CHAPTER 1

INTRODUCTION

1.1 General

Masonry infill panels can be found as interior and exterior partition walls in reinforced concrete framed structures in low and rise buildings in Egypt. Since they are normally considered as architectural elements, their presence is often ignored by structural engineers and considered as non-structural elements in the design. However, these walls tend to interact with the surrounding frame when the structure is subjected to lateral loads. The interaction with the bounding frame may induce a load resistance mechanism that is not accounted for in design. Therefore, damage of infill walls can occur in the form of cracking, spalling, and possible collapse, particularly in case where infill walls are typically constructed with very weak brick masonry and low quality masons.

Hence ignoring the effect of infill in stiffening and strengthening the surrounding frame is not always a conservative approach, since the stiffer the structural element, usually, the higher lateral loads it attracts. Also the interaction between the infill panel and the frame under lateral loads drastically changes the stiffness and the characteristics of the composite structure and its response to loads.

1.2 Problem Statement and Research Significance

The available numerical and experimental information is still not enough to help structural designers to evaluate the behavior of reinforced concrete infilled frame systems under cyclic loading. Furthermore, previous experimental research studied the performance of solid infill panels, while infill in most buildings has large window or door openings. Also, there is a lack of simple numerical methods to reliably estimate the lateral-load resistance of reinforced concrete frames with masonry infill. Consequently, the engineering community needs more information on the behavior of these composite systems, and guidelines to evaluate the structural integrity and further studies should be conducted to develop design guidelines for engineered infill.

Therefore a numerical study is necessary to investigate the in-plane lateral-deformation behavior of reinforced concrete frames infilled with masonry which have different shapes, dimensions, statical systems, and material properties. Also one of the purposes of the research is to find the contribution of each component (infill masonry and R.C frame) to strength and stiffness of the composite system.

1.3 Main Objectives, Scope and Methodology of the Study

Main purposes of this research, is to develop a numerical model to provide solution for configurations that have not been investigated experimentally, as well as provide data that cannot be measured. The present study used a finite element program, ANSYS®, which is capable of carrying out structural nonlinearity for all elements. After being validated by the published experimental results, the used computer program will be used in a parametric study to investigate different parameters affecting the structural behavior of this composite system.
Thesis outlines and objectives are as follow:

1- Develop an analytical model capable to represent the experimental results done by other researchers in the field of behavior of infilled frames under cyclic loading. Then use this model to extend the level of knowledge beyond the available information through experimental results and to obtain a better understanding of masonry infill wall behavior.
2- Carry out numerical parametric study to investigate different factors affecting the behavior of reinforced concrete infilled frames under seismic and cyclic loading.
3- Develop a rational approach for design of reinforced concrete infilled frames.

CHAPTER 2

LITERATURE REVIEW and RECENT DEVELOPMENTS

2.1 Masonry Walls

Masonry structures constitute a large percentage of the current building inventory in Egypt and in most countries around the world. Many of these buildings were designed and built before modern building code requirements for seismic resistance were established. The brittle failure of the masonry wall is affected by the rapid degradation of stiffness, strength, and energy dissipation capacity.

Priestley M. J. N., (1986), Discussed the strength and ductility of concrete masonry shear walls under seismic loading. Arguments were presented for using a capacity design approach involving ultimate strength design for flexure, detailed assessment of ductility, capacity, and protection against shear failure. He recommended that the ultimate strength theory should be used for flexure design of masonry shear walls with the following restrictions:

Normal reinforced concrete equation for flexure design may be conducted using the ultimate compression strain of 0.0025 for flexure of unconfined masonry, and the strength reduction factors should be 0.05 lower than that provided by ACI 318-83. Moreover, the adequate ductility as a function of ultimate curvature ϕ_u can be expressed as equation 2-1:

$$\phi_u = \in_{cu} / c \qquad 2\text{-}1$$

Where $\in_{cu}$ is the ultimate compression strain, and c is the distance from the extreme compression fiber to the neutral axis equation 2-2:

$$c \leq 0.4 \, \ell_w / \mu \qquad 2\text{-}2$$

Where ℓ_w is the wall length and μ is the required ductility.

Early experimental studies into the strength and ductility of concrete masonry shear walls concentrated on walls of low aspect ratio were conducted to support these arguments.

Krishna N., et. al. (1989), Studied the behavior of brick masonry under cyclic compressive loading. Specimens of dimension 700mm x 700mm x 230mm were tested under four line loads. Three types of tests were conducted for increasing steadily loading, cyclic loading, and loading and unloading several times per cycle. The envelope stress-strain curve, the common point curve, and the stability point curve were established for brick masonry loaded both perpendicular and parallel to the bed joint. A general analytical expression was proposed equation 2-3 and 2-4 for these curves which were found to provide reasonable fit:

$$\sigma = \beta \frac{\in}{\alpha} e^{1-(\in/\alpha)} \qquad 2\text{-}3$$

$$\ln \frac{\sigma}{\in} = \left[\ln \frac{\beta}{\alpha} + 1 \right] - \frac{\in}{\alpha} \qquad 2\text{-}4$$

Where σ is the normalized stress ratio $\sigma/\sigma_{m;}$ $\in$ is the normalized strain ratio $\frac{\in_a}{\in_m}$; and α and β are constants. For loading perpendicular to bed joint, α = 0.85 β+0.15, and for loading parallel to bed joint, α = 0.77 β+0.23. These equations are derived from experimental and no data for the descending branch were conducted. The values of β were varied from 1.0 to 0.65 for bed joint perpendicular to load and from 1.0 to 0.71 for bed joint parallel to load.

Salah E. E. E., et. al. (1991), Described an analytical method for predicting the bearing capacity of concrete masonry walls using the Newmark integration technique but they extended this technique to account for the softening behavior of the wall. The true stress-strain relationship of masonry work was implemented in the analysis as proposed by Priestly and Elder. A strip of the wall of unit width was treated as a beam-column in a state of a plane strain. The wall strip was analyzed as one-dimensional structure, i.e., the constitutive relations of the beam-column were expressed in uniaxial form. They concluded that the wall load-carrying capacity is found to be very sensitive to small changes of end eccentricity, especially in the case of short walls.

Robert G. D., et. al. (1995), Tested thirty-six panels to investigate the in-plane behavior of grouted concrete masonry under well-defined biaxial tension-compression loading conditions. These tests were shown to be suited to the study of anisotropic characteristics, including cracked masonry and post-yielding of reinforcement. The variables considered include the bed joint orientation, the principal stress ratio σ1/σ2, and the percentages of reinforcement normal and parallel to the bed joints. The strength characteristics were shown in Fig. (2.1). Modes of failure, strengths, and stress-strain relationships were found to depend on the bed joint orientation and the principal stress ratio. And the tests showed that relatively large amounts of shear reinforcement can be beneficial to both shear strength and ductility, if attention is paid to the details and ratios of reinforcement. Moreover, strength and deformation characteristics of grouted concrete masonry under uniaxial compression are dependent on the bed joint orientation θ. At θ = 67.5 deg., the shear failure mode along the bed joint plane corresponded to a 36 percent reduction in the ultimate compressive stress, compared to the test for θ = 0 deg. The behavior of grouted concrete masonry and its dependence on the bed joint orientation change with the ratio between the principal stresses. A change in the applied stresses from uniaxial tension to a state of σ1/σ2 = 1/-1 resulted in a reduced dependence of the masonry strength on the bed joint orientation.

Sakr K. (2000), Tested one reference un-reinforced clay brick wall and four clay brick walls reinforced by CFRP laminates under monotonic, in-plane loading by applying a horizontal concentrated force at the top of the wall. The walls were anchored to concrete pedestal at the top and bottom of the wall. The overall dimension of the reference un-reinforced clay brick wall was 1470mm in length, 1240mm in height, and 90mm thickness. The compressive strength (fm) was 10.0