AIP Conf. Proc. / Volume 1020 / Issue 1

Seismic Vulnerability and Performance Level of confined brick walls

AIP Conf. Proc. -- July 8, 2008 -- Volume 1020, pp. 1738-1746
2008 SEISMIC ENGINEERING CONFERENCE: Commemorating the 1908 Messina and Reggio Calabria Earthquake; DOI:10.1063/1.2963806

Issue Date: 8 July 2008

ABSTRACT

M. Ghalehnovi[a] and H. A. Rahdar[b]
[a]*University of Sistan and Baluchestan, Zahedan, Iran*
[b]*University of Sistan and Baluchestan, Zahedan, Iran*

There has been an increase on the interest of Engineers and designers to use designing methods based on displacement and behavior (designing based on performance) Regarding to the importance of resisting structure design against dynamic loads such as earthquake, and inability to design according to prediction of nonlinear behavior element caused by nonlinear properties of constructional material.Economically speaking, easy carrying out and accessibility of masonry material have caused an enormous increase in masonry structures in villages, towns and cities. On the other hand, there is a necessity to study behavior and Seismic Vulnerability in these kinds of structures since Iran is located on the earthquake belt of Alpide.Different reasons such as environmental, economic, social, cultural and accessible constructional material have caused different kinds of constructional structures.In this study, some tied walls have been modeled with software and with relevant accelerator suitable with geology conditions under dynamic analysis to research on the Seismic Vulnerability and performance level of confined brick walls. Results from this analysis seem to be satisfactory after comparison of them with the values in Code ATC40, FEMA and standard 2800 of Iran. ©2008 *American Institute of Physics*

KEYWORDS

Keywords

structural engi

PACS

- 91.55.Ln **Kinema deforma**
- 91.30.P- **Earthqu**
- 91.30.-f **Seismol**
- YEAR: 2

PUBLICATI

Permalink: http://link.aip.org/link/?APCPCS/1020/1738/1

proceedings.aip.org/dbt/dbt.jsp? KEY=APCPCS & volume=1020 & Issue=1 Sign on

SAO/NASA ADS Physics Abstract Service

· **Find Similar Abstracts (with default settings below)** Toggle Highlighting
· **Electronic On-line Article (HTML)**
· **Table of Contents**
· **Also-Read Articles** (Reads History)
·
· **Translate This Page**

Title:	Seismic Vulnerability and Performance Level of confined brick walls
Authors:	Ghalehnovi, M.; Rahdar, H. A.
Affiliation:	AA(University of Sistan and Baluchestan, Zahedan, Iran. ghalehnoviatyahoo.com), AB(University of Sistan and Baluchestan, Zahedan, Iran)
Publication:	2008 SEISMIC ENGINEERING CONFERENCE: Commemorating the 1908 Messina and Reggio Calabria Earthquake. AIP Conference Proceedings, Volume 1020, pp. 1738-1746 (2008). (AIPC Homepage)
Publication Date:	07/2008
Origin:	AIP
Keywords:	structural engineering, earthquakes, seismology
Abstract Copyright:	(c) 2008: American Institute of Physics
DOI:	10.1063/1.2963806
Bibliographic Code:	2008AIPC.1020.1738G

Abstract

There has been an increase on the interest of Engineers and designers to use designing methods based on displacement and behavior (designing based on performance) Regarding to the importance of resisting structure design against dynamic loads such as earthquake, and inability to design according to prediction of nonlinear behavior element caused by nonlinear properties of constructional material.

Economically speaking, easy carrying out and accessibility of masonry material have caused an enormous increase in masonry structures in villages, towns and cities. On the other hand, there is a necessity to study behavior and Seismic Vulnerability in these kinds of structures since Iran is located on the earthquake belt of Alpide.

Different reasons such as environmental, economic, social, cultural and accessible constructional material have caused different kinds of constructional structures.

In this study, some tied walls have been modeled with software and with relevant accelerator suitable with geology conditions under dynamic analysis to research on the Seismic Vulnerability and performance level of confined brick walls. Results from this analysis seem to be satisfactory after comparison of them with the values in Code ATC40, FEMA and standard 2800 of Iran.

Bibtex entry for this abstract **Preferred format for this abstract** (see Preferences) Toggle Highlighting

Add this article to private library

Remove this article from private library

Find Similar Abstracts:

Use: Authors
Title
Keywords (in text query field)
Abstract Text

Return: Query Results Return 100 items starting with number 1

Query Form

Database: Astronomy
Physics
arXiv e-prints

Send Query Reset

Seismic Vulnerability and Performance Level of confined brick walls

M.Ghalehnovi[a] and.H.A Rahdar[b]
[a]*University of Sistan and Baluchestan, Zahedan, Iran, ghalehnovi@yahoo.com*
[b]*University of Sistan and Baluchestan, Zahedan, Iran, rah_h84@yahoo.com*

Abstract: There has been an increase on the interest of Engineers and designers to use designing methods based on displacement and behavior (designing based on performance) Regarding to the importance of resisting structure design against dynamic loads such as earthquake , and inability to design according to prediction of nonlinear behavior element caused by nonlinear properties of constructional material .
Economically speaking, easy carrying out and accessibility of masonry material have caused an enormous increase in masonry structures in villages, towns and cities. On the other hand, there is a necessity to study behavior and Seismic Vulnerability in these kinds of structures since Iran is located on the earthquake belt of Alpide.
Different reasons such as environmental, economic, social, cultural and accessible constructional material have caused different kinds of constructional structures.
In this study, some tied walls have been modeled with software and with relevant accelerator suitable with geology conditions under dynamic analysis to research on the Seismic Vulnerability and performance level of confined brick walls. Results from this analysis seem to be satisfactory after comparison of them with the values in Code ATC40, FEMA and standard 2800 of Iran.

Key words: performance level, masonry structures, Seismic Vulnerability , accelerator suitable with geology conditions

INTRODUCTION

Studies on masonry buildings after earthquake shows that fragility of materials and non continuity of these buildings are main factor of destruction at the time of earthquake, There are similar damages occurred by earthquake on these structures Regarding to kind of construction of these structures. Some of these damages are horizontal cracks at the joint of ceiling and walls, indicated in Fig1. These cracks are caused due to unsuitability of connection between ceiling and walls .Also disconnection between walls at the joints and out surface collapse has been seen in most of masonry buildings at the time of earthquake Fig2, 3. As time passes along with research and experiments, using horizontal and vertical ties has been suggested to solve the problem. On the other hand, inertia force caused by earthquake on the building is divided on the structure elements in a way that a part by widthwise walls, a part by longitudinal walls and a part by ceiling are transferred. The proportion transferred from widthwise walls to ceiling and foundation and from ceiling to longitudinal walls. In fact, this mechanism defines the importance of longitudinal walls in transferring force caused by earthquake and the damage and destruction of them can have a noticeable effect on vulnerability and destruction of the whole structure. [1]

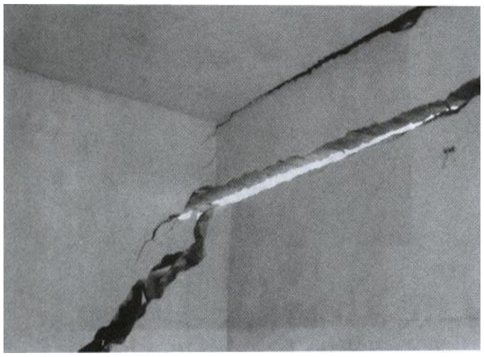

FIGURE 1. Deep cracks between ceiling and walls

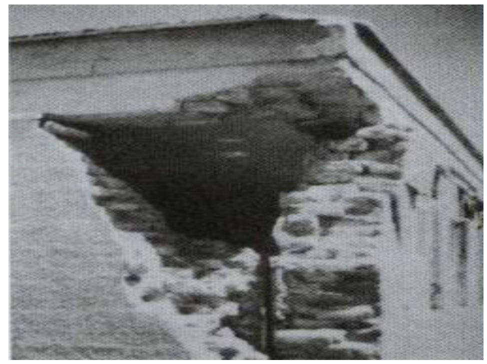

FIGURE 2. Discretion orthogonal walls

FIGURE 3. Out surface collapse of wall

In this study, destruction analysis method is introduced for confined brick wall and the effect of some parameters such as span length, numbers of span and number of floors on the destruction caused by earthquake. The common method to model of confined brick wall is taking equivalent diagonal member in to consideration. Park & Ang damage index and IDARC software has been used to analyze destruction. [2, 3]

MASONRY BRICK WALL

Compressive stress-strain diagram of masonry brick constructional material is illustrated in fig4. This diagram is considered as a parabolic function till the maximum stress of f_m', then with the increase of strain the value of stress is decreasing linearly and after that is a fixed value. Assumed model for coverage of strength of brick panel is illustrated in fig 5 that this coverage model shows compressive behavior.

Cyclic force-displacement diagram for compressive situation is shown in fig 6. Resulted formulas for coverage are presented according to studies done by Sanee nezhad and Houbez. [4]

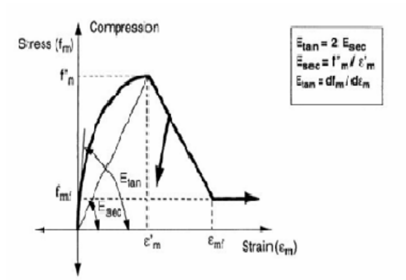

FIGURE 4. Stress-strain behavior of brick materials

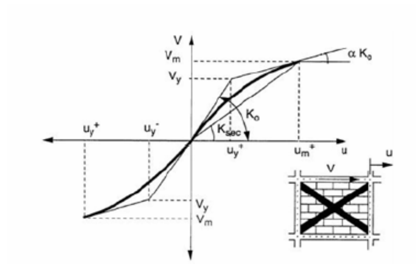

FIGURE 5 brick panel strength coverage

With taking a confined brick wall in fig 7 in to consideration, maximum lateral force V_m and the relevant displacement U_m are as following; [4]

$$V_m \le A_d f_m' \cos\theta \le \frac{vtl'}{(1-0.45\tan\theta')\cos\theta} \le \frac{0.83(Mpa)tl'}{\cos\theta} \tag{1}$$

$$U_m = \frac{\varepsilon_m' L_d}{\cos\theta} \tag{2}$$

Where t is the thickness of wall, f_m' is prism strength of masonry materials; ε_m' is relevant strain, V is basic shear resistance or tenacity of masonry, A_d , L_d are area and equivalent length of diagonal member respectively . [5]

$$A_d = (1-\alpha_c)\alpha_c th' \frac{\sigma_c}{f_c} + \alpha_b tl' \frac{\tau_b}{f_c} \le \frac{0.5h' \frac{f_a}{f_c}}{\cos\theta} \tag{3}$$

$$L_d = \sqrt{(1+\alpha_c)^2 h'^2 + L'^2} \tag{4}$$

The values of α_c ، α_b ، τ_b ، f_a و f_c are related to geometry and the characteristics of confined material and wall (infill frame). Allowable stress f_a is resulted from the Equations following;

$$f_c = 0.6 \times \phi \times f_m' \quad f_a = f_c\left[1 - \left(\frac{L_{eef}}{40\,t}\right)\right] \ , \ \phi = 0.65 \tag{5}$$

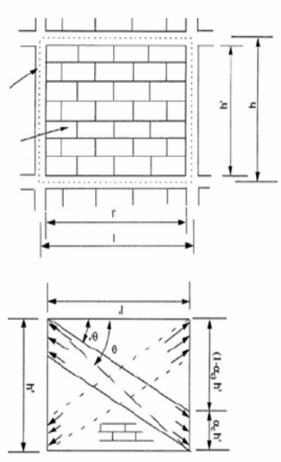

FIGURE 6. brick panel and equivalent compressive member

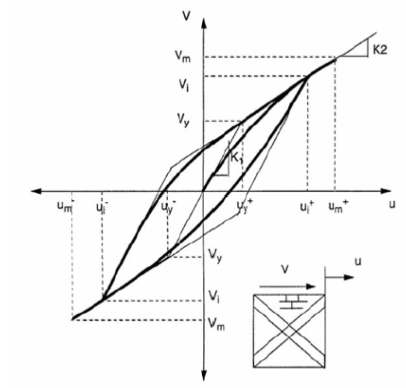

FIGURE 7 VAN-Bouk model for Cyclic response of brick panel

Uniform contact stresses at the time of fracture at the joint of vertical ties with wall σ_{c0} and horizontal ties with brick wall σ_{bo} based on Tereska hexagonal gauges yielding is as following ;

$$\sigma_{co} = \frac{f_c}{\sqrt{1+3\mu_f^{\,2} r^4}} \qquad \sigma_{b0} = \frac{f_c}{\sqrt{1+3\mu_f^{\,2}}} \tag{6}$$

Where r is height of wall to length of wall ratio and μ_f is friction factor of wall with ties .In one dimensional force-displacement diagram, maximum force of V_m And the relevant displacement U_m , initial stiffness K_0 and. stiffness of ultra yielding to initial stiffness ratio α are considered. The initial stiffness K_0 can be estimated as following;

$$k_0 = \frac{V_y}{U_y} \tag{7}$$

Lateral yielding force and the relevant displacement in brick panel are as following;

$$V_y = \frac{V_m - \alpha K_0 U_m}{1-\alpha} \tag{8}$$

$$U_Y = \frac{V_m - \alpha K_0 U_m}{K_0(1-\alpha)} \tag{9}$$

For α the value 0.1 is suggested.

PERFORMANCE LEVEL AND ACCEPTANC CRITERIA

Different codes for performance based design have similar interpretations. The goal of seismic design of buildings is defined for different kinds separately and the selection of performance of structure is on the employer decision so the designer should take it for safety in to consideration.

Performance level is showing some boundary conditions where the acceptable value and amount of damage of a building because of an earthquake is defined. These boundary conditions are described by physical damage in the structure and the life danger for residents inside the building and the amount of serviceability of structure after the earthquake. A building consists of complicated elements and members which many of these elements have an independent performance than other elements, so for designing level, different kinds of elements performance should be considered.

Elements of a structure have 4 main performance levels as following;

1. Immediat occupancy performance level
2. Life safety performance level
3. Collapese prevention performance level
4. Not considered performance level

to study a structure performance ; result of analysis must be compared with some boundary values of performance where these boundary values are categorized in 2 parts of general acceptable criteria of a building and acceptable criteria of elements. And if the result of each analysis be more than the acceptable criteria then performance level is not accepted.

The general acceptance criteria of building as following;

Resistance against of lateral load: According to ATC 40 the lateral resistance of structure at performance point should not decrease more than 20 percent of ultimate resistance [7] and according to FEMA-273 base shear at performance point should not be less than 80 percent of base shear at limit yielding. [8]

Lateral displacement; Lateral displacement is controlled by relative lateral displacement conception. So the allowable limits for relative lateral displacement and inelastic lateral displacement are as table (1). [7]

TABEL 1. allowable relative displacements in different performance levels

Immediate occupancy	**Damage control**	**Life safety**	**Collapse prevention**	
0.01	0.01-0.02	0.02	0.33 Vi/Pi	relative lateral displacement
0.005	0.005-0.015	unlimited	unlimited	inelastic relative lateral displacement

DAMAGE INDAX

Cyclic smooth Model is used for cyclic panel modeling. This model includes the effects of stiffness deterioration, resistance deterioration, and slip. Introduced Cyclic model here is based on Van-bouk model. [5, 6] Force-displacement relationship for cyclic model is as following;

$$V_i = V_y\left[\alpha\mu_i + (1-\alpha)Z_i\right] \tag{10}$$

Where V_i, V_y Are yielding force and instantaneous force respectively and μ_i is uniform displacement.

$$\mu_i = \frac{u_i}{u_y} \tag{11}$$

The subscript i is applied to define instantaneous values, μ_y yielding displacement, α is stiffness of ultra yielding to initial stiffness ratio and Z_i is cyclic component.

To describing the damage value quantitively, suitable damage index for brick wall is used. The reduce coefficient relationship of S_β and damage index is as following;

$$S_\beta = 1 - DI \tag{12}$$

Used damage index is a function of resulted ductility and wasted cyclic energy.

$$DI = \frac{\mu_{\max}^{p} - 1}{\mu_c - 1} \times \frac{1}{\left(1 - 0.25 s_{p1} \int \left(\frac{V}{V_y}\right) \frac{d_\mu}{(\mu_c - 1)}\right)^{s_{p2}}} \tag{13}$$

Where $\mu_{\max}^{p}$ is maximum ductility at response history, μ_c capacity of the ductility of brick wall and S_{p1}, S_{p2} are parameters of strength deterioration rate.

CONSIDERD WALLS

Walls of a building, with 3 and 5 meters span and the height of 3 meters in one floor and 2 floor buildings have been analyzed by nonlinear dynamic analysis.

In theses walls section and bars of ties are considered according to the Standard code 2800 of Iran. It is noted that load bearing surface of wall is 4 meters. Also, the used records related to Mexicosity, Northridge, Bam, Naghan, and Tabas earthquake are with maximum accelerator of 0.3g. To ease the work , tied walls have abbreviated like nS_mP_L where n is number of floors , m number of span , L is length of span and S,P are abbreviation form of story and panel respectively.

EFFECT OF SPAN LENGHT

To study the effect of span length, walls with the span of 3, 4, and 5 meters for mentioned earthquakes have been analyzed by nonlinear dynamic analysis and the results are based on total relative displacement of roof as following ;(table2)

TABEL 2. total relative displacement of roof

	Bam l	Bam T	Naghan	Tabas	Northridge	Mexicosity
1S-1P-3	0.0036	0.0035	0.0033	0.0054	0.0043	0.0038
1S-1P-4	0.0034	0.0033	0.0029	0.0042	0.0039	0.0035
1S-1P-5	0.0031	0.003	0.0024	0.0039	0.0034	0.0031

Results shows that in all earthquakes along with the increased of span length, total relative displacement of roof is decreasing. Increase of span length increases the stiffness of wall which is a factor to decrease the displacement.

EFFECT OF NUMBERS OF SPANS AND FLOORS

To study the effect of number of spans and number of floors, tied walls of 3,4,5 meters of one and two spans in one and two floors have been analyzed by nonlinear dynamic analysis. Results are as following ;(table3)

TABEL 2. total relative displacement of roof

	Bam L	Bam T	Naghan	Tabas	Northridge	Mexicosity
1S-2P-3	0.0033	0.0028	0.0025	0.0041	0.0038	0.0035
1S-2P-4	0.003	0.0025	0.0022	0.0037	0.0034	0.0033
1S-2P-5	0.0029	0.0022	0.0019	0.0034	0.0031	0.0030
2S-1P-3	0.0240	0.0215	0.0216	0.0260	0.0261	0.0153
2S-1P-4	0.0189	0.0185	0.0171	0.0227	0.0241	0.0123
2S-1P-5	0.0173	0.0145	0.0127	0.0189	0.0225	0.0103
2S-2P-3	0.0230	0.0202	0.0187	0.0242	0.0205	0.0130
2S-2P-4	0.0182	0.0188	0.0145	0.0189	0.0193	0.0110
2S-2P-5	0.0158	0.0154	0.0112	0.0163	0.0148	0.0099

Results shows that increase in number of spans causes decrease in total relative displacement which is influenced by increase of stiffness but increase in number of floors will cause increase in total displacement of roof.

Amount of damage index on analyzed wall is as following ;(table4)

TABEI 4. damage index value for walls

	Bam l	Bam T	Naghan	Tabas	Northridge	Mexicosity
1S-1P-3	0.280	0.245	0.259	0.208	0.234	0.264
1S-1P-4	0.219	0.139	0.179	0.228	0.250	0.242
1S-1P-5	0.037	0.041	0.280	0.051	0.043	0.048
1S-2P-3	0.119	0.221	0.090	0.188	0.186	0.243
1S-2P-4	0.112	0.200	0.011	0.121	0.163	0.121
1S-2P-5	0.010	0.009	0.009	0.010	0.131	0.010
2S-1P-3	0.155	0.167	0.179	0.195	0.157	0.193
2S-1P-4	0.145	0.120	0.160	0.165	0.137	0.112
2S-1P-5	0.090	0.088	0.147	0.115	0.167	0.091
2S-2P-3	0.195	0.261	0.266	0.289	0.400	0.155
2S-2P-4	0.181	0.163	0.219	0.223	0.366	0.147
2S-2P-5	0.148	0.140	0.162	0.154	0.171	0.112

After study on destruction index resulted from analysis and comparison with Park-Ang damage index values, we can say that 5 meters walls, One span one floor, and 2 spans 2 floors and 5 meters walls of 2 spans one floor has got a damage index of less than 0.1 where it is located in repairable level, but on other walls the damage index is located in unrepairable area and any of analyzed walls is not located in collapse level;

RESULT

After study the results of analysis , we can say that in 1S-1P-3,1S-1P-4,1S-1P-5,1S-2P-3,1S-2P-4 and 1S-2P-5 the total relative displacement of roof is less than 0.01, and according to table 1, have got Performance level of 1, but the walls of 2S-1P-4, 2S-1P-3 for Tabas , Northridge earthquakes and also 2S-1P-3 wall for Bam and Naghan earthquakes is located between safety limit and collapse prevention whereas walls 2S-2P-4, 2S-2P-5, 2S-1P-5 and in some earthquakes the 2S-1P-4 wall have got the total relative displacement between 0.01 and 0.02 which have got limited destruction performance level.

Comparing the resulted damage index with Park-Ang shows that 1S-1P-5, 1S-2P-5 and 2S-2P-5 walls were repairable after the earthquake and the other walls were unrepeatable.

REFERENCES

1. Moghadam,hasan," Seismic design of Structures" (2002)
2. Reinhorn.A. M.,Kunnath. S.k, and Valles-Mattox. R,(1996),IDARC 2D Version4.0:user manual.Department of Civil Engineering, State University of New York at Bufalo.
3. Park, Y-J. and Ang A.H-S.(1985)"Mechanistic Seismic Damage Model for Reinfoeced Concret", Journal of Structural Engineering, ASCE,Vol 111,No.ST,PP.722-739.
4. Saneingjad.A.and,Hobbs.B,"Inelastic Design of Infilled Frames"Journal of Structural Engineering,Vol.121,No.,1995,PP.63-650, April
5. Bouc. R."Forced Vibration of Mechanical Systems with Hysterrsis"Proceedings of 4th Conference on Nonlinear Oscillators, Prague.1967.
6. Baber. T.T.andNoori.M.N,"Random Vibration of Degrading Pinching System"Journal of Engineering Mechanics. Vol 111, No.8.1985.PP.1010-1026
7. ATC, 1996, Seismic Evaluation and Retrofit Concrete building, prepared by the Applied Technology council,(Report No. ATC-40)
8. NEHRP, 1997, Guidelines for the Seismic Rehabilitation of Building (FEMA Publication 273)
9. Ghalehnovi.M., Rahdar.H.A." Seismic Vulnerability and Performance Level of Masonry Structures" (2007)
10. Iranian Coed of Practice for Seismic Resistant Design of Buildings