# Why is vertical reinforcement required in masonry buildings?

## Response of Masonry Walls

Horizontal bands are provided in masonry buildings to improve their earthquake performance. These bands include *plinth band*, *lintel band* and *roof band*. Even if horizontal bands are provided, masonry buildings are weakened by the openings in their walls (Figure 1). During earthquake shaking, the masonry walls get grouped into three sub-units, namely *spandrel masonry*, *wall pier masonry* and *sill masonry*.

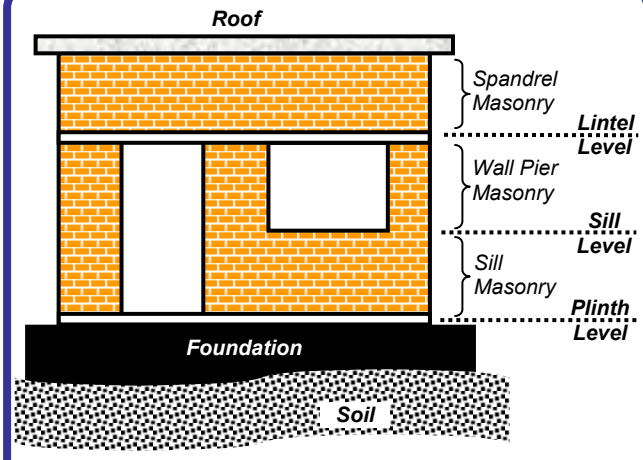



**Figure 1: Sub-units in masonry building** – *walls behave as discrete units during earthquakes.*

Consider a hipped roof building with two window openings and one door opening in a wall (Figure 2a). It has *lintel* and *plinth bands*. Since the roof is a hipped one, a *roof band* is also provided. When the ground shakes, the inertia force causes the small-sized masonry *wall piers* to disconnect from the masonry above and below. These masonry sub-units rock back and forth, developing contact only at the opposite diagonals (Figure 2b). The rocking of a masonry pier can crush the masonry at the corners. Rocking is possible when masonry piers are slender, and when weight of the structure above is small. Otherwise, the piers are more likely to develop diagonal (X-type) shear cracking (Figure 2c); this is the most common failure type in masonry buildings.

In un-reinforced masonry buildings (Figure 3), the cross-section area of the masonry wall reduces at the opening. During strong earthquake shaking, the building may *slide* just under the roof, below the lintel band or at the sill level. Sometimes, the building may also slide at the plinth level. The exact location of sliding depends on numerous factors including building weight, the earthquake-induced inertia force, the area of openings, and type of doorframes used.

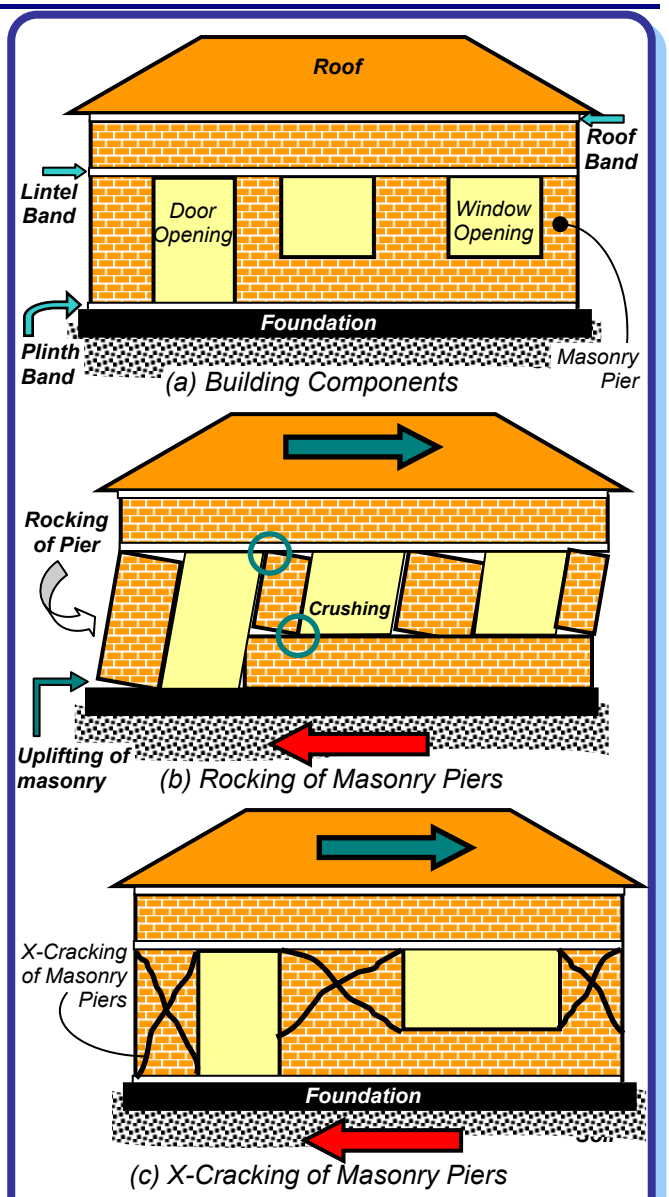



**Figure 2: Earthquake response of a hipped roof masonry building** – *no vertical reinforcement is provided in walls.*

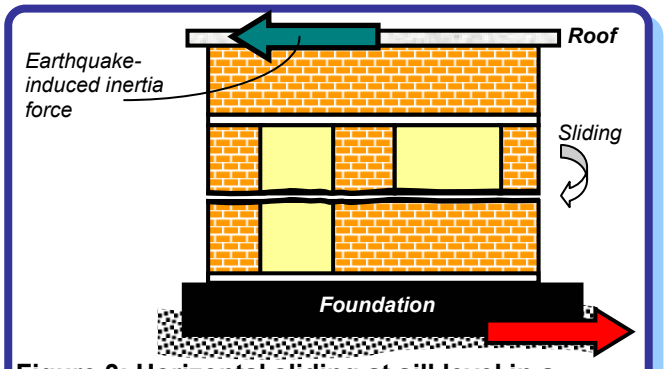
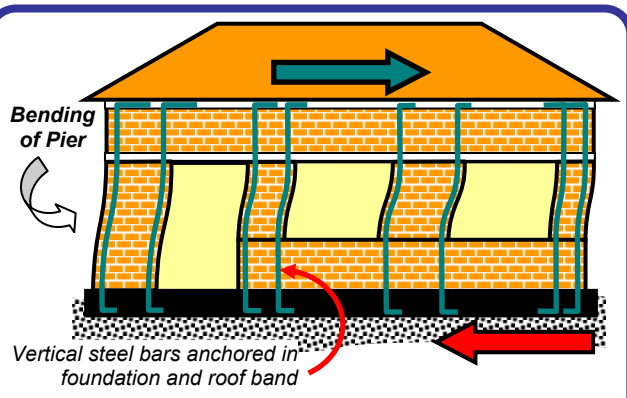


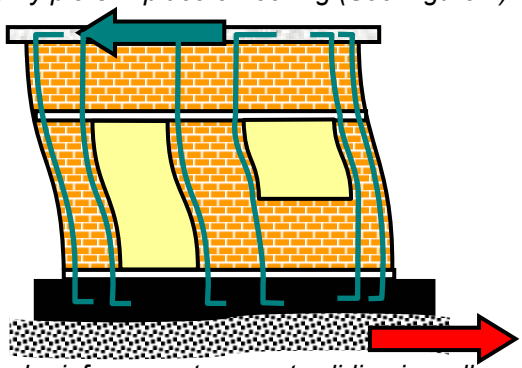

**Figure 3: Horizontal sliding at sill level in a masonry building** – *no vertical reinforcement.*

## How Vertical Reinforcement Helps

Embedding vertical reinforcement bars in the edges of the wall piers and anchoring them in the foundation at the bottom and in the roof band at the top (Figure 4), forces the slender masonry piers to undergo *bending* instead of *rocking*. In wider wall piers, the vertical bars enhance their capability to resist horizontal earthquake forces and delay the X-cracking. Adequate cross-sectional area of these vertical bars prevents the bar from yielding in tension. Further, the vertical bars also help protect the wall from sliding as well as from collapsing in the weak direction.




*(a) Vertical reinforcement causes bending of masonry piers in place of rocking (See Figure 2).*

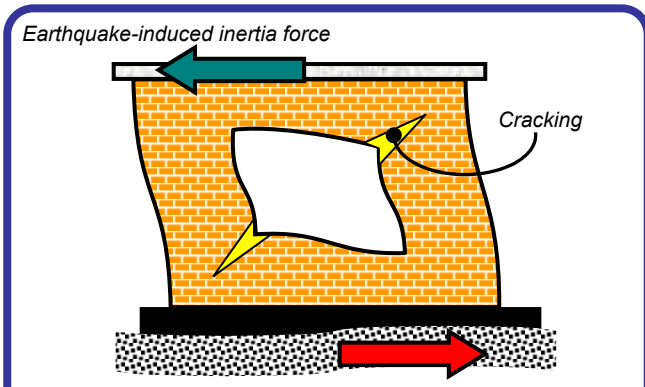


*(b) Vertical reinforcement prevents sliding in walls (See Figure 3).*

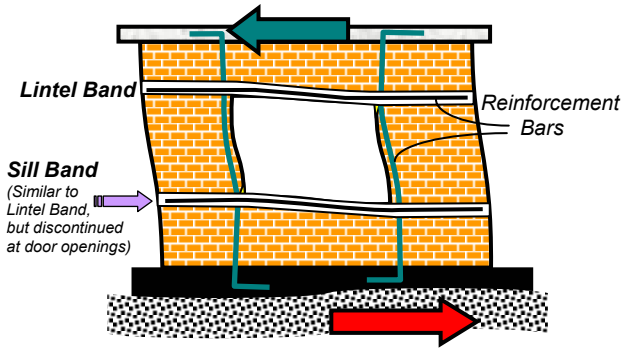
**Figure 4: Vertical reinforcement in masonry walls** – *wall behaviour is modified.*

## Protection of Openings in Walls

Sliding failure mentioned above is rare, even in unconfined masonry buildings. However, the most common damage, observed after an earthquake, is diagonal X-cracking of wall piers, and also inclined cracks at the corners of door and window openings. When a wall with an opening deforms during earthquake shaking, the shape of the opening distorts and becomes more like a *rhombus* - two opposite corners move away and the other two come closer. Under this type of deformation, the corners that come closer develop cracks (Figure 5a). The cracks are bigger when the opening sizes are larger. Steel bars provided in the wall masonry all around the openings restrict these cracks at the corners (Figure 5b). In summary, lintel and sill bands above and below openings, and vertical reinforcement adjacent to vertical edges, provide protection against this type of damage.




*(a) Cracking in building with **no** corner reinforcement*




*(b) No cracks in building **with** vertical reinforcement*

**Figure 5: Cracks at corners of openings in a masonry building** – *reinforcement around them helps.*

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*Tip12: How brick masonry houses behave during earthquakes?*
*Tip13: Why masonry buildings should have simple structural configuration?*
*Tip14: Why horizontal bands are required in masonry buildings?*

## Resource Material

Amrose,J., (1991), *Simplified Design of Masonry Structures,* John Wiley & Sons, Inc., New York, USA.

BMTPC, (2000), *Guidelines: Improving Earthquake Resistance of Housing*, Building Materials and Technology Promotion Council, New Delhi.

IS 4326, (1993), *Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Buildings*, Bureau of Indian Standards, New Delhi.

IS 13828, (1993), *Indian Standard Guidelines for Improving Earthquake Resistance of Low-strength Masonry Buildings*, Bureau of Indian Standards, New Delhi.

## Next Upcoming Tip

How to improve seismic behaviour of stone masonry buildings?

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