CORRECTION/EXCEPTION MANUAL for MASONRY STRUCTURE for houses that have been built under the HOUSING RECONSTRUCTION PROGRAMME

Government of Nepal
National Reconstruction Authority
Singhadurbar, Kathmandu

Final inspection
2nd inspection
1st inspection

2017
CORRECTION/EXCEPTION MANUAL
for MASONRY STRUCTURE

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National Reconstruction Authority
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I would like to congratulate all involved in the development of the Corrections / Exceptions Manual for Reconstruction of Earthquake Resistant Houses, which has been produced by the National Reconstruction Authority (NRA) to support households who have already rebuilt, or have started rebuilding, under reconstruction programme to implement any corrections required to comply with the standards as set out in the inspection guidelines. The manual also addresses exceptions outside of the MRs which are structurally sound.

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. The grant is disbursed in number of tranches based on compliant construction. Unfortunately, the compliance rate is currently estimated to be very low which means that many households are not approved to receive the next tranche of the grant. Every effort is required to support households to meet the compliance standards so that they can receive the full grant amount. This manual has been developed for technical staff to identify exceptions in relation to certain MRs under certain conditions and also to go through the process of implementing required corrections so that they could guide the households.

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 houses.

Dr. Govind Raj Pokharel
Chief Executive Officer, NRA
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Under the housing reconstruction programme, houses that have been constructed or are in the process of construction need to comply with the Minimum Requirements (MRs) for compliant construction. In order to receive the housing reconstruction grant, the buildings need to comply with all the descriptions mentioned in the inspection check sheet which were formulated on the basis of MRs. The houses that have been reconstructed till date do not fulfill all the MRs as a result many houses have not been approved to receive the grant. Hence, this manual is prepared to introduce the exceptional cases, other than mentioned in MRs. and several correction measures along with their step by step procedures for mitigation measures.

Beneficiaries whose houses were considered as non-compliant will get a chance to make their house compliant if their house falls under any case of the exception or adopt the appropriate correction measures mentioned in this manual. On the other hand, this manual is helpful to all the engineers who are working for the reconstruction and are deployed by GoN for inspection. As many exceptional cases and tolerance were introduced in this manual, it will help them to fill up the inspection check sheet.

The manual has been divided into two sections so that they could be conveniently used for inspection and provide correction order, if need.

PART-A: Exception / Correction
PART-B: Mitigation measures

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

Standardization Committee, NRA for Reconstruction of Earthquake Resistant Houses
## ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GoN</td>
<td>Government of Nepal</td>
</tr>
<tr>
<td>PDNA</td>
<td>Post Disaster Needs Assessment</td>
</tr>
<tr>
<td>NRA</td>
<td>National Reconstruction Authority</td>
</tr>
<tr>
<td>MoUD</td>
<td>Ministry of Urban Development</td>
</tr>
<tr>
<td>DUDBC</td>
<td>Department of Urban Development and Building Construction</td>
</tr>
<tr>
<td>MoFALD</td>
<td>Ministry of Federal Affairs and Local Development</td>
</tr>
<tr>
<td>CL-PIU</td>
<td>Central Level Project Implementation Unit</td>
</tr>
<tr>
<td>DL-PIU</td>
<td>District Level Project Implementation Unit</td>
</tr>
<tr>
<td>IOE, TU</td>
<td>Institute of Engineering, Tribhuvan University</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>NSET</td>
<td>National Society for Earthquake Technology-Nepal</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>HRRP</td>
<td>Housing Recovery and Reconstruction Platform-Nepal</td>
</tr>
<tr>
<td>MRs</td>
<td>Minimum Requirements</td>
</tr>
<tr>
<td>NBC</td>
<td>Nepal National Building Code</td>
</tr>
<tr>
<td>IS</td>
<td>Indian Standard</td>
</tr>
<tr>
<td>SMM</td>
<td>Stone Masonry in Mud mortar</td>
</tr>
<tr>
<td>BMM</td>
<td>Brick Masonry in Mud mortar</td>
</tr>
<tr>
<td>SMC</td>
<td>Stone Masonry in Cement mortar</td>
</tr>
<tr>
<td>BMC</td>
<td>Brick Masonry in Cement mortar</td>
</tr>
<tr>
<td>RCC</td>
<td>Reinforced Cement Concrete</td>
</tr>
<tr>
<td>RC</td>
<td>Reinforced Concrete</td>
</tr>
<tr>
<td>CGI</td>
<td>Corrugated Galvanized Iron</td>
</tr>
<tr>
<td>GI</td>
<td>Galvanized Iron</td>
</tr>
<tr>
<td>PP</td>
<td>Polypropylene</td>
</tr>
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BACKGROUND

Under the Government of Nepal (GoN) housing reconstruction programme, a housing reconstruction grant is disbursed based on construction compliance with the Minimum Requirements (MRs) as per the Nepal National Building Code (NBC) and the inspection checklists. Many houses have been found during inspection to be non-compliant with these MRs. These buildings are therefore vulnerable to future earthquakes, as they do not have the required earthquake resistant elements. In order to bring these houses to compliance, corrective measures are required.

This manual has been developed to support engineers responsible for the compliance inspection process. The engineers will use this manual to provide advice and guidance to households for the implementation of required corrective measures. Home owners will need to complete these corrective measures in order to be eligible to receive the subsequent tranches of the housing reconstruction grant.
SCOPE

☐ Applicability

This manual is applicable within certain limitations as guided by NBC 202 and NBC 203, which are based on NBC 105 seismic design code. The corrections and the exceptions set forth in this manual are applicable only for the residential houses that have been constructed after Gorkha earthquake 2015 under the GoN housing reconstruction program. The manual intends to achieve the minimum acceptable structural safety envisioned in NBC 105. The designs mentioned in the manual are ready-to-use designs for all structural components, but some provisions mentioned are set as advisory measures.

☐ Limitations

This corrections / exceptions manual covers only load bearing masonry buildings under the GoN housing reconstruction programme. The corrective measures are only for buildings that are newly constructed, or under construction.

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

I. Residential and fall under category ‘C’ and ‘D’ of NBC.

☑ 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 4.5 meters.

☑ Category "D": Small houses, sheds made of baked or unbaked brick, stone, clay, bamboo, grass etc., except those set forth in clauses (a), (b) and (c).

* If the construction up to plinth level is as per requirement, applications can be recommended for second tranches. Correction or mitigation works at super structure should be made before third tranche.
PART-A: Exception/ Correction

[Exception]
Exception is the cases of the buildings that do not comply with MRs but are structurally safe as per NBC 105 including the cases mentioned in NBC. The exceptional cases were drafted by the NRA technical standardization committee on the basis of seismic requirements following NBC 105. Hence, when all required corrective measures have been completed the building can be approved for the subsequent tranche of the housing reconstruction grant.

[Correction]
Correction is the corrective measures required to make newly constructed or under construction buildings compliant with the seismic resistance standard as per NBC 105.
The appropriate corrective measures can be carried out on any individual building which is missing earthquake resistant elements as per MRs and at any stage of construction. These measures were drafted by the NRA technical standardization committee on the basis of seismic requirements following NBC 105.
Hence, when all required corrective measures have been completed the building can be approved for the subsequent tranche of the housing reconstruction grant.
1.1 Site condition (treatment / retaining wall)

- The building site shall be safe to withstand natural hazards. Where there is evidence of inherent natural hazard in a locality, any existing buildings shall be studied to assess site conditions. Similarly, local practices used to manage such hazards, shall be judged based on the required level of acceptable risk. Areas which are susceptible to liquefaction during an earthquake should also be avoided.

**Problem**

- Site selection shall be done so as to minimize risks in relation to natural hazards. No buildings shall be constructed in hazardous areas:

<table>
<thead>
<tr>
<th>HAZARD AREA</th>
<th>Exception / Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological fault or</td>
<td>- Not to be evaluated for residential building</td>
</tr>
<tr>
<td>Ruptured area</td>
<td></td>
</tr>
<tr>
<td>Water-Logged area</td>
<td>- Constructions is allowable, if the site is appropriately treated be undertaken.</td>
</tr>
<tr>
<td>River Bank</td>
<td>- Maintain minimum distance from river bank and observed high flood level.</td>
</tr>
<tr>
<td>Steep Slope</td>
<td>- If the terrain is stable and soil is medium to hard, construction on steep slopes is allowable.</td>
</tr>
<tr>
<td>Filled Area</td>
<td>- If a building is to be constructed on filled-ground, the foundation shall be deep enough so as to rest on the firm ground surface beneath the fill.</td>
</tr>
<tr>
<td>Rock-fall Area</td>
<td>- Building can be constructed in such areas except in risky rock fall area identified by geological study and local knowledge.</td>
</tr>
</tbody>
</table>

**Steep slope area**

**Constructed retaining wall**
Retaining walls should be constructed following the standards in the building code and related guidelines. Table 1 below provides some examples of masonry retaining walls.

**Table 1. Masonry retaining walls to select for different conditions**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Dry stone</th>
<th>Banded dry stone</th>
<th>Cement Masonry</th>
<th>Gabion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagrammatic cross-section</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Top width</td>
<td>0.6~1.0m</td>
<td>0.6~1.0m</td>
<td>0.5~1.0m</td>
<td>1m</td>
</tr>
<tr>
<td>Base width</td>
<td>0.5~0.7H</td>
<td>0.6~0.65H</td>
<td>0.5~0.65H</td>
<td>0.6~0.75H</td>
</tr>
<tr>
<td>Front batter</td>
<td>Vertical</td>
<td>Varies</td>
<td>10 : 1</td>
<td>6 : 1</td>
</tr>
<tr>
<td>Back batter</td>
<td>Varies</td>
<td>Vertical</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Nward drip Foundation</td>
<td>1 : 3</td>
<td>1 : 3</td>
<td>Horizontal or 1 : 6</td>
<td>1 : 6</td>
</tr>
<tr>
<td>Foundation depth</td>
<td>0.5m</td>
<td>0.5~1.0m</td>
<td>0.5~1.0m</td>
<td>0.5m</td>
</tr>
<tr>
<td>Range of height</td>
<td>1~3m</td>
<td>1~6m</td>
<td>1~8m</td>
<td>1~6m</td>
</tr>
<tr>
<td>Hill slope angle</td>
<td>&lt;35°</td>
<td>&lt;35°</td>
<td>&lt;45°</td>
<td>&lt;45°</td>
</tr>
<tr>
<td>General</td>
<td>Set stones along foundation bed. Use long band stones hand. Hand packed stones in back fills.</td>
<td>Cement masonry bands of 50cm thickness at 3m c/c. Other specifications as per dry stone wall.</td>
<td>Weep holes 15x15cm size at 1~2m c/c 50cm rubble backing for drainage.</td>
<td>Stones to be hand packed stone shape important. Blocky preferable to tabular.</td>
</tr>
</tbody>
</table>

*Modified from IS 14458-1 [Guidelines for retaining wall for hill area, Part 1: Selection of type of wall].

*See Mitigation Measures 1 for advice on how to construct retaining wall.
2-1. Span of wall, Size of room, Height of wall

**Problem**

- Long or high unrestrained walls will deflect during earthquakes.
- Irregular shaped buildings will experience torsional effect during earthquakes.
- Complex shapes increase stress on parts of the building during earthquakes and will cause damage or failure.

**Common Defects**

- Span of wall is more than 4.5m.
- Size of room is more than 13.5sq.m.
- Height of wall is more than 3.0m.

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Shape of building</td>
<td>Clear span of wall</td>
<td>Not more than 12 times thickness of wall and not more than 4.5m.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size of room</td>
<td>Not more than 13.5sq.m.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height of wall</td>
<td>Floor height shall not be more than 3.0m.</td>
</tr>
</tbody>
</table>
2. Shape of building

**Exception**

E1. The span of wall up to 12 times of wall thickness is acceptable in one direction, in case where wall thickness is more than 350mm.

E2. The size of room is restricted to 13.5 sq.m only for those houses with RCC slab. The thickness of RCC slab should be 115mm -125mm.

E3. The height of wall can be variable, if the wall thickness is more than 350mm and 230mm for stone and brick masonry respectively. However, the height to wall thickness ratio of a wall shall not be more than 1:8 for stone masonry and 1:12 for brick masonry.

**Solution**

- Provide buttress wall with RCC band or wooden band with proper connection of buttress wall to existing wall. Use of buttress add strength and stiffness to long walls.
- Provide cross walls with R.C.C or wooden bands to divide the building into smaller spans.

**Correction**

Span and size of room is more than in MRS

*See Mitigation Measures 2 and 3, for advice on how to construct buttress and cross wall*
2.2 Shape of building (Proportion)

Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Shape and size of building</td>
<td>Proportion</td>
<td>Simple and regular shaped as square and rectangular shapes. The length of house shall not be more than 3 times of its width. Avoid setbacks.</td>
</tr>
</tbody>
</table>

Problem

- Complex shapes increase the stress on parts of the building during earthquakes and will cause damage or failure.
- In order to minimize torsion motions, the building should be symmetrical and have a simple rectangular plan.

Common Defects

- L, U and T shapes
- The length of house is more than 3 times of its width.
2. Shape of building

Exception

E1. The projected length up to (one fifth 1/5) of building length is acceptable, if all other requirements of MRs are fulfilled.

E2. For small residential buildings not exceeding 100 sq.m. in plinth area with flexible floor and cross walls, the shape criterion of building can be ignored.

E3. The cantilever-projection of roof/floor, where provided, shall not exceed 1m from center of wall. No load bearing walls shall be constructed over such cantilever-projections.

E4. If the load bearing wall continues from ground floor to first floor on the same vertical line, vertical setback is allowable.

Solution

- Provide expansion joint.
  - For preventing hammering or pounding damage between blocks, a physical separation of 40mm to 50mm throughout the height and above the plinth level shall be provided.

Correction

Expansion joint for L-shape

Expansion joint for long building
### Problem

- Excessive storeys above the limits leads to high risk during an earthquake.

### Common Defects

- One storey plus attic constructed by stone masonry in mud mortar with wooden band.
- Two storeys constructed by stone masonry in mud mortar.
- Mix used of construction materials i.e. stone and mud mortar masonry ground floor and CGI and timber first floor.

### Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Shape of building</td>
<td>No. of storey</td>
<td>SMM/BMM RC band Not more than one plus habitable attic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SMM/BMM Timber band Not more than one storey.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SMC/BMC Not more than two plus attic</td>
</tr>
</tbody>
</table>

Two storeys constructed by stone masonry in mud mortar.

One+Attic by stone masonry in mud mortar with wooden band

Mixed structure

*See Options in ANNEX For advice on strengthen methods*
2. Shape of building

Exception

E1. If structure is found to be safe after structural calculation.

Solution

• Demolish storeys above the limits prescribed in MRs.
• Incase of one storey and attic in SMM or BMM with wooden band, provide RC roof band or provide gabion wire mesh or wooden members connecting the roof band to lower level band (floor band or lintel band).

Correction

One storey plus attic constructed by stone masonry in mud mortar with wooden band.

- Adding RC Roof Band
- Adding Wooden element
- Adding gabion wire mesh

*See Mitigation Measures 8
For advice on construct horizontal band

*See Mitigation Measures 11
For advice on strengthen the wall
### 3.1 Using improper materials, Mix materials

#### Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>Materials</td>
<td>Stone</td>
<td>Avoid use of rounded, subrounded, easily breakable soft stone and boulder stones in its natural shape. River stone shall be dressed. Size of stone shall not be smaller than 50mm in thickness and 150mm in length or breadth.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brick</td>
<td>Over burnt, under burnt and deformed bricks shall not be used. Shall have minimum crushing strength of 3.5 Mpa for construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timber</td>
<td>Well seasoned hard wood without knots shall be used for structural purpose. Timber treatment such as use of coal tar or any other preservative can prevent timber from being decayed and attacked by insects.</td>
</tr>
</tbody>
</table>

#### Problem

- Load bearing masonry must have sufficient stability and strength to withstand lateral forces. Substandard walls may fail by cracking.
- Construction of walls or parts of the building in different materials results in poor connections.

#### Common Defects

- Improper size of stone was used.
- Use of easily breakable soft stone and boulder stones as river stone in its natural shape.
- Mix-use of stone, brick, and concrete block.
- Use of untreated and soft wood in structural member.
3. Materials

**Exception**

E1. The size of stone, used as fillers for proper bonding can be variable.
E2. Well treated locally available wood can be used. The size of these wood shall be as per mentioned in MRs.
E3. Mix use of stone and brick is acceptable if there is proper connection between these materials.
E4. Mix use of wooden and concrete band at different level is acceptable in mud masonry.

**Solution**

- Treatment of wood
- Strengthen the weak masonry wall, using proper correction method.
- Provide jacketing for masonry wall.

**Correction**

*Correction method for weak masonry walls is shown in section 7. about Wall. Jacketing for masonry walls is a potential correction method.*

*See Mitigation Measures 11 For advice on strengthen the wall*
## 4.1 Insufficient Foundation

### Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Foundation</td>
<td>General</td>
<td>It shall be continuous strip footing of uniform width at same level throughout the foundation in flat area. * If the building has to be constructed in existing foundation consult with expert.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type of soil</td>
<td>One storey</td>
</tr>
<tr>
<td></td>
<td>SMM</td>
<td>All</td>
<td>&gt; 750mm</td>
</tr>
<tr>
<td></td>
<td>BMM</td>
<td>All</td>
<td>&gt; 750mm</td>
</tr>
<tr>
<td></td>
<td>SMC</td>
<td>All</td>
<td>&gt; 800mm</td>
</tr>
<tr>
<td></td>
<td>BMC</td>
<td>All</td>
<td>&gt; 800mm</td>
</tr>
</tbody>
</table>

|     | Type of soil | One storey | Two storey |
|     | SMM          | Soft soil  | > 800mm    | -           |
|     | Medium soil  | > 750mm    |            |
|     | Hard soil    | > 750mm    |            |
|     | BMM          | Soft soil  | > 750mm    | -           |
|     | Medium soil  | > 650mm    | -           |
|     | Hard soil    | > 550mm    |            |
|     | SMC          | Soft soil  | > 800mm    | Not recommended |
|     | Medium soil  | > 600mm    | > 800mm    |
|     | Hard soil    | > 600mm    | > 600mm    |
|     | BMC          | Medium soil| > 550mm    | > 650mm    |
|     | Hard soil    | > 550mm    | > 550mm    |

### Problem

- In order to transmit the load of the building to the ground uniformly, a proper foundation is required. Soft soil can cause more settlement and distortion during earthquakes.

### Common Defects

- No foundation
- Improper foundation

![No foundation](image1.jpg)

![Shallow depth of foundation](image2.jpg)
### Exception

E1. Foundations size can be variable for hard rock bed. Here, proper levelling of foundation is required with proper anchorage of vertical element to the rock.

### Solution

- Excavate and provide additional foundation with proper connection with existing foundation.

*Foundation correction is relatively difficult and should be carefully managed.*

### Correction

- Insufficient Foundation.
  - Depth
  - Width
  - Shape

Additional external foundation

1. Old foundation
2. New concrete beams
3. Connecting lateral concrete beams
5.1 R.C Vertical Member

### Minimum Requirements

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Vertical</td>
<td>General</td>
<td>Shall be started right from the foundation and continue up to the roof band.</td>
</tr>
<tr>
<td></td>
<td>member</td>
<td></td>
<td>Place vertical member at all corners, junctions of walls and adjacent to all</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>doors and windows. Steel or timber can be used as vertical member.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement</td>
<td>At corners and junctions vertical reinforcing bar shall be 12mm for one</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>storey, and 16mm for two storey. They shall be covered with concrete or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1:4 mortar in cavities made around them during the masonry construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anchorage</td>
<td>Should be started right from the foundation and continue up to the band.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In case of using existing foundation, it shall be anchored to plinth band.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The anchorage length shall be 60 times diameter of the bar.</td>
</tr>
</tbody>
</table>

### Problem

- 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.

### Common Defects

- Absence of reinforcement at corner and T-junction.
- Placement of reinforcement bars in incorrect positions.
- Size of reinforcement bars is different than MRs.
- Absence of vertical reinforcement bars at the side of openings.

Absence of reinforcement at corner and T-junction.  
Vertical reinforcement provided at different location.
5. Vertical Member

**Exception**

E1. 12mm diameter vertical reinforcement can be used in one storey and one plus attic building.
E2. If total length, height and location of opening is appropriate as per MRs, reinforcement of opening can be ignored. (*Height of opening should be less than 50% of wall height)
E3. If the windows are provisioned with wooden double framed box and well connected to sill and lintel horizontal bands then vertical reinforcement around the windows can be ignored.

**Solution**

- Provide RC vertical reinforcement(splint) on the wall wherever required and anchor them sufficiently with the wall.
- Provide Welded GI wire mesh splint on the wall wherever required and anchor them sufficiently with the wall.

*In corner and T-junctions, RC vertical reinforcement(splint) can be provide only on outside.

**Correction**

No RC vertical member.

*See Mitigation Measures 4 and 5 For advice on installation RC vertical reinforcement and bandage*
5.2 Wooden Vertical Member

Minimum Requirements

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Vertical member</td>
<td>General</td>
<td>Shall be started right from the foundation and continue up to the roof band. Place vertical member at all corners, junctions of walls and adjacent to all doors and windows. Steel or timber can be used as vertical member.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement</td>
<td>Timber Hard wood. One member of 75mm x 100mm for corner. Two member of 75mm x 100mm for openings</td>
</tr>
</tbody>
</table>

Problem

- 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.

Common Defects

- Absence of vertical wooden members at corner and T-junction
- Placement of vertical wooden members in incorrect positions.
- Size of wooden members is different than as per MRs.
- Use of untreated soft wood.
5. Vertical Member

**Exception**

E1. If total length, height and location of opening is appropriate as per MRs, vertical members of openings is not restricted. (*Height of opening should be less than 50% of wall height)

E2. If the openings are provisioned with wooden double framed box and properly connected to horizontal bands then vertical members around the openings as well as can be ignored.

**Solution**

- Place vertical member at the inside or outside corner of the wall.
- Use double framed box windows or doors instead of reinforcement of side of openings.

**Correction**

*See Mitigation Measures 6 For advice on installation wooden vertical member

**Installation of vertical member**

- Vertical member from inside of the wall
- Vertical member from outside of the wall

*See Mitigation Measures 6 For advice on installation wooden vertical member
6.1 No Plinth beam / Level of Plinth

Minimum Requirements

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Plinth</td>
<td>General</td>
<td>The level of plinth shall not be less than 300mm from ground level.</td>
</tr>
</tbody>
</table>

Problem

- An unequal or loosely packed plinth will not provide a base of sufficient stability during an earthquake.
- Rotten timber in structural members will fail during an earthquake. Timber should be kept away from contact of moisture.

Common Defects

- Absence of plinth band
- Level of plinth is less than 300mm from ground level.
E1. The height of plinth level can be changed as per site condition such as surrounding road level, rainfall intensity of area, drainage condition etc.

Solution

- If the plinth band is missing, provide external plinth band on the wall with proper connection.
- If the height of plinth is less than 300mm,
  - Improve site drainage and provide apron.
  - Increase ground floor level.
  - Provide Damp proofing course.
*Wooden band should be protected from ground water, rainwater and contact of moisture.

Correction

For no plinth beam
Provide external plinth band

*same methods as additional horizontal band.

For low level of Plinth
Improving site drainage

Drainage

Increasing floor level

*See Mitigation Measures 8 and 9
For advice on construct horizontal band
7.1 Weak masonry / Lack of Through stone

Problem

- Load bearing masonry must have sufficient stability and strength to withstand lateral forces. Substandard walls may fail by cracking.
- During earthquakes, delamination of wall is caused due to the absence of through stone and overuse use of small stones.
- Construction using mixed materials for the wall may result in poor connections and requires additional detailing to tie the building together.

Common Defects

- Weak masonry using low quality of material.
- Absence of through stone and horizontal or vertical distance of through-stone is inappropriate.
- Mix of materials used in masonry walls.
Exception

E1. If full-length stones are not available, pairs of stones, each not less than three quarters of the wall thickness long shall be used in place of one full-length stone so as to provide an overlap between them.

E2. Alternatively, seasoned wooden dowels or precast concrete or in-situ concrete or steel hooked link or S-shaped tie can be used instead of through stones.

Solution

- Insert through stone or connector at the required spacing.
- Strengthen the weak masonry wall, using appropriated correction method, for example jacketing method for masonry walls.

Correction

For absence of through stone

Insert through stone

For weak masonry

Jacketing for masonry wall

*SSee Mitigation Measures 11 For advice on strengthen the wall

*Correction measure are advisory only.
7.2 Vulnerable Gable wall

Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Walls</td>
<td>Gable wall</td>
<td>Provide light gables using wood, CGI sheets etc.</td>
</tr>
</tbody>
</table>

Problem

- Gable masonry walls causes unbalanced mass in the building. During earthquake this masonry is highly vulnerable as it is not restrained.

Damage of stone masonry gable wall

Common Defects

- Unsupported masonry gable wall.

Unsupported gable wall

Unsupported gable wall
**Exception**

E1. Masonry gable wall with gable RC band is acceptable, if all other requirement of MRs are fulfilled. However, it is efficient to replace gable masonry wall with a truss covered with light weight materials.

**Solution**

- Replace the gable masonry with light weight material.
- Provide additional RC gable band over gable wall and connect it with the roof truss.

**Correction**

*See Mitigation Measures Band 9 For advice on construct horizontal band*
8.1 Inappropriate Position and Size of Openings

Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Doors / windows.</td>
<td>8</td>
<td>Keep lintel level same for all doors and windows. 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total length</td>
<td>The total length of openings in a wall is not to exceed 30 % of the length of the wall between consecutive cross-walls in single-storey construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMM/BMM</td>
<td>The total length of openings in a wall is not to exceed 50 % of the length of the wall between consecutive cross-walls in single-storey construction, 42 % in two-storey construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance</td>
<td>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.</td>
</tr>
</tbody>
</table>

Problem

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

Common Defects

- Lintel level of opening is different.
- Percentage of opening is greater than its allowable.
- Position of opening is different than as per MRs.
8. Door and Windows

**Solution**

- Strengthening opening itself (wooden double frame).
- Strengthening around openings, i.e. providing vertical reinforcement.

**Correction**

**Exception**

E1. If vertical elements of side of opening is appropriate as per MRs, total length and location of opening can be ignored.
E2. If wooden double framed door and window with appropriate connection with horizontal band are provided, position and size of openings can be variable.
E3. If concrete wall is constructed between two opening, the horizontal distance less than 600mm is acceptable.
E4. In case of projected walls to make Dalan, the wall along the orthogonal direction should be equal or more than two times of wall thickness with proper resistant elements.

*See Mitigation Measures 7 For advice strengthening opening*
9.1 R.C. Horizontal band

**Minimum Requirements**

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Horizontal</td>
<td>General</td>
<td>Horizontal bands shall be provided throughout the entire wall at plinth, sill, lintel, and roof level.</td>
</tr>
<tr>
<td></td>
<td>band</td>
<td>RC band</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sill band</td>
<td>A continuous sill band shall be provided through all walls at the bottom level of windows. The minimum thickness is 75mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel band</td>
<td>A continuous lintel band shall be provided through all walls at the top level of opening. Where opening width do not exceed 1.25m and masonry height above opening do not exceed 0.9m, 75mm lintel is sufficient. For opening width upto 2m and masonry height above opening upto 1.2m, 150mm lintel band is necessary.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stitch band</td>
<td>At corners and junctions, stitches (dowels) shall be provided addition at a vertical spacing of 500-700mm. The minimum length is 1.2m. The minimum thickness is 75mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof band</td>
<td>It shall be provided at the top-level of walls, so as to integrate them properly at their ends and fix them into the walls. The minimum thickness is 75mm.</td>
</tr>
</tbody>
</table>

**Problem**

- Horizontal bands 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.

**Common Defects**

- Absence of horizontal band
- Insufficient reinforcement was used
- Discontinuous horizontal band
- Insufficient thickness of band.
- Absence of reinforcement in RC band.
9. Horizontal Band

Exception

E1. If the floor height is less than or equal to 2.5m, the lintel band can be integrated with the floor / roof band.
E2. If required amount of reinforcement with appropriate cover, as per MRs is provided thickness of band can be accepted within 10% tolerance, if all other requirement of MRs are fulfilled.

Solution

• Provide external continuous RC horizontal bands on both faces of the wall.
• If lintel band is not provided, dismantle masonry above opening and construct a continuous lintel band.
• Provide Welded GI wire mesh bandages on both faces of wall wherever required and anchor them sufficiently with the wall

Correction

*See Mitigation Measures 8 and 9 For advice on construct RC horizontal band
**9.2 Wooden Horizontal Band**

**Minimum Requirements**

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Horizontal band</td>
<td>General</td>
<td>Wooden band</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sill band</td>
<td>Main wooden member, 2-75mmX38mm shall be placed along with wall and properly connected with batten, 50mmX38mm @ 500c/c.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lintel band</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stitch band</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roof band</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reinforcement</td>
<td>* Stitch (Mid band) shall be continuous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connection</td>
<td>Main wooden member shall be properly connected with 4 nails and batten with 2 nails. 5mm wooden nail or 3.15mm galvanized steel nail can be used.</td>
</tr>
</tbody>
</table>

**Problem**

- Horizontal band helps to tie the orthogonal wall together. If it is absent the building is more vulnerable to earthquakes.
- In plane and out of plane failure of wall might takes place in absence of horizontal wall.

**Common Defects**

- Absence of horizontal band
- Insufficient size of wood was used
- Discontinuous sill and lintel band.

Absence of lintel band  
Discontinuity of band  
Absence of horizontal band  
Absence of horizontal band
**9. Horizontal Band**

**Exception**

E1. If the floor height is less than or equal to 2.5m, the lintel band can be integrated with the floor / roof band.

**Solution**

- Provide horizontal wooden member from outer and inner wall and tie with GI wire, or provide RC and GI wire mesh bandage.

**Correction**

*See Mitigation Measures 10 For advice on construct Wooden horizontal band*
10.1 Connection / Heavy Material for Roofing

Minimum Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Sub-category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Roof</td>
<td>General</td>
<td>Use light roof comprising wooden or steel truss covered with CGI sheets.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connection</td>
<td>All members of the timber truss or joints shall be properly connected. Arrangements shall be done for connecting roof and wall.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bracing</td>
<td>For flexible diaphragm, diagonal bracings shall be considered.</td>
</tr>
</tbody>
</table>

Problem

- The roof needs to be framed as a box to add stiffness to the main frame and to resist wind loads.

Common Defects

- Use heavy weight material for roofing. (ex. slate stone, clay tile)
- Absence of connection between wall and roof

Slate stone roof

Clay tile roof

Connection of wooden truss

Connection of wooden truss
E1. If structural details for fixing roof materials are found to be safe using locally available materials.

**Solution**

- Using correct fixing for roofing materials.
- Connect the roof with the roof band by inserting reinforcement or GI sheet.
- Slatestone and clay tiles should be properly anchored to purlin as NBC.

**Correction**

- Use a continuous wall plate, ridge and purlins to tie the rafters or trusses together.
PART-B: Mitigation Measures

[Mitigation Measures]
Different corrective measures have been introduced for the non-compliant issues, whereas some similar non-compliant issues can be solved by using different corrective measures. The Mitigation Measures consist of step by step procedure for implementing such correction. Depending upon the availability of materials and workmanship suitable Mitigation Measures can be adopted.
1. Construction of retaining wall

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geometry: Slope</strong></td>
</tr>
<tr>
<td>• The front face of the wall should be inclined at a slope of 1:5, either in a slope or in steps.</td>
</tr>
<tr>
<td>• The rear face should be vertical or slope parallel to the front face.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geometry: Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The base width of the wall should be minimum $\frac{1}{2}$ of the retained height, ideally $\frac{2}{3}$rd of the retained height. The top of the wall should be 2 ft. wide.</td>
</tr>
<tr>
<td>• Terracing of the site can reduce the height of the wall and therefore the required width and total volume of masonry</td>
</tr>
</tbody>
</table>

![Diagram of retaining wall](image)

<table>
<thead>
<tr>
<th>Workmanship:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stones should be laid cours ed, at an incline to the vertical, sloping downwards towards the retained slope.</td>
</tr>
<tr>
<td>• Stone should be placed tightly to ensure good interlocking and friction.</td>
</tr>
<tr>
<td>• Use flat field stones, do not use round stones. Mortar should not be a substitute for good masonry.</td>
</tr>
<tr>
<td>• Through stones, should be laid every 4ft. Vertically and horizontally, perpendicular to the length of the wall.</td>
</tr>
</tbody>
</table>
2. Strengthening wall with Buttressing

**Wooden horizontal band**

- **Existing wall**
- **New wall (Buttress)**

**Steps**:
1. Drill & insert steel bars of new wall bands inside existing wall.
2. Remove cover from band on other side of wall.
3. Bend the bars and reconcrete.

- Interlocking stone at every 600mm height

**Materials**:
- 4mm thick metal strap
- 3 layers of GI sheet 28 gauge (0.35mm)
- 3.55mmΦ 75mm long nails

**Addition of buttress wall when length of wall is greater than 12t**

**RC horizontal band**

- **Existing wall**
- **New wall (Buttress)**

**Steps**:
1. Drill & insert steel bars of new wall bands inside existing wall.
2. Remove cover from band on other side of wall.
3. Bend the bars and reconcrete.

- Interlocking stone at every 600mm height

**Materials**:
- Φ75mm long nails
- 38mm

**Connection of buttress wall to existing wall**
3. Adding Cross wall

Addition of cross wall when length of wall is greater than 12t.

**RC horizontal band**

- Step 1: Drill & insert steel bars of new wall bands inside existing wall.
- Step 2: Remove cover from band on other side of wall.
- Step 3: Bend the bars and reconcrete.

**Wooden horizontal band**

- Interlocking stone at every 600mm height.

**Connection of cross wall to existing wall**

- 4mm thick metal strap or 3 layers of GI sheet 28 gauge (0.35mm)
- 3.55mm Ø 75mm long nails
4. Installation RC vertical reinforcement

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

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

Option I: Round Shaped Random Rubble Masonry
- At Corner
- At T-Junction

Option II: Other Masonry, (except Option I)
- At Corner
- At T-Junction

Details of splints
4. Installation RC vertical reinforcement

Note: Installation RC vertical reinforcement as per Option I is similar. However, construction procedures for option II is more clearly presented in following pages.

Details of foundation for splints

Anchorage Details

Details of anchorage of splints at corner and junction of wall
# Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 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. | ![Image](image1.png) |
| 2.   | **Foundation Preparation**  
• Dig out trench for foundation as per suggested depth for placing tie beams for splints.  
• Stone soling on the trench | ![Image](image2.png) |
| 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) | ![Image](image3.png) |
| 4.   | **Concreting of tie beam** | ![Image](image4.png) |
## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5.</strong></td>
<td><strong>Make holes for anchorage</strong>&lt;br&gt;i) For through GI wire :&lt;br&gt;• Make through holes in mud mortar on walls using steel rod and hammer at suggested locations.&lt;br&gt;• Insert GI wires at suggested interval and location&lt;br&gt;• When it is not possible to make a straight hole through the wall:&lt;br&gt;  - Remove stone on one side of wall, then insert a GI wire through the wall by bending it&lt;br&gt;  - Place the removed stone back into the wall using mortar&lt;br&gt; ii) For anchorage bar :&lt;br&gt;• Make holes on one wyth of wall using steel rod and hammer.&lt;br&gt;• Insert steel anchorage bars at suggested interval and location&lt;br&gt;• When it is not possible to make a hole on wall:&lt;br&gt;  - Remove stone on one wyth of wall, then place anchorage bar&lt;br&gt;  - Place the removed stone back into the wall using mortar</td>
<td><img src="image1.png" alt="Imagery showing a worker inserting a GI wire through a wall" /> <img src="image2.png" alt="Imagery showing removing a stone from a wall" /></td>
</tr>
<tr>
<td><strong>6.</strong></td>
<td><strong>Anchor reinforcing bar mesh</strong>&lt;br&gt;• Fix reinforcing bars into the wall using inserted steel anchorage bars, jam the anchorage bar using cement slurry.&lt;br&gt;• Connect inner and outer mesh using inserted through G.I. wires</td>
<td><img src="image3.png" alt="Imagery showing a worker fixing reinforcing bars into a wall" /></td>
</tr>
</tbody>
</table>
### 4. Installation RC vertical reinforcement

#### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 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. | ![Image](image1.jpg) |
| 8.   | **Curing of concrete**  
  • Cure the concrete for 14days.  
  • Use jute bags/ mats for better curing | ![Image](image2.jpg) |
5. Installation GI mesh for splint

Provide GI Welded wire mesh 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 splint

Corners

Junctions

450mm

30mm

30mm

Welded GI wire mesh
10 gauge (3.24mm)Φ bar @ 25mm c/c

1:3 cement sand plaster or stabilized mud mortar plaster

PART-B: Mitigation Measures

450mm

450mm

30mm

30mm

450mm

450mm

30mm
5. Installation GI mesh for splint

Details of foundation

Anchorage Detail

Details of anchorage of splints at corner and junction of wall
## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 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 \(\frac{1}{2}-1\)"  
  - Clean the surface, but do not use water for cleaning as mud mortar will be moved.  
  - Apply a thin layer of cement slurry on these areas. | ![Image 1](image1.png) |
| 2.   | **Foundation Preparation:**  
  - Dig out trench for foundation at suggested portion for placing tie beams for splints  
  - Stone soling on the trench | ![Image 2](image2.png) |
| 3.   | **Make holes for anchorage**  
  i) For through GI wire:  
    - Make through holes in mud mortar on walls using steel rod and hammer at suggested interval and location.  
    - Insert GI wires at suggested interval and location  
    - When it is not possible to make a straight hole through the wall.  
      - Remove stone on one side of wall, then insert a GI wire through the wall by bending it.  
      - Place the removed stone back into the wall using mortar.  
  ii) For anchorage bar:  
    - Make holes on one width of wall using steel rod and hammer.  
    - Insert steel anchorage bars at suggested interval and location  
    When it is not possible to make a hole in the wall:  
      - Remove stone on one wyth of wall, then place anchorage bar.  
      - Place the removed stone back into the wall using mortar | ![Image 3](image3.png) |
| 4.   | **Painting of GI wire mesh**  
  - Welded GI wire mesh generally available in market are not galvanized properly, hence get corroded easily.  
  - Hence to prevent it from corrosion, paint it with Black Japan Paint or Bitumen emulsion paint | ![Image 4](image4.png) |
5. Installation GI mesh for splint

**Construction procedure**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 5.   | **Placing of GI wire mesh**  
  • Place the horizontal bars in the trench  
  • Now, place vertical GI wire mesh of splints  
  • Anchor them to the steel bar of trench  
  (Note: Lapping of mesh wherever required should be minimum 1 feet.) | ![Image](image1.png) |
| 6.   | **Anchor GI wire mesh**  
  • Connect inner and outer mesh using inserted through G.I. wires.  
  • Fix mesh into the wall using inserted steel anchorage bars, jam the anchorage bar using cement slurry. | ![Image](image2.png) |
| 7.   | **Concreting of foundation beam** | ![Image](image3.png) |
| 8.   | **Plastering**  
  • Apply 1:3 plaster about 1/2” thick in two layers. (Total thickness is 1”)  
  Or  
  Apply stabilized mud mortar plaster if cement is not available | ![Image](image4.png) |
| 9.   | **Curing of plaster**  
  • In case of cement sand plaster, cure the plaster area for 7days.  
  • Use jute bags/mats for better curing | ![Image](image5.png) |
### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Pictures</th>
</tr>
</thead>
</table>
| **1.** | **Surface preparation:**  
• Remove the plaster from the areas of the wall where reinforcements are to be placed.  
• Rake out the mortar up to the depth of ½”-1”.  
• Clean the surface, but do not use water for cleaning as mud mortar will be removed.  
• Apply a thin layer of cement slurry on these areas. | ![Surface preparation](image1) |
| **2.** | **Make holes for anchorage:**  
• Make through holes in mud mortar on walls using steel rod and hammer at suggested location.  
• Insert GI wires at suggested intervals and location.  
• When it is not possible to make a straight hole through the wall:  
  - Remove stones on one side of the wall, then insert a GI wire through the wall by bending it.  
  - Place the removed stone back into the wall using mortar. | ![Make holes for anchorage](image2) |
| **3.** | **Installation of vertical wooden member:**  
• Place 100mmX75mm vertical wooden member on either side of wall. | ![Installation of vertical wooden member](image3) |
| **4.** | **Anchor GI wire mesh:**  
• Connect the vertical wooden member with the wall using inserted GI mesh, jam the mesh using cement slurry or mud plaster. | ![Anchor GI wire mesh](image4) |
6. Installation of wooden vertical member

Details of wooden diagonal bracing

Details of connection of horizontal and vertical elements

- 4mm thick metal plate
- Or
- 3 layer of GI sheet plate of 28 gauge (0.35mm)
- 75mm X 100mm vertical timber post
- 4 nos. of 3.55mm dia 75mm long nails
7. Strengthen Opening

Option 1: Provide RCC splint on outer faces of wall wherever required and anchor them sufficiently with the wall.

**Openings**

- 2-10mm Φ bars 225mm
- 50mm
- 2-10mm Φ bars

**Details of splints around openings**

- 4.75mm Φ stirrups @150mm c/c
- 50mm
- 25mm
- 2-10mm Φ bars

**M15 Concrete**
- 1Part cement
- 2 part sand
- 4 part 10mm down aggregate

**Details of anchorage of splints around openings**

- 3.25mm (10 gauge) Φ GI wire (Connecting inner & outer mesh)
- 4.75mm anchorage bar
- Hole filled with cement slurry
- 16mm hole
- Anchorage bar
- Through Gabion wire
- 1200mm
7. Strengthen Opening

Option 2: Provide Welded GI wire mesh splint on outer faces of wall wherever required and anchor them sufficiently with the wall.
## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 1.   | **Surface preparation:**  
• Remove the plaster from the areas of the wall where reinforcements are to be placed.  
• Prop the lintel and sill band for embedment of reinforcement.  
• Rake out the mortar up to a depth of ½”-1”.  
• Clean the surface, but do not use water for cleaning as mud mortar will be removed.  
• Apply a thin layer of cement slurry on these areas. | ![Surface preparation](image1.png) |
| 2.   | **Installation of reinforcement:**  
• Install reinforcement bar for the vertical band.  
• The diameter of the bar should be as per the MRs  
• Place the removed stone back into the wall using mortar. | ![Installation of reinforcement](image2.png) |
| 3.   | **Installation of formwork:**  
• Install the formwork for the vertical band and pour concrete.  
• Short Crete an be used wherever feasible. | ![Installation of formwork](image3.png) |
| 4.   | **Curing:**  
• Cure the freshly laid concrete for 10 days.  
• Use jute bags/mats for better curing | ![Curing](image4.png) |
### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 1.   | **Surface preparation:**  
      - Clean the surface, but do not use water for cleaning as mud mortar will be removed.  
      - Take back the wall from around the opening | ![Surface preparation](image1.png) |
| 2.   | **Installation of wooden member:**  
      - Install the wooden batten to make the connection between the opening frame and wall.  
      - Connect the member and opening with steel plate and nails. | ![Installation of wooden member](image2.png) |
| 3.   | **Connection:**  
      - Connect the wooden member and the external wall with the wooden key | ![Connection](image3.png) |
8. Adding RC Horizontal band

Option 1: Provide RC horizontal bands on both side of wall on outer faces wherever required as shown in the following figures:

When it is not possible to transport concrete and steel to the site:

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

PART-B: Mitigation Measures

M15 Concrete
(1 part cement
2 part sand
4 part 10mm down aggregate)

3.25mm (10 gauge) GI wire
(Connecting inner & outer mesh)

4.75mm Φ stirrups @150 mm c/c

2-10mm Φ bars

Details of additional horizontal band
8. Adding RC Horizontal band

- **Detail of inserting through GI wire in wall**
  - 3.25mm (10 gauge) GI wire (Connecting inner & outer mesh)

- **Detail of inserting anchorage bar in wall**
  - 4.75mm anchorage bar
  - Hole filled with cement slurry

- **Detail of anchorage**
  - 16mm hole
  - 4.75mm anchorage bar
  - Hole filled with cement slurry

- **Detail of fixing RC band**
  - 16mm hole
  - 4.75mm anchorage bar
  - Hole filled with cement slurry

- **Gabion wire**
  - Anchorage bar
  - Through Gabion wire 1200 mm
  - 1200 mm
  - 50 mm
  - 50 mm
## 8. Adding RC Horizontal band

### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 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 \(\frac{3}{8}''-1''\)  
• 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 | ![Removing plaster](image1.png) |
| 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) | ![Reinforcement](image2.png) |
| 3.   | **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  
   • When it is not possible to make a straight hole through the wall:  
     - Remove stone on one side of wall, then insert a GI wire through the wall by bending it.  
     - Place the removed stone back into the wall using mortar.  
   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  
   • When it is not possible to make a hole on wall:  
     - Remove stone on one wyth of wall, then place anchorage bar  
     - Place the removed stone back into the wall using mortar | ![Holes](image3.png) |
### 8. Adding RC Horizontal band

#### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 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 | ![Anchor reinforcing bar mesh](image1.jpg) |
| 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. | ![Application of Micro Concrete](image2.jpg) |
| 6.   | **Curing of concrete**  
|      | • Cure the concrete for 14days.  
|      | • Use jute bags/ mats for better curing | ![Curing of concrete](image3.jpg) |
Option 2: Provide welded GI wire mesh bandages on outer faces of wall wherever required and anchor them sufficiently with the wall as shown in the following figures:

When it is not possible to transport concrete and steel to the site:

- **PART B: Mitigation Measures**
  - **Welded GI wire mesh**
    - 10 gauge (3.24 mm) Ø bar @ 25 mm/c
  - **1:3 cement sand plaster or Stabilized mud mortar plaster**
    - 30 mm

---

**Sill & Plinth band**

**Lintel & Floor band**

**Details of bandage**
9. Adding bandage (GI wire mesh)

PART-B: Mitigation Measures

Through Gabion wire
1200 mm
Anchorage bar

50 mm

1200 mm

50 mm

Detail of anchorage

Detail of fixing RC band
## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 1.   | **Surface Preparation:**  
• Remove the plaster from the areas of the wall where bandages are to be placed.  
• Rake out mortar upto the depth of $\frac{1}{2}”$-1”  
• Clean the surface, but don’t use water for cleaning as mud mortar will flow  
• Apply a thin layer of cement slurry on these areas | ![Removing plaster](image1.png) |
| 2.   | **Painting of GI wire mesh**  
• Welded GI wire mesh generally available in market are not galvanized properly, hence get corroded easily.  
• Hence to prevent it from corrosion, paint it with Black Japan Paint or Bitumen emulsion paint | ![Black Japan Paint](image2.png) |
| 3.   | **Placing of GI wire mesh**  
• Place horizontal GI wire mesh of bandages  
(Note: Lapping of mesh wherever required should be minimum 1 feet.) | ![Placing GI wire mesh](image3.png) |
| 4.   | **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  
• When it is not possible to make a straight hole through the wall:  
  - Remove stone on one side of wall, then insert a GI wire through the wall by bending it.  
  - Place the removed stone back into the wall using mortar.  
ii) For anchorage bar:  
• Make holes in one wyth of wall using steel rod and hammer  
• Insert steel anchorage bars at suggested interval and location  
• When it is not possible to make a hole in the wall:  
  - Remove stone on one wyth of wall, then place anchorage bar  
  - Place the removed stone back into the wall using mortar | ![Make holes for anchorage](image4.png) |
### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Image</th>
</tr>
</thead>
</table>
| **5.** | **Anchor GI wire mesh**  
  - Connect inner and outer mesh using inserted through G.I. wires  
  - Fix mesh into the wall using inserted steel anchorage bars, seal the anchorage bar using cement slurry | ![Anchor GI wire mesh](image1.png) |
| **6.** | **Plastering**  
  - Apply 1:3 plaster about 1/2” thick in two layers. (Total thickness is 1”)  
  - Or  
  - Apply stabilized mud mortar plaster if cement is not available | ![Plastering](image2.png) |
| **7.** | **Curing of plaster**  
  - In case of cement sand plaster, cure the plaster area for 7 days.  
  - Use jute bags/ mats for better curing | ![Curing of plaster](image3.png) |
# 10. Adding Horizontal band (Wood)

## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 1.   | **Surface preparation:**  
  • Remove the plaster from the areas of the wall where reinforcements are to be placed.  
  • Rake out the mortar up to a depth of ½”-1”.  
  • Clean the surface, but do not use water for cleaning as the mud mortar will be removed.  
  • Apply a thin layer of cement slurry on these areas. | ![Surface preparation](image1.png) |
| 2.   | **Make holes for anchorage:**  
  • Make through holes in mud mortar on walls using steel rod and hammer at 300mm c/c.  
  • Insert Gi wires at suggested intervals and location.  
  • When it is not possible to make a straight hole through the wall:  
    • Remove stones on one side of the wall, then insert a Gi wire through the wall by bending it.  
    • Place the removed stone back into the wall using mortar. | ![Drilled holes](image2.png) |
| 3.   | **Installation of horizontal wooden member:**  
  • Place 75mmX38mm horizontal wooden member on either side of wall. | ![Installation](image3.png) |
| 4.   | **Anchor Gi wire mesh:**  
  • Connect the horizontal wooden member with the wall using inserted Gi mesh, seal the mesh using cement slurry or mud plaster. | ![Anchor](image4.png) |
10. Adding Horizontal band (Wood)

- **4mm thick metal plate**
  - Or
  - **3 layer of GI sheet plate of 28 gauge (0.35mm)**

- **4 nos. of 3.55mm dia. 75mm long nails**

- **3 nos. of 3.25mm (10 gauge) gabion wire connecting inner and outer @600mm c/c**

Connection of wooden band
11. Strengthen wall by Jacketing

Option 1: GI welded wire mesh jacketing

When both horizontal and vertical reinforcements are missing:

For full jacketing covered by cement mortar, 16 gauge galvanized wire mesh with 19mm c/c spacing can be used with anchoring on both sides of the wall.

Construction procedure
Part B: Mitigation Measures

11. Strengthen wall by Jacketing

Option 2: Gabion wire mesh jacketing

When both horizontal and vertical reinforcements are missing.

Details of gabion wire mesh jacketing

- Vertical 3.25 mm Φ (10 gauge) gabion wire @ 50mm both side
- Vertical 3.25 mm Φ (10 gauge) gabion wire @ 100mm both side
- Horizontal 3.25 mm Φ (10 gauge) gabion wire @ 62mm both side
- Cement Plaster or Stabilized Mud Mortar Plaster
11. Strengthen wall by Jacketing

Details of foundation

- 2mm ØGI wire (Connecting inner & outer mesh)
- Vertical Bar
- 4.75 mm Anchorage bar
- Ground Level
- Portion to be refilled 2 nos 12 mmØ bars
- Concrete M15 Stone Soling
- Existing Floor Finish
- Half wall thick Anchorage

Details of anchorage of gabion wire mesh with wall

- 3.25 mm (10 gauge)ØGI wire (Connecting inner & outer mesh)
11. Strengthen wall by Jacketing

## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Preparation:</strong></td>
<td></td>
<td><img src="image" alt="Surface Preparation" /></td>
</tr>
<tr>
<td>1.</td>
<td>• Remove the plaster from the wall</td>
<td><img src="image" alt="Surface Preparation" /></td>
</tr>
<tr>
<td><strong>Foundation preparation:</strong></td>
<td></td>
<td><img src="image" alt="Foundation Preparation" /></td>
</tr>
</tbody>
</table>
| 2. | • Dig out trench around foundation for placing tie beams for vertical gabion wire anchorage.  
• Stone soling in the trench | ![Foundation Preparation](image) |
| **Painting Gabion wire** |  | ![Painting Gabion Wire](image) |
| 3. | • Gabion wire generally available in markets is not galvanized properly, and corrodes easily.  
• To prevent gabion wires from corrosion, paint with Black Japan Paint or Bitumen emulsion paint | ![Painting Gabion Wire](image) |
| **Make holes for anchorage** |  | ![Make Holes](image) |
| 4. | • Make through holes in mud mortar on walls using steel rod and hammer at suggested locations  
• Insert GI wires at suggested interval and location  
• When it is not possible to make a straight hole through the wall:  
• Remove stone on one side of wall, then insert a GI wire through the wall by bending it  
• Place the removed stone back into the wall using mortar | ![Make Holes](image) |
### 11. Strengthen wall by Jacketing

#### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| **5.** | **Placing of Gabion wire mesh**  
- Place the horizontal bars in the trench  
- Now, place vertical Gabion wire mesh at suggested interval  
- Anchor them to the steel bar in the trench  
- Connect the vertical wires properly to the wall at the top also  
- Then, tie the horizontal Gabion wire mesh with the vertical gabion wires at suggested intervals  
(Note: Lapping of wire wherever required should be minimum 1 feet.) | ![Image of Gabion wire mesh placement] |
| **6.** | **Concreting of foundation beam** | ![Image of foundation beam concreting] |
| **7.** | **Anchor GI wire mesh**  
- Connect inner and outer mesh using inserted through G.I. wires | ![Image of anchor GI wire mesh] |
| **8.** | **Plastering**  
- If possible plaster the mesh using stabilized mud mortar or it can be kept exposed as well. | ![Image of plastering] |

PART-B: Mitigation Measures
11. Strengthen wall by Jacketing

Option3: PP (Polypropylene) band mesh jacketing

When both horizontal and vertical reinforcements are missing:

Vertical-Polypropylene (PP) band @38 mm both side
Vertical-Polypropylene (PP) band @100 mm both side
Horizontal-Polypropylene (PP) band @38 mm both side
Cement Plaster or Stabilized Mud Mortar Plaster

Details of PP (Polypropylene) band mesh jacketing
11. Strengthen wall by Jacketing

Details of foundation

- 2mm Φ GI wire (Connecting inner & outer mesh)
- 4.75 mm Anchorage bar
- Ground Level
- Portion to be refilled
- 2 nos 12 mm Φ bars
- Concrete M15
- Stone Soling

Details of anchorage of PP band mesh with wall

- 3.25 mm (10 gauge) Φ GI wire (Connecting inner & outer mesh)
**11. Strengthen wall by Jacketing**

### Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
</table>
| 1.   | **Surface preparation:**  
• Remove the plaster from the wall | ![Image](image1.png) |
| 2.   | **Foundation preparation:**  
• Dig out trench around foundation for placing tie beams for vertical PP band anchorage  
• Stone soling on the trench | ![Image](image2.png) |
| 3.   | **Make holes for anchorage:**  
• Make through holes in mud mortar on walls using steel rod and hammer at suggested locations  
• Insert GI wires at suggested interval and location  
• When it is not possible to make a straight hole through the wall:  
  o Remove stone on one side of wall, then insert a GI wire through the wall by bending it  
  o Place the removed stone back into the wall using mortar | ![Image](image3.png) |
| 4.   | **Installation of PP band.**  
• Place the horizontal bars in the trench  
• Now, place vertical PP band mesh at suggested interval  
• Tie them to the steel bar in the trench  
• Then, place horizontal PP band mesh at suggested intervals  
• Connect the vertical and horizontal bands by welding (Note: Lapping of PP band wherever should be minimum 1 feet.) | ![Image](image4.png) |
## Construction procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description of work</th>
<th>Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>Concreting of foundation beams.</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
</tbody>
</table>
| 6    | **Anchor GI wire mesh**  
   - Connect inner and outer mesh using inserted through G.I. wires and aluminum plate | ![Image](image2.png) |
| 7.   | **Plastering**  
   Plaster the mesh using stabilized mud mortar | ![Image](image3.png) |
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ANNEX I
Option 1. Wooden frame with wooden connection

**FLOOR PLAN (STONE MASONRY)**
Typical Wooden plinth, sill, lintel & Roof band

**OPTION 1**

100X100 wooden post
38X 75 Horizontal band
38 X 50 connector

**DESCRIPTION**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Size &amp; Spacing (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vertical Post</td>
<td>100 X 100 rectangular or 100 dia circular @ corner &amp; side of opening</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Horizontal band</td>
<td>38X75 at plinth, sill, lintel &amp; roof level@ both side of wall</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Connector</td>
<td>38X50 @750 to 900</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Wedge</td>
<td>15X15 wedge/12mm metal rod</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
- Stitch band can be constructed depending upon the structure
- Diagonal bracing may required in some cases.
Option 2. Wooden frame and corner with diagonal bracing with wooden connection

FLOOR PLAN (STONE MASONRY)
Typical Wooden plinth, sill, lintel & Roof band

DESCRIPTION

<table>
<thead>
<tr>
<th>S.N</th>
<th>Item</th>
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<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vertical Post</td>
<td>100 X 100 rectangular or 100 dia circular @ corner &amp; side of opening</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Horizontal band</td>
<td>38X75 at plinth, sill, lintel &amp; roof level@ both side of wall</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Corner bracing</td>
<td>75X100 @each corner</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Connector</td>
<td>38X50 @750 to 900</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Wedge</td>
<td>15X15 wedge/12mm metal rod</td>
<td></td>
</tr>
</tbody>
</table>

Option 2

ANNEX I
Option 3. Wooden frame with iron nut bolt connection

FLOOR PLAN (STONE MASONRY)
Typical Wooden plinth, sill, lintel & Roof band

DESCRIPTION

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Size &amp; Spacing (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vertical Post</td>
<td>100 X 100 rectangular or 100 dia circular @ corner &amp; side of opening</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Horizontal band</td>
<td>38X75 at plinth, sill, lintel &amp; roof level@ both side of wall</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Connector</td>
<td>12mm dia@750 to 900mm c/c</td>
<td>Iron nut bolt</td>
</tr>
</tbody>
</table>

Cover Plinth band with stabilized mud mortar
Option 4. Wooden frame and corner diagonals with iron rod connection

**ANNEX I**

**OPTION 4**

Wooden post
(100X100 rectangular post/100 dia circular post/16mm dia rod)  
38X 75 Horizontal band

12mm dia connector @ 750 to 900 c/c

38X 75 Horizontal band  
15X15 Wedge/12mm metal rod  
Corner Bracing (75X100) or 16mm dia rod

**FLOOR PLAN (STONE MASONRY)**

Typical Wooden plinth, sill, lintel & Roof band

**DESCRIPTION**

<table>
<thead>
<tr>
<th>S.N</th>
<th>Item</th>
<th>Size &amp; Spacing (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vertical Post</td>
<td>100 X 100 rectangular or 100 dia circular or 16mm rod @ corner &amp; side of opening</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Horizontal band</td>
<td>38X75 at plinth, sill, lintel &amp; roof level@ both side of wall</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Corner bracing</td>
<td>75X100 each corner or 16mm rod</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Connector</td>
<td>12mm dia rod@750 to 900</td>
<td></td>
</tr>
</tbody>
</table>

Cover Plinth band with stabilized mud mortar
## Option 5. Gabion Wire Wrappings

### DESCRIPTION

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Size &amp; Spacing (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gabio wire</td>
<td>10 Guage (3.24mm dia) 300mm width gabion wire @ plinth/sill/stitch/lintel/Roof band.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Connector</td>
<td>10 guage (3.24mm dia)@750 to 900mm c/c</td>
<td></td>
</tr>
</tbody>
</table>

* Note: Please refer mitigation measures: Adding bandage(GI wire mesh) page 56

### FLOOR PLAN (STONE MASONRY)

Typical Wooden plinth, sill, lintel & Roof band

- **Lintel band**
- **Sill band**
- **Plinth band**

Cover Plinth band with stabilized mud mortar
6. Precast concrete frame with Iron rod connection

OPTION 6
Circular/Rectangular 150X150 Precast concrete post
12mm dia connector @ 750 to 900 c/c
150 X150 Horizontal band
4 - 12mm dia
8mm dia@150mm c/c

Vertical post (150X150) at least 300mm away from opening

Circular/Rectangular 150X150 Precast concrete post
Detail at ‘X’

DESCRIPTION

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Item</th>
<th>Size &amp; Spacing (mm)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Vertical Post</td>
<td>150 X 150 rectangular or 150 dia circular @ corner &amp; side of opening</td>
<td>Precast concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Note: Precast concrete should be 4-12mm dia</em></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Horizontal band</td>
<td>150 X 150 at plinth, sill, lintel &amp; roof level@ both side of wall</td>
<td>Precast concrete</td>
</tr>
<tr>
<td>3.</td>
<td>Connector</td>
<td>12mm dia rod@750 to 900</td>
<td>Iron rod</td>
</tr>
<tr>
<td>4.</td>
<td>Wedge</td>
<td>12mm dia bar</td>
<td>Iron rod</td>
</tr>
</tbody>
</table>
ANNEX II
Option 1. Use of Wooden/Bamboo Sections

Building description:

Plan area Approx. 55.8 square meter.
Building height Approx. 2.75 meter.
Occupancy It is a residential building for approximately five to seven membered family.
Construction/Material Ground floor made of stone in mud and first floor timber frame with CGI sheet partition. Roof is composed of timber with CGI sheet.
Earthquake Resistant Wooden bands as per code are used

Exception

E1. If structure is found to safe after structural calculation
E2. Overall Exception: If the construction is up to plinth level is as per requirement second tranche recommendation for second tranches can be recommended, correction or mitigation at super structure shall be made before third tranche.

Solution

• Provide Vertical Wooden Post near openings, T, Corner Junction. Add diagonal Bracing as shown below.
• Make proper connection between lower and upper floor/Storey.
• Use environment friendly locally available materials such as bamboo mesh or other suitable materials.

Correction

• Wooden Member Size: X-sectional area 100mmx100mm (equivalent bamboo)
• Member Connection: As per MRT or equivalent with Metal Nails or Timber Nails

Mix structures are considered safe, if lower masonry structure is as per requirement. For upper structure, bracing or vertical props with proper connections shall be advisable if not provided.
**Option 2. Use of Wooden/Bamboo Sections**

### Building description:

<table>
<thead>
<tr>
<th>Plan area</th>
<th>Approx. 37.16 square meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building height</td>
<td>Approx. 2.75 meter, masonry 0.9 meter, remaining light partitions</td>
</tr>
<tr>
<td>Occupancy</td>
<td>It is a residential building for approximately five to seven membered family.</td>
</tr>
<tr>
<td>Construction/Material</td>
<td>Single floor made of stone in mud/cement up to sill level and remaining height wooden frame with CGI sheet partition. Roof is composed of timber with CGI sheet.</td>
</tr>
<tr>
<td>Earthquake Resistant Element</td>
<td>Wooden bands as per code are used</td>
</tr>
</tbody>
</table>

### Exception

E1. If structure is found to be safe after structural calculation

### Solution

- Provide Vertical Wooden Posts @ 1 m to 1.5 m spacing including near openings, T, Corner Junction. Add diagonal Bracing as shown below.

### Correction

Wooden member size: X-sectional area 38mmx50mm (equivalent bamboo)
Member Connection: As per MRT or equivalent with Metal Nails or Wooden Nails
Option 3. Use of Wooden/Bamboo Sections (Both side)

Connection between roof band and wall

Roof Band connected to roof beams

Lintel Band

Vertical battens

Lintel Band

Sill Band

Connecting ridge beam to the main structure

Connecting beams with wooden batten

Diagonal bracings to prevent relative movement of rafters

Cement plaster (outermost layer)

Wire mesh laid over dry stone masonry both on inside and outside screwed with metallic hooks

Metallic hooks connecting as well as securing internal and external wire mesh
Option 4. Use of Wooden/Bamboo Sections (Both side)

Solution

Connection details:

- Vertical, Horizontal & Diagonal members connection using GI Wire (10 Gauge)
- Vertical - Horizontal & Diagonal members fitting connection using lashing technique
- Vertical, Horizontal & Diagonal members connection using Lacing (Jute, Lylion, or equivalent) Techniques
- One Vertical, Two Horizontal members fitting connection combined with lashing technique
Option 5. Use of Iron Sections

Building description:
- Mixed structural system
  - Ground floor: Masonry structure
  - First floor: Wooden light weight structure

Exception

E1. If structure is found to safe after structural calculation

Solution

- Provide Vertical Wooden Post near openings, T, Corner Junction. Add diagonal Bracing as shown below.
- Wooden member size: Equivalent to ISBN 40 (M) square hollow pipe
- Member connection: Fillet welding 3mm thick all around.
Option 6. Use of Iron Sections with prefab panels

Building description:

- Mixed structural system
  - Ground floor: Masonry structure
  - First floor: prefab panels with iron sections

Exception

E1. As per Design and details by service provider and should be safe.

Solution

- Wooden member size: As per Design and details by service provider
- Member connection: Fillet welding 3mm thick all around or Nut bolts.
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