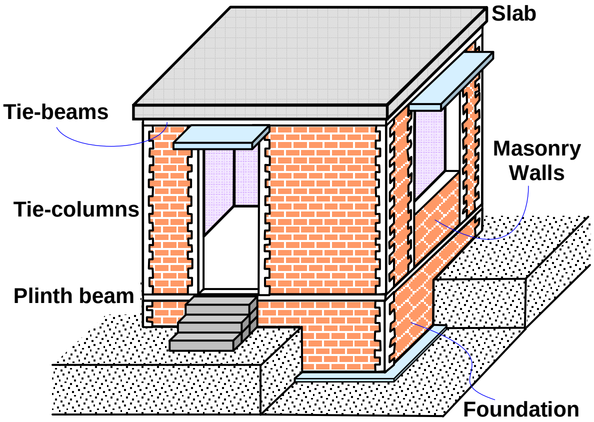
IITK - BMTPC Earthquake Tip 28

Learning Earthquake Design and Construction

What is a Confined Masonry Construction?

Basics of Confined Masonry

Confined Masonry (CM) construction typically consists of: traditional *strip foundation* (in masonry); reinforced concrete (RC) *plinth beam*; masonry *walls* (in bricks or concrete block units) built on top of plinth beam; small RC *vertical & horizontal confining elements built* around these masonry walls; and RC *floor and roof slabs* built monolithically with the confining elements (Figure 1a). These vertical and horizontal confining elements are called *tie-columns* and *tie-beams*, respectively. CM construction has a mandatory *plinth beam* on top of plinth masonry. CM is a good construction technology for *low-* and *medium-rise* houses in seismic areas (Figure 1b).



(a)

Photos: *World housing Encyclopedia, EERI, 1999*

(b)

Figure 1: Confined Masonry Construction – *(a) components of CM system, and (b) 4-storey house constructed in Chile with CM system.*

Construction of CM building with *RC confining elements* involves making masonry walls in small panels, each of which is confined on all four sides by vertical and horizontal RC elements. Concrete is poured in vertical and horizontal confining elements after walls are built. RC confining elements hold the masonry in place and improve integrity of the house during seismic shaking (Figure 2). CM houses performed well even in several severe earthquakes, such as the 2010 Chile earthquake (Magnitude 8.8), while many unreinforced masonry (URM) and even RC buildings suffered damage during the same events.

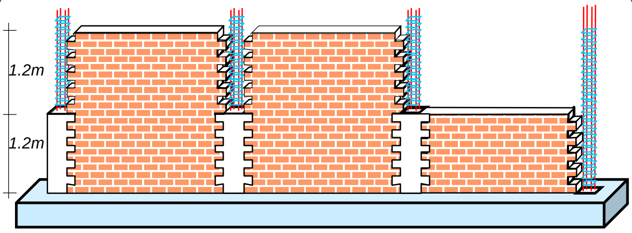


Figure 2: Construction Sequence – *Plain masonry walls built first, are held snugly by adjoining RC elements that are cast in-situ later*

The concept of masonry wall construction confined with wood elements has been used for centuries in many earthquake-prone regions along the *Alpine-Himalayan belt*. For example, in the Kashmir Valley in J&K State (India), *Dhajji Dewari* constructions consists of large masonry walls broken into smaller panels with wood verticals, horizontals and diagonals. These houses showed *excellent* performance in many past earthquakes and helped avoid loss of life. These houses have simple architectural design, good quality materials and good quality of construction.

CM is different from MRF with URM Infills

CM houses are different substantially from RC *moment resisting frame* (MRF) houses with masonry infills, even though both technologies use the same constituent structural materials (concrete and masonry) and have very similar appearance when the buildings are completed. The key differences are:

(a) *Different Behaviour*:

CM houses are *load-bearing structures*, because *masonry walls* carry both *gravity* and *earthquake-induced lateral forces*. This is similar to *unreinforced masonry* (URM) construction, which has been used in India for many centuries. URM houses perform well under gravity loads, but experience significant damage during earthquake shaking, because masonry cannot take tension that develops during earthquake shaking. On the other hand, RC MRF houses classify under *moment-resisting frame system*. RC frames are infilled with unreinforced masonry walls in some countries, *e.g.*, India (see *IITK-BMTPC Earthquake Tips 17, 21* and *22*), and with engineered infills in others, *e.g.*, New Zealand.

(b) *Different Construction Sequence*:

Construction sequence is distinctly different for the two construction types, namely *CM* and *MRF with masonry infills*. In CM construction, masonry walls are built simultaneously with reinforcement in *vertical and horizontal* RC confining elements, and concrete is poured in these elements at the end (Figure 3a). In RC MRF construction with masonry infills, *first* the RC frame is built (*i.e.*, footings, columns, beams, and slabs) and *then* the masonry wall panels are infilled in open bays between RC columns and beams (Figure 3b).

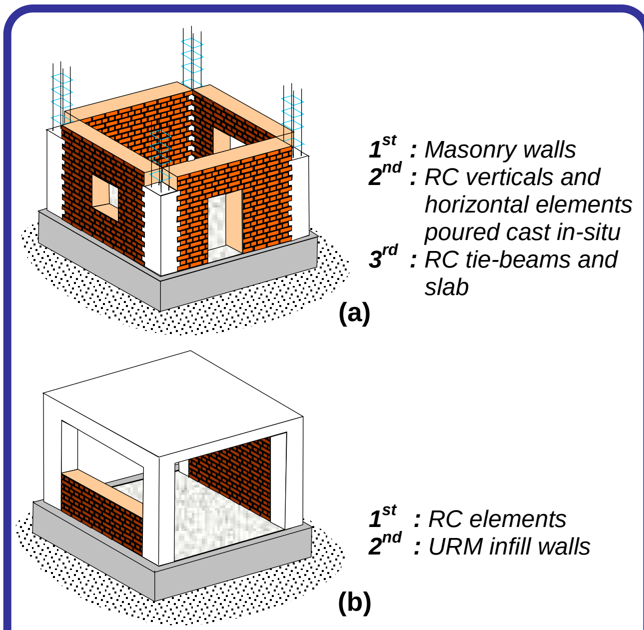


Figure 3: Construction Sequence – *(a) CM; and (b) RC frame with URM infills*

(c) *Different Design Complexity*:

In CM houses, RC elements act primarily in *compression* and *tension* (similar to posts in wood construction), and the connections between these elements are pinned (there is no *flexure*); hence, RC tie-beams and tie-columns are smaller in size and require less reinforcement compared to RC frame members. In RC MRF houses, RC members largely undergo *bending* and *shearing*, and therefore they need to be larger in terms of *size* and amount of *reinforcement*. *Prescriptive approach* may be adequate for design of low-rise CM houses with typical room sizes and floor heights (See Meli *et al*, 2011; Brzev, 2008), but *engineered design approach* is required for RC MRF houses. Thus, design effort may be considerably smaller for CM houses than for RC MRF houses.

RC confining elements in CM construction (Figure 4) enhance stability and strength of brittle masonry walls, *e.g.*, interaction between masonry walls, structural integrity, and containment of earthquake damage within the masonry walls. These advantages lead to superior (more *ductile*) earthquake performance of CM houses over those of alternative concrete and masonry building technologies, with relatively lower level of technical effort. Also, CM houses are more economical for the same functional use. For these reasons, *confined masonry* construction is more suitable for *low-* and *medium-rise* housing in earthquake prone areas than for RC MRF construction.

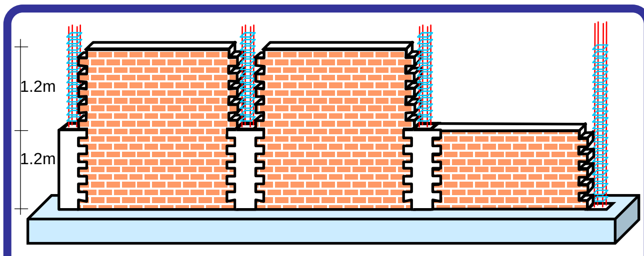


Figure 4: Advantage of Construction Sequence – *Plain masonry walls built first, are held snugly by adjoining RC elements cast later*

Construction of Buildings with Confined Masonry

Design Codes for CM houses have been in place for more than 50 years in several countries, like Chile, Mexico and Argentina. But, CM construction has not been practiced in many countries, including India; hence, code provisions were not available in these countries for many years, but now some are being developed (See Brzev, 2008; Schacher, 2009). Most design codes lay down *prescriptive* guidelines for *architectural*, *structural* and *constructional* aspects of low-rise CM buildings, and provide requirements for engineered design of tall CM buildings. These design codes are based on *experimental verification* in laboratories, *analytical research* as well as *earthquake performance* of such constructions in past earthquakes.

Related IITK - BMTPC Earthquake Tips

Tip 12: How do brick masonry buildings behave during earthquakes?
Tip 13: Why should masonry buildings have simple structural configuration?
Tip 17: How do earthquakes affect reinforced concrete buildings?
Tip 29: What are the essential features of confined masonry houses?

Resource Material

Brzev,S.N., (2008), *Earthquake-Resistant Confined Masonry Construction*, National Information Center of Earthquake Engineering, IIT Kanpur, www.nicee.org

Meli,R., *et al* (2011), *Seismic Design Guide for Low-Rise Confined Masonry Buildings*, Earthquake Engineering Research Institute, and International Association for Earthquake Engineering

Schacher,T., (2009), *Confined Masonry for one and two storey buildings in low-tech environments*, A guidebook for technicians and artisans, National Information Center of Earthquake Engineering, IIT Kanpur, www.nicee.org

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