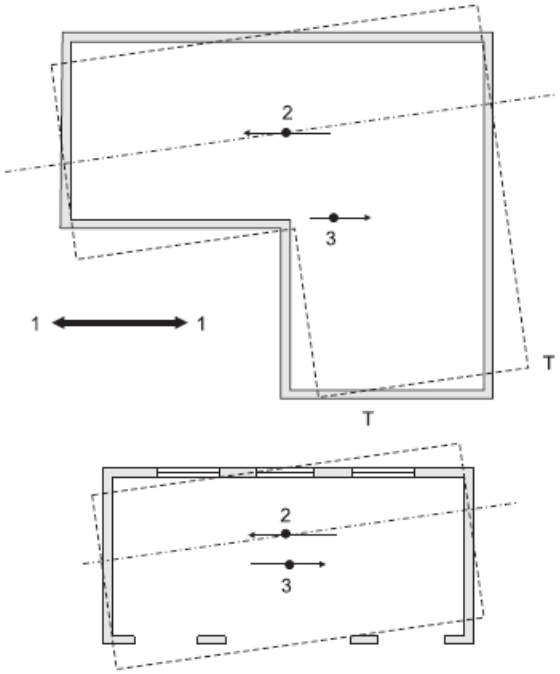
Frequently Asked Questions

Question 01:

How does the plan of a building add to its resistance to earth quakes? Elaborate.

Answer:

- Symmetry: The building or its various blocks should be kept symmetrical about both the axes. Asymmetry leads to torsion during earthquakes and is dangerous,
- Regularity: Simple rectangular shapes, behave better in an earthquake than shapes with many projections. Torsional effects of ground motion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times its width.
- Separation of Blocks: Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block.



1 - Earthquake force
2 - Centre of stiffness or resisting force
3 - Centre of gravity or the applied inertia force
T - Twisted building

- Simplicity: Ornamentation invo1ving large cornices, vertical or horizontal cantilever projections, facia stones and the like are dangerous and undesirable from a seismic viewpoint.

- Enclosed Area: A small building enclosure with properly interconnected walls acts like a rigid box since the earthquake strength which long walls derive from transverse walls increases as their length decreases.

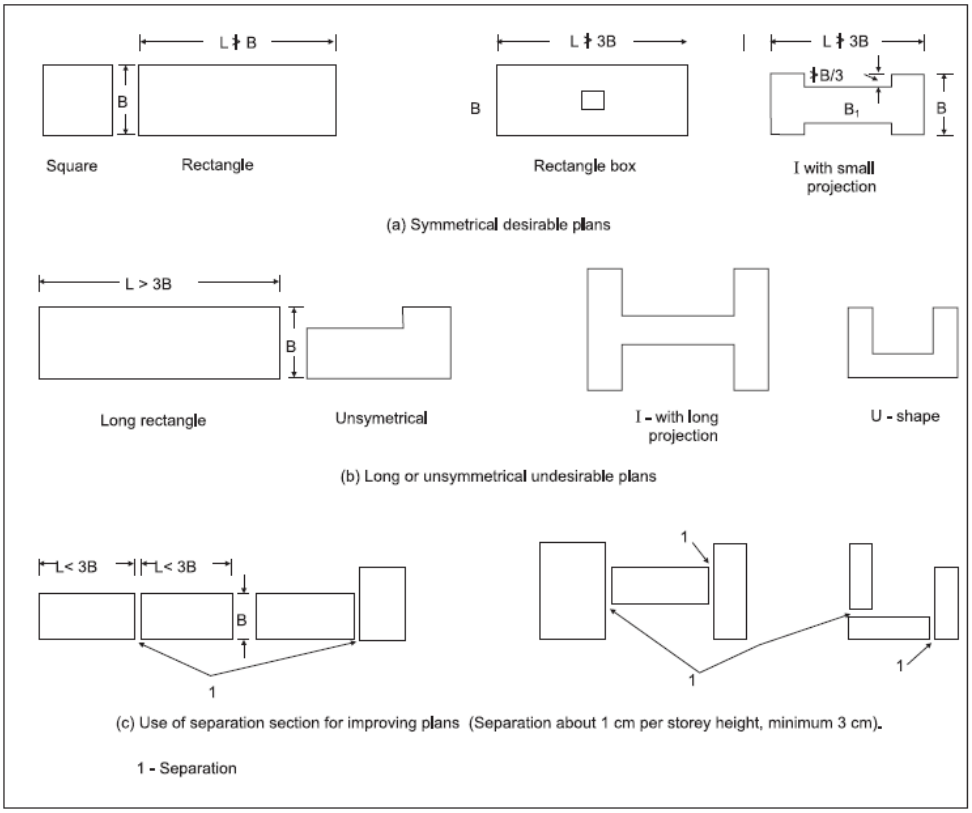
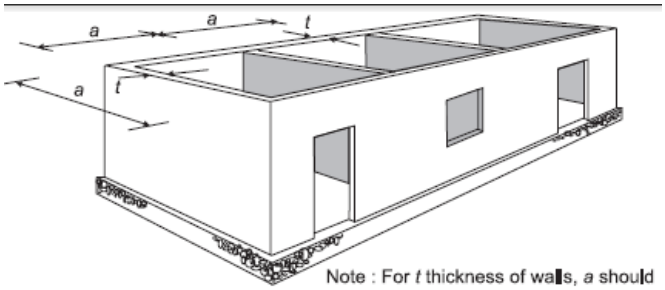


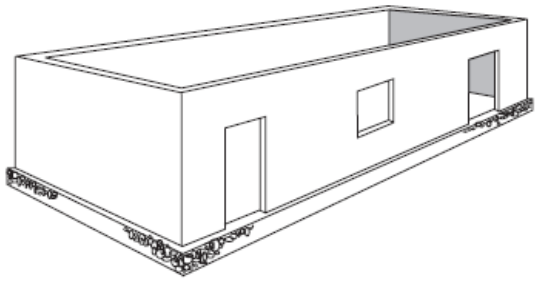
Fig 3.2 Plan of building blocks.

- Separate Buildings for Different Functions: In view of the difference in importance of hospitals, schools, assembly halls, residences, communication and security buildings, etc., it may be economical to plan separate blocks for different functions so as to affect economy in strengthening costs.

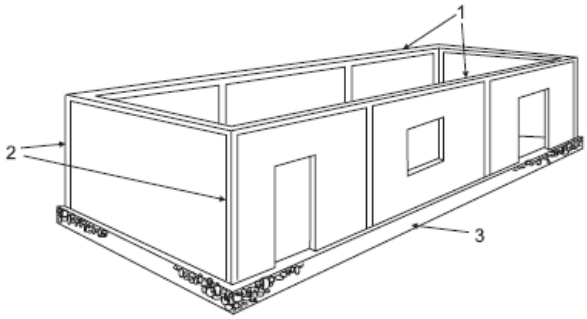


Note : For *t* thickness of walls, *a* should be such that $a/t \leq 40$. Otherwise framing be used as shown at (c).

(a) Many crosswalls, small boxes, seismically strong



(b) No crosswall, large box, seismically weak



(c) Wall with framing elements, usually reinforced concrete

1 – Collar beam
2 – Column or buttress
3 – Foundation

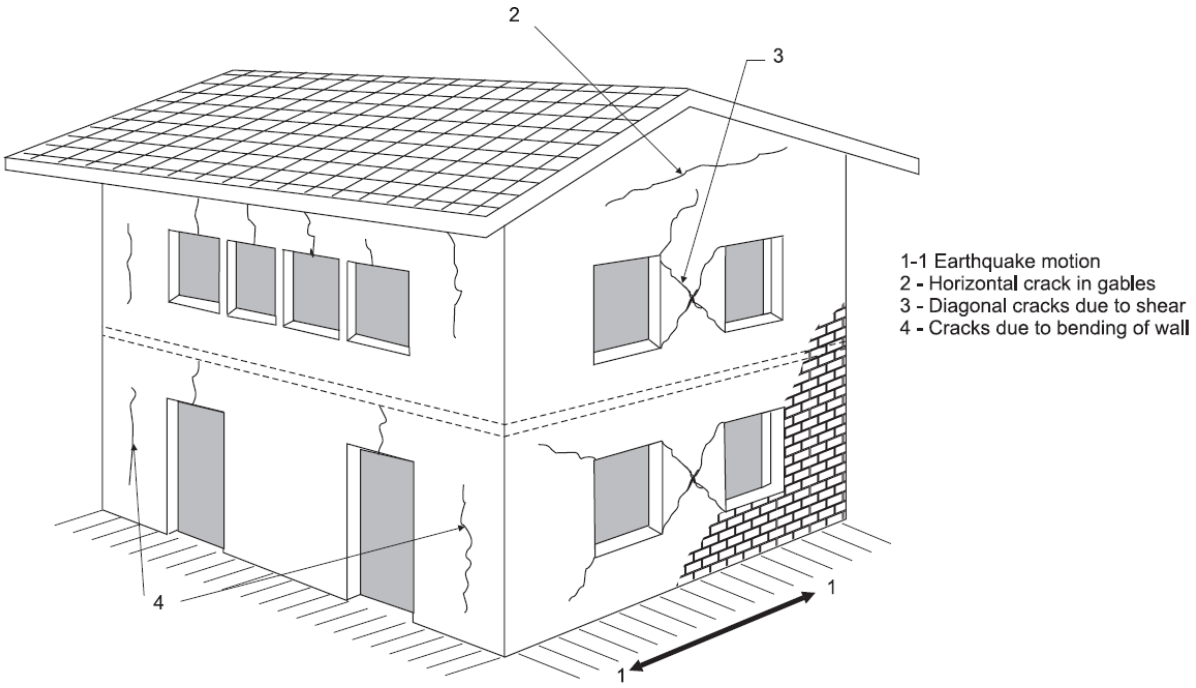
Question 02:

What are the typical damage and failure of a masonry building?

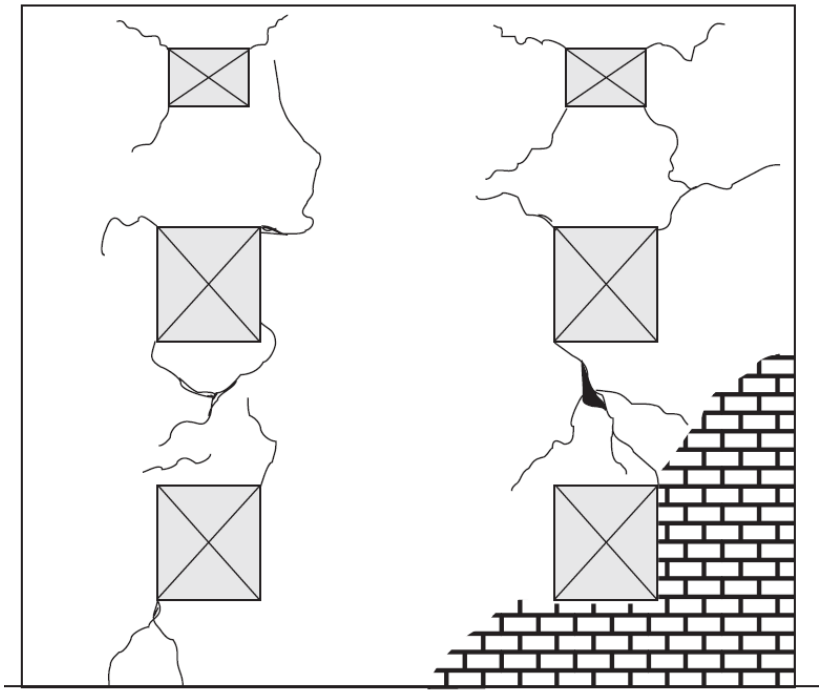
Answer:

- The creation of tensile and shearing stresses in walls of masonry buildings.
    - The non-structural damage is that due to which the strength and stability of the building is not affected. Such damage occurs very frequently even under moderate intensifies of earthquakes:
- Cracking and overturning of masonry parapets, roof chimney, large cantilever cornices and balconies.

- Cracking and overturning of partition walls, filler walls and cladding walls from inside of frames. Though not usually accounted for in calculations, this type of damage reduce the lateral strength of the building.
- Cracking and failing of ceilings.
- Cracking of glass panes.
- Failing of loosely placed objects, overturning of cupboards, etc.



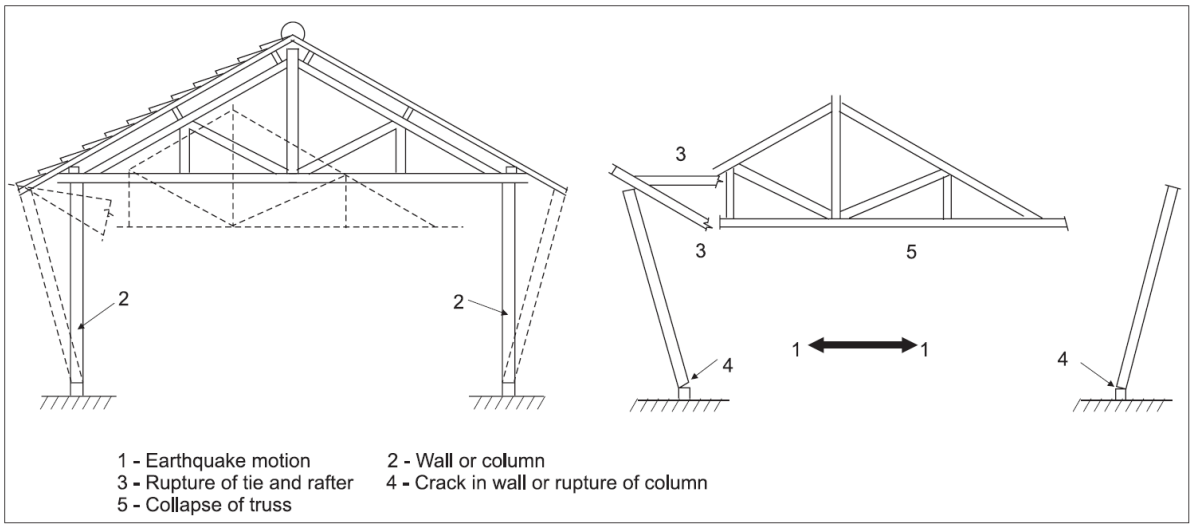
- Failure due to racking shear is characterized by diagonal cracks which could be due to diagonal compression or diagonal tension.
- Such failure may be either through the pattern of joints or diagonally through masonry units.
- These cracks usually initiate at the corner of openings and sometimes at centre of wall segment.



- Inadequate depth of foundation:
    - Shallow **foundations** deteriorate as a result of weathering and consequently become weak for earthquake resistance.
- Differential settlement of foundation:
    - During severe ground shaking, liquefaction of loose water-saturated sands and differential compaction of weak loose soils occur which lead to excessive cracking
- Sliding of slopes: Earthquakes cause
    - Sliding failures in man-made as well as natural hill slopes and any building resting on such a slope have a danger of complete disastrous disintegration.

<u>Failure of roofs and floors</u>

- Dislodging of roofing material: Improperly tied roofing material is dislodgeddue to inertia forces acting on the roof. This mode of failure is typical of sloping roofs.
- Weak roof to support connection is the cause of separation of roof trussfrom supports, although complete roof collapse mostly occurs due to collapse of supporting structure
- Heavy roofs as used in rural areas with large thickness of earth over round timbers cause large inertia forces on top of walls.



Causes of damage in masonry buildings:

- Heavy weight and very stiff buildings, attracting large seismic inertia forces.
- Very low tensile strength, particularly with poor mortars.
- Low shear strength, particularly with poor mortars.
- Brittle behavior in tension as well as compression.
- Weak connection between wall and wall.
- Stress concentration at corners of windows and doors.
- Overall asymmetry in plan and elevation of building.
- Asymmetry due to imbalance in the sizes and positions of openings inthe walls.

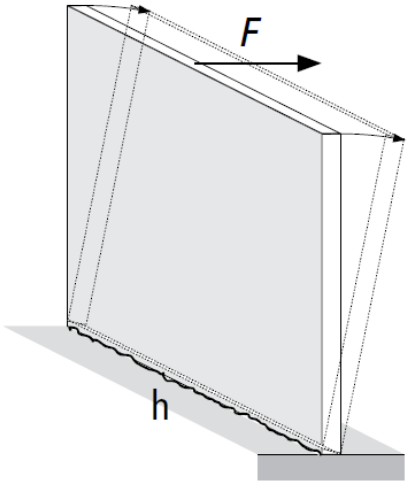
Question 03:

How does a free-standing masonry wall behave during an earth quake?

Answer:

Ground shaking:

- Consider a free-standing masonry wall.
- The ground motion is acting transverse to a free-standing wall.



a) Out-of-plane force causing overturning

- The out-of-plane inertia force acting on the mass of the wall tends to overturn it.
- The seismic resistance of the wall is by its weight and tensile strength of mortar. It is obviously very small. This wall will collapse by overturning under the ground motion.
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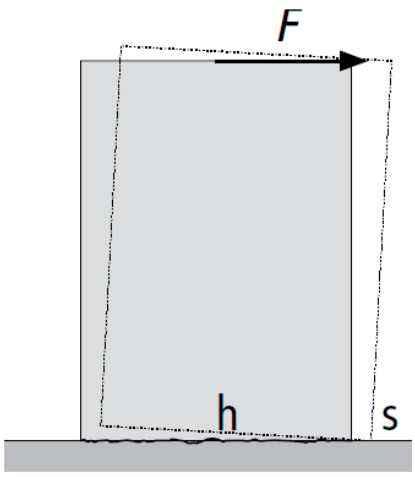
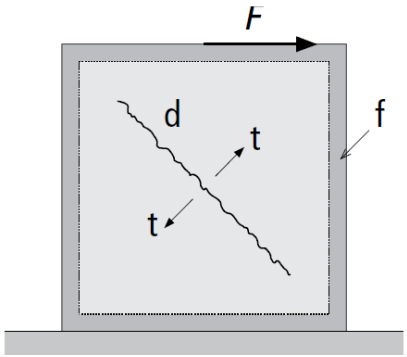


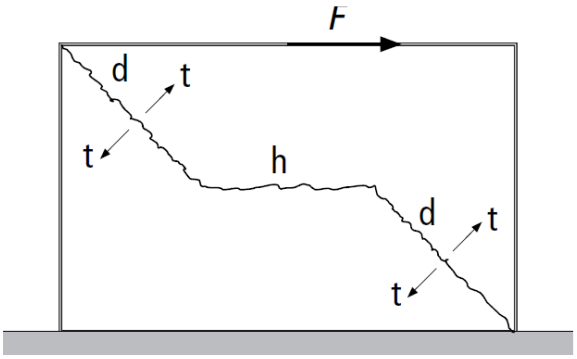
b) Wall with large aspect ratio

- The free-standing wall fixed on the ground is subjected to ground motion in its own plane.
- In this case, the wall will offer much greater resistance because of its large depth in the direction of the force and the plane of bending.

- Such a wall is termed a shear wall.
- The damage modes of an unreinforced shear wall depend on the height-to-length ratio or aspect ratio of the wall.
- A wall with large aspect ratio will generally develop a horizontal crack at the bottom due to bending tension and then slide due to shearing.
- A wall with moderate aspect ratio and bounding frame cracks diagonally due to shearing as shown in figure.
- A wall with small aspect ratio, on the other hand, may develop diagonal tension cracks at both sides and horizontal cracks at the middle.



c) Wall with moderate aspect ratio



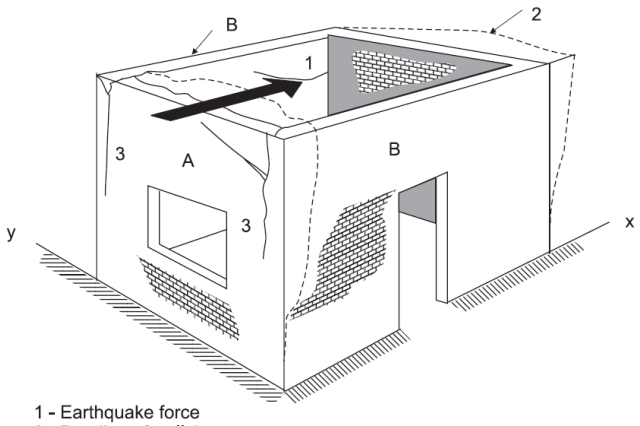
d) Wall with small aspect ratio

(F: earthquake force, d: diagonal cracking, f: frame, h: horizontal cracking, s: sliding, t: tensile stress)

Question 04:

How does a wall enclosure without roof behave during an earth quake? Elaborate.

Answer:



1 - Earthquake force
2 - Bending of wall A
3 - Bending cracks at ends of wall A

- Consider the combination of walls A and B as an enclosure shown in Figure.
- For the X direction of force as shown, walls B act as shear walls and, besides taking their own inertia, they offer resistance against the collapse of wall A as well.
- As a result walls A now act as vertical slabs supported on two vertical sides and the bottom plinth. The walls A are subjected to the inertia force on their own mass.
- Near the vertical edges, the wall will carry reversible bending moment. the horizontal plane for which the masonry has little strength.
- Consequently cracking and separation of the walls may occur along these edges shown in the figure.
- If the connection between walls A and B is not lost due to their bonding action as plates, the building will tend to act as a box and its resistance to horizontal loads will be much larger.
- Most unreinforced masonry enclosures, however, have very weak vertical joints between walls meeting at right angles due to the construction procedure involving toothed joint that is generally not properly filled with mortar.
- Consequently the corners fail and lead to collapse of the walls.