STRUCTURAL SYSTEM ANALYSIS AND DESIGN FOR SAFE HOUSE

Mohammad Rezaeianpakizeh

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Dedicated to my beloved mother and devoted father.

Words cannot describe how much they mean to me.

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ABSTRACT

The observation of post-earthquakes damages on reinforced concrete buildings has clearly shown that the presence of nonstructural elements, such as infill walls, may significantly affect the seismic performance of buildings. The study describes the analysis and design, the engineering process the new type of safe room according to the FEMA guidance. It also evaluates the effects of in-fill frames and the linear response of reinforced concrete braced frames and comparison with frames with shear wall. The main conclusion drawn from this study is to elaborate that the masonry in-fills, are strongly influence the structural seismic response and contribute to the overall stiffness and can decrease drifts and displacements. Infill walls have significant role in the strength and ductility of RC framed structures and should be considered in both analysis and design globally. These walls make the structure significantly stiffer, and reduce the natural period of the structure. Locally, infill walls changed the load path, the distribution of forces between different elements of the structure, and the demand forces on their adjacent elements of the bounding frame. Due to the high relative stiffness of the infill frames, they act as the main lateral load-resisting system and attract larger portions of the earthquake-induced inertia forces.

ABSTRACT

Pemerhatian selepas gempa bumi yang menaberi kerosakan ke atas bangunan konkrit bertetulang telah jelas menunjukkan bahawa kehadiran unsur bukan struktur seperti dinding pengisian, boleh memberi kesan kepada prestasi seismik bangunan. Kajian ini menerangkan analisis dan reka bentuk, proses kejuruteraan jenis baru “safe room” mengikut kepada petunjuk FEMA dan menilai kesan kerongka pengisi dan tindak balas linear kerangka berembat konkrit bertetulang dan dengan kerangka dinding ricih. Kesimpulan utama yang diperolehi daripada kajian ini adalah untuk menjelaskan bahawa bato dalam-mengisi. Kuat mempengaruhi tindak balas seismik struktur dan menyumbang kepada kekukuhan keseluruhan dan boleh mengurangkan sesaran dan anjakan. Dinding pengisian mempunyai peranan penting dalam kekuatan dan kemuluran struktur kerangka RC dan perlu dipertimbangkan dalam analisis dan reka bentuk global. Dinding ini membuat struktur ketara yang lebih kuat, mengurangkan tempoh gegaran semulajadi struktur. Dinding pengisian mengubah laluan beban, dan mengagihkan daya di antara elemen-elemen struktur yang berbeza, dan berkuasa memindahkan beban ke bersebelahan. Disebabkan oleh kekukuhan tinggi berbanding dengan kerang ka pengisian, mereka bertindak sebagai sistem sisi utama menentang beban dan menarik bahagian yang lebih besar daya inersia.

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G = gust effect factor for MWFRSs of flexible buildings and other structures

GCp,, = combined net pressure coefficient for a parapet

GCp =product of external pressure coefficient and gusteffect factor to be used in determination of wind loads for buildings

GCpj = product of the equivalent external pressure coefficient and gust-effect factor to be used in determination of wind loads for MWFRS of low-ris buildings

GCpi = product of internal pressure coefficient and gusteffect factor to be used in determination of wind loads for buildings

q = velocity pressure, in lb/ft2 (IV/m2)

qj, = velocity pressure evaluated at height *z* = *h*, in lb/ft2 (IV/m2)

q; = velocity pressure for internal pressure determination, in lb/ft2 (IV/m2)

qp =velocity pressure at top of parapet, in lb/ft2 (IV/m2)

q, =velocity pressure evaluated at height *z* above ground, in lb/ft2 (IV/m2)

R = resonant response factor

Ss = mapped MCE, 5 percent damped, spectral response acceleration parameter at short periods

S1 = mapped MCE, 5 percent damped, spectral response acceleration parameter at a period of 1 s

SaM = the site-specific MCE spectral response acceleration at any period

SDs = design, 5 percent damped, spectral response acceleration parameter at short periods

SMs = the MCE, 5 percent damped, spectral response acceleration at short periods adjusted
for site class effects

SMl = the MCE, 5 percent damped, spectral response acceleration at a period of 1 s adjusted for site class effects

T = the fundamental period of the building

T, = approximate fundamental period of the building

TL = long-period transition period

CHAPTER 1

INTRODUCTION

1.1 Introduction

Buildings in any geographic location are subject to a wide variety of natural phenomena such as windstorms, floods, earthquakes, and other hazards. While the occurrence of these incidents cannot be precisely predicted, their impacts are well understood and may be can able to be managed effectively through a comprehensive program of hazard mitigation planning.

Every year earthquakes, tornadoes and other extreme windstorm cause fatalities or even kill people, devastate and millions of dollars' worth property. The likelihood that a tornado will strike building is a matter of probability. Tornado damage to building is predictable at certain accuracy. Administrator of school and other public buildings should have a risk analysis performed to determine the likelihood that a natural disaster will occur and look at the potential severity of the event. If a building determined to be at risk, the safest part of the building may offer the protection if a natural disaster strikes. From the local perspectives a tornado is the most destructive of all atmospheric phenomena. The wind speed generated by some tornadoes is so great such that designing for these extreme winds is unaffordable and beyond the scope of building codes and engineering standard.

Most buildings that have received engineering attention, such as schools, and that are built in accordance with sound construction practices can usually withstand wind speeds but may provide sufficient resistance to tornadic wind only if the building is located on the outer edge of the tornado vortex. In addition if a portion of the building is built to a higher tornado design standard, then both building and occupant survival ability are improved.

It is an important measure for the international society establishing the emergency shelter to deal with the emergent events and victims. And also, the emergency shelter is the temporary living place for people in modern big cities to avoid the danger of natural disasters, such as the earthquake, fire, explosion, flood, and so on. Based on scientific planning and standard management, the emergency shelter could be used to supply the basic subsistence requirements for people in dangers. Actually, the planning construction of the emergency shelter in cities is a kind of systems project, which included all kinds of inspects in society.

Shear walls, and braced frames, have been an effective and valuable method to enhance structures against lateral loads. In wind or seismic excitations, inclined elements react as truss web elements which would bear compression or tension stresses.

1.2 Problem statement

When the extreme hazard events occur almost every things will be destroy and cause devastation and fatalities. The structure will be damaged from various aspects of structural engineering. Well-constructed houses destroy and some structure lift from foundation, roofs and some walls torn from structure and extensive damage will be to non-structural elements such as, windows, doors and some curtain walls. Some buildings have shelter or small safe-room, but there are not available or accessible during event. The orders to study the effects of natural disaster, the nature of extreme earthquake and flood have to be understood in structural engineering point of view.

The observation of post-earthquakes damages on reinforced concrete buildings has clearly shown that the presence of nonstructural elements, such as infill walls, may significantly affect the seismic performance of buildings, both in terms of seismic demand and capacity. The experience developed about the seismic assessment of existing buildings has definitely demonstrated that infill masonry walls often behave like real primary elements, and anyway have a significant role in the structural response recently, the influence of infill walls on the seismic structural response of RC buildings has been widely investigated by many research experimental and numerical studies.

Low tensile strength of concrete material and moulding made it a challenge to use in inclined members. In practice, there have been various methods to consider this defect such as disengagement of brace elements in tension or utilization of pre-stressed braces.

1.3 Objectives of study

The specific objectives of this study are as follows:

- To describe in the form of analysis and design, the engineering process of the new type of shelter or safe room embedded inside the main building.

- To evaluate of linear response of reinforced concrete frames, braced frames and comparison with frames with shear wall.

- To investigate the stiffness of infills in frames of building and evaluate the interstory drift for lateral loads.

1.4 Scope of study

The purpose of this research is to study the linear response of the new type of shelter or safe room that surrounded by reinforced concrete frames which contain reinforced concrete braces or shear wall as the major structural elements against lateral loads.

This study focuses on evaluation of displacement and inter-story drift of reinforced concrete braced frames for earthquake and compare with frames with shear wall in two cases, infill frame and non-infill frame.

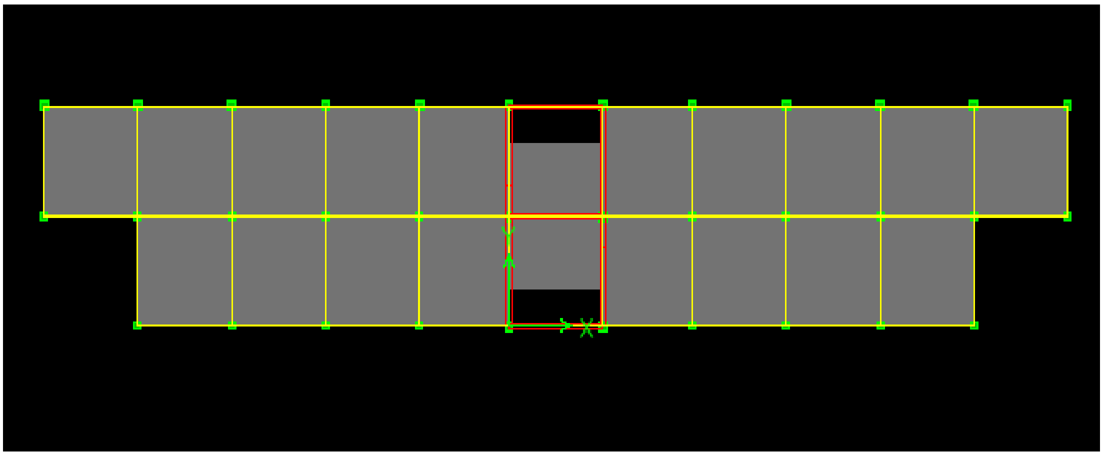

Figure 1.1 Plan of building with safe house

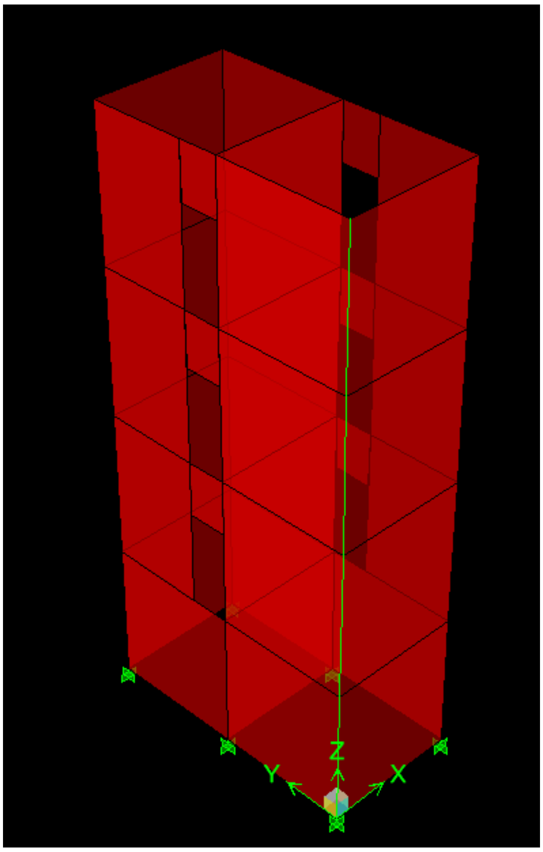

Figure 1.2 Perspective view of safe house by shear wall

1.5 Significant of study

A reliable assessment of the seismic response of existing RC framed buildings should include an accurate model of the infill panels. In this research, the numerical analysis is carried out to evaluate the effect of stiffness of the infill walls on the behavior of structures subjected to lateral loads. It is observed that the presence of correctly distributed infill elements can mitigate horizontal displacements and increase the overall resistance to horizontal actions. In general, a significant increase in the stiffness of the system could be induced, with a consequent decrease of the natural vibration periods of the building.

Figure 1.3 (a) typical column failure in the first story. Infill wall contributed to lateral stiffness and short column effects around windows. (b), (c): soft storey mechanism at the first level in a RC building

6.1 REFERENCES

1. Desai JP, Jain AK, Arya AS, Seismic response of R.C. braced frames, Computers and Structures, No. 4, 29[1988]557-68.
2. Iskhakov I, Self-Variable Stiffness System for Optimal Seismic Response of RC Frame with Concrete Braces, Earthquake Resistant Engineering Structures III, [2001]
3. Xu S, Niu D, Seismic behavior of reinforced concrete braced frame, ACI Structural Journal, No. 1, 100(2003)120-25.
4. Watanabe, Development of the "Self-Installing PCa Brace Method" for Seismic Reinforcement of Building Walls, October 2002.
5. Khaloo∗ and M. Mahdi Mohseni, NONLINEAR SEISMIC BEHAVIOR OF RC FRAMES WITH RC BRACES.A.R. Department of Civil Engineering, Sharif University of Technology, Azadi Avenue P.O. Box: 11365-9313, Tehran, Iran [2004]
6. Bayındırlık ve _skan Bakanlıgı, “Afet Bölgelerinde Yapılacak Yapılar Hakkında Yönetmelik” (ABYYHY-98), Türkiye Hazır Beton Birligi, [1999].
7. Sucuoglu, H. and McNiven, H. D. “Seismic Shear Capacity of Reinforced Masonry Piers”, Journal of Structural Engineering, Vol. 117, No. 7, pp. 2166-2187, July [1991].
8. Sucuoglu, H. and Erberik, A., “Performance Evaluation of a Three-Storey Unreinforced Masonry Building During the 1992 Erzincan Earthquake, Earthquake Engineering and Structural Dynamics, Vol. 26, [1997].
9. Paulay, T. and Priestley, M. J. N, Seismic Design of Reinforced Concrete and Masonry Buildings”, John Wiley & Sons, Inc, [1992].
10. Smith, B. S. and Coull, A., “Tall Building Structures: Analysis and Design”, John Wiley & Sons, Inc., [1991].

11. Smith, B.S. and Carter, C., “A Method of Analysis for Infilled Frames”,Proc. ICE, Vol. 44, pp.31-48, September [1969].

12. Applied Technology Council, “NEHRP Guidelines for the Seismic Rehabilitation of Buildings” (ATC 33), Federal Emergency Management Agency Report FEMA 273, Washington [1997].

13. Roko Zarinic, Design Loads for Building, Turkish Standards Institute, Ankara, November [1997].

14. Gülkan, P. and Sözen, M.A., “Procedure for Determining Seismic Vulnerability of Building Structures”, ACI Structural Journal, Vol. 96, No.3, pp. 336-342, [1999].

15. Ersoy, U. and Marjani, F., “ Behavior of Brick Infilled Reinforced Concrete Frames Under Reversed Cyclic Loading”, ECAS 2002 Internatiol Symposium on Structural and Earthquake Engineering Symposium Proceedings, pp. 142-150, October [2002].

16. Demir, F. and Sivri, M., “Earthquake Response of Masonry Infılled, July 2003

17. Pujol S, Fick D. The test of a full-scale three-story RC structure with masonry infill walls, *Engineering Structures* **32**[2010].

18. Mónica Puglisi, Maylett Uzcategui, Modeling of masonry of infilled frames, Part I: The plastic concentrator, *Engineering Structures* **31**[2009]113-8.