strength Tests for Walls]

The walls were constructed using poor quality HCB units and tested in accordance with the method of test for prism test.

Walls are tested for compressive strength in accordance with the specification of Indian Standard. Table below gives the crushing strength:

Block Unit Test		Wall Test	
Average Block Unit Strength	Lowest Individual Block Strength	Average Wall Strength	Lowest Individual Wall Strength
5 MPa (Less)	1.4 MPa	1 MPa	0.78 MPa

[Wall Dimension]

Length	Height	Width
810 mm	370 mm	150 mm

[Input of Structural Analysis and Design]

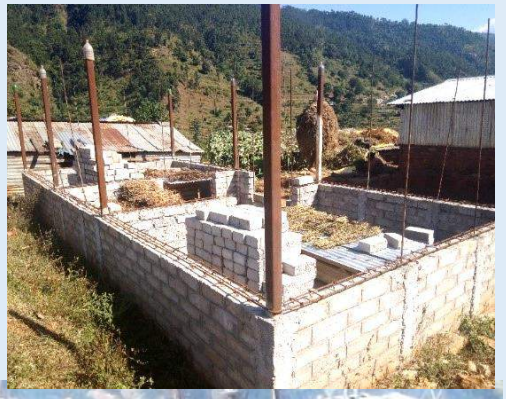
The corrective measure were developed considering the poor quality of HCB units as follows:

- **Compressive strength of walls** : The design value of capacity of walls in compression were taken as 40% of the capacity of the wall from wall sample having the lowest compressive strength value.
- **Unit weight** : 16 kN/m^3

Photo : Laboratory Test of Walls

2.3 Structural Use of Concrete Blocks

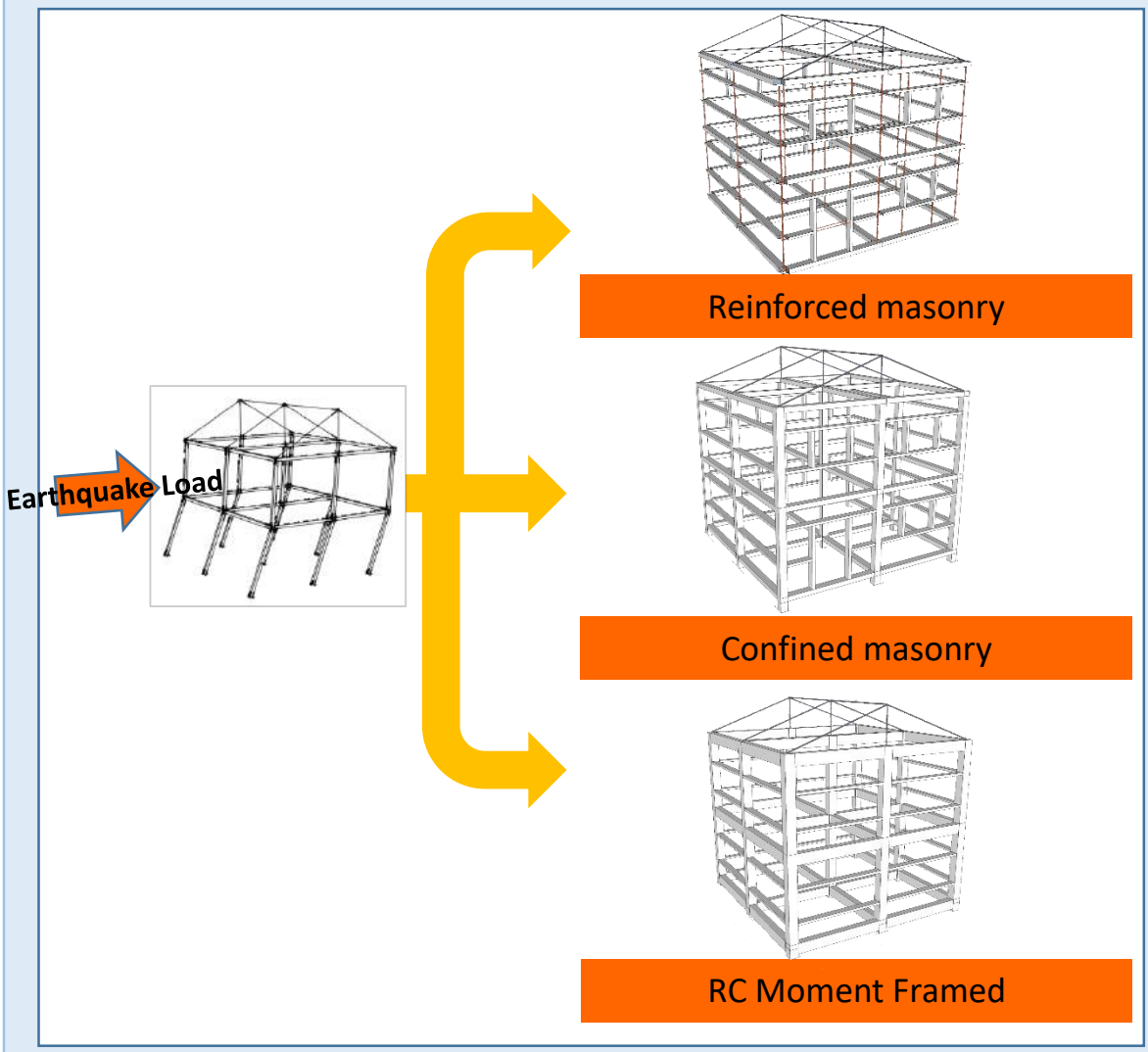
NRA Technical Team (TWG) surveyed concrete block buildings across different areas of Rupa Gaupalika, Annapurna Gaupalika, and Pokhara-Lekhnath Metropolitan in Kaski district. The team also received information on prevalent HCB constructions from 32 EQ affected districts from various sources. The team noted all the architectural and structural detailing of existing building components along with material specifications.



Current trend of concrete blocks use in building typology

From the compiled data, concrete block buildings can be classified into three structural systems as below:

1. Reinforced masonry structural wall system
2. Confined masonry structural wall system
3. RC Moment framed system with infills

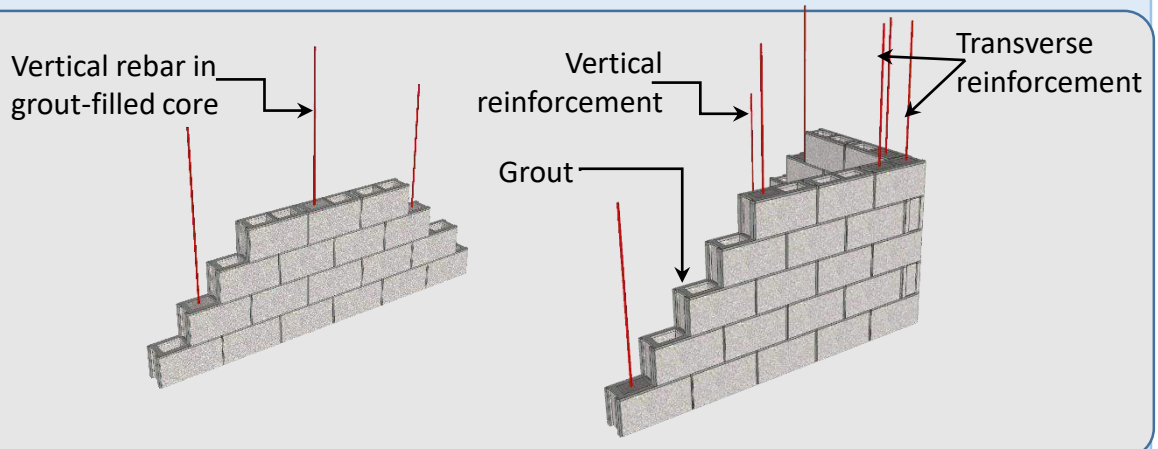


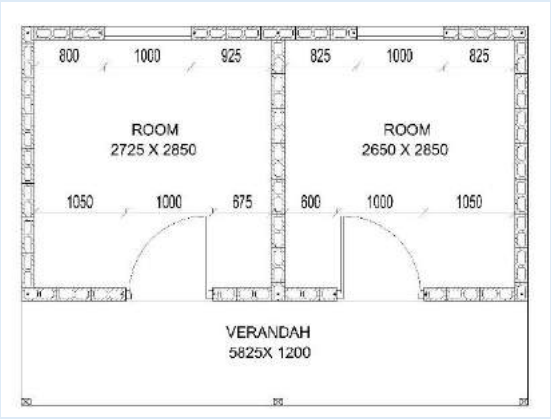
Classification of structural system of concrete block building

Reinforced Masonry Structural Wall System

In **reinforced masonry**, vertical and horizontal reinforcing bars are provided to enhance the strength and ductility (deformability) of masonry walls. Vertical reinforcing bars are placed in the hollow cores, which are subsequently grouted with a cement-based grout to anchor the reinforcement and protect it from corrosion.

Vertical reinforcement is placed at the wall corners and intersections, around the openings, and at additional locations depending on expected seismic loads. Horizontal reinforcement is provided in the form of ladder-shaped wire reinforcement placed in horizontal joints, or deformed reinforcing bars placed in bond beams, typically located at plinth, sill, lintel and roof levels.

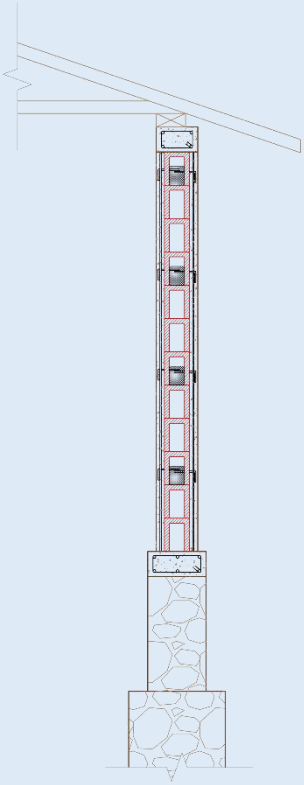




- **[Exceptional Cases]** : The [Practical] RC columns and beams are provided with flexible floor/roof and the building does not comply to MR according neither to RCC Framed nor to Confined Masonry.

Confined Masonry Structural Wall System

Concrete block wall resists the lateral loads and RC element confines the walls. Concrete block walls with toothing are constructed up to sill level leaving space for columns and then columns and sill are monolithically casted. Same process is applied after constructing concrete block wall up to lintel.



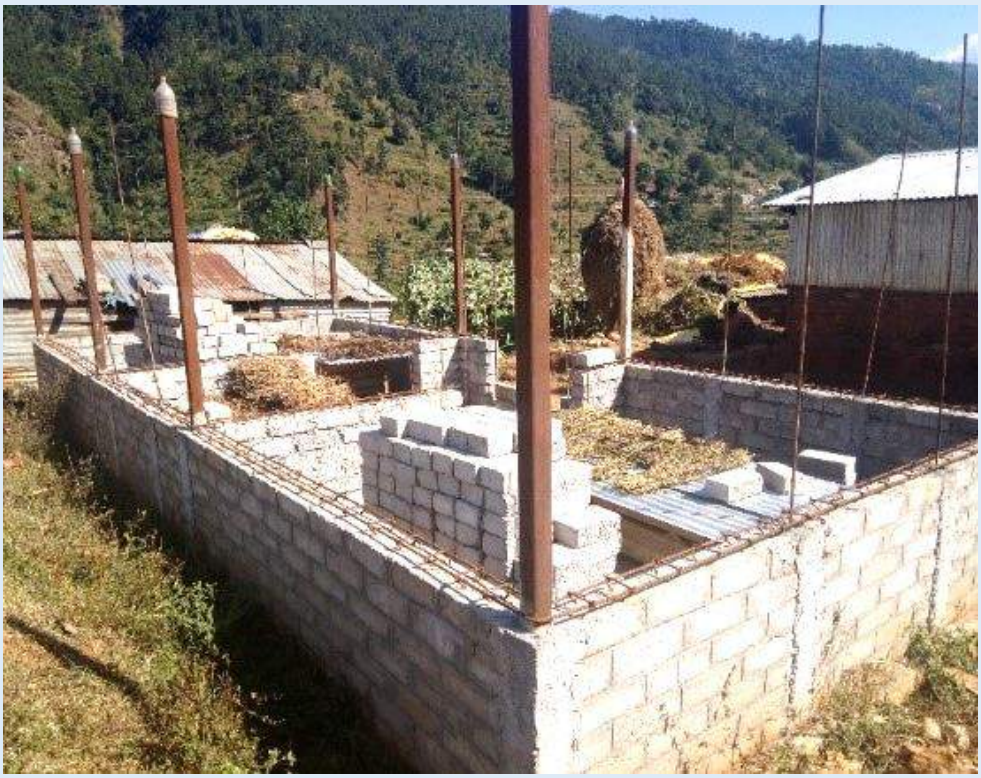
Section

RC Moment Framed

RC frames resist both gravity and lateral loads through their relatively large beams, columns, and their connections. Masonry in fills are not load- bearing walls

- **[Exceptional Cases]** : The rebar (in building infilled with HCB) can differ but shall be justify with Structural Analysis and Design.

[Structural Use of HCB: (single storey building with light roof)]



Square Hollow Pipe Sections & Rebar at Critical Location of Masonry Structures

Rebar at Critical Location of Masonry Structures, [construction sequence: Confined Masonry]

[Structural Use of HCB: (Double storey building with light roof)]

[Practical] RC Column and Beams

[Practical] RC Column and Beams

[Structural Use of HCB: (Double storey building with light roof)]

HCB Infilled Timber Framed Structure

HCB Infilled Timber Framed Structure

[Structural Use of HCB: (Double storey building with light roof)]

Hybrid Structure
[Upper Storey : Light Timber Frame Structure]
[Lower Storey : HCB Structure]

Hybrid Structure
[Upper Storey : HCB Structure]
[Lower Storey : Stone in Cement Structure]

2.4 Inspection Method

[Building Typology based on Inspection Form]

[Reinforced Masonry Structural Wall System]
Those buildings which falls under this typology shall be inspected using

[Confined Masonry Structural Wall System]
Those buildings which falls under this typology shall be inspected using

[Framed System with HCB Infills
Those buildings which falls under this typology shall be inspected using

- Note : All other structures except mentioned above in this page, can be inspected with help of Hybrid Structure Manual and Light Timber/Steel Frame Structure Manual.

Inspection Method

[Inspection Methodology]

Under reconstruction programme, if conditions of building are below, inspection shall be based on specification provided in this manual hence, structural calculation is not required.

1. Upto two storey, ground floor with masonry (SMC, BMC ONLY) structure and first floor with Hollow Concrete Block structure.
2. Upto two storey, both ground and first floor with Hollow Concrete Block
3. However, if the building is more than two storey, structural calculation is mandatory.

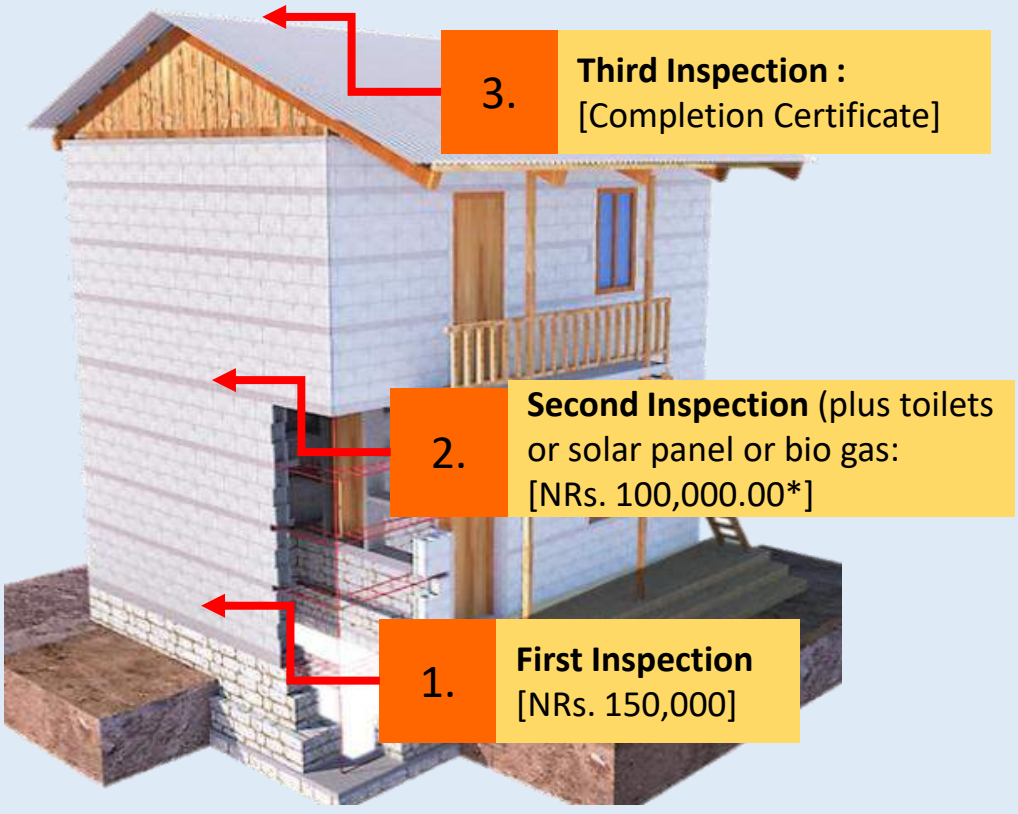


Photo : 3D view of HCB Houses

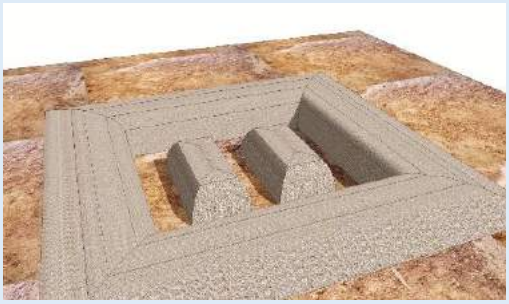
PART-3: TECHNICAL SPECIFICATION
[Reinforced Masonry Structural Wall System]

3.1. Construction Sequence of Building
3.2 Building Components
3.3. Minimum Requirements

3.1 Construction Sequence

Construction Sequence of **Reinforced Masonry Structural Wall System** using hollow concrete blocks unit as described below:

1 Excavation



2 Stone soling

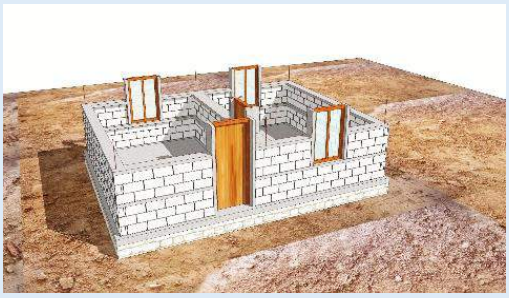
3 Placing lean concrete

4 Construction of foundation with installation of vertical element

5 Construction of Plinth band

6 Filling and placing lean concrete

7 Construction of masonry wall, sill and stitch band

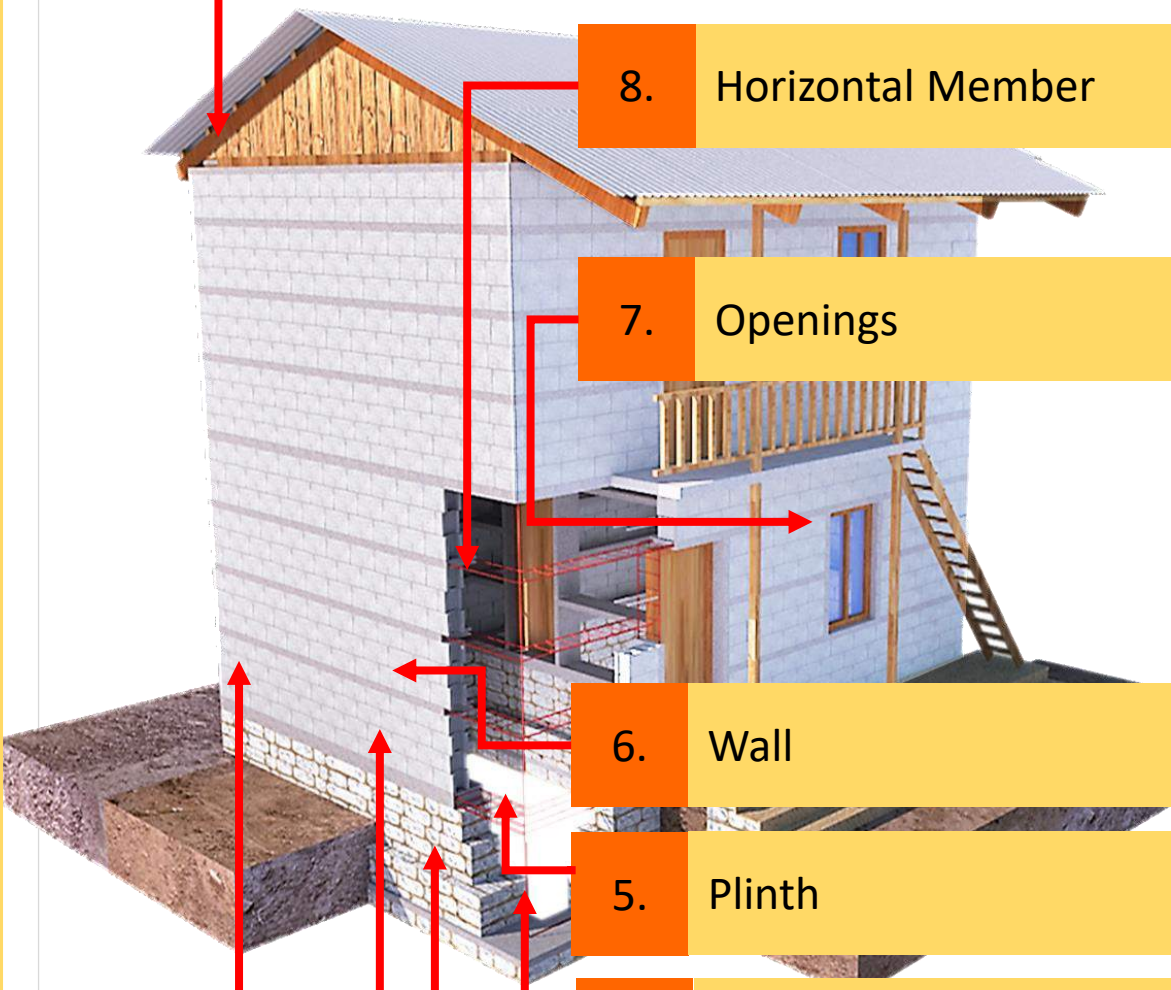


8 Construction of lintel and roof band

9 Installation of Roof

10 Installation of CGI sheet

3.2 Building Components



9. Roof
8. Horizontal Member
7. Openings
6. Wall
5. Plinth
4. Vertical Member
3. Foundation
2. Materials
1. Shape and Size of building

1. Shape and Size of building

Simple rectangular shapes behave better in an earthquake than shapes with projections. The inertia forces are proportional to the mass (or weight) of the building and only building elements or contents that possess mass will give rise to seismic forces on the building.

2. Materials

Inadequate materials do not have sufficient stability and strength to withstand the lateral forces. Hence, use of these substandard materials might lead to the failure or ultimately collapse of the overall structure.

3. Foundation

Buildings which are structurally robust against earthquakes sometimes fail due to inadequate foundation. Tilting, cracking and failure of superstructures may result from soil liquefaction and differential settlements of footing.

4. Vertical Member

Vertical reinforcement is used in masonry building to improve the integrity of the walls, to tie the walls together, and to tie the building from the foundation to roof band. Buildings with substandard or absent reinforcement are vulnerable during earthquakes.

5. Plinth

An unequal or loosely packed plinth will not provide a base of sufficient stability during an earthquake.

6. Wall

Load bearing masonry must have sufficient stability and strength to withstand lateral forces. Substandard walls may fail by cracking.

7. Openings

Openings reduce the strength and stability of the wall.T oo close to each other and to the corner reduce the overall strength of masonry.

8. Horizontal member

Horizontal members are essential to tie the building together to act as a box. In absence of these bands, the building shall face in plane or out of plane failure.

9. Roof

In order to resist against lateral forces, proper connection of roof to the vertical post and top plate is essential. Depending upon the structures, cross bracing is also required.

3.3 Minimum Requirements

No.	Category	Sub Category	Description
1.	Site selection	Site should be away from	Geological fault or rupture areas
			Landslide susceptible areas
			Steep Slope > 20° (1:3, Vertical : Horizontal)
			Filled areas
			Liquefaction susceptible Area
			River bank and Water logged Area
			Rock fall Area
2.	Shape and size of building	No. of storey	Not more than two storey [For inspection basis)
		Clear span of wall	Not more than 4.05m.
		Floor Area	Not more than 100 sq.m.
		Proportion	Simple and regular shaped as square and rectangular. The length of house shall not be more than 3 times of its width.
3.	Materials	Concrete block	Size: Full block 400mm*150mm*200mm Half block 200mm*150mm*200mm
		Mortar	Cement sand mortar shall not be leaner than 1:6 (1 part cement and 6 parts sand by volume) for masonry.
		Concrete Grade	M20 grade (1 cement: 1.5 sand: 3 aggregate)
		Rebar	High strength deformed bars with Fy = 415 Mpa /500 Mpa.
4.	Foundation	It shall be continuous strip footing of uniform width at same level throughout the foundation in flat area.	
		Depth of foundation below GL	For one story : 450mm For two story : 650mm
		Base width	For one story : 450mm For two story : 650mm
5.	Vertical member	Shall be started right from the foundation and continue up to the roof band.	
		it shall be provided at each corner, T-junction and side of opening.	
		Reinforcement	Refer table 1or 2, in the manual
		Anchorage	The anchorage length shall be 60 times diameter of the bar.

No.	Category	Sub Category	Description
6.	Plinth	General	The level of plinth shall not be less than 300mm from ground level.
		Thickness	The thickness of band shall be 150 mm.
		Width	It shall not be less than wall thickness.
		Reinforcement	Main reinforcement shall be 4-12 dia with 6mm dia. stirrups at 150mm centres. Bars shall have a clear cover of 25mm concrete.
7.	Wall	Masonry shall not be laid staggered or straggled in order to avoid continuous vertical joints.	
		Thickness	It shall not be less than 150mm
		Joints	Mortar joints shall not be more than 20mm and less than 10mm in thickness.
		Buttress wall	Provide for long span of wall .
		Gable wall	Provide light gables using wood, CGI sheets etc.
8.	Doors / windows.	Location	Openings are to be located away from inside corners by a clear distance equal to at least 1/4 of the height of the opening, but not less than 600 mm.
		Total length	The total length of openings in a wall is not to exceed 60 % of the length of the wall between consecutive cross-walls in both single and two-storey construction.
		Distance	The horizontal distance between two openings is to be not less than one half of the height of the shorter opening, but not less than 600 mm.
9.	Horizontal band	Sill band [concrete size & Reinforcement]	A continuous band having thickness 75mm, rebars 2-12 Ø stirrups 6Ø @150 mm with clear concrete cover 25mm shall be provided through all walls at the bottom level of windows opening.
		Lintel band [concrete size & Reinforcement]	A continuous band having thickness 150mm, rebars 4-12 Ø stirrups 6Ø @150 mm with clear concrete cover 25mm shall be provided through all walls at the lintel level of windows/door openings.
		Stitch band [concrete size & Reinforcement]	At corners and T- junctions, stitches(dowels) shall be provided at a vertical spacing of 600mm. Band thickness 75mm, rebars 2-12 Ø stirrups 6Ø @150 mm with clear concrete cover 25mm shall be provided through all walls at the bottom level of windows opening.
		Roof band & Gable [concrete size & Reinforcement]	A continuous band having thickness 150mm, rebars 4-12 Ø stirrups 6Ø @150 mm with clear concrete cover 25mm shall be provided through all walls at the roof level of windows/door openings.
		Rebars lapping and anchorage	The anchorage length shall be 60 times diameter of the bar.
10.	Roof	Material	Use of light roof
		Connection	All member shall be properly connected.
		Bracing	For flexible diaphragm, diagonal bracing shall be considered.

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PART-4 QUALITY CONTROL VS. ASSURANCE

[PART-4 QUALITY CONTROL AND QUALITY ASSURANCE]

4.1 Material Quality

4.2 Manufacturing Process

- ❖ Mixture of Mortar
- ❖ Batching and Mixing
- ❖ Moulding and Compaction
- ❖ Curing and Drying

4.3 Quality Standards and Tests

4.4 Manufacturer's Certificate

4.1 Material Quality

Minimum Requirements

2.	Materials	Concrete block	Size: Full block 400mm*150mm*200mm Half block 200mm*150mm*200mm
		Mortar	Cement sand mortar shall not be leaner than 1:6 (1 part cement and 6 parts sand by volume) for masonry.
		Concrete Grade	M20 grade (1 cement: 1.5 sand: 3 aggregate)
		Rebar	High strength deformed bars with fy = 415 MPa /500 MPa.

[Quality of Materials]

The quality of raw materials must be ensured to meet the NS/IS standards prior the block making process.

Cement

- ✓ Ordinary Portland Cement
- ✓ Special Cement

Aggregate

- ✓ Mixture of Sand or Chips Gravel
- ✓ Max. particle size should be 10mm.
- ✓ Most appropriate aggregates are obtained from natural sources (river beds, gravel pits, volcanic deposits) or from industrial by-process (granulated blast furnace slag, sintered fly ash)

Cement- Aggregate Ratio

- ✓ Suitable proportion of cement to aggregate must be taken from standard testing.
- ✓ Common ratios are 1:6, 1:8 (C/S)

Water-Cement Ratio

- ✓ Only drinking quality water should be used to mix the concrete
- ✓ Recommended Water-Cement ratio is 0.5

4.2 Manufacturing Process

Depending upon the types of compression force, Hollow Concrete Blocks can be divided as:

- **Manual Made**: The force required to compress the HCBs are imparted manually through the compression machine.
- **Machine Made:** The force required to compress the HCBs are imparted automatically through the compression machine. The blocks produced thus have similar compressive strength. Cement requirement too is 15% less compared to the manually made HCBs to achieve same compressive strength.

Mixture of Mortar

1:6 Mortar
(1 part cement and 6 parts sand by volume)

1. In first step pour six bucket of sand

2. Add one bucket of cement and mix it properly

3. After mixing make a dig and pour water

4. Mix all the materials until uniform texture is obtain

5. Check the quality of concrete

[Batching and Mixing]

- ✓ Batch aggregates and cement by volume.
- ✓ Mix cement and aggregates using mattock, shovel or mixer until it reaches homogeneous condition.
- ✓ Add some water
- ✓ In hot climates, the fresh mix must be shaded from sun.

Batching by Volume

½ bucket water

1 bucket cement

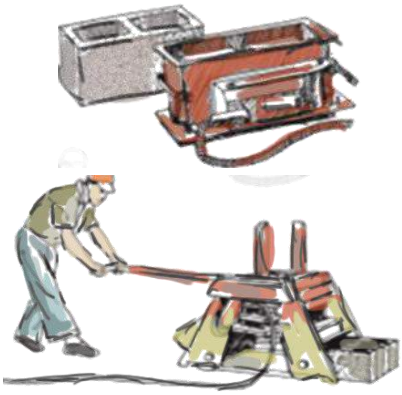
7 bucket aggregate

Manual Made HCBs

Machine Made HCBs

[Moulding and Compaction]

- ✓ Put the mixture into wooden or steel mould boxes or moulding machine.
- ✓ Place the blocks in the compressing machine and compress according to the compressing machine type (Manual or Machine).
- ✓ Demould blocks immediately after compaction.



[Curing and Drying]

- ✓ Cover demoulded blocks with plastic sheets for 24 hrs.
- ✓ Keep the concrete blocks moist by immersing in water tanks or by regularly spraying with water for 7 days.
- ✓ Do not expose to direct sun light; keep the blocks in a dry and covered area
- ✓ Store the blocks for 2 weeks before usage.

Manufacturing Process Steps

1. Batching

2. Mixing

3. Moulding and Compaction

4. Fresh HCB

4.3 Quality Standards and Tests

[Quality Standards]

Both national and international standards exist for the production of HCBs. NS Standard (Nepal Standard 119/2042) has been issued by National Bureau of Standards and Measurements. It covers the standards of raw materials, physical properties of HCB and different standard testing methods.
Indian Standard Code (IS 2572:2005) too can be referred.

Physical Properties (NS 119/2042)	
Density	1600kg/m3
Compressive Strength	5N/mm2 (Minimum)
Drying Shrinkage	0.04% (Maximum)
Moisture Movement	0.03% (Maximum)
Water Absorption	240kg/mm3 (Maximum)
Water Content	40%

The standard tests requiring for ensuring quality of blocks are:

[Material Density Test]

- Three blocks taken at random from the samples selected in accordance with 10, shall be dried to constant mass in a suitable oven heated to approximately 100°C.
- After cooling blocks to room temperature, the dimensions of each block shall be measured in centimeters (to the nearest millimeter) and the overall volume computed in cubic centimeters.
- The block then be weighed in kilograms (to the nearest 10g) and the density of each block calculated as follows:
- **Density = Mass of block in kg/Volume of specimen in cm3 X 10^6 kg/m3**
- The average for the three blocks shall be taken as the average density.

[Compressive Strength Test]

It Shall be carried out as per either NS119/2042 or IS 2185.1.2005. and the results must comply with specified standards.

[Sample Report of HCB Laboratory Test Result]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING
CENTRAL MATERIAL TESTING LABORATORY

COMPRESSIVE STRENGTH

Tribhuvan University Institute of Engineering Department of Civil Engineering Central Materials Testing Labratory

Name : Housing Recovery & Reconstruction Platform-Nepal (HRRP)
Location : Jwagal, Lalitpur, Nepal

Date : 2074/01/02

Material :Hollow Block
Marked as : SBU
District : Dhading

Cement Concrete Hollow Block		1	2	3	Remarks
Date of testing					
Age	(Days)	More than 28 days			
Dimension	cm.	39.5x14.5x20	39.5x14.5x20	39.5x14.5x20	
Surface area	cm^2	386.25	386.25	386.25	
Volume.	cm^3	8445.00	8445.00	8445.00	
Weight	gms.	20300.00	20000.00	20100.00	
Density	gm/cm^3	2.404	2.368	2.380	
Breaking Load	Kg	400.00	250.00	250.00	
Breaking Strength.	KN/cm^2	1.03	0.64	0.64	
Avg. Breaking Strength	KN/cm^2				

Note : Concrete hollow block were supplied by HRRP

Ram S. Timilsinna
Tested by

(Rajendra R.Pant)
Dy.Chief

Dy. Chief

To ensure the quality of HCB units at construction site, refer User's Guidelines for Quality Tests,

Annex A~

4.4 Manufacture's Certificate

[Manufacturer's Certificate]

The manufacturer shall satisfy himself that the blocks conform to the requirements of this specification and, if requested, shall forward a certificate to this effect to the purchaser.

[Sample Certificate]

S.N	Category	Description	HCB Manual Standards	Minimum requirements		Remarks
				Yes	No	
1	**Block Size**	Dimension of Block	Full Block:400X200X150(mm) Half Block:200X200X150(mm)	☐	☐	Tolerances of ±3 mm on length and ±1.5mm on breadth and height
2	**Block Quality and Properties**	Proportion of HCB	1:6 (Cement: Sand & Aggregate) 1:8 (Cement: Sand & Aggregate)	☐	☐	
		Maximum Size of Aggregate	10 mm	☐	☐	
		Density	1600 kg/m3	☐	☐	
		Compressive Strength	5N/mm2	☐	☐	
		Water absorption	240kg/mm3	☐	☐	
3	**Manufacture Details**	Type of Compaction	Manual	☐	☐	
			Machine	☐	☐	
		Curing Type	Immersion/Spray	☐	☐	
		Curing Period	Minimum 7 days	☐	☐	

Details of Producer:

Name	
Address	
Signature & Date	
PAN/VAT Number	

Certificate is needed because producers are the first responders to ensure quality construction, so knowledge of safer construction practices at consumer level can be imparted from the producer level.

PART-5 CORRECTION MEASURES

5.1 Major Non-compliance Issues
5.2 Strengthening Opening
5.3 Addition of RC Horizontal Bands
5.4 Addition of RC Vertical Bands
5.5 Jacketing Against Localized Failures

5.1 Major Non-Compliance Issues

[Summary of Problem Statement] Major non-compliance issues are due to poor quality of HCB units and Missing of Seismic Bands at critical location of building units requiring according to MR.

Case/s	Block Unit Quality	Seismic Bands	MITIGATION WORKS (Correction)	MITIGATION OPTIONS
Case1	OK	OK	NO	No Mitigation
Case2	OK	NOT OK	YES	Splint & Bandage at Critical Location*
Case3	NOT OK	NOT OK	YES	Jacketing [Global] #
Case4	NOT OK	OK	YES	Jacketing [Panel Specific] !

Case 1: During the inspection of building, Block units quality is found as per MR and Seismic bands are provisioned in building units, then no mitigation (correction) work is advisable.

*Case 2: During the inspection of building, Block units quality is found as per MR and Seismic bands are not provisioned in building units, then splint and bandage (at critical location) method of mitigation (correction) works is advisable.

#Case 3: During the inspection of building, Block units quality is not found as per MR and also seismic bands are not provisioned in building units, then Jacketing (whole building unit) method of mitigation (correction) works is advisable.

!Case 4: During the inspection of building, Block units quality is not found as per MR and but seismic bands are provisioned in building units, then Jacketing (panel specific) method of mitigation (correction) works is advisable.

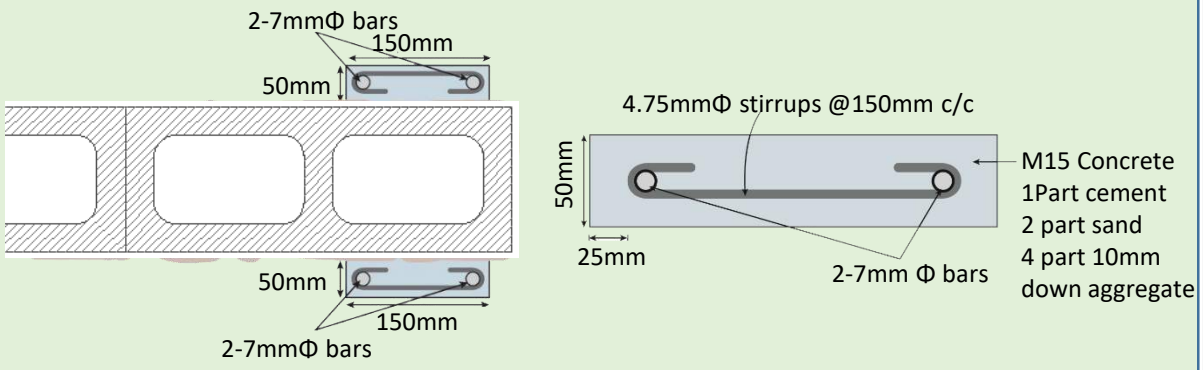
NOTE

- **Note : Block units quality can be ensured either laboratory test results certified by supplier or means of non-destructive test at site.**

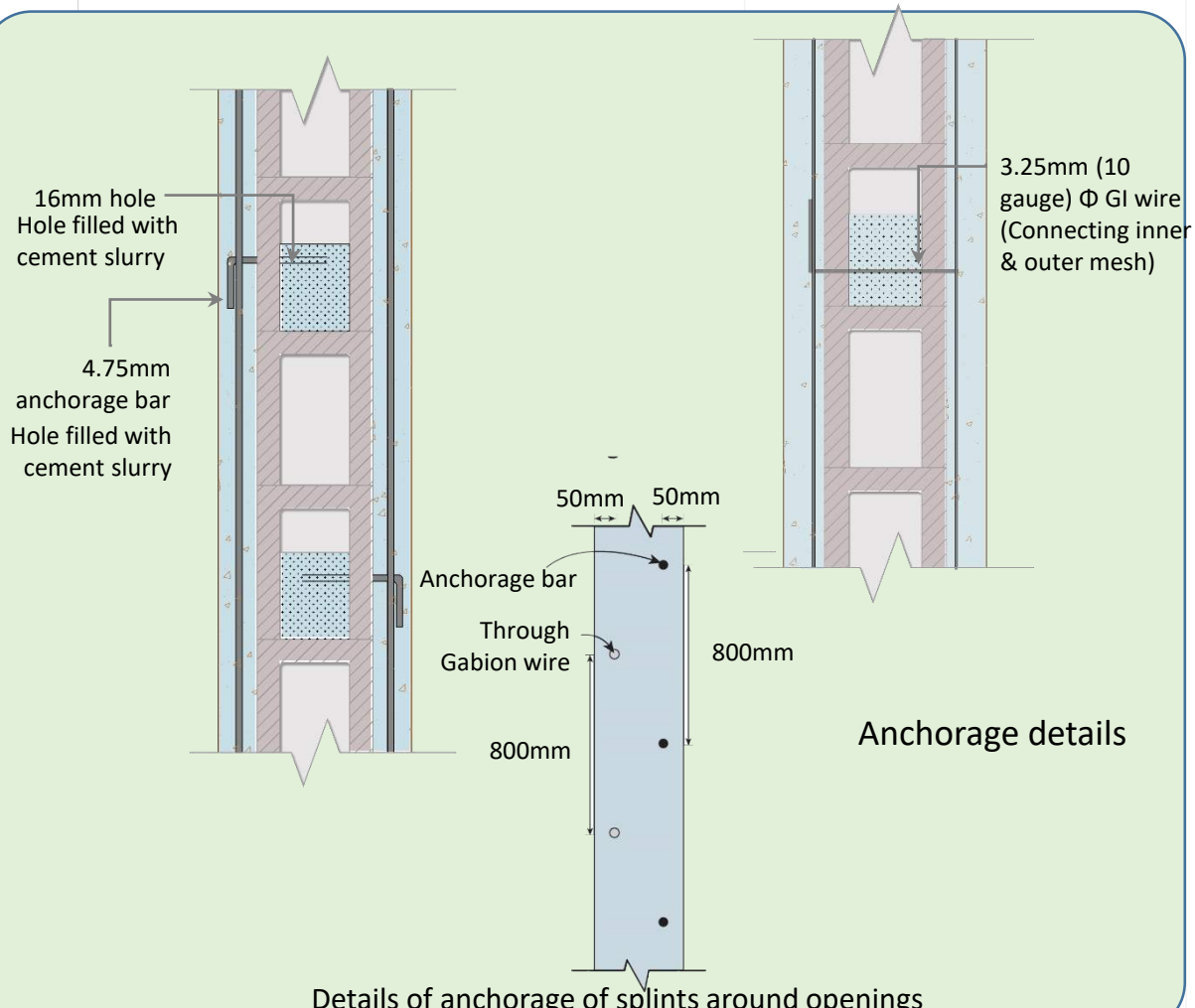
5.2 Strengthening Opening

Provide RCC splint on outer faces of wall wherever required and anchor them sufficiently with the wall.

Openings



Details of splints around openings

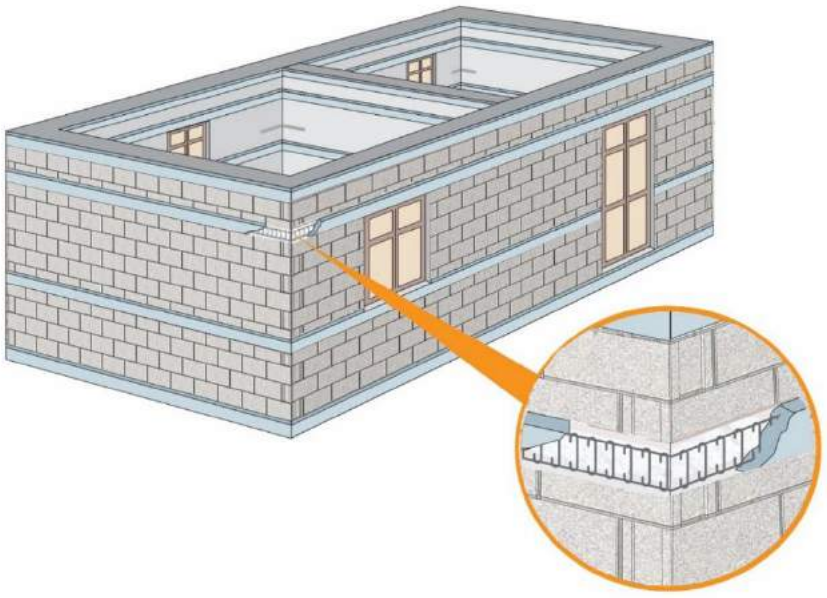


Anchorage details

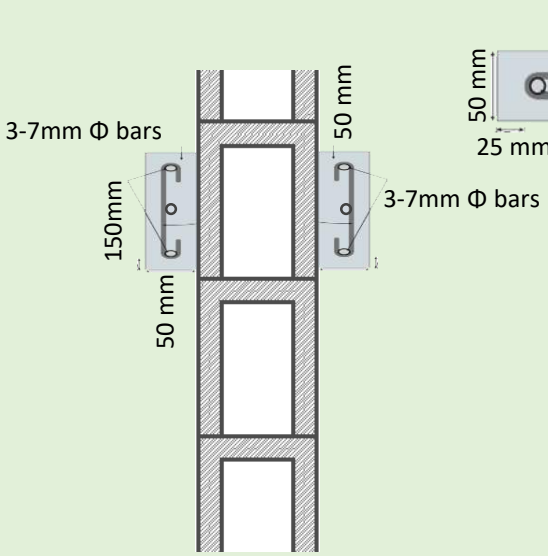
Details of anchorage of splints around openings

5.3 Adding RC Horizontal Band

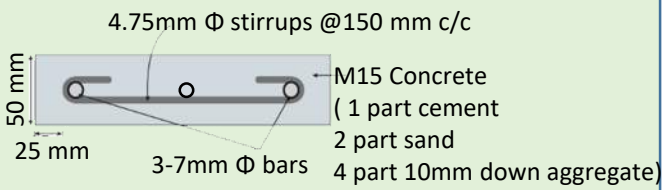
Provide RC horizontal bands on both side of wall on outer faces wherever required as shown in the following figures:



Addition of bandages on outer faces of wall when plinth/ sill/ lintel/ roof bands are missing

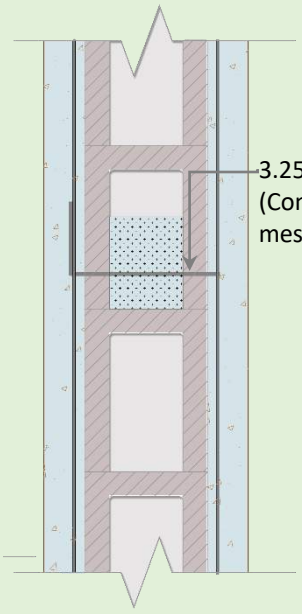


X-sectional Elevation View

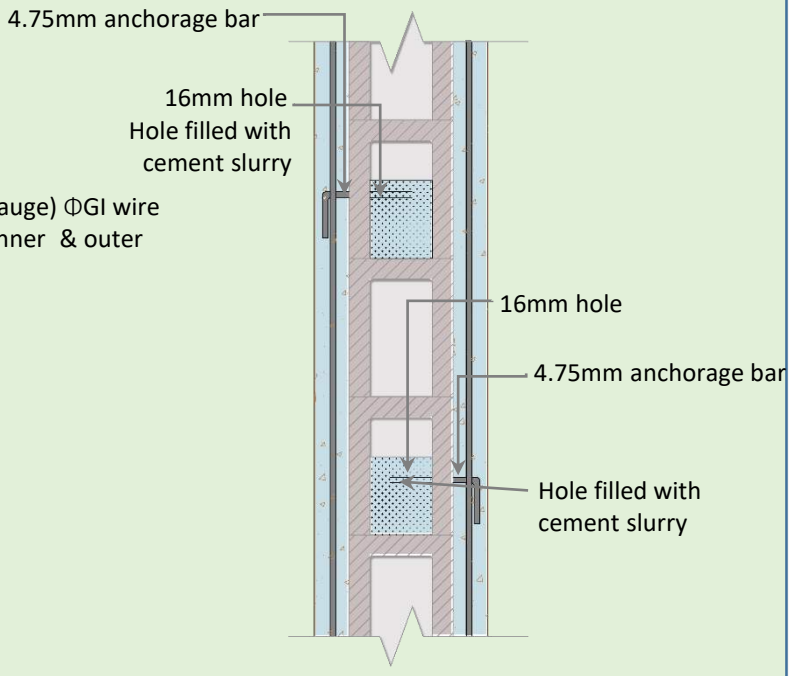


Details of additional horizontal band

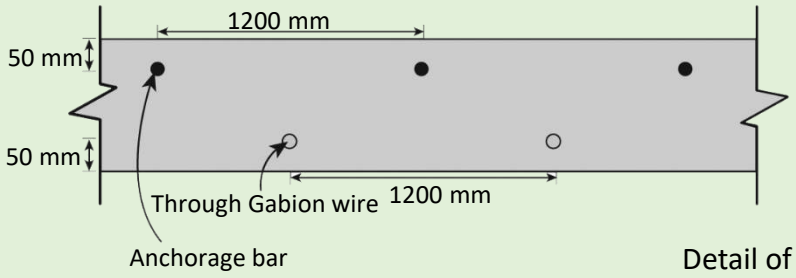
5.4 Adding RC Horizontal Band



Detail of inserting through GI wire in wall [PLAN VIEW]



Detail of inserting anchorage bar in wall [PLAN VIEW]

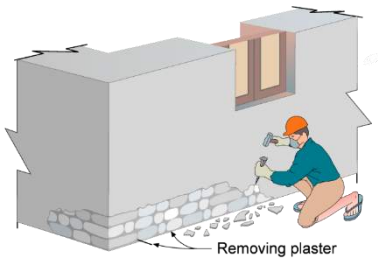
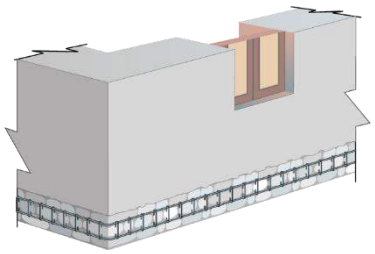
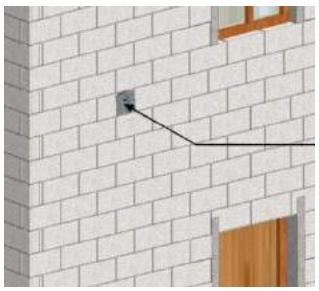


Detail of anchorage

Detail of fixing RC band

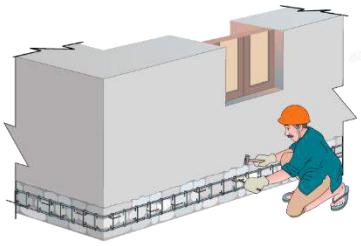
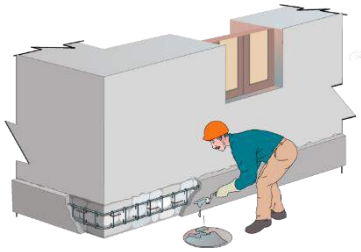
Adding RC Horizontal Band

Construction procedure

Step	Description of work	Images
1.	**Surface Preparation:** • Remove the plaster from the areas of the wall where bandages are to be placed. • Rake out mortar up to the depth of ½"-1“ • Clean the surface, but don’t use water for cleaning as mud mortar will be removed • Apply a thin layer of cement slurry on these area	
2.	**Placing of Reinforcement** • Place horizontal steel bar mesh of bandages. • Place stirrups on bandages • (Note: Lapping of steel bars wherever required should be equal to development length: 4.75mm bar- 300mm lap 8 mm bar- 450mm lap 10 mm bar- 600mm lap 12 mm bar- 720mm lap 16 mm bar- 960mm lap)	
3.	**Make holes for anchorage** i) For through GI wire : • Make through holes in walls using steel rod and hammer at suggested locations. • Insert GI wires at suggested interval and location. ii) For anchorage bar : • Make holes on one side of wall using steel rod and hammer. • Insert steel anchorage bars at suggested interval and location.	  Drill through the walls

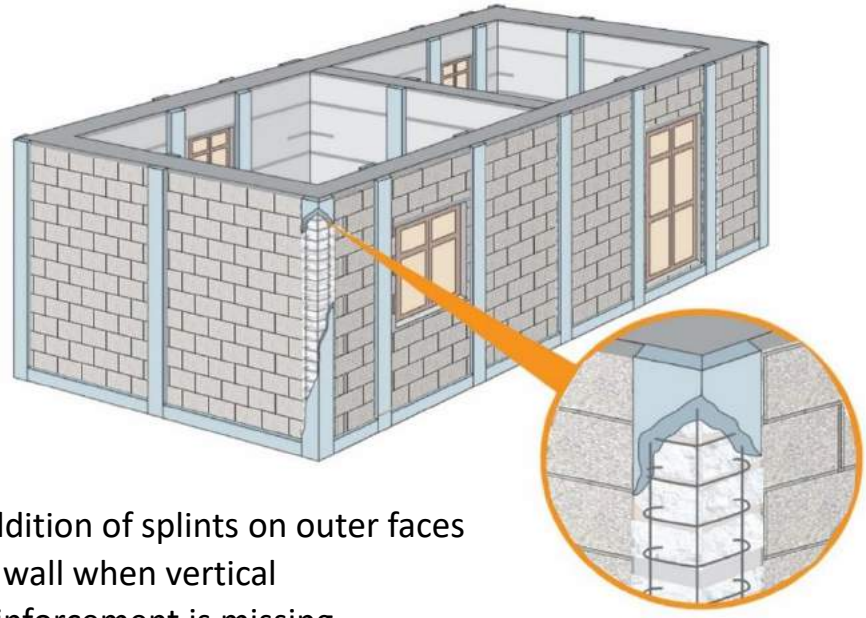
Adding RC Horizontal Band

Construction procedure

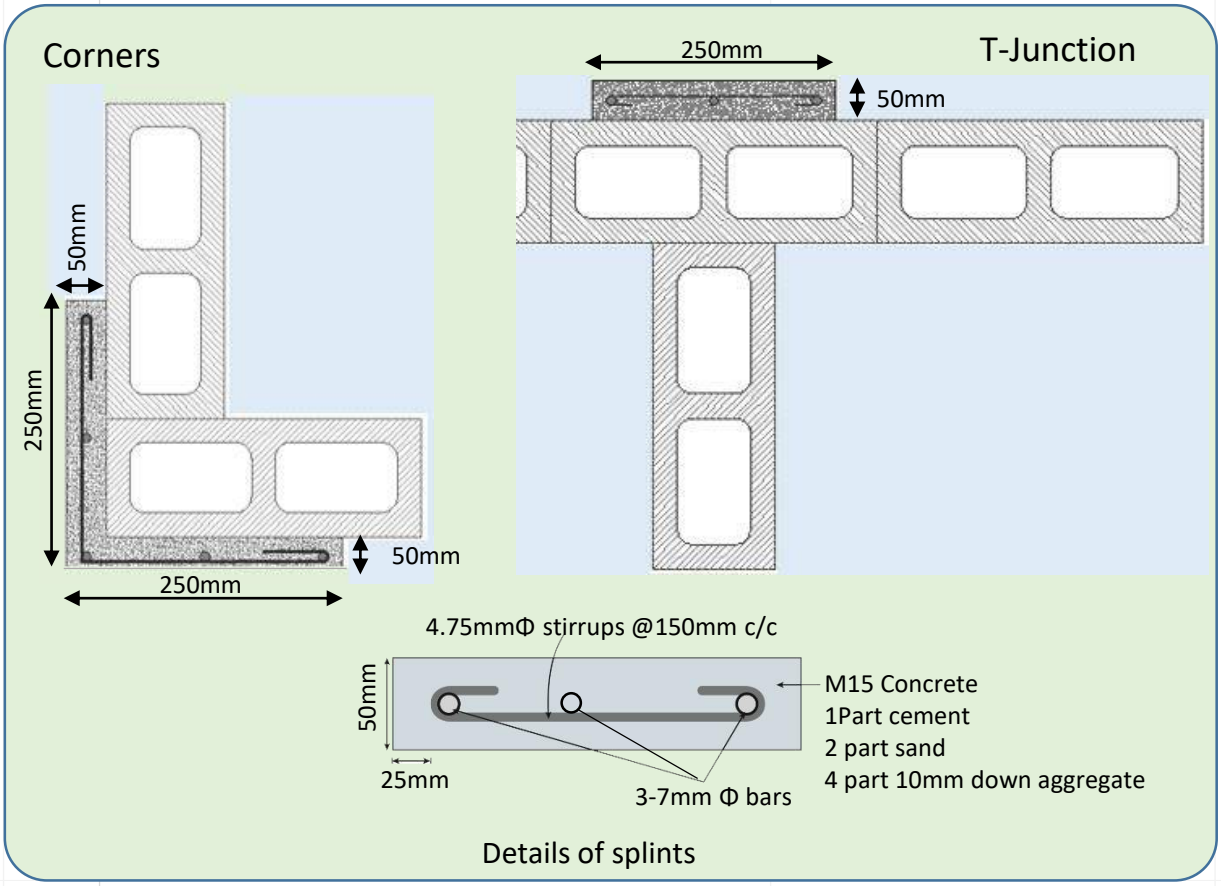
Step	Description of work	Images
4.	**Anchor reinforcing bar mesh** • Fix reinforcing bars into the wall using inserted steel anchorage bars, seal the anchorage bar using cement slurry • Connect inner and outer mesh using inserted through G.I. wires	
5.	**Application of Micro Concrete** • Apply micro concreting on the reinforced splint and bandages with rich micro-concrete (M15) -20 to 25 mm thick in two layers. (Total thickness is 40-50mm) • Micro concreting can be done by hand, similar to plastering, without shotcrete machine like in plastering.	
6.	**Curing of concrete** • Cure the concrete for 14days. • Use jute bags/ mats for better curing	

5.4 Addition of RC Vertical Bands

Provide RC vertical reinforcement(splint) on outer faces of wall wherever required and anchor them sufficiently with the wall as shown in the following figures:

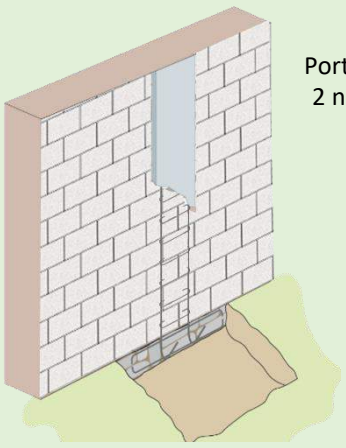


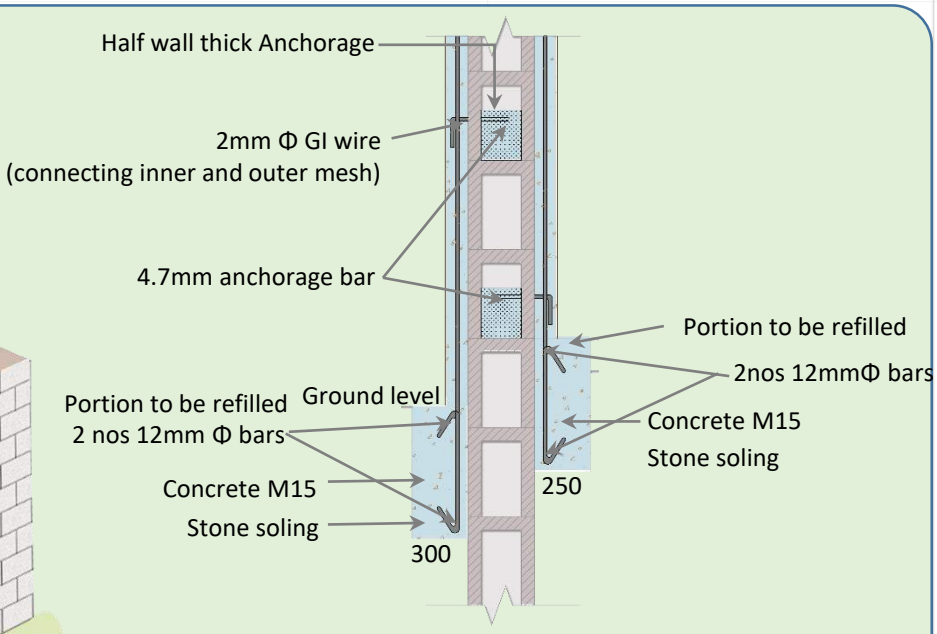
Addition of splints on outer faces of wall when vertical reinforcement is missing



Details of splints

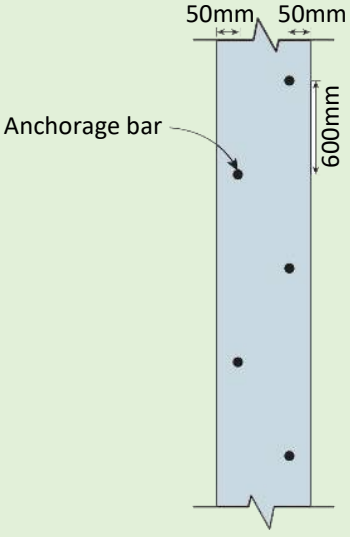
Addition of RC Vertical Bands

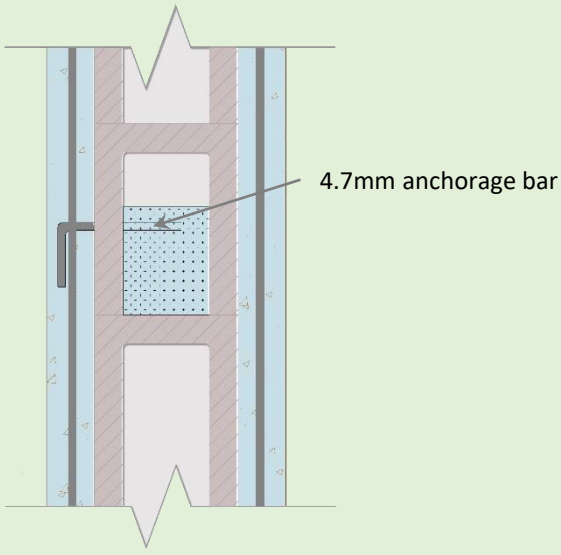




Details of foundation for splints

Anchorage Details





Details of anchorage of splints at corner and junction of wall

Addition of RC Vertical Bands

Construction procedure

Step	Description of work	Images
1.	**Surface Preparation** • Remove the plaster from the areas of the wall where bandages are to be placed. • Rake out mortar upto a depth of ½"-1". • Clean the surface, but don't use water for cleaning as mud mortar will be removed. • Apply a thin layer of cement slurry on these areas.	
2.	**Foundation Preparation** • Dig out trench for foundation as per suggested depth for placing tie beams for splints. • Stone soling on the trench	
3.	**Placing of reinforcement** • Place the horizontal bars in the trench • Now, place vertical bars of splints • Anchor them to the steel bar of trench • Place stirrups on vertical bars • (Note: Lapping of steel bars wherever required should be equal to development length: 4.75mm bar- 300mm lap 8 mm bar- 450mm lap 10 mm bar- 600mm lap 12 mm bar- 720mm lap 16 mm bar- 960mm lap)	
4.	**Concreting of tie beam**	

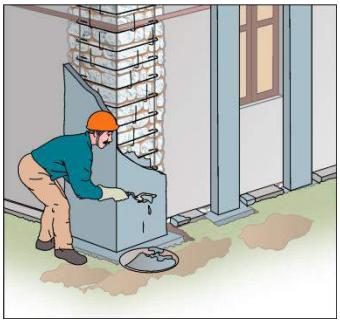
Addition of RC Vertical Bands

Construction procedure

Step	Description of work	Images
5.	**Make holes for anchorage** i) For through GI wire : • Make through holes in mud mortar on walls using steel rod and hammer at suggested locations. • Insert GI wires at suggested interval and location ii) For anchorage bar : • Make holes on one wyth of wall using steel rod and hammer. • Insert steel anchorage bars at suggested interval and location	  Drill through the walls
6.	**Anchor reinforcing bar mesh** • Fix reinforcing bars into the wall using inserted steel anchorage bars, jam the anchorage bar using cement slurry. • Connect inner and outer mesh using inserted through G.I. wires	

Addition of RC Vertical Bands

Construction procedure

Step	Description of work	Images
7.	**Application of Micro Concrete** • Apply micro concreting on the reinforced splint and bandages with rich micro-concrete (M15) -20 to 25 mm thick in two layers. (Total thickness is 40-50mm) • Micro concreting can be done by hand without shotcrete machine like in plastering.	
8.	**Curing of concrete** • Cure the concrete for 14days. • Use jute bags/ mats for better curing	

5.5 Jacketing Against Localized Failure

Example 1

[Reinforced masonry structural wall building] : Provide welded GI wire mesh as per specification ((100mm X 100 mm Square Mesh, 16 Gauge) on both side of wall panel and anchored them sufficiently. Apply plastering layer of mortar mixture of 1:4 to 1: 6 (cement to sand ratio). The thickness of plaster varies 15 mm to 20 mm on inner face of wall and 20 to 30 mm on outer face of walls. The construction sequence are mentioned in exception/correction manual], published by NRA.

Figures : Jacketing of HCB building using GI wires and plaster

Example 2

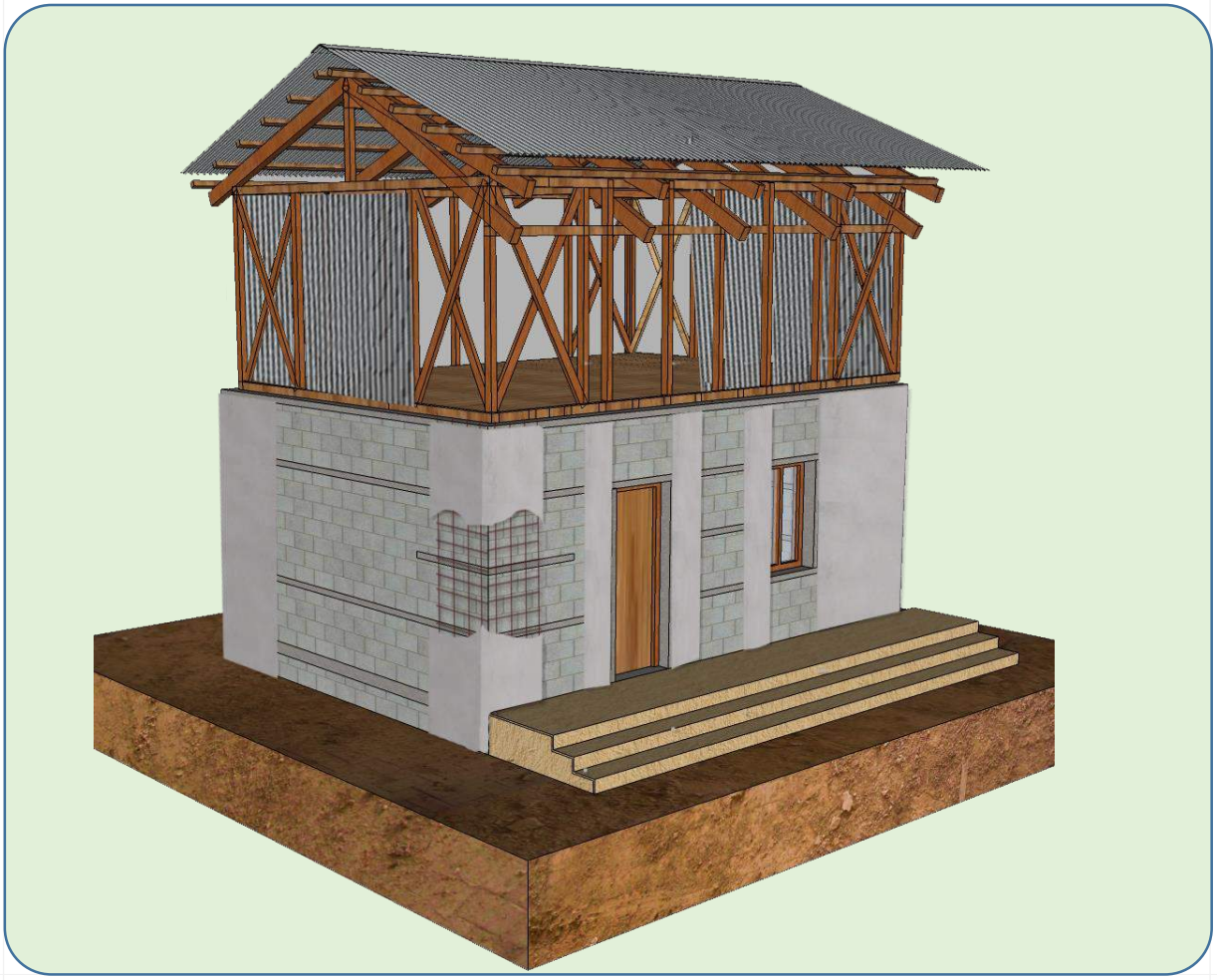
[Reinforced masonry structural wall building] : Provide welded GI wire mesh as per specification ((100mm X 100 mm Square Mesh, 16 Gauge) on both side of wall panel and anchored them sufficiently. Apply plastering layer of mortar mixture of 1:4 to 1:6 (cement to sand ratio). The thickness of plaster varies 15 mm to 20 mm on inner face of wall and 20 to 30 mm on outer face of walls. The construction sequence are mentioned in exception/correction manual], published by NRA.

Figures : Jacketing of HCB building using GI wires and plaster

Example 3
Hybrid Structures

[In lower floor] Provide welded GI wire mesh as per specification ((100mm X 100 mm Square Mesh, 16 Gauge) on both side of wall panel and anchored them sufficiently. Apply plastering layer of mortar mixture of 1:4 to 1:6 (cement to sand ratio). The thickness of plaster varies 15 mm to 20 mm on inner face of wall and 20 to 30 mm on outer face of walls. The construction sequence are mentioned in exception/correction manual], published by NRA.

[In upper floor] provide diagonal bracing as per specification (refer, Light Timber/Steel Frame Structure Manual).



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PART-6 : READY TO USE DESIGNS

This section presents design summary for HCB masonry building which requires correction and reinforcement requirement for HCB buildings to be built as per Nepal NBC 2002 : 1994:

[Typical description of building]

- Number of storey : 2
- Storey height : 2.50 m (maximum)
- Total height : 5.00m
- Unsupported wall length: 4.05 m (maximum)
- Plinth area : 100.00 sq.m.

The following details shall be followed in placing the horizontal and vertical steel in HCB masonry using cement mortar:

Summary of Correction Design

Table 1 : Summary of Seismic Belts Design

Table 1(A): Horizontal Bands Details (applicable for correction)

S.N.	Length or Wall	Reinforcement in Horizontal bands with overlapping of Ld mm	
	In meter	Concrete Size (mm)	Rebar (No & diameter)
1.	< 4.05	150 x 40	3#7Ø

Note : Material grade : M20 and Fe 500 or 415 , ties 4.75 mm diameter bars @ 150 m spacing.

Table 1 (B): Rebar **in RC vertical splint with overlapping of Ld mm,**

SN	No. of storey	Storey	At T-Junction Concrete size 250x40		At Corner Junction Concrete size 250x40		At near opening Concrete size 150x40	
Concrete Grade M 20, Rebar Grade Fe 500			No	Bar Ø (mm)	No	Bar Ø (mm)	No	Bar Ø (mm)
1	One		3	7	3	7	2	7
2.	One plus attic	Attic	3	7	3	7	2	7
		Ground	3	7	3	7	2	7
3.	Two	First	3	8	3	8	2	8
		Ground	3	8	3	8	2	8
4.	Three	Second	Design Specific					
		First						
		Ground						

Note :1) Material grade : M20 and Fe 500 or 415 , ties 4.75 mm diameter bars @ 150 mm spacing.

Table 2 : Summary of Seismic Belts Design

Table 2(A): Horizontal Bands Typical Details (applicable for new construction)

S.N.	Length or Wall	Reinforcement in Horizontal bands with overlapping of Ld mm	
	In meter	Concrete Size (M20) (mm)	Rebar & stirrups (Fe 500)
1.	≤ 4.05	150 Thk	4#12Ø (stirrups 6mm dia @ 150 mm spacing c/c)

Note : The horizontal bands can be provided as per NBC 202:2015.

Table 2(B) : Vertical Reinforcement with overlapping of Ld mm,

SN	No. of storey	Storey	At T-Junction		At Corner Junction		At near opening	
Concrete Grade M 20, Rebar Grade Fe 500			No	Bar Ø (mm)	No	Bar Ø (mm)	No	Bar Ø (mm)
1	One		1	10	1	10	1	10
2.	One plus attic	Attic	1	10	1	10	1	10
		Ground	1	12	1	12	1	12
3.	Two	First	1	12	1	12	1	12
		Ground	1	12	1	12	1	12
4.	Three	Second	1	12	1	12	1	12
		First	1	12	1	12	1	12
		Ground	1	12	1	12	1	12

The vertical bars specified in above table shall be located conveniently inside the cavities of the hollow blocks. The cavities containing bars are to be filled by using a concrete mix of (1:2;4) or cement course-sand mortar (1:3) , and are properly compacted .

Source ; [NBC 202:1994]

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ANNEX A: HCB UNIT QUALITY TEST AT SITE

[Annex A: User's Guidelines for Quality Tests]

A.1 Drop Test

A.2 Visual Test

A.3 Cutting Test

A.1 Drop Test

Drop 5 blocks from 1.50 m height on hard surface (concrete surface) :
MORE THE PIECES LESS THE STRENGTH

When drop from chest height.

Also, drop from head height.

Acceptable quality (less than 1 HCB broken)

Poor quality (more than 1 HCB broken)

A.2 Visual Test

Press the corner of the block. It should not break.

[If no practice columns are casted], Press the corner of the block in actual construction site where block edge is exposed or remove plaster (if required).

A.3 Cutting Test

Cut the block with chisel at the centre as shown beside. Block should always break only in two pieces. If it breaks into many pieces, it indicates low strength.

More the cutting depth of the block, more the strength.

Cut evenly at all four sides to know the strength of the block.

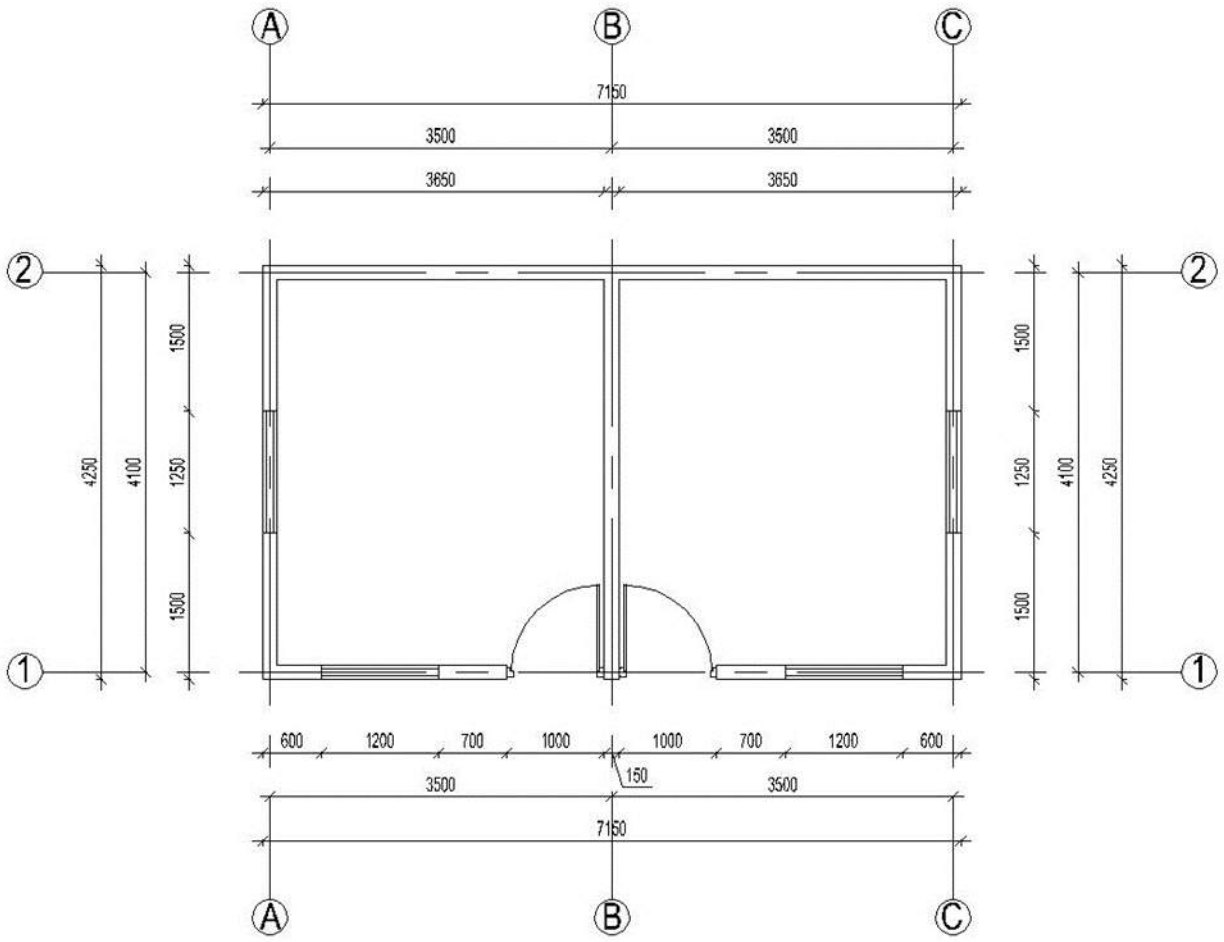
ANNEX B : STRUCTURAL ANALYSIS AND DESIGN

This section presents representative sample calculation referred in structural analysis and design of existing building as well as new buildings.

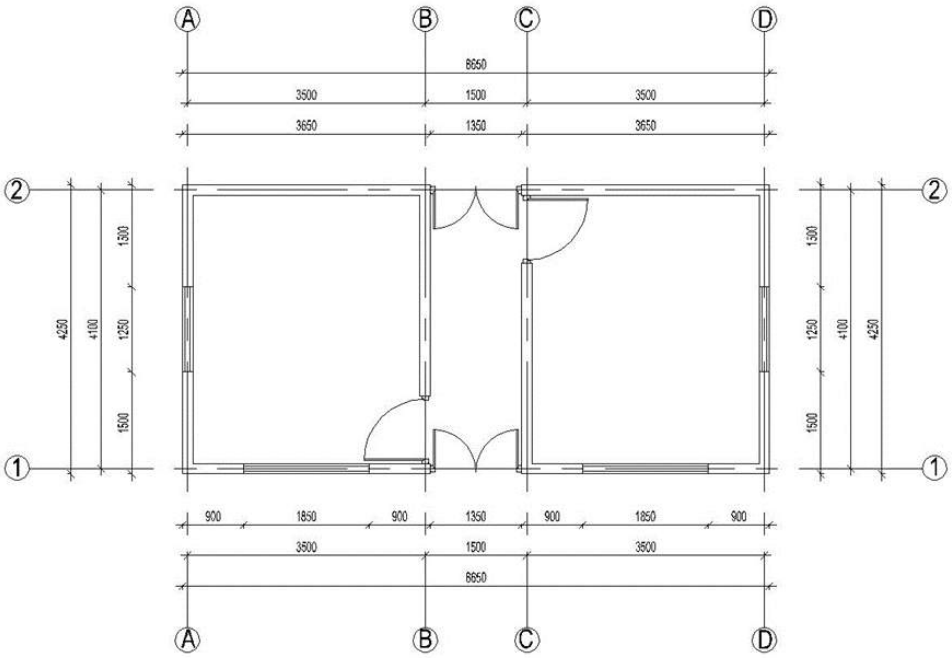
Description of existing building:

A team consisting engineers from Housing Recovery and Reconstruction Platform (HRRP)-Nepal, engineers from National Reconstruction Authority (NRA) and local representatives visited Rupa Gaupalika, Annapurna Gaupalika and Pokhara-Lekhnath Metropolitan City of Kaski district from 30th July to 3rd August 2018. Most of the existing buildings at the site are one storeyed and two storeyed, load bearing structures with flexible roof and majority of them are represented by either of the models presented below:

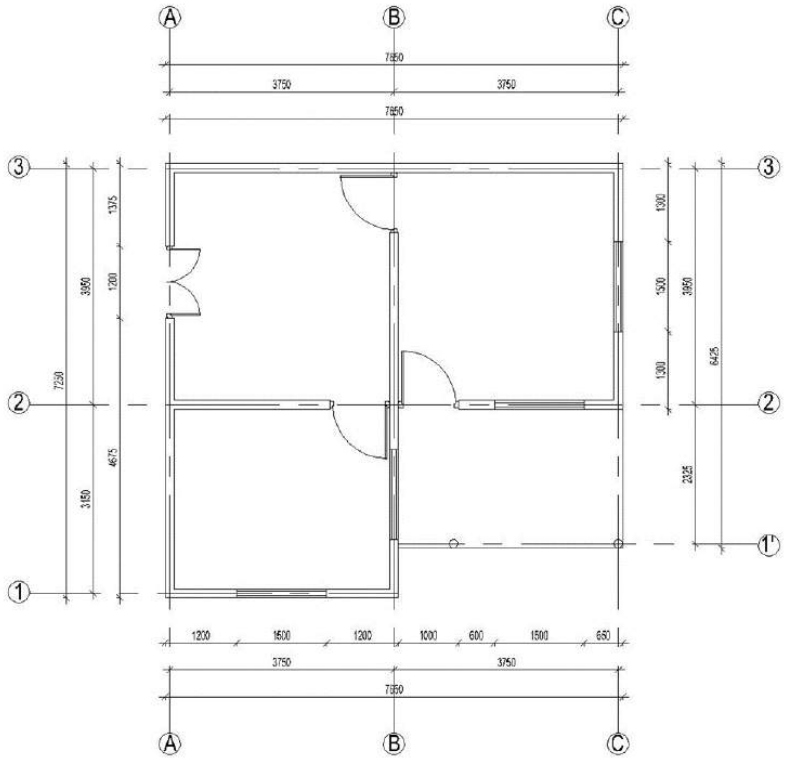
a. Two Roomed Building (2R model)



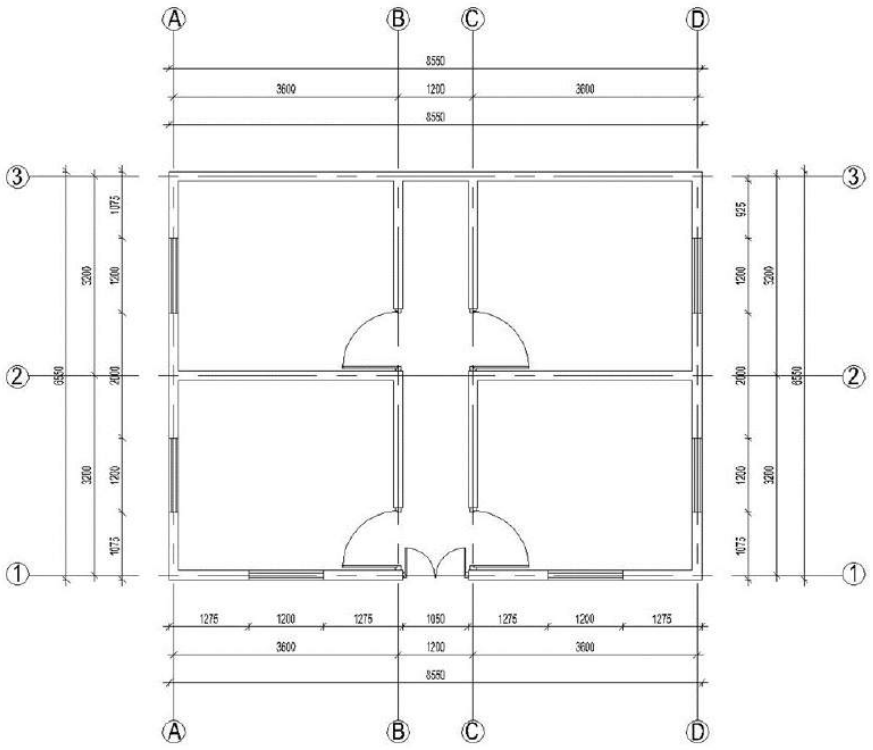
b. Two Roomed Building with passage (2R+P model)



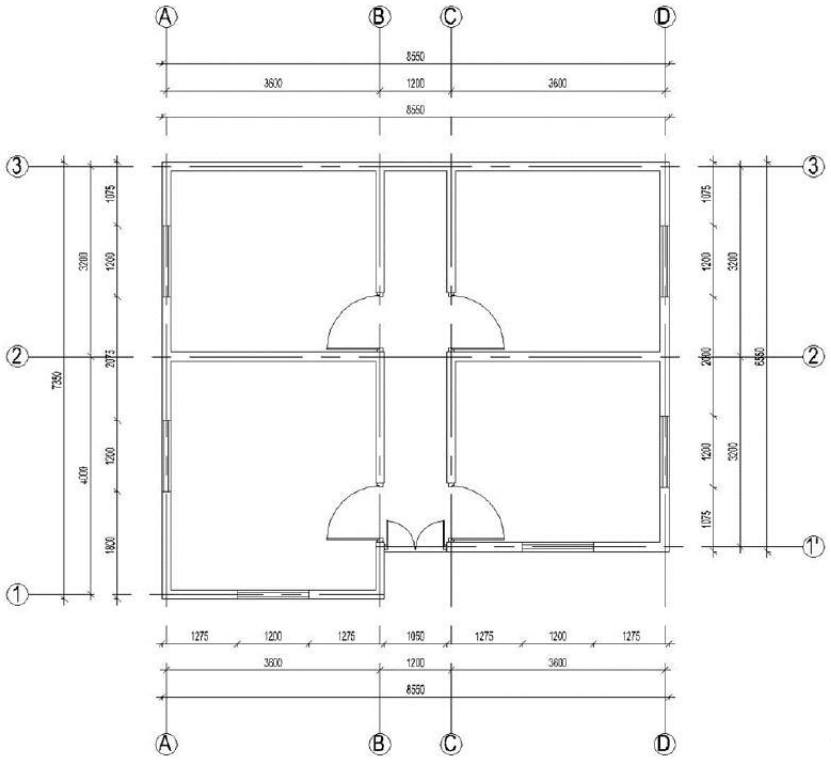
c. Three Roomed Building with Veranda (3R+V model)



d. **Four Roomed Building with Passage (4R+P model)**



e. Four Roomed Building with Passage and Veranda (4R+P+V model)



In this Annex, we will discuss all the details regarding Four roomed building with Passage and Veranda (4R+P+V model) and moreover, all the procedures followed during design of other four types buildings are same as followed for 4R+P+V model.

Dimensions:

This considered building has a planar dimensions of 8.4 m X 7.2 m, and the storey height of the building is 2.8 m and the gable height is one meter.

Walls:

The thickness of internal and external walls is six inches, which is the width of block. The longest dimension of the room of the considered building is 4 m. The top of sill level is 1 m and the spandrel height is 0.6 m. This is a load bearing structure; thus, walls are the structural elements in this building.

Material Properties:

HCB Walls

Unit weight = 16 kN/m^3 [from test, IOE/TU]

Modulus of elasticity =$27x10^5$ kN/m^2

Compressive strength = 0.321 MPa [from test, IOE/TU]

Wood

The wood used in modelling is chir wood with following properties:
Unit weight = 5.75 kN/m^3
Modulus of elasticity =9600000 kN/m^2
Bending strength (inside location) = 8.2 Mpa
Compressive strength (inside location) = 6.3 Mpa
Shear strength, horizontal in beams = 0.6 Mpa
Shear strength, along grain = 0.9 Mpa
References: NBC 112 (1994)

Roofing material
Type = CGI sheet
Unit weight = 0.056 kN/m^2 (*References: IS 875 Part I, T-1.39, for 0.63 mm, Class 1)*

Modelling:
Loads
Live load in roof = 0.75 kN/m2

Design Horizontal Seismic Coefficient (NBC 105:1994)

Zone factor	Z	1		Figure 8.2
Importance factor	I	1		cl 8.1.7, table 8.1, other structures
Structural performance factor	K	2.5		for Retrofitted Masonry
Height of the building	h	2.8	m	Refer dwg.
Dimension of the building along X	D_x	8.4	m	Refer dwg.
Dimension of the building along Y	D_y	7.2	m	Refer dwg.

Time period of the building along X	T_x	0.087	sec	Tx = 0.09h/√Dx, Cl 7.3
Time period of the building along Y	T_y	0.094	sec	Ty = 0.09h/√Dy, Cl 7.3
Soil type		Soft (Type III)		Cl 8.1.5
Basic seismic coefficient along X	C_x	0.08		Cl 8.1.4, fig 8.1
Basic seismic coefficient along Y	C_y	0.08		Cl 8.1.4, fig 8.2
Design horizontal seismic coefficient	C_d	0.2		Cd = CZIK, Cl 8.1.1

Assumptions:

•All the rafters, purlins, joists, posts are assumed to be simply supported i.e. torsional capacity is released at one end whereas moment capacity is released at both ends.

•In field, some buildings have 230 mm columns in all corners with 4-12 mm bars; during analysis these columns are not taken into consideration; however, the capacity of four bars is checked against the corner requirements as suggested by the design.

•The support system, line foundation, is assumed to be Hinge system.
The modelling of the 4R+P+V model is done by using ETABS 2016 Version 16.2.1. The 3D view of the model is shown below:

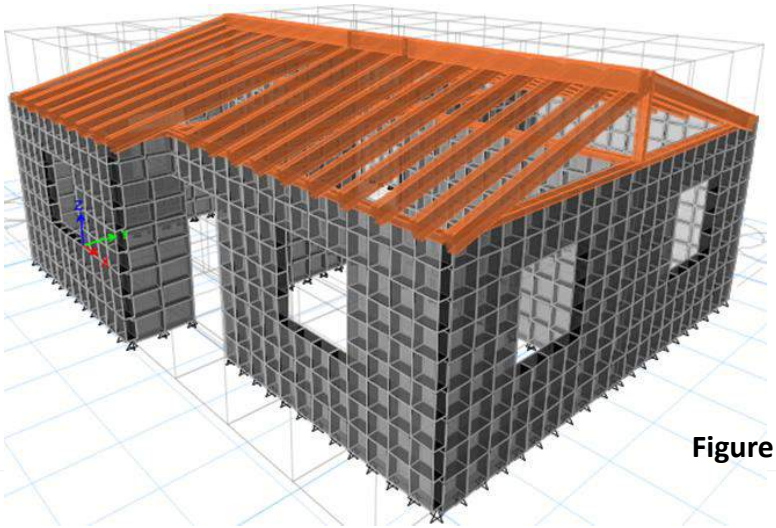


Figure 1: 3D Model

Analysis:

The analysis of the building is done by using ETABS 2016 Version 16.2.0. Seismic Coefficient Method is used to analyse the building in earthquake load.

Calculation of Base Shear

Load Pattern	Type	Direction	C	Weight Used	Base Shear
				kN	kN
EQx	Seismic	X	0.2	287.00	57.4
EQy	Seismic	Y	0.2	287.00	57.4

Load combinations for the analysis of the building:

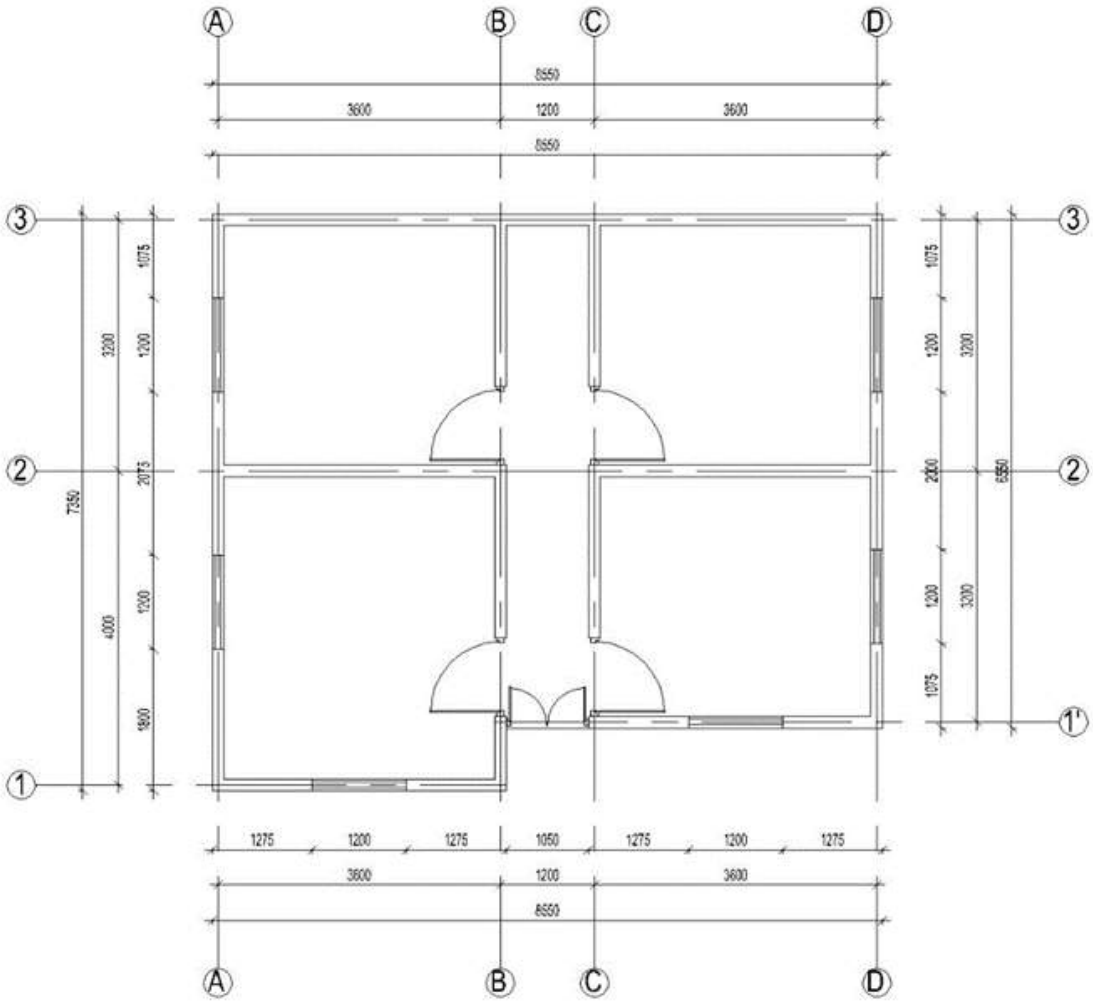
The design loads for the Working Stress Method as per NBC 105:1994 are:

- Including the Earthquake Load
- DL+LL+EQx
- DL+LL-EQx
- DL+LL+Eqy
- DL+LL-EQy
- 0.7DL+EQx
- 0.7DL-EQx
- 0.7DL+EQy
- 0.7DL-EQy

After subjecting the model to aforementioned load combinations, in-plane stress, out-plane stress was read out for all the walls, and on the basis of stress values extracted from the model, all the necessary checks were done, and the design was suggested.

Sample calculations:

Wall chosen for explanation of design (to be replaced by Autocad drawings)



In-plane stress check:

Wall Identity: X1

Pier: P1

Check in Tension:

Average Tensile stress, T (N/mm2): 0.065

Corresponding zone, z: 1200 mm

Thickness of wall, t: 152.4 mm (6-inch block)

Induced Tensile force: T*z*t= 11.89 kN

fy= 415 Mpa

dia of rebar considered = 2-4.75 mm

Area, A = 35.44 mm2

Allowable tensile strength of Fe-415 rebars, ta = 230 Mpa

(Ref: IS 456: 2000, T-22)

Tensile strength of splint: 1.25 * ta *A = 10.2 kN

Since, splints are provided on inner and outer surface of the wall, there will be at least two number of splints in a pier, therefore, minimum tensile strength of the pier= 2*10.2 =20.4 kN > 11.89 kN, **Safe**

Check in Compression:

Compressive strength of hollow block wall: 0.321 MPa equivalent to brick strength taken, though from the compressive strength test of hollow block wallet, the ultimate compressive strength obtained from minimum compression load among three sample is: 0.8 MPa

Average compressive stress, C (N/mm2): 0 < 0.321 MPa., **safe**.

Similarly, same process is repeated for all the piers.

Out of plane stress check:

Horizontal bending Check:

Wall: X1

Bending stress induced at lintel level: 0.61 kN-m/m

tributary width: 1 m

wall thickness: 152.4 mm

Moment induced: 0.61*1= 0.61 kN-m.

fy: 415 Mpa

fta: 230 Mpa

fca: 190 Mpa

(Ref: IS 456: 2000, T-22)

dia of rebar considered = 2-4.75 mm

Area, A = 35.44 mm2

Tensile strength, T: 1.25*230*35.44/1000= 10.19 kN/m

z= t+c= 152.4+40= 192.4 mm

where, t is thickness of wall and c is the micro-concreting thickness

Moment capacity: T*z= 10.19*192.4 =1.96 kN-m/m > 0.61 kN-m/m **Safe.**

Similarly, all walls are checked against horizontal out of plane bending.

Vertical bending check:

Wall: X1

Pier: P1

Tributary width: 0.6 m

for DL+LL+EQy,

Tensile stress: 0.11 Mpa

Compressive stress: 0.13 Mpa

Tension zone: 0.11/ (0.11+0.13) *152.4= 69.85 mm

Compression zone: 82.55 mm

Tension force, T: 1/2*69.85*0.11*0.6*1000/1000= 2.31 kN

Design compressive stress= 0 (Since, 0.13-0.321 < 0)

Compression force, C: 0

taking Fe 415 into consideration,

fta: 230 Mpa

fca: 190 Mpa

Tension capacity of splint for 2-4.75 mm bars: 1.25*fta*Area of bars: 10.19 kN > 2.31 kN, **Safe**

Similarly, same pier is checked for all load combinations producing out of plane effect. Furthermore, same process is repeated for all the piers. All the calculations are presented below:

Design for stress S22 (In-plane)

Wall	Stress	DL+LL+EQx		DL+LL-EQx		0.7DL+EQx		0.7DL-EQx		Max. Avg Stress	Zone	Wall	Induced Force	fy	φ1	Nos	φ	Nos	A	fta	fca	Tensile Strength of band	Comp. Strength of band	Check
		Stress	Zone	Stress	Zone	Stress	Zone	Stress	Zone			Th.												
		N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	mm	KN	N/mm^2	mm		mm		mm^2	N/mm^2	N/mm^2	KN	KN	
X1: P1	Tension	0.13	1200	0.11	1200	0.10	1200	0.07	1200	0.065	1200	152	11.89	415	4.75	1	4.75	1	35.44	230.00	190.00	20.379		OK
	Compression	0.18	1200	0.14	1200	0.14	1200	0.10	1200	0.000	1200	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X1: P2	Tension	0.11	1200	0.20	1200	0.05	1200	0.15	1200	0.100	1200	152	18.29	415	4.75	1	4.75	1	35.44	230.00	190.00	20.379		OK
	Compression	0.15	1200	0.24	1200	0.11	1200	0.09	1200	0.008	1200	152	1.55	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X2: P1	Tension	0.01	300	0.04	300	0.03	300	0.04	600	0.020	600	152	1.83	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.10	1200	0.08	1200	0.09	1200	0.07	1200	0.000	1200	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X2: P2	Tension	0.02	300	0.02	300	0.04	400	0.03	300	0.020	400	152	1.22	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.07	1200	0.11	1200	0.06	1200	0.09	1200	0.000	1200	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X3: P1	Tension	0.00	0	0.00	0	0.00	0	0.00	0	0.000	0	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.07	3600	0.06	3600	0.05	3600	0.04	3600	0.000	3600	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X3: P2	Tension	0.00	0	0.00	0	0.00	0	0.01	300	0.005	300	152	0.23	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.06	3600	0.05	3600	0.04	3600	0.04	3600	0.000	3600	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X4: P1	Tension	0.02	600	0.04	2400	0.02	400	0.03	2100	0.020	2400	152	7.32	415	4.75	1	4.75	1	35.44	230.00	190.00	20.379		OK
	Compression	0.05	3600	0.06	3600	0.03	3600	0.04	3600	0.000	3600	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X4: P2	Tension	0.02	600	0.04	500	0.02	600	0.03	1200	0.020	500	152	1.52	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.03	1200	0.06	1200	0.02	1200	0.04	1200	0.000	1200	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
X4: P3	Tension	0.01	600	0.03	1200	0.01	500	0.03	1800	0.015	1800	152	4.11	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.06	3600	0.06	3600	0.05	3600	0.04	3600	0.000	3600	152	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK

Design for stress S22 (In-plane)

Wall	Stress	DL+LL+EQy		DL+LL-EQy		0.7DL+EQY		0.7DL-EQY		Max. Avg Stress	Zone	Wall	Induced Force	fy	φ1	Nos	φ	Nos	A	fta	fca	Tensile Strength of band	Compressive Strength of band	Check
		Stress	Zone	Stress	Zone	Stress	Zone	Stress	Zone			Th.												
		N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	N/mm^2	mm	mm	KN	N/mm^2	mm				mm^2	N/mm^2	N/mm^2	KN	KN	
YA: P1	Tension	0.01	400	0.07	1500	0.020	300	0.06	1500	0.035	1500	230	12.08	415	4.75	1	4.75	1	35.44	230.00	190.00	20.379		OK
	Compression	0.09	1800	0.09	1800	0.09	1800	0.08	1800	0.000	1800	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YA: P2	Tension	0.01	300	0.01	300	0.030	400	0.02	300	0.015	400	230	1.38	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.06	1000	0.10	1000	0.05	1000	0.08	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YA: P3	Tension	0.03	300	0.00	0	0.030	300	0.02	300	0.015	300	230	1.04	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.11	1000	0.06	1000	0.08	1000	0.05	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YA: P4	Tension	0.04	300	0.01	200	0.050	400	0.02	300	0.025	400	230	2.30	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.08	1000	0.08	1000	0.06	1000	0.07	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YB: P1	Tension	0.00	0	0.06	400	0.040	300	0.07	500	0.035	500	230	4.03	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.11	915	0.25	915	0.10	915	0.17	915	0.014	915	350	4.32	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YB: P2	Tension	0.03	300	0.00	0	0.050	500	0.02	400	0.025	500	230	2.88	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.09	2100	0.15	2100	0.06	2100	0.13	2100	0.000	2100	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YB: P3	Tension	0.06	500	0.02	300	0.070	700	0.02	300	0.035	700	230	5.64	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.06	2100	0.13	2100	0.05	2100	0.12	2100	0.000	2100	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YC: P1	Tension	0.08	700	0.04	400	0.100	1000	0.04	300	0.050	1000	230	11.50	415	4.75	1	4.75	1	35.44	230.00	190.00	20.379		OK
	Compression	0.06	2100	0.19	2100	0.05	2100	0.17	2100	0.000	2100	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YD: P1	Tension	0.02	200	0.05	400	0.030	300	0.05	500	0.025	400	230	2.30	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.09	1000	0.08	1000	0.08	1000	0.07	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YD: P2	Tension	0.02	200	0.03	300	0.040	400	0.03	300	0.020	400	230	1.84	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.06	1000	0.12	1000	0.05	1000	0.10	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YD: P3	Tension	0.03	300	0.02	300	0.030	300	0.04	300	0.020	300	230	1.38	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.12	1000	0.06	1000	0.10	1000	0.06	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK
YD: P4	Tension	0.04	300	0.02	300	0.050	500	0.03	300	0.025	500	230	2.88	415	4.75	1	4.75	1	35.44	230.00	190.00	10.189		OK
	Compression	0.08	1000	0.10	1000	0.06	1000	0.08	1000	0.000	1000	350	0.00	415	4.75	1	4.75	1	35.44	230.00	190.00		8.417	OK

Design for M11(Out of plane)

Walls		Moments M11 (max)									Moment Induced (M11)	Wall Thk.	fy	φ1	n1	φ2	n2	A	fta	Tensile Strength	z	Moment of Resistance of wall	Check Moment
		DL+ LL+ EQY	Width	M11	0.7 DL+ EQy	M11	DL+ LL- EQy	M11	0.7 DL- EQy	M11													
		kNm/m	m	KN/m	kNm/m	KN/m	kNm/m	KN/m	kNm/m	KNm	KNm		N/mm^2	mm	nos	mm	nos	mm^2	N/mm^2	KN/m strip/face	mm	KN-m/m	
X1	Sill	0.080	1.150	0.092	0.060	0.069	0.400	0.460	0.300	0.345	0.460	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.080	1.000	0.080	0.070	0.070	0.610	0.610	0.500	0.500	0.610	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.200	0.300	0.060	0.250	0.075	0.610	0.183	0.500	0.150	0.183	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
X2	Sill	0.150	1.150	0.173	0.150	0.135	0.200	0.180	0.200	0.180	0.180	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.170	1.000	0.170	0.190	0.190	0.400	0.400	0.300	0.300	0.400	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.200	0.300	0.060	0.190	0.057	0.600	0.180	0.350	0.105	0.180	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
X3	Sill	0.200	1.150	0.230	0.300	0.270	0.350	0.315	0.350	0.315	0.315	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.500	1.000	0.500	0.500	0.500	0.500	0.500	0.450	0.450	0.500	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.620	0.300	0.186	0.650	0.195	0.650	0.195	0.650	0.195	0.195	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
X4	Sill	0.250	1.150	0.288	0.250	0.225	0.150	0.135	0.200	0.180	0.288	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.770	1.000	0.770	0.650	0.650	0.170	0.170	0.250	0.250	0.770	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	1.350	0.300	0.405	1.150	0.345	0.400	0.120	0.600	0.180	0.405	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK

Design for M11(Out of plane)

Walls		Moments M11 (max)									Moment Induced (M11)	Wall Thk.	fy	φ1	n1	φ2	n2	A	fta	Tensile Strength	z	Moment of Resistance of wall	Check Moment
		DL+ LL+ Eqx	Width	M11	0.7 DL+ Eqx	M11	DL+ LL- Eqx	M11	0.7 DL- Eqx	M11													
		kNm/m	m	KN/m	kNm/m	KN/m	kNm/m	KN/m	kNm/m	KN/m	KN/m		N/mm^2	mm		mm		mm^2	N/mm^2	KN/m strip/face	mm	KN-m/m	
Y1	Sill	0.130	1.150	0.150	0.350	0.403	0.200	0.230	0.200	0.230	0.403	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.600	1.000	0.600	0.450	0.450	0.400	0.400	0.400	0.400	0.600	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.900	0.300	0.270	0.550	0.165	0.600	0.180	1.000	0.300	0.300	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
Y2	Sill	0.300	1.150	0.345	0.350	0.403	0.250	0.288	0.100	0.115	0.403	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.550	1.000	0.550	0.550	0.550	0.500	0.500	0.400	0.400	0.550	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.600	0.300	0.180	0.600	0.180	0.800	0.240	0.600	0.180	0.240	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
Y3	Sill	0.300	1.150	0.345	0.300	0.345	0.300	0.345	0.300	0.345	0.345	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.400	1.000	0.400	0.400	0.400	0.500	0.500	0.500	0.500	0.500	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.550	0.300	0.165	0.500	0.150	0.600	0.180	0.550	0.165	0.180	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
Y4	Sill	0.270	1.150	0.311	0.250	0.288	0.300	0.345	0.300	0.345	0.345	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Lintel	0.400	1.000	0.400	0.400	0.400	0.450	0.450	0.450	0.450	0.450	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK
	Floor	0.500	0.300	0.150	0.500	0.150	0.550	0.165	0.500	0.150	0.165	152.4	415	4.75	1	4.750	1.00	35.44	230.00	10.189	192.4	1.960	OK

Design for S22 (Out of plane)

Wall	Pier	Combination	Thickness of Wall	Tributary	Tensile Stress	Compressive Stress	Tension Zone	Comp. Zone	Design Tensile Stress	Design Comp Stress	Design Force		fy	Tensile Strength	Compressive Strength	ϕ	Nos of Bar	Tension Capacity	Check
											Tension (T)	Comp. (C)							
			mm	m	Mpa	Mpa	mm	mm	Mpa	Mpa	KN	KN	pa	Mpa	Mpa	mm		KN	
X-1	P1	DL+LL+EQy	152.4	0.60	0.11	0.13	69.85	82.55	0.11	0.00	2.31	0.00	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	0.60	0.11	0.14	67.06	85.34	0.11	0.00	2.21	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	0.60	0.07	0.09	66.68	85.73	0.07	0.00	1.40	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	0.60	0.07	0.11	59.27	93.13	0.07	0.00	1.24	0.00	415	230	190	4.8	2	10.19	OK
	P2	DL+LL+EQy	152.4	0.60	0.15	0.16	73.74	78.66	0.15	0.00	3.32	0.00	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	0.60	0.19	0.19	76.20	76.20	0.19	0.00	4.34	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	0.60	0.09	0.10	72.19	80.21	0.09	0.00	1.95	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	0.60	0.13	0.14	73.38	79.02	0.13	0.00	2.86	0.00	415	230	190	4.8	2	10.19	OK
X-2	P1	DL+LL+EQy	152.4	0.60	0.04	0.11	40.64	111.76	0.04	0.00	0.49	0.00	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	0.60	0.04	0.21	24.38	128.02	0.04	0.00	0.29	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	0.60	0.04	0.09	46.89	105.51	0.04	0.00	0.56	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	0.60	0.04	0.10	43.54	108.86	0.04	0.00	0.52	0.00	415	230	190	4.8	2	10.19	OK
	P2	DL+LL+EQy	152.4	0.60	0.04	0.20	25.40	127.00	0.04	0.00	0.30	0.00	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	0.60	0.03	0.06	50.80	101.60	0.03	0.00	0.46	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	0.60	0.04	0.07	55.42	96.98	0.04	0.00	0.67	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	0.60	0.02	0.11	23.45	128.95	0.02	0.00	0.14	0.00	415	230	190	4.8	2	10.19	OK
X-3	P1	DL+LL+EQy	152.4	1.80	0.04	0.30	17.93	134.47	0.04	0.08	0.65	2.39	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	1.80	0.05	0.13	42.33	110.07	0.05	0.00	1.91	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	1.80	0.06	0.13	48.13	104.27	0.06	0.00	2.60	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	1.80	0.05	0.12	44.82	107.58	0.05	0.00	2.02	0.00	415	230	190	4.8	2	10.19	OK
	P2	DL+LL+EQy	152.4	1.80	0.04	0.31	17.42	134.98	0.04	0.09	0.63	2.97	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	1.80	0.06	0.25	29.50	122.90	0.06	0.03	1.59	0.32	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	1.80	0.07	0.13	53.34	99.06	0.07	0.00	3.36	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	1.80	0.07	0.13	53.34	99.06	0.07	0.00	3.36	0.00	415	230	190	4.8	2	10.19	OK
X-4	P1	DL+LL+EQy	152.4	1.80	0.04	0.35	15.63	136.77	0.04	0.13	0.56	5.67	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	1.80	0.05	0.25	25.40	127.00	0.05	0.03	1.14	0.33	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	1.80	0.04	0.14	33.87	118.53	0.04	0.00	1.22	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	1.80	0.03	0.12	30.48	121.92	0.03	0.00	0.82	0.00	415	230	190	4.8	2	10.19	OK
	P2	DL+LL+EQy	152.4	0.60	0.04	0.10	43.54	108.86	0.04	0.00	0.52	0.00	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	0.60	0.01	0.15	9.53	142.88	0.01	0.00	0.03	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	0.60	0.04	0.10	43.54	108.86	0.04	0.00	0.52	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	0.60	0.03	0.02	91.44	60.96	0.03	0.00	0.82	0.00	415	230	190	4.8	2	10.19	OK
	P3	DL+LL+EQy	152.4	1.80	0.03	0.25	16.33	136.07	0.03	0.03	0.44	0.36	415	230	190	4.8	2	10.19	OK
		DL+LL-EQy	152.4	1.80	0.05	0.15	38.10	114.30	0.05	0.00	1.71	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL+EQy	152.4	1.80	0.01	0.15	9.53	142.88	0.01	0.00	0.09	0.00	415	230	190	4.8	2	10.19	OK
		0.7DL-EQy	152.4	1.80	0.03	0.12	30.48	121.92	0.03	0.00	0.82	0.00	415	230	190	4.8	2	10.19	OK

Design for S22 (Out of plane)

Wall	Pier	Combination	Thickness of Wall	Tributary	Tensile Stress	Compressive Stress	Tension Zone	Comp. Zone	Design Tensile Stress	Design Comp Stress	Design Force		fy	Tensile Strength	Compressive Strength	ϕ	Nos of Bar	Tension Capacity	Check
											Tension (T)	Comp. (C)							
			mm	m	Mpa	Mpa	mm	mm	Mpa	Mpa	KN	KN	Mpa	Mpa	Mpa	mm		KN	
Y-A	P1	DL+LL+Eqx	152.4	0.9	0.09	0.15	57.15	95.25	0.09	0.00	2.31	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.9	0.03	0.17	22.86	129.54	0.03	0.00	0.31	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.9	0.08	0.09	71.72	80.68	0.08	0.00	2.58	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.9	0.04	0.10	43.54	108.86	0.04	0.00	0.78	0.00	415	230	190	4.8	3	15.28	OK
	P2	DL+LL+Eqx	152.4	0.5	0.01	0.23	6.35	146.05	0.01	0.01	0.02	0.01	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.01	0.26	5.64	146.76	0.01	0.04	0.01	0.19	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.06	21.77	130.63	0.01	0.00	0.05	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.10	13.85	138.55	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
	P3	DL+LL+Eqx	152.4	0.5	0.01	0.23	6.35	146.05	0.01	0.01	0.02	0.01	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.02	0.26	10.89	141.51	0.02	0.04	0.05	0.19	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.06	21.77	130.63	0.01	0.00	0.05	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.10	13.85	138.55	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
	P4	DL+LL+Eqx	152.4	0.5	0.05	0.37	18.14	134.26	0.05	0.15	0.23	1.96	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.03	0.33	12.70	139.70	0.03	0.11	0.10	1.21	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.02	0.13	20.32	132.08	0.02	0.00	0.10	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.11	12.70	139.70	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
Y-B	P1	DL+LL+Eqx	152.4	0.5	0.01	0.16	8.96	143.44	0.01	0.00	0.02	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.01	0.16	8.96	143.44	0.01	0.00	0.02	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.03	0.10	35.17	117.23	0.03	0.00	0.26	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.08	16.93	135.47	0.01	0.00	0.04	0.00	415	230	190	4.8	3	15.28	OK
	P2	DL+LL+Eqx	152.4	1.1	0.01	0.15	9.53	142.88	0.01	0.00	0.05	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	1.1	0.01	0.14	10.16	142.24	0.01	0.00	0.06	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	1.1	0.02	0.09	27.71	124.69	0.02	0.00	0.30	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	1.1	0.02	0.08	30.48	121.92	0.02	0.00	0.34	0.00	415	230	190	4.8	3	15.28	OK
	P3	DL+LL+Eqx	152.4	1.1	0.02	0.09	27.71	124.69	0.02	0.00	0.30	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	1.1	0.02	0.09	27.71	124.69	0.02	0.00	0.30	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	1.1	0.02	0.06	38.10	114.30	0.02	0.00	0.42	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	1.1	0.02	0.07	33.87	118.53	0.02	0.00	0.37	0.00	415	230	190	4.8	3	15.28	OK

Design for S22 (Out of plane)

Wall	Pier	Combination	Thickness of Wall	Tributary	Tensile Stress	Compressive Stress	Tension Zone	Comp. Zone	Design Tensile Stress	Design Comp Stress	Design Force		fy	Tensile Strength	Compressive Strength	ϕ	Nos of Bar	Tension Capacity	Check
											Tension (T)	Comp. (C)							
			mm	m	Mpa	Mpa	mm	mm	Mpa	Mpa	KN	KN	Mpa	Mpa	Mpa	mm		KN	
Y-C	P1	DL+LL+Eqx	152.4	1.1	0.01	0.07	19.05	133.35	0.01	0.00	0.10	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	1.1	0.02	0.06	38.10	114.30	0.02	0.00	0.42	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	1.1	0.02	0.06	38.10	114.30	0.02	0.00	0.42	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	1.1	0.02	0.05	43.54	108.86	0.02	0.00	0.48	0.00	415	230	190	4.8	3	15.28	OK
Y-D	P1	DL+LL+Eqx	152.4	0.5	0.01	0.19	7.62	144.78	0.01	0.00	0.02	0.00	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.02	0.20	13.85	138.55	0.02	0.00	0.07	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.10	13.85	138.55	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.02	0.06	38.10	114.30	0.02	0.00	0.19	0.00	415	230	190	4.8	3	15.28	OK
	P2	DL+LL+Eqx	152.4	0.5	0.01	0.26	5.64	146.76	0.01	0.04	0.01	0.19	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.02	0.23	12.19	140.21	0.02	0.01	0.06	0.01	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.11	12.70	139.70	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.07	19.05	133.35	0.01	0.00	0.05	0.00	415	230	190	4.8	3	15.28	OK
	P3	DL+LL+Eqx	152.4	0.5	0.02	0.26	10.89	141.51	0.02	0.04	0.05	0.19	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.02	0.23	12.19	140.21	0.02	0.01	0.06	0.01	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.11	12.70	139.70	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.01	0.07	19.05	133.35	0.01	0.00	0.05	0.00	415	230	190	4.8	3	15.28	OK
	P4	DL+LL+Eqx	152.4	0.5	0.03	0.33	12.70	139.70	0.03	0.11	0.10	1.21	415	230	190	4.8	3	15.28	OK
		DL+LL-Eqx	152.4	0.5	0.04	0.37	14.87	137.53	0.04	0.15	0.15	2.01	415	230	190	4.8	3	15.28	OK
		0.7DL+Eqx	152.4	0.5	0.01	0.11	12.70	139.70	0.01	0.00	0.03	0.00	415	230	190	4.8	3	15.28	OK
		0.7DL-EQx	152.4	0.5	0.02	0.14	19.05	133.35	0.02	0.00	0.10	0.00	415	230	190	4.8	3	15.28	OK

Conclusion:

In model 4R+P+V,2-4.75mm bars in splint and bandage are sufficient to resist the developed tension whereas there is no need of compression reinforcements. However In other models such as 3R+V,2R,2-8mm bars are required in splint. Hence for simplification and to address other uncertainities, it is recommended to use 2-8mm bars in splint and bandage for one storey block masonry buildings which use cement mortar.

On the other hand,2-10mm bars are necessary in splint and 2-8m bars are required in bandage for two-storey block masonry buildings in general.

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Plans of Existing Building
One Storey with Attic Structures

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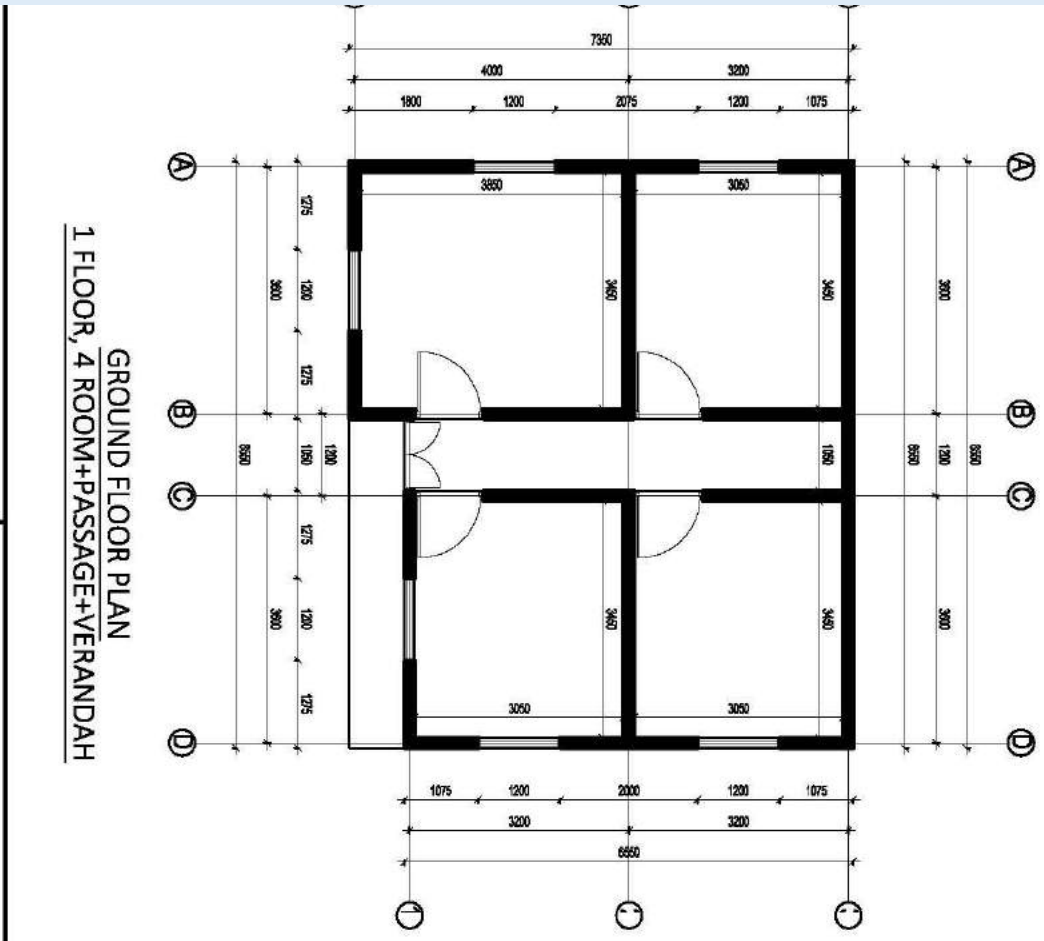
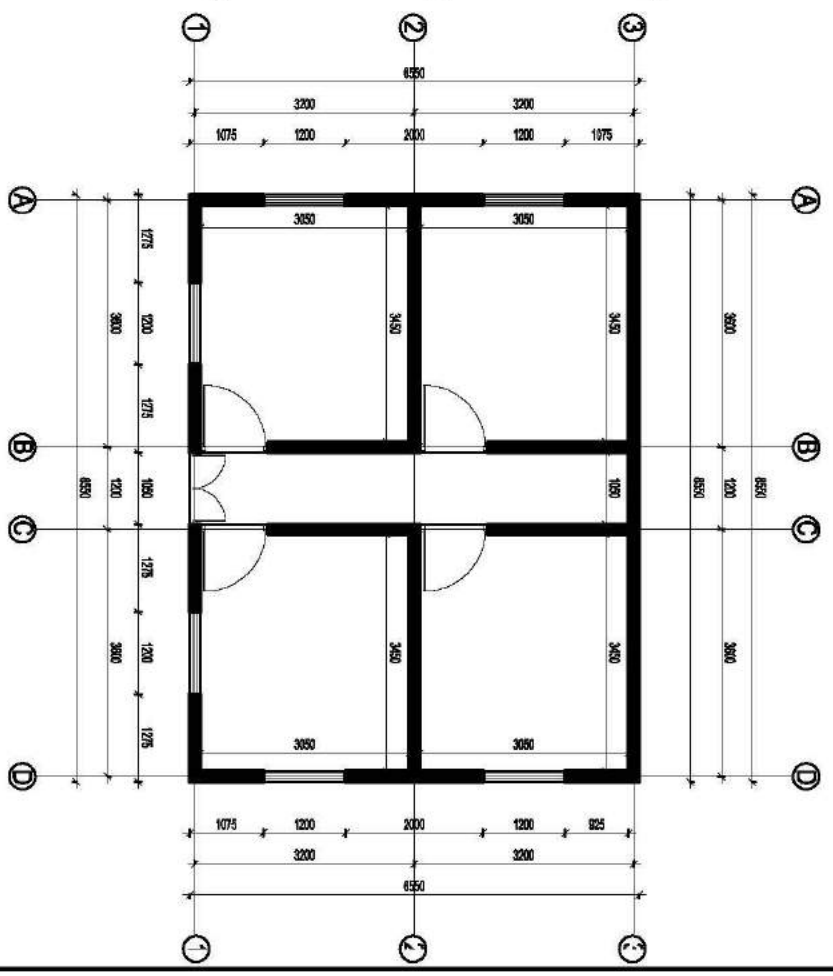
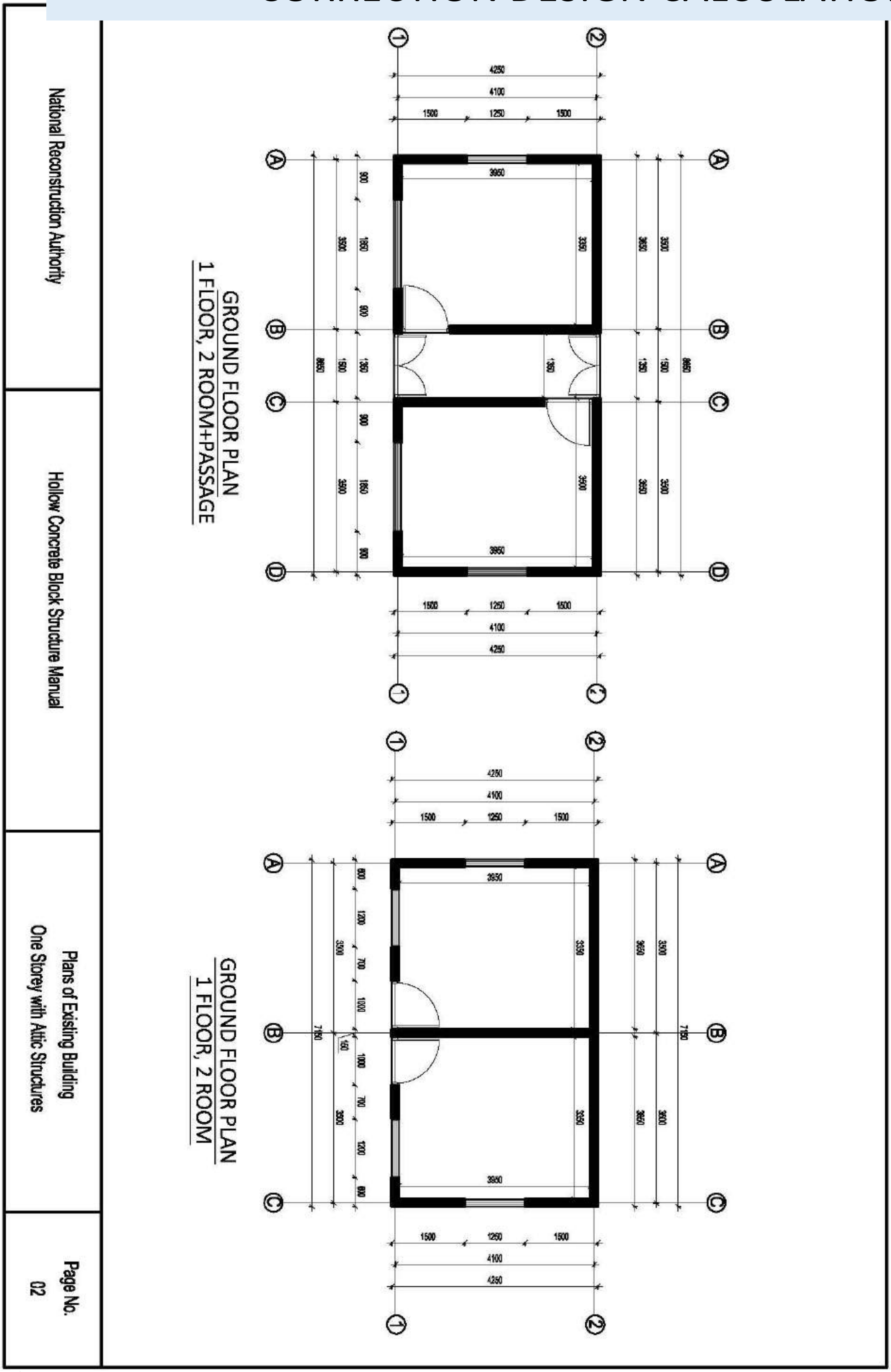


GROUND FLOOR PLAN
1 FLOOR, 4 ROOM+PASSAGE+VERANDAH



GROUND FLOOR PLAN
1 FLOOR, 4 ROOM+PASSAGE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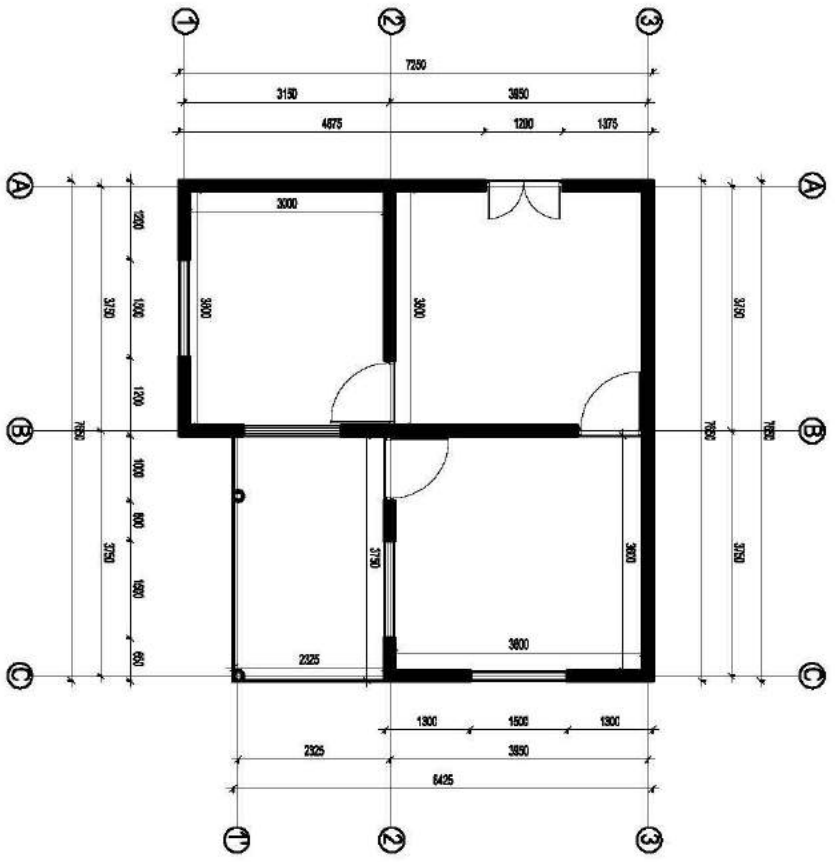
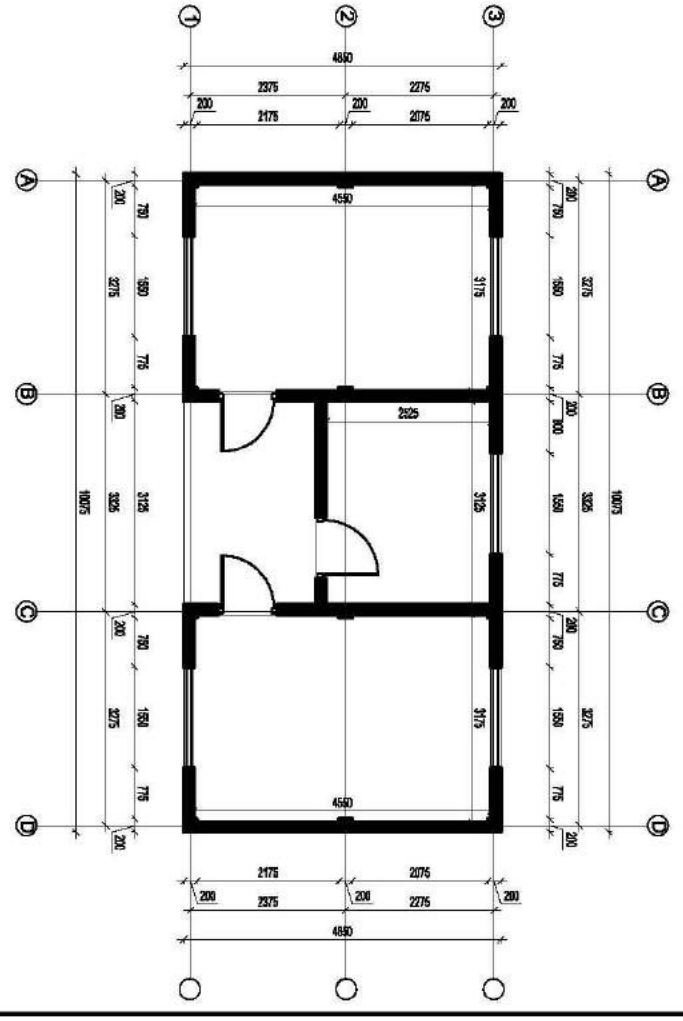
GROUND FLOOR PLAN
1 FLOOR, 2 ROOM+PASSAGE
GROUND FLOOR PLAN
1 FLOOR, 2 ROOM

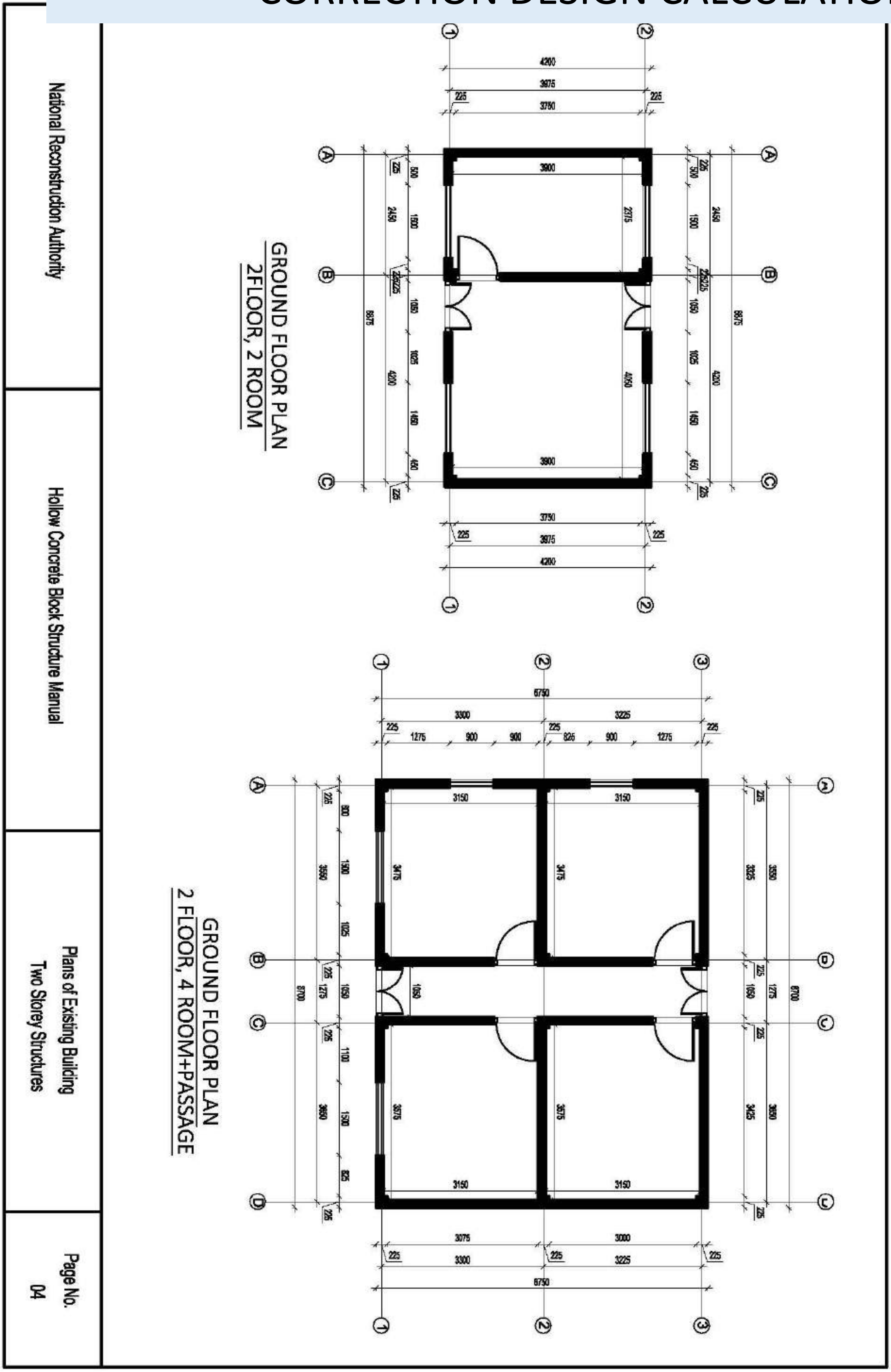
CORRECTION DESIGN CALCULATION

GROUND FLOOR PLAN
1 FLOOR, 3 ROOM+VERANDAH



GROUND FLOOR PLAN
2 FLOOR, 3 ROOM+VERANDAH




GROUND FLOOR PLAN
2FLOOR, 2 ROOM
GROUND FLOOR PLAN
2 FlOOR, 4 ROOM+PASSAGE
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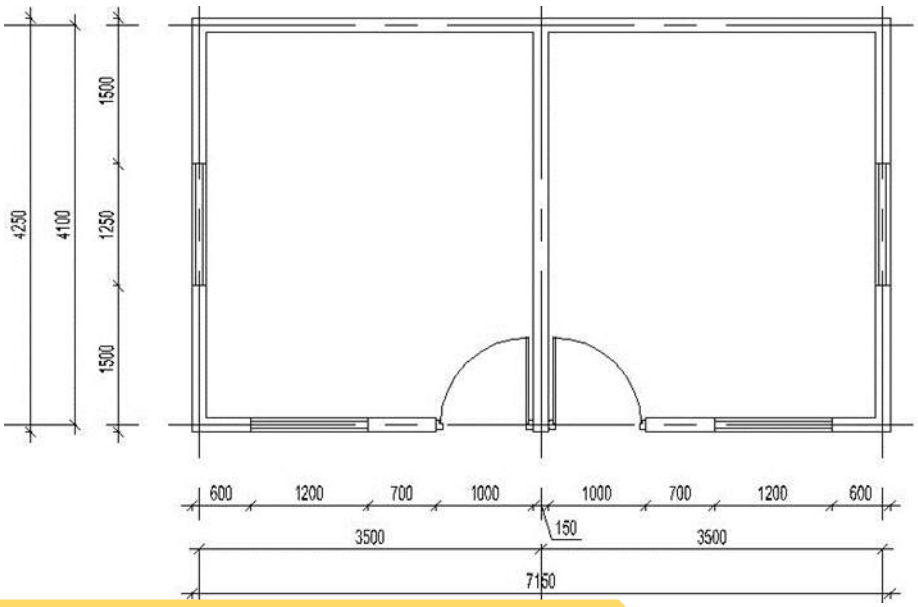
ANNEX C : ESTIMATE OF CORRECTION

This section presents representative sample cost estimate of correction works on existing building.

Description of existing building:

A team consisting engineers from Housing Recovery and Reconstruction Platform (HRRP)-Nepal, engineers from National Reconstruction Authority (NRA) and local representatives visited Rupa Gaupalika, Annapurna Gaupalika and Pokhara-Lekhnath Metropolitan City of Kaski district from 30th July to 3rd August 2018. Most of the existing buildings at the site are one storeyed and two storeyed, load bearing structures with flexible roof and majority of them are represented by either of the models presented below:

a. Two Roomed Building (2R model)



[a] Abstract of Cost

	Items	Quantity	Calculation	Unit Rate (NRs.)	Amount	Unit
Abstract of Cost	GI wire(1.63 Dia)	65	25	180	11619.483	kg
	Cement	10	35+27	750	7455.0468	bag
	Sand	47	29+37	70	3300.318	bag
	Longitudinal Bars (4.75mm)	15	32	85	1287.58	kg
	Aggregate (10 mm down chips)	8	39	100	811.5	bag
				Total Amount (NRs.)	**24,473.93**	

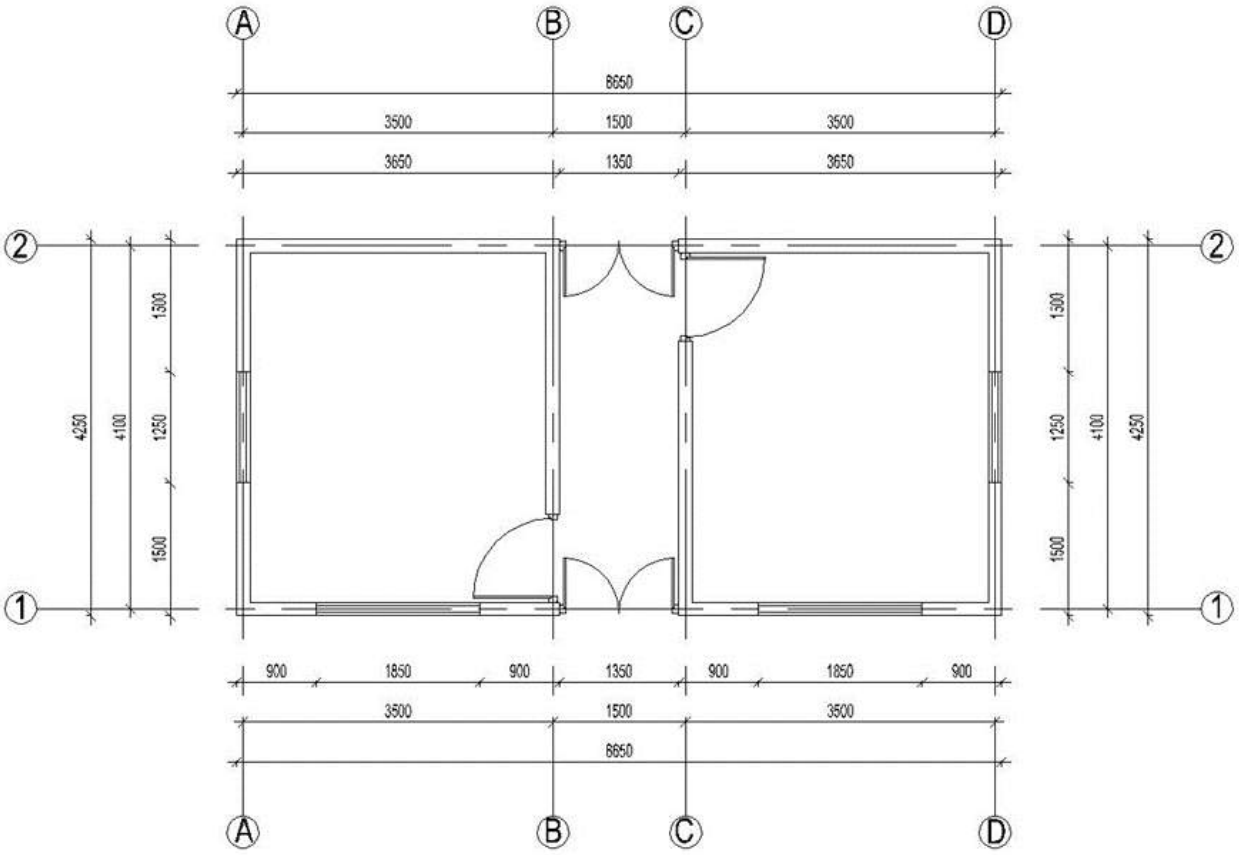
[a] Estimate for Correction Measures

Estimate for Correction Measures							Note : INPUT	
Measuremnt of Building and Quantity	Building Overall Dimension	Plinth	Length of Building		1	7.15	m
			Width of Building		2	4.25	m
			Height of Building		3	2.16	m
			Number of Long Wall		4	2	number
			Number of Short wall		5	3	number
			Total Area of Building	**1*4+2*5**	6	27.05	m^2
		Total Area of Walls (Elevation)		**6*3**	7	58.428	m^2
	Opening Deduction	Window	Number of Window		8	4	number
			Length of Window		9	1.25	m
			Height of Window		10	1.25	m
			Area of Window	8*9*10	11	6.25	m^2
		Door	Number of Door		12	2	number
			Length of Door		13	1	m
			Height of Door		14	2.06	m
			Area of Door	12*13*14	15	4.12	m^2
		Total Area (Deductable)		**11+15**	16	10.37	m^2
	Net Area	Wall Area	Single Face of Walls	7-16	17	48.058	m^2
			Double Face of WallS	**17+17**	18	**96.116**	m^2
	Tie bandage		Length [One side)	4*1+5*2	19	27.05	m
			Length (Two side)	19+19	20	54.1	m
			Thickness		21	0.04	m
			Height of Bandage		22	0.15	m
		Total Volume		**19*21*22**	23	0.1623	
		Total Volume of Tie Bandage		**23+23**	24	**0.3246**	m^3
Materials Breakdown (B.O.Q.)	Wall Jacketing	GI wire(1.63 Dia)	Weight Per Unit Area	0.7	25		kg/m^2
			Total Weight	**25*18**	26	**65**	kg
		Cement (1 Part)	Cement Bag Per Unit Area	0.0764	27		bag/m^2
			Net Cement Quantity (Bag)	**27*18**	28	**7**	bag
		Sand (6 part)	Sand Bag Per Unit Area	0.45	29		bag/m^2
			Net Sand Quantity (Cement Bag)	**29*18**	30	**43**	bag
	Tie Bandage	Longitudinal Bars (4.75mm)	Weight Per Unit Length	0.14	31		kg/m
			Number of Main bar		32	2	
			Total Weight	**32*31*20**	33	**15.148**	kg
		Cement	Cement Bag Per Unit Volume	8	34		bag/m^3
			Net Cement Quantity (Bag)	**24*34**	35	**3**	bag
		Sand	Sand Bag Per Unit Volume	12	36		bag/m^3
			Net Sand Quantity (Cement Bag)	**36*24**	37	4	bag
		Aggregate (10 mm down chips)	Aggregate Bag Per Unit Volume	25	38		bag/m^3
			Net Agg. Quantity (Cement Bag)	**38*24**	39	8	bag

Description of existing building:

Other details are same as previous except passage in the middle as shown in plan below:

[b] Two Roomed Building with passage (2R+P model)



[b] Abstract of Cost

	Items	Quantity	Calculation	Unit Rate (NRs.)	Amount	Unit
Abstract of Cost	GI wire(1.63 Dia)	76	25	180	13712.334	kg
	Cement	12	35+27	750	8969.0244	bag
	Sand	56	29+37	70	3918.726	bag
	Longitudinal Bars (4.75mm)	19	32	85	1632.68	kg
	Aggregate (10 mm down chips)	10	39	100	1029	bag
				Total Amount (NRs.)	**29,261.76**	

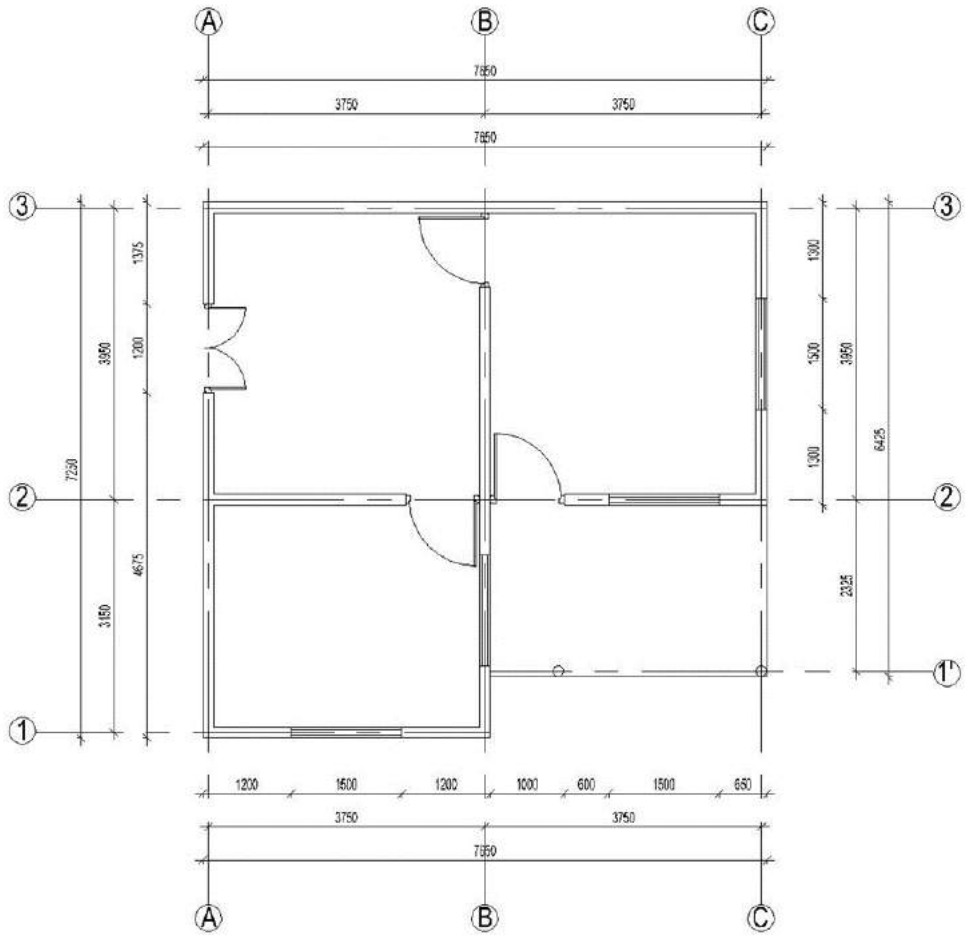
[b] Estimate for Correction Measures

Estimate for Correction Measures								
Measuremnt of Building and Quantity	Building Overall Dimension	Plinth	Length of Building		1	8.65	m
			Width of Building		2	4.25	m
			Height of Building		3	2.16	m
			Number of Long Wall		4	2	number
			Number of Short wall		5	4	number
			Total Area of Building	**1*4+2*5**	6	34.3	m^2
		Total Area of Walls (Elevation)		**6*3**	7	74.088	m^2
	Opening Deduction	Window	Number of Window		8	4	number
			Length of Window		9	1.25	m
			Height of Window		10	1.25	m
			Area of Window	8*9*10	11	6.25	m^2
		Door	Number of Door		12	4	number
			Length of Door		13	1.35	m
			Height of Door		14	2.06	m
			Area of Door	12*13*14	15	11.124	m^2
		Total Area (Deductable)		**11+15**	16	17.374	m^2
	Net Area	Wall Area	Single Face of Walls	7-16	17	56.714	m^2
			Double Face of WallS	**17+17**	18	**113.428**	m^2
	Tie bandage		Length [One side)	4*1+5*2	19	34.3	m
			Length (Two side)	19+19	20	68.6	m
			Thickness		21	0.04	m
			Height of Bandage		22	0.15	m
		Total Volume		**19*21*22**	23	0.2058	
		Total Volume of Tie Bandage		**23+23**	24	**0.4116**	m^3
Materials Breakdown (B.O.Q.)	Wall Jacketing	GI wire(1.63 Dia)	Weight Per Unit Area	0.7	25		kg/m^2
			Total Weight	**25*18**	26	**76**	kg
		Cement (1 Part)	Cement Bag Per Unit Area	0.0764	27		bag/m^2
			Net Cement Quantity (Bag)	**27*18**	28	**9**	bag
		Sand (6 part)	Sand Bag Per Unit Area	0.45	29		bag/m^2
			Net Sand Quantity (Cement Bag)	**29*18**	30	**51**	bag
	Tie Bandage	Longitudinal Bars (4.75mm)	Weight Per Unit Length	0.14	31		kg/m
			Number of Main bar		32	2	
			Total Weight	**32*31*20**	33	**19.208**	kg
		Cement	Cement Bag Per Unit Volume	8	34		bag/m^3
			Net Cement Quantity (Bag)	**24*34**	35	**3**	bag
		Sand	Sand Bag Per Unit Volume	12	36		bag/m^3
			Net Sand Quantity (Cement Bag)	**36*24**	37	5	bag
		Aggregate (10 mm down chips)	Aggregate Bag Per Unit Volume	25	38		bag/m^3
			Net Agg. Quantity (Cement Bag)	**38*24**	39	10	bag

Description of existing building:

Other details are same as previous except verandah in the middle as shown in plan below:

[C] Three Roomed Building with Veranda (3R+V model)



[C] Abstract of Cost

	Items	Quantity	Calculation	Unit Rate (NRs.)	Amount	Unit
Abstract of Cost	GI wire(1.63 Dia)	110	25	180	19859.843	kg
	Cement	17	35+27	750	12631.644	bag
	Sand	80	29+37	70	5625.396	bag
	Longitudinal Bars (4.75mm)	25	32	85	2127.72	kg
	Aggregate (10 mm down chips)	13	39	100	1341	bag
				Total Amount (NRs.)	**41,585.60**	

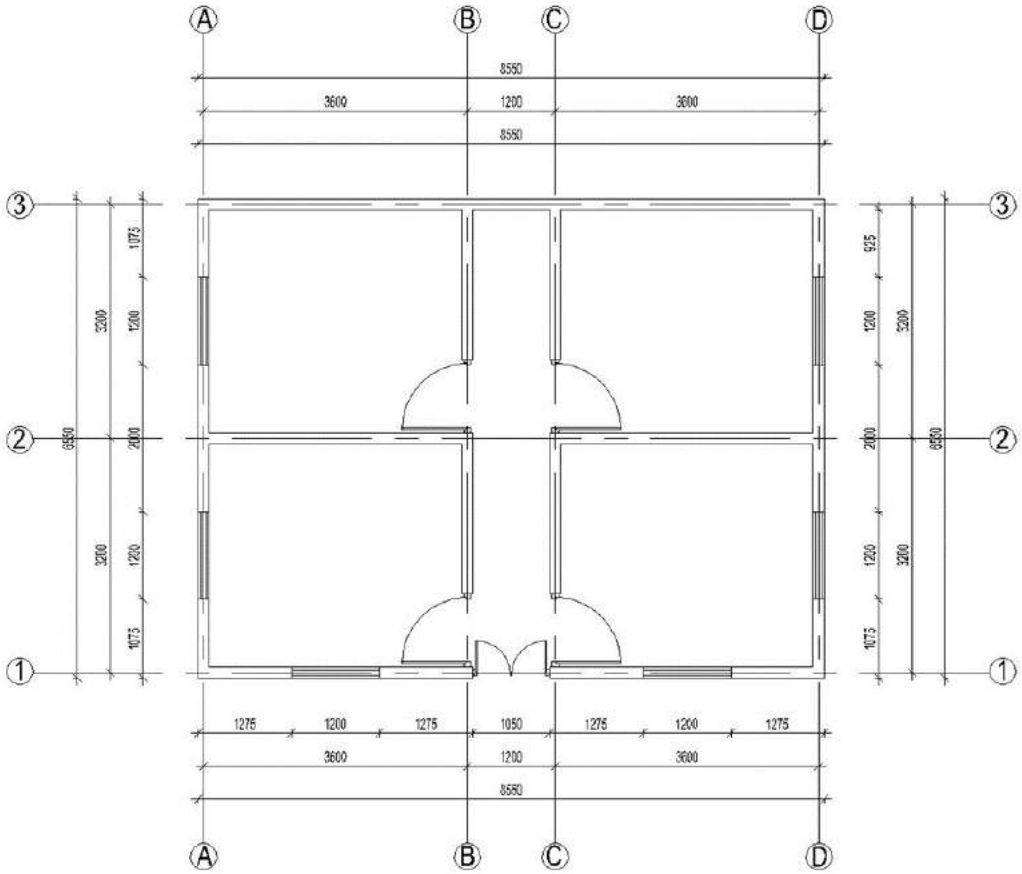
[C] Estimate for Correction Measures

Estimate for Correction Measures								
Measuremnt of Building and Quantity	Building Overall Dimension	Plinth	Length of Building		1	7.65	m
			Width of Building		2	7.25	m
			Height of Building		3	2.16	m
			Number of Long Wall		4	3	number
			Number of Short wall		5	3	number
			Total Area of Building	**1*4+2*5**	6	44.7	m^2
		Total Area of Walls (Elevation)		**6*3**	7	96.552	m^2
	Opening Deduction	Window	Number of Window		8	4	number
			Length of Window		9	1.2	m
			Height of Window		10	1.2	m
			Area of Window	8*9*10	11	5.76	m^2
		Door	Number of Door		12	4	number
			Length of Door		13	1.05	m
			Height of Door		14	2.06	m
			Area of Door	12*13*14	15	8.652	m^2
		Total Area (Deductable)		**11+15**	16	14.412	m^2
	Net Area	Wall Area	Single Face of Walls	7-16	17	82.14	m^2
			Double Face of WallS	**17+17**	18	**164.28**	m^2
	Tie bandage		Length [One side)	4*1+5*2	19	44.7	m
			Length (Two side)	19+19	20	89.4	m
			Thickness		21	0.04	m
			Height of Bandage		22	0.15	m
		Total Volume		**19*21*22**	23	0.2682	
		Total Volume of Tie Bandage		**23+23**	24	**0.5364**	m^3
Materials Breakdown (B.O.Q.)	Wall Jacketing	GI wire(1.63 Dia)	Weight Per Unit Area	0.7	25		kg/m^2
			Total Weight	**25*18**	26	**110**	kg
		Cement (1 Part)	Cement Bag Per Unit Area	0.0764	27		bag/m^2
			Net Cement Quantity (Bag)	**27*18**	28	**13**	bag
		Sand (6 part)	Sand Bag Per Unit Area	0.45	29		bag/m^2
			Net Sand Quantity (Cement Bag)	**29*18**	30	**74**	bag
	Tie Bandage	Longitudinal Bars (4.75mm)	Weight Per Unit Length	0.14	31		kg/m
			Number of Main bar		32	2	
			Total Weight	**32*31*20**	33	**25.032**	kg
		Cement	Cement Bag Per Unit Volume	8	34		bag/m^3
			Net Cement Quantity (Bag)	**24*34**	35	**4**	bag
		Sand	Sand Bag Per Unit Volume	12	36		bag/m^3
			Net Sand Quantity (Cement Bag)	**36*24**	37	6	bag
		Aggregate (10 mm down chips)	Aggregate Bag Per Unit Volume	25	38		bag/m^3
			Net Agg. Quantity (Cement Bag)	**38*24**	39	13	bag

Description of existing building:

Other details are same as previous except passge in the middle as shown in plan below:

[d] Four Roomed Building with Passage (4R+P model)



[d] Abstract of Cost

	Items	Quantity	Calculation	Unit Rate (NRs.)	Amount	Unit
Abstract of Cost	GI wire(1.63 Dia)	124	25	180	22374.601	kg
	Cement	19	35+27	750	14338.399	bag
	Sand	91	29+37	70	6352.731	bag
	Longitudinal Bars (4.75mm)	29	32	85	2468.06	kg
	Aggregate (10 mm down chips)	16	39	100	1555.5	bag
				Total Amount (NRs.)	**47,089.29**	

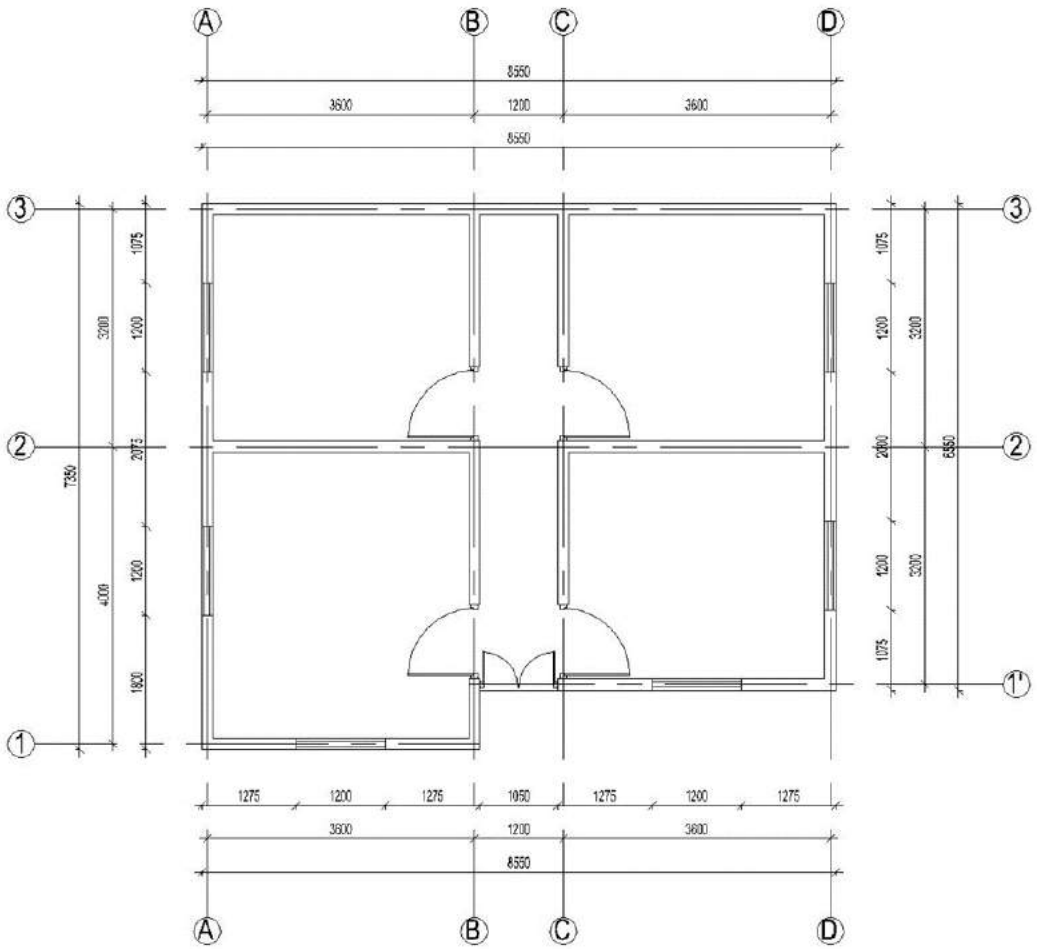
[d] Estimate for Correction Measures

Estimate for Correction Measures							
Measuremnt of Building and Quantity	Building Overall Dimension	Plinth	Length of Building		1	8.55	m
			Width of Building		2	6.55	m
			Height of Building		3	2.16	m
			Number of Long Wall		4	3	number
			Number of Short wall		5	4	number
			Total Area of Building	**1*4+2*5**	6	51.85	m^2
		Total Area of Walls (Elevation)		**6*3**	7	111.996	m^2
	Opening Deduction	Window	Number of Window		8	6	number
			Length of Window		9	1.2	m
			Height of Window		10	1.2	m
			Area of Window	8*9*10	11	8.64	m^2
		Door	Number of Door		12	5	number
			Length of Door		13	1.05	m
			Height of Door		14	2.06	m
			Area of Door	12*13*14	15	10.815	m^2
		Total Area (Deductable)		**11+15**	16	19.455	m^2
	Net Area	Wall Area	Single Face of Walls	7-16	17	92.541	m^2
			Double Face of WallS	**17+17**	18	**185.082**	m^2
	Tie bandage		Length [One side)	4*1+5*2	19	51.85	m
			Length (Two side)	19+19	20	103.7	m
			Thickness		21	0.04	m
			Height of Bandage		22	0.15	m
		Total Volume		**19*21*22**	23	0.3111	
		Total Volume of Tie Bandage		**23+23**	24	**0.6222**	m^3
Materials Breakdown (B.O.Q.)	Wall Jacketing	GI wire(1.63 Dia)	Weight Per Unit Area	0.7	25		kg/m^2
			Total Weight	**25*18**	26	**124**	kg
		Cement (1 Part)	Cement Bag Per Unit Area	0.0764	27		bag/m^2
			Net Cement Quantity (Bag)	**27*18**	28	**14**	bag
		Sand (6 part)	Sand Bag Per Unit Area	0.45	29		bag/m^2
			Net Sand Quantity (Cement Bag)	**29*18**	30	**83**	bag
	Tie Bandage	Longitudinal Bars (4.75mm)	Weight Per Unit Length	0.14	31		kg/m
			Number of Main bar		32	2	
			Total Weight	**32*31*20**	33	**29.036**	kg
		Cement	Cement Bag Per Unit Volume	8	34		bag/m^3
			Net Cement Quantity (Bag)	**24*34**	35	**5**	bag
		Sand	Sand Bag Per Unit Volume	12	36		bag/m^3
			Net Sand Quantity (Cement Bag)	**36*24**	37	7	bag
		Aggregate (10 mm down chips)	Aggregate Bag Per Unit Volume	25	38		bag/m^3
			Net Agg. Quantity (Cement Bag)	**38*24**	39	16	bag

Description of existing building:

Other details are same as previous except passage and verandah in the middle as shown in plan below:

e. Four Roomed Building with Passage and Veranda (4R+P+V model)



[e] Abstract of Cost

	Items	Quantity	Calculation	Unit Rate (NRs.)	Amount	Unit
Abstract of Cost	GI wire(1.63 Dia)	134	25	180	24045.787	kg
	Cement	20	35+27	750	15360.914	bag
	Sand	97	29+37	70	6820.443	bag
	Longitudinal Bars (4.75mm)	31	32	85	2620.38	kg
	Aggregate (10 mm down chips)	17	39	100	1651.5	bag
				Total Amount (NRs.)	**50,499.02**	

[e] Estimate for Correction Measures

Estimate for Correction Measures								
Measuremnt of Building and Quantity	Building Overall Dimension	Plinth	Length of Building		1	8.55	m
			Width of Building		2	7.35	m
			Height of Building		3	2.16	m
			Number of Long Wall		4	3	number
			Number of Short wall		5	4	number
			Total Area of Building	**1*4+2*5**	6	55.05	m^2
		Total Area of Walls (Elevation)		**6*3**	7	118.908	m^2
	Opening Deduction	Window	Number of Window		8	6	number
			Length of Window		9	1.2	m
			Height of Window		10	1.2	m
			Area of Window	8*9*10	11	8.64	m^2
		Door	Number of Door		12	5	number
			Length of Door		13	1.05	m
			Height of Door		14	2.06	m
			Area of Door	12*13*14	15	10.815	m^2
		Total Area (Deductable)		**11+15**	16	19.455	m^2
	Net Area	Wall Area	Single Face of Walls	7-16	17	99.453	m^2
			Double Face of WallS	**17+17**	18	**198.906**	m^2
	Tie bandage		Length [One side)	4*1+5*2	19	55.05	m
			Length (Two side)	19+19	20	110.1	m
			Thickness		21	0.04	m
			Height of Bandage		22	0.15	m
		Total Volume		**19*21*22**	23	0.3303	
		Total Volume of Tie Bandage		**23+23**	24	**0.6606**	m^3
Materials Breakdown (B.O.Q.)	Wall Jacketing	GI wire(1.63 Dia)	Weight Per Unit Area	0.7	25		kg/m^2
			Total Weight	**25*18**	26	**134**	kg
		Cement (1 Part)	Cement Bag Per Unit Area	0.0764	27		bag/m^2
			Net Cement Quantity (Bag)	**27*18**	28	**15**	bag
		Sand (6 part)	Sand Bag Per Unit Area	0.45	29		bag/m^2
			Net Sand Quantity (Cement Bag)	**29*18**	30	**90**	bag
	Tie Bandage	Longitudinal Bars (4.75mm)	Weight Per Unit Length	0.14	31		kg/m
			Number of Main bar		32	2	
			Total Weight	**32*31*20**	33	**30.828**	kg
		Cement	Cement Bag Per Unit Volume	8	34		bag/m^3
			Net Cement Quantity (Bag)	**24*34**	35	**5**	bag
		Sand	Sand Bag Per Unit Volume	12	36		bag/m^3
			Net Sand Quantity (Cement Bag)	**36*24**	37	8	bag
		Aggregate (10 mm down chips)	Aggregate Bag Per Unit Volume	25	38		bag/m^3
			Net Agg. Quantity (Cement Bag)	**38*24**	39	17	bag

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ANNEX D: CASE STUDY ON INSPECTION

This section presents representative sample calculation referred in structural analysis and design of existing building as well as new buildings.

Single Storey HCB Building

CASE STUDY - 1

BUILDING DESCRIPTION

- Single storey building with CGI roofing. Rooms sizes vary; 2 Rooms to 4 Rooms including verandah at front and corridor inside.
- Masonry units are concrete blocks (solid, hollow, ACC) with baked bricks.
- Vertical RC post [concrete M15, 230mmx230mm, rebars Fe 415MPa, 4 Nos. of 12 mm diameter tied with stirrups 8 mm diameter at 150 mm c/c] are provided at each junction of rooms and at various locations in verandah.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Plinth band	: NC
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Horizontal reinforcement	: NC
✓	Horizontal bands	: NC
✓	Gable walls	: NC
✓	Roofing	: C

Building Typology

- Reinforced Masonry Structural Wall System

Non-Compliance Issue

- According to the analysis, seismic requirement is not satisfied due to missing horizontal bands at plinth, sill, lintel, roof or gable.

Recommendation

- Correction method is introduced in this manual. Horizontal bands shall be provided at both side of wall.

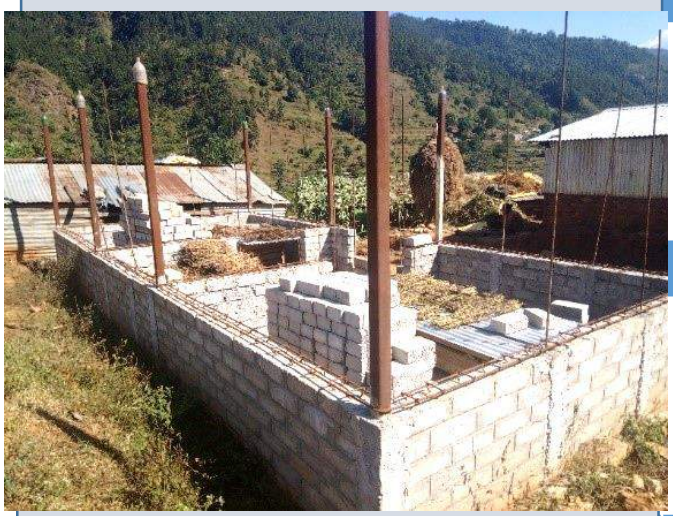
*See Correction Measures,

Single Storey HCB Building

CASE STUDY - 2

BUILDING DESCRIPTION

- Single storey building with CGI roofing.
  - ➢ Hollow square pipe is used at wall crossings and rebars near openings



Structural Assessment check list

✓	Building site	: **C**
✓	Building configuration	: **C**
✓	Storey height	: **C**
✓	Unit size 400x150x200,LBH	: **C**
✓	Foundation	: **C**
✓	Vertical reinforcement	: **C**
✓	Plinth band	: C
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Sill bands	: C
✓	Gable walls	: NK
✓	Roofing	: C

Building Typology

- Reinforced Masonry Structural Wall System

Non-Compliance Issue

- None.

Recommendation

- Inspection can be done as concrete block masonry presented in this manual.

Remarks

Single Storey HCB Building

CASE STUDY - 3

BUILDING DESCRIPTION

- Two storey building with CGI roofing. Room sizes vary; 3 Rooms with verandah at front.
- Masonry units are concrete blocks (solid or hollow).
- Single rebars are used at critical location and RC post at verandah.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Plinth band	: NC
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Horizontal reinforcement	: NC
✓	Horizontal bands	: NC
✓	Gable walls	: NC
✓	Floor/Roofing	: C

Building Typology

- Reinforced Masonry Structural Wall System

Non-Compliance Issue

- According to the analysis, seismic requirement is not satisfied due to missing horizontal bands at plinth, sill, lintel, roof or gable.

Recommendation

- Correction method is introduced in this manual. Horizontal bands shall be provided at both side of wall.

Remarks

Double Storey HCB Building with Light Roofing

CASE STUDY - 4

BUILDING DESCRIPTION

- Two storey with CGI roofing building rooms sizes varies; 3 Room with verandah at front.
- Masonry units are infilled in timber frames. Resistance to loads is provided by combined action of frame and infilled blocks.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Plinth band	: NC
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Horizontal reinforcement	: NC
✓	Horizontal bands	: NC
✓	Gable walls	: NC
✓	Roofing	: C

Building Typology

- Reinforced Masonry Structural Wall System

Non-Compliance Issue

- According to the analysis, seismic requirement is not satisfied due to missing horizontal bands at plinth, sill, lintel, roof or gable.

Recommendation

- Use simplified calculation of brace member, [Refer: Light Timber/Steel Frame Structure Manual]

Remarks

Hybrid Structure

CASE STUDY - 5

BUILDING DESCRIPTION

- Two storey building with CGI roofing and verandah at front.
- This building is HYBRID STRUCTURAL SYSTEM as **lower storey is Reinforced masonry structural wall system and upper storey is Light timber structure.**
- Lower storey can be inspected as reinforced masonry structural wall system stated in this manual and upper story can be inspected as hybrid structure [refer hybrid manual]. For correction, HCB Manual or Hybrid Structure Manual shall be applied.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Horizontal banding	: C
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Hybrid Structure	: NC
✓	Roofing	: C

Building Typology

- Hybrid Structure

Non-Compliance Issue

- CGI sheet partition and connection of upper floor to lower floor.

Recommendation

- Use simplified calculation of brace member, [Refer: Light Timber/Steel Frame Structure Manual]

Remarks

Hybrid Structure [SMC + HCB]

CASE STUDY - 6

BUILDING DESCRIPTION

- Two storey building with CGI roofing and verandah at front.
- This building is mixed in type as **lower storey is Reinforced stone masonry and upper storey is Concrete block masonry.**
- **Lower storey can be inspected as SMM and upper storey can be inspected as concrete block as stated in this manual.**

Building Typology

- Hybrid Structure

Non-Compliance Issue

- Use of different material at different level (Stone in Cement and HCB in Cement)

Recommendation

- Apply MR of SMC and HCB Masonry.

Structural Assessment check list

- ✓ Building site : C
- ✓ Building configuration : C
- ✓ Storey height : C
- ✓ Unit size 400x150x200,LBH : C
- ✓ Foundation : C
- ✓ Vertical reinforcement : C
- ✓ Horizontal banding : C
- ✓ Un supported wall length : C
- ✓ Openings in wall : C
- ✓ Openings location : C
- ✓ Roofing : C

Remarks

HCB Infilled Timber Frame Structure Building

CASE STUDY - 7

BUILDING DESCRIPTION

- Two storey building with CGI roofing and timber flooring.
- The masonry walls are infilled in timber frame at lower storey and timber planks are fixed in upper storey of the building.

Building Typology

- HCB Infilled Timber Frame Structure

Non-Compliance Issue

- HCB masonry partitioned wall are not tied with timber frames

Recommendation

- Inspection of this building can be done as per Light Timber/Steel Frame Structure Manual.

Remarks

Double Storey HCB Building with Light Roofing

CASE STUDY - 8

BUILDING DESCRIPTION

- Two storey building with CGI roofing and verandah at front.
- RC posts (4-12 dia bars, 8 mm stirrups @150mm c/c) are provided at each corners of room.
- RC beam (4-12 dia bars, 8 mm stirrups @150mm c/c) are provided at floor/room bands.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Plinth band	: NC
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Horizontal reinforcement	: NC
✓	Horizontal bands	: NC
✓	Gable walls	: NC
✓	Floor/Roofing	: C

Building Typology

- These buildings are **Confined masonry structural wall system.**

Non-Compliance Issue

- According to the analysis, seismic requirement is not satisfied due to missing confining element near openings

Recommendation

- Correction method is introduced in this manual. Horizontal bands at sill and lintel level and vertical bands shall be provided near opening.

Remarks

Double Storey HCB Building with Light Roofing

CASE STUDY - 9

BUILDING DESCRIPTION

- Single storey with CGI roofing building with verandah at front.
- Confining element at required locations.

Structural Assessment check list

✓	Building site	: C
✓	Building configuration	: C
✓	Storey height	: C
✓	Unit size 400x150x200,LBH	: C
✓	Foundation	: C
✓	Vertical reinforcement	: C
✓	Plinth band	: C
✓	Un supported wall length	: C
✓	Openings in wall	: C
✓	Openings location	: C
✓	Horizontal reinforcement	: C
✓	Horizontal bands	: C
✓	Gable walls	: C
✓	Roofing	: C

Building Typology

- These buildings are **Confined masonry structural wall system.**

Non-Compliance Issue

- According to the analysis, seismic requirement is not satisfied due to missing confining element near openings

Recommendation

- Inspection of these building typology shall be done according to INSPECTION FORM for Confined Masonry Building

Remarks

HCB Infilled RC Frame Structure Building

CASE STUDY - 10

BUILDING DESCRIPTION

- Masonry infilled RCC framed structure, gravity and lateral loads are resisted by frame.
- Infills should be stable in its plane against out of plane loads

Building Typology

- These buildings are **Reinforced Concrete Framed Structure with Masonry Infill**

Non-Compliance Issue

- N/K

Recommendation

- Inspection of these building typology shall be done according to INSPECTION FORM for RCC BUILDING. **Except, longitudinal rebar in bands can be 2- 6mm diameter with C-hooks 4.75mm diameter @ 150 mm at centers.**

Remarks

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ANNEX E: INSPECTION FORM (HCB MASONRY)

This section presents Inspection forms for HCB Load Bearing Buildings.

First Inspection Form

अनुशूची २१: - सिमेन्ट मसलाको जोडाइम कंक्रिट ब्लकको गरोवाला "ग" वर्गको घरको प्राबिधिक निरीक्षण फारम

नेपाल सरकार
राष्ट्रिय पुनर्निर्माण प्राधिकरण
केन्द्रीय परियोजना कार्यन्वयन इकाई (भवन)

घरधनी/लाभग्राहीको जानकारी		निरीक्षण मिति :	गते	महिना	वर्ष
नाम:		अनुदान म्फौता नं.			
ठेगाना:	जिल्ला: गा.वि../न.पा.: वडा:टोल: जग्गाको कित्ता नं.:				
फोन / मोबाइल नं :-	अनुदान म्फौतामा उल्लेखित बैंक खाता नं:-	बैंकको नाम :-			

खण्ड -१ :घरको जाचको लागि दिइएको आवेदनमा भएको विवरण

स्वीकृत नक्शा-डिजाइन मध्येको भए		डिजाइन नं.:	
अन्य आफ्नै नक्शा डिजाइन भए अनुदान ससम्फौतामा दिइएको घरको विवरण		निर्माण सामाग्री र प्रविधि छाना र सामाग्रीको निर्माण	
प्राविधिक सहायक	☐छ ☐छैन	संस्था	☐नेपाल सरकार ☐गैरसरकारी संस्था
	☐छ ☐छैन	माटोको प्रकार	☐कडा ☐मध्यम ☐नरम

खण्ड -२ : विस्तृत प्राविधिक विवरण

न्यूनतम मापदण्ड क्रम नं	वर्गिकरण	विवरण		न्यूनतम मापदण्ड पालना गरिएको		टिप्पणी
				छ	छैन	
१	निर्माण स्थलको छनोट निम्न स्थान बाट टाढा हुनुपर्छ ।	भौगर्भिक चिरा परेको ठाउँ ।		☐	☐	
		भिरालो क्षेत्र > २०° ।		☐	☐	
		नदीको बगर वा सिमसार ठाउँ ।		☐	☐	
		ढुङ्गा भर्ने ठाउँ ।		☐	☐	
		तरलीकरण हुन सक्ने ठाउँ ।		☐	☐	
		माटो भरेको वा पुरुवा माटो भएको स्थान		☐	☐	
२	भवनको आकार प्रकार र नाप	तल्ला संख्या	२	☐	☐	
		गारोको लम्बाइ	बढीमा ४.०५ मि.	☐	☐	
		भुइको नाप	बढीमा १००.०० वर्ग.मि.	☐	☐	
		अनुपात	वर्गकार वा आयातकार । लम्बाई चौडाइको ३ गुणा भन्दा बढी हुनुहुँदैन् ।	☐	☐	
३	निर्माण सामाग्री	कंक्रिट ब्लक	Minimum compressive strength shall be 2MPa, Size: 400mm*150mm*200mm	☐	☐	
		मसला	१ : ६ (१ भाग सिमेन्ट र ६ भाग बालुवा) वरावर अथवा त्यो भन्दा बढी भार क्षमता भएका	☐	☐	
		कंक्रिट ग्रेड	M २० ग्रेड M १:१.५:३ (१ भाग सिमेन्ट १.५ भाग बालुवा र ३ भाग गिटी)	☐	☐	
		डण्डी		☐	☐	

First Inspection Form

न्यूनतम मापदण्ड क्रम नं	वर्गिकरण	विवरण		न्यूनतम मापदण्ड पालना गरिएको		टिप्पणी
				छ	छैन	
४	जग	एकैनासको गारो वाला जगको खाडल		☐	☐	
		जगको गहिराइ	१ तल्ला : ४५० मि.मि. २ तल्ला : ६५० मि.मि.	☐	☐	
		जगको चौडाइ	१ तल्ला : ४५० मि.मि. २ तल्ला : ६५० मि.मि.	☐	☐	
५	ठाडो सबलीकरण	जगबाट शुरु हुनुपर्छ ।	एक मात्र	☐	☐	
		गारोको सुरमा, जोर्नीमा र भ्याल ढोकाको दायाँ बायाँ राखेको हुनुपर्छ ।		☐	☐	
		ठाडो डण्डी	१२ मि.मि. न्युनतम	☐	☐	
		खप्टयाउने लम्बाई	६० गुणा डण्डीको ब्यास	☐	☐	
६	कुर्सी सतह (डि.पि.सि)	जमिन सतह माथिको उचाइ	कम्तीमा ३०० मि.मि.	☐	☐	
		मोटाइ	७५ मि.मि.।	☐	☐	
		चौडाइ	१५० मि.मि.।	☐	☐	
		डण्डी र रिङ्ग	२–१२ मि.मि. ब्यासको डण्डी । ६ मि.मि. ब्यासको रिङ्ग १५० मि.मि. दूरीमा, १५ मि.मि. (कभर) ढलान ।	☐	☐	

अन्य

(क) घरको कम्तीमा छवटा फोटोहरु खिची फोटो नं.हरु उल्लेख गर्ने (जस्तै : dsc0152.jpg; फोटो फाइलको नाम

अगाडिको भोडा (Front view):		पछाडिको भोडा (Back view):		
दायाँ साइड (Right side view):		बायाँ साइड (Left side view):		
माथिको दृश्य (Top view):		साइटको नक्सा (Site Plan):		
(ख) जि.पि.एस. को–अर्डिनेट:	अक्षांश:	देशान्तर:	समुन्द सतहबाट उचाइ:	

(ग) घरको मोहामोटी नक्सा:

(घ) देखिएका प्राविधिक विवरणहरुको विश्लेषण गरी निर्माण भइसकेका घरमा थप सुधार कार्यको लागि- सुझाव दिनु पर्ने: ☐ देखिन्छ ☐ देखिदैन
अनुसार सुधार÷प्रबलीकरण आदेश दिइएको छ ।

(ङ) जाँचमा देखिएका प्राविधिक विवरणहरु ठीक/जोची छन् । यो प्राविधिक निरीक्षण र सिफारिस नेपाल सरकारबाट भूकम्प प्रभावित लाभग्राही घरधनीलाई दिइने निजी आवास अनुदान भुक्तानी प्रयोजनका लागि मात्र लागु हुनेछ भन्ने व्यहोरा मलाई मंजुर छ । साथै यो घर मैले आफै बनाएको हुँ र यसको गुणस्तर तथा सुरक्षाको सम्पूर्ण जिम्मेवारी म आफै लिनेछु भनी स्वीकार गर्ने :
घरधनी ÷ लाभग्राही वा प्रतिनिधिको नाम, थर ..... हस्ताक्षर .....
प्रतिनिधिको घरधनी ÷ लाभग्राहीसंगको नाता ..... मिति .....

(च) प्राविधिक जाँचको विवरण स्वीकृतिको लागि पेश गर्ने: .....
MoUD-DLPIU को सुपरीवेक्षक: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

(छ)प्राविधिक जाँचको विवरण स्वीकृत गर्ने
MoUD-DLPIU को सुपरीवेक्षण इन्जिनियर: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

Second Inspection Form

अनुशूची २१: - सिमेन्ट मसलाको जोडाइम कंक्रिट ब्लकको गरोवाला "ग" वर्गको घरको प्राबिधिक निरीक्षण फारम

नेपाल सरकार
राष्ट्रिय पुनर्निर्माण प्राधिकरण
केन्द्रीय परियोजना कार्यन्वयन इकाई (भवन)

घरधनी/लाभग्राहीको जानकारी		निरीक्षण मिति :	गते	महिना	वर्ष
नाम:		अनुदान म्फौता नं.			
ठेगाना:	जिल्ला: गा.वि../न.पा.: वडा:टोल: जग्गाको कित्ता नं.:				
फोन / मोबाइल नं :-	अनुदान म्फौतामा उल्लेखित बैंक खाता नं:-	बैंकको नाम :-			

खण्ड -१ :घरको जाचको लागि दिइएको आवेदनमा भएको विवरण

स्वीकृत नक्शा-डिजाइन मध्येको भए		डिजाइन नं.:	
अन्य आफ्नै नक्शा डिजाइन भए अनुदान ससम्फौतामा दिइएको घरको विवरण		निर्माण सामाग्री र प्रविधि छाना र सामाग्रीको निर्माण	
प्राविधिक सहायक	☐छ ☐छैन	संस्था	☐नेपाल सरकार ☐गैरसरकारी संस्था
	☐छ ☐छैन	माटोको प्रकार	☐कडा ☐मध्यम ☐नरम

खण्ड -२ : विस्तृत प्राविधिक विवरण

न्यूनतम मापदण्ड क्रम नं	वर्गिकरण	विवरण		न्यूनतम मापदण्ड पालना गरिएको		टिप्पणी
				छ	छैन	
७	गारो	गारोहरु घन्टी मिलाएर सिधा ठाडो हुने गरी लगाइएको		☐	☐	
		मोटाई	एक तल्ला : कम्तीमा १५० मि.मि.	☐	☐	
		जोर्नी	२० मि. मि.भन्दा बढी र १० मि. मि.भन्दा कम हुनुहुँदैन ।	☐	☐	
		आड दिने गारो	धेरै लामो गारोमा प्रदान गरिएको	☐	☐	
		चूली गारो	हलुका सामाग्रीको प्रयोग गरिएको	☐	☐	
८	गारोमा राखिने खुल्ला भाग	स्थान	गारोको सुरवाट कम्तिमा ६०० मि.मि.	☐	☐	
		कुल लम्बाई	हरेक गारोको लम्बाईको कम्तिमा ६०% भन्दा बढी हुनु हुँदैन ।	☐	☐	
		दूरी	कम्तिमा ६०० मि.मि.	☐	☐	
९	तेर्सो बन्धन	सिल पटीको नाप (भ्यालको तल्लो सतह)	सबै गारो वरिपरी पट्टीको प्रयोग कम्तिमा ७५ मि.मि.	☐	☐	

Second Inspection Form

न्यूनतम मापदण्ड क्रम नं	वर्गिकरण	विवरण		न्यूनतम मापदण्ड पालना गरिएको		टिप्पणी
				छ	छैन	
९	तेर्सो बन्धन	लिन्टेल पटीको नाप (झ्याल ढोकाको माथिल्लो सतह)	सबै गारो वरिपरी पटीको प्रयोग यदि खुल्ला भागको चौडाई १.२५ मि. र यस माथिको गारोको उचाई ०.९ मि. भन्दा बढी भए ७५ मि.मि.भन्दा कम हुनुहुँदैन। यदि खुल्ला भागको चौडाई श्र १.२५ मि.र यस माथिको गारोको उचाई १.२ मि. भन्दा बढी भए १५० मि.मि.भन्दा कम हुनुहुँदैन।	☐	☐	
		स्टीच पटीको नाप	बढीमा सुर र जोर्नीमा ६०० मि. लम्बाई कम्तिमा ७५ मि.मि. मोटाई।	☐	☐	
		छानाको पटीको नाप	सबै गारो वरिपरी पटीको प्रयोग कम्तिमा ७५ मि.मि.	☐	☐	
		पटीको नाप, डण्डी र रिङ्ग	१५०मि.मि.मोटाइको पटीमा ४–१२मि.मि. ब्यासको डण्डी र ७५ मि.मि. मोटाईको पटीमा २–१२ मि.मि. ब्यासको डण्डी । ६ मि.मि. ब्यासको रिङ्ग १५० मि.मि. दूरीमा, २५ मि.मि. (कभर) ढलान ।	☐	☐	
		डण्डीको खप्ट्याउने लम्बाई	६० गुणा डण्डीको व्यासको लम्बाई	☐	☐	
१०	गारो	चूली गारो	हलुका सामाग्रीको प्रयोग गरिएको	☐	☐	
११	छाना	सामग्री	हलुका छाना प्रयोग गरिएको	☐	☐	
		जोडाई	एकआपसमा र गारो सँग उपयूक्त तरिकाले बाँधेका	☐	☐	
		छड्के तान	ट्रस वा दलिनहरु बाँध्न छड्के तानको प्रयोग	☐	☐	

अन्य

(क) घरको कम्तीमा छुवटा फोटोहरु खिची फोटो नं.हरु उल्लेख गर्ने (जस्तै : dsc0152.jpg; फोटो फाइलको नाम

अगाडिको भोडा (Front view):		पछाडिको भोडा (Back view):		
दायाँ साइड (Right side view):		बायाँ साइड (Left side view):		
माथिको दृश्य (Top view):		साइटको नक्शा (Site Plan):		
(ख) जि.पि.एस. को–अर्डिनेट: अक्षांश:		देशान्तर:	समुद्र सतहबाट उचाइ:	

(ग) घरको मोटामोटी नक्शा:

(घ) देखिएका प्राविधिक विवरणहरुको विश्लेषण गरी निर्माण भइसकेका घरमा थप सुधार कार्यको राय- सुझाव दिनु पर्ने: ☐ देखिएन ☐ देखिदैन
सुधार÷पुनर्बलीकरण गर्नुपर्ने देखिएकोले अनुसूची - ११ अनुसार सुधार÷पुनर्बलीकरण आदेश दिइएको छ ।

(ङ) जाँचमा देखिएका प्राविधिक विवरणहरु ठीक/जोची छन् । यी प्राविधिक निरीक्षण र सिफारिस मेपाल सरकारबाट भूकम्प प्रभावित लाभग्राही घरधनीलाई दिइने निजी आवास अनुदान भुक्तानी प्रयोजनका लागि मात्र लागु हुनेछ भन्ने व्यहोरा मलाई मंजुर छ । साथै यो घर मैले आफै बनाएको हुँ र यसको गुणस्तर तथा सुरक्षाको सम्पूर्ण जिम्मेवारी म आफै लिनेछु भनी स्वीकार गर्ने :
घरधनी÷ लाभग्राही वा प्रतिनिधिको नाम, थर ..... हस्ताक्षर .....
प्रतिनिधिको घरधनी÷ लाभग्राहीसंगको नाता ..... मिति .....

(च) प्राविधिक जाँचको विवरण स्वीकृतिको लागि पेश गर्ने: .....
MoUD-DLPIU को सुपरीवेक्षक: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

(छ)प्राविधिक जाँचको विवरण स्वीकृत गर्ने
MoUD-DLPIU को सुपरीवेक्षण इन्जिनियर: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

Third Inspection Form

अनुशूची २१: - सिमेन्ट मसलाको जोडाइम कंक्रिट ब्लकको गरोवाला "ग" वर्गको घरको प्राबिधिक निरीक्षण फारम

नेपाल सरकार
राष्ट्रिय पुनर्निर्माण प्राधिकरण
केन्द्रीय परियोजना कार्यन्वयन इकाई (भवन)

घरधनी/लाभग्राहीको जानकारी		निरीक्षण मिति :	गते	महिना	वर्ष
नाम:		अनुदान म्फौता नं.			
ठेगाना:	जिल्ला: गा.वि../न.पा.: वडा:टोल: जग्गाको कित्ता नं.:				
फोन / मोबाइल नं :-	अनुदान म्फौतामा उल्लेखित बैंक खाता नं:-		बैंकको नाम :-		

खण्ड -१ :घरको जाचको लागि दिइएको आवेदनमा भएको विवरण

स्वीकृत नक्शा-डिजाइन मध्येको भए		डिजाइन नं.:	
अन्य आफ्नै नक्शा डिजाइन भए अनुदान ससम्फौतामा दिइएको घरको विवरण		निर्माण सामाग्री र प्रविधि छाना र सामाग्रीको निर्माण	
प्राविधिक सहायक	☐छ ☐छैन	संस्था	☐नेपाल सरकार ☐गैरसरकारी संस्था
	☐छ ☐छैन	माटोको प्रकार	☐कडा ☐मध्यम ☐नरम

खण्ड -२ : विस्तृत प्राविधिक विवरण

न्यूनतम मापदण्ड क्रम नं	वर्गिकरण	विवरण		न्यूनतम मापदण्ड पालना गरिएको		टिप्पणी
				छ	छैन	
१०	गारो	चूली गारो	हलुका सामाग्रीको प्रयोग गरिएको	☐	☐	
११	छाना	सामग्री	हलुका छाना प्रयोग गरिएको	☐	☐	
		जोडाई	एकआपसमा र गारो सँग उपयुक्त तरिकाले बाँधेका	☐	☐	
		छड्के तान	ट्रस वा दलिनहरु बाँध्न छड्के तानको प्रयोग	☐	☐	

अन्य

(क) घरको कलरमा खुवटा फोटोहरु खिची फोटो नं.हरु उल्लेख गर्ने (जस्तै : dsc0152.jpg; फोटो फाइलको नाम

अगाडिको भोडा (Front view):		पछाडिको भोडा (Back view):		
दायाँ साइड (Right side view):		बायाँ साइड (Left side view):		
माथिको दृश्य (Top view):		साइटको नक्शा (Site Plan):		
(ख) जि.पि.एस. को–अर्डिनेट: अक्षांश:		देशान्तर:	समुन्द मतलवाट उचाइ:	

(ग) घरको मोहामोटी नक्शा:

(घ) देखिएका प्राविधिक विवरणहरुको विश्लेषण गरी निर्माण भइसकेका घरमा थप सुधार कार्यको गरु- सुझाव दिनु पर्ने: ☐ देखिएन ☐ देखिदैन
सुधार÷पुनर्बलकरण गर्नुपर्ने देखिएकोले अनुसुची - १५ अनुसार सुधार÷पुनर्बलकरण आदेश दिइएको छ ।

(ङ) जाँचमा देखिएका प्राविधिक विवरणहरु ठीक/जाँची छन् । यो प्राविधिक निरीक्षण र सिफारिस नेपाल सरकारबाट भूकम्प प्रभावित लाभग्राही घरधनीलाई दिइने निजी आवास अनुदान भुक्तानी प्रयोजनका लागि मात्र लागु हुनेछ भन्ने व्यहोरा मलाई मंजुर छ । साथै यो घर मैले आफै बनाएको हुँ र यसको गुणस्तर तथा सुरक्षाको सम्पूर्ण जिम्मेवारी म आफै लिनेछु भनी स्वीकार गर्ने :
घरधनी÷लाभग्राही वा प्रतिनिधिको नाम, थर ..... हस्ताक्षर .....
प्रतिनिधिको घरधनी÷लाभग्राहीसंगको नाता ..... मिति .....

(च) प्राविधिक जाँचको विवरण स्वीकृतिको लागि पेश गर्ने:
MoUD-DLPIU को सुपरीवेक्षक: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

(छ)प्राविधिक जाँचको विवरण स्वीकृत गर्ने
MoUD-DLPIU को सुपरीवेक्षण इन्जिनियर: .....
नाम: .....
पद: ..... हस्ताक्षर: ..... मिति: .....

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Government of Nepal
National Reconstruction Authority
Housing reconstruction programme
Singhadurbar, Kathmandu
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