A Comparative Study Between Confined Masonry and Reinforced Concrete Buildings Performances

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1 Introduction

Confined Masonry (CM) construction is a seismic-resistant construction technique where the walls are confined with horizontal and vertical ties to ensure stability and safety during seismic loading. Whereas Reinforced Concrete (RC) frame structure is a connected frame of members which are firmly connected by rigid joints. CM structures are appearing as an accepted building construction technique in many earthquake-prone countries including India. And moreover, CM structures become economically feasible and seismic resistant for low-rise buildings. Therefore, research works have been carried out to seek detailed information for CM structures. Rangwani et al. [1] conducted a comparative analysis of CM shear walls using Wide Column Model (WCM) approach and FEM macro-modeling approach. The results are obtained in terms of roof displacements, stiffness values and internal forces. No differences in results have been observed using both approaches. Pandey et al. [2] performed an investigation study on confined masonry for its seismic resistance and cost-effectiveness to compare with equivalent RC construction for low-rise residential buildings in Nepal using pushover analysis. The study showed that CM technology offers a better economic incentive in addition to enhanced performance in seismic loading pertinent to hazards defined by the current National Building Code (NBC) of Nepal. Sukarwa et al. [3] performed a numerical investigation of the behavior of confined masonry and its application for use as the main structure of multi-story buildings subjected to seismic loading. It was revealed that using shell elements for masonry walls, reinforced concrete beams, and tie-columns, the CM model mimics the load-deformation curve of tested specimens better than that

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using frame and shell elements in SAP2000. Arle Pratibha et al. [4] performed a comparative study between RC frame and CM constructions on different aspects like load resisting systems, foundation construction, etc. It has been found that for the seismic region, CM buildings give a better alternative for low-cost earthquake-resistant building construction. Chourasia et al. [7] discussed masonry construction in an Indian scenario and studied the performance of CM buildings on past earthquakes and their behavior under lateral cyclic loading. CM is found to be a promising technology that performs better under seismic loading and exhibits no significant damage. Also, the performance of CM buildings in India in comparison with unreinforced masonry (URM) and reinforced masonry (RM) in strength showed about 3.42 & 2.3 times improvement respectively. Ahmed et al. [9] analyzed the seismic functioning of CM brick buildings in earthquake-prone areas of Pakistan and other similar regions of the world. The results from this experimental study concluded that CBM building is sturdy against seismic loads because of the confining elements and is efficient in enhancing seismic performance. It has been observed from the above literature that CM structures are found to be economically feasible and seismic resistant when compared to their counterpart RC frame structures. Thus, in this paper, an attempt has been made to conduct a detailed comparative analysis between CM and RC structures along with their cost implications. Two similar buildings one as a CM structure and the other as an RC structure have been modeled SAP2000. Then the results have been compared in terms of storey drift, base shear and cost efficiency analysis.

2 Modeling

A five-room floor plan residential building of plan size 45’ × 42’ has been drawn in AutoCAD for RCC and Equivalent Confined Masonry buildings respectively. The buildings are three storeys (G + 2) with 3.1 m storey height and with equal floor plan. The floor plans for RCC and CM structures are shown in Fig. 1a and b respectively.

2.1 Modeling of RC Frame Building Frame in SAP2000

Modeling of RC building is done using frame elements for columns, beams, equivalent strut, and shell element for slabs as shown in Fig. 2. The model is designed using IS 456: 2000, also the width of the equivalent strut for infill was designed using IS 1893 (Part 1): 2016, Clause 7.9. Dimensions considered for the design of G + 2 RCC building are listed in Tables 1 and 2.

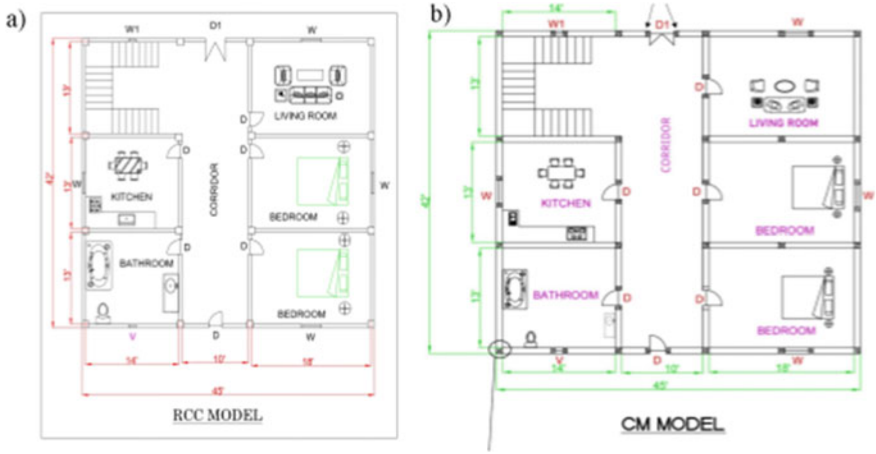

Fig. 1 **a** RC Framed Building and **b** Equivalent CM building plan

Fig. 2 RCC model in SAP2000 (using frame elements)

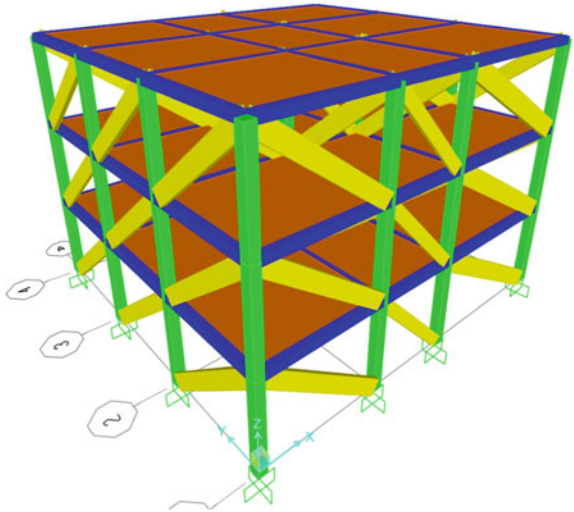

Table 1 Dimensions used to design the G + 2 RCC building

Specification	Value
Plan size	45ft × 42ft
No of floors	3
Floor height	3.1 m
Material	RCC
Thickness of slab	0.15 m
Column size	0.3 m × 0.3 m
Beam size	0.25 m × 0.25 m

Table 2 Dimensions of struts**

Length of wall	Length of equivalent strut (m)	Width of Equivalent strut (m)	Thickness of strut (m)
10ft wall	3.959	0.42	0.15
13ft wall	4.88	0.53	0.15
14ft wall	4.88	0.53	0.15
18ft wall	5.917	0.64	0.15

** Dimension of strut is designed according to IS 1893 (Part 1):2016, clause 7.9

2.2 Modeling of Confined Masonry in SAP2000

Modeling of the CM building has been done using Shell elements [3] (see Fig. 3) and designed in accordance to EERI, 2011 [23].

Dimensions considered for the design of G + 2 CM building are listed in Table 3.

2.2.1 Wall Density Index

The wall density index along Y-axis for the Ground floor, 1st floor and 2nd floor are 5.84% each and that along X-axis for the Ground floor, 1st floor and 2nd floor are 6.21, 6.44 and 6.44% respectively wheren all of them are greater than 5%, which

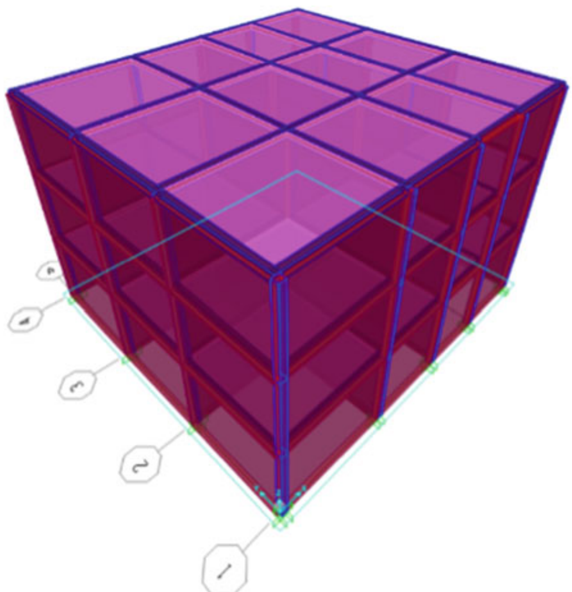

Fig. 3 CM model in SAP2000 (using shell elements)

Table 3 Dimensions used to design the G + 2 CM building

Parameter	Value
Plan size	45ft × 42ft
Wall thickness	0.23 m
Tie column	(depth × width) (0.23 m × 0.2 m)
Tie beam	(depth × width) (0.23 m × 0.2 m)
Slab thickness	0.15 m

Table 4 Mechanical properties of CM building

Indian standard design	Value	Remark
Reinforcing bar	Min 10 mm dia	
Stirrup	6 mm dia	
Rebar	8 mm dia	
Modulus of elasticity of brick masonry, E (Mpa)	1,573,072.1	IS 1893, clause 7.9.2.1
Poisson, u	0.26	
Coefficient of thermal expansion, A,(°C $^{-1}$)	4.5810^{-6}	

is the minimum requirement according to [7] which states that wall density index should be at least 5% for the site of seismic Zone V for India.

3 Analysis of Results

Loading and load combination has been adopted as per IS: 875 (parts 1 and 2) [7, 8], IS 456 [6] and IS 1893 (Part 1) [9]. Equivalent static method is adopted for seismic analysis. The results are presented in terms of base shear, storey drift and cost analysis.

3.1 Base Shear and Storey Drift

It has been found that the base of RC structure is comparatively low (i.e., Vb = 460.40211 KN) as compared to that of CM structure (i.e., Vb = 1098.575 KN) as shown in Fig. 4. The reason for less base shear in case of RC and high base shear in case of CM structures are due to less design horizontal seismic coefficient for RC and high design horizontal seismic coefficient for CM structures. Although base shear for CM structure is higher as compared to that of RC structure, however storey drift

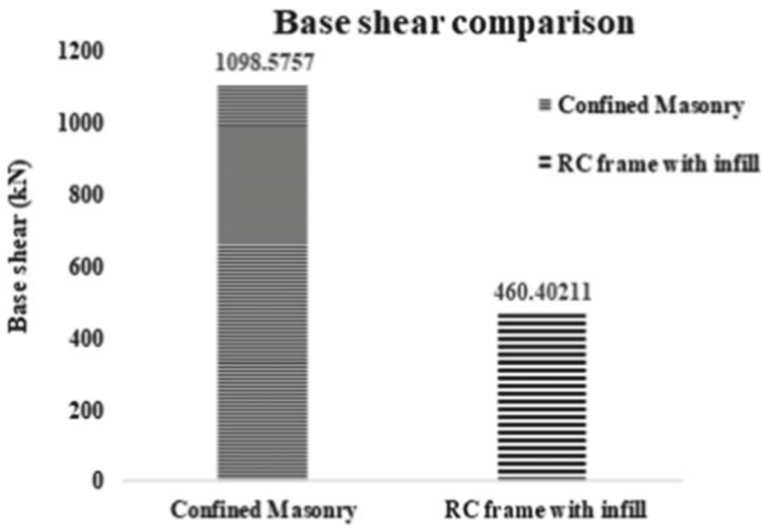

Fig. 4 Base shear comparison of Confined masonry and RC frame building with infill

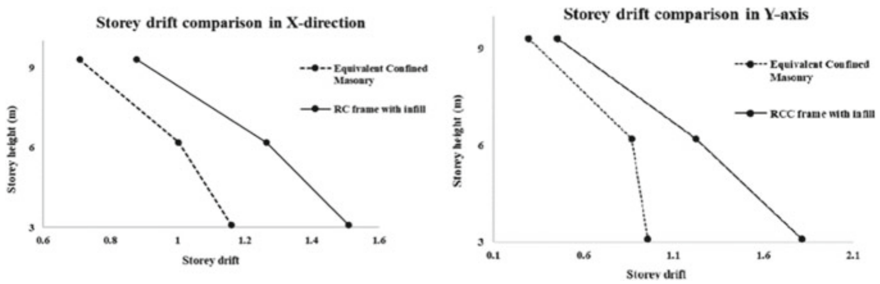

Fig. 5 Storey drift comparison of RC and CM structures along **a** X-direction and **b** Y-direction

of CM structure is found to be less than that of RC structures as shown in Fig. 5a and b.

3.2 Cost Estimation

Cost comparison has been conducted between RC and CM structures keeping concrete work, brick work and Steel reinforcement as differentiating factors [10]. It has been observed that CM structure cost 5.53% less as compared to RC structure as shown in Fig. 6. Thus, cost wise CM structure is more cost efficient than that of counterpart RC structure.

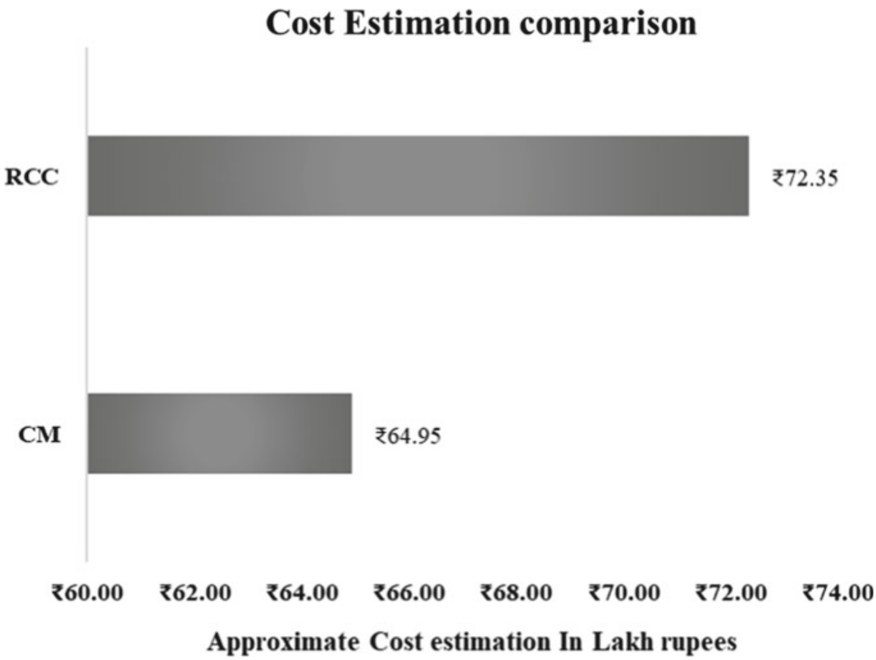

Fig. 6 Cost Estimation comparison of RC frame building with infill and equivalent Confined masonry building

4 Conclusion

In this paper, comparative study has been carried out between Confined Masonry (CM) and Reinforced Concrete (RC) building structures using SAP2000. Two similar building structures, one made of CM and the other made of RC have been modeled in SAP2000. CM building is modeled using shell elements and RC frame building is modeled using frame elements. The same loadings in the form of dead load, live load and seismic load have been applied to both the structures. It has been observed that confined masonry structure exhibits higher base shear and lower storey drift as compared to that of reinforced concrete structure. Further, it has also been observed that construction cost is less for confined masonry building than that of reinforced concrete building for the same building configuration.

In this paper, a comparative study has been conducted between Confined Masonry (CM) and Reinforced Concrete (RC) building structures of similar building geometry. CM building has been modeled using shell elements, whereas RC frame building has been modeled by using frame elements. The same loadings have been applied to both the building structures. The following conclusions have been drawn from the analysis.

1. It has been observed that Confined Masonry (CM) structure exhibits higher base shear as compared to that of Reinforced Concrete (RC) building structures when subjected to same loading conditions.
2. Storey drift ratio of Confined Masonry (CM) structure has been found to be less as compared to that of Reinforced Concrete (RC) building structures for the same loadings.
3. It has also been found that Confined Masonry (CM) structure is more cost efficient as compared to that of Reinforced Concrete (RC) structure of same building configuration.

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