

Introduction:

As usual new construction of buildings under IAY, Prime Minister Rojgar Yojana and buildings under various other National and State schemes get started in the month of May. The Ministry of Home Affairs is keen that **All New Buildings** should be made earthquake resistant in the first instant so that we do not add to the stock of existing unsafe buildings. Since most of the buildings are constructed using brickwork or, solid hollow concrete blocks with flat roofs, very simple illustrated guidance is provided in the attached brochure for incorporating the earthquake resistant features suitable for seismic zone III.

Essential Elements for Earthquake Safety¹:

The essential elements required to make a building earthquake safe are as given in **Figure 1**. Some additional requirements are detailed in the following paragraphs.

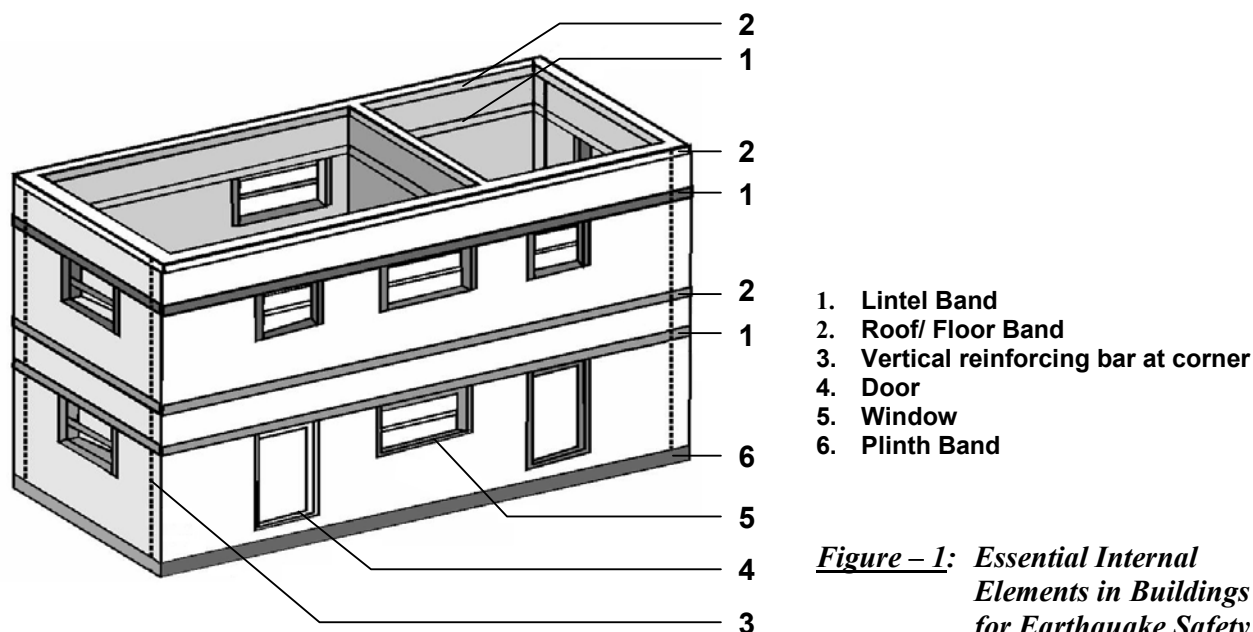


Figure – 1: Essential Internal Elements in Buildings for Earthquake Safety

1. GOOD CEMENT MORTAR:

The cement mortar should be used in the ratio of 1 part of cement with 6 parts of sand (1 sack of cement mixed with 6 equal sacks of sand).

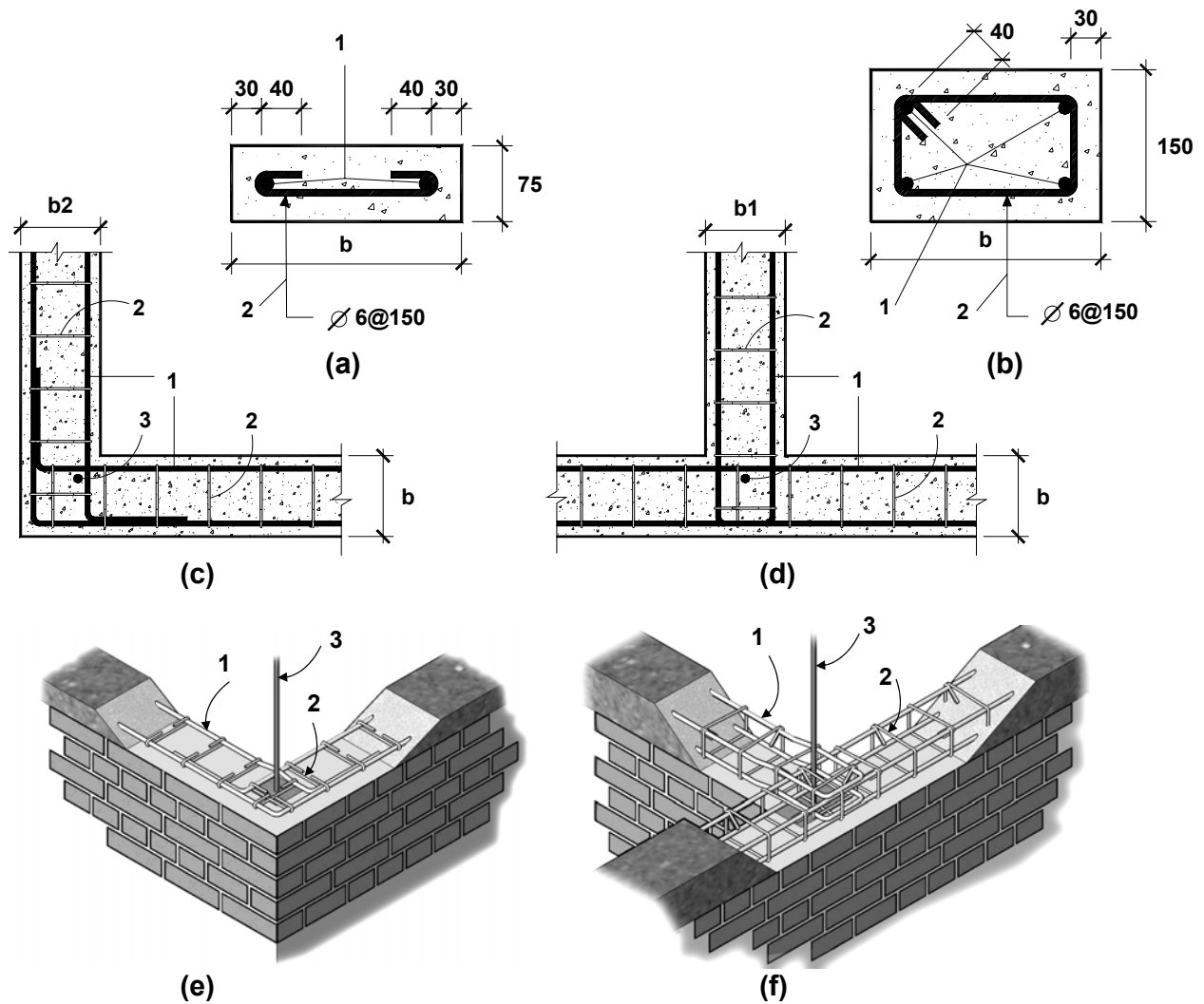
2. HORIZONTAL SEISMIC BANDS:

A seismic band consists of reinforced concrete flat runner through **all external and internal masonry walls** at the following levels in the building.

- at the plinth level of the building
- at the levels of lintels of doors and windows
- at the ceiling level of roofs consisting of wooden joists or, prefabricated reinforced concrete beams or, planks. (*Such band will not be necessary if the roof consists of Reinforced Concrete or, Reinforced Brick slabs cast on the walls covering a minimum of 2/3 of the thickness of the wall.*)

The dimensions of the band and the reinforcement inside depend upon the length of the walls between the perpendicular cross walls. The table below (**Table-1**) shows the dimensions to be adopted for the seismic bands and the internal reinforcement details to be provided. The reinforcement and bending details of seismic bands are given in the **Figure-2**. Reinforcing bars will be of Fe 415 type [TOR or, High Yield Strength Deformed, i.e. HYSD bars]

¹ The details given here are extracted from **IS: 4326-1993 Code of Practice** as applicable to buildings with Brick/ Concrete block walls and R.C. flat slab roofs. Details not given here may be seen in the Code.



- (a) Section of the Band with 2 longitudinal steel bars
 (b) Section of the Band with 4 longitudinal steel bars
 (c) Structural Plan at L - type wall junction
 (d) Structural Plan at T - type wall junction
 (e) 3 Dimensional view of the L - type wall junction
 (f) 3 Dimensional view of the T - type wall junction
1. Longitudinal reinforcements
 2. Lateral Ties
 3. Vertical reinforcement at corners
 b, b1, b2 Wall thickness

Figure-2: Reinforcement and Bending Details of Seismic Bands

Table-1: Recommended size and longitudinal steel in Seismic Bands (Zone III)

| Internal length of wall | Residential buildings | | | Important Public Buildings (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) | | |
|-------------------------|-----------------------|-------------|----------|--|-------------|----------|
| | Size of the band | No. of Bars | Dia (mm) | Size of the band | No. of Bars | Dia (mm) |
| 5 m or, less | 10 cm x wall width | 2 | 8 | 10 cm x wall width | 2 | 8 |
| 6 m | 10 cm x wall width | 2 | 8 | 10 cm x wall width | 2 | 10 |
| 7 m | 15 cm x wall width | 2 | 10 | 15 cm x wall width | 2 | 12 |
| 8 m | 15 cm x wall width | 2 | 12 | 15 cm x wall width | 4 | 10 |

3. VERTICAL REINFORCEMENT IN THE BRICK WALLS:

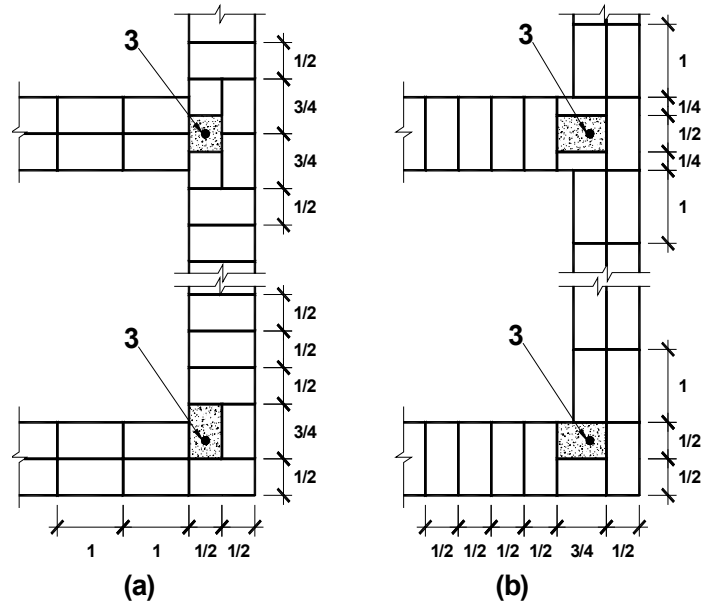
For earthquake safety in seismic zone III reinforcing bars have to be embedded in brick masonry at the corners of all the rooms and the side of the door openings. Window openings larger than 60 cm in width will also need such reinforcing bars (**Figure – 4**). The diameter of the bar depends upon the number of storeys in the building. The recommendations are given in **Table-2**.

Providing the vertical bars in the brickwork and concrete blocks requires special techniques which could be easily learnt by the supervising engineers and masons will need to be trained.

These vertical bars have to be started from the foundation concrete, will pass through all seismic bands where they will be tied to the band reinforcements using binding wire and embedded to the ceiling band/roof slab as the case may be using a 300 mm 90° bend. Sometimes the vertical bars will not be made in one full length. In that case the extension of the vertical reinforcement bars are required, an overlap of minimum of **50 times the bar diameter** should be provided. The two overlapped reinforcement bars should be tied together by using the binding wires.

Table-2: Recommended size of vertical steel in Seismic Bands (Zone III)

| No. of storeys | Floor | Residential buildings * | Important Public Buildings * (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) |
|----------------|--------|--|---|
| | | Dia of Single HYSD (TOR) Bar at corners of room (mm) | Dia of Single HYSD(TOR) Bar at corners of room (mm) |
| One | - | - | 10 |
| Two | Top | - | 10 |
| | Bottom | - | 12 |
| Three | Top | 10 | 10 |
| | Middle | 12 | 12 |
| | Bottom | 12 | 12 |
| Four | Top | 10 | 10 |
| | Third | 10 | 12 |
| | Second | 12 | 16 |
| | Bottom | 12 | 20 |



- a & b** : Alternate courses in one brick wall
1 : One brick length
1/2 : Half brick length
1/4 : Quarter of a brick length
3/4 : Three quarters of a brick length
3 : Vertical reinforcement bars with Concrete/ mortar filling in pocket of M20 grade (1:1½:3 nominal mix)

Figure-3: Typical Details of Providing Vertical Steel Bars in Brick Masonry

Table-3: Recommended joint details with the vertical reinforcement at corner for masonry walls using different kind of materials

| Type of Joint | Corner reinforcement in case of Brick Masonry | Corner reinforcement in case of Solid Concrete Block Masonry | Corner reinforcement in case of Hollow Concrete Block Masonry (see the hole and slit made) |
|---------------|---|--|--|
| L- Joint | | | |
| T- Joint | | | |

4. VERTICAL REINFORCEMENT AT JAMBS OF OPENINGS:

All door and window openings wider than 600 mm will have vertical reinforcement in jambs as shown in **Figure-4** where required as per Table-2.

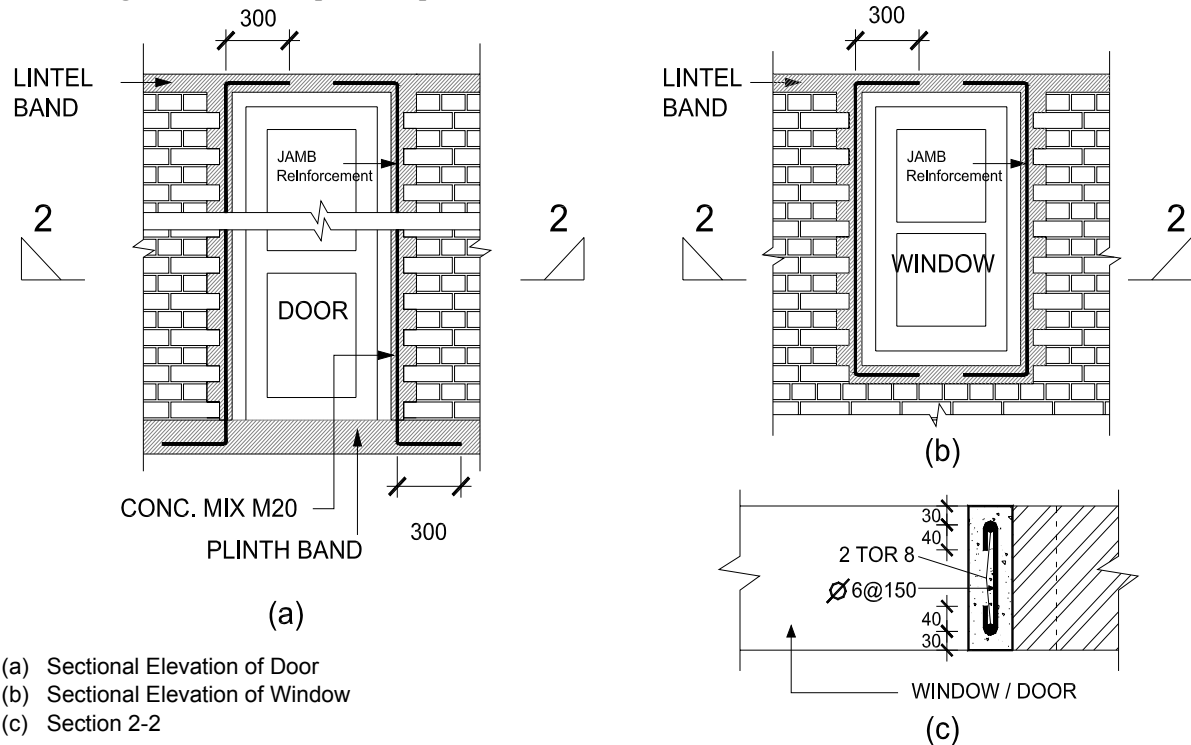


Figure-4: Typical Details of Providing Vertical Steel Bars around doors/windows

5. FOUNDATION

Foundation width 'B' should be decided by the load coming on the foundation and the bearing capacity. Masonry width may be reduced by $\frac{1}{2}$ times T in every step of 150 mm height.

NOTE:

In sandy soils with high water table within 5 m depth below ground level, which may get liquefied during earthquake of MSK intensity VII, pile foundation need to be used in consultation with the Structural/Geotechnical Engineer.

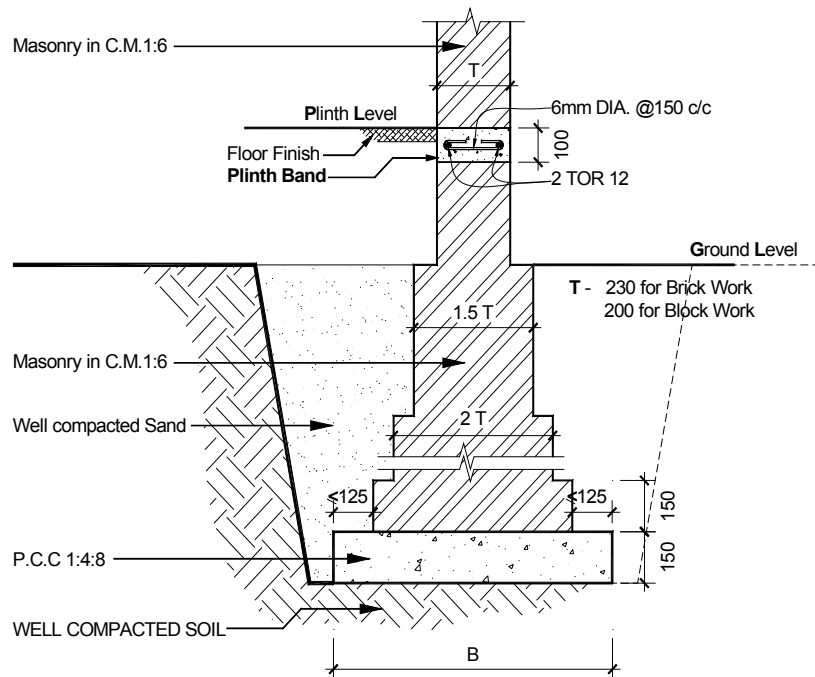


Figure-5: Foundation Detail with Plinth Band in Brick or, Concrete Block Masonry

Prepared by:

Professor Anand S. Arya and Jnananjan Panda

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Introduction:

As usual new construction of buildings under IAY, Prime Minister Rojgar Yojana and buildings under various other National and State schemes get started in the month of May. The Ministry of Home Affairs is keen that **All New Buildings** should be made earthquake resistant in the first instant so that we do not add to the stock of existing unsafe buildings. Since most of the buildings are constructed using brickwork or, solid hollow concrete blocks with flat roofs, very simple illustrated guidance is provided in the attached brochure for incorporating the earthquake resistant features suitable for seismic zone IV.

Essential Elements for Earthquake Safety¹:

The essential elements required to make a building earthquake safe are as given in **Figure 1**. Some additional requirements are detailed in the following paragraphs.

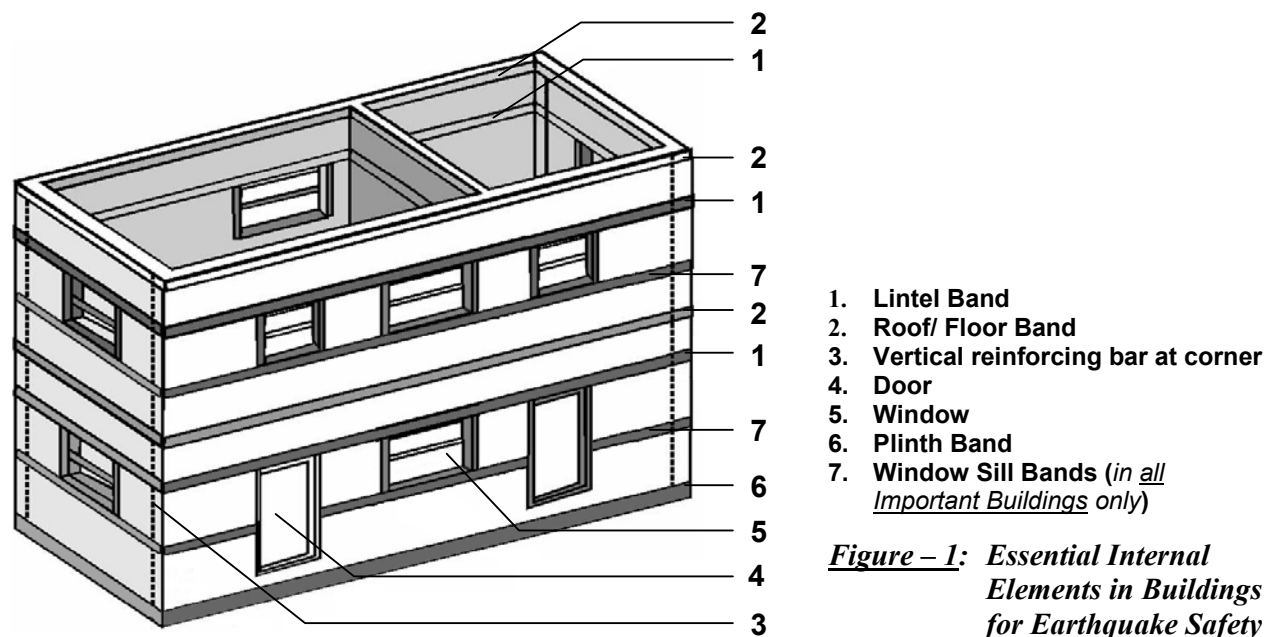


Figure – 1: Essential Internal Elements in Buildings for Earthquake Safety

1. GOOD CEMENT MORTAR:

The cement mortar should be used in the ratio of 1 part of cement with 6 parts of sand (1 sack of cement mixed with 6 equal sacks of sand).

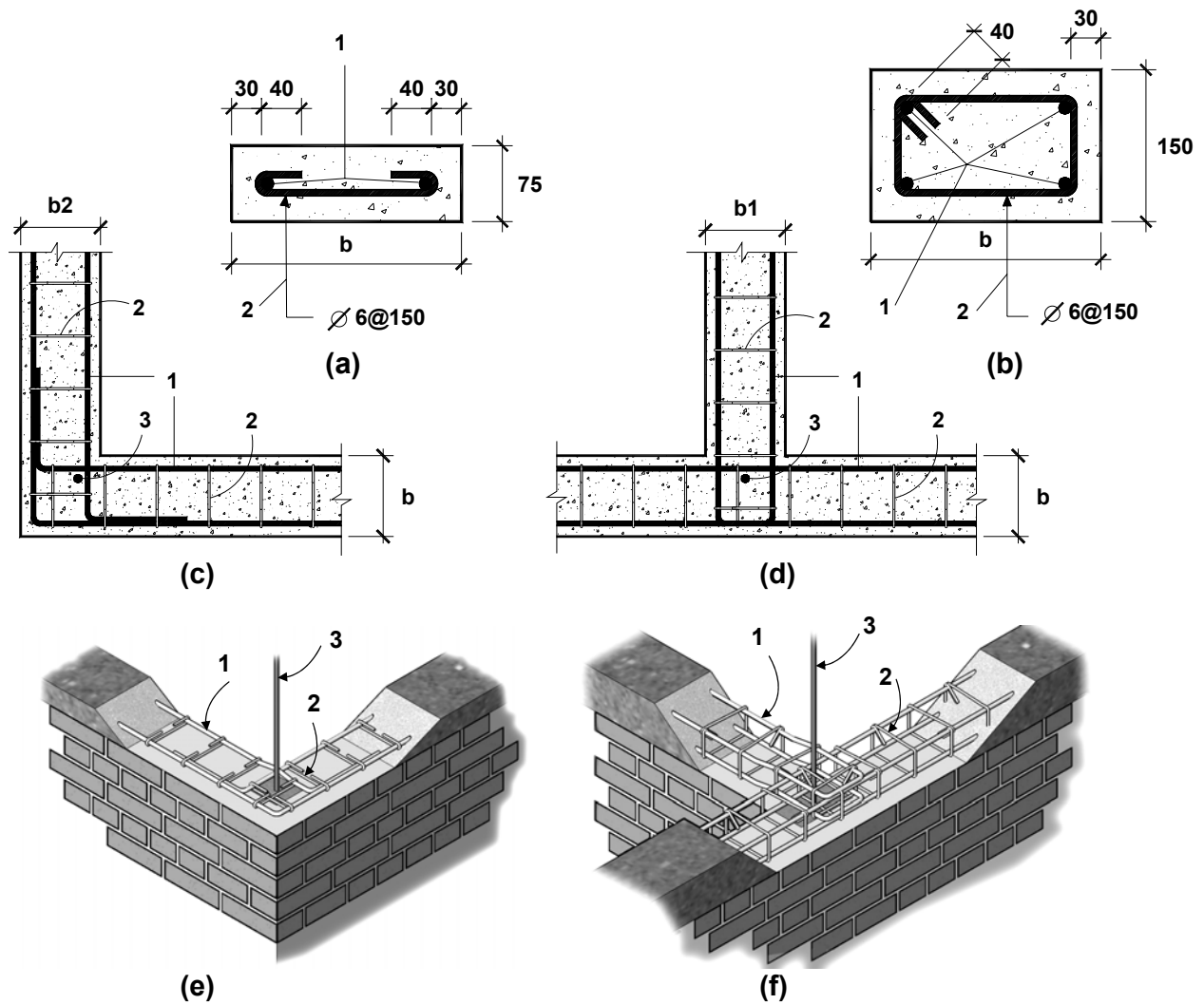
2. HORIZONTAL SEISMIC BANDS:

A seismic band consists of reinforced concrete flat runner through **all external and internal masonry walls** at the following levels in the building.

- at the plinth level of the building
- at the levels of lintels of doors and windows
- at the ceiling level of roofs consisting of wooden joists or, prefabricated reinforced concrete beams or, planks. (*Such band will not be necessary if the roof consists of Reinforced Concrete or, Reinforced Brick slabs cast on the walls covering a minimum of 2/3 of the thickness of the wall.*)

The dimensions of the band and the reinforcement inside depend upon the length of the walls between the perpendicular cross walls. The table below (**Table-1**) shows the dimensions to be adopted for the seismic bands and the internal reinforcement details to be provided. The reinforcement and bending details of seismic bands are given in the **Figure-2**. Reinforcing bars will be of Fe 415 type [TOR or, High Yield Strength Deformed, i.e. HYSD bars]

¹ The details given here are extracted from **IS: 4326-1993 Code of Practice** as applicable to buildings with Brick/ Concrete block walls and R.C. flat slab roofs. Details not given here may be seen in the Code.



- (a) Section of the Band with 2 longitudinal steel bars
 (b) Section of the Band with 4 longitudinal steel bars
 (c) Structural Plan at L - type wall junction
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 (e) 3 Dimensional view of the L - type wall junction
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1. Longitudinal reinforcements
 2. Lateral Ties
 3. Vertical reinforcement at corners
 b, b1, b2 Wall thickness

Figure-2: Reinforcement and Bending Details of Seismic Bands

Table-1: Recommended size and longitudinal steel in Seismic Bands (Zone IV)

| Internal length of wall | Residential buildings | | | Important Public Buildings (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) | | |
|-------------------------|-----------------------|-------------|----------|--|-------------|----------|
| | Size of the band | No. of Bars | Dia (mm) | Size of the band | No. of Bars | Dia (mm) |
| 5 m or, less | 10 cm x wall width | 2 | 8 | 10 cm x wall width | 2 | 10 |
| 6 m | 10 cm x wall width | 2 | 10 | 10 cm x wall width | 2 | 12 |
| 7 m | 15 cm x wall width | 4 | 8 | 15 cm x wall width | 4 | 10 |
| 8 m | 15 cm x wall width | 4 | 10 | 15 cm x wall width | 4 | 12 |

3. VERTICAL REINFORCEMENT IN THE BRICK WALLS:

For earthquake safety in seismic zone IV reinforcing bars have to be embedded in brick masonry at the corners of all the rooms and the side of the door openings. Window openings larger than 60 cm in width will also need such reinforcing bars (**Figure – 4**). The diameter of the bar depends upon the number of storeys in the building. The recommendations are given in **Table-2**.

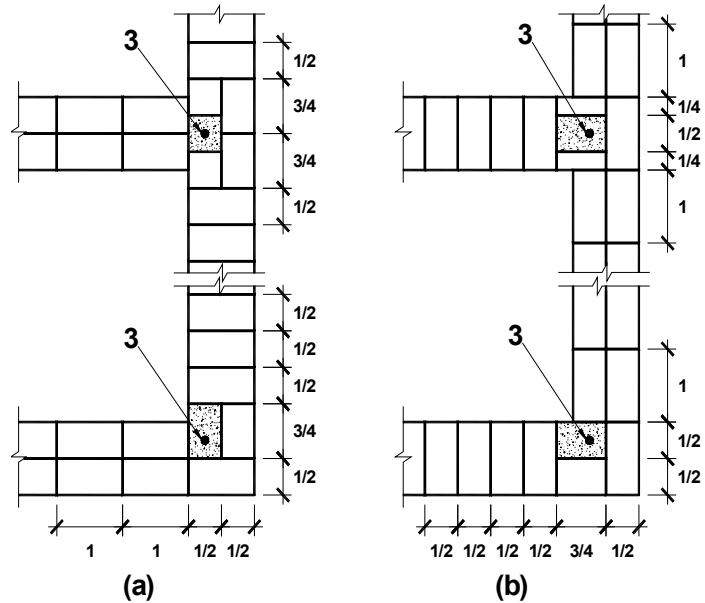
Providing the vertical bars in the brickwork and concrete blocks requires special techniques which could be easily learnt by the supervising engineers and masons will need to be trained.

These vertical bars have to be started from the foundation concrete, will pass through all seismic bands where they will be tied to the band reinforcements using binding wire and embedded to the ceiling band/roof slab as the case may be using a 300 mm 90° bend. Sometimes the vertical bars will not be made in one full length. In that case the extension of the vertical reinforcement bars are required, an overlap of minimum of **50 times the bar diameter** should be provided. The two overlapped reinforcement bars should be tied together by using the binding wires.

Table-2: Recommended size of vertical steel in Seismic Bands (Zone IV)

| No. of storeys | Floor | Residential buildings * | Important Public Buildings * (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) |
|----------------|--------|--|---|
| | | Dia of Single HYSD (TOR) Bar at corners of room (mm) | Dia of Single HYSD (TOR) Bar at corners of room (mm) |
| One | - | 10 | 12 |
| Two | Top | 10 | 12 |
| | Bottom | 12 | 16 |
| Three | Top | 10 | 12 |
| | Middle | 12 | 16 |
| | Bottom | 12 | 16 |

* Building of four storey though permitted in Zone IV, but not desirable.



a & b : Alternate courses in one brick wall

1 : One brick length

1/2 : Half brick length

3/4 : Quarter of a brick length

1/4 : Three quarters of a brick length

3 : Vertical reinforcement bars with Concrete/ mortar filling in pocket of M20 grade (1:1½:3 nominal mix)

Figure-3: Typical Details of Providing Vertical Steel Bars in Brick Masonry

Table-3: Recommended joint details with the vertical reinforcement at corner for masonry walls using different kind of materials

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|---------------|---|--|--|
| L- Joint | | | |
| T- Joint | | | |

4. VERTICAL REINFORCEMENT AT JAMBS OF OPENINGS:

All door and window openings wider than 600 mm will have vertical reinforcement in jambs as shown in **Figure-4**.

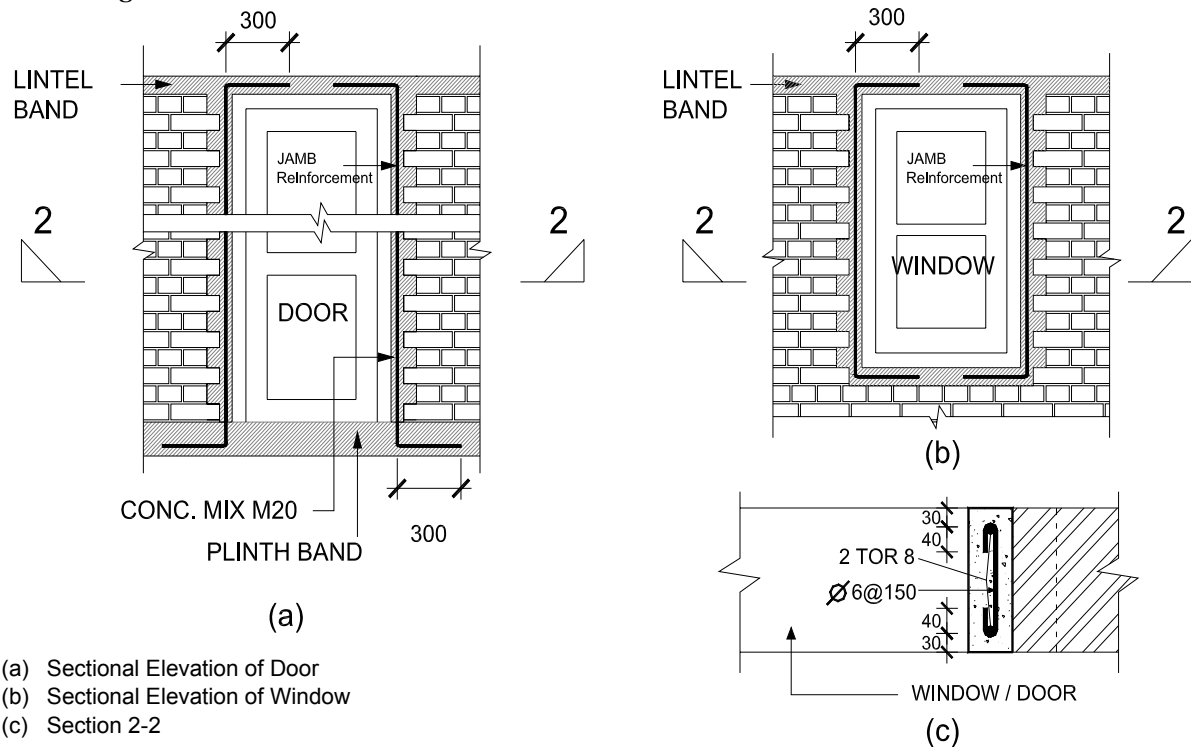


Figure-4: Typical Details of Providing Vertical Steel Bars around doors/windows

5. FOUNDATION

Foundation width 'B' should be decided by the load coming on the foundation and the bearing capacity. Masonry width may be reduced by $\frac{1}{2}$ times T in every step of 150 mm height.

NOTE:

In sandy soils with high water table within 8 m depth below ground level, which may get liquefied during earthquake of MSK intensity VIII, pile foundation need to be used in consultation with the Structural/ Geotechnical Engineer.

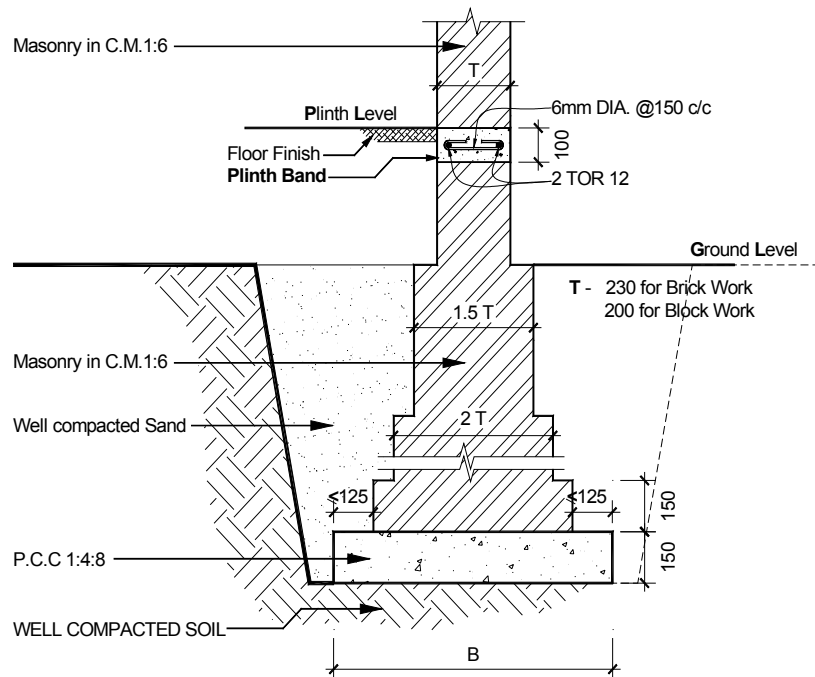


Figure-5: Foundation Detail with Plinth Band in Brick or, Concrete Block Masonry

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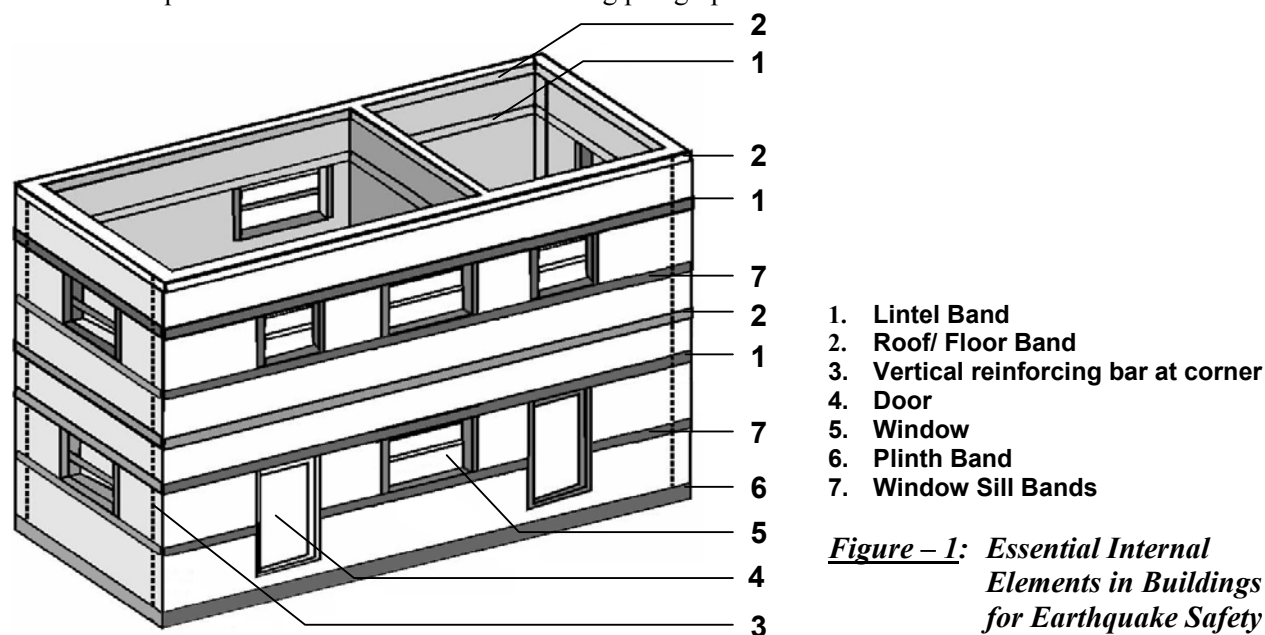


Figure – 1: *Essential Internal Elements in Buildings for Earthquake Safety*

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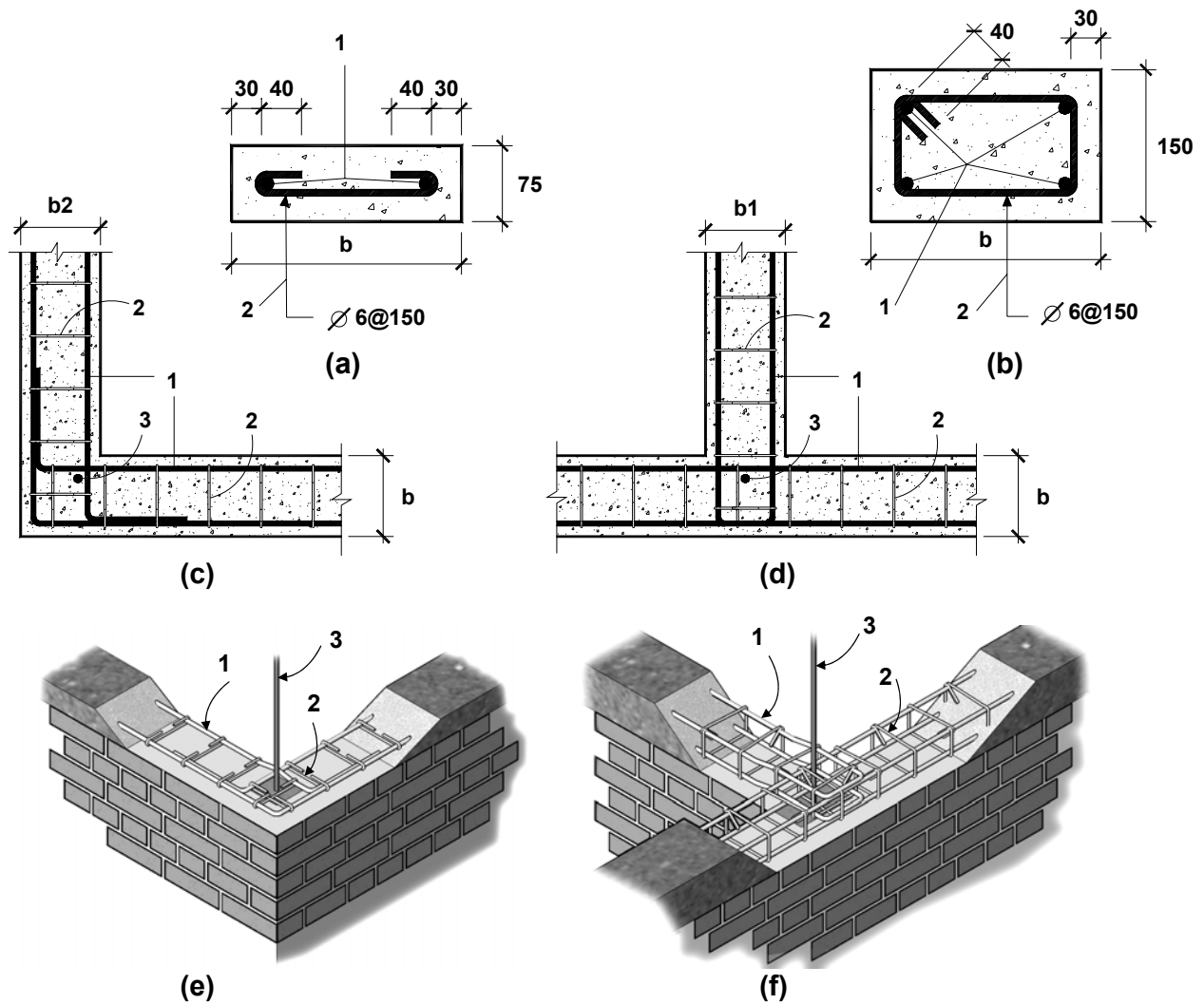
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 b, b1, b2 Wall thickness

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Table-1: Recommended size and longitudinal steel in Seismic Bands (Zone V)

| Internal length of wall | Buildings of all types i.e., Residential buildings & Public Buildings (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) | | |
|-------------------------|---|-------------|----------|
| | Size of the band | No. of Bars | Dia (mm) |
| 5 m or, less | 10 cm x wall width | 2 | 10 |
| 6 m | 10 cm x wall width | 2 | 12 |
| 7 m | 15 cm x wall width | 4 | 10 |
| 8 m | 15 cm x wall width | 4 | 12 |

3. VERTICAL REINFORCEMENT IN THE BRICK WALLS:

For earthquake safety in seismic zone V reinforcing bars have to be embedded in brick masonry at the corners of all the rooms and the side of the door openings. Window openings larger than 60 cm in width will also need such reinforcing bars (**Figure – 4**). The diameter of the bar depends upon the number of storeys in the building. The recommendations are given in **Table-2**.

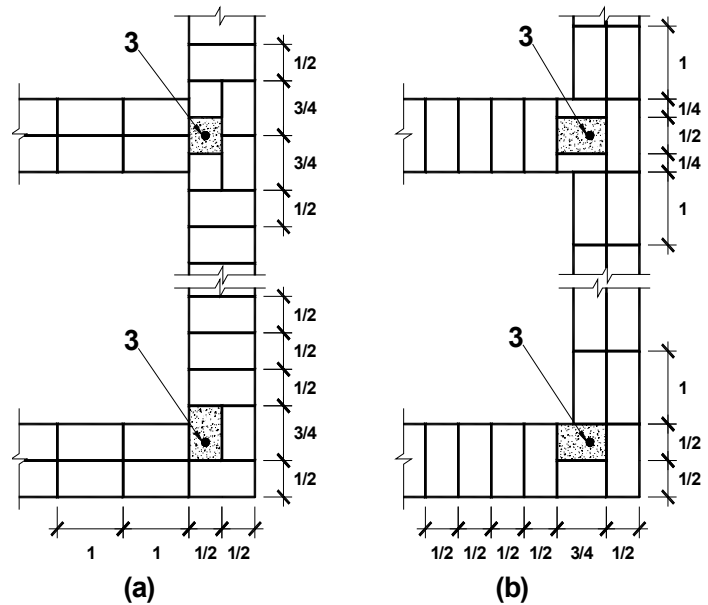
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| Buildings of all types i.e., Residential buildings & Public Buildings * (Schools, Hospitals, Meeting Halls, Anganwadis, etc.) | | |
|---|--------|---|
| No. of storeys | Floor | Dia of Single HYSD(TOR) Bar at corners of room (mm) |
| One | - | 12 |
| Two | Top | 12 |
| | Bottom | 16 |
| Three | Top | 12 |
| | Middle | 16 |
| | Bottom | 16 |

* Building of four storey not permitted in Zone V.



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1 : One brick length
1/2 : Half brick length
3/4 : Quarter of a brick length
3 : Vertical reinforcement bars with Concrete/ mortar filling in pocket of M20 grade (1:1½:3 nominal mix)

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|---------------|---|--|--|
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| T- Joint | | | |

4. VERTICAL REINFORCEMENT AT JAMBS OF OPENINGS:

All door and window openings wider than 600 mm will have vertical reinforcement in jambs as shown in **Figure-4**.

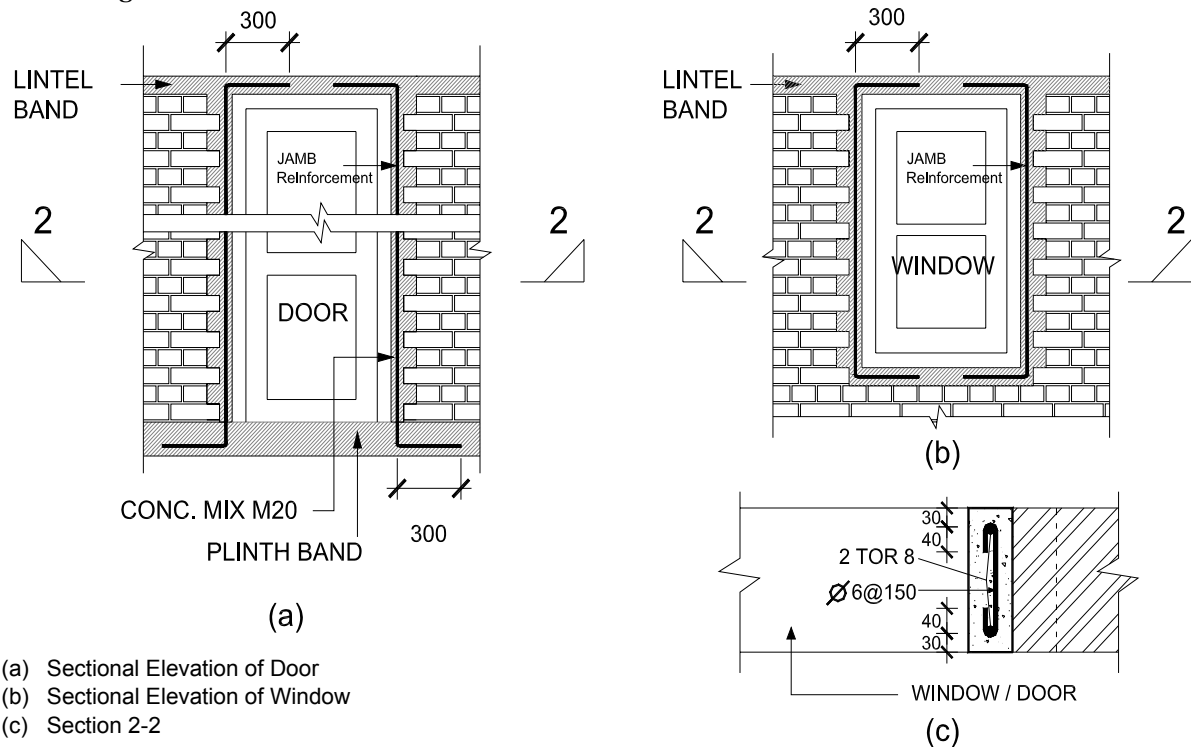


Figure-4: *Typical Details of Providing Vertical Steel Bars around doors/windows*

5. FOUNDATION

Foundation width 'B' should be decided by the load coming on the foundation and the bearing capacity. Masonry width may be reduced by $\frac{1}{2}$ times T in every step of 150 mm height.

NOTE:

In sandy soils with high water table within 8 m depth below ground level, which may get liquefied during earthquake of MSK intensity VIII to IX, pile foundation need to be used in consultation with the Structural/ Geotechnical Engineer.

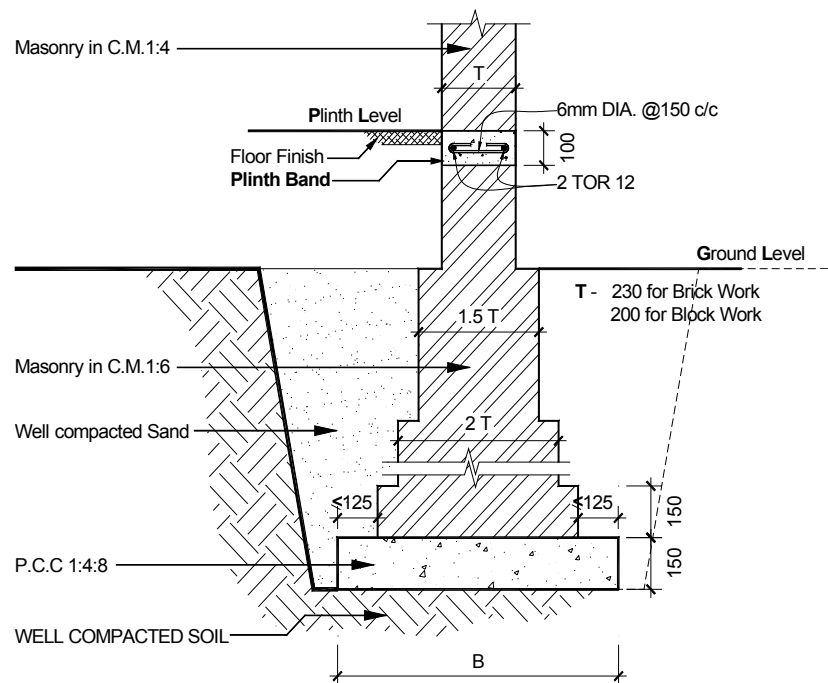
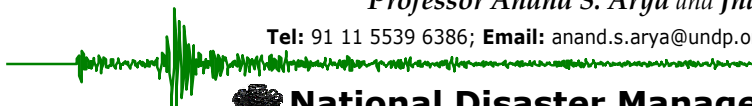


Figure-5: Foundation Detail with Plinth Band in Brick or, Concrete Block Masonry

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