

## **EARTHQUAKE RESISTANT CONFINED MASONRY STRUCTURE WITH CONCRETE BEAMS AND COLUMNS**

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### **Abstract**

The article is focused on confined masonry structures. A number of unreinforced masonry buildings collapsed, several multistorey buildings in confined masonry damaged slightly in the past earthquake in Pakistan. Based on the results of additional model experiments, the confined masonry and concentrated reinforced masonry structures have been widely applied to the low-rise and medium-rise buildings respectively in the seismic-zone. For the low-rise buildings the reinforced concrete ring beams are placed at each floor and the post-cast tie columns are placed at each intersection of interior and exterior masonry walls. For the medium –rise building in additions to the ring beams and tie columns ,the post-cast reinforced concrete intermediate columns and horizontal belts are placed in all the masonry walls at spacing of 2~3m and 1~1.5m respectively. Model Experiments and engineering practices show that masonry structures have a good strength, deformability, seismic reliability and can be applied to the multistorey buildings up to 10 stories in the seismic zone.

**Keywords:** Confined Masonry; Ring Band; Tie Beams; Tie Columns

### **1. Introduction**

Pakistan divided into four seismic zones .Confined masonry structures are best suitable for seismic resistance and from economical point of view in these areas. In these seismic zones a lot of unreinforced masonry buildings were damaged in past earth quakes. Therefore it is important to take countermeasures to improve the horizontal load bearing capacity and a seismic reliability of masonry buildings. To strengthen the masonry structures it is essential to provide tie-columns and tie-beams .Confined masonry structure resist both vertical and lateral loads .The tie-columns resist overturning moments and confinement effects, due to tie-columns and tie-beams improves the wall displacement capacity and the seismic behavior under cyclic loads. The building structure is approximately symmetrical along each principal axis in plan for both stiffness and mass distribution.

## 2. Analytical Model

Experimental results show that tie-beam at different levels prevents diagonal cracks and the crack on the wall surface is restricted within the area between the bands. Experimental results show also that on the increment of the horizontal bearing capacity of the wall the reinforced concrete belt is better than mortar joints reinforcement. Experimental results shows that the tie-

Column provided in the structures increase the horizontal and vertical load bearing capacity of the wall and it gives the partial method on the improvement of ductility and bearing capacity of masonry building. The confining members reduce the brittleness of the masonry wall under earthquake load and hence improving this earthquake performance. The confined masonry structure shown in fig.01.

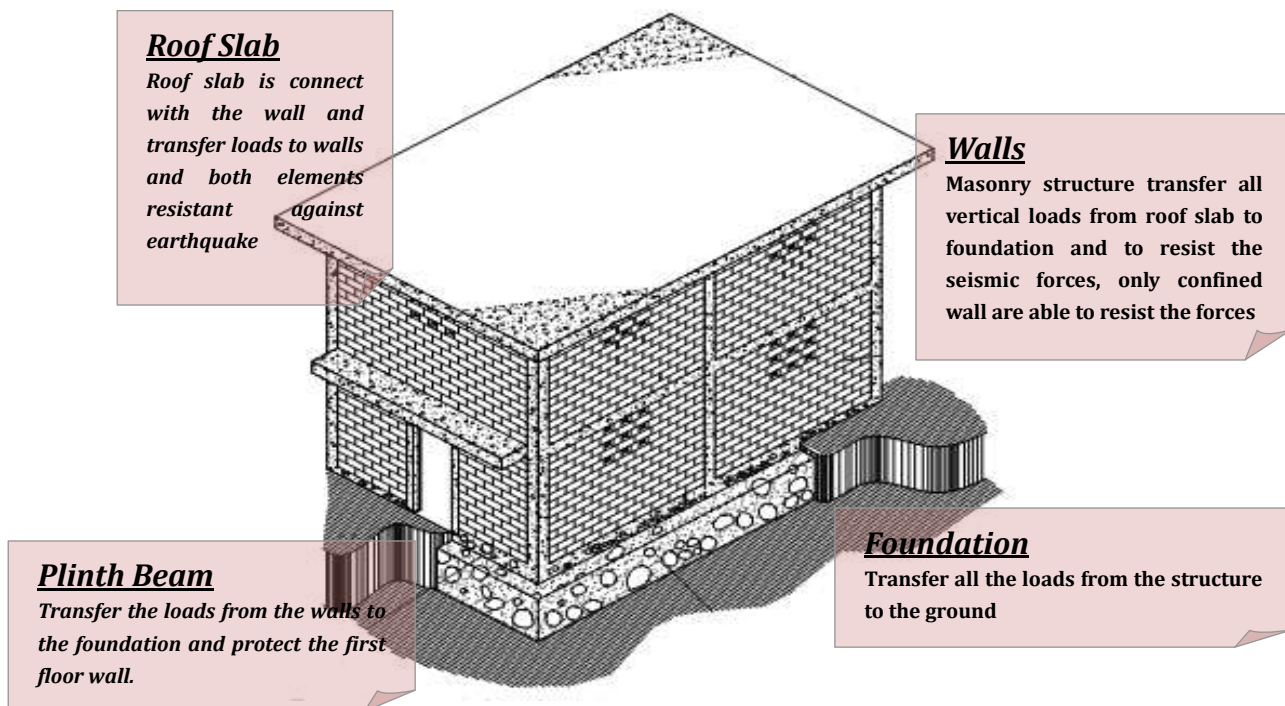
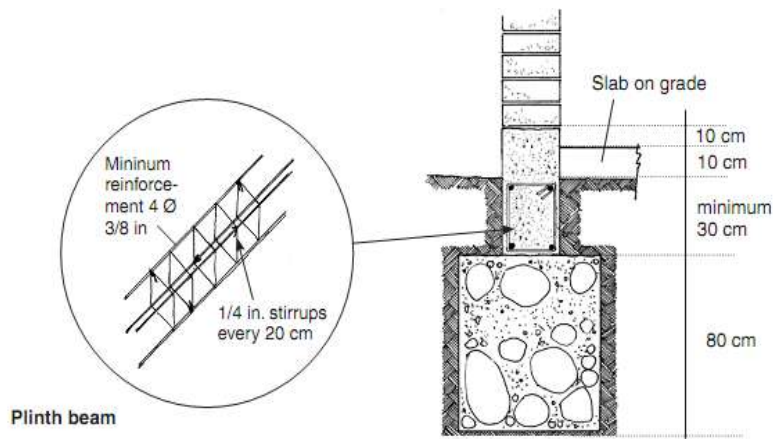
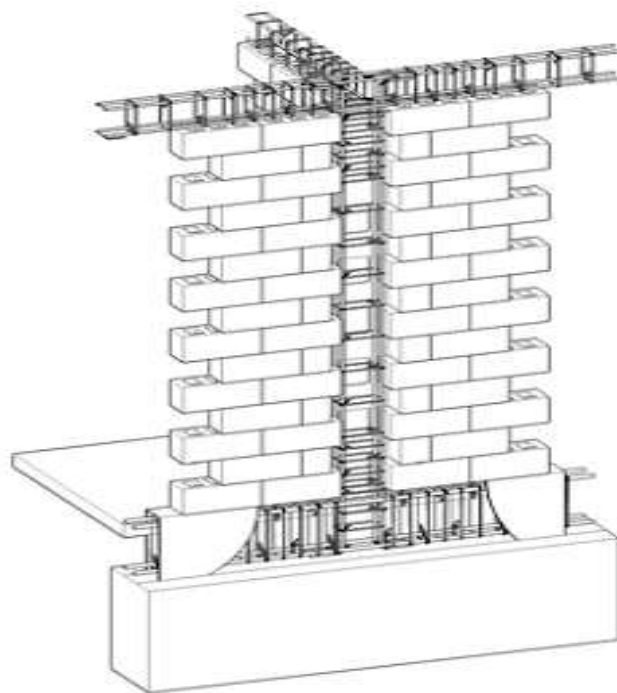


Fig.01: A confined Masonry earthquake-resistant structure.

The behavior of strip foundation depends on the ground conditions. A trench digging for continuous foundation should be made. Bottom of trench should be compacted and leveled. Reinforcement bars of columns previously assembled as a basket are placed and previously fixed into the foundation with reinforcement of all columns placed and provisionally fixed, continuous foundation is filled with simple concrete. It will be better to use steel in floor slab. A plinth band should be constructed on top of foundation, the function of plinth band in confined masonry is to tie the neck column as shown in fig. 02and 03.

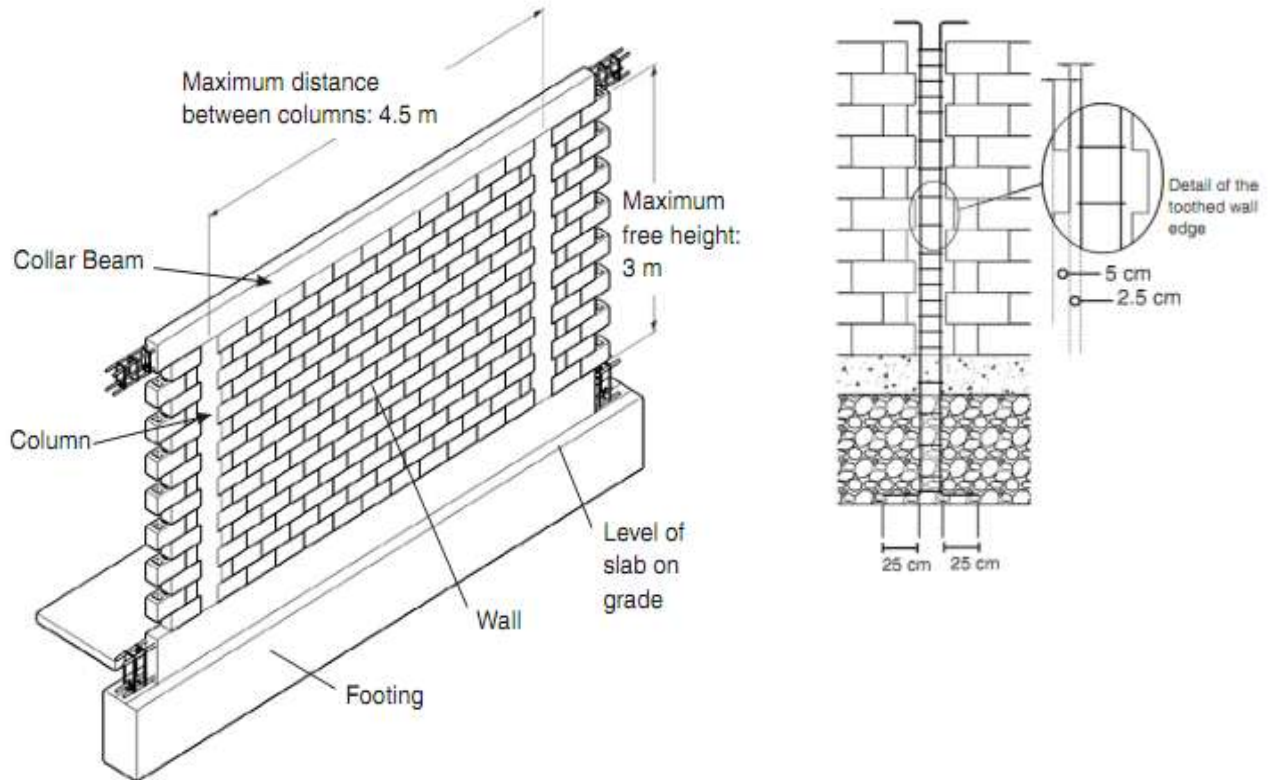


**Fig.02: Plinth beam/band Steel Reinforcement.**



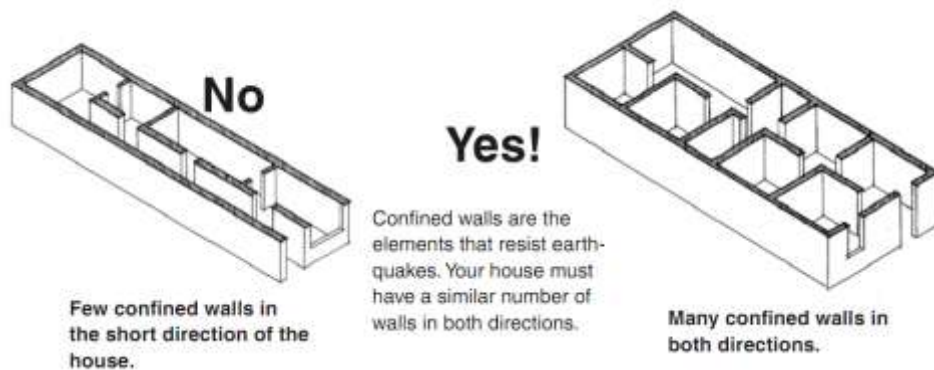
**Fig .03 Beam with Column Reinforcement.**

**About the over-plinth beam, it starts layering of brick/block units over mortar bed, forming masonry wall. Toothed edge must be left on each side of the wall. Toothed edges are essential for adequate wall confinement, which contributes to satisfactory earthquake performance. Masonry wall structure is uniform and regular. Details of confined masonry walls shown in following fig 04.**



**Fig 04:** Left figure shows maximum distance the confined elements with the masonry wall and right figure shows toothed edges of the wall with tie columns.

In Confined masonry structures walls are the main load bearing and earthquake resistance elements. Wall density of at least 2% in each of two orthogonal directions is required to ensure good earthquake performance of confined masonry construction. Since the earthquake performance of confined masonry buildings largely depends on the shear resistance of masonry walls Confined masonry structures will be more safe and stable if the walls are symmetrical along both sides, as shown in fig. 05.



**Fig 05:** Left figure shows poor distribution of walls and right figure shows good distribution of walls in confined masonry structures.

Then tie-column will be poured after construction of masonry wall in the performs vertical channel of walls. Reinforced concrete tie-columns are the main structural members to confine the masonry wall in order to increase the horizontal and vertical load bearing capacities, deformation ability and seismic reliability. It may be divided into wall terminal tie-columns and wall intermediate tie-columns. Reinforcement details of column are shown as follow in fig 06.

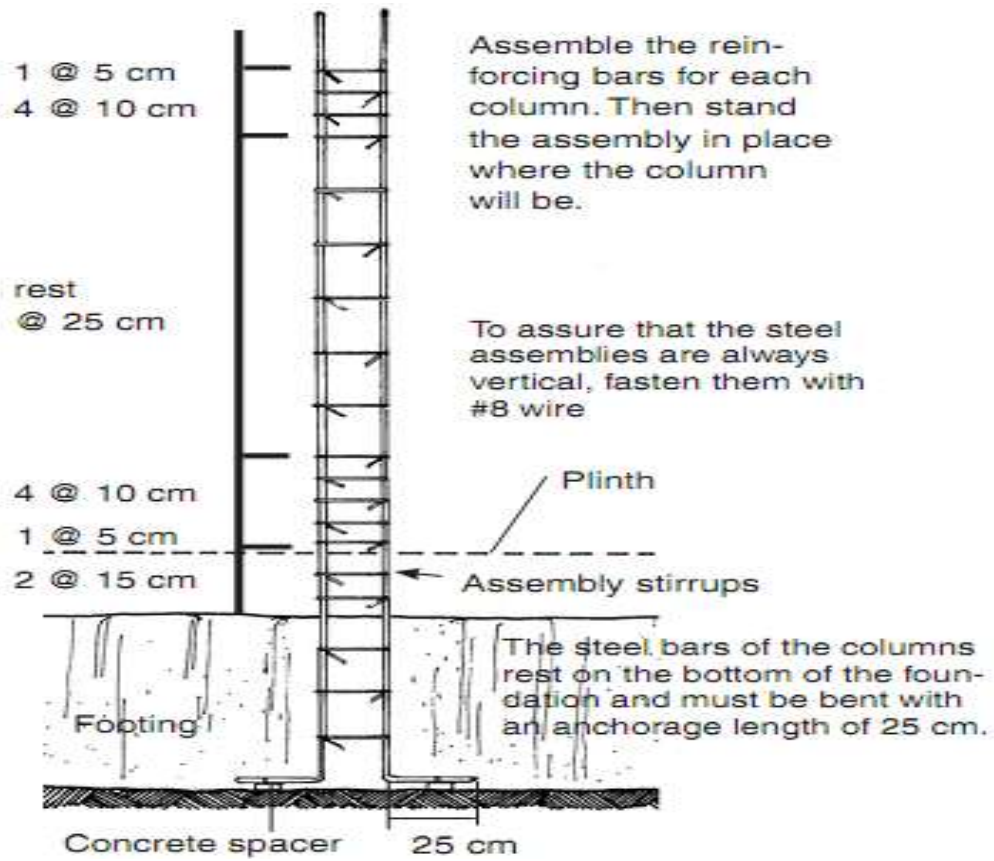


Fig 06: Tie-column steel reinforcement shown before the pouring of concrete.

Horizontal reinforced concrete bands are placed at sill and lintel level. The band do as well have a role of “crack stopper” blocking diagonal cracks before they stretch over the whole wall panel, thus ensuring an increase in wall homogeneity during earthquake. Tie-beams should be placed on every floor level. Vertical spacing of tie-beams should not exceed 3m. Hooks for column and beams must be bent at 135 degree in earthquake construction. The details are shown in following figure i.e. fig 07 and fig 08.

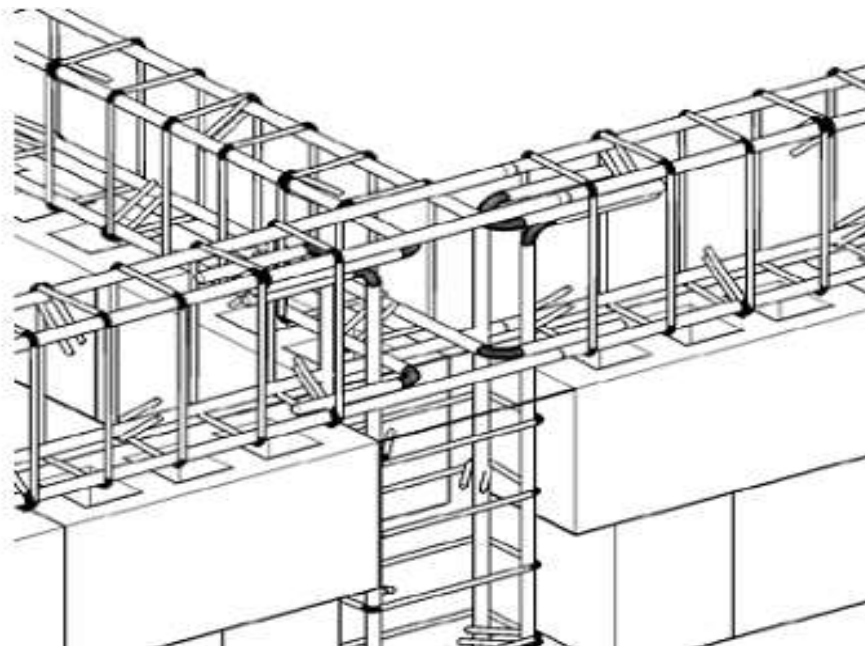
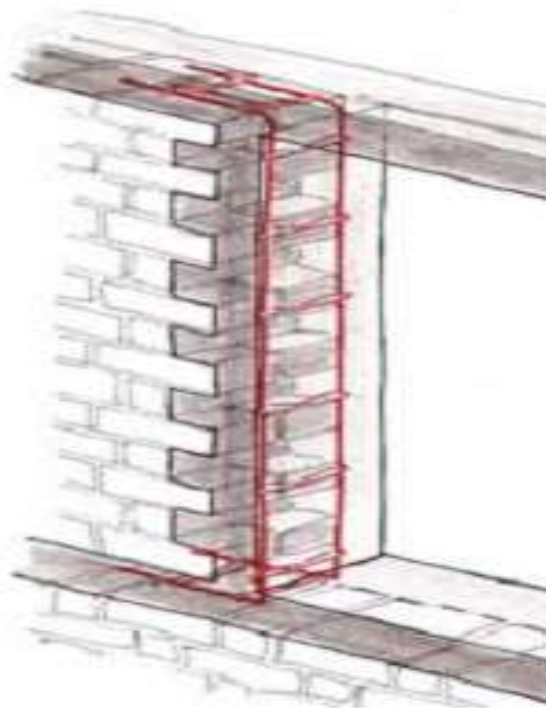


Fig 07: Tie-beam and Tie-Column reinforcement at intersection must be satisfactory for earthquake performance.

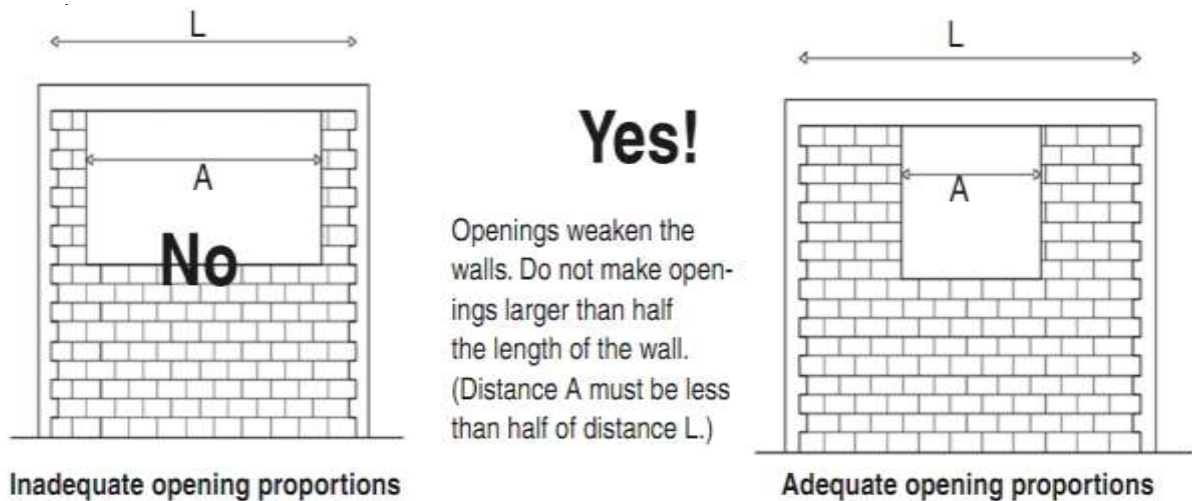


**Fig 08:** Hooks of column and beam at 135 degree and length of hook is 3inches/7.5 cm.

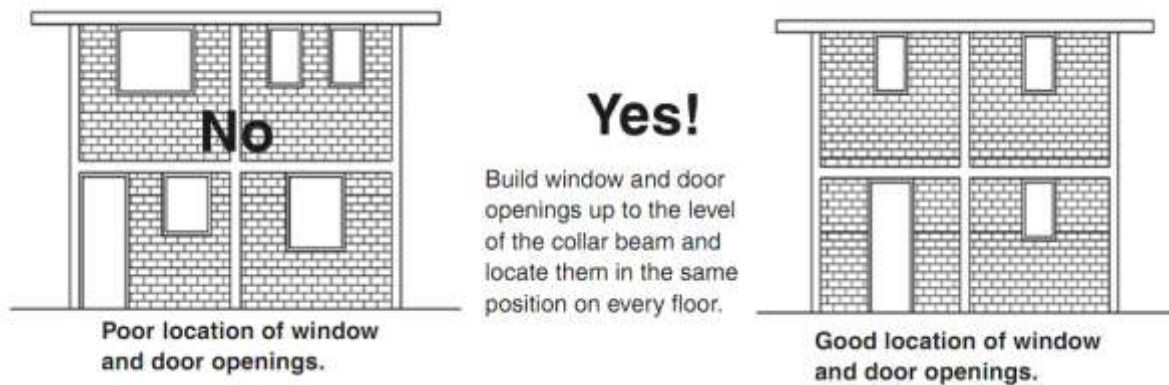
All opening are confined with vertical bands. Contrary to the main vertical ties (with 4bars, dia1/2inch, 12mm).The confinement of opening have only 2 bars. The length of the opening not larger than the half length of the wall. Otherwise special lintel beam required for large openings and tie-columns placed at both sides of any large opening in order to enable the diagonal strut action. Opening (door and windows) should be placed in the same position up the building height. Details of opening are as shown figure 09, 10 and 11.



**Fig 09:** Confined opening reinforcement details.



**Fig 10: Left figure shows inadequate opening proportions and right figure shows adequate opening proportions for confined masonry structures.**



**Fig 11: Left figure shows poor location of window and door openings and right figure shows good location of window and doors openings for confined masonry structures.**

These differences between Confined masonry structures and RC frame structures are summarized in the Table 1.

**Table 1. A Comparison between Confined Masonry building with RC frame construction building.**

	Confined masonry construction	RC frame construction
Gravity and lateral load-resisting system	Masonry walls are the main load bearing elements and are expected to resist both gravity and lateral loads. Confining elements (tie-beams and tie-columns) are significantly smaller in size than RC beams and columns.	RC frames resist both gravity and lateral loads through their relatively large beams, columns, and their connections. Masonry in fills is not load-bearing walls.
Foundation Construction	Strip footing beneath the wall and the RC plinth beam	Isolated footing beneath each column.
Superstructure construction sequence	1. Masonry walls are constructed first.	1. The frame is constructed first.

	<p>2. Subsequently, tie-columns are cast in place.</p> <p>3. Finally, tie-beams are constructed on top of the walls, simultaneously with the floor/roof slab construction.</p>	<p>2. Masonry walls are constructed at a later stage and are not bonded to the frame members; these walls are nonstructural, that is, non-load bearing walls.</p>
<b>Time period</b>	Confined masonry building takes less time for completion.	RC frame construction building takes more time for completion.
<b>Economical</b>	Confined masonry is more economical than RC structure.	RC frame construction building is less economical than confined masonry structures.
<b>Architectural Design</b>	Confined masonry building architectural design is simpler than RC frame construction buildings.	RC frame construction building architectural design is less simple than Confined masonry buildings.
<b>Easier Construction</b>	Confined masonry buildings are easier to construct as compare to RC frame construction.	RC frame Construction is difficult to construct as compare to Confined masonry buildings.

Confined masonry structures construction practices in Pakistan are shown in the following figure.



**Fig 12: Construction procedure of tie-column pouring with brick masonry**





**Fig 13: Vertical reinforcements around openings**



**Fig 14: Under construction confined masonry structure**



**Fig 15: Finished confined masonry structure showing seismic reinforcement**

### 3. Conclusions

**In the light of above discussion and experimental results we prefer confined masonry structures are best suitable in earthquake region because of its good strength, seismic reliability, deformability, ductility, stability, economical and easier in construction.**

### References

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