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Lateral Strength of Confined Masonry Walls

S. Eshghi[1*], B. Sarrafi[2]

1- Associate Professor, International Institute of Earthquake Engineering and Seismology (IIEES)
2- PhD in Earthquake Engineering, International Institute of Earthquake Engineering and Seismology (IIEES)

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ABSTRACT

Unreinforced masonry system was a conventional form of construction in rural areas in worldwide countries in last decades. The main advantage of using this system is that it is cheaper than other building systems such as reinforced concrete or steel. Iranian seismic code proposes masonry walls to be confined by reinforced concrete or timber ties. This building type called confined masonry is very popular in Iranian construction practise but code provisions regarding this topic have not been improved during recent years and are very similar to the old provisions proposed for unconfined masonry buildings.

In this study, the specifications of confined masonry buildings are described. Then some equations proposed by different codes to estimate the lateral resistance of masonry walls are reviewed. An equation is proposed to estimate the lateral strength of confined masonry walls designed and built according to the Iranian code. The proposed equation then is validated with the results of the tests the authors conducted on seven confined masonry walls.

KEYWORDS:

Confined Masonry Walls, Lateral Strength, Seismic Behavior

* Corresponding Author, Email: s.eshghi@iiees.ac.ir

1- INTRODUCTION

Confined masonry construction consists of masonry walls and horizontal and vertical reinforced concrete ties built on all four sides of a masonry wall panel as confining elements. This structural system provides an alternative to both unreinforced masonry and frame system construction. This system can be a conventional form for constructing new buildings as well as an alternative for the post-disaster reconstruction of buildings—especially for people on low income.

The key point about a CM wall is the sequence of its construction. The first step is to build masonry walls with toothed age; then tie columns and tie beams are cast in place. This construction sequence provides a stiff connection between the masonry panel and the ties and plays an important role in the lateral resistance of CM walls [1].

CM buildings have exhibited good performance during earthquakes of the past. In 1939, an earthquake with a magnitude M7.8 occurred in Chile where the Modified Mercalli Intensity was estimated at MMI=IX. In this earthquake, about 3,500 dwellings were inspected, of which only 4.5% were of the CM type. Sixteen% of the inspected CM houses and 57% of the unreinforced masonry houses collapsed or partially collapsed. On the other hand, over 50% of all inspected CM buildings had sustained the earthquake without any damage, whereas around 60% of unreinforced masonry buildings either partially or entirely collapsed [2].

On December 26, 2003 a destructive earthquake hit Bam city in Iran. The earthquake caused the collapse of different types of buildings. Observations showed that CM buildings demonstrated good seismic performance but in order to have a three dimensional resisting system, tie-columns should be properly connected at all intersection points to tie-beams. If there is no suitable detailing for reinforcing bars in the concrete joints, the building cannot stand against earthquake. Moreover, the distance between axes of two tie-columns should be limited to 5 meters [3].

The one-story, one-bay, confined masonry wall was selected as a typical structure. The height/length (h/L) ratio of the masonry panel in the confined masonry wall selected was 1/1.5. Two similar samples of the confined masonry wall were built in the IIEES laboratory in order to compare the results. The Iranian seismic code provisions were used for making both test specimens (A and B). These specimens were ½ scale models to represent an interior bay of a one story prototype building. During testing, the static monotonic lateral displacement load was applied on each specimen by means of one servocontrolled hydraulic actuator. Test results indicated that shear failure was a dominant mode of failure of the confined masonry walls subjected to lateral loading. Shear failure with characteristic diagonal tension cracks was observed in both of the confined masonry specimens. Shear failure occurred when the maximum principal stresses developed in the wall under a combination of vertical and horizontal loads exceeded the tensile strength of the masonry material [4].

2- METHODOLOGY

In this study the results of experimental test have been performed by authors on confined masonry walls under lateral loads are discussed. A finite element model is set up for the same model using DIANA finite element analysis package [5] to verify results of tests and material properties.

Then equations proposed by different codes and standards are investigated to find the best match for test results. Based on this investigation a simple equation is proposed to estimate lateral resistance of confined masonry walls recommended by Iranian codes that matches test results.

3- RESULTS AND DISCUSSION

From tests done on confined masonry walls under lateral loads overall behavior of thee walls can be simplified as a curve shown in Figure 1 [6]. Initial behavior is linear elastic until first inclined crack occurs (point A). Corresponding shear to this point is V_{cr} (cracking) that is considered as lateral capacity of masonry walls in most codes.

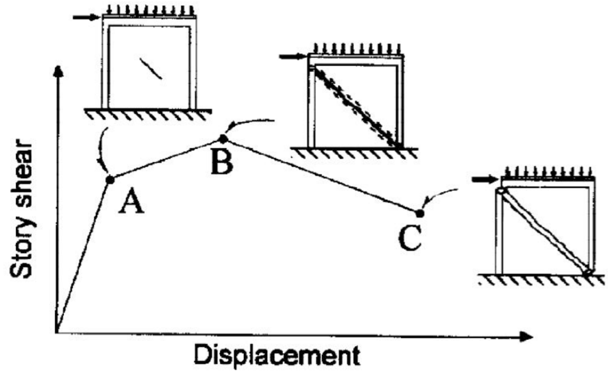

Figure 1. Typical curve from tests of confined masonry walls [6]

Figure 2. Cracks formed in specimen CMSW-04

In this study the results of experimental test have been performed by authors on confined masonry walls under lateral loads [7] have been analyzed to derive V_{cr} in 7 tested specimens.

The walls were designed according to the Iranian Seismic Code, which represents a typical qualitative code for masonry structures. The walls, all parts of which (including the bricks) were assigned a scale of 1:2, are subjected to lateral cyclic loading. The effect of the head joints, mortar properties and vertical loading on the seismic behavior of such confined masonry walls is investigated. Figure 2 shows cracked shape of one of specimens in final stage (Refer to [7] for more details).

Analyzing results from tests, authors propose following equation to estimate lateral resistance of confined masonry walls (V_{cr}) built according to Iranian codes and common practice:

$$V_{cr} = 0.28\tau_m A_m + 0.43N \quad (1)$$

n which A_m is wall gross section area, τ_m is shear strength of masonry from diagonal compression test, N is axial vertical load. A comparison between results of above-mentioned tests and proposed equation is shown in Table 1.

Table 1. Comparison of experimental test results with proposed equation

Wall	N (kN)	τ_m (MPa)	V_{cr} (kN) Exp.	V_{cr} (kN) Eq.(1)	Cal./ Exp.
CMSW-01	0.23	0.01	12.5	11.4	0.91
CMSW-02	0.11	0.01	11.5	11.4	0.99
CMSW-03	0.11	0.2	26.3	22.8	0.87
CMSW-04	0.20	0.2	32.1	31.4	0.98
CMOW-01	0.11	0.53	40.4	35.5	0.88
CMOW-02	0.11	0.53	50.9	35.5	0.7
CMOW-03	0.11	0.53	33.5	35.5	1.06

4- Conclusions

Results of tests performed on 7 confined masonry walls under cyclic lateral loads analyzed to develop a simple equation to estimate lateral resistance of confined masonry walls built according to Iranian codes and common practice. Furthermore results of a finite element analysis of the same walls are used to verify material test results and properties. As shown in Table 1, results derived from proposed equation have an acceptable correlation with test results.

5- REFERENCES

[1] Brzev, S.; Astroza M.; and Moroni, M. O.; "Performance of Confined Masonry Buildings in the February 27, 2010 Chile Earthquake", EERI.

[2] Moroni, M. O.; Astroza, M.; and Acevedo, C.; "Performance and Seismic Vulnerability of Masonry Housing Types Used in Chile", Journal of Performance of Constructed Facilities, ASCE, Vol. 18, No. 3, pp. 173-179, 2004.

[3] [3] Eshghi, S.; and Zare, M.; "Bam Earthquake of 26 December 2003, Mw6.5: A Preliminary Reconnaissance Report", First ed., International Institute of Earthquake Engineering and Seismology (IIEES), Iran, 2003.

[4] [4] Pourazin, K.; and Eshghi, S.; "In-Plane Behavior of a Confined Masonry Wall", TMS Journal, Vol. 27, No. 1, 2009.

[5] Witte, F. C.; and Kikstra, W. P.; "DIANA-Finite Element Analysis, User's Manual release 9-Material Library", TNO DIANA BV, 2005.

[6] Flores, L. E.; and Alcocer, S. M.; "Calculated Response of Confined Masonry Structures", Proc. 11th World Conf. Earthquake Engng., paper No. 1830, 1996.

[7] Sarrafi, B.; and Eshghi, S.; "Behavior of Clay Brick Confined Masonry Walls under Cyclic Loads", TMS Journal, Vol. 30, No. 1, 2012.