Simple Retrofitting Details for Improving Earthquake Resistance of Brick Masonry Buildings in NCT of Delhi and the NCR

Dear Citizens of NCT of Delhi and NCR,

You have by now assessed the seismic damageability in the brick masonry building you are residing in. The observed data may show some deficiencies and weaknesses. These will require rectification for achieving adequate earthquake resistance of the building. Here below simple methods are suggested for your information and adoption:

(i) Number of storeys:- Five storeys are not permitted for masonry buildings in the seismic Zone. Therefore the easiest rectification will be to remove fifth storey.

(ii) Thickness of Load Bearing Walls: - Less than one brick thick (9inches or 23 cm) is not permitted. If half-brick thick (4.5 inches or 11.4 cm) has been used, then either it will have to be rebuilt using one-brick thick wall or retrofitted by adding pilasters and/or by ferro-cement plating (or fibre-wrapping, not covered here).

(iii) Mortar used to Construct brick walls: - If the mortar is cement-sand, 1:6 mix, or richer in cement, it is OK. However, if weaker mortar, like lime-sand or lime-cinder or clay mud was used, the building will need additional retrofitting elements to those normally provided in the Building Code (IS: 4326) such as seismic belt at window sill level.

(iv) Larger size/number of Door–Window openings in any wall or use of small size piers between consecutive openings: - Reinforcing required around the opening and on piers by ferro-cement plating (or fibre-wrapping).

(v) Absence of Horizontal Seismic Bands:- In place of seismic bands required to be provided inside the walls during construction. *Seismic Belts* will need to be provided at the corresponding level on both faces of all the walls (see **2.3**).

(vi) Absence of Vertical Reinforcing Bars at Corners of Rooms:- Where required as per Building Code (IS:4326), either equivalent Ferro-Cement plating or equivalent bars are to be located at the room corners and fully connected with the walls (see **2.4**).

2. DETAILS OF RETROFITTING ELEMENTS

2.1 Ferro-Cement Plating:-

It consists of a *galvanized iron mesh* fixed to the walls through nails or connector-links drilled through the wall thickness and the mesh is covered by rich mix of cement-sand mortar in the ratio of 1:3. To achieve good results, the following step-wise procedure is to be followed:-

(i) Mark the height or width of the desired plating based on the weld mesh number of longitudinal wires and the mesh size (see table 1).

(ii) Cut the existing plaster at the edge by a mechanical cutter for neatness, and remove the plaster (see fig.1).

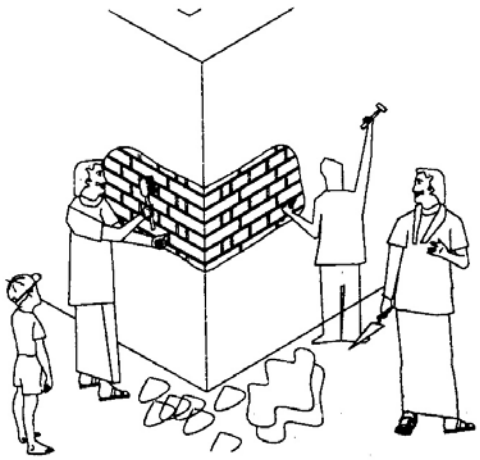


Fig.1:- Removal of Plaster & Raking of Joints

(iii) Rake the exposed joints to a depth of 20 mm. Clean the joints with water jet.

(iv) Apply neat cement slurry and plaster the wall with 1:3 cement – coarse sand mix by filling all raked joints fully and covering the wall with a thickness of 15 mm. Make the surface rough for better bond with the second layer of plaster.

(v) Fix the mesh to the plastered surface through 15 cm long nails driven into the wall at a spacing of 45 cm tying the mesh to the nails by binding wire (see fig.2).

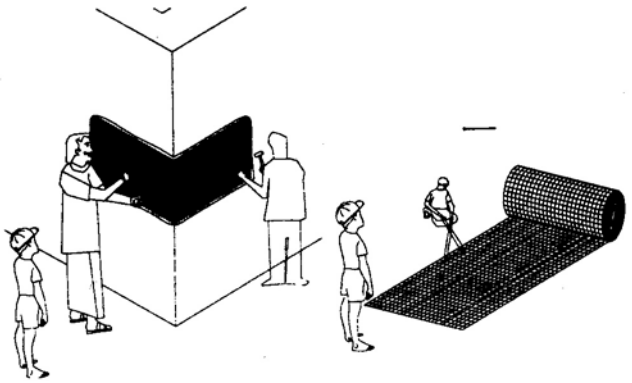


Fig. 2 :- Galvanised steel wire mesh

(vi) Now apply the second layer of plaster with a thickness of 15 mm above the mesh. Good bonding will be achieved with the first layer of plaster and mesh if neat cement slurry is applied by a brush to the wall and the mesh just in advance of the second layer of plaster.

(vii)Cure the plaster by sprinkling water for a minimum period of 10 days.

Note:- Where the RC belt is provided on both faces of the wall, the nails should be replaced by twisted wire links through drilled holes filled with mortar grout and tied to the meshes on both faces.

2.2 Galvanized Steel Wire Mesh:-

Galvanising of the steel mesh is necessary to prevent corrosion. The gauge of wires and mesh size will depend upon the functional purpose:-

(i) To strengthen a half brick thick load bearing wall

The welded wire mesh may be of 14 gauge wires @ 35 to 40 mm apart both ways. Provision of mesh on external or internal faces with an overlap of 30 cm at the corners will suffice for upto 3 m long walls. For longer walls, ferro-cement plating be provided on both faces.

(ii) To provide horizontal seismic belts

The welded mesh size and the height of the belt will depend on the length of wall between the cross walls. *See Table 1.*

2.3 Providing Horizontal Seismic Belts (see fig.3, 4 & 5)

2.3.1 Seismic Belt Locations

(i) Seismic belts are to be provided on *all* walls on *both* the faces just above lintels of door and window openings and below floor or roof.

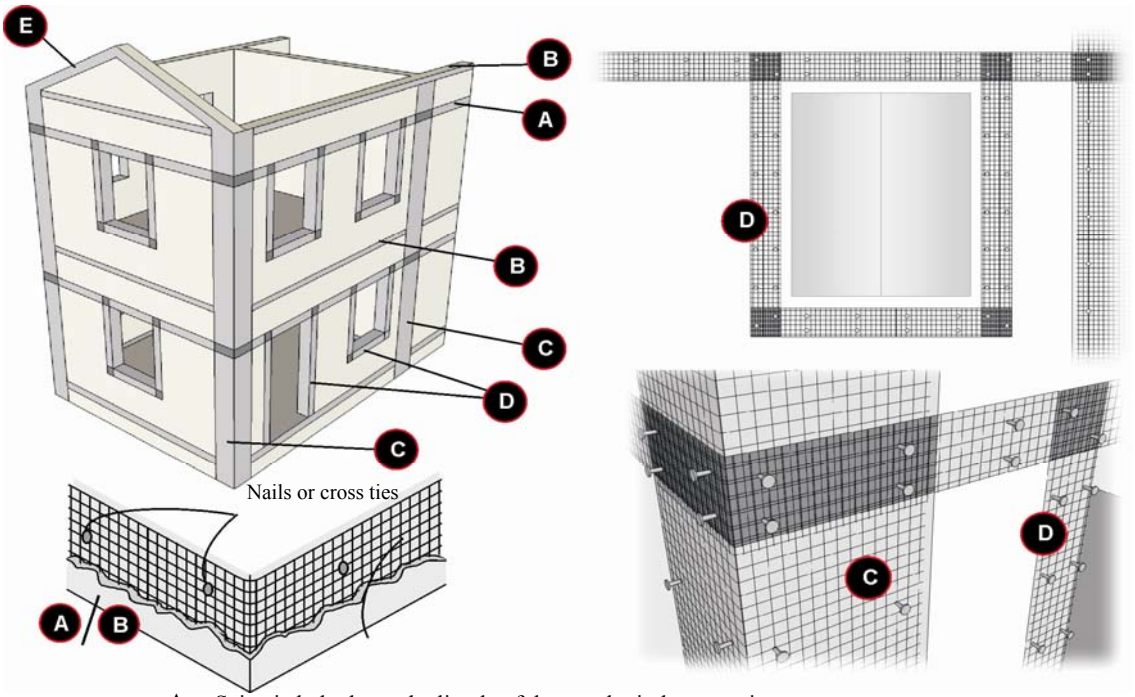
NOTE - On small wall lengths in a room (less than 4 m) seismic belt only on the outside face will suffice.

(ii) The roof belt may be omitted if the roof or floor is of RCC slab.

(iii) Seismic belt is not necessary at plinth level, unless the plinth height is more than 900 mm.

(iv) Install similar seismic belt at the eave level of sloping roof and near top of gable wall, below the roof.

NOTE — If the height of eave level above the top of door is less than 900 mm, only the eave level belt may be provided and lintel level belt may be omitted.



A Seismic belt above the lintels of door and window openings.
B Seismic belt just below the roof
C Vertical Seismic belt at wall junctions (L & T junctions)
D Seismic belt around doors & windows
E Seismic belt around the gable wall
Note:- Use of galavanised welded steel wire mesh as reinforcement every where

Fig. 3: Overall arrangement of Seismic Belt

2.3.2 Description of Reinforcement in Belt.

The reinforcement may be of mesh types as suggested in Table 1 for seismic zone IV.

NOTE :-

1. Alternatively, any other mesh of equivalent longitudinal wires may be used. For example, for room length of 6 m, MW 21 weld mesh (with long wires 5 of 4.5 mm dia. spaced at 75 mm apart; cross wires of 3.15 mm dia. placed at 300 mm apart) can be used, the height of the belt being kept as 375 mm.
2. Weld mesh has to be provided continuously. If splicing is required, there should be minimum overlap of 300 mm.

Table 1:- Mesh Reinforcement in Seismic Belts in Seismic Zone IV for Residential Masonry Building

Length of wall (m)	Gauge	N	H
≤ 5.0	g 12	9	250
6.0	g 10	10	280
7.0	g 10	14	380
8.0	g 10	18	460

NOTES —

1. Gauges: g10=3.25 mm, g11=2.95 mm, g12=2.64 mm, g13=2.34 mm, g14=2.03 mm.
2. N = Number of made longitudinal wires in the belt at spacing of 25 mm.
3. H = Height of belt on wall in micro-concrete, mm.
4. The transverse wires in the mesh could be spaced upto 150 mm.
5. The mesh should be galvanized to save from corrosion.

Fig.4:- Seismic belts provided at eaves and gable levels joined together.

Fig.5 :- Seismic belts provided in a school building at ceiling level and around openings

2.4 Vertical Seismic Belt at Corners

Vertical reinforcing is required at the corners of rooms and junctions of walls as per Table 2. The width of this belt on each side of the corner has to be kept 25 mm extra to the width of the mesh. This reinforcement should be started 300 mm below the plinth level and continued into the roof/eave level horizontal belt. (*see* Fig. 6).

2.5 Providing Vertical Reinforcement at Corners, Junctions of Walls.

The vertical reinforcement consisting of TOR bar as per Table 2 or equivalent shall be provided on the inside corner of room starting from 750 mm below the ground floor going into the roof slab, passing through each middle floor through holes made in the slabs. (See Fig.7) The reinforcement will be connected to the walls by using L shape dowels of 8 mm TOR bar, the vertical leg of 400 mm

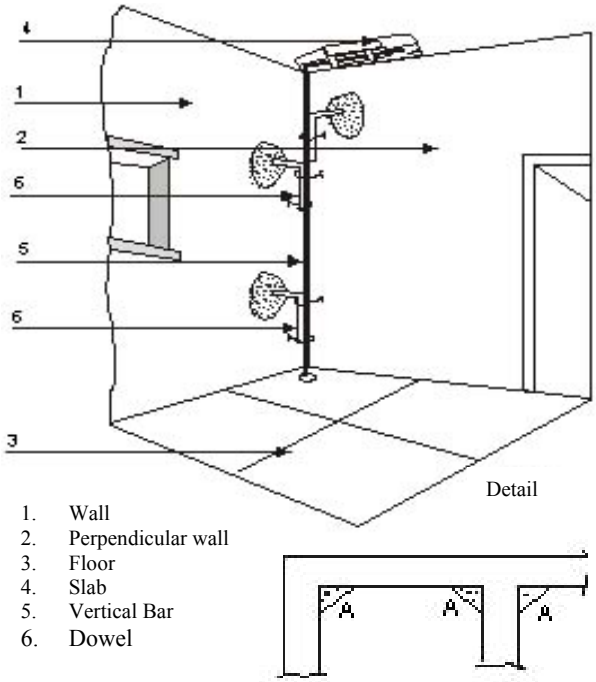
Table 2:- Vertical Bar or Mesh Reinforcement in Vertical Belt at Corners of rooms (Zone IV Residential Masonry Building)

No. of Storeys	Storeys	Single Bar, mm	Mesh (g10)	
			N	B
One	One	10	10	300
Two	Top	10	10	300
	Bottom	12	14	400
Three	Top	10	10	300
	Middle	12	14	400
	Bottom	12	14	400

NOTES —

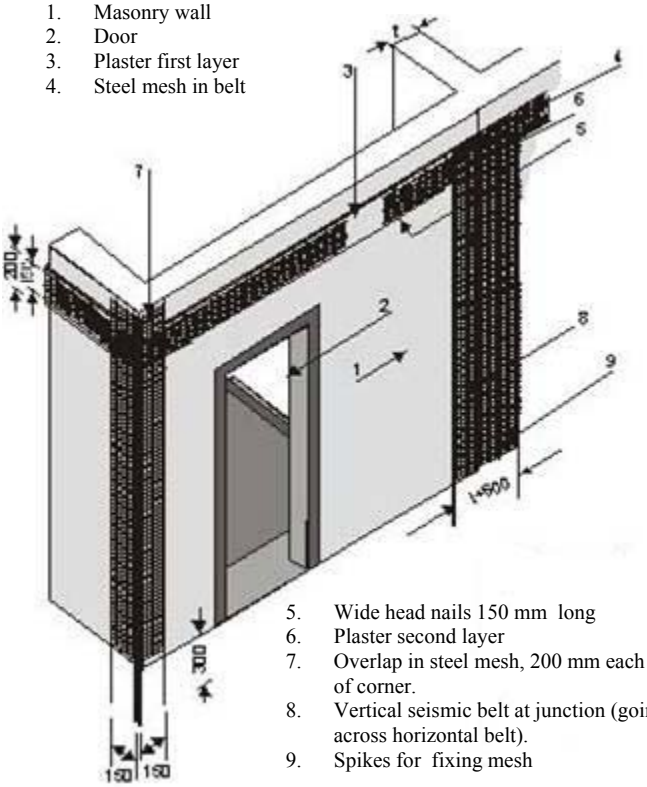
1. Gauge 10 (3.25 mm dia) galvanized mesh with 25 mm spacing of wires shall be used.
2. Single bar, if used, shall be HSD or TOR type. If two bars are used at a T-junction, the diameter can be taken as follows. For one of 10 or 12 mm take 2 of 8 mm, and for one of 16 mm take 2 of 12 mm.
3. N = Number of longitudinal wires in the mesh.
4. B = Width of the micro concrete belt, half on each wall meeting at the corner or T-junction.
5. The transverse wires in the mesh could be at spacing up to 150 mm

length firmly tied to the vertical reinforcement bars and the horizontal leg of minimum 150 mm length embedded in the walls through 75 mm dia. holes drilled in the wall into which the 8 mm dia. leg of the dowel will be grouted using non- shrink cement cum polymer grout. Such dowels will be provided, first one just above plinth level and then at about every 1 m distance apart. The corner reinforcement will be covered with 1:3 cement mortar or 1:1 1/2:3 micro concrete fully bonded with the walls giving a minimum cover of 15 mm on the bar (see fig.8).



1. Wall
2. Perpendicular wall
3. Floor
4. Slab
5. Vertical Bar
6. Dowel

Fig. 7:- Vertical Bar at inside corner



1. Masonry wall
2. Door
3. Plaster first layer
4. Steel mesh in belt
5. Wide head nails 150 mm long
6. Plaster second layer
7. Overlap in steel mesh, 200 mm each side of corner.
8. Vertical seismic belt at junction (going across horizontal belt).
9. Spikes for fixing mesh

Fig. 6 : Vertical Seismic Band at Corner and Junctions

3. CONCLUDING REMARKS

Tests using half size brick masonry models on vibration tables under earthquake like base motions have conclusively proven that retrofitted masonry buildings as explained above will become adequately earthquake resistant and will neither collapse nor severly crack in the seismic zone IV earthquake Intensities.

Fig.8 :- Retrofitting done with reinforcing bars at corner

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